Site Units of the University of British Columbia Alex Fraser Research Forest

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PHOTO CREDITS

The cover photograph is of Gavin Lake, taken from the field camp in the Gavin Lake Block of the UBC Alex Fraser Research Forest. The photographs presented in this report were taken by the authors, C. Chourmouzis, and field staff of B.A. Blackwell and Associates.

SUMMARY

Knowledge about ecosystems and their distribution across the landscape is essential for stand level forest management and research, as trees and associated vegetation develop according to the sites on which they grow. Following the initiative of K. Day, manager of the UBC Alex Fraser Research Forest (AFRF), this project was undertaken to provide an advanced and detailed ecological framework for supporting ecosystem-specific research, education, planning, and operations at the research forest. Products from this project include: (1) a large-scale site series map, (2) site identification tools specific to the forest, (3) silvicultural and forest nutrient status interpretations, (4) a printed report, (5) a CD-ROM (combining the report, maps, and linked digital images), (6) field demonstration sites and, (7) images of forest communities for each site series at different locations.

This project is a co-operative effort between the UBC Forest Sciences Department (K. Klinka, P. Varga), the Alex Fraser Research Forest (C. Trethewey, C. Koot, and M. Rau) and Forest Management Institute, Czech Republic (A. Kusbach and J. Macku, who as Visiting Scientists, contributed their expertise in site classification, mapping, and map and pamphlet production).

With some deviations, we followed the 1998 Standards for Ecosystem Mapping in British Columbia and used the classification system described in the 1997 Field guide for site identification and interpretation for the Cariboo Forest Region. Sites that were difficult to identify or had not yet been classified were additionally sampled. We introduced the concept of a transitional (interzonal) area between adjacent biogeoclimatic units, recognizing the fact that climate changes gradually along a longitudinal gradient in both Knife Creek and Gavin Lake blocks and, in consequence, vegetation and sites along the zonal boundary feature transitional properties. We described local site modifiers to further enhance environmental information at the site series level. The 1:10,000 mapping scale allowed for the delineation of a high proportion of single-site-series polygons thus reducing the need to group several site series within a polygon. We used a global positioning system (GPS) for locating 2,269 waypoints during reconnaissance and ground inspection phases. To ensure maximum map reliability, approximately 90% of the polygons were inspected in the field and, if required, polygon boundaries, site identification, and modifiers were revised. During the field inspection, 1,783 digital images were taken to develop a visual library of forest stands, plant species, and sites in the forest.

One of the interpretive maps shows the locations of old-growth stands and the location of western hemlock and western redcedar in the transition area between the SBS and ICH zones in the Gavin Lake block. Species suitability, site productivity (site index), and stand nutrient status interpretive maps have also been produced. Sample plot, and soil and foliar chemistry data are hyperlinked to polygons in a GIS to provide a spatial database for each site series; similarly, hyperlinked images of forest communities provide a virtual reference of vegetation in various stages of disturbance and succession for each site series. These tools are expected to improve understanding of site classification, identification, and interpretation, as well as the management and research activities in the forest.

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1 INTRODUCTION

Application of the ecosystem-specific approach to forest management ought to be supported by ecosystem classification and site maps. The Alex Fraser Research Forest (AFRF), which is an important education, research, and demonstration facility, needs effective site identification tools and accurate site maps. Such maps and tools will make instruction in ecology, silvics, silviculture, and other disciplines more effective, and provide a necessary spatial ecological framework for research and sustainable management of the forest. Consequently, we developed further site classification, prepared forest-specific site identification tools, provided new information on forest productivity and foliar nutrient status, produced large-scale site maps of the forest, and presented all this information in a CD-ROM that will be made available to students, researchers, foresters, and visitors of the forest.

Although Steen and Coupe (1997) developed site classification, identification, and interpretation for the ecosystems in the Cariboo Forest Region, very little sampling had been done within the AFRF. Consequently, site identification was often ambiguous and confusing, and there were sites that could not be matched to the delineated site units. For example, site identification using vegetation is often difficult as understory vegetation is frequently not well developed and some site units are poorly floristically differentiated. Furthermore, little is known about the nutrient status of Douglas-fir - the most important crop species in the forest. This situation creates difficulties in (1) instructing forestry students in site identification and mapping during the Interior Field School (FRST 351), and (2) site identification by operational staff when preparing stand-level plans. Many operational and research projects carried out in the forest require accurate site identification, and information about soil and foliar nutrient status that is necessary for forest fertilization decision-making. More importantly, the lack of a site map resulted in the lack of a spatial ecological framework that is necessary for a range of land-use decision-making applications and planning including biodiversity, silviculture, forest protection, growth-yield modeling, and spatial modeling of timber supply.

The goals of this project were accomplished by:

- a high-intensity, GPS-assisted, ground reconnaissance,
- sampling vegetation and soil of those ecosystems that were difficult to identify,
- sampling foliage of young Douglas-fir and lodgepole pine stands,
- analysis of sampled vegetation, soils, and foliage,
- procurement of digital images of different forest communities at different locations to demonstrate their spatial variability and dynamics,
- development of site identification tools,
- production of large-scale site maps,
- production of small-scale interpretive maps, and
- production of a CD-ROM containing all gathered information.

This report consists of ten sections and appendices. Section 2 describes the adopted approach and concepts. The area and environmental setting of two blocks comprising the AFRF are given in Section 3. Section 4 outlines the applied methodology. Brief information on the zonal classification and zonal units encountered in the forest is provided in Section 5. Section 6 deals with classification, identification, and maps of site units. Site units of the forest are described and illustrated in Section 7. Section 8 includes interpretive information and maps. Extension products are summarized in Section 9. Finally, in the appendices we present the collected vegetation, soil, and foliar nutrient data and the map pockets include folded site maps for the Knife Creek and Gavin Lake Blocks. Several small-scale maps and interpretive maps can be viewed in a CD-ROM.

An electronic version of the report and an interactive version of the maps are contained in a CD-ROM, which provide cost-effective distribution. By integrating and linking written, image, and spatial information, the CD-ROM is an effective tool for self-learning. We believe that this self-contained report, including the CD-ROM, will (i) strengthen the application of an ecosystem-specific approach, and (ii) make the process of learning and doing site identification in the forest more effective for all users.

2 APPROACH, CONCEPTS, AND PRINCIPLES

In this Section, we discuss the concepts and principles intrinsic to biogeoclimatic classification, focusing on zonal and site units, and the adopted approach to ecosystem mapping. We assume that the reader is familiar with the fundamentals of classification. A more complete description of classification is given in Pojar et al. (1987), Meidinger and Pojar (1991), and Steen and Coupe (1997).

2.1 Ecosystem Classification

Definition of Ecosystem

A terrestrial ecosystem is defined as a landscape segment that is relatively uniform in five basic components: (1) climate, (2) soil, including topography or relief (representing physical environment, site, or habitat), (3) vegetation, (4) animals, and (5) microorganisms (representing biotic community) (Pojar et al. 1987). Vegetation and soil are the easiest components to observe, describe and study. Thus, for convenience, a terrestrial ecosystem is characterized by a plant community and the associated soil.

Plants and soil, considered simultaneously, integrate all ecosystem components and reflect ecosystem processes. Climate is the factor with the greatest influence on the soil and vegetation; animals and microorganisms depend on the vegetation and soil that is present on a site.

An ecosystem has geographical bounds; its size is determined by the extent of the plant community and the associated soil. The smallest size of a terrestrial ecosystem corresponds to the size of a sample plot. It is approximately no less than 100 m^2 for forested ecosystems and no less than 1 m^2 for non-forested ecosystems. Smaller areas are referred to as micro-ecosystems (micro-communities or microsites).

Many individual ecosystems occur within a forest - none are exactly the same but some are similar enough that they can be grouped. If a population of ecosystems is very large and the variation within it is so great that we are unable to see similarities and differences between individual ecosystems, we frame classes (classify) by grouping individuals that are alike in selected characteristics. A class is a concept (a group of individuals or of other classes), similar in select properties and distinguished from all other classes of the same population by differences in these properties. Ecology, like any science, requires a system of classification for organizing knowledge about ecosystems. The application of an ecosystem-specific approach in forestry requires that a forest that consists of many different ecosystems be stratified into ecologically uniform segments. When it is stratified, management of that forest can be simplified and, at the same time, given a sound ecological foundation. Consistent and ecologically meaningful stratification requires an appropriate classification system.

Levels of Ecosystem Classification

To show relationships among ecosystems in form (likeness) and space, the biogeoclimatic ecosystem classification (BEC) system organizes ecosystems at the local and regional levels using three types of classification. At the local level, vegetation (plant communities) and site (habitats) classifications are developed. The former produces a hierarchy of vegetation units, the latter a hierarchy of site units. In vegetation classification, local ecosystems are classified, identified, and mapped according to similarities in selected vegetation characteristics. In site classification, using the principal of ecological equivalence and late seral vegetation, local ecosystems are classified according to similarities in climate, soil moisture and nutrient conditions, and, eventually, other environmental factors that strongly influence potential vegetation. At the regional level, using the zonal concept, zonal (climatic) classification is developed producing a hierarchy of zonal (biogeoclimatic) units. Thus, regional ecosystems (groups of geographically adjacent local ecosystems) are classified, identified, and mapped according to similarities in vegetation characteristics of zonal ecosystems.

All three types of classification (vegetation, site, and zonal) are considered ecosystem classifications despite being different ways of classifying the same things (i.e., ecosystems). When vegetation classification is used, it is then more appropriate to prefix derived identification tools and maps with the adjective **plant community** or **vegetation**; similarly, when site classification is used, it is then more appropriate to prefix derived identification tools and maps with the adjective **site**.

While vegetation classification is important in developing the BEC system, zonal and site classification are most relevant to field application. Vegetation changes over time following disturbance and, consequently, forests contain a mosaic of plant communities or ecosystems in different successional or stand development stages. It is therefore easier and more useful to apply zonal classification because it provides a relatively stable climatic superstructure. The landscape can be stratified into climatically uniform segments, with each zonal unit having a characteristic distribution of local ecosystems. Similarly, it is more useful to apply site classification because it circumvents vegetation dynamics and provides for landscape stratification into relatively stable segments that have similar site qualities (i.e., climatic and edaphic conditions), potential vegetation, and productivity.

2.2 Ecosystem Maps

The logical application of biogeoclimatic ecosystem classification is local and regional ecosystem mapping, i.e., identification and mapping of vegetation, site, or zonal units. Ecosystem maps provide a geographical inventory of ecosystems and show how they are related to each other and to landscape features. They make it possible to determine the area and location of ecosystems present, which is important information for a variety of land-use applications.

Ecosystem Classification and Mapping Units

There are three types of ecosystem mapping units: (i) zonal, (ii) site, and (iii) vegetation units. **Zonal** units (zones, subzones, and variants) have been mapped at the scale of 1:125,000 and higher for the whole province. **Site** unit mapping, referred to as Terrestrial Ecosystem Mapping (TEM), has expanded since 1995 and covers a large area of the provincial forest. This mapping produces site series maps at scales ranging from 1:10,000 to 1:20,000. **Vegetation** unit mapping, as explained earlier, cannot be carried out because comprehensive classification of seral vegetation has not yet been developed.

Desirable Ecosystem Map Content

It could be argued that site maps are not true ecosystem maps because they only indicate the potential vegetation and environment of a site and not the present vegetation. However, site maps do not require updating over time because the potential vegetation and site quality are not expected to change providing the climate remains relatively stable. Classification of present vegetation would necessitate periodic updates of site maps. Forest cover maps are updated periodically with current inventory information about (i) tree species composition, (ii) age (and implicitly structural stage), (iii) density (stocking), and (iv) productivity, however, temporal changes in vegetation on sites are unfortunately not registered in forest inventories.

Any large-area ecosystem mapping is a relatively expensive proposition and should produce reliable maps in return for the investment. A good and reliable ecosystem map is the result of (i) correct identification of the units within a map polygon, (ii) drawing accurate polygon boundaries, (iii) a high proportion of monotypic mapping units, and (iv) intelligible presentation, which is manifested in choosing the right type of mapping units, size of polygons, and symbols.

3 ALEX FRASER RESEARCH FOREST

In this Section, we give information about management and objectives of the forest, and describe the location, history, physiography, and forest cover of two blocks comprising the forest. More information about the climate, vegetation, and soils of the blocks in relation to zonal units is given in Section 5.

The AFRF was established in April 1987 and is part of a department of the Faculty of Forestry, University of British Columbia. This forest is one of three research forests operated by the University. AFRF is located on crown land and complies with the same land-use regulations as other industrial forestry companies, with priority given to education, research and demonstration objectives.

The objective of the forest is to provide an optimum environment for education, research, and demonstration in all aspects of forest resource management. Any and all aspects of forestry in the BC interior can be examined in the forest, including the effects of forestry operations in relation to wildlife habitat, domestic range, and recreation; the impact of intensive forestry treatments on forest growth; forest insect and diseases; forest fire hazard and behaviour; and many other subjects. By having a research forest in interior BC, research work can be concentrated in one area so that forestry students and professionals and the public can view the results, techniques, and values of various approaches to problems. This is of great importance for extending research findings into accepted practice.

The forest provides a training ground for students in vocational, technical, and academic programs related to forest resources management. Third-year students from Faculty of Forestry, University of British Columbia, visit the forest every August to take part in the Interior Field School, part of the required study at the university. In addition, the forest acts as an outdoor classroom for hundreds of school students and general public that visit the forest each year.

The character of both blocks of the forest is, to a large measure, a product of history. Frequent wildfire in the Knife Creek Block created uneven-aged stands, and in the Gavin Lake Bock resulted in a predominance of early-seral stands. Harvesting dates back to the mid1940s (and probably before) in the Knife Creek Block, and to early 1960s in the Gavin Lake Block. The harvesting history and associated development and silvicultural activities, combined with fire suppression, have changed the structure of the forest considerably. In addition, grazing and range management, trapping, hunting, fishing, and fish and wildlife management have helped to shape the forest. Although mining activities have been limited, much of the Gavin Lake Block has been staked with mineral and placer claims.

The AFRF is situated on 9,844 ha of crown land in the Cariboo Forest Region. The forest is separated into two blocks: (1) the Knife Creek Block is 3,484 ha in size near 150 Mile House; (2) the Gavin Lake Block is 6,360 ha in size near Beaver Valley. The drier cool temperate climate of the Knife Creek Block, which is located within the Interior Douglas-fir zone, presents different ecological settings, problems, and opportunities from the sub-boreal and wetter cool temperate climates of the Gavin Lake Block, which is located within the Sub-boreal Spruce and Interior Cedar-Hemlock zones. The forest reasonably represents a range of central interior conditions.

3.1 Knife Creek Block

The southern, Knife Creek Block is located on gentle landscape terrain adjacent to San Jose Valley. It is easily accessed from Highway 97. The whole block is under the influence of summer-dry, cool temperate climate. The driest and warmest sites occur on low-elevation sites (approximately <800 m) in the southwestern part of the block, while the slightly wetter and cooler sites occupy a greater area of the block on a plateau. The elevation ranges from 720 m to 1,020 m. Douglas-fir is the predominant species occupying about 3,000 ha (87%) of the block.

The block is predominantly a plateau (a part of the Fraser Basin) with escarpment or very steep slopes close to the northern, southern, and western boundaries. The basin is a low-relief, low-lying plain covered by glacial, often drumlinized, glacial till and lacustrine deposits. The dominant soil parent material is a gravelly, base-rich, silt-loamy, morainal blanket; the dominant soils are Orthic Gray Luvisols. There are no permanent creeks or lakes within the block. A few scattered wetlands that dry out during the late summer occur on the northern boundary of the block. The soils have low-permeability and therefore the soil moisture regime on flat and depression sites fluctuates during the growing season, especially following heavy summer storms.

3.2 Gavin Lake Block

The northern, Gavin Lake Block is located on a hilly (gently to strongly rolling) landscape adjacent to Beaver Valley near Quesnel Lake. The elevation ranges from 690 m to 1,250 m. It is accessible from the Likely Road and the Gavin Lake Forest Service Road. The western part of the block is influenced by a drier and warmer, montane boreal climate (represented by the SBS zone), while the eastern part of the block is influenced by a wetter, cool temperate climate (represented by the ICH zone). Precipitation and temperature markedly increase along this longitudinal gradient.

The western portion is dominated by stands of Douglas-fir, lodgepole, and trembling aspen occurring in pure or mixed-species stands. Hybrid white spruce is scattered and restricted to cool-slopes and wetter sites. The eastern portion supports western redcedar. Douglas-fir is the predominant species on the whole block, occupying 3,322 ha (56%); hybrid spruce occupies 908 ha (15%), lodgepole pine 555 ha (9%), western redcedar 517 ha (10%), and trembling aspen 315 ha (6%).

The block is a part of the Fraser Plateau. It is underlain primarily by flat-lying to gently dipping olivine basalt, which is typically covered by a mantle of medium-textured glacial till. The dominant soil parent material is a gravelly, base-rich, silt-loamy, morainal blanket; the dominant soils are Brunisolic Orthic Gray Luvisols. There are many intermittent and several permanent creeks and nine lakes within the block, the largest being Gavin Lake.

4 MATERIALS AND METHODS

All previous work concerning the ecological setting of the AFRF was assembled and reviewed, to decide which information to include in the project database. This included road maps, air-photo maps, forest cover maps, slope gradient maps, slope-aspect maps, a biogeoclimatic subzone/variant map, Vegetation Resource Inventory pilot project files, the Management and Working Plan for the forest, and the regional field guide (Steen and Coupe 1997).

4.1 Ground Reconnaissance and Inspections

Intensive ground reconnaissance was carried out in selected transects throughout the forest in summer 2002 and was followed by ground (field) inspections in summer 2003. The purpose of the reconnaissance was to identify a wide range of sites and to assess the efficiency of existing site identification tools. The purpose of the inspections was to verify mapped polygon boundaries, site identification, and site modifiers. Transects were selected to ensure representation of major climatic, terrain, and edaphic variations in the forest. We used GPS 12 XL GARMIN units (Garmin Corporation 1998) to register station locations (waypoints) during the field reconnaissance and inspections. A total of 460 and 1,809 waypoints were measured in the Knife Creek Block and Gavin Lake Block, respectively, and the average intensity was 1 waypoint per 8.3 ha (Knife Creek) and 3.6 ha (Gavin Lake).

During the field work, site series for the ecosystem at each station was identified according to the tools provided in the regional field guide (Steen and Coupe 1997); one or more digital images of the plant community(ies) surrounding the station were taken; and any special features of the inspected ecosystem were recorded. A total of 1,783 digital images were taken to develop a visual library of forest stands, plant species, and sites in the forest. Special attention was given to ecosystems for which the identification was ambiguous or their characteristics did not fit existing descriptions of site units in the guide. These 'undescribed' ecosystems were selected for sampling.

Following the reconnaissance, all GPS-located stations were plotted on an air photo mosaic to determine distribution of transects. Additional field transect work was undertaken to fill large gaps and increase the density of ground verification, particularly of the boundary between biogeoclimatic units. GPS stations were later added as a layer in the GIS database to spatially link all information and visuals gathered at those locations. Similar procedures were employed for ground inspections. To ensure maximum map reliability, approximately 90% of the polygons (excluding landings and wetlands) were inspected on both blocks in the field and, if required, polygon boundaries, site identification, and modifiers were revised. This is equivalent to 1 inspection per 9.24 ha in the Knife Creek block, and 1 inspection per 6.26 ha in the Gavin Lake Block.

4.2 Sampling and Analysis

A total of 52 plots were established for detailed site sampling and descriptions. At each site selected for sampling, a rectangular or square 0.04 ha sample plot was established in uniform stand and site conditions. Site, vegetation, soil, and stand characteristics of each plot were described according to Anonymous (1998). Site descriptions included elevation, slope position and gradient, aspect, microtopography, parent materials, and surface substrates. The vegetation descriptions included identification and estimation of the percent cover of all plant species present in the tree, shrub, herb and moss layers. A minimum of five replicates was considered sufficient for defining a new site unit.

A soil pit was dug at each plot. Soil texture and structure, coarse fragment content, thickness and sequence of soil horizons, and potential rooting depth were described following the Soil Classification Working Group (1998). Humus forms were identified following Green et al. (1993). From each pit five forest floor and mineral soil samples (to a depth of 30 cm) were collected, composited, air-dried, ground or sieved, and submitted for chemical analysis. We estimated soil moisture and nutrient regimes (SMRs and SNRs) in the field by: (1)

evaluating topographic (slope aspect, gradient, and position) and soil morphological properties (humus form, rooting depth, texture, coarse fragment content, soil aeration, mineralogy, and presence and depth of growing-season water table) (Green and Klinka 1994) and, (2) indicator plant analysis (Klinka et al. 1989). Field estimates of SNRs were verified by soil nutrient data.

Forest floor and mineral soil samples were analyzed for basic nutrient properties according to Lavkulich (1981) (Table 1). Soil pH was measured with a pH meter in a 1:1 water suspension for mineral soil, and a 1:5 suspension for forest floor. Total carbon was determined by loss on ignition at 500°C (induction furnace) using a LECO carbon analyzer. Total N was analyzed using a Technicon Autoanalyzer following micro-Kjehldal digestion. Soil Chemical analysis was done by Pacific Soil Analysis, Inc. Richmond, BC. Soil nutrient data, obtained predominantly in the Knife Creek Block, were stratified and summarized according to zonal units and delineated site series.

During late September approximately 25 g fresh weight of the current year's foliage was sampled from 67 stands of planted immature Douglas-fir and lodgepole pine across gradients of soil moisture and soil nutrients in each zonal unit. GPS locations of each sampled stand were registered. Samples were taken from 5 branchlets on each of 5 branches located in the upper crown of each of three dominant or co-dominant trees, following the protocol of Ballard and Carter (1986) and Brockley (2001). Samples were kept in paper bags at ambient temperature, and oven-dried in the laboratory at 70ºC to constant mass. The mass of 100 dried needles was determined prior to chemical analysis. Foliage samples were ground and analyzed for total N, P, K, Ca, Mg, Mn, Fe, active Fe, Zn, Cu, B, S, and sulphate-S using the extraction and analytical methodology described in Ballard and Carter (1986) and Brockley (2001). Guidelines of Ballard and Carter (1986) and Brockley (2001) were used to evaluate Douglas-fir stand nutrient status using dry-mass concentrations.

Summary vegetation and soil and foliar chemistry data are hyperlinked to polygons in a GIS to provide a spatial database of this information for each site series. These data are included in Appendices 1, 2, 9, and 10 of this report. The CD-ROM contains all products (except extension products) from this project.

4.3 Classification, Identification Tools, and Digital Images

Classification of newly sampled plots was integrated with the existing site classification (Steen and Coupe 1997). The classification process followed the methods and principles described by Pojar et al. (1987). Floristic plot data were stratified into similar groups using TWINSPAN (Hill 1979). The following analysis was conducted with the aid of VTAB Ecosystem Reporter, Revision 199907a (Emanuel 1999) (i) to detect floristic similarities and differences among sample plots and (ii) to produce plot, summary, and diagnostic tables required in vegetation analysis and synthesis.

Based on the sampling, data analysis, reconnaissance, and inspection, we updated and produced the following identification tools (described in Section 6):

1. Keys to identification of soil moisture and nutrient regimes (Appendix 3)
2. Landscape profiles (Appendix 5)
3. Site series keys based predominantly on environmental properties (Appendix 6)
4. Edatopic grids (Appendix 7)
5. Environmental summaries for site series (Appendix 8)

Digital images of plant communities, plants, and soils were used to create a visual library. We used the community (stands) images to demonstrate spatial variability and dynamics of vegetation for each site series. Images are hyperlinked to mapped site series polygons and can be viewed on the CD-ROM.

All these identification tools and digital images are expected to improve understanding of site identification and temporal variation in vegetation of the AFRF ecosystems.

4.4 Mapping and Map Presentation

The approach taken for ecosystem mapping generally followed TEM standards (RIC 1998), but departed from them in several ways in order to meet the project objectives in a cost-efficient manner (Green 2001). For example, we did not include terrain attributes and structural stage in the database. Photo-typing was done on alternate boxed 1:15,000 colour air photos and involved delineation of polygons using recognizable terrain and landscape features, and inferences related to changes in the stand appearance. Non-forested areas within the forest were also mapped. In contrast to a routine TEM projects, site mapping of the AFRF was done using ground surveys to ensure maximum map reliability (see Section 4.1) and using the updated site identification tools.

Paragon Resource Mapping Inc, Williams Lake, using mono-restitution technique, digitized the polygon linework and GPS stations. The first draft of 1:15,000 maps was checked for errors in linework transfer and then returned for revisions. A revised second draft was used for the final attributing phase. The remaining linework revisions were done in-house, by M. Rau, AFRF.

Zonal unit boundaries were located on the map following existing mapped lines as much as possible. Where required, we added new lines and subdivided existing polygons to ensure correct location of the boundaries (see Section 5.6). Polygon attributes were recorded on attribute data forms and entered into an Excel database.

Two main editing phases were conducted: (i) editing the final attribute database before linking it with the spatial polygon data, and (ii) editing the linked spatial and attribute data. We checked for inconsistencies and errors in the site unit codes and polygon components not summing to 100% and corrected where required. Editing of the linked GIS data was done with ArcView GIS. Updates were fully incorporated into the GIS database to produce final maps linked to corrected and verified attribute data.

A limited number of site maps were produced in a hard copy format, as folded, unfolded, and cut and laminated maps. The intent was to display information in a way that readily conveys the general ecological features of the forest, while providing polygon-specific attributes for more detailed review. A simple colour scheme was used to clearly convey key edaphic properties of site units. The colour assigned to each site series and mapping polygon helps to identify the particular site unit on the map according to its edaphic properties. The maps display labeled zonal unit boundaries and numbered polygons that can be cross-referenced with attribute tables. More detailed information is given in Section 6.7. The site maps were used to derive interpretive maps.

4.5 Interpretations and Interpretive Maps

Although more interpretations can be done, in view of time constraints, we selected three topics: (1) Occurrence of western redcedar, western hemlock, and old-growth western redcedar and Douglas-fir-dominated stands in the Gavin Lake Block, (2) suitability and productivity of Douglas-fir, lodgepole pine, and hybrid spruce in both blocks, and (3) predicted nitrogen status for Douglas-fir and lodgepole pine in both blocks.

For the first interpretation, we used an air photo base to depict the occurrence of western redcedar, western hemlock, and old-growth western redcedar and Douglas-fir-dominated stands.

For the second interpretation, we used three suitability classes (suitable/viable, limited suitability/viability, and non-suitable/viable) and five productivity classes (very high, high, intermediate, low, and very low). Suitability classes were applied to the dominant site series in mapping polygons; productivity classes were applied to all site series in mapping polygons for which the tree species were considered suitable/viable. Suitability interpretations were tree species-specific and based on ecology of the species and delineated site units (e.g., Krajina 1969; Burns and Honkala 1990; Steen and Coupe 1997; Klinka et al. 2003).

The sources of potential site index estimates for the three major coniferous crop tree species were: (1) Mah and Nigh (2003) SIBEC Site Index Estimates in Support of Forest Management in British Columbia, (2) J.S.

Thrower and Associates (2002) Site Index Adjustment for the Wet-Belt Portion of the Okanagan TSA, and (3) Kayahara et al. (1995) Site Index -Site Quality Relationships for Lodgepole Pine, Interior Spruce, and Subalpine Fir in the SBS zone of British Columbia. Mean site index for a particular species and polygon was calculated as a weighted mean of site indices for the site series included in that polygon and was weighted by the site series proportional areas. In uneven-aged stands site index may not be the best measure of potential growth and the existing stands may not reflect site productivity potential.

In the third interpretation, we interpreted foliar nutrient data obtained for Douglas-fir and lodgepole pine using critical levels from Ballard and Carter (1986). We related the nutrient data to site series and quantified SNRs following the approach and methods used by Klinka et al. (2002). Estimates for unsampled site units were extrapolated using established trends in the variation of foliar nitrogen to soil nutrient regimes (e.g., Kabzems and Klinka 1987; Klinka and Carter 1990; Klinka et al. 1994; Brisco 2001).

4.6 CD-ROM Development

The CD-ROM contains an electronic version of this report, maps and visuals. Attributes and photographs of each polygon are integrated with the site maps via hyperlinks. The CD-ROM was developed following the approach and methodology used by Klinka and Varga (1999) and Klinka et al. (2000). The electronic version of the report was created in Adobe Acrobat format (PDF) using the methodology developed for the Scientia Silvica Extension Series. The PDF files can be accessed by the free Acrobat Reader and allow inclusion of full colour visuals and hyperlinks to related information. All the maps were created using ArcGIS and 'published' so they can be viewed by the free ArcReader. ArcReader allows the user to explore the maps in a variety of ways, such as selecting which layer to view, or which area to zoom into or print.

5 ZONAL UNITS

In this Section, we summarize climatic, vegetation, and soil characteristics of zonal units identified in the forest and comment on their boundaries. The Knife Creek Block is under the influence of a drier cool temperate climate delineated by the Interior Douglas-fir (IDF) zone, while the Gavin Lake Block is in the transition between montane boreal climate, delineated by the Sub-boreal Spruce (SBS) zone, and wetter cool temperate climate, delineated by the Interior Cedar-Hemlock (ICH) zone.

5.1 Nomenclature

Zonal units represent groups of regional ecosystems that are influenced by similar regional climate, i.e., the climate not affected by vegetation and local topography. Biogeoclimatic zones are named for one or more of the dominant climax (shade-tolerant) tree species present on zonal (edaphically intermediate) sites and in some cases, with a geographic or climatic modifier; e.g., Interior Douglas-fir zone. For brevity, zone names are abbreviated by a two-to four-letter code; e.g., IDF. Subordinate units, i.e., subzones, are named for relative precipitation and temperature regimes within the zone (e.g., Dry Cool IDF (IDFdk) subzone) (Table 5.1.1). Minor but influential variation of regional climate subzones are accounted for by variants, which are given geographic names that may or may not reflect differences in subzone climate, e.g., Fraser IDFdk (IDFdk3) variant.

Table 5.1.1. Letter codes used to describe relative moisture and temperature regimes of subzones.

Relative precipitation		Relative temperature	
very dry	vd	hot	h
dry	d	warm	w
moist	m	mild	m
wet	w	cool	k
very wet	vw	cold	c
		very cold	v

5.2 Interior Douglas-fir Zone

Two subzones of the IDF zone were identified in the Knife Creek Block: (1) Very Dry Mild (IDFxm) subzone and (2) Dry Cool Interior Douglas-fir (IDFdk) subzone, specifically the Fraser (IDFdk3) variant. The climate of both units is similar and characterized by warm, dry summers and cool, dry winters; the lower-elevation IDFxm subzone is somewhat drier and warmer compared to the higher-elevation IDFdk3 variant (Steen and Coupe 1997).

Peak precipitation periods are early summer and early winter. Maximum snowpack is typically 30 to 50 cm. Significant soil moisture deficits occur during most of the growing season. Frost may occur at any time during the growing season, especially in low-lying areas (Steen et al. 1990). Due to the light snowpack and low winter temperatures, soils are frozen during winter months.

The climax tree species on zonal sites is moderately shade-tolerant Douglas-fir. Hybrid white spruce is present only on fresh and wetter sites. While much of the IDFxm subzone is parkland or grasslands (especially on warm-slopes), aspen groves, and Douglas-fir stands, the IDFdk3 variant features continuous, predominantly disturbed, Douglas-fir stands.

Douglas-fir stands in the Knife Creek Block are usually multi-age and multi-sized, with abundant Douglas-fir regeneration, except on the driest sites. Most stands feature widely spaced, single or groups of old Douglas-fir trees that have survived past surface fires. The forest understory is dominated by pine grass or, under dense forest canopies, mosses, except on excessively and very dry sites. Lodgepole pine is rare in the IDFxm subzone but more frequent in the IDFdk3 variant. Wetlands, predominantly fens, marshes, and shrub carrs, are infrequent.

Soils of the IDF zone have developed primarily from base rich, basalt-derived glacial till. Soils are typically Orthic Gray Luvisols with a clay-enriched horizon in the 20 cm to 40 cm mineral soil layer. Soil texture is mostly loamy and often gravelly.

On gentle slopes in the eastern portion of the Knife Creek Block, on zonal sites, we observed an increased presence of (i) lodgepole pine, albeit scarcely regenerating in the understory, (ii) hybrid white spruce, and (iii) bunchberry (*Cornus canadensis*), black huckleberry (*Vaccinium membranaceum*), dwarf blueberry (*Vaccinium caespitosum*), and velvet-leaved blueberry (*Vaccinium myrtilloides*). However, consistent presence of Douglas-fir and its advanced regeneration in small openings suggest that lodgepole pine will not be a major species in climax stands on zonal sites. In consequence, we treated this area a climatic transition between the IDFdk and Moist Cool Sub-boreal Pine-Spruce (SBPSmk) subzones, and the ecosystems (sites) within the area were considered interzonal (i.e., between two zonal units) (see Section 5.5 and Section 5.6).

5.3 Sub-boreal Spruce Zone

One subzone - Dry Warm SBS (SBSdw), specifically Horsefly (SBSdw1) variant - of the SBS zone was identified in the western portion of the Gavin Lake Block. The SBSdw subzone is associated with the gently rolling topography of the Fraser Plateau. This area represents the easternmost extent of the SBSdw1 variant, while the eastern portion of the block is represented by the ICHmk3 variant.

With respect to climate and vegetation, the SBSdw subzone in the Gavin Lake Block may be regarded as transitional between the IDFdk and ICHmk subzones, but it appears to be more floristically similar to the IDFdk subzone. This affinity is a reflection of the block being located in the northern limit of the IDF zone and the southern limit of the SBS zone. The climate is relatively warm and slightly drier than average for the SBS zone. About half of the annual precipitation falls during the winter, and peak snowpack is about 100 cm. The wettest period is typically late spring and early summer when thunderstorms are common. Frost can occur any time of the year, especially in low-lying areas.

Climax tree species on zonal sites are moderately shade-tolerant hybrid white spruce and shade-tolerant subalpine fir. However, due to frequent wildfires in the past, old-growth stands on zonal sites are very infrequent. Lodgepole pine is the most common seral species, followed by Douglas-fir, especially on drier and warmer sites. In contrast to the IDFdk subzone, mature Douglas-fir stands in the SBSdw subzone are even-aged and single-storied with infrequent advance regeneration of Douglas-fir in the understory. Trembling aspen is also a common seral species but rarely forms large stands.

The understory vegetation on zonal sites features a moderately well developed, species-diverse shrub layer. Common shrubs include thimbleberry (*Rubus parviflorus*), black huckleberry (*Vaccinium membranaceum*), high-bushcranberry (*Viburnum edule*), birch-leaved spirea (*Spiraea betulifolia*), soopalallie (*Sheperdia canadensis*) , and Sitka alder (*Alnus sinuata*). The herb layer is less diverse, characterized by abundant pine grass (*Calamagrostis rubescens*) and rough-leaved ricegrass (*Oryzopsis asperifolia*) , sarsaparilla (*Aralia nudicaulis*) , baneberry (*Actaea rubra*), twinflower (*Linnaea borealis*), bunchberry (*Cornus canadensis*), and queen's cup (*Clintonia uniflora*). Although mosses are abundant, herbs often obscure their presence. Common moss species include: stepmoss (*Hylocomium splendens*), feathermoss (*Pleurozium schreberi*), knight's plume (*Ptilium crista-castrensis*), and electrified cat's-tail moss (*Rhytidiadelphus triquetrus*).

Soils of the SBSdw subzone have developed from base rich, basalt-derived glacial till. On zonal sites, the soils are predominantly Brunisolic Gray Luvisols with a loamy texture and moderate to high content of coarse fragments (25 - 50%). Brunisols occur on well-drained, coarse-textured materials, while Gleysols and Organics occur on water-receiving and -collecting sites of lower slopes and depressions.

The regional zonal map identifies the moist hot SBS subzone (SBSmh) in the northern part of Beaver Valley. Where the Likely Road crosses the valley, the subzone is shown on the map as a very narrow, approximately 1.5 km wide and 6 km long polygon that extends southeast into the valley where it then ends abruptly and is replaced by the SBSdw1 variant. This polygon suggests that the warm steep slopes along the southwestern boundary of the block are climatically different sites compared to the adjacent sites on a higher plateau. We agree, but attribute the climatic differences to be a result of local climatic influences (not regional) and therefore consider this area to be within the SBSdw1 variant. Difficulties in distinguishing between the influence of local and regional climate are discussed in Section 5.5 and Section 5.6.

5.4 Interior Cedar - Hemlock Zone

One subzone - Moist Cool ICH (ICHmk), specifically Horsefly (ICHmk3) variant - of the ICH zone was identified in the eastern portion of the Gavin Lake Block. It is distinguished by the presence of western redcedar, however, the occurrence of western hemlock in this variant is very rare. The ICHmk subzone has cool, wet winters and warm, moist summers. About 40% of the annual precipitation falls during the growing season, from May through September. Peak precipitation periods are early winter and early summer. Snow accounts for about 35% of the annual precipitation and results in maximum snowpacks of about 1.5 m on plateaus. Growing-season frost is less common than in the IDF and SBS zones due to higher humidity and cloud cover, resulting in reduced overnight radiation cooling.

The climax tree species on zonal sites is shade-tolerant western redcedar and subalpine fir. Hybrid spruce and subalpine fir are frequent in old-growth stands on cool sites. The principal seral species is shade-intolerant Douglas-fir, which dominates forest cover after wildfire. In the ICHmk subzone, where wildfires were common, Douglas-fir stands with an understory of western redcedar and subalpine fir cover much of the landscape.

The understory vegetation in mature and old-growth stands on zonal sites is characterized by dense advanced regeneration, a moderate cover of shrubs and herbs, and well-developed moss layer. In old-growth stands, western redcedar regenerates primarily by layering. Common shrubs are: blueberries (*Vaccinium caespitosum*, *V. membranaceum*, and *V. myrtlloides*), falsebox (*Pachistima myrsinites*), devil's club (*Oplopanax horridus*) and thimbleberry (*Rubus parviflorus*); common species in the herb layer herbs are: foamflowers (*Tiarella trifoliata* and *unifoliata*), oak fern (*Gymnocarpium dryopteris*), five-leaved bramble (*Rubus pedatus*), and one-sided wintergreen (*Orthilia secunda*); common mosses include: red-stemmed feather moss (*Pleurozium schreberi*), stepmoss (*Hylocomium splendens*), knight's plume (*Ptilium crista-castrensis*), and electrified cat's-tail moss (*Rhytidiadelphus triquetrus*).

Soils were derived predominantly from base rich volcanic till. On zonal sites in the ICHmk3 variant, the soils range from loamy to clayey Brunisolic Gray Luvisols to coarse-textured Orthic Humo-Ferric Podzols. Brunisols occur on water-shedding ridge crests and coarse-skeletal materials; Gleysols are common on water-collecting sites.

In a broad sense, the ICHmk3 variant is considered a climatic transition between the SBS zone and the wettest portion of the ICH zone of the Quesnel Highlands. However, we observed a relatively wide transition between the SBSdw1 and ICHmk3 variants in the Gavin Lake Block. Moving from the SBS dw1 variant eastward, the presence of western redcedar was used as the principal indicator of transition into the ICH mk3 variant. On cool-slopes, the transition and appearance of western redcedar is surprisingly very abrupt, while on plateaus and warm-slopes it is more gradual (see Section 8.2).

5.5 Identification of Zonal Units

Zonal units are identified in the field by locating and examining vegetation and soils of several late-seral (old-growth) stands on zonal sites, i.e., sites with intermediate soil moisture and nutrient conditions on gentle slopes or heights of land where the influence of local climate is insignificant. Site characteristics (e.g., elevation, humus form, and soil type) and vegetation characteristics (e.g., the species composition of the tree layer and advanced regeneration, and the floristic composition of the shrub, herb, and moss layers) of the stands should be compared to the diagnostic characteristics distinguished for the zonal units expected in the area. The unit that provides the best match is then selected.

On-site identification of subzones/variants may be difficult in (i) areas with disturbed forest cover and infrequent occurrence of zonal sites, and (ii) situations where climatic change in the area occurs along latitudinal and/or longitudinal gradients. Both of these scenarios were encountered in the forest. Scarcity or absence of undisturbed mature and old-growth stands and preponderance of young stands with poorly developed understory vegetation do not provide sufficient and/or reliable floristic information for confident identification, especially in the areas of gradual climatic gradients.

In view of these difficulties, we used the small-scale zonal map provided by the Regional Ecologist for locating preliminary zonal boundaries on the 1:10,000 working site maps. Steen and Coupe (1997) remind users that the boundaries may require some revisions. Two main reasons for this are: (1) transferring boundary lines from small-scale to large-scale maps is imprecise and (2) difficulty distinguishing between regional and local climates.

5.6 Boundaries of Zonal Units

We encountered difficulties in drawing zonal boundaries in the Knife Creek Block between the IDFxm and IDFdk subzones, and in identifying the zonal unit in the northeastern portion of the block where the existing vegetation indicated features of both IDFdk and SBPSmk subzones. In the Gavin Lake Block, there was uncertainty about the location of boundary between the SBSdw and ICHmk subzones, and whether steep, warm-slopes along Beaver Valley Lake are part of the SBSdw or SBSmh subzone.

We expect that subzone boundaries delineated on Research Forest site maps are more precise than those on subzone maps. This is because site mapping provides a more detailed resolution of the distribution of zonal ecosystems in the landscape than zonal mapping. If the scale of subzone maps were the same as that used for site mapping, i.e., 1:10,000 to 1: 20,000, and if subzone boundaries were precise, then, understandably, there should not be any discrepancies between subzone boundaries shown on the site and subzone maps. However, we know that this is not the case and that we can expect minor or major discrepancies in subzone boundaries between the large- and small-scale maps.

Considering the nature of climate, regional ecosystems are evidently less-discrete bodies than local ecosystems. Therefore, the boundary between zonal units, each representing an area influenced by a particular regional climate, cannot be abrupt. Boundaries between two zonal units (regional climates) are typically diffuse, except along steep altitudinal gradients. A regional climatic change in an undulating landscape can occur over long distances ranging between several hundred meters and several kilometers. Consequently, it would be unreasonable to mark the boundary between two zonal units in a particular place with a thin line indicating an abrupt boundary.

Another reason for difficulties in distinguishing zonal boundaries lies in the climatic variation imposed by local topography. Climatic localism can occur over short distances in the landscape influenced by cool continental climates due to variation in topography (position on a slope, slope gradient, and aspect), where slope gradient and aspect are most influential. Topography will affect snowpack, snow duration, duration of the growing season and growing-degree days (temperature). As a result, the boundary between zonal units in complex topographic situations should not follow a certain elevation limit. For example, warm-slopes without the presence of zonal ecosystems will feature the ecosystem characteristics of the neighbouring warmer and/or drier zonal unit, and conversely, cool-slopes without the presence of zonal ecosystems, will feature the ecosystem characteristic of the neighbouring cooler and/or wetter zonal unit.

Several questions arise: Do we consider climatic localism to reflect changes in regional or local climate? How do we distinguish between local and regional climate? What is the minimum area of a zonal unit?
The answers to these questions are not simple and require addressing complex and elusive issues. It is doubtful whether attempts to define local and regional climate would be worthwhile. The benefits gained by improving the conceptual utility of the biogeoclimatic ecosystem classification system should be weighed against losses in the utility of the system by increasing its complexity.

In the Alex Fraser Research Forest, we believe that the occurrence of the ecosystems within a zonal unit, that resemble ecosystems of an adjacent zonal unit, is the manifestation of local climate. We suggest that ecosystems under the influence of local climate (local topography) should be treated as part of the zonal unit in which they occur, with the provision that it is indicated that they are warmer or cooler than expected for the unit (e.g., Hills 1955). The boundary between zonal units in these situations should follow general elevational limits determined for the units.

We circumvented problems with locating and drawing abrupt zonal boundaries in the AFRF by indicating the presence of transitional (interzonal) areas. Hence, the presence of associated transitional (interzonal) site units featuring floristic and environmental characteristics between (1) the IDFxm subzone and IDFdk3 variant (IDFxm-IDFdk3 transition), (2) the IDFdk3 variant and SBPSmk subzone (IDFdk3-SBPSmk transition), and (3) the ICHmk3 and SBSdw1 variants (ICHmk3-SBSdw1 transition). Furthermore, ecosystems in the Gavin Lake block, that are located on warm-slopes facing Beaver Valley, were assigned to the SBSdw1 variant and given the site modifier 'local climate' (specifying the influence of a warm local climate).

6 CLASSIFICATION, IDENTIFICATION AND MAPS OF SITE UNITS

This section contains all general resources concerning site units, specifically site series. First, a brief overview of site classification, including nomenclature of site units, is presented. A synopsis of site units (in decreasing generalization: groups, associations, series, and site modifiers) and their relation to zonal units (subzones/variants) and to each other are given next. The principles of site unit differentiation, the process of site identification, the boundaries of site units, and present identification tools that include edatopic grids, landscape profiles, and keys are discussed. The last subsection describes the design adopted for the site maps.

6.1 Site Units and Nomenclature

Site Association

A site association (conceptually similar to habitat type of Daubenmire (1968)), the basic unit of the site classification, represents a group of ecosystems, which regardless of the present vegetation, have a certain vegetation and productivity potential. Each site association includes ecologically-equivalent sites (i.e., sites with similar growing conditions) that are characterized by a unique range of climate (zonal units), soil moisture and nutrient regimes, and, eventually, by other environmental factors. The **Fd–Feathermoss–Step moss** is an example of a site association, with similar edaphic conditions but a somewhat wider climatic range, that spans the IDFxm subzone and IDFdk3 variant.

Site associations are named using one or two, usually shade-tolerant, tree species (using the BC Forest Service (BCFS) codes), followed by one or two common names of understory species present in late-seral succession stages; e.g.; Fd–Feathermoss–Step moss site association. For brevity and ease of communications, we used a Latin (or common) name of a single understory indicator species, e.g., **Hylocomium** (or Step moss) and excluded tree species codes. The user should be aware that the species used to name a site series may not always be present and/or may also be present on sites of a different site series.

Site Series

Site series represent a climatically uniform group of ecosystems within a site association where the climatic range extends across two or more zonal units. Site series are named after the parent site association preceded by the subzone or variant code; e.g., **IDFdk3/Hylocomium** (or Step moss). For brevity, site series are numbered with a 2-digit code; e.g. **IDFdk3/05**. Within a subzone or variant, zonal (edaphically intermediate) site series are always numbered 01; the other site series are numbered sequentially from the relatively driest to wettest and nutrient-poorest to -richest.

Site Groups

Site groups, units used for a higher level of site classification, are formed by grouping environmentally and floristically similar site associations. As precise criteria have not yet been established, classification of site groups has not yet been developed. Consequently, the site groups framed in this project are provisional and used to organize the information about site series in a way that is easily retained in memory and conveyed through instructions. They help to define relationships with the greatest possible number of properties. Our approach was (i) to group recognized, floristically similar site series into site associations and (ii) to group the associations into site groups based predominantly on edaphic properties. For example, the **rocky site** group including all site series (and hence all associations) on rocky sites, i.e., representing forested ecosystems inhabiting rock outcrops and adjacent cliffs and talus deposits, was framed regardless of vegetation differences. This approach is justified by the similarity of ecosystem processes and management implications across these sites.

Site Modifiers

To account for environmental variations within site series, site modifiers, which describe specific aberrant properties of a site (Appendix 4.1), were used. For brevity, the modifiers are abbreviated to two-letter codes; e.g., stony = ny. Modified site series represent an environmentally uniform group of ecosystems, which are thought to respond similarly to disturbance or treatment. Modified site series are named after the parent series followed by the edaphic adjectives connoting aberrant edaphic properties; e.g., **IDFdk3/Hylocomium/slope-skeletal** or **IDFdk3/05sk**.

6.2 Differentiation of Site Units

The analysis of vegetation data is a necessary component of site classification as it assists in delineating, and consequently, identifying, ecologically equivalent sites with certain potential vegetation, i.e., site associations. The distinguished vegetation units represent provisional site associations pending examination of the climatic and edaphic range of the included sample plots. It is essential that each site association must be exclusive in the following criteria: climatic range, soil moisture and nutrient regime range, and eventually, some other environmental factors affecting vegetation.

If two vegetation units in a region have identical climatic and edaphic ranges and the differences in vegetation cannot be explained by any other environmental factors, then these two units are merged into one site association and the differences are attributed to temporal variation in vegetation. This situation has not occurred in our analysis indicating that our sampling covered late-seral succession stages and the distinguished vegetation units can be considered representative of framed site associations.

The approach adopted to differentiate site units was as follows:

- If the climatic range of two or more vegetation units was the same or overlapping but the edaphic range was different but not overlapping, regardless of whether the difference is in soil moisture or soil nutrient conditions or both, then two or more site associations were framed, each differentiated according to climate (zonal units). This was the common scenario in the Knife Creek Block data as the climatic range of nearly all distinguished vegetation units included the IDFxm subzone and IDFdk3 variant.

- Overlapping range in soil moisture and soil nutrient conditions was resolved by adding additional differentiating characteristics, such as slope and aspect, implying differences in local climate. If two vegetation units with overlapping edaphic, or even the same edaphic range, were associated with different local climates i.e. one on cool-slopes and one on warm-slopes, they were considered environmentally unique and thus framed as separate two site associations.

- If the climatic range of two or more vegetation units was different, but not overlapping, then, regardless of the edaphic range, two or more site associations were framed each with one or more site series depending on the climatic range measured by zonal units.

- Results of the vegetation analysis for the Knife Creek Block are given in Section 6.4.

6.3 Synopsis of Site Units

The synopsis of site series according to zonal units is given in Table 6.3.1. The IDFxm site series are also used for the IDFxm-IDFdk3 transition as the sites in the transition area are more similar to those in the IDFxm subzone than the IDFdk3 variant; similarly, the ICHmk3 site series are used for the sites in the ICHmk3-SBSdw1 transition. The numerical codes for sites series were kept the same as the BCFS codes for the original site series, except for two new site series: (1) IDFdk3/10 (Cornus) which has been recognized in the IDFxm subzone but not in the IDFdk3 variant, and (2) ICHmk3/08 (Rubus) which has been recognized in the SBSdw1 variant but not in the ICHmk3 variant.

The stratification of site series into site groups according to zonal units is shown in Table 6.3.2. Nine site groups representing all forested sites in the forest were framed and used for describing site series (see Section 7). Site associations can be distinguished in the table by the same abbreviated names of site series. A site group consists of all site series included in a particular row. The same colour scheme as used in the table is applied to edatopic grids, landscape profiles, and site maps.

Table 6.3.1. Synopsis of site series for the Alex Fraser Research Forest according to zonal units, including the BCFS codes and full names and the equivalent codes and abbreviated names used in this project.

BC Forest Service code and name for site series	Code and name for abbreviated nomenclature
01 IDFxm/Fd-Pinegrass-Feathermoss	01 IDFxm/**Calamagrostis** (Pine grass)
02 IDFxm/Fd-Elymus-Penstemon	02 IDFxm/**Juniperus** (Common and Rocky Mountain junipers)
03 IDFxm/Fd-Juniper-Cladonia	03 IDFxm/**Arctostaphylos** (Kinnikinnick)
04 IDFxm/Fd-Bluebunch wheatgrass-Pasture sage	04 IDFxm/**Allium** (Nodding onion)
05 IDFxm/Fd-Feathermoss-Step moss	05 IDFxm/**Hylocomium** (Step moss)
06 IDFxm/Fd-Ricegrass-Feathermoss	06 IDFxm/**Oryzopsis** (Rough-leaved rice grass)
07 IDFxm/Fd-Prickly rose-Sasparilla	07 IDFxm/**Aralia** (Sarsaparilla)
08 IDFxm/Sxw-Snowberry-Prickly rose	08 IDFxm/**Cornus** (Red-osier dogwood)
09 IDFxm/Sxw-Horsetail	09 IDFxm/**Equisetum** (Horsetail)
01 IDFdk3/FdPl-Pinegrass-Feathermoss	01 IDFdk3/**Calamagrostis** (Pine grass)
02 IDFdk3/Fd-Juniper-Kinnikinnick	02 IDFdk3/**Arctostaphylos** (Kinnikinnick)
03 IDFdk3/Fd-Juniper-Peltigera	03 IDFdk3/**Juniper** (Common and Rocky Mountain junipers)
04 IDFdk3/Fd-Bluebunch wheatgrass-Needlegrass	04 IDFdk3/**Allium** (Nodding onion)
05 IDFdk3/Fd-Feathermoss-Step moss	05 IDFdk3/**Hylocomium** (Step moss)
06 IDFdk3/Fd-Pinegrass-Aster	Combined with 04 (Allium) site series
07 IDFdk3/SxwFd-Prickly rose-Sedge	07 IDFdk3/**Lonicera** (Black twinberry)
08 IDFdk3/SxwFd-Prickly rose-Sarsaparilla	08 IDFdk3/**Aralia** (Sarsaparilla)
09 IDFdk3/Sxw-Horsetail-Glow moss	09 IDFdk3/**Equisetum** (Horsetail)
no equivalent site series	10 IDFdk3/**Cornus** (Red-osier dogwood) (newly recognized site series)
01 SBSdw1/SxwFd-Pinegrass	01 SBSdw1/**Calamagrostis** (Pine grass)
02 SBSdw1/FdPl-Cladonia	02 SBSdw1/**Cladonia** (Lichens)
03 SBSdw1/Fd-Saskatoon-Pinegrass	03 SBSdw1/**Chimapila** (Prince's pine)
04 SBSdw1/Pl-Pinegrass-Feathermoss	04 SBSdw1/**Vaccinium** (Velvet-leaved blueberry)
05 SBSdw1/SxwFd-Ricegrass	05 SBSdw1/**Hylocomium** (Step moss)
06 SBSdw1/SxwFd-Thimbleberry	06 SBSdw1/**Rubus** (Thimbleberry)
07 SBSdw1/Sxw-Twinberry-Coltsfoot	07 SBSdw1/**Lonicera** (Black twinberry)
08 SBSdw1/Sxw-Twinberry-Oak fern	08 SBSdw1/**Gymnocarpium** (Oak fern)
09 BSdw1/Sxw-Horsetail-Glow moss	09 SBSdw1/**Equisetum** (Horsetail)
01 ICHmk3/CwSxw-Falsebox-Knight's plume	01 ICHmk3/**Ptilium** (Knight's plume)
02 ICHmk3/FdCw-Wavy-leaved moss	02 ICHmk3/**Cladonia** (Lichens)
03 ICHmk3/CwSxw-Soopollalie	03 ICHmk3/**Chimaphila** (Prince's pine)
04 ICHmk3/CwSxw-Oak fern-Cat's-tail moss	04 ICHmk3/**Gymnocarpium** (Oak fern)
05 ICHmk3/SxwCw-Oak fern	05 ICHmk3/**Lonicera** (Black twinberry)
06 ICHmk3/CwHw-Devil's club-Lady fern	06 ICHmk3/**Streptopus** (Twisted stalks)
07 ICHmk3/CwSxw-Devil's club-Horsetail	07 ICHmk3/**Equisetum** (Horsetail)
no equivalent site series	08 ICHmk3/**Rubus** (Thimbleberry) (newly recognized site series)

Table 6.3.2. Stratification of site series of the Alex Fraser Research Forest according to site groups and zonal units. Site series with the same digit code and/or name shown in the same row and/or column belong to the same site association.

Site group	IDFxm and IDFxm-IDFdk3 transition	IDFdk3 and IDFdk3-SBPSmk transition	SBSdw1	ICHmk3 and ICHmk3-SBSdw1 transition
Rocky sites	**02 Juniper**	**03 Juniper**	**02 Cladonia**	**02 Cladonia**
Water-shedding, crest sites	**03 Arctostaphylos**	**02 Arctostaphylos**	**03 Chimaphila** **04 Vaccinium**	**03 Chimaphila**
Water-shedding, warm-slope sites	**04 Allium**	**04 Allium**	**03 Chimaphila**	**03 Chimaphila (upper slopes)** **01 Ptilium (mid-slopes)**
Water-shedding, cool-slope sites	**05 Hylocomium**	**05 Hylocomium**	**05 Hylocomium**	**01 Ptilium (mid-slopes)**
Near-zonal and zonal sites	**01 Calamagrostis**	**01 Calamagrostis**	**01 Calamagrostis**	**01 Ptilium**
Water-enriched, poorly drained sites	**06 Oryzopsis**	**07 Lonicera**	**07 Lonicera**	**05 Lonicera**
Inherently rich and intermittent seepage sites	**07 Aralia**	**08 Aralia**	**06 Rubus**	**08 Rubus** **04 Gymnocarpium**
Water-receiving (seepage) sites	**8 Cornus**	**10 Cornus**	**08 Gymnocarpium**	**06 Streptopus**
Water-collecting (waterlogged) sites	**09 Equisetum**	**09 Equisetum**	**09 Equisetum**	**07 Equisetum**

6.4 Vegetation Analysis of Site Series in the Knife Creek Block

The diagnostic combinations of species extracted for sites series are arranged along a soil moisture gradient from the driest to the wettest sites (Appendix 1.1). Except for intermediate ('mesic') series (i.e., IDFdk3/01 and IDFdk3-SBPSmk/01), all other series are reasonably well differentiated floristically. There are, however, several common species without any diagnostic values as they occur across a wide range of sites, such as *Amelanchier alnifolia*, *Calamagrostis rubescens*, *Pluerozium schreberi*, and *Rosa acicularis* (see non-diagnostic species Appendix 1.3).

The rocky sites in the IDFxm subzone and IDFdk3 variant are associated with forest communities featuring a combination of xerophytic species, with *Penstemon fruticosus* and *Prunus virginiana* being differential. Based on the edaphic (excessively dry soil moisture conditions and rocky habitats) and floristic affinities, the original IDFxm/02 (Fd-Elymus-Penstemon) and IDFdk3/03 (Fd-Juniper-Peltigera) site series were combined into one (**Juniperus**) site association (Table 6.3.1 and Table 6.3.2; Appendix 1.1).

Using the same procedure, the original IDFxm/03 (Fd-Juniper-Cladonia) and IDFdk3/02 (Fd-Juniper-Kinnikinick) site series were combined into one (**Arctostaphylos**) site association, with *Apocynum androsaemifolum* and *Arctostaphylos uva-ursi* being differential species. Similarly, the original IDFxm/04 (Fd-Bluebunch wheatgrass-Pasture sage) was combined with the IDFdk3/04 (Fd-Bluebunch wheatgrass-Needlegrass) site series into one (**Allium**) site association, differentiated by several species (Table 6.3.1 and Table 6.3.2; Appendix 1.1). Clearly, the local climatic and edaphic affinities between these two pairs of site series override minor climatic differences between the IDFxm subzone and IDFdk3 variant. Based on indicator values of differential species, the Arctostaphylos site association appears to be slightly more acid compared to the Allium site association.

In addition, the original IDFdk3/06 (Fd-Pinegrass-Aster) site series was incorporated with the IDFxm/04 (Fd-Bluebunch wheatgrass-Pasture sage) and IDFdk3/04 (Fd-Bluebunch wheatgrass-Needlegrass) site series in the Allium site association considering (i) floristic and edaphic similarities and (ii) difficulties in estimating accurately the relative submesic (SMR = 3) soil moisture regime (Table 6.3.1 and Table 6.3.2; Appendix 1.1).

Clearly, the original IDFxm/05 (Fd-Feathermoss-Step moss), IDFdk3/05 (Fd-Feathermoss-Step moss), and SBSdw1/05 (SxwFd-Ricegrass) site series form one (**Hylocomium**) site association (Table 6.3.1 and Table 6.3.2; Appendix 1.1). Omitting minor difference in climax tree species (i.e., lodgepole and hybrid white spruce) and considering edaphic and floristic similarities, the original IDFxm/01 (Fd-Pinegrass-Feathermoss), IDFdk3/01 (FdPl-Pinegrass-Feathermoss), and SBSdw1/01 (SxwFd-Pinegrass) site series were combined into one (**Calamagrostis**) site association.

Similarly, the original IDFxm/07 (Fd-Prickly rose-Sarsaparilla) and IDFdk3/08 (SxwFd-Prickly rose-Sarsaparilla) site series were combined into one (**Aralia**) site association, and IDFdk3/07 (SxwFd-Prickly rose-Sedge), SBSdw1/07 (Sxw-Twinberry-Coltsfoot), and ICHmk3/05 (SxwCw-Oak fern) into one (**Lonicera**) site association (Table 6.3.1 and Table 6.3.2; Appendix 1.1). As the vegetation of waterlogged sites is similar across different climates, it was not surprising to detect floristic similarities among the original IDFxm/09 (Sxw-Horsetail), IDFdk3/09 (Sxw-Horsetail-Glow moss), SBSdw3/09 (Sxw-Horsetail-Glow moss), and ICHmk3/07 (CwSxw-Devil's club-Horsetail) site series. Therefore, they were combined into one (**Equisetum**) site association. Similar framing of site associations was done for other site series (Table 6.3.1 and Table 6.3.2; Appendix 1.1).

6.5 Identification of Site Units

The ability to identify sites has to be acquired through skills and experience. Skills involve ability to identify landforms, topographic features, soil properties, and plants. Experience is obtained from training and practising site identification over a range of sites in a forest. In a way, site identification resembles the process of identifying any object. For example, it is easy to identify a given species, such as Douglas-fir without a great amount of deliberation. Similarly it should become easy, but perhaps requiring more thought, to identify a given site as a particular site series. The difficulty is in considering and integrating a great amount of qualitative and quantitative site information. Some sites, such as on rock outcrops or waterlogged site are identified effortlessly, while the identification of other sites, such as those representing intergrades of two related site units, may not be easy.

However, if site classification accounted for all sites in a forest and the diagnostic characteristics of distinguished site units rendered explicit differentiation, the identification of site units in the field would require only observation of selected topographic, soil, and floristic properties and eventually the application of identification tools. After some practice, site identification can become a routine procedure that can be carried out even without the use of any identification tools in a way similar to plant identification - seeing or observing a plant can bring to mind its name without apparent effort.

Site units are differentiated by environmental characteristics; therefore, the same characteristics are used for site identification in the field. In situations where lesser vegetation is sufficiently developed, floristic features may be used as accessory characteristics for identification, namely as indicators of site quality. This approach allows for site identification regardless of the vegetation present on a site. The primary environmental characteristics for site identification in the AFRF are: (1) regional climate (zonal unit), (2) SMR, (3) SNR, (4) landform, and (5) slope position, aspect, and gradient. Once the zonal unit is identified from regional maps, then site identification is concerned with determining site series and the application of site modifiers.

The identification process begins with selecting a sampling station (identification or observation area) within the site in question. The chief concern is to locate the station outside of the transitional zone between neighbouring sites. The complete process of site identification is depicted in Figure 6.5.1. In the second step, the zonal unit is identified according to its location on the zone (Section 5.5) or site map. In the third step, all individual site properties affecting SMR and SNR are estimated or measured, landform is identified, and slope position, aspect, and gradient of the site are determined. A more detailed description of site identification is given in Steen and Coupe (1997).

In support of site identification, we offer several tools. It is recommended that they are used in the following order; however, the user may change the order or ignore some tools at his/her discretion:

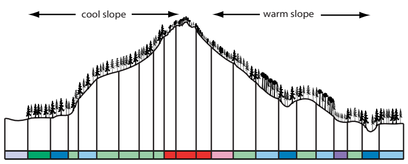
1. Keys to soil moisture and nutrient regimes (Appendix 3)
2. Landscape profile specific to the zonal unit identified for the site (Appendix 5)
3. Key to the site series specific to the zonal unit of the site (Appendix 6)
4. Edatopic grid specific to the zonal unit identified for the site (Appendix 7)
5. Distinguishing environmental features of site units (Appendix 8)

Identifying Forest Sites

Start

Identify **biogeoclimatic unit** on a map, e.g. ICHmk3

What is the **slope position**, **gradient** and **aspect**?



e.g. ICHmk3 landscape profile

Dig a **soil pit** and determine:

- humus form
- texture
- % gravel, cobbles, stones
- depth
- soil type
- depth and type of restrictive layer
- exposed bedrock

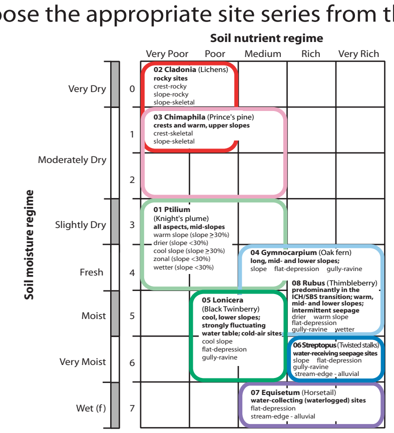
Inventory vegetation
Learn indicator plants (e.g. this ICHmk3 species) and their indicator values.

Oplopanax horridus
Devil's club

Use **site series identification key** (based predominantly on topography and soils) and compare with other findings

Determine:
Soil Moisture Regime (SMR) and
Soil Nutrient Regime (SNR) using keys

Choose the appropriate site series from the **edatopic grid**



e.g. Edatopic Grid for ICHmk3 and ICHmk3 - SBSdw1 Transition

Cross-check with

Vegetation characteristics table
* applicable only if understory vegetation is well developed

Site characteristics table

Interpretations

Operational considerations
(cutting methods, equipment types, harvesting season, etc.)

Tree species selection
for reforestation

Silviculture treatment options
(regeneration method, brushing, stand tending, etc.)

Other

Figure 6.5.1. Flow chart indicating the process of identifying forest sites in the Alex Fraser Research Forest

Soil Moisture Regime

Soil moisture regime (SMR) refers to the average annual amount of soil water available to plants. **Relative SMR** uses eight classes to rank the relatively driest soil (0) to the relatively wettest soil (7) within a particular zonal unit. It is inferred from selected topographic and soil features. Relative SMR classes do not reflect the actual amount of available water, as this is a function of climate. **Actual SMR** is therefore used to quantitatively describe soil moisture conditions based on annual water balance and water table depth (Klinka et al. 1989). Nine classes are recognized (excessively dry, very dry, moderately dry, slightly dry, fresh, moist, very moist, wet, and very wet). The *dry* classes represent growing season water deficits, the *fresh* class represent regimes with neither deficits nor surpluses during the growing season, and *moist* to *very wet* classes indicate growing season water surplus, often with growing-season water table.

As it is important to know actual soil moisture conditions for forest sites, the relationships of relative SMRs to actual SMRs are presented in Table 6.5.1 as well as on each of the four edatopic grids (Appendix 7). It is stressed that the actual SMRs values are only estimates that were adapted and slightly revised from Steen and Coupe (1997). Within a zonal unit, plant-available water increases with increasing soil water-holding capacity from relative SMR 0 through 7, or from water-deficiency to water-surplus; within the same relative SMR, plant-available water increases with increasing humidity and decreasing temperature of regional climate from the IDFxm subzone through to the ICHmk3 variant.

Recognizing that relative SMRs describe growing-season plant-available water on freely-drained sites, i.e., rapidly to moderately-well drained soils on slopes, is emphasized. The soil water dynamics on sites with poor lateral drainage, such as on flats with fine-textured soils, will feature a fluctuating water table in response to temporal variations in precipitation (Table 6.5.1). These soil moisture conditions are usually encountered with relative SMR 5, 6, and 7 on flats and in depressions, typically on the Lonicera sites (Table 6.3.2).

Table 6.5.1. Relationships between relative and actual soil moisture regimes in four zonal units of the Alex Fraser Research Forest.

	Relative soil moisture regime							
Subzone/variant	0	1	2	3	4	5	6	7
IDFxm IDFxm-IDFdk3	**excessively dry**	**very dry**	**very dry**	**moderately dry**	**moderately dry**	**slightly dry to fresh**	**moist (to very moist)**	**wet**
IDFdk3 IDFdk3-SBPSmk	**excessively dry**	**very dry**	**very dry**	**moderately dry**	**moderately to slightly dry**	**slightly dry to fresh**	**moist (to very moist)**	**wet**
SBSdw1	**very dry**	**very dry**	**moderately dry**	**moderately dry**	**slightly dry**	**fresh**	**moist to very moist**	**wet**
ICHmk3 ICHmk3-SBSdw1	**very dry**	**moderately dry**	**moderately dry**	**slightly dry**	**fresh**	**moist**	**very moist**	**wet**

Soil Nutrient Regime

Soil nutrient regime (SNR) refers to the amount of essential soil nutrients, particularly nitrogen, that are available to plants (Klinka et al. 1989). Five classes are recognized, ranging from *very poor* with low amounts of available N and other nutrients and slow turnover of organic matter, to *very rich* with relatively large amounts of available N and other nutrients, and rapid turnover of organic matter.

Edatopic Grids

The design of standard edatopic grids (as presented in the regional field guides) was improved upon in the following ways (Appendix 7):

1. Relationships between relative and actual SMRs are shown for each zonal unit and possible occurrence of fluctuating soil water table is indicated by the letter f.
2. The plots of site series follow the boundaries of SMRs and SNRs cells, i.e., each site series occupies a clearly defined region of the grid.
3. Applicable modifiers are given for each site series.
4. Overlapping edaphic regions of two or three site series are accounted for by additional differentiating environmental characteristics, which are listed. This information enhances the value of the grids as identification tools.
5. The colour outline for each site series relates it to the site map.

Site Series Keys

Site series keys (Appendix 6) are based on landform (topographic and soil) properties. The rationale for this choice was (i) to emphasize the environmental nature of site units and (ii) the presence of large areas of disturbed sites and stands with poorly developed understory vegetation. The disturbed sites (cutovers and young plantations on burned sites) featured a mixture of early seral and remnants of the original vegetation, and ubiquitous boreal mosses dominated the understory of dense, immature stands. In addition, floristic differentiation of many site series was weak, probably due to the transitional nature of the IDFxm subzone in the Knife Creek Block and the SBS and ICH zones in the Gavin Lake block. Many easily identifiable and common plants, such as *Amelanchier alnifolia*, *Calamagrostis rubescens*, and *Rosa acicularis,* occur over a wide range of sites.

The intent of the keys was to provide for unambiguous environmental differentiation of site series. While recognizing site series on rocky, water shedding, cool- or warm-slope, water-receiving (seepage), and water-collecting sites is straightforward, identification of site series portrayed in the center of edatopic grids may require a more detailed site examination, such as distinguishing zonal (01) site series on medium sites from inherently rich sites (e.g., Aralia, Rubus, and Gymnocarpium site series).

Landscape Profiles

Showing a pattern of site series, zonal unit-specific landscape profiles serve as another useful but supplemental tool for site identification (Appendix 5). The profiles were developed for low and high relief landscapes and cool- and warm-slopes, as local climate is an important factor affecting vegetation development and its spatial pattern in cool temperate and boreal climates. The profiles also show site series modifiers indicating terrain and selected soil properties that are the driving factors controlling water movement and soil moisture conditions.

Distinguishing Environmental Features

Similarly, zonal unit-specific tables summarizing distinguishing environmental features of site series serve as another supplemental tool for site identification (Appendix 8). Essentially, they include all features considered in the development of (i) the keys to identification of SMRs, SNRs, and site series, (ii) edatopic grids, and landscape profiles.

6.6 Boundaries of Site Units

For several reasons, no ecosystem map can render an exact representation of the ecosystem pattern in the landscape; the best efforts result in an acceptable approximation. Local ecosystems, and even more so, regional ecosystems, are not discrete objects like plants. Boundaries between two local ecosystems may occur where there has been, or is now, a significant difference in one or more ecosystem forming factors (i.e., local climate, relief, soil parent materials, biota, and time). The lateral boundaries between two local ecosystems may be abrupt but are more commonly gradual or diffuse, indicating a more or less wide (several meters or even wider) transitional area between two ecosystems. Transitional areas are usually avoided in ecosystem sampling and classification, but one has to be prepared to deal with them in mapping, possibly by employing several types of boundary lines.

6.7 Site Unit Maps

The design of the site maps focused on two aspects of presentation – format and colour – and followed the approach of Klinka and Skoda (1977). The major objective of the format was to produce maps as self-contained publications. Therefore, the explanatory materials deemed necessary for the map to function also as an educational tool were included. This additional information to the map body included:

1. Title
2. General legend
3. Sheet location
4. Credits
5. Outline
6. Mapping methods
7. Mapping unit legend
8. Mapping polygons
9. Mapping statistics
10. Application
11. Acknowledgements

The colour scheme defines each sites series within a one-dimensional space. In this space, wavelength (hue) is assigned to represent site group. As the sequence of site groups progresses for rocky sites through water-collecting sites, the availability of soil water and nutrients increase approximately in the same sequence. The colour scale progresses from a red hue, assigned to site series on rocky sites, through pink, orange, yellow, light green, dark green, light blue, and dark blue to purple, which represents water-collecting sites (Figure 6.7.1). This assignment constitutes a physiological spacing.

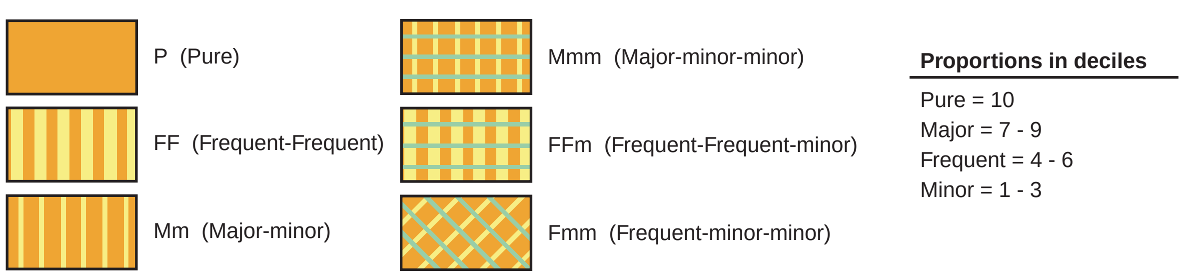


Figure 6.7.1. Colour scheme devised to portray polygons containing one, two, and three mapping units.

7 DESCRIPTION OF SITE UNITS

To eliminate redundancies and to emphasize the nature of site classification, the descriptions of site series were combined according to site groups (Table 6.3.2). Each site group includes all site series with edaphically (but not climatically) similar (comparable) sites. For example, it can be seen from Table 6.3.2 that the Equisetum site series (albeit with different codes in different zonal units) are all related to water-collecting sites across all four zonal units. There will be minor or major variation in vegetation and forest productivity depending on climate but the fundamental site properties and ecosystem processes will be similar in all Equisetum site series. Therefore, it will not be proficient to repeat the description for each of the four Equisetum site series forming a single site group when the description can be integrated. However, when a particular site group includes two or more different site series, e.g. Rocky Sites include Juniperus (IDFxm/02 and IDFdk3/03) and Cladonia (SBDdw1/02 and ICHmk3/02) site series, individual descriptions are presented. The site descriptions are brief and include (1) selected, characteristic site images, and (2) for the Knife Creek Block, references to vegetation and soil data in Appendices. Suitability and productivity information for the major crop species and Douglas-fir and lodgepole nutrient status information are given in Section 8.

7.1 Rocky Sites

Excessively to very dry, nutrient-poor, water-shedding, rapidly drained, shallow soils over basaltic or andesitic bedrock, cliffs, and adjacent colluvium

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

This site group combines all rocky sites (135.2 ha) in the forest. They include IDFxm/02, IDFdk3/03, SBSdw1/02, and ICHmk3/02 site series (Table 6.3.1 and Table 6.3.2). They occur infrequently in small areas across the landscape, most commonly along the southern boundary in the Gavin Lake Block, and may include minor rock outcrops.

Juniperus and Cladonia sites lack continuous vegetation and soil cover. Much of the ground surface is exposed mineral soil and bedrock. Three site modifiers were used: (1) crest-rocky, (2) slope-rocky, and (3) slope-skeletal, with crest-rocky representing the central edaphic condition.

Crest-rocky sites generally have very shallow (<30cm), slightly alkaline, nitrogen-low, Brunisols, with some deep soil microsites (Appendix 2.1). Slope-rocky sites represent a complex of often treeless, precipitous cliffs and bluffs with narrow ledges, reefs, crevasses, crevices, and other irregularities. Surface flow of fine material (humus flow) captured in fissures and cracks and deposited on ledges provide marginal nutrient additions. During and shortly after rainfall there is intermittent surface and subsurface seepage over the exposed rock surfaces and underneath the shallow soil layer, but the soils dry quickly. Extreme microsite variation in soil moisture and nutrients is reflected in the complex vegetation pattern. The slope-skeletal sites, occupying colluvial deposits, feature a continuous cover of stones supporting the growth of xerophytic bryophytes and lichens. Interstices, partly filled with fine earth, are rooting substrates for shrubs and herbs. The microsites in which fine soil materials have accumulated feature Moder humus formation.

Forest stands on the Juniperus sites have open canopies with single or group tree distribution patterns. Douglas-fir is the dominant tree species, with a minor presence of lodgepole pine and aspen in the IDFdk3 variant (Figure 7.1.1 and Figure 7.1.2). Douglas-fir regeneration is sparse and is restricted to shaded microsites. Similarly, forest stands on the Cladonia sites have open canopies with single or group tree distribution patterns. Slow-growing Douglas-fir and lodgepole pine are the major tree species, with a minor proportion of spruce, redcedar, and subalpine fir in the ICHmk3 variant (Figure 7.1.3 and Figure 7.1.4). Scattered shrubs (*Amelanchier alnifolia*, *Juniperus communis*, *J. scopulorum*, *Spiraea betulifolia*, *Sheperdia canadensis*, and *Rosa acicularis*), graminoids (*Festuca occidentalis* and *Oryzopis asperifolia*), herbs, mosses (*Rhacomitrium* spp.), and lichens (*Cladina* spp., *Cladonia* spp., and *Peltigera* spp.) occupy treeless areas. Detailed vegetation data for sites in the Knife Creek block is given in Appendix 1.1 and for ICHmk3 sites in Gavin Lake Block in Appendix 1.2.

Rocky sites are affected by degradation geomorphic processes. Surface runoff concentrates in intermittent drainages, easily eroding and transporting thin and fine surface materials. Trees can only root in fissures and cracks, which trap flowing surface waters and transported materials. As a result, forest productivity is marginal and the sites are unsuitable for timber production.

Figure 7.1.1. Scattered old-growth Douglas-fir trees on a crest- and slope-rocky **Juniperus** site (IDFxm/02cr-sr). Rocky Mountain juniper (*Juniperus scopulorum*), chokecherry (*Prunus virginiana*), bluebunch wheatgrass (*Elymus spicatus*), and shrubby penstemon (*Penstemon fruticosu*) are infrequent.

Figure 7.1.2. Scattered young and old Douglas-fir with scattered shrubs on a disturbed crest-rocky **Juniperus** site (IDFxm/IDFdk3/02cr).

Figure 7.1.3. Mid-seral Douglas-fir stand interspersed with bedrock outcropping on a crest-rocky **Cladonia** site (SBSdw1/02cr).

Figure 7.1.4. A segment of an irregular, open-canopy, mid-seral stand of spruce with some redcedar regeneration on a cool-slope-rocky **Cladonia** site (ICHmk3/02sr).

7.2 Water-shedding, Crest Sites

Very dry to moderately dry, nutrient-poor, water-shedding, well drained, sandy- or loamy-skeletal soils over bedrock controlled crests and adjacent upper slopes, or on sandy-skeletal fluvial terraces

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

Water-shedding crest sites (including the warm, upper slope Chimaphila sites) occupy 561.7 ha in the forest. They include IDFxm/03, IDFdk3/02, SBSdw1/03 and 04, and ICHmk3/03 site series (Table 6.3.1 and Table 6.3.2). They occur frequently in small areas across the landscape, primarily in the hilly landscape of the Gavin Lake Block. Four site modifiers were used: (1) crest-skeletal, (2) slope-skeletal, (3) stony, and (4) flat-skeletal (only with SBSdw1/04 site series).

The Arctostaphylos sites are located on coarse-skeletal (often stony) crests, flats, or upper, warm-slopes. The associated soils are coarse-textured, circum-neutral, nitrogen-low Brunisols or Luvisols (Appendix 2.2). The associated Douglas-fir stands are typically uneven-aged with open canopies and sparse advanced regeneration (Figure 7.2.1 and Figure 7.2.2). The understory vegetation is sparse featuring xerophytic shrubs (*Amelanchier alnifolia*, *Arctostaphylos uva-ursi*, *Juniperus communis* and *J. scopulorum*), and lichens. More detailed vegetation data for the Arctostaphylos sites are given in Appendix 1.1; for Chimaphila sites see Appendix 1.2

Chimaphila sites occupy the similar environmental niche as Arctostaphylos sites, but in wetter and cooler climates. Old-growth Douglas-fir stands are rare and invariably display a fire history. Seral stands may be dominated by Douglas-fir, lodgepole pine, or both species, and the ICHmk3/03 site series may feature an admixture of spruce and regeneration of redcedar and subalpine fir (Figure 7.2.3 and Figure 7.2.5). The cover of understory vegetation is moderate, featuring low shrubs (*Amelanchier alnifolia*, *Spiraea douglasii*, *Paxistima myrsinites*, *Sheperdia canadensis*, and *Rosa acicularis*), some graminoids (*Calamagrostis rubescens* and *Oryzopsis asperifolia*), herbs (*Linnaea borealis*), and boreal mosses.

The Vaccinium site (SBSdw1/04), a lodgepole pine-dominated site series, is rare in the forest and was delineated only on 23.3 ha. According to Steen and Coupe (1997) it occurs primarily on sandy-skeletal, glaciofluvial terraces, which do not occur in the forest, and sometimes on gentle crests or heights of lands. Our delineated Vaccinium sites are dominated by Douglas-fir and are edaphically similar to the Chimaphila sites, except for the prominent presence of *Vaccinium myrtilloides* (Figure 7.2.4).

The change in climate from IDFxm/03 and IDFdk3/02 (Arctostaphylos) site series to SBSdw1/03 (Chimaphila) site series is manifested in increasing presence of lodgepole pine, and from the SBSdw1/03 to ICHmk3/03 (Chimaphila) site series in an increasing presence of spruce, subalpine fir, and redcedar. Along the same regional climatic gradient, the cover of understory increases and shows a large proportion of mesophytic species. Young and dense stands on the Chimaphila sites feature a moss-dominated understory (*Hylocomium splendens*, *Pleurozium schreberi*, and *Ptilium crista-castrensis*) (Figure 7.2.3 and Figure 7.2.5).

These water-shedding, crest sites support a low-productivity forest growth considering a growing-season water deficit and severe nitrogen deficiency. Fire and/or logging disturbance often result in site degradation and the formation of long-lasting, early-seral stages. Soil water and suspended materials are rapidly removed from the soils. Wind strongly influences the vegetation on crests and upper slopes by removing organic particles, affecting crown development and causing frequent windthrow. The open canopy of mature stands provides little protection to the understory.

Figure 7.2.1. Open-canopy, old-growth Douglas-fir stand with sparse understory vegetation (*Amelanchier alnifolia* and *Spiraea betulifolia*) and exposed mineral soil on a crest-skeletal **Arctostaphylos** site (IDFxm/03ck).

Figure 7.2.2. The edge of a late-seral, irregular Douglas-fir stand on a crest-skeletal **Arctostaphylos** site (IDFdk3/02). *Sheperdia canadensis*, *Amelanchier alnifolia*, and *Calamagrostis rubescens* are the dominant understory species.

Figure 7.2.3. A dense, mid-seral Douglas-fir stand with mossy understory on a crest-skeletal **Chimaphila** site (SBSdw1/03ck).

Figure 7.2.4. A mid-seral Douglas-fir stand with moderately well developed shrub (*Sheperdia canadensis* and *Vaccinium myrtilloides*) and herb (*Calamagrostis rubescens*) layers on a crest-skeletal **Vaccinium** site (SBSdw1/04ck).

Figure 7.2.5. A dense, mid-seral Douglas-fir stand with occasional lodgepole pine, scattered subalpine fir regeneration, and mossy understory on a crest-skeletal **Chimaphila** site (ICHmk3/03ck).

7.3 Water-shedding, Warm-Slope Sites

Very dry to moderately dry, nutrient-medium to -rich, water-shedding, well to moderately well drained, loamy-skeletal soils on crests and warm, upper and mid-slopes

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

The site series profile of this site group varies with climate - from the Allium site series in the IDF zone to the Chimaphila and Ptilium site series in the ICHmk3 variant (Table 6.3.1 and Table 6.3.2). In this Section we describe only the Allium site series. Chimaphila site series are described in Section 7.2 and the warm-slope Ptilium is described in Section 7.5.

The Allium site series is confined to the IDF zone of the Knife Creek Block (although Allium cernuum itself may occur in the SBS zone of the Gavin Lake Block) and occupies 326.6 ha. It occurs frequently on crests with deeper soils in the IDFxm subzone but most often on warm-slopes with deeper soils in both IDFxm and IDFdk3 zonal units. We could not reliably distinguish the IDFdk3/06 (Fd-Pinegrass-Aster) from either IDFdk3/04 (Allium) or IDFdk3/01 (Calamagrostis) site series as the environmental characteristics of all these site series overlap; thus we combined the IDFdk3/06 with the IDFdk3/04 and designated this variation on less-steep, warm-slopes as 'wetter'. Three site modifiers were applied to the Allium sites: (1) crest-skeletal, (2) slope-skeletal, and (3) wetter.

The understory vegetation consists of a mixture of xerophytic and mesophytic species, however, the best diagnostic species for the Allium sites in the Knife Creek Block are: *Allium cernuum*, *Astragalus miser*, *Balsamorhiza sagittata*, and *Solidago spathulata*. More detailed vegetation data for the Allium sites in the Knife Creek block are given in Appendix 1.1.

The effects of the very warm local climate and severe water deficit produce open canopied, often very patchy, stands of Douglas-fir, occasionally with scrubby trembling aspen (Figure 7.3.1 and Figure 7.3.2). Nearly all old trees have fire scars indicating past fire history. Natural regeneration of Douglas-fir is sparse and very slow to establish, especially when the removal of larger tree groups promotes the growth of shrubs and graminoids (*Amelanchier alnifolia*, *Juniperus scopulorum*, *Symphoricarpus albus*, *Elymus spicatus*, *Agropyron spicatum*, and *Calamagrostis rubescens*) (Figure 7.3.1 and Figure 7.3.2). It is surmised that lodgepole pine is largely absent on the Allium sites for edaphic reasons i.e., close to or slightly alkaline soils (Appendix 2.3).

With growing-season water deficit and severe nitrogen deficiency, Allium sites can only support low-productivity forest growth. Fire and/or logging disturbance often result in the formation of long-lasting, early-seral stands. Many of these sites provide mule deer winter range. Frequently, epiphytic lichens (*Alectoria sarmentosa*) develop in the mid- and lower crown of Douglas-fir giving the appearance of a 'lichen forest' (Figure 7.3.3).

Figure 7.3.1. A solitary, old-growth Douglas-fir cohort on a sparsely vegetated, crest-skeletal, **Allium** site (IDFxm/04ck site series).

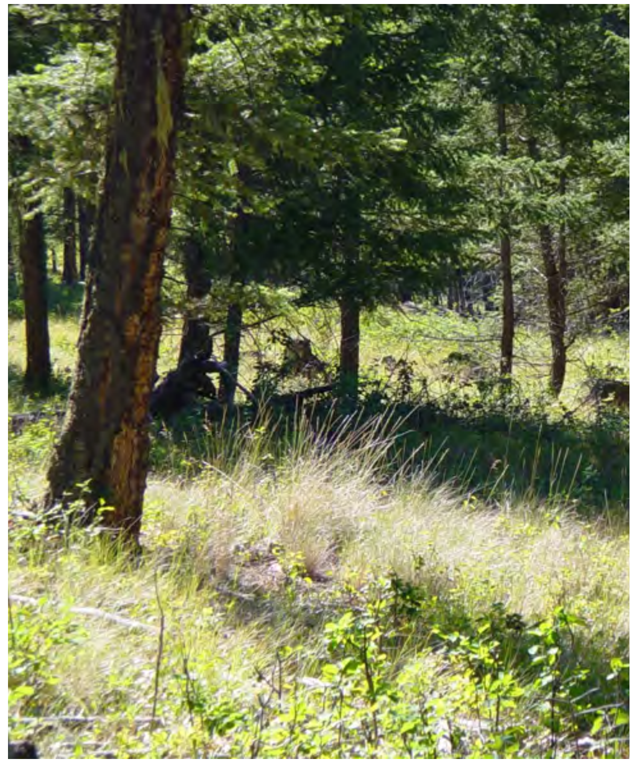


Figure 7.3.2. Disturbed, uneven-aged Douglas-fir stand on a slope-skeletal **Allium** site (IDFdk3/04sk). Note the well-developed grassy understory.

Figure 7.3.3. A 'lichen' forest - an irregularly spaced (clumpy), uneven-aged Douglas-fir stand on a slope-skeletal **Allium** site (IDFxm/04sk).

7.4 Water-shedding, Cool-Slope Sites

Very dry to fresh, nutrient-very poor to -medium, water-shedding, loamy-skeletal soils on cool, upper and mid-slopes

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

The site series profile across zonal units changes in the ICHmk3 variant, where Hylocomium sites are replaced by the Ptilium sites (Table 6.3.1 and Table 6.3.2). In this Section only the Hylocomium site series are described; the cool slope Ptilium site series are included in Section 7.5.

The cool-slope Hylocomium sites occur in the IDF zone of the Knife Creek Block and in the SBS zone of the Gavin Lake Block where they occupy a relatively small area of 108.9 ha. Only two site modifiers were used: (1) slope-rocky and (2) slope-skeletal. The associated soils are very skeletal (infrequently rocky), slightly acid, nitrogen-low, Brunisols (Appendix 2.4).

The understory vegetation generally has a very low species diversity, dominated by a mixture of ubiquitous boreal mosses (*Hylocomium splendens*, *Pleurozium schreberi*, and to a minor extent, by *Ptilium crista-castrensis*); the cover of shrubs, graminoids, and herbs is very low (Figure 7.4.1, Figure 7.4.2, and Figure 7.4.3). The dominance of mosses distinguishes these sites, however, be cautious when using this characteristic as a moss understory can be present on other sites when the forest canopy is dense and closed. More detailed vegetation data for the Hylocomium sites are given in Appendix 1.1.

In consequence of a cooler local climate and a less severe water deficit, Hylocomium sites support closed canopy, dense, Douglas-fir stands, frequently with an admixture of lodgepole pine, spruce, and occasionally with birch and aspen (Figure 7.4.1 and Figure 7.4.2). No old-growth stands were observed on the Hylocomium sites, only immature or mature, Douglas-fir dominated stands. These sites support medium-productivity forest growth considering a less severe growing-season water deficit and nitrogen deficiency. Fire and/or logging disturbance does not appear to result in regeneration delays due to a cooler local climate.

Figure 7.4.1. A mature Douglas-fir stand on a slope-skeletal **Hylocomium** site (IDFxm/05sk). Note the discontinuous vegetation cover.

Figure 7.4.2. Irregular, immature stand of Douglas-fir and spruce on a slope-skeletal **Hylocomium** site (IDFdk3/05sk). Note the well-developed moss cover and scattered graminoids.

Figure 7.4.3. A dense, immature, Douglas-fir stand on a slope-skeletal **Hylocomium** site (SBSdw1/05sk site series). Note the well-developed moss cover with scattered low shrubs.

7.5 Near-zonal and Zonal Sites

Moderately dry to fresh, nutrient-poor to medium, neither water-shedding nor -receiving, moderately well drained, loamy-skeletal soils on mid-slopes or heights-of-lands

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

This section describes all near-zonal and zonal sites including slope Ptilium sites. The site series profile varies somewhat with climate, however the Ptilium sites (ICHmk3/01) differ the most (Table 6.3.1 and Table 6.3.2; Appendix 7). By definition, zonal sites must have an intermediate SMR (i.e., 4) and a medium SNR (Pojar et al 1987). The concept of a 'zonal site series' is misleading as it encompasses sites within a wider SNR range and occasionally wider SMR range. In fact, all 01 site series in the regional guide edatopic grids are portrayed as ranging from poor to rich SNRs. This range was considered too wide for this project. While major changes in vegetation occur with increasing nutrient regime, the most significant change occurs between medium and rich sites. These sites are more strikingly dissimilar than poor and medium sites, or rich and very rich sites. We have limited the nutrient range of 01 site series from very poor (rare) to medium. Since these sites have neither significant losses nor additions of moisture and nutrients, their vegetation and soils will approximate zonal ecosystem characteristics for each zonal unit.

The 01 site series (Calamagrostis in the IDFxm, IDFdk3, and SBSdw1 zonal units and Ptilium in the ICHmk3 variant) is the most common, occupying 65% of the Knife Creek and 37% of the Gavin Lake block areas. The following modifiers were applied: (1) drier, (2) stony (only in the IDF zone), (3) zonal, (4) wetter, (5) warm-slope (only in the SBS and ICH zones), and (6) cool-slope (only in the SBS and ICH zones). The associated soils in the Knife Creek Block are moderately deep, loamy-skeletal, slightly acid, nitrogen-low, Orthic Gray Luvisols. They grade to more acidic and nitrogen-richer Brunisolic Gray Luvisols in the SBSdw1 and ICHmk3 variants in the Gavin Lake Block (Appendix 2.5).

The Calamagrostis sites in the IDFxm subzone, and to a lesser degree in the IDFdk3 variant, feature clumpy, uneven-aged, multi-storied Douglas-fir stands, with variable densities of advance regeneration depending on the fire history and harvesting disturbance (Figure 7.5.1 and Figure 7.5.2). Many old-growth trees have fire scars indicating past fire history. Occurrence of aspen and the cover of understory vegetation increase from the IDFxm subzone to the IDFdk3 variant. The understory vegetation in the IDF zone consists of scattered shrubs, graminoids (most prominently *Calamagrostis rubescens*), a few herbs, and mosses in sheltered microsites (*Hylocomium splendens*, *Pleurozium schreberi*, and *Rhytidiadelphus triquetrus*). More detailed vegetation data for these sites in the Knife Creek Block are given in Appendix 1.1; for these sites in the ICHmk3 see Appendix 1.2.

In contrast to the 01 Calamagrostis sites in the IDF zone, uniform, closed-canopy, even-aged, trembling aspen, paper birch, and lodgepole pine stands are frequent in the SBSdw1 variant (Figure 7.5.3, Figure 7.5.4, and Figure 7.5.5). The lesser vegetation, especially in aspen stands, is well developed and diverse, and can occupy the sites completely when stand densities are not too high.

While the few old-growth stands on 01 Ptilium sites in the Gavin Lake Block consist of redcedar and scattered Douglas-fir, spruce, and subalpine fir, the majority of stands are mid- or late-seral, even-aged mixed-species stands of Douglas-fir and spruce (Figure 7.5.5, Figure 7.5.6, and Figure 7.5.7). Apart from advance regeneration, the understory vegetation is generally a mixture of shrubs (*Paxistima myrsinites* and *Vaccinium membranaceum*), herbs (*Cornus canadensis*, *Clintonia uniflora*, *Linnaea borealis*, and *Rubus pedatus*), and mosses (*Hylocomium splendens*, *Pleurozium schreberi*, and *Ptilium crista-castrensis*).

The 01 sites represent medium-productivity sites, with productivity increasing from IDFxm subzone through to the ICHmk3 variant. The foliar data suggests a severe nitrogen deficiency for Douglas-fir in all zones. Nitrogen deficiency in lodgepole pine ranged from very severe (IDF zone) to moderate (ICH zone). Moderately shade-tolerant Douglas-fir usually dominates seral communities following disturbance, with the presence of lodgepole pine and spruce increasing in the SBSdw1 and ICHmk3 variants. In these wetter zonal units, natural regeneration of spruce, subalpine fir, and redcedar typically establishes in mid-seral stages (Figure 7.5.5 and Figure 7.5.6). Seral coniferous stands are usually dense with depauperate understory vegetation.

Figure 7.5.1. An irregular, uneven-aged Douglas-fir stand on a drier **Calamagrostis** site (IDFxm/01dr).

Figure 7.5.2. A typical, recently disturbed, uneven-aged Douglas-fir stand with dense, old, advance regeneration on a zonal **Calamagrostis** site (IDFdk3/01zn).

Figure 7.5.3. A closed-canopy, mid-seral, Douglas-fir - lodgepole stand with a mossy understory on a flat, zonal **Calamagrostis** site (SBSdw1/01zn).

Figure 7.5.4. A uniform aspen stand on a zonal **Calamagrostis** site (SBSdw1/01zn). Note the well developed shrub and herb layers.

Figure 7.5.5. A late-seral, mixed-species stand with old-growth Douglas-fir cohorts and abundant subalpine fir regeneration on a zonal **Calamagrostis** site (SBSdw1/01zn).

Figure 7.5.6. An immature, mid-seral, uniform, stand of Douglas-fir and spruce on a zonal **Ptilium** site (IDFmk3/01zn). Note the well developed shrub and herb layer.

Figure 7.5.7. A transitional old-growth stand of Douglas-fir, spruce, redcedar and subalpine fir on a zonal **Ptilium** site (ICHmk3/01zn).

7.6 Water-enriched, Poorly Drained Sites

Slightly dry to very moist , nutrient-poor to -medium, imperfectly to poorly drained, weekly to strongly gleyed soils on water-collecting sites, in cold-air accumulating depressions with fluctuating water table

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

Site series in this site group include Oryzopis (IDFxm/06) and Lonicera in all other zonal units (Table 6.3.1 and Table 6.3.2; Appendix 7). In the IDF zone, these sites are infrequent and small (153.0 ha). Their size and frequency increases in the SBSdw1 and, particularly, in the ICHmk3 variant where they occupy 546.2 ha. The following modifiers were applied: (1) cool-slope, (2) flat-depression, and (3) gully-ravine. The associated soils are loamy-skeletal (stony), slightly acid, nitrogen-low, slightly to prominently mottled, weakly to strongly gleyed, Gray Luvisols (Appendix 2.7). For the sake of exclusive environmental differentiation, we restricted the soil nutrient regime to the very poor (rare) to medium range.

Oryzopsis sites are distinguishable from the wetter Calamagrostis (IDFxm/01wt) sites, only by slope position. They were identified nearly exclusively in shallow and narrow depressions and gullies. Compared to zonal sites, the understory has a greater cover and abundance of mosses. The extant Douglas-fir stands are clumpy, open canopy, and multi-storied with the density of advanced regeneration depending on the fire history and harvesting disturbance (Figure 7.6.1)

Lonicera sites are associated with cool local climate (cool-slopes), often cold-air drainage, and may be affected by growing season frost, especially on low-lying flats and depressions. The forest canopy is usually closed, particularly in second-growth stands, and dominated by a mixture of spruce, lodgepole pine, aspen, and occasionally with scattered Douglas-fir and paper birch (Figure 7.6.2 and Figure 7.6.4). In the ICHmk3 variant, redcedar, spruce, and/or subalpine fir dominate the forest canopy and advanced regeneration. Cutovers in this variant were typically planted to spruce, lodgepole pine and/or Douglas-fir, with the latter species usually affected by growing-season frost.

In addition to the common species of zonal sites, the understory vegetation of Lonicera sites includes several 'moist-site' indicators (such as *Cornus sericea*, *Lonicera involucrata*, and *Petasites palmatus*), scattered herbs, and high moss cover (*Hylocomium splendens*, *Pleurozium schreberi*, and *Ptilium crista-castrensis*). It is important to note that *Cornus sericea* and *Lonicera involucrata* are not always reliable diagnostic species as they occur more frequently and abundantly on nutrient-rich Aralia, Rubus, Gymnocarpium, and Streptopus sites. Ferns and devil's club are either lacking or occur only infrequently and with a low cover. In the ICHmk3, Lonicera sites grade to (and are often adjacent to) Gymnocarpium, Rubus or Streptopus sites. More detailed vegetation data for the 07 Lonicera sites in the Knife Creek Block are given in Appendix 1.1; for Lonicera ICHmk3 sites in the Gavin Lake Block see Appendix 1.2

In depression landforms, restricted outflow of excess groundwater after snowmelt and heavy summer precipitation can cause a more or less strongly fluctuating and stagnant groundwater table. The absence of nitrophytic species and the presence of sedges, rushes, and *Petasites palmatus* signify medium or lower soil nutrient regime and poorer aeration than on better-drained, intermittent seepage and water-receiving sites.

Lonicera sites support medium- to high-productivity growth of lodgepole pine, aspen, black cottonwood, and spruce (Figure 7.6.3 and Figure 7.6.4). Douglas-fir may be present on better drained, flat, nutrient-medium sites (Figure 7.6.2) that occur in small to medium sized, concave, often stony and compacted terrain. The foliar nutrient data suggests severe nitrogen deficiency for Douglas-fir and moderate to severe nitrogen deficiency for lodgepole pine. Severe compaction caused by past harvesting, has resulted in regeneration delay and sites have reverted to long-lasting, early-seral stages. Accumulation of organic materials in these sites progresses at a greater rate than their decomposition. Mor humus formation and gleyzation are the characteristic soil forming processes on these depression sites.

Figure 7.6.1. An irregular, uneven-aged Douglas-fir stand in a dry gully **Oryzopsis** site (IDFxm/06gr).

Figure 7.6.2. A nearly mature, mixed species stand of aspen, Douglas-fir, and spruce on a flat **Lonicera** site (IDFdk3/07fd).

Figure 7.6.3. An old, poorly regenerated, compacted cutover on a flat **Lonicera** site (IDFdk3/07fd).

Figure 7.6.4. A uniform, even-aged, mid-seral spruce stand on a flat **Lonicera** site (SBSdw1/07fd).

7.7 Inherently Rich and Intermittent Seepage Sites

Moderately dry to moist, nutrient-rich to very rich, moderately well-drained soils or intermittent seepage sites on lower slopes, flats, or in depressions

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

This site group includes three site series with soil nutrient regimes ranging from medium to very rich (Table 6.3.1 and Table 6.3.2). Compared to near-zonal and zonal sites, a greater nutrient availability is the result of (1) deeper, loamy, well-aerated soils (often Brunisols) with a low coarse fragment or (2) nutrient input by temporary seepage (relative SMR 5). Because the catchment areas around these sites are usually small (or precipitation is low, such in the IDF zone of the Knife Creek Block and the SBS zone of the Gavin Lake Block), the seepage influence is weak. A high water- and nutrient-holding capacity of deep loamy soils compensates for the lack of seepage. Near-zonal sites and these sites overlap on the edatopic grids in the relative SMR 4 and medium SNR cell; however, the inherently rich and intermittent seepage sites are differentiated in this situation by slope position, aspect, and gradient. In this Section we describe only the Aralia and Rubus site series as the Gymnocarpium sites series is described in Section 7.8.

The Aralia (IDFxm/07 and IDFdk3/08), Rubus (SBSdw1/06 and ICHmk3/08), and Gymnocarpium (ICHmk3/04) site series occupy 228.7 ha in the Knife Creek Block and 1,461.9 ha in the Gavin Lake Block (1,690.6 ha in total). The difference in area between the two blocks indicates a greater seepage input in the Gavin Lake Block. The following modifiers were applied: (1) drier, (2) wetter, (3) warm-slope (only with SBSdw1/06 (Rubus) and ICHmk3/08 (Rubus), (4) slope (only with ICHmk3/04 (Gymnocarpium)), (5) flat-depression, and (6) gully-ravine. The Rubus sites, originally recognized only in the SBSdw1 variant (SBDdw/06), were observed to occur also in the SBSdw1-ICHmk3 transition, and occasionally within the ICHmk3 variant in the Gavin Lake Block. These were sampled, analyzed, and included in the site classification. The diagnostic combination of species for Aralia sites in the Knife Creek Block, and for the ICHmk3 Rubus sites in the Gavin Lake Block are given in Appendix 1.1, and Appendix 1.2, respectively.

The associated soils in the Knife Creek Block are deep, loamy-skeletal, circum-neutral, Orthic Gray Luvisols, grading to Brunisolic Gray Luvisols or Brunisols in the SBSdw1 and ICHmk3 variants in the Gavin Lake Block. Compared to the other sites, the Aralia soils in the Knife Creek Block have a low C/N ratio in the upper mineral soil layer indicating a greater plant-available nitrogen supply (Appendix 2.6). Compared to the Aralia soils, the Rubus soils (ICHmk3/08) are slightly more acidic and have a greater C/N ratio (Appendix 2.9).

Aralia sites in the IDF zone of the Knife Creek Block occur primarily on lower, cool-slopes influenced by seepage following spring snowmelt and infrequent, heavy summer rains. Douglas-fir dominates moderately dense stand canopies which often include paper birch and Douglas maple (Figure 7.7.2); the presence of hybrid spruce, lodgepole pine, and trembling aspen increases on 'wetter' Aralia sites (Figure 7.7.1). Although the Aralia sites support a more diverse and abundant understory vegetation than the near-zonal and zonal sites, they are primarily differentiated from all other sites by a high cover of *Aralia nudicaulis*.

Rubus sites are common in the SBSdw1 variant and extend through the SBSdw1-ICHmk3 transition to warm sites into the ICHmk3 variant. *Rubus parviflorus* often dominates the understory vegetation in both coniferous stands (Douglas-fir and hybrid spruce) and hardwood stands (typically trembling aspen and paper birch) (Figure 7.7.3 A).

High-productivity sites for the growth of Douglas-fir, lodgepole pine, hybrid spruce, trembling aspen, and paper birch occur where soils are inherently rich and seepage is intermittent (relative SMR 5). Productivity increases from the IDFxm subzone through ICHmk3 variant (Figure 7.7.2). Foliar data suggest only moderate nitrogen deficiency for Douglas-fir and lodgepole pine. Douglas-fir, whose shade tolerance decreases from the IDFxm subzone through ICHmk3 variant, usually dominates seral communities following disturbance. The occurrence of lodgepole pine and spruce increases in the SBSdw1 and ICHmk3 variants. In these wetter zonal units natural regeneration of spruce, subalpine fir, and western redcedar typically establishes in mid-seral stages (Figure 7.7.3 B). However, extensive stands of trembling aspen (especially on warm-slopes) and paper birch have developed on Rubus sites in the SBSdw1 variant (Figure 7.7.3 A).

Figure 7.7.1. An irregular, mixed-species stand of aspen and spruce on a wetter **Aralia** site (IDFxm/07wt).

Figure 7.7.2. An **Aralia** site (IDFdk3/08fd-gr) with an irregular, open canopy, mature, and very productive Douglas-fir stand on a flat bench (grading into a gully).

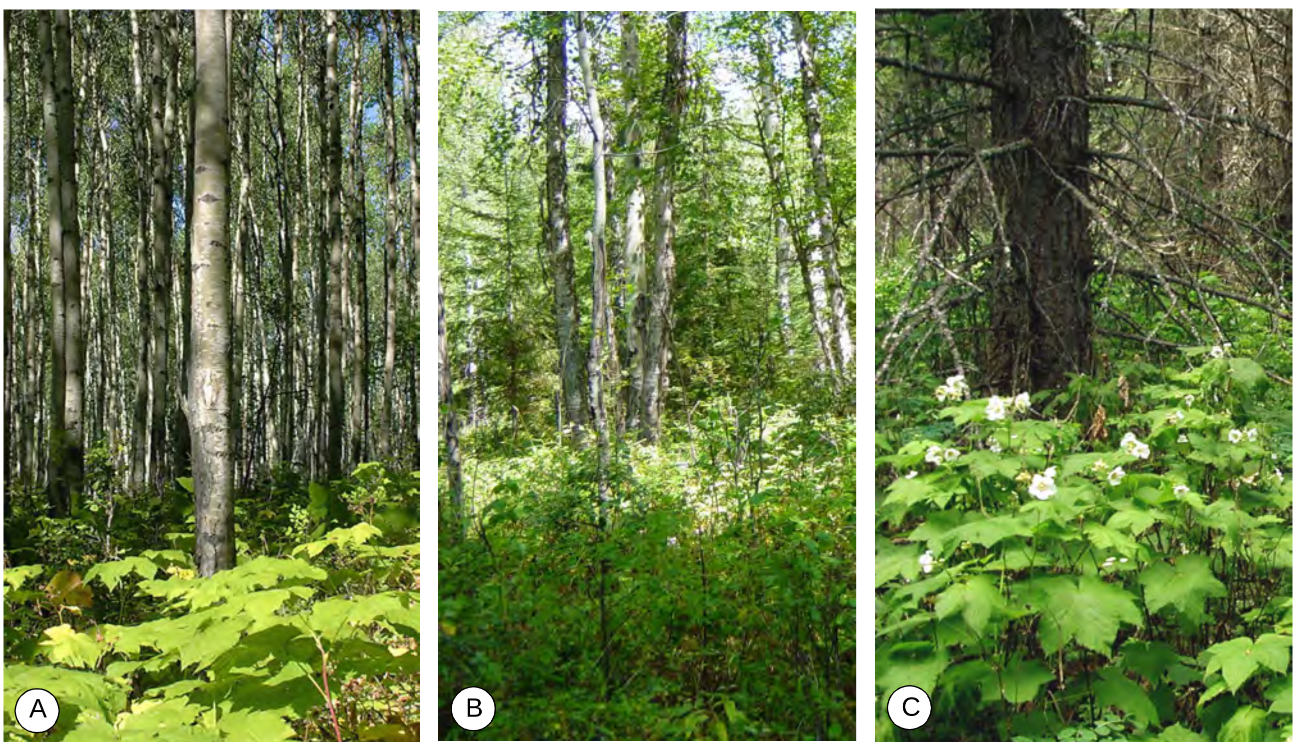


Figure 7.7.3. A dense, uniform, aspen stand (stem exclusion stage) on a warm-slope **Rubus** site (SBSdw1/06ws) (A), an irregular, clumpy, birch stand (with scattered sub-canopy spruce) on a flat **Rubus** site (SBSdw1/06fd) (B), and a mid-seral, uniform, branchy stand of Douglas-fir and spruce on a flat **Rubus** site (ICHmk3/SBSdw1/08fd).

7.8 Water-recieving (Seepage) Sites

Moist to very moist, nutrient-rich to -very rich, well to imperfectly drained soils on water-receiving (seepage) sites of lower and toe slopes or on alluvial terraces

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

This site group includes Cornus, Gymnocarpium, and Streptopus site series with the soil nutrient regime ranging from rich to very rich (Table 6.3.1 and Table 6.3.2). The high nutrient availability is the result of deep, loamy, well-aerated soils with a low coarse fragment content, often adjacent to streams (alluvial deposits) or derived from lacustrine deposits, and enriched by nutrient inputs from nearly permanent seepage due to their position on lower and toe slopes. Nutrient inputs may also occur together with surface flow of fine materials on steep slopes or flooding. Weak melanization, weak to strong gleyzation, and Moder or Mull humus formation are characteristics of these soils.

The Cornus (IDFxm/08 and IDFdk3/10), Gymnocarpium (SBSdw1/08 and ICHmk3/04), and Streptopus (ICHmk3/06) site series occupy only 38.4 ha in the Knife Creek Block and 572.2 ha in the Gavin Lake Block (610.6 ha in total). The difference in area is due to greater seepage inputs in the Gavin Lake Block. The following modifiers were applied: (1) drier (only with Rubus site series in the SBSdw1 variant), (2) wetter (only in the with Rubus site series in the SBSdw1 variant), (3) warm-slope (only with Rubus site series in the SBSdw1 variant), (4) slope (only with Gymnocarpium and Streptopus site series in the ICHmk3 variant), (5) flat-depression (6) gully-ravine, and (7) stream-edge-alluvial. More detailed vegetation data for Cornus sites in the Knife Creek Block are given in Appendix 1.1; for Gymnocarpium and Streptopus ICHmk3 sites in the Gavin Lake Block see Appendix 1.2.

The associated soils in the Knife Creek Block are deep, loamy, slightly acid, Brunisols or Regosols grading to Brunisolic Gray Luvisols or Brunisols in the SBSdw1 and ICHmk3 variants in the Gavin Lake Block (Appendix 2.8). Compared to all the other sites, the Cornus soils in the Knife Creek Block have the lowest C/N ratio in the upper mineral soil layer indicating a high supply of plant-available nitrogen.

Cornus sites in the IDF zone of the Knife Creek Block occur on lower and toe slopes or flats adjacent to a few permanent streams. Forest canopy is variable, ranging from dense spruce stands to irregular, open canopy mixed-species stands of spruce, black cottonwood, and aspen (Figure 7.8.1). Depending on the tree species composition and density of stands, the understory vegetation varies from low to high shrub and herb cover, with *Cornus sericea* and *Symphoricarpos albus* being the prominent shrub species.

Gymnocarpium sites are common in the SBSdw1 and ICHmk3 variants where they are often associated with Lonicera and Streptopus sites. Spruce is the principal species in the forest canopy in the SBSdw1 variant, often associated with Douglas-fir and subalpine fir (Figure 7.8.2). In the ICHmk3 variant, redcedar or spruce dominated stands prevail with Douglas-fir present predominantly on slopes. In addition to the diagnostic Gymnocarpium dryopteris, Oplopanax horridus dominates the understory vegetation, especially in canopy gaps. Old-growth redcedar stands feature abundant advanced regeneration of redcedar (predominantly of vegetative origin). Understory vegetation, however, is suppressed due to low light conditions and large accumulations of decaying wood (Figure 7.8.3).

Streptopus sites, typically adjacent to Equisetum sites in the ICHmk3 variant, are environmentally and floristically similar to Gymnocarpium sites in the SBSdw1 variant in representing very moist and nutrient-rich sites (Figure 7.8.4). However, stand density is usually lower and tree distribution pattern is clumpier than on the Gymnocarpium sites. Advanced regeneration consists of western redcedar and subalpine fir. The understory vegetation is diverse including a mixture of shrubs (*Oplopanax horridus*), herbs and ferns (*Streptopus amplexifolius*, *S. roseus*, *Tiarella trifoliata*, *Athyrium filix-femina*, and *Gymnocarpium dryopteris*), and mosses (*Mnium* spp. and *Plagiomnium* spp.).

The water-receiving sites support the most productive growth of Douglas-fir, hybrid spruce, western redcedar, subalpine fir, black cottonwood, paper birch, and trembling aspen in AFRF, with productivity increasing from the IDFxm subzone through to the ICHmk3 variant. Foliar data suggest only moderate or slight nitrogen deficiency for Douglas-fir and lodgepole pine. The tree species composition varies depending on successional stage with spruce dominating old-growth stands in the IDF zone of the Knife Creek Block (Figure 7.8.1), and mixed-species stands of redcedar, spruce, and subalpine fir dominating old-growth stands in the ICHmk3 variant of the Gavin Lake Block (Figure 7.8.3 and Figure 7.8.4).

Figure 7.8.1. A dense, mature, uniform, spruce stand on a flat lacustrine **Cornus** site (IDFxm/08).

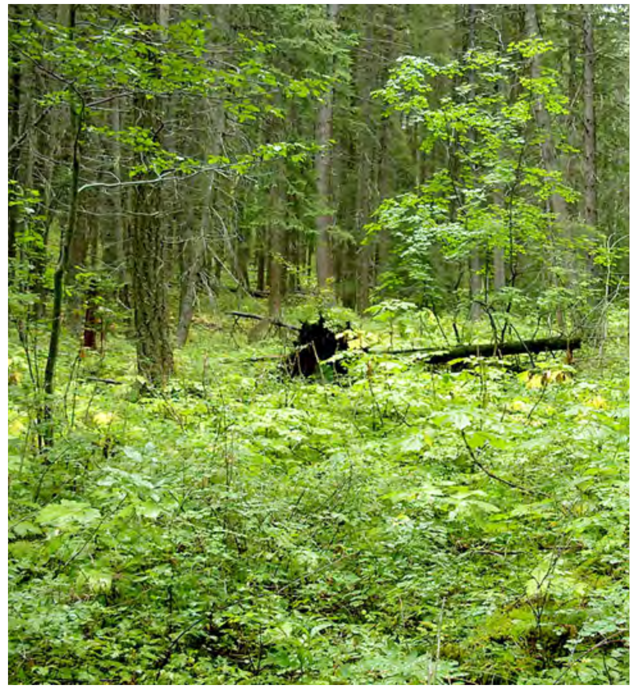


Figure 7.8.2. A uniform, mid-seral, stand of Douglas-fir and spruce on a flat **Gymnocarpium** site (SBSdw1/08fd).

Figure 7.8.3. An old-growth redcedar stand with scattered spruce and subalpine fir on a flat **Gymnocarpium** site (ICHmk3/04fd).

Figure 7.8.4. An irregular, mature stand of Douglas-fir and spruce with advanced redcedar regeneration on a slope **Streptopus** site (ICHmk3/06sl).

7.9 Water-collecting (Waterlogged) Sites

Wet, nutrient-medium to -very rich, poorly to very poorly drained gleysolic soils on water collecting (waterlogged) sites in cold-air accumulating depressions with fluctuating water table

References: Site modifiers (Appendix 4), Landscape profiles (Appendix 5), Site series keys (Appendix 6), Edatopic grids (Appendix 7), Environmental properties (Appendix 8)

Waterlogged Equisetum sites occupy 376.6 ha in the forest (IDFxm/09, IDFdk3/09, SBSdw1/09, and ICHmk3/07 site series). Their occurrence increases with increasing precipitation and the presence of depressions on the landscape, i.e., from the IDFxm to IDFdk3 to SBSdw1 to ICHmk3 zonal units (Table 6.3.1 and Table 6.3.2; Appendix 7). Regardless of the zonal unit, Equisetum sites are easily recognized by the distinct open canopy, horsetail-spruce communities, with tree growth restricted to mounds (Figure 7.9.1 and Figure 7.9.2). The lesser vegetation also displays a distinct mound-depression pattern. More detailed vegetation data for these sites in the Knife Creek Block are given in Appendix 1.1; for ICHmk3 sites in the Gavin Lake Block see Appendix 1.2.

Equisetum sites are always in depressions or low terraces bordering permanent streams, and are often found adjacent to non-forested wetlands. The associated soils are Gleysols and infrequently Humisols, with a seasonally fluctuating water table ranging from the ground surface to <50 cm. We used two site modifiers, the first being the most common: (1) flat-depression (including shallow gullies) and (2) stream-edge-alluvial.

The discontinuous and clumpy forest canopy is due to windthrow events and the presence of water pools inhibiting the establishment of terrestrial vegetation. Successful regeneration and productive growth of trees is confined to drier, raised mounds of organic materials originating from stumps and uprooted trees. Water movement and depth of groundwater table, both controlling the amount of dissolved oxygen, are the major determinants of productivity and understory composition; forest productivity abruptly decreases with decreasing rooting depth.

Equisetum sites lie at the threshold of the productive forest, i.e., descisions about including Equisetum sites in the managed forest should be made on a site-specific basis as regeneration is often difficult and extends over a long time. Vegetation succession on disturbed, gleysolic soils usually proceeds from mountain alder to spruce communities. On severely disturbed sites the groundwater table rises to the ground surface and a hydrosere succession begins from graminoid to shrub and, finally, forested communities.

The wettest and richest variation of Equisetum sites is represented by Lady fern-Mountain alder communities (Figure 7.9.3). These sites, typically associated with narrow and shallow, old melt-water stream channels, with no or little lateral drainage, do not appear to support forest growth. They occur predominantly in the Gavin Lake Block.

Figure 7.9.1. An irregular, spruce stand on a depression **Equisetum** site (IDFdk3/09).

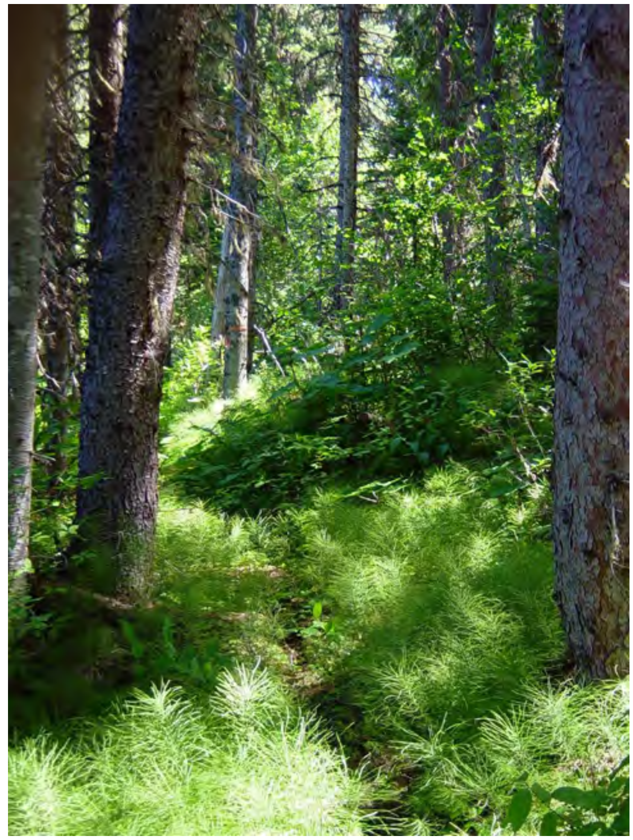


Figure 7.9.2. Open canopy, mature spruce stand on an alluvial (lacustrine) **Equisetum** site (ICHmk3/07) bordering Gavin Lake.

Figure 7.9.3. The Lady fern-Mountain alder community represents the wettest and richest variation of **Equisetum** sites and occurs mainly in the Gavin Lake Block.

7.10 Non-forested Sites

Bedrock and Talus

There are only minor occurrences of non-forested rock outcrops, cliffs, and talus deposits. Each occupies a very small area in complex with rocky sites (Juniper or Cladonia) and is usually included in mapping polygons delineating rocky sites; rarely were they delineated as separate polygons. These sites present outstanding viewpoints and support a number of xerophytic plant species (Figure 7.10.1).

Figure 7.10.1. An outstanding southwest view from a small rock outcrop above Prouton Lake. Note a few scattered graminoids and junipers.

Disturbed Sites

Disturbed sites include mostly landings, with a few gravel and rock pits, a pipeline in the Knife Creek Block, meadows, and rural areas (buildings, farms, and cultivated fields). Landings occupy a considerable area in each block (a total of 53.9 ha).

The three types of landings are:
1. old and non-forested (usually large, compacted, and stony) (Figure 7.10.2),
2. old and restored (decompacted and planted), and
3. recent (usually of a small area).

Figure 7.10.2. One of the old, large, not yet rehabilitated landings.

Grasslands

Grasslands in the AFRF are restricted to the IDF zone, where they occupy 7.9 ha. We are uncertain whether grasslands are encroaching on forest ecosystems or vice versa. Grasslands in the Knife Creek Block are edaphic and occur on upper warm-slopes or flats with a shallow root-restricting layer (Figure 7.10.3). The associated soils are usually alkaline. The major graminoids are: *Agropyron spicatum* and *Elymus spicatum* (Bunchgrasses), *Stipa richardsonii* (Spreading needlegrass), *Stipa curtiseta* (Porcupine grass), and *Danthonia intermedia* (Timber oatgrass).

Figure 7.10.3. A knoll occupied by a small, south-east exposed grassland with sparse regeneration of trembling aspen.

Wetlands

Wetlands provide important wildlife habitat and occur in each block with a total area of 63.7 ha. Their occurrence increases with increasing precipitation and the frequency of depressions in the landscape, i.e., from the IDFxm to IDFdk3 to SBSdw1 to ICHmk3 zonal units. Three types were recognized in order of decreasing water table: (1) wetland fen, (2) wetland marsh (Figure 7.10.4), and (3) wetland shrub-carr (Steen and Coupe 1997). Sedge-dominated fens border lakes and slowly moving streams; graminoid-dominated marshes usually occur on sites with seasonally fluctuating water tables, and willow-dominated shrub-carrs border forested sites. Mountain alder-dominated swamps were included in water-collecting (waterlogged) Equisetum sites. More information about wetlands is given in Steen and Roberts (1988).

Figure 7.10.3. One of a few larger wetlands (a marsh with a strongly fluctuating water table) in the Knife Creek Block.

Site Units

8 INTERPRETATIONS AND INTERPRETIVE MAPS

Three interpretations were developed: (1) occurrence of western redcedar, western hemlock, and old-growth western redcedar and Douglas-fir-dominated stands in the Gavin Lake Block (1 map), (2) suitability and productivity of Douglas-fir, lodgepole pine, and hybrid spruce in both blocks (6 maps), and (3) predicted nitrogen status for Douglas-fir and lodgepole pine in both blocks (2 maps). All interpretations are spatially presented as small-scale maps on the CD-ROM.

8.1 Occurrence of Western Redcedar, Western Hemlock, and Old-growth Stands in the Gavin Lake Block

This interpretive map shows occurrence of (1) western redcedar (including seedlings, saplings, and trees) along the longitudinal, transitional gradient from the SBSdw1 to the ICHmk3 variant, (2) rare localities of western hemlock within the ICHmk3 variant, and (3) scattered locations of old-growth, western redcedar- and Douglas-fir-dominated stands in the Gavin Lake Block. This information obtained from ground surveys represents a comprehensive coverage of the block (a total of 1,809 GPS waypoints). Some of the occurrences were captured as images and hyperlinked to this report; more images are hyperlinked to individual polygons and can be seen on the CD-ROM.

In general, the occurrence of western redcedar increases gradually from west to east reflecting a gradual change of regional climate, as well as local climatic conditions, along a longitudinal gradient in this undulating landscape. This change occurs abruptly on cool-slopes and gradually on flat terrain and warm-slopes. The occurrences of redcedar within the ICHmk3 variant were not highlighted as they are confounded by the history of forest fires and harvesting, especially in the eastern part of the block where harvesting was followed by slashburning. Consequently, many stands in the ICHmk3 variant show no, occasional, or infrequent presence of western redcedar. The occurrence of western redcedar was used to delineate boundaries of the SBSdw1 variant, ICHmk3-SBSdw1 transition, and ICHmk3 variant.

The occurrence of western hemlock in the ICHmk3 variant is rare as the species is characteristic of the ICHwk subzone, particularly of the adjacent ICHwk2 variant (Figure 8.1.1). Their presence suggests that there are special local climatic conditions in those locations and, as such, they should be protected.

The identified old-growth stands (with a total estimated area of only 122 ha), especially those of Douglas-fir, can serve as benchmarks of forest development for demonstration and comparative studies of forest habitat, diversity, dynamics, and function, if protected (Figure 8.1.2).

Figure 8.1.1. A rare group of uneven-aged western hemlock trees (and advanced regeneration) (left) and the lower crown of an old-growth western hemlock (right) in redcedar stand on a **Streptopus** site (ICHmk3/06gr) in the Gavin Lake Block.

Figure 8.1.2. Old-growth western redcedar twins on a **Gymnocarpium** site (ICHmk3/04fd) in the Gavin Lake Block.

8.2 Suitability and Productivity of Douglas-fir, Lodgepole Pine, and Hybrid Spruce

The productivity interpretations represent the best available estimates of potential growth using site index for Douglas-fir, lodgepole pine, and hybrid spruce in relation to sites on which these species may grow as ecologically viable tree species in both Knife Creek and Gavin Lake Blocks. Suitability of other potential crop tree species, such as western redcedar, trembling aspen, paper birch, and black cottonwood, has not been estimated. Photographs of productive growth and good growth form can be seen here; additional images can be viewed on the CD-ROM where they are linked to mapping polygons. The estimates of potential site index in relation to site series, and conversion of the mean site index estimate to a nominal 5-class growth scale are presented in Table 8.2.1, Table 8.2.2, Table 8.2.3, and Table 8.2.4. More importantly, the spatial pattern of forest productivity for each species is illustrated for each of the blocks on six interpretive maps.

This suitability and productivity information provides decision-support for site-specific tree species selection and timber supply analysis. The pattern of the site index variation shown in Table 8.2.1 through Table 8.2.4 corresponds to the general trend reported for many native Western North American tree species (Klinka et al. 2003). On the regional scale, the potential tree productivity or height growth increases with increasing duration of growing season (growing degree days); on the local scale, it increases from water- and nutrient- deficient sites to fresh or moist and nutrient-medium or -rich sites. Further increases in soil moisture towards wet sites result in decreasing growth. Regardless of varying edaphic tolerances of different tree species to the deficiency or surplus of water and nutrients, nearly all species grow most productively within a narrow edaphic range, i.e., on fresh or moist sites and nutrient-medium or -rich sites.

Table 8.2.1. Site index (m @ 50 yr bh) estimates for the major viable crop tree species for the **IDFxm** and **IFDxm-IDFdk3** transition site series.

Site series	Douglas-fir		Lodgepole pine		Interior spruce	
	Site index or suitability	Site index class	Site index or suitability	Site index class	Site index or suitability	Site index class
01 Calamagrostis	17	3	non-viable	na	non-viable	na
02 Juniperus	<9	5	non-viable	na	non-viable	na
03 Arctostaphylos	12	4	non-viable	na	non-viable	na
04 Allium	14	3	non-viable	na	non-viable	na
05 Hylocomium	16	3	non-viable	na	non-viable	na
06 Oryzopsis	18	2	non-viable	na	non-viable	na
07 Aralia	20	2	non-viable	na	non-viable	na
08 Cornus	non-viable	na	non-viable	na	22	2
09 Equisetum	non-viable	na	non-viable	na	17	3

Table 8.2.2. Site index (m @ 50 yr bh) estimates for the major viable crop tree species for the **IDFdk3** and **IFDdk3-SBPSmk** transition site series.

Site series	Douglas-fir		Lodgepole pine		hybrid spruce	
	Site index or suitability	Site index class	Site index or suitability	Site index class	Site index or suitability	Site index class
01 Calamagrostis	19	2	20	2	non-viable	na
02 Arctostaphylos	13	4	14	4	non-viable	na
03 Juniperus	<9	5	non-viable	na	non-viable	na
04 Allium	15	3	non-viable	na	non-viable	na
05 Hylocomium	17	3	18	2	non-viable	na
07 Lonicera	19/limited	2	19	2	18	2
08 Aralia	22	1	22	1	22	2
09 Equisetum	non-viable	na	non-viable	na	18	3
10 Cornus	non-viable	na	non-viable	na	23	1

Table 8.2.3. Site index (m @ 50 yr bh) estimates for the major viable crop tree species for the **SBSdw1** site series.

Site series	Douglas-fir		Lodgepole pine		hybrid spruce	
	Site index or suitability	Site index class	Site index or suitability	Site index class	Site index or suitability	Site index class
01 Calamagrostis	22	2	23	1	21	2
02 Cladonia	<9	5	12	4	non-viable	na
03 Chimaphila	15	3	16	3	non-viable	na
04 Vaccinium	17	3	19	2	non-viable	na
05 Hylocomium	19	2	20	2	18/limited	2
06 Rubus	23	1	23	1	23	1
07 Lonicera	22/limited	2	24	1	23	1
08 Gymnocarpium	24/limited	1	23/limited	1	25	1
09 Equisetum	non-viable	na	non-viable	na	19	2

Table 8.2.4. Site index (m @ 50 yr bh) estimates for the major viable crop tree species for the **ICHmk3** and **ICHmk3-SBSdw1** transition site series.

Site series	Douglas-fir		Lodgepole pine		hybrid spruce	
	Site index or suitability	Site index class	Site index or suitability	Site index class	Site index or suitability	Site index class
01 Ptilium	23	1	23	1	22	2
02 Cladonia	10	4	12	4	non-viable	na
03 Chimaphila	17	3	19	2	non-viable	na
04 Gymnocarpium	24	1	24	1	24	1
05 Lonicera	23/limited	1	23	1	23	1
06 Streptopus	24/limited	1	non-viable	na	25	1
07 Equisetum	non-viable	na	non-viable	na	19	2
08 Rubus	25	1	25	1	25	1

Evidently, the climate of SBSdw1 and ICHmk3 variants supports more productive tree growth than that of the IFD zone. While the Aralia sites in the IDF zone support productive Douglas-fir growth (Figure 7.7.2), Cornus sites support productive growth of black cottonwood, trembling aspen, and hybrid spruce (Figure 7.8.1) (Table 8.2.1 and Table 8.2.2). Considering that the Gavin Lake Block occupies the easternmost part of the SBS zone and the westernmost part of the ICH zone, the similarity of site indices for equivalent site series is not surprising (Table 8.2.3 and Table 8.2.4). Productive growth of Douglas-fir and lodgepole pine was found on several sites in the SBS and ICH zones (Figure 8.2.1), but the most productive growth and good growth form appear to be associated with the SBSdw1/08 (Gymnocarpium) and ICHmk3/08 (Rubus) sites (Table 8.2.3 and Table 8.2.4). Paper birch also appears to grow most productively on the SBSdw1/08 (Gymnocarpium) and ICHmk3/08 (Rubus) sites (Figure 7.7.3). The productive growth of hybrid spruce and black cottonwood was found on SBSdw1/08 (Gymnocarpium) and ICHmk3/06 (Streptopus) sites (Figure 8.2.2), however, both species also performed well on some Equisetum sites (Table 8.2.3 and Table 8.2.4).

Figure 8.2.1. Excellent growth and form of an old Douglas-fir tree on a **Ptilium** site (ICHmk3/01wt) in the Gavin Lake Block.

Figure 8.2.2. Excellent growth and form of a hybrid spruce and black cottonwood cohort on a **Streptopus** site (ICHmk3/06fd) in the Gavin Lake Block.

8.3 Predicted Nitrogen Status for Douglas-fir and Lodgepole Pine

These predictions present the best available estimates of nitrogen status of Douglas-fir and lodgepole pine for the sites on which they are considered viable crop species. Estimates for some site series were derived through interpretation of results from foliar nutrient analyses of foliage samples from the forest. Other estimates were extrapolated using recognized trends published in literature. The results of foliar nutrient analysis and interpretations for all sampled stands are given in Appendix 9 and Appendix 10. This section and four interpretive maps, showing the spatial pattern of nitrogen status for each of the two tree species, are included on the CD-ROM. Figure 8.3.1 through Figure 8.3.4 illustrate the sampled stands with severe and moderately severe nitrogen deficiencies.

Considering all macro- and micronutrients (N, P, Ca, Mg, K, S, Cu, Zn, Fe, Mn, and B), a comparison between the tree species indicated that Douglas-fir generally had higher nutrient concentrations than lodgepole pine, except for N and Cu, which were similar for both species. In both species, nutrient concentrations varied with (1) zonal unit, more so in Douglas-fir than lodgepole pine, and (2) site series; however, no clear trends were revealed due to insufficient sampling (Appendix 9).

Interpretation of foliar analysis data, using critical levels (Ballard and Carter 1986), revealed consistent, albeit variable N-deficiencies. Therefore, we based our interpretations on nitrogen status and recognized three interpretive classes: (1) Very severe to severe N deficiency, (2) severe N deficiency, and (3) moderate N deficiency. None of the sampled stands indicated adequate N status.

The colour shown for a particular site series on the maps indicates one of the three interpretive classes (red - very severe to severe N deficiency; flesh-tone - severe deficiency; light yellow - moderate N deficiency). For polygons including more than one site series, prediction of nitrogen status was made only for a dominant site series (≥50% of the polygon area) (Table 8.3.1 and Table 8.3.2). Predicted nitrogen status tables also note the source of the interpretation (based on sampling or extrapolation). No sampling and interpretation was conducted for stands on non-productive Cladonia sites and sites for which the study species are considered non-viable. Polygons that include sites on which the species is non-viable are shown without colour.

It is likely that B, Ca, Cu, Mn, and Zn are in adequate supply on all productive sites as very little to no deficiencies were detected (Appendix 10).

Actual or inducible S deficiency were detected for both species, however N/S ratios indicated no or possible deficiency (Appendix 10).

Nearly no P deficiency was detected for Douglas-fir, however, slight to moderate deficiencies, increasing with increasing N deficiencies, were detected for lodgepole pine (Appendix 10).

Slight to moderate Mg deficiencies were detected for both Douglas-fir and lodgepole pine. K deficiencies, however, were more common in both tree species and ranged from slight to severe deficiency. Both Mg and K deficiencies did not appear to be related to N deficiencies but were related to sites (Appendix 10).

The prediction of nitrogen status provides decision support for silvicultural treatments. It appears that tree growth at the AFRF may be stimulated by the addition of N, as well as other nutrients individual sites are deficient in. Forest fertilization can lead to: (1) growth stimulation, where the cost of operational fertilization is justified by the economic benefits of volume growth response, and (2) rehabilitation, where effective stand establishment or normal tree development may require relief from acute nutrient deficiencies. Decisions to fertilize should be made on a site-specific basis.

Figure 8.3.1. A very severly nitrogen-deficient, young Douglas-fir cohort on an **Allium** site (IDFxm/04ck) in the Knife Creek Block lock (P110, sample plot KF37).

Figure 8.3.2. A late regeneration stage of a Douglas-fir plantation with a moderately severe nitrogen deficiency on a **Streptopus** site (ICHmk3/06gr) in the Gavin Lake Block (P485, sample plot GF56).

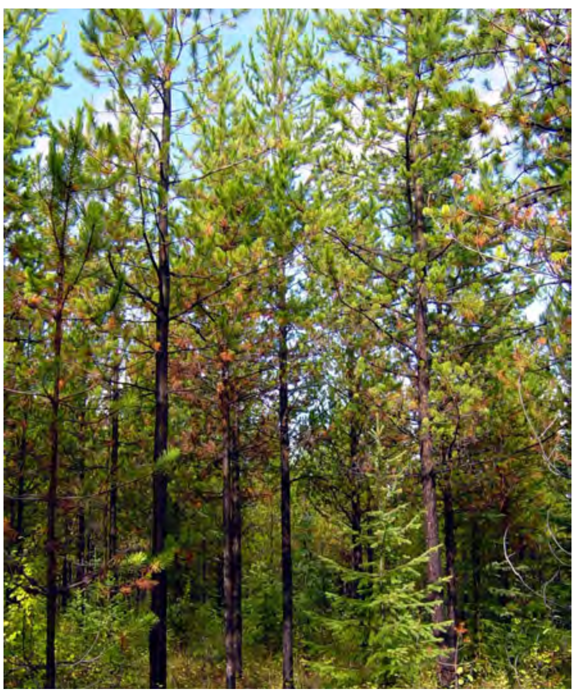


Figure 8.3.3. A very severly nitrogen-deficient, immature, lodgepole pine stand on a **Calamagrostis** site **(**SBSdw1/01) in Gavin Lake Block (P160, sample plot GF17).

Figure 8.3.4. An open canopy, immature lodgepole stand with a moderately severe nitrogen deficiency on a **Lonicera** site (IDFdk3-SBPSmk/07fd) in the Knife Creek Block (P614, sample plot KF27).

Table 8.3.1. Predicted nitrogen status for Douglas-fir in relation to zonal and site units in the Alex Fraser Research Forest. Colour codes for the three interpretive classes are: red - very severe to severe N deficiency; flesh-tone - severe deficiency; light yellow - moderate N deficiency.

Site series	**IDFxm** and **IDFxm-IDFdk3** transition	**IDFdk3** and **IDFdk3-SBPSmk** transition	**SBSdw1**	**ICHmk3** and **ICHmk3-SBSdw1** transition
01	sampled	sampled	sampled	sampled
02	non-productive sites	extrapolated	non-productive sites	non-productive sites
03	extrapolated	non-productive sites	sampled	extrapolated
04	sampled	extrapolated	extrapolated	extrapolated
05	extrapolated	extrapolated	extrapolated	sampled
06	sampled	site series absent	extrapolated	sampled
07	sampled	sampled	sampled	non-viable
08	non-viable	extrapolated	extrapolated	extrapolated
09	non-viable	non-viable	non-viable	site series absent
10	site series absent	non-viable	site series absent	site series absent

Table 8.3.2. Predicted nitrogen status for lodgepole pine in relation to zonal and site units in the Alex Fraser Research Forest. Colour codes for the three interpretive classes are: red - very severe to severe N deficiency; flesh-tone - severe deficiency; light yellow - moderate N deficiency.

Site series	**IDFxm** and **IDFxm-IDFdk3** transition	**IDFdk3** and **IDFdk3-SBPSmk** transition	**SBSdw1**	**ICHmk3** and **ICHmk3-SBSdw1** transition
01	non-viable	sampled	sampled	sampled
02	non-viable	extrapolated	non-productive sites	non-productive sites
03	non-viable	non-productive sites	sampled	extrapolated
04	non-viable	non-viable	extrapolated	extrapolated
05	non-viable	extrapolated	extrapolated	sampled
06	non-viable	site series absent	extrapolated	non-viable
07	non-viable	sampled	sampled	non-viable
08	non-viable	extrapolated	extrapolated	extrapolated
09	non-viable	non-viable	non-viable	site series absent
10	site series absent	non-viable	site series absent	site series absent

9 EXTENSION PRODUCTS

9.1 Academic Poster

Purpose:
To increase awareness among educators, Research Forest researchers and managers at the UBC Faculty of Forestry about the importance and potential applications of project products.
Venue and Date: UBC Research Forests Poster Session and Contest (first prize), UBC Forest Sciences Centre, October 28, 2003.

Description:
The project is introduced, its methodology is outlined, and innovations are identified. Project products and their applications are also listed.

Available at:
Forest Management Institute of the Czech Republic website.

Citation:
Klinka, K, C. Koot, A. Kusbach, J. Macku, M. Rau, C. Trethewey, and P. Varga. 2004. Ecological Site Mapping of the UBC Alex Fraser Research Forest. Poster presented at the UBC Research Forests Poster Session and Contest, Vancouver, B.C.

Available from:
http://www.uhul.cz/ubcafrf/index.php.

9.2 SISCO Display and Presentation

Purpose:
To outline the process of developing detailed site mapping and identification tools and how these tools can be applied to forest management.

Venue and Date:
Winter SISCO Conference and Poster Session, Penticton Lakeside Resort, March 1-3, 2004.

Description:
In addition to the above poster, sample site and interpretive maps, an edatopic grid, site series key and landscape profile with corresponding indicator plant images were displayed. Claire Trethewey provided 3, 20-minute presentations about the project for interested natural resources professionals, as well as interpretation for drop-in visitors.

Citation:
Not applicable.

9.3 Pamphlet

Purpose:
To outline the process of developing detailed site mapping and identification tools and how these tools can be applied to forest management.

Description:
A full-colour, 14-panel pamphlet provides an introduction and rationale, methodology, illustrations of sample products, and summaries of innovations and their relevance to forest management.

Available at:
UBC Alex Fraser Research Forest, and Gavin Lake Forest Education Centre, Forest Management Institute of the Czech Republic (in English and Czech).

Citation:
Koot, C. 2004. Ecological site mapping of the UBC Alex Fraser Research Forest - The process behind the development of detailed ecosystem mapping and identification tools. University of British Columbia Alex Fraser Research Forest, Williams Lake, B.C. Brochure.

9.4 "Branch Lines" Newsletter Article

Purpose:
To inform UBC Faculty of Forestry researchers, staff and students about the process and products of this project.

Venue and Date:
March, 2004 issue of the UBC Faculty of Forestry newsletter, "Branch Lines".

Description:
A one-page article with photo summarizing project methodology and products.

Available at:
UBC Faculty of Forestry website (www.forestry.ubc.ca), UBC Forest Sciences Centre, UBC Alex Fraser Research Forest

Citation:
Klinka, K. and C. Koot. 2004. Site Mapping of the Alex Fraser Research Forest. Branch Lines, 15(1). University of British Columbia Faculty of Forestry, Vancouver, B.C.

9.5 FORREX "LINK" Newsletter Article

Purpose:
To inform natural resources professionals and users about the innovations achieved in the completion of this project.

Venue and Date:
Summer, 2004 issue of FORREX's newsletter, "LINK"

Description:
A two-page, feature illustrating and highlighting the innovations in ecosystem mapping and site series identification developed in this project.

Available at:
FORREX website (www.FORREX.org) and hard-copy distribution points province-wide.

Citation:
Koot, C. and C. Trethewey. 2004. Innovations in Ecosystem Mapping and Site Series Identification. LINK, 6(1). FORREX, Kamloops, B.C.

9.6 Two Demonstration Sites

Purpose:

a) To introduce the concept of site mapping to the general public and correlate indicator plants, climate and soil properties with management implications.

b) To reinforce the process of site series identification and interpretation with forestry and natural resources post-secondary students.

Venues:

a) Mule Deer Trail, Knife Creek Block, Alex Fraser Research Forest,

b) Gavin Lake Trail, Gavin Lake Block, Alex Fraser Research Forest

Description:

a) A professionally designed interpretive sign combining text and graphics (diagrams, photos, site map) placed along the most frequently used trail by the public.

b) Another interpretive sign of a flowchart outlining the process of site series identification using new and existing tools, as well as a permanent soil pit to be used for demonstration during university field courses.

Citation:

Not applicable.

9.7 Booklet and Site Maps

Purpose:

To provide the new site series identification tools along with the folded site maps to Research Forest staff and researchers.

Description:

Edatopic grids, landscape profiles, site series identification keys, environmental features tables, and soil moisture and soil nutrient regime keys for the IDFxm subzone, and IDFdk3, SBSdw1, and ICHmk3 variants at AFRF, along with printed attribute tables for delineated map polygons for the Knife Creek and Gavin Lake Blocks. Folded copies of the site maps for field use are also included.
Available: Copies can be borrowed from the Alex Fraser Research Forest library.

Citation:

Klinka, K, C. Koot, A. Kusbach, J. Macku, M. Rau, C. Trethewey, and P. Varga. 2004. Site Identification Tools, Field Site Maps, and Polygon Summaries for the UBC Alex Fraser Research Forest. University of British Columbia Alex Fraser Research Forest, Williams Lake, B.C. Unpublished Booklet.

9.8 DVD

Purpose:

To demonstrate to post-secondary students and agencies considering conducting similar projects the process involved with detailed site mapping.

Description:

A 20-minute documentary describing biogeoclimatic ecosystem classification in British Columbia, the process of creating detailed site maps, and how they apply to forest management.

Available:

Alex Fraser Research Forest.

Citation:

Kusbach, A. 2004. Ecosystem Mapping of the Alex Fraser Research Forest. Hartola Film and Forest Management Institute, Plzen, Czech Republic. DVD Recording.

9.9 CD ROM

Purpose:
To provide an efficient and effective medium for distribution and extension of project products to post-secondary students, researchers, and natural resources professionals.

Description:
An interactive, digital interface that presents the final report, site maps, interpretive maps, image library (>1700 images) and polygon attribute tables. A GIS viewer enables users to visually navigate through the maps. Each map polygon is numbered and hyperlinked with its site attribute details. Images of forest communities are similarly linked, providing a "virtual forest" that facilitates learning about site identification and interpretation.

Available:
Alex Fraser Research Forest.

Citation:
Klinka, K, C. Koot, A. Kusbach, J. Macku, M. Rau, C. Trethewey, and P. Varga. 2004. Site Units of the UBC Alex Fraser Research Forest. University of British Columbia Forest Sciences Department, Vancouver, B.C. CD-ROM.

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11 APPENDICES

Appendix 1 Vegetation Data for Knife Creek Block

Appendix 1.1 Diagnostic combinations of species for site units in the Knife Creek Block.

The combination of species for each unit is shaded in grey. Species diagnostic values: dd = dominant differential, d = differential, ic = important companion. Species presence classes as percent of frequency: I = 1-20%, II = 21-40%, III = 41-60%, IV = 61-80%, V = 81-100%. Presence values ≥ III are printed in bold fonts. Species significance classes and the corresponding mid-point and range (in parentheses) of cover are: + = 0.001 - 1.00, 1 = 1.001 - 5.00, 2 = 5.001 - 25.00, 3 = 25.001 - 50.00, 4 = 50.001 - 75.00, 5 = 75.001 - 100.00.

Subzone/variant		IDFxm	IDFxm IDFdk3	IDFxm	IDFxm IDFdk3	IDFdk3	IDFdk3 SBPS	IDFxm IDFdk3	IDFdk3	IDFxm	IDFxm IDFdk3
Site series		**02**	**03/02**	**04**	**05**	**01**	**01**	**07/08**	**07**	**08**	**09**
Number of plots		7	6	12	4	6	4	8	9	6	2
Species	**Diagnostic value**	**Species Presence and Significance**									
Rocky, Crest, and Water-shedding Sites											
Allium cernuum	(d)	**III** 1	**V** 2	**V** 2	**IV** 1	I +			II +		
Antennaria microphylla	(ic)	II +	II +	**III** 1							
Artemisia frigida	(ic)	I +	II +	I +							
Carex concinnoides	(d)	**IV** 1	**IV** 1	**IV** 1		II 1	II +	II +	II +		
Elymus spicatus	(d)	**IV** 2	**V** 2	**IV** 2	**III** 2	I +					
Festuca occidentalis	(ic)	II +	II +	II 1							
Festuca saximontana	(d)	**III** 1	**IV** 1	II +							
Juniperus communis	(ic)	I +	II 2	II 1	II +						
Juniperus scopulorum	(ic)	II 2	II +	I 1	I 1	I +					
Tragopogon dubius	(ic)	I +	I +	II +						I +	
Rocky Sites (represented by Juniperus (IDFxm/02) samples)											
Penstemon fruticosus	(ic)	**III** 1	II +								
Prunus virginiana	(d)	**IV** 2	II +	I +				I +			
Water-shedding, Crest Sites (represented predominantly by Arctostaphylos (IDFdk3/02) samples)											
Apocynum androsaemifolium	(ic)		II 2	I 1							
Arctostaphylos uva-ursi	(dd)		**V** 3	**IV** 2	**III** 1	**V** 2	II +	I 1	II 1	I +	
Water-shedding, Warm-slope Sites (represented predominantly by Allium (IDFxm/04) samples)											
Aster ciliolatus	(d)	I +	**III** 1	**V** 1		**V** 1	**IV** 1	**IV** 2	**V** 2	**V** 2	**III** 2
Aster conspicuus	(d)	II 1		**III** 2	**V** 2	**V** 2	**IV** 1	**V** 2	**III** 2	**IV** +	
Astragalus miser	(d)			**III** 2		**IV** 1					
Balsamorhiza sagittata	(ic)		I +	II +		I +					
Lathyrus nevadensis	(d)			**III** +	**III** +	**III** 1	**V** 1	**III** 1	**IV** 1	**V** 1	
Oryzopsis asperifolia	(d)			**III** 1	II +	II +	**V** 1	**IV** 2	**IV** 1	**IV** 1	
Solidago spathulata	(d)	II 1	II 2	**IV** 2	II +	II +					
Water-shedding, Cool-slope and Near Zonal and Zonal Sites											
Dicranum polysetum	(d)	I 2	I 1	I +	**III** 2	II 2		II 2	I 2		

Subzone/variant		IDFxm	IDFxm IDFdk3	IDFxm	IDFxm IDFdk3	IDFdk3	IDFdk3 SBPS	IDFxm IDFdk3	IDFdk3	IDFxm	IDFxm IDFdk3
Site series		**02**	**03/02**	**04**	**05**	**01**	**01**	**07/08**	**07**	**08**	**09**
Number of plots		7	6	12	4	6	4	8	9	6	2
Species	**Diagnostic value**	**Species Presence and Significance**									

Water-shedding, Cool slope Sites (represented by Hylocomium (IDFxm/05 and IDFdk3/05 samples)

Allium cernuum	(d)	III 1	V 2	V 2	IV 1	I +			II +		
Aralia nudicaulis	(d)				III 1	I 1		V 3	I +	IV 1	
Disporum hookeri	(d)	II +			III 1	I +	II +	IV 1	I +	IV +	
Disporum trachycarpum	(ic)				II +			I 1			
Elymus spicatus	(d)	IV 2	V 2	IV 2	III 2	I +					
Lathyrus ochroleucus	(d)	I +	I +	I +	III 1	I +		II 1	II 1		

Near-zonal and Zonal Sites (represented by Calamagrostis (IDFdk3/01) samples)

Achillea millefolium	(d)	II +	IV 1	IV 1		III 1	IV 1		IV 1	II +	
Antennaria neglecta	(d)		I +	II +		III 2	V 1		I 1		
Antennaria racemosa	(d)		II +	II +		IV 1		II +			
Arctostaphylos uva-ursi	(d)		V 3	IV 2	III 1	V 2	II +	I 1	II 1	I +	
Aster ciliolatus	(d)	I +	III 1	V 1		V 1	IV 1	IV 2	V 2	V 2	III 2
Astragalus miser	(d)			III 2		IV 1					
Fragaria virginiana	(d)	I +	IV 1	IV 1	II +	IV 1	V 2	IV 1	V 1	V 1	
Galium boreale	(d)	II +	IV 1	III 1	II +	IV 1	IV 1	II +	V 1	IV 1	
Goodyera oblongifolia	(d)					III +	IV 1	II +	III +	I +	
Orthilia secunda	(d)					III 2	III +	IV 1	III 1	IV 1	
Viola adunca	(d)	I +	I +	II +	II +	IV 1	II +	III +	III 1	II +	

Near-zonal and Zonal Sites (in the IDFdk3/SBPSmk transition), **Inherently Rich** (Intermittent Seepage), **Water-receiving Sites**

Cornus canadensis	(ic)				II +		V 2	IV 2	IV 2		
Disporum hookeri	(ic)	II +			III 1	I +	II +	IV 1	I +	IV +	
Goodyera oblongifolia	(ic)					III +	IV 1	II +	III +	I +	
Lilium columbianum	(ic)						II +	II +	I +	III +	
Mahonia aquifolium	(d)	I 1	I +	I +		II +	IV 1	III 2	III 1	IV 1	
Orthilia secunda	(d)					III 2	III +	IV 1	III 1	IV 1	
Oryzopsis asperifolia	(d)			III 1	II +	II +	V 1	IV 2	IV 1	IV 1	
Picea engelmannii x glauca	(ic)						III 2	IV 2	V 4	V 4	V 5
Populus tremuloides	(d)			I 1	II 1	III 1	V 2	IV 2	V 3	V 3	
Pyrola chlorantha	(ic)			I +		I +	IV 1	I +	III 1	II +	
Rubus pubescens	(ic)					I +	III 1	II 2	IV 1	IV 1	V 3
Thalictrum occidentale	(d)						III 1	II 1	IV 1	IV 1	

Near-zonal and Zonal Sites (in the IDFdk3/SBPSmk transition, represented by Calamagrostis (IDFk3/SBSmk/01))

Antennaria neglecta	(d)		I +	II +		III 2	V 1		I 1		
Arnica cordifolia	(ic)			I +	II 1	II 2	V 1	IV 1	II +		
Chimaphila umbellata	(d)				II +	II +	IV 1	I +			
Geocaulon lividum	(ic)				II +		V 2	II 1	V 2	II +	III 1
Lupinus sericeus	(ic)						II +				
Pinus contorta	(ic)		II 2	I +	II +	III 2	IV 1	I +	III 2		
Ptilium crista-castrensis	(ic)			I +	II 1	I 1	IV 2	I 1	III 1		
Vaccinium membranaceum	(d)				II +		III 1				

Inherently Rich (Intermittent Seepage) Sites (represented by Aralia (IDFxm/07 and IDFdk3/08) samples)

Aralia nudicaulis	(d)				III 1	I 1		V 3	I +	IV 1	
Spiraea betulifolia	(d)	II 2	V 2	V 2	IV 2	III 1		V 2			

Subzone/variant		IDFxm	IDFxm IDFdk3	IDFxm	IDFxm IDFdk3	IDFdk3	IDFdk3 SBPS	IDFxm IDFdk3	IDFdk3	IDFxm	IDFxm IDFdk3
Site series		02	03/02	04	05	01	01	07/08	07	08	09
Number of plots		7	6	12	4	6	4	8	9	6	2
Species	**Diagnostic value**	**Species Presence and Significance**									

Poorly-drained and Water-receiving Sites

Species	Diagnostic value	02	03/02	04	05	01	01	07/08	07	08	09
Elymus glaucus	(ic)								II +	III 2	
Geranium viscosissimum	(d)						II +		III 1	III +	
Geum rivale	(ic)								I +	II +	
Lonicera involucrata	(ic)						II +	II 1	IV 1	V 2	V 3
Osmorhiza berteroi	(d)						II +	II +	IV 1	V 1	
Petasites palmatus	(ic)								III +	II +	
Trifolium pratense	(d)		I +					I +	III 1	IV 1	

Water-enriched, Poorly-drained Sites (represented by Lonicera (IDFdk3/07 and IDFdk3/SBPSmk/07) samples)

Species	Diagnostic value	02	03/02	04	05	01	01	07/08	07	08	09
Achillea millefolium	(d)	II +	IV 1	IV 1		III 1	IV 1		IV 1	II +	
Cornus canadensis	(d)				II +		V 2	IV 2	IV 2		
Epilobium angustifolium	(d)				II +	I +	IV 1	II +	III 1		
Geocaulon lividum	(d)				II +		V 2	II 1	V 2	II +	III 1
Goodyera oblongifolia	(d)					III +	IV 1	II +	III +	I +	
Mitella nuda	(d)							IV 2	III 1	I +	V 3
Pinus contorta	(d)		II 2	I +	II +	III 2	IV 1	I +	III 2		
Platanthera orbiculata	(d)					I +			III +		
Ptilium crista-castrensis	(d)			I +	II 1	I 1	IV 2	I 1	III 1		
Shepherdia canadensis	(d)		I 2	II 1	IV 2	III 2	IV 2	III 1	III 2	I +	
Smilacina racemosa	(d)				II +		II +	II +	III +		
Viburnum edule	(d)						II +	II 1	III 1		III 1

Water-receiving (Seepage) Sites (represented by Cornus (IDFxm/08) samples)

Species	Diagnostic value	02	03/02	04	05	01	01	07/08	07	08	09
Actaea rubra	(d)								I +	III +	
Aralia nudicaulis	(d)				III 1	I 1		V 3	I +	IV 1	
Carex sp.	(d)							I +		IV 1	
Circaea alpina	(ic)									II 2	
Cornus stolonifera	(d)							I 1		V 1	V 3
Galium triflorum	(d)							I +	I +	V 1	
Petasites sagittatus	(ic)									II +	
Plagiomnium insigne	(ic)									II +	
Ribes lacustre	(d)	I +						I +	I +	IV 1	
Rubus parviflorus	(ic)									II +	
Smilacina stellata	(d)							II +	II +	V 1	III 2
Symphoricarpos albus	(d)	III 2	II 2	III 2	III 1	III 2		III 2	III 1	V 3	III 1
Taraxacum officinale	(d)	I +	I +	I +		I +		II +	III 1	V 1	
Vicia americana	(d)	III 1	III 1	IV 1			II +	II +	II +	V 1	
Viola canadensis	(d)							I +	III 1	V 1	

Water-collecting Sites (represented by Equisetum (IDFxm/09 and IDFdk3/09) samples)

Species	Diagnostic value	02	03/02	04	05	01	01	07/08	07	08	09
Brachythecium sp.	(d)							I 1		I +	III 1
Carex disperma	(d)										III 3
Cinna latifolia	(d)									II 2	III 2
Cornus stolonifera	(ic)							I 1		V 1	V 3
Equisetum arvense	(dd)								I +	I 1	V 5
Lonicera involucrata	(ic)						II +	II 1	IV 1	V 2	V 3
Mitella nuda	(d)							IV 2	III 1	I +	V 3
Mnium sp.	(d)									I 2	III 1
Picea engelmannii x glauca	(ic)						III 2	IV 2	V 4	V 4	V 5

Appendix 1.2 Diagnostic combinations of species for ICHmk3 site series in the Gavin Lake Block derived from the BCFS data (Steen and Coupe 1997), except for the 08 Rubus site series, which was sampled as part of this project.

The combination of species for each unit is shaded in grey. Species diagnostic values: dd = dominant differential, d = differential, ic = important companion. Species presence classes as percent of frequency: I = 1-20%, II = 21-40%, III = 41-60%, IV = 61-80%, V = 81-100%. Presence values ≥ III are printed in bold fonts. Species significance classes and the corresponding mid-point and range (in parentheses) of cover are: + = 0.001 - 1.00, 1 = 1.001 - 5.00, 2 = 5.001 - 25.00, 3 = 25.001 - 50.00, 4 = 50.001 - 75.00, 5 = 75.001 - 100.00.

	Site series							
	02	03	01	04	05	**08**	06	07
Species	**Species Presence and Significance**							
Pseudotsuga menziesii	**III** 5	**III** 5	II 2			II 4		
Chimaphila umbellata	I 3	II 4	t 1					
Acer glabrum	I 3	t 1						
Aster conspicuus	I 3	t 1						
Festuca occidentalis	I 3	I 2						
Mahonia aquifolium	I 3	t 1						
Oryzopsis asperifolia	I 3	I 3						
Peltigera aphthosa	I 3	I 3						
Shepherdia canadensis	I 3	t 1						
Cladina & Cladonia spp.	I 3							
Dicranum polysetum	II 4							
Juniperus communis	I 3							
Pinus contorta	I 3							
Thuja plicata		t 1	**III** 5	**III** 5	II 4	t 1	**III** 5	**III** 5
Abies lasiocarpa			II 4	I 2	**III** 5	I 2	II 4	II 4
Picea engelmannii x glauca			II 4	I 2	**III** 5	II 4	**III** 5	**III** 5
Tiarella unifoliata			II 2					
Mitella nuda			t 1	I 2	II 3	I 2	II 3	I 3
Galium triflorum				I 2	I 2	I 3	I 3	I 3
Oplopanax horridus				I 3	I 3	t 1	I 3	II 4
Plagiomnium medium				t 1	I 3	t 1	I 2	I 3
Tiarella trifoliata				I 3	I 2	t 1	II 4	I 3
Gymnocarpium dryopteris			t 1	**III** 5	t 1	t 1	I 3	I 2
Cornus stolonifera					I 3	II 4	t 1	I 3
Lonicera involucrata					I 3	I 3	t 1	I 3
Disporum hookeri						I 2		
Lathyrus ochroleucus						I 3		
Rubus parviflorus				I 2	I 2	**III** 5	I 3	
Smilacina racemosa						I 3		
Smilacina stellata						I 3		
Symphoricarpos albus						II 4		
Streptopus roseus			t 1	I 2	I 2		**III** 5	
Athyrium filix-femina					t 1	t 1	I 2	II 4
Streptopus amplexifolius							I 2	II 4
Alnus tenuifolia								II 4
Cinna latifolia								t 1
Circaea alpina								I 3
Equisetum arvense								**III** 5

Appendix 1.3 Non-diagnostic species for site units distinguished in support of site mapping in the Knife Creek Block.

Species presence classes as percent of frequency: I = 1-20%, II = 21-40%, III = 41-60%, IV = 61-80%, V = 81-100%. Presence values ≥ III are printed in bold fonts. Species significance classes and the corresponding mid-point and range (in parentheses) of cover are: + = 0.001 - 1.00, 1 = 1.001 - 5.00, 2 = 5.001 - 25.00, 3 = 25.001 - 50.00, 4 = 50.001 - 75.00, 5 = 75.001 - 100.00

Subzone/variant	**IDFxm**	**IDFxm IDFdk3**	**IDFxm**	**IDFxm IDFdk3**	**IDFdk3**	**IDFdk3 SBPS**	**IDFxm IDFdk3**	**IDFdk3**	**IDFxm**	**IDFxm IDFdk3**
Site series	**02**	**03/02**	**04**	**05**	**01**	**01**	**07/08**	**07**	**08**	**09**
Number of plots	7	6	12	4	6	4	8	9	6	2
Species	Species Presence and Significance									
Amelanchier alnifolia	**V** 2	**V** 2	**V** 2	**IV** 2	**V** 1	**V** 2	**V** 2	**IV** 2	**IV** 2	
Betulapa pyrifera						II +	I 2		**I** 1	
Calamagrostis rubescens	**IV** 2	**V** 1	**IV** 2	**V** 3	**V** 3	**V** 3	**V** 2	**V** 2	**V** 2	
Cladina rangiferina	I +	II 1	**III** 1	II +	II +	**III** 1				
Cladonia sp.	II 2	II 2	I +	II 1	II 2			I +		
Clematis occidentalis				II +		**III** 1	II +			
Dicranum polysetum	I +	I +	**III** 1	**III** 2	**III** 2	**V** 2	**IV** 2	**IV** 2	II 1	
Epilobium angustifolium				II +	I +	**IV** 1	II +	**III** 1		
Erigeron speciosus		**III** 1	**IV** 1		II +		I +			
Heuchera cylindrica	I +	I +		II 1						
Hieracium umbellatum		I +	II +				I +			
Hylocomium splendens	I +	I +	I 1	V 3	**V** 2	**V** 2	**V** 3	**IV** 2	**III** 2	**V** 3
Linnaea borealis			I +	**III** 1	**III** 2	**V** 2	**IV** 2	**V** 2	**V** 2	**V** 3
Melampyrum lineare					II +			I +	I +	
Peltigera aphthosa			I +	**III** 1	**III** 1	**IV** 2	**III** 1	**III** 1	I 1	
Peltigera sp.	**IV** 1	**V** 2	**III** 1	**III** 2	II 2		**IV** 2	I +	I +	
Pleuroziums chreberi	**III** 2	**III** 2	**III** 2	**V** 4	**V** 4	**V** 3	**V** 3	**V** 3	**V** 2	**V** 3
Polytrichum juniperinum	I +			II +						
Pseudotsuga menziesii	**V** 4	**V** 3	**V** 4	**V** 5	**V** 5	**V** 4	**V** 5	**IV** 3	**V** 2	
Rhytidiadelphus triquetrus			I 1	**IV** 2	**IV** 1	**IV** 2	**IV** 2	**V** 2	**IV** 1	**III** 1
Rosa acicularis	**V** 2	**V** 2	**V** 2	**V** 2	**V** 2	**V** 2	**V** 3	**V** 2	**V** 2	**V** 3

Appendix 2 Selected Soil Data

Appendix 2.1 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Juniperus (IDFxm/02) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
110	110A	IDFxm/02	7.9	1.79	0.12	15.4
110	110B	IDFxm/02	7.1	1.91	0.10	19.5
110	108A	IDFxm/02	7.7	1.24	0.08	16.5
110	109	IDFxm/02	8.3	1.44	0.07	21.5
	108B	IDFxm/02	8.0	1.31	0.11	12.4
Mean			**7.8**	**1.54**	**0.10**	**17.1**

Appendix 2.2 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Arctostaphylos (IDFxm/03 and IDFdk3/02) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
438	501	IDFdk3/02	6.1	3.85	0.26	14.9
163	603	IDFxm/03	6.7	1.44	0.09	16.7
235	310	IDFxm/03 & IDFdk3/03	6.8	1.30	0.07	17.6
235	311	IDFxm/03 & IDFdk3/03	6.7	1.66	0.08	21.8
Mean			**6.6**	**2.06**	**0.11**	**17.8**

Appendix 2.3 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for Allium (IDFxm/04, IDFxm-IDFdk3/04, and IDFdk3/04) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H_2O)	Total C (%)	Total N (%)	C/N ratio
248	307	IDFxm-IDFdk3/04	7.8	0.84	0.05	17.5
247	306	IDFxm-IDFdk3/04	6.1	1.78	0.07	24.1
163	604	IDFxm/04	6.4	1.66	0.09	18.2
248	309	IDFxm-IDFdk3/04	7.3	1.35	0.08	16.9
388	204N	IDFdk3/04	7.2	3.25	0.18	18.3
113	102	IDFxm/04	6.8	1.57	0.09	16.9
113	101	IDFxm/04	7.3	1.13	0.07	17.1
107	105	IDFxm/04	7.3	1.66	0.09	17.8
107	104	IDFxm/04	6.8	2.22	0.14	16.4
384	203N	IDFdk3/04	5.8	0.97	0.06	17.6
Mean			**6.9**	**1.64**	**0.09**	**18.1**

Appendix 2.4 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Hylocomium (IDFxm/05 and IDFdk3/05) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
334	202N	IDFdk3/05	6.1	1.28	0.08	15.4
106	106	IDFxm/05	6.8	2.35	0.14	16.8
Mean			**6.5**	**1.82**	**0.11**	**16.1**

Appendix 2.5 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Calamagrostis (IDFxm/01, IDFxm-IDFdk3/01, and IDFdk3-SBPDmk/01) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
234	601	IDFxm-IDFdk3/01	6.4	1.80	0.09	20.5
234	602	IDFxm-IDFdk3/01	6.1	1.15	0.06	19.2
108	103A	IDFxm/01	6.7	0.90	0.05	16.7
602	401A	IDFdk3-SBPSmk/01	5.4	0.53	0.03	17.1
402	403	IDFdk3/01	5.6	0.60	0.03	17.65.9
602	401B	IDFdk3-SBPSmk/01	6.1	1.15	0.06	19.2
512	302	IDFdk3/01	6.0	0.99	0.06	17.4
Mean			**6.0**	**1.02**	**0.05**	**18.4**

Appendix 2.6 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Aralia (IDFxm/07 and IDFdk3/08) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
334	212	IDFdk3/08	6.9	1.01	0.09	11.7
303	111B	IDFdk3/08	7.0	1.66	0.11	15.0
302	111A	IDFdk3/08	6.4	0.73	0.06	15.0
108	103B	IDFxm/07	6.3	0.93	0.07	13.9
Mean			**6.7**	**1.08**	**0.08**	**13.9**

Appendix 2.7 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Lonicera (IDFdk3/07) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
345	201N	IDFdk3/07	6.4	1.93	0.16	11.8
516	301	IDFdk3/07	6.7	4.94	0.35	14.0
526	303	IDFdk3/07	6.0	0.99	0.06	17.4
480	305	IDFdk3/07	5.7	0.73	0.06	12.6
507	402	IDFdk3/07	6.8	1.14	0.05	22.8
408	502	IDFdk3/07	6.3	0.47	0.03	14.7
Mean			**6.3**	**1.70**	**0.12**	**15.6**

Appendix 2.8 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Cornus (IDFxm/08 and IDFdk3/10) sample plots in the Knife Creek Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
134	606	IDFxm/08	6.2	0.45	0.03	13.2
134	607	IDFxm/08	6.0	1.79	0.18	9.9
159	605	IDFxm/08	6.2	0.84	0.06	14.5
Mean			**6.1**	**1.03**	**0.09**	**12.5**

Appendix 2.9 Acidity, total carbon, total nitrogen, and C/N ratio for the upper (0 to 30 cm) mineral soil layer for the Rubus (SBSdw1/06 and ICHmk3/08) sample plots in the Gavin Lake Block.

Polygon No.	Plot No.	Site series	pH (H2O)	Total C (%)	Total N (%)	C/N ratio
FOREST FLOOR						
T213	GL01	ICHmk3/ SBSdw1	4.6	47.70	1.10	43.4
T213	GL02	ICHmk3/ SBSdw1	5.5	31.00	1.10	28.2
T210	GL03	ICHmk3/ SBSdw1	6.8	32.70	0.87	40.9
S325	GL05	SBSdw1/06	7.2	41.10	1.46	19.3
T210	GL06	ICHmk3/ SBSdw1	5.1	61.40	1.55	39.6
T006	GL07	ICHmk3/ SBSdw1	4.4	38.80	0.65	59.7
T006	GL08	ICHmk3/ SBSdw1	5.6	27.40	0.80	34.2
Mean			**5.6**	**40.01**	**1.08**	**37.9**
MINERAL SOIL						
T213	GL01	ICHmk3/ SBSdw1	5.1	1.10	0.06	18.3
T213	GL02	ICHmk3/ SBSdw1	7.1	1.60	0.09	17.8
T210	GL03	ICHmk3/ SBSdw1	7.0	2.40	0.11	21.8
S325	GL05	SBSdw1/06	7.2	8.57	0.43	19.9
T210	GL06	ICHmk3/ SBSdw1	6.3	1.95	0.06	32.5
T006	GL07	ICHmk3/ SBSdw1	5.6	0.83	0.05	16.6
T006	GL08	ICHmk3/ SBSdw1	5.6	27.40	0.80	34.2
Mean			**6.3**	**6.26**	**0.23**	**23.0**

Site Units

Appendix 3 SMR and SNR Keys

Appendix 3.1. Explanation of terms used in the SMR and SMR keys.

Crest	Wide height of land (summit) with gentle convex shape.
Depression	An area that is concave-shaped (basin) usually in subdued terrain.
Flat	Any level area (excluding toe slopes); the surface shape is straight with no significant aspect (slope gradient <5%).
[2]Floodplain	Post-glacial (recent) alluvial deposits along rivers and streams, still under the influence of periodic flooding. Soil moisture regime of floodplain sites are also designated with suffixes referring to bench height: l (low bench), m (middle bench), and h (high bench), e.g., 5h.
Forest floor	All organic material (L, F, and H horizons) on the mineral soil surface.
Forest floor materials friable	Well-decomposed organic material that has a crumbly consistency.
Growing-season water table	The surface of a zone of prolonged water saturation and free water primarily on level terrain.
Lower slopes	The straight or concave lower (water-receiving) portion towards the base of a mesoslope. It includes toes slopes, which are nearly level areas directly below and adjacent to the lower slope.
Middle (mid) slope	The portion of a mesoslope between the upper and lower slopes; the slope shape is usually straight
Mor	
Mottles	Reddish or orange spots or blotches within the dull blue, olive, or yellowish soil matrix developed under the influence of periodic or sustained water saturation.
Particle size coarse	Sandy (LS, S) with >35% coarse fragments; or loamy with >70% coarse fragments.
Particle size fine	Silty or clayey with low coarse fragments
Ridge	Narrow height of land with a well-defined convex shape and rock outcrops.
Seepage	Downslope subsurface movement of free water above an impermeable soil layer
Soil depth	Depth from the ground surface to a restricting layer such as bedrock, strongly compacted, or strongly cemented material.
Soil dark-coloured	Soil with high organic matter content, indicated by dark chocolate-brown colours (Munsell colour value ≤4)
Soil light-coloured	Soil with very low organic matter content, indicated by very pale colours (Munsell colour value ≥6).
Soil colluvial	Soils derived from colluvial parent materials.
[1]Strongly fluctuating water table	Excessive changes in water table depth occurring in poorly drained, fine-textured soils in response to the seasonal pattern of precipitation. Such soil moisture regimes are also designated by suffix f, e.g., 6f.
Upper slope	The convex-shaped, upper (water-shedding) portion of mesoslope below the ridge or crest.
Warm-slope	Any slope with slope gradient >30% and aspect from 135° to 315°, inclusive
Wet soil	Soil that has a growing-season water table ≤30 cm from the ground surface.

Appendix 3.2 Key to the identification of relative **soil moisture regime** in the Alex Fraser Research Forest.

		SMR
Ridges, crests, upper slopes, and cliffs		
Soils ≤ 30 cm deep		
a	Exposed bedrock on >35% of ground surface	**0**
b	Particle size coarse	**1**
c	Particle size fine	**2**
d	Other soils	**1-2**
Soils >30 cm deep		
a	Particle size coarse **and** warm-slope	**1**
b	Other soils and slopes	**2-3**
Mid slopes		
Growing-season water table, seepage **or** mottles present		
a	at >60 cm depth	**5**
b	at ≤60 cm depth	**6**
Soils ≤50 cm deep		
a	Particle size coarse **and** warm-slope	**2**
b	Particle size fine **and** warm-slope	**3**
c	Other particle size and slope	**3 - 4**
Soils >50 cm deep		
Warm-slopes >35%		
a	Particle size fine	**4**
b	Other soils	**3**
Other slopes		
a	Particle size coarse	**3**
b	Particle size fine	**5**
c	Other soils	**4**
Lower slopes, toe slopes, gullies, ravines		
Growing-season water table, seepage **or** mottles present		
a	at >60 cm depth	**5**
b	between 30 and 60 cm depth	**6**
c	at <30 cm depth	**7**
Other soils		**4 - 5**

		SMR
Depressions		
Growing-season water table, seepage **or** mottles present		
a	at >60 cm depth	**5** or **5**[1]
b	between 30 and 60 cm depth	**6** or **6**[1]
c	at <30 cm depth	**7** or **7**[1]
Other soils		**5**
Floodplains, stream-edge—alluvial		
Growing-season water table, seepage **or** mottles present		
a	at >60 cm depth	**5**[2]
c	between 30 and 60 cm	**6**[2]
b	at <30 cm depth	**7**[2]
Other soils		
a	particle size coarse	**3**
b	particle size fine	**5**
c	Other soils	**4**
Other flat (level) landforms		
Particle size fine		
Growing-season water table, seepage **or** mottles present		
a	present at >60 cm depth	**5**[1]
b	present between 30 and 60 cm depth	**6**[1]
c	present at <30 cm depth	**7**[1]
Growing-season water table, seepage, or mottles **not** present		**4** - **5**[1]
Particle size other than fine		
Growing-season water table, seepage **or** mottles present		
a	present at >60 cm depth	**5**
b	present between 30 and 60 cm depth	**6**
c	present at <30 cm depth	**7**
Growing-season water table, seepage, or mottles **not** present		
a	particle size coarse	**2** - **3**
b	Other soils	**4**

[1, 2] See Appendix 3.1 for explanation

Appendix 3.3 Key to the identification of **soil nutrient regime** in the Alex Fraser Research Forest.

	SNR
Wet soils (SMR = 7)	
Thin forest floor ($\leq$ 10cm thick)	
Mor humus forms	
a Soil light-coloured **or** particle size coarse	**VP - P**
b Other soils	**M**
Other humus forms	
a Soil dark-coloured **or** Ah horizon ±5 cm	**VR**
b Other soils	**R**
Thick forest floor (> 10cm thick)	
a Forest floor materials poorly decomposed	**VP**
b Forest floor materials well-decomposed **and** friable	**R - VR**
c Forest floor materials well-decomposed and **not** friable	**M - R**
Shallow soils (soil depth $\leq$30cm); SMR $\neq$ 7	
Mor humus forms	
a Soil light-coloured	**VP**
b Other soils	**P**
Other humus forms	
a Soil dark-coloured or Ah horizon ±5cm	**M**
b Other soils	**P**
Deeper soils (soil depth >30cm); SMR $\neq$ 7	
Mor humus forms	
Particle size coarse	
a soil light-coloured	**VP**
b soil dark-coloured **and** colluvial	**M - R**
c soil not dark-coloured **and** other than colluvial	**P**
Particle size other than coarse	
a Soil light-coloured	**P**
b Soil **not** light-coloured **and** influenced by intermittent or permanent seepage	**R**
c Soil **not** light-coloured **and not** influenced by intermittent or permanent seepage	**M**
Other humus forms	
a Soil dark-coloured **or** Ah horizon >5 cm **and** particle size coarse	**R**
b Soil dark-coloured **or** Ah horizon >5 cm **and** particle size not coarse	**VR**
c Soil light-coloured **and** particle size coarse	**M**
d Soil light-coloured **and** particle size not coarse	**R**

Appendix 4 Site Modifiers

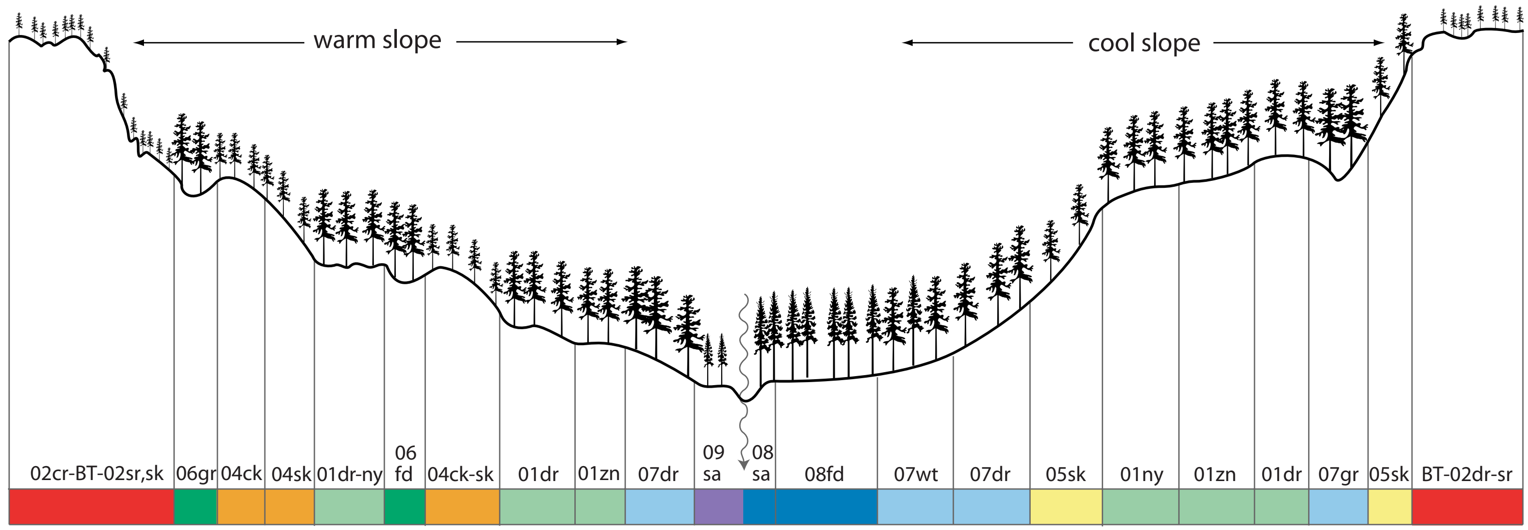
Appendix 4.1 Site modifiers are used to describe specific aberrant properties (environmental variation) of sites in the Alex Fraser Research Forest. These modifer codes follow the site series name codes, and appear in Appendix 5.

Name	Code	Description
cool-slope	**cs**	sites on slopes with the aspect ranging from 315° through 135°; slope gradient varies with site series
crest-rocky	**cr**	sites with very shallow (<30 cm) soils and exposed bedrock on ridges and hilltops
crest-skeletal	**ck**	sites on crests and ridges with ≥30 cm deep soils and >35% or more coarse fragments (gravel, rubble, or stones) on the ground surface and/or in the soil
drier	**dr**	drier than the average for the site unit; either on warm-slopes or associated with the coarse particle-size soils
flat-depression	**fd**	sites on level terrain and slopes <10%, or water-collecting sites on concave terrain; often frost-pockets
flat-skeletal	**fk**	sites on level terrain and slopes <10% with ≥35% or more coarse fragments (gravel, rubble, or stones) on the ground surface and/or in the soil
frost-site	**fs**	sites in depressions and on extensive flats prone to be affected by growing season frost
gully-ravine	**gr**	sites in gullies or ravines typically with no surface water flow during growing season
local climate	**lc**	modification of regional climate by the local climate of steep, warm slopes; this modifier is used occasionally with the SBSdw1/03sk site series
slope	**sl**	sites on slopes with the gradient varying with site series
slope-rocky	**sr**	sites on slopes with a discontinuous complex of shallow soils and exposed bedrock
slope-skeletal	**sk**	sites on slopes (generally ≥30%) with ≥30 cm deep soils and ≥35% or more coarse fragments (gravel, rubble, or stones) on the ground surface and/or in the soil
stony	**ny**	sites on flats and slopes with ≥30 cm deep soils and ≥35% or more coarse fragments (predominantly stones) on the ground surface and in the soil
stream-edge-alluvial	**sa**	sites that are adjacent to permanent streams (creeks, rivers) and may be subjected to temporary flooding and deposition of new materials
warm-slope	**ws**	sites on slopes with the aspect ranging from 135° through 315°; includes insolated sites on steep slopes; the slope gradients varies with site series
wetter	**wt**	wetter than the average for the unit, typically on flats and cool aspect slopes
zonal	**zn**	sites on flats or gentle (<30%) slopes with moderately deep soils that have loamy texture, <35% coarse fragments, and intermediate soil moisture and nutrient regimes

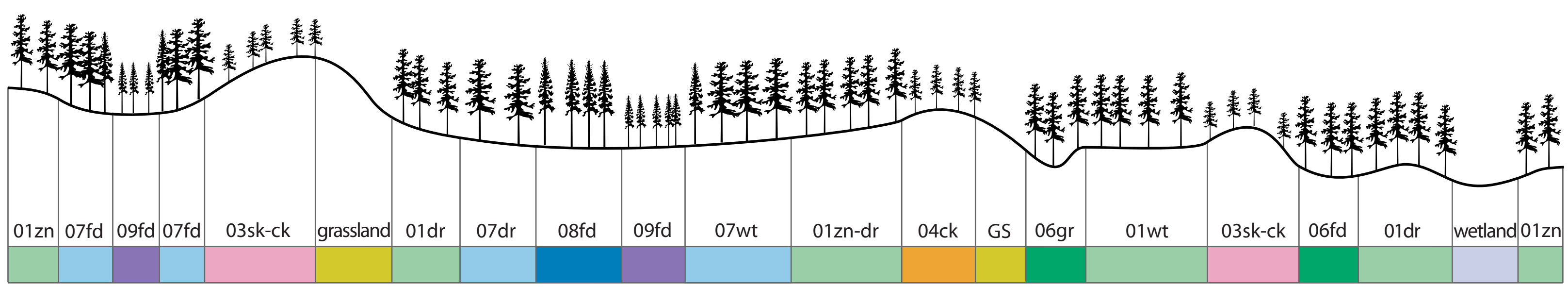
Appendix 5 Landscape Profiles for Each Zonal Unit

Appendix 5.1 Generalized profile indicating position of the **IDFxm** and **IDFxm-IDFdk3 transition** site series in the landscape. Site series codes and colours as in Table 6.3.1 and Table 6.3.2; modifiers as in Appendix 4.

(a) high relief landscape

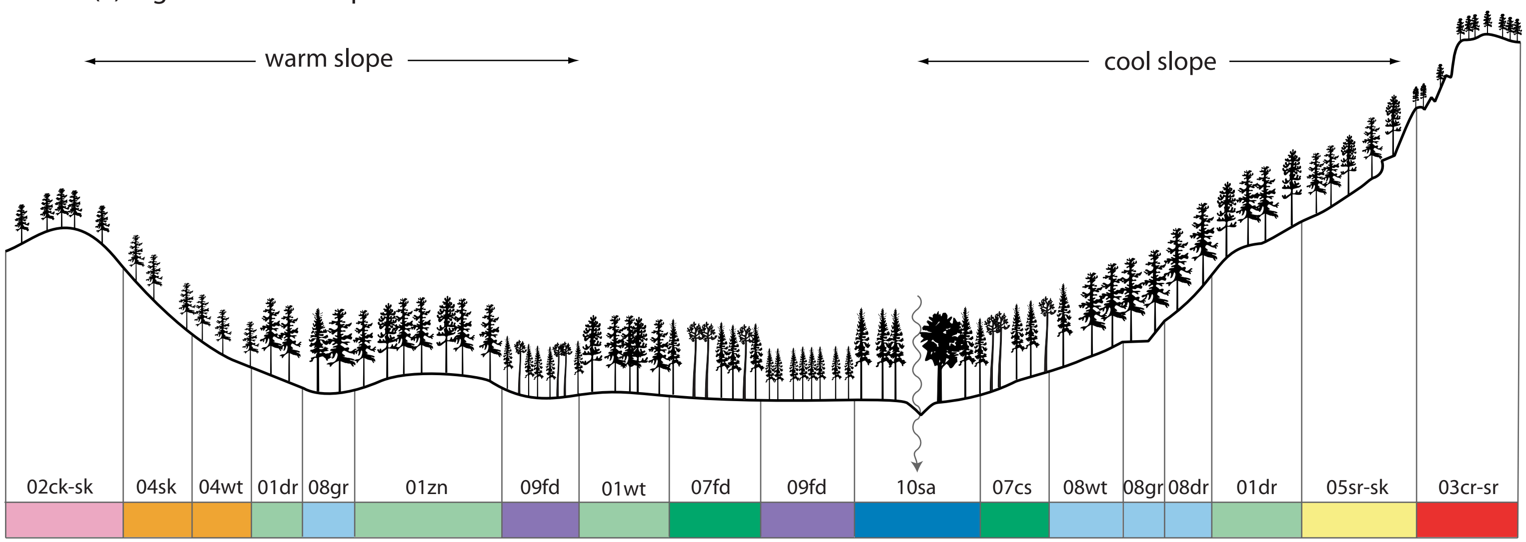


(b) low relief landscape

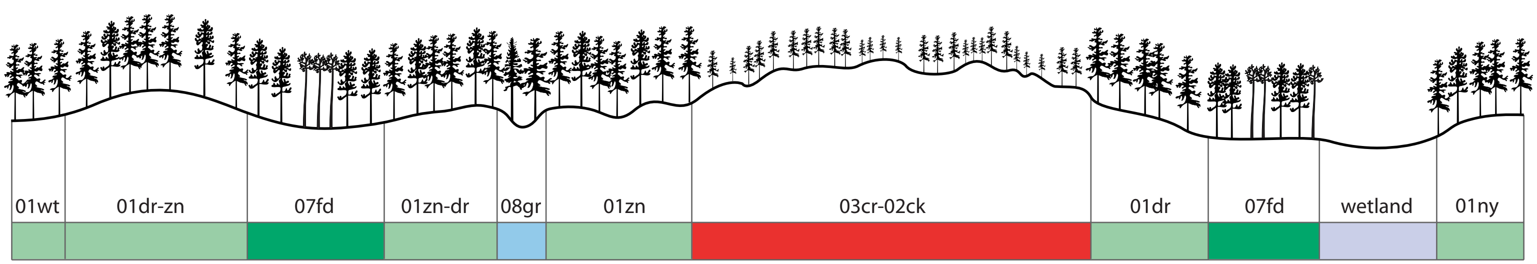


Appendix 5.2 Generalized profile indicating position of the **IDFdk3** and **IDFdk3-SBPSmk transition** site series in the landscape. Site series codes and colours as in Table 6.3.1 and Table 6.3.2; modifiers codes as in Appendix 4.

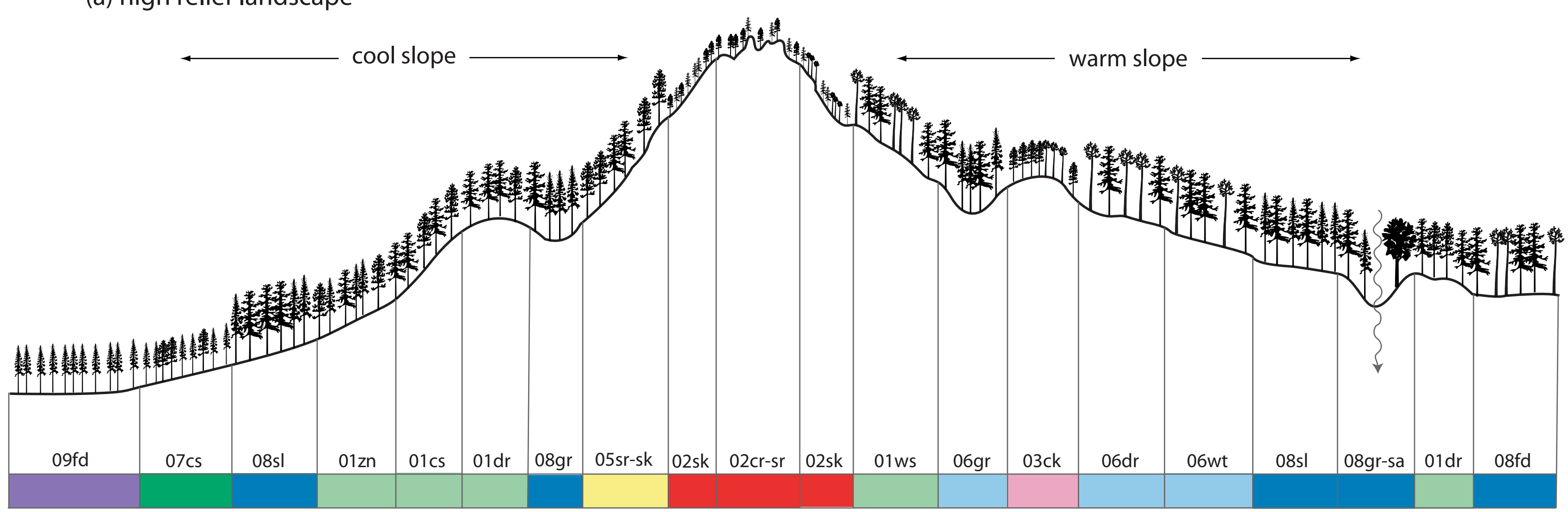
(a) high relief landscape

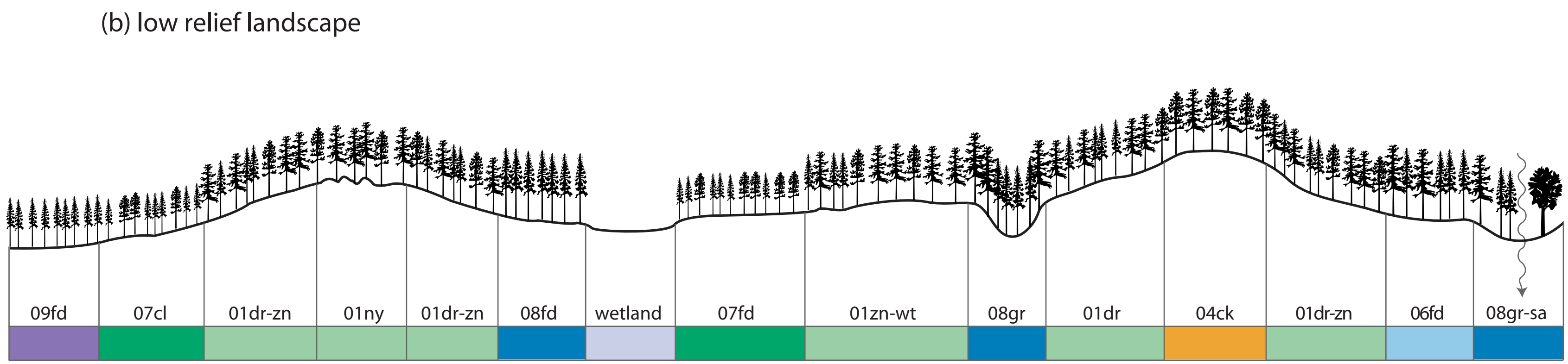


(b) low relief landscape

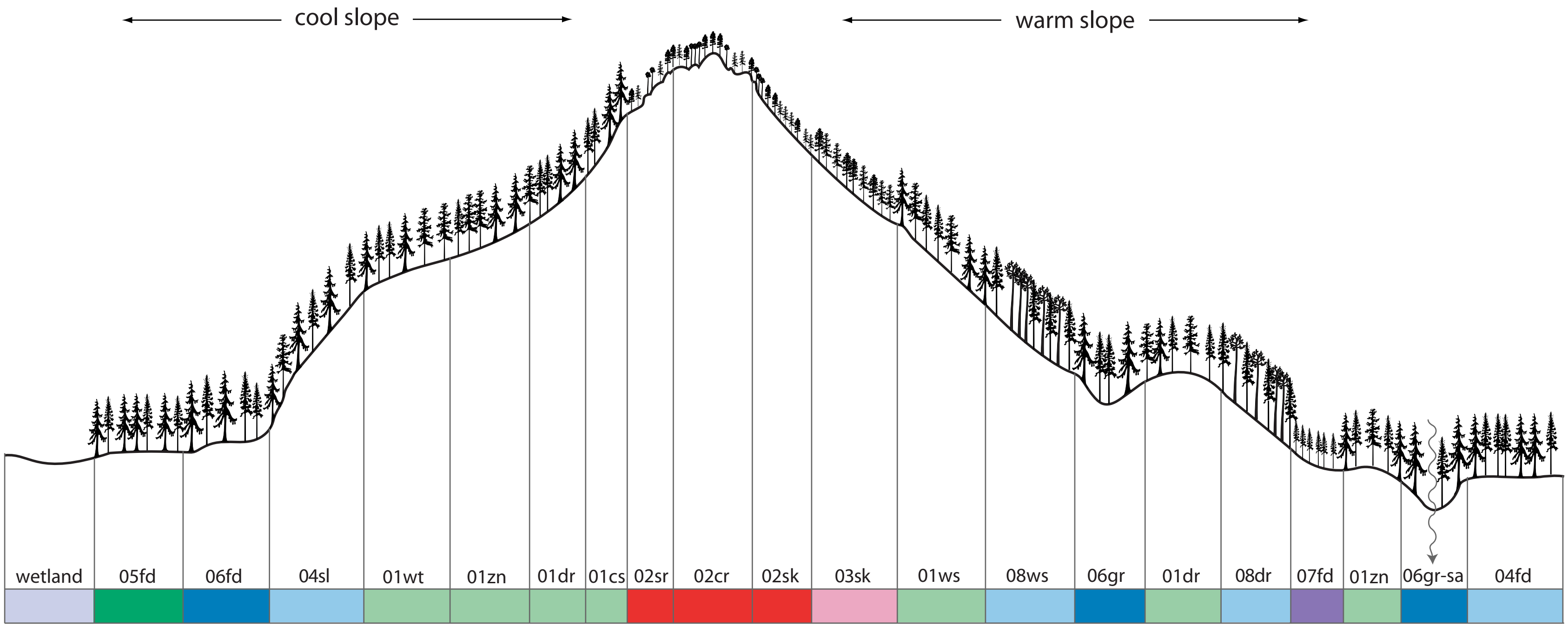


Appendix 5.3 Generalized profile indicating position of the **SBSdw1** site series in the landscape. Site series codes and colours as in Table 6.3.1 and Table 6.3.2; modifiers codes as in Appendix 4.





Appendix 5.4 Generalized profile indicating position of the **ICHmk3** and **ICHmk3-SBSdw1 transition** site series in the landscape. Site series codes and colours as in Table 6.3.1 and Table 6.3.2; modifier codes as in Appendix 4.



Appendix 6 Keys to Site Series for Each Zonal Unit

Appendix 6.1 Key to identification of the forested **IDFxm** and **IDFxm-IDFdk3 transition** site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; site modifiers defined in Appendix 4.1

Landform Features	Site Series	Site Modifiers
Rocky Sites		
a Rock outcrops and adjacent, warm-slope cliffs and fragmental colluvial deposits; exposed bedrock on >35% of ground surface; soils very shallow (<30 cm) and discontinuous **or** fragmental soil particle size	**02 Juniperus**	crest-rocky slope-rocky slope-skeletal
b Cool, upper, rocky slopes ≥30%; soils very shallow (≤30 cm) and discontinuous	**05 Hylocomium**	slope-rocky
Water Shedding Sites		
a Crests or warm, upper slopes generally <35% or fluvial terraces; soils coarse (sandy)-skeletal (gravely or stony)	**03 Arctostaphylos**	crest-skeletal slope-skeletal stony
b Crests **or** warm, upper and mid slopes generally ≥35%; soils loamy-skeletal	**04 Allium**	crest-skeletal slope-skeletal
c Upper and mid-position at short, cool-, **poor to medium** slopes ≥35%	**05 Hylocomium**	slope-skeletal
d Mid, **rich to very rich** slopes generally ≥35% **or** lower, **medium to very rich**, long, cool slopes without intermittent seepage	**07 Aralia**	drier
Near-Zonal and Zonal Sites		
a Near-zonal and zonal sites (heights-of-land or mid slopes <35%); neither water-shedding nor water-enriched sites)	**01 Calamagrostis**	drier stony zonal wetter
Intermittent Seepage Sites		
a Weakly water-enriched, **poor to medium** sites on short, lower slopes or in depressions and gullies; soil weakly mottled	**06 Oryzopsis**	gully-ravine flat-depression
b Weakly water-enriched, **rich to very rich** sites on long, lower and toe-slopes and flats or in depressions or gullies; soils weakly mottled	**07 Aralia**	gully-ravine flat-depression
Water-Receiving and -Collecting Sites		
a Water-receiving (seepage) sites on flats, in depressions, gullies, or at stream-edge and alluvial sites; soils weakly to prominently mottled; growing-season water table at ±60 cm depth	**08 Cornus**	flat-depression gully-ravine stream-edge–alluvial
b Water-collecting (waterlogged) sites; gleysolic soils; growing-season water table at ±30 cm depth	**09 Equisetum**	flat-depression stream-edge–alluvial

Appendix 6.2 Key to identification of the forested **IDFdk3** and **IDFdk3-SBPSmk transition** site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; site modifiers defined in Appendix 4.1

Landform Features		Site Series	Site Modifiers
Rocky Sites			
a	Rock outcrops and adjacent, warm-slope cliffs and fragmental colluvial deposits; exposed bedrock on >35% of ground surface; soils very shallow (<30 cm) and discontinuous **or** fragmental soil particle size	**03 Juniperus**	crest-rocky slope-rocky slope-skeletal
b	Cool, upper, rocky slopes ≥30%; soils very shallow (≤30 cm) and discontinuous	**05 Hylocomium**	slope-rocky
Water Shedding Sites			
a	Crests **or** warm, upper slopes generally <30%; soils coarse (sandy)-skeletal (gravely or stony)	**02 Arctostaphylos**	crest-skeletal slope-skeletal stony
b	Crests **or** warm, upper and mid slopes generally ≥30%; soil moderately deep to deep, medium- or fine-textured	**04 Allium**	crest-skeletal slope-skeletal wetter*
c	Cool, short, upper slopes ≥30%	**05 Hylocomium**	slope-skeletal
d	Mid, **rich to very rich** cool slopes generally ≥30% **or** lower, **medium to very rich**, long, cool slopes without intermittent seepage	**08 Aralia**	drier
Near-Zonal and Zonal Sites			
a	Near-zonal and zonal sites (heights-of-land or mid-slopes <30%); neither water-shedding nor water-enriched sites	**01 Calamagrostis**	drier stony zonal wetter
Intermittent Seepage Sites			
a	Weakly water-enriched sites, **poor to medium** sites on short, cool, lower slopes or weakly water-collecting sites in shallow depressions; soil weakly to strongly mottled and stony; fluctuating water table; poor lateral drainage; **cold-air sites**	**07 Lonicera**	cool-slope flat-depression
b	Weakly water-enriched, **medium to very rich**, intermittent seepage sites on long, lower and toe-slopes, flats, or in gullies; soils weakly mottled	**08 Aralia**	gully-ravine flat-depression
Water-Receiving and -Collecting Sites			
a	Water-receiving (seepage) sites on flats, in gullies or at stream-edge and alluvial sites; soils weakly to prominently mottled; growing-season water table at ±60 cm depth	**10 Cornus**	flat-depression gully-ravine stream-edge-alluvial
b	Water-collecting (waterlogged) sites in depressions; gleysolic or organic soils; growing-season water table at ±30 cm depth	**09 Equisetum**	flat-depression stream-edge-alluvial

*The wetter variation of the 04 (Allium) site series represents 06 (Fd-Pinegrass-Aster) site series that has been combined with the 04 (Allium) site series.

Appendix 6.3 Key to identification of the forested **SBSdw1** site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; site modifiers defined in Appendix 4.1

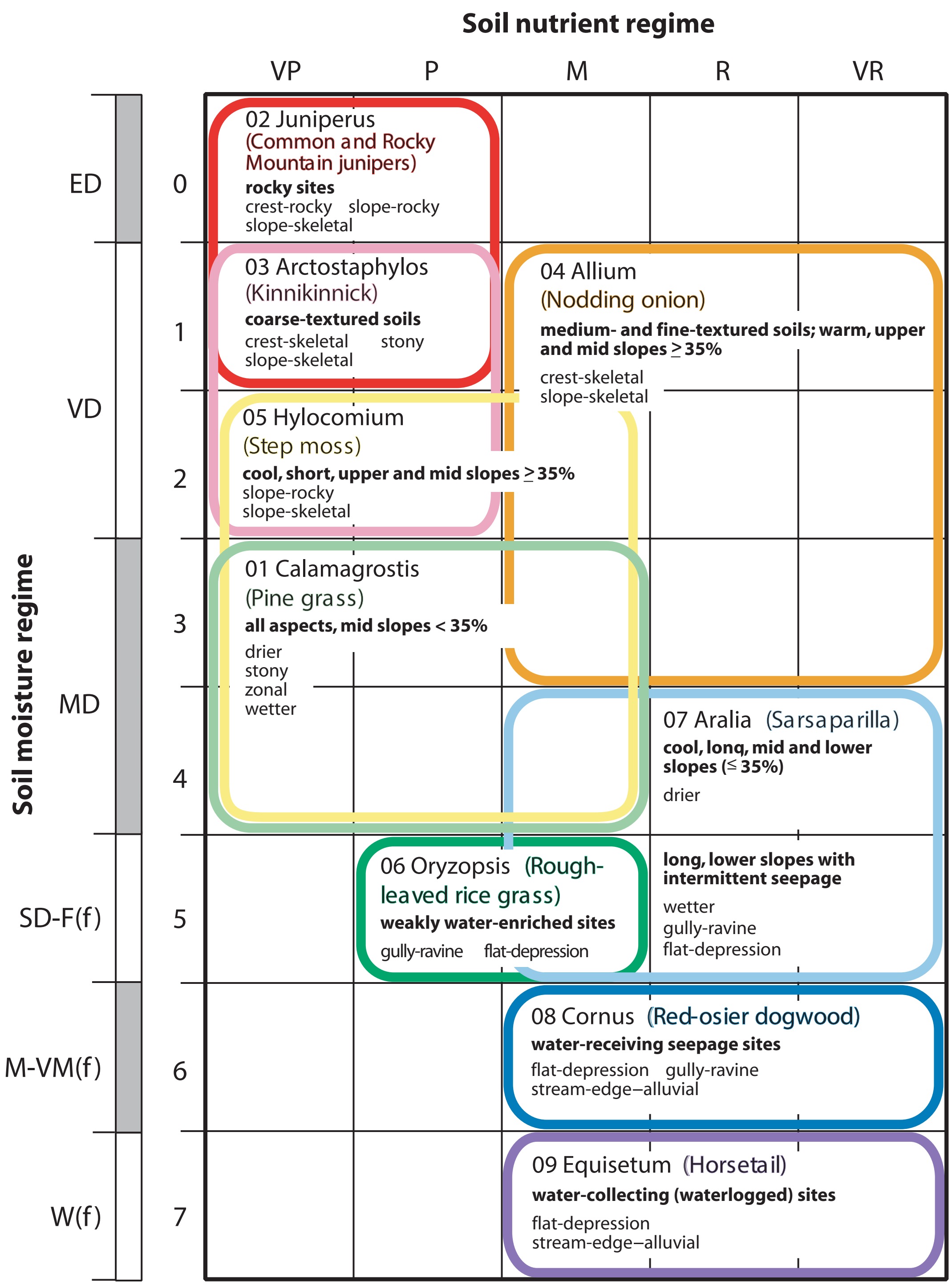
Landform Features		Site Series	Site Modifiers
Rocky Sites			
a	Rock outcrops and adjacent, warm-slope cliffs and fragmental colluvial deposits; exposed bedrock on discontinuous or fragmental >35% of ground surface; soils very shallow (<30 cm) and discontinous **or** fragmental	**02 Cladonia**	crest-rocky slope-rocky slope-skeletal
b	Cool, upper, rocky slopes ≥30%; soils very shallow (≤30 cm) and discontinuous	**05 Hylocomium**	slope-rocky
Water Shedding Sites			
a	Crests or warm, upper slopes generally ≥30%; loamy-skeletal soils	**03 Chimaphila**	crest-skeletal slope-skeletal stony
b	Cool, upper, ≥30% slopes	**05 Hylocomium**	slope-skeletal
c	Crest **or** flats (fluvial terraces); coarse (sandy)-skeletal (gravely or stony) soils	**04 Vaccinium**	crest-skeletal flat-skeletal
Near-Zonal and Zonal Sites			
a	Near-zonal and zonal sites (heights of land, gentle to moderate mid-slopes <30%; neither water-shedding nor water-enriched sites	**01 Calamagrostis**	drier warm-slope cool-slope stony zonal wetter
b	Mid, **rich to very rich**, **warm** slopes generally≤30% **or** lower, **medium to very rich**, **long**, **warm** slopes without intermittent seepage	**06 Rubus**	drier warm-slope
Intermittent Seepage Sites			
a	Weakly water-enriched, **poor to medium** sites on short, cool, lower slopes; or weakly water-sites in shallow depressions or gullies; weakly to strongly mottled, **stony** soils; fluctuating water table;collecting poor lateral drainage; **cold-air sites**	**07 Lonicera**	cool-slope flat-depression gully-ravine
b	Weakly water-enriched, **medium to rich**, intermittent seepage sites on long, lower slopes, and toe-slopes, on flats, **or** in gullies; soils weakly mottled	**06 Rubus**	wetter gully-ravine flat-depression
Water-Receiving and -Collecting Sites			
a	Water-receiving (seepage) sites on flats and lower slopes, in gullies, or at stream-edge and alluvial sites; soils mottled; growing-season water table at ±60 cm depth	**08 Gymnocarpium**	slope flat-depression gully-ravine stream-edge-alluvial
b	Water-collecting (waterlogged) sites in depressions; gleysolic or organic soils; growing-season water table at ±30 cm depth	**09 Equisetum**	flat-depression stream-edge-alluvial

Appendix 6.4 Key to identification of the forested **ICHmk3** and **ICHmk3-SBSdw1** transition site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; site modifiers defined in Appendix 4.1

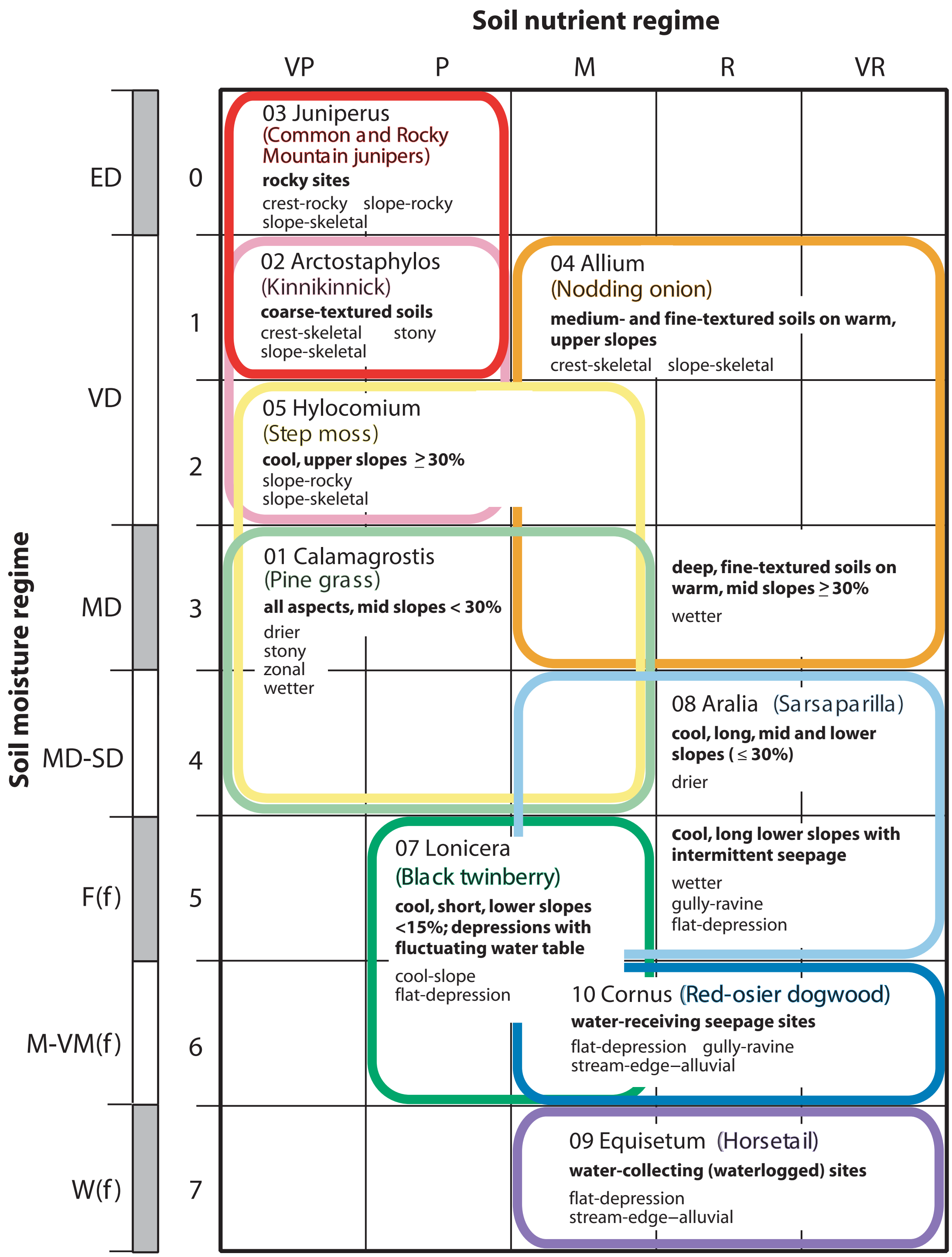
Landform Features	Site Series	Site Modifiers
Rocky Sites		
a Rock outcrops and adjacent, warm-slope cliffs and fragmental colluvial deposits; exposed bedrock on >35% of ground surface; soils very shallow (<30 cm) and discontinuous or fragmental	**02 Cladonia**	crest-rocky slope-rocky slope-skeletal
Water Shedding Sites		
a Crests or warm, upper slopes generally ≥30%; loamy-skeletal soils	**03 Chimaphila**	crest-skeletal slope-skeletal
Near-Zonal and Zonal Sites		
a flats and moderate mid-slopes (0 to <30%) or steep slopes (≥30%); neither water-shedding nor-water-enriched sites	**01 Ptilium**	drier warm-slope cool-slope zonal wetter
b **Mid, rich to very rich, warm** slopes generally <30% or lower, **medium to very rich, warm** slopes without intermittent seepage **predominantly within the ICHmk3-SBSdw1 transition**	**08 Rubus**	drier warm-slope
c **Mid, rich to very rich, cool** slopes **or lower,** medium to very rich, **cool** slopes without intermittent seepage **predominantly within the ICHmk3 variant**	**04 Gymnocarpium**	slope
Intermittent Seepage Sites		
a Weakly water-enriched, poor to medium sites on short, cool, lower slopes; or weakly water-collecting sites in shallow depressions or gullies; weakly to strongly mottled, stony soils; fluctuating water table; poor lateral drainage; **cold-air sites**	**05 Lonicera**	cool-slope flat-depression gully-ravine
b Weakly water-enriched, medium to very rich, intermittent seepage sites on long lower slopes and toe-slopes, on flats, or in gullies, **predominantly within the ICHmk3-SBSdw1 transition**; soils weakly mottled	**08 Rubus**	wetter gully-ravine flat-depression
c Weakly water-enriched, medium to very rich, intermittent seepage sites on long lower slopes and toe slopes, on flats, or in gullies, predominantly within the ICHmk3 variant; soils weakly mottled	**04 Gymnocarpium**	slope flat-depression gully-ravine
Water-Receiving and -Collecting Sites		
a Water-receiving (seepage) sites on flats and lower slopes, in gullies and ravines, and at stream-edge and alluvial sites; soils mottled; growing-season water table at ±60 cm depth	**06 Streptopus**	slope flat-depression gully-ravine stream-edge-alluvial
b Water-collecting (waterlogged) sites in depressions or along low gradient streams; gleysolic or organic soils; growing-season water table at ±30 cm depth	**07 Equisetum**	flat-depression stream-edge-alluvial

Appendix 7 Edatopic Grids for Each Zonal Unit

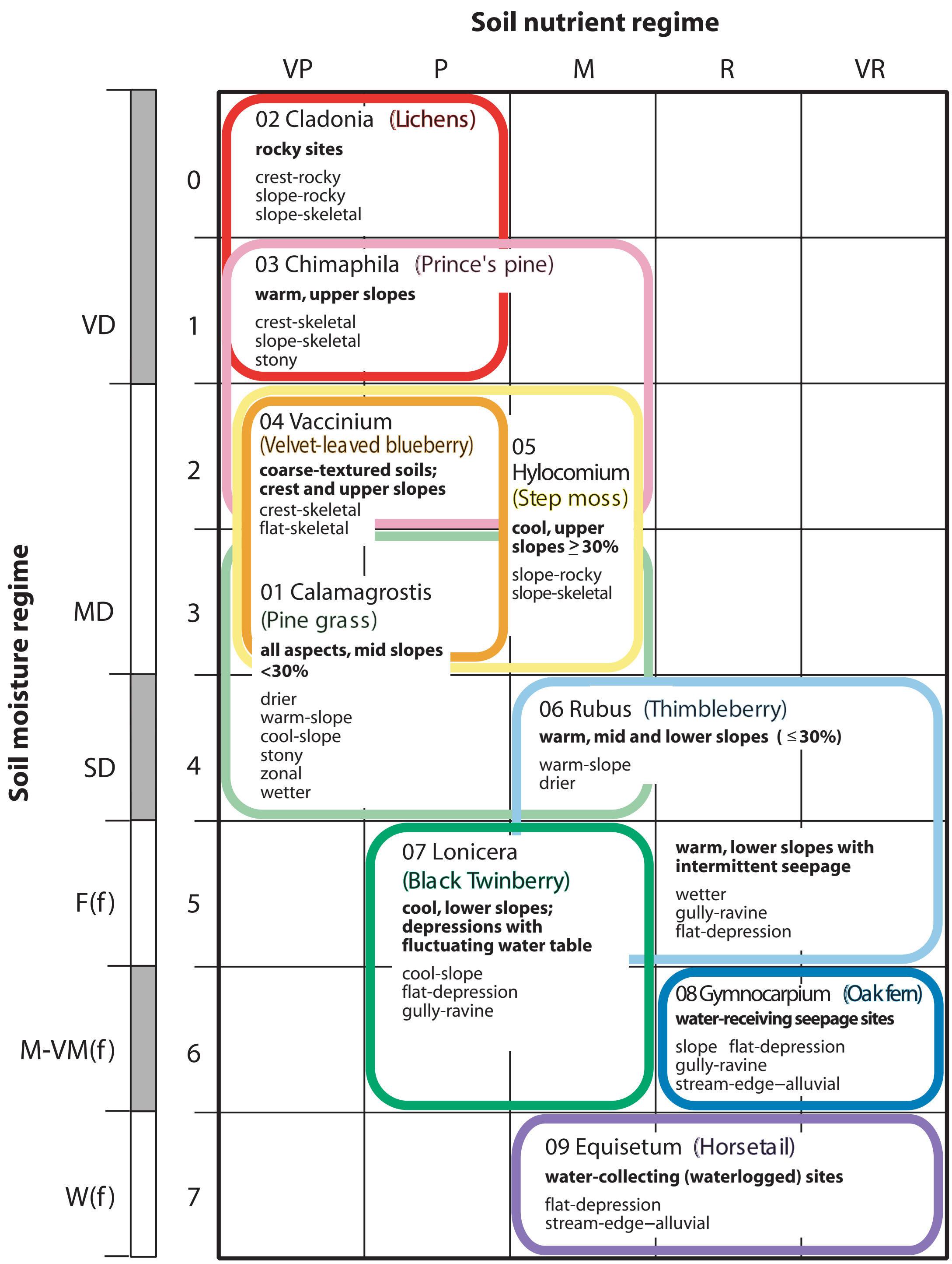
Appendix 7.1 Edatopic grid showing relations of the IDFxm and IDFxm-IDFdk3 transition site series to soil moisture and nutrient regimes. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2; modifier codes as in Appendix 4.



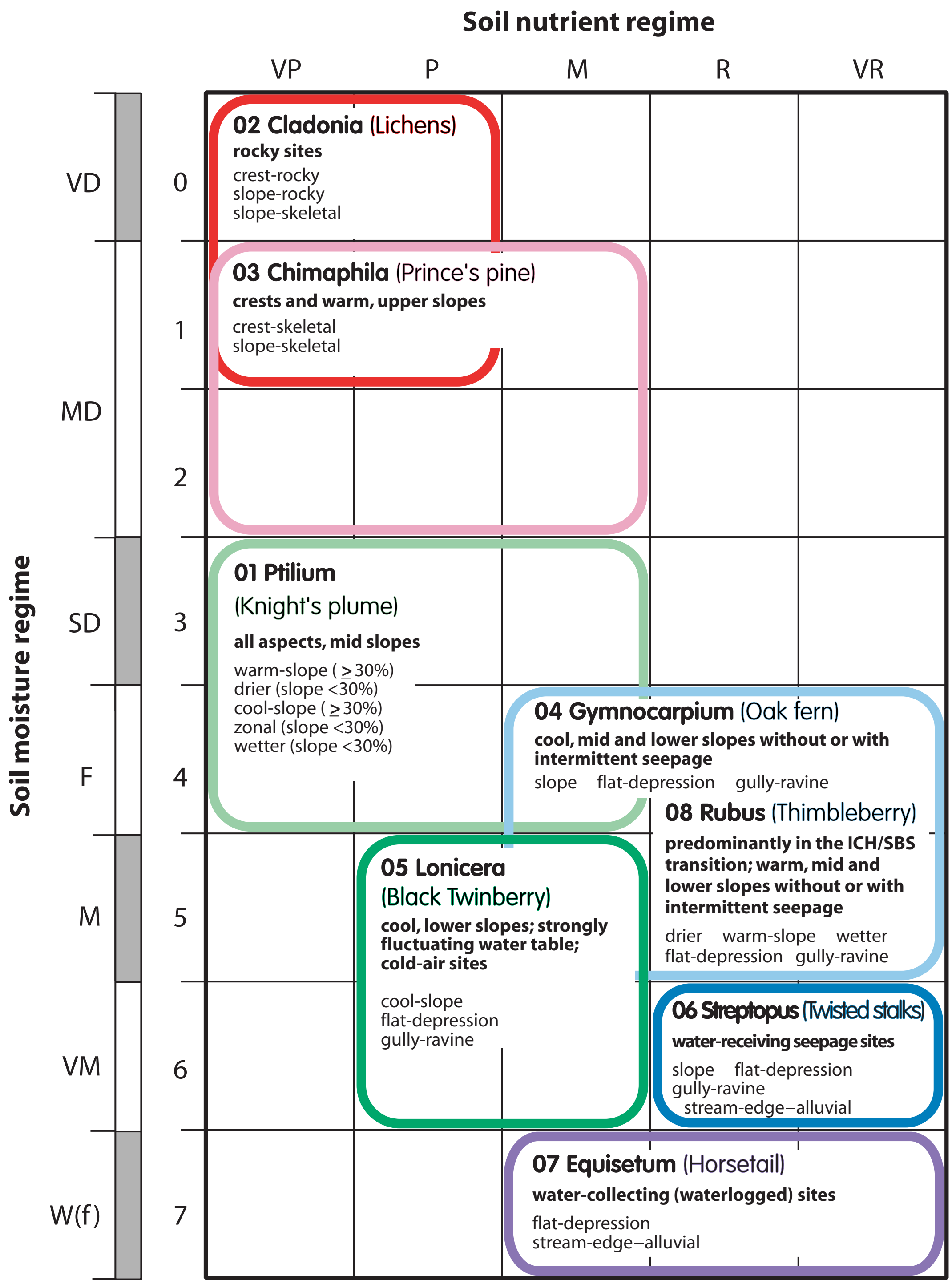
Appendix 7.2 Edatopic grid showing relations of the IDFdk3 and IDFdk3-SBPSmk transition site series to soil moisture and nutrient regimes. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2; modifier codes as in Appendix 4.



Appendix 7.3 Edatopic grid showing relations of the SBSdw1 site series to soil moisture and nutrient regimes. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2; modifier codes as in Appendix 4.



Appendix 7.4 Edatopic grid showing relations of the **ICHmk3** and **ICHmk3-SBSdw1 transition** site series to soil moisture and nutrient regimes. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2; modifier codes as in Appendix 4.



Appendix 8 Distinguishing Environmental Features for Site Series in Each Zonal Unit

Appendix 8.1 Distinguishing environmental features of the forested **IDFxm** and **IDFxm-IDFdk3** site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2.

Site series	Soil parent materials	Slope position-landform	Slope aspect	Slope gradient	Drainage regime	Soils	SMR & SNR	Distinguishing features	Occurrence & size
01 Calamagrostis	morainal	heights-of-land, mid-slopes	all aspects	level to <35%	near-zonal to zonal	loamy-skeletal	3 - 4 VP - M	near-zonal to zonal sites; Fd stands	very frequent large
02 Juniperus	bedrock, colluvium	crests, upper slopes	none, warm-slopes	level to ≥35%	water-shedding	discontinuous, very shallow or fragmental	0 - 1 VP - P	rocky sites; discontinuous, open-canopy Fd stands	infrequent small
03 Arctstaphylos	fluvial, morainal	flats, crests, upper slopes	none, warm-slopes	level to <35%	water-shedding	sandy-skeletal	1 - 2 VP - P	gravely or stony sites; low-productivity Fd stands	infrequent small
04 Allium	morainal, colluvium/ morainal	upper and mid-short slopes	warm-slopes	generally ≥35%	water-shedding	loamy-skeletal	1 - 3 M - VR	warm-slope sites, semi-open canopy, Fd stands	frequent intermediate
05 Hylocomium	bedrock, colluvium/ morainal	upper and mid-slopes	cool-slopes	generally ≥35%	water-shedding	shallow to deep, loamy-skeletal	2 - 4 VP - M	cool-slope sites, closed-canopy Fd stands	frequent intermediate
06 Oryzopsis	morainal	lower short slopes, depressions, gulies	none	variable	water-enriched to - receiving	deep, loamy-skeletal; weakly mottled	5 - 6 P - M	generally depression or gully sitessemi-open canopy Fd stands	infrequent small
07 Aralia	morainal; colluvium/ morainal	long, mid- and lower slopes, flats, depressions, gullies	generally cool-slopes	on mid-slopes Ò35%	mesic to water-enriched	loamy-skeletal; weakly mottled	4 - 5 M - VR	generally cool slope, water-enriched sites productive, closed-canopy Fd stands	frequent intermediate
08 Cornus	alluvial, lacustrine, morainal	flats, gullies, stream-edge, alluvial	none	generally level	water-receiving	loamy or silty; prominently mottled	6 M - VR	growing-season water table at ±60 cm depth; high-productivity Sx stands	infrequent small
09 Equisetum	alluvial, lacustrine, morainal	depressions, stream-edge, alluvial	none	generally level	water-collecting, waterlogged	loamy or silty; gleysolic	7 M - VR	growing-season water table at ±30 cm depth; open canopy Sx stands	infrequent small

Appendix 8.2 Distinguishing environmental features of the forested **IDFdk3** and **IDFdk3-SBPSmk** site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2.

Site series	Soil parent materials	Slope position-landfrom	Slope aspect	Slope gradient	Drainage regime	Soils	SMR & SNR	Distinguishing features	Occurrence & size
01 Calamagrostis	morainal	heights-of-land, mid-slopes	all aspects	level to <30%	near-zonal to zonal	loamy-skeletal	3 - 4 VP - M	near-zonal to zonal sites; Fd and Pl stands	very frequent large
02 Arctstaphylos	fluvial, morainal	flats, crests, upper slopes	none, warm-slopes	level to <30%	water-shedding	sandy-skeletal	1 - 2 VP - P	gravely or stony sites; low-productivity Fd stands	infrequent small
03 Juniperus	bedrock, colluvium	crests, upper slopes	none, warm-slopes	level to ≥30%	water-shedding	discontinuous, very shallow or fragmental	0 - 1 VP - P	rocky sites; discontinuous, open-canopy Fd stands	infrequent small
04* Allium	morainal, colluvium/ morainal	upper and mid-slopes	warm-slopes	generally ≥30%	water-shedding	loamy-skeletal to loamy	1 - 3 M - VR	warm-slope sites, semi-open canopy, Fd stands	frequent intermediate
05 Hylocomium	bedrock, colluvium / morainal	upper and mid-slopes	cool-slopes	generally ≥30%	water-shedding	shallow to deep, loamy-skeletal	2 - 4 VP - M	cool-slope sites, closed-canopy Fd stands	frequent intermediate
07 Lonicera	morainal	lower short slopes, shallow depressions	none, cool-slopes	level to <15%	water-enriched to -collecting	loamy-skeletal; weakly to strongly mottled	5 - 6 P - M	generally cold-air depressions; predominantly Pl, At, and Sx stands	infrequent small to intermediate
08 Aralia	morainal; colluvium/ morainal	long, mid- and lower slopes, flats, gullies	generally cool-slopes	on mid-slopes Ò 30%	mesic to water-enriched	deep, loamy-skeletal; weakly mottled	4 - 5 M - VR	generally cool slope, water-enriched sites productive Fd, At, Sx stands	frequent intermediate
09 Equisetum	alluvial, lacustrine, morainal	depressions, stream-edge, alluvial	none	generally level	water-collecting, waterlogged	loamy or silty; organic or gleysolic	7 M - VR	growing-season water table at ±30 cm depth; open canopy Sx stands	infrequent small
10 Cornus	alluvial, lacustrine, morainal	flats, gullies, stream-edge, alluvial	none	generally level	water-receiving	loamy or silty; prominently mottled	6 M - VR	growing-season water table at ±60 cm depth; high-productivity Sx, Ac stands	infrequent small

*The wetter variation of the 04 (Allium) site series represents 06 (Fd-Pinegrass-Aster) site series that has been combined with the 04 (Allium) site series.

Appendix 8.3 Distinguishing environmental features of the forested **SBSdw1** site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2.

Site series	Soil parent materials	Slope position-landform	Slope aspect	Slope gradient	Drainage regime	Soils	SMR & SNR	Distinguishing features	Occurrence & size
01 Calamagrostis	morainal	height-of-land, mid-slopes	all aspects	level to <30%	near-zonal to zonal	loamy-skeletal	3 - 4 VP - M	near-zonal to zonal sites; Fd, Pl, Sx stands	very frequent large
02 Cladonia	bedrock, colluvium	crests, upper slopes	none, warm-slopes	level to ≥30%	water-shedding	discontinuous, very shallow or fragmental	0 - 1 VP - P	rocky sites; discontinuous, open-canopy Fd/Pl stands	infrequent small to intermediate
03 Chimaphila	morainal, colluvium/ morainal	crests, upper slopes	none to warm-slopes	level to ≥30%	water-shedding	loamy-skeletal	1 - 2 VP - M	crests, warm-slope sites, low-productivity Fd, Pl stands	frequent small to intermediate
04 Vaccinium	morainal, fluvial	flats, crests	none	generally level	water-shedding	sandy-skeletal, loamy-skeletal	2 - 3 VP - P	generally gravelly or stony fluvial sites; Pl stands	infrequent small
05 Hylocomium	bedrock, colluvium / morainal	upper slopes	cool-slopes	≥30%	water-shedding	shallow to deep, loamy-skeletal	2 - 3 VP - M	cool-slope sites, closed-canopy Fd, Pl, Sx stands	infrequent intermediate
06 Rubus	morainal; colluvium/ morainal	long, mid- and lower slopes, flats, gullies	generally warm slopes	on mid-slopes Ò 30%	mesic to water-enriched	deep, loamy-skeletal; weakly mottled	4 - 5 M - VR	generally warm-slope, water-enriched sites productive Fd, At, Sx stands	frequent intermediate
07 Lonicera	morainal	lower slopes, flats, depressions	none to cool slopes	generally level	water-enriched to water-collecting	loamy-skeletal; (stony); weakly to strongly mottled	5 - 6 P - M	generally cold-air flats and depressions; Pl, At, and Sx stands	frequent small
08 Gymnocarpium	alluvial, lacustrine, morainal	lower slopes, flats, gullies, stream-edge, alluvial	none to variable	generally level	water-receiving; seepage sites	loamy or silty; strongly mottled	6 R - VR	growing-season water table at ±60 cm depth; high-productivity stands	infrequent small
09 Equisetum	alluvial, lacustrine, morainal	depressions, stream-edge, alluvial	none	generally level	water-collecting, waterlogged	loamy or silty; organic or gleysolic	7 M - VR	growing-season water table at ±30 cm depth; open canopy Sx stands	frequent small

Appendix 8.4 Distinguishing environmental features of the forested **ICHmk3 and ICHmk3-SBSdw1 transition** forested site series based predominantly on landform (topography and soil) features. Site series numerical codes and abbreviated names as in Table 6.3.1 and Table 6.3.2, respectively; colours as in Table 6.3.2.

Site series	Soil parent materials	Slope position-landform	Slope aspect	Slope gradient	Drainage regime	Soils	SMR & SNR	Distinguishing features	Occurrence & size
01 Ptilium	morainal, colluvium/ morainal	heights-of-land, mid-slopes	all aspects	level to ≥30%	near-zonal to zonal	loamy-skeletal	3 - 4 VP - M	near-zonal to zonal sites; Fd, Pl, Sx stands	very frequent large
02 Cladonia	bedrock, colluvium	crests, upper slopes	none, warm-slopes	level to ≥30%	water-shedding	discontinuous, very shallow or fragmental	0 - 1 VP - P	rocky sites; discontinuous, open-canopy Fd/Pl stands	infrequent small to intermediate
03 Chimaphila	morainal, colluvium/ morainal	crests, upper slopes	none, warm-slopes	level to ≥30%	water-shedding	sandy-skeletal,loamy -skeletal	1 - 2 VP - M	crests, warm-slope sites, low-productivity Fd, Pl stands	frequent small to intermediate
04 Gymnocarpium	morainal	mid- and lower slopes, flats, gullies	generally cool slopes	level to 30%	mesic to water-receiving	loamy-skeletal; weakly mottled	4 - 5 M - VR	generally cool-slopes, rich siteshigh-productivity Cw, Sx, Bl, (Fd) stands	frequent intermediate
05 Lonicera	morainal	lower slopes, flats, depressions	none, cool slopes,	level to <30%	water-receiving to water-collecting	loamy-skeletal; (stony); weakly to strongly mottled	5 - 6 P - M	cold-air flats and depressions; predominantly Pl, At, and Sx stands	frequent small to intermediate
06 Streptopus	alluvial, lacustrine, morainal	lower slopes, flats, gullies, stream-edge, alluvial	variable	generally level	water-receiving	loamy or silty; strongly mottled	6 R - VR	growing-season water table at ±60 cm depth; high-productivity Cw, Sx, Bl, (Fd) stands	infrequent small
07 Equisetum	alluvial, lacustrine, morainal	depressions, stream-edge, alluvial	none	generally level	water-collecting, waterlogged	loamy or silty; organic or gleysolic	7 M - VR	growing-season water table at ±30 cm depth; open canopy Sx stands	frequent small
08 Rubus	morainal; colluvium/ morainal	mid- and lower slopes, flats, gullies	generally warm slopes	level to 30%	mesic to water-receiving enriched	deep, loamy-skeletal; weakly mottled	4 - 5 M - VR	generally warm-slopes, rich siteshigh-productivity Fd, Sx, Bl, (Cw) stands	frequent intermediate

Appendix 9 Foliar Data for Douglas-fir and Lodgepole Pine Stands

Appendix 9.1 Foliar nutrient concentrations and needle weight for **Douglas-fir** stands sampled in the Alex Fraser Research Forest.

Plot	Polygon	Site series	N %	P %	Ca %	Mg %	K %	S %	Cu ppm	Zn ppm	Fe ppm	Mn ppm	B ppm	Weight of 100 needles g
GF01	P008	ICHmk3/05fd	1.09	0.21	0.40	0.086	0.60	0.098	5	27	35	297	19	0.458
GF02	P005	ICHmk3/01zn	1.15	0.20	0.42	0.117	0.71	0.093	4	31	34	570	20	0.382
GF05	P155	ICHmk3/01zn	1.22	0.23	0.58	0.140	0.76	0.091	4	30	43	432	17	0.439
GF06	P132	ICHmk3/01zn	1.18	0.20	0.37	0.114	0.73	0.089	5	33	39	441	19	0.476
GF09	P337	ICHmk3/05fd	1.04	0.19	0.38	0.094	0.66	0.091	5	25	34	300	17	0.467
GF11	P038	ICHmk3/01zn	1.26	0.24	0.52	0.108	0.86	0.095	4	34	36	325	13	0.393
GF18	S160	SBSdw1/01dr	1.30	0.22	0.36	0.110	0.90	0.101	4	29	36	287	11	0.334
GF19	S297	SBSdw1/03ck	1.02	0.17	0.22	0.082	0.72	0.077	4	21	29	486	12	0.301
GF21	S295	SBSdw1/01zn	1.17	0.21	0.38	0.101	0.80	0.098	4	28	35	543	11	0.336
GF42	S083	SBSdw1/03sk	1.27	0.21	0.31	0.088	0.92	0.093	6	28	34	136	20	0.417
GF43	S054	SBSdw1/01dr	1.29	0.22	0.29	0.100	0.92	0.099	4	22	41	129	20	0.334
GF56	P485	ICHmk3/06gr	1.34	0.25	0.36	0.094	0.75	0.105	5	18	34	226	16	0.370
GF57	P559	ICHmk3/06sl	1.15	0.21	0.48	0.086	0.83	0.106	6	18	31	526	16	0.320
GF58	P485	ICHmk3/01zn	1.34	0.23	0.44	0.096	0.84	0.115	5	21	38	130	14	0.435
GF59	P383	ICHmk3/01zn	1.23	0.24	0.53	0.103	0.90	0.102	5	26	37	214	17	0.430
GF66	S322	SBSdw1/01zn	1.26	0.22	0.37	0.106	0.87	0.100	4	29	35	573	13	0.254
GF67	S160	SBSdw1/01zn	1.15	0.21	0.44	0.094	0.79	0.087	6	24	30	445	5	0.306
KF26	614	IDFdk3/SBPSmk/01dr	1.02	0.21	0.44	0.092	0.62	0.082	4	28	32	769	20	0.399
KF29	602	IDFdk3/SBPSmk/01ny	1.22	0.19	0.37	0.110	0.73	0.091	4	23	32	505	22	0.436
KF30	402	IDFdk3/LD	1.33	0.22	0.34	0.103	0.89	0.096	4	26	34	183	28	0.472
KF32	402	IDFdk3/01dr	1.22	0.20	0.41	0.104	0.79	0.087	4	25	41	374	17	0.369
KF33	108	IDFxm/04sk	1.13	0.19	0.40	0.198	0.69	0.089	6	23	44	269	20	0.314
KF34	109	IDFxm/04sk	0.98	0.16	0.36	0.140	0.66	0.072	4	24	34	408	18	0.337
KF35	108	IDFxm/06gr	1.08	0.18	0.36	0.124	0.86	0.088	4	24	26	409	21	0.309
KF36	107	IDFxm/04ck	1.11	0.17	0.38	0.157	0.74	0.087	8	27	38	577	26	0.338
KF37	110	IDFxm/04ck	1.07	0.19	0.45	0.120	0.82	0.094	5	23	29	245	20	0.266
KF38	105	IDFxm/01dr	1.01	0.18	0.37	0.104	0.83	0.086	5	23	28	569	16	0.308
KF39	108	IDFxm/01zn	1.10	0.20	0.40	0.134	0.81	0.080	4	23	26	373	17	0.359
KF48	341	IDFdk3/01zn	1.10	0.18	0.35	0.112	0.73	0.086	4	21	27	369	16	0.268
KF49	345	IDFdk3/01zn	1.04	0.18	0.35	0.120	0.75	0.085	6	20	30	255	18	0.360
KF50	345	IDFdk3/07fd	1.20	0.20	0.39	0.137	0.86	0.105	8	18	41	266	23	1.396
KF51	218	IDFxm/IDFdk3/01zn	1.09	0.18	0.33	0.109	0.75	0.090	5	22	32	273	20	0.401
KF52	220	IDFxm/IDFdk3/04ck	0.93	0.15	0.31	0.093	0.72	0.078	5	22	28	350	11	0.241
KF53	217	IDFxm/IDFdk3/07gr	1.10	0.19	0.39	0.117	0.73	0.085	6	18	31	447	19	0.393
KF55	384	IDFdk3/01zn	1.12	0.20	0.39	0.116	0.83	0.098	5	26	35	193	15	0.341
KF60	105	IDFxm/01zn	1.12	0.19	0.39	0.153	0.81	0.098	5	27	30	293	19	0.273
KF61	108	IDFxm/01zn	1.15	0.19	0.38	0.113	0.79	0.090	4	26	25	425	20	0.348
KF62	108	IDFxm/01zn	1.15	0.19	0.35	0.113	0.85	0.088	4	25	27	396	12	0.293

Appendix 9.2 Foliar nutrient concentrations and needle weight for **lodgepole pine** stands sampled in the Alex Fraser Research Forest.

Plot	Polygon	Site series	N %	P %	Ca %	Mg %	K %	S %	Cu ppm	Zn ppm	Fe ppm	Mn ppm	B ppm	Weight of 100 needles g
GF03	P154	ICHmk3/07fd	1.21	0.13	0.12	0.091	0.46	0.086	4	41	31	77	12	1.525
GF04	P150	ICHmk3/01wt	1.32	0.14	0.10	0.070	0.60	0.092	5	45	32	132	12	2.023
GF07	P104	ICHmk3/06fd	1.19	0.14	0.20	0.097	0.48	0.080	4	48	28	135	11	1.856
GF08	P038	ICHmk3/01wt	1.23	0.13	0.14	0.071	0.44	0.082	4	41	27	145	10	1.914
GF10	P038	ICHmk3/01zn	1.20	0.14	0.16	0.085	0.56	0.087	4	46	37	166	12	1.858
GF12	S144	SBSdw1/01dr	1.10	0.13	0.18	0.090	0.42	0.075	4	40	24	140	10	1.502
GF14	S147	SBSdw1/07fd	1.03	0.12	0.22	0.107	0.36	0.080	5	61	26	67	19	1.391
GF15	S148	SBSdw1/01ny	1.09	0.12	0.12	0.077	0.42	0.084	4	4	23	57	15	1.594
GF16	S158	SBSdw1/07fd	1.15	0.13	0.18	0.113	0.40	0.090	6	47	33	60	18	1.758
GF17	S160	SBSdw1/01zn	0.99	0.12	0.20	0.089	0.39	0.081	4	46	25	315	10	1.312
GF20	S297	SBSdw1/03ck	1.14	0.16	0.13	0.081	0.43	0.089	7	47	40	317	16	0.782
GF22	S295	SBSdw1/01dr	1.18	0.15	0.16	0.081	0.49	0.086	5	45	38	163	14	1.624
GF23	S292	SBSdw1/01cs	1.17	0.14	0.14	0.087	0.49	0.082	7	49	44	297	15	1.430
GF24	S293	SBSdw1/01dr	0.88	0.13	0.14	0.080	0.50	0.083	4	44	33	357	16	1.290
GF40	S054	SBSdw1/01dr	1.18	0.12	0.13	0.074	0.47	0.080	4	41	24	69	19	1.561
GF41	S083	SBSdw1/03sk	1.24	0.14	0.13	0.084	0.48	0.093	5	45	38	103	15	1.057
GF44	S054	SBSdw1/01zn	1.18	0.14	0.14	0.089	0.48	0.093	4	43	28	112	21	1.312
GF45	S116	SBSdw1/03ck	1.15	0.16	0.15	0.087	0.48	0.085	4	45	26	162	17	0.887
GF46	S113	SBSdw1/01zn	0.99	0.11	0.11	0.070	0.32	0.082	4	46	24	198	15	1.448
GF47	S190	SBSdw1/03sk	1.05	0.13	0.15	0.084	0.42	0.080	6	44	29	180	15	1.393
GF64	P412	ICHmk3/01zn	1.41	0.16	0.14	0.102	0.56	0.111	4	44	33	162	13	1.594
GF65	P038	ICHmk3/01zn	1.32	0.16	0.15	0.075	0.54	0.094	6	51	34	142	13	1.784
KF25	614	IDFdk3/SBPSmk/01dr	1.01	0.12	0.16	0.099	0.40	0.080	4	45	28	135	13	1.351
KF27	614	IDFdk3/SBPSmk/07fd	1.22	0.14	0.15	0.112	0.48	0.087	5	41	27	186	15	1.229
KF28	602	IDFdk3/SBPSmk/01dr	1.14	0.14	0.18	0.112	0.46	0.084	4	55	23	147	19	1.316
KF31	402	IDFdk3/01dr	1.13	0.13	0.14	0.105	0.46	0.085	5	42	25	159	14	1.358
KF54	384	IDFdk3/01zn	1.11	0.13	0.19	0.132	0.44	0.088	4	50	26	188	13	0.998
KF63	397	IDFdk3/01zn	1.05	0.13	0.17	0.101	0.38	0.081	5	45	28	199	14	0.843

Appendix 10 Interpretations of Foliar Data for Douglas-fir and Lodgepole Pine Stands

Appendix 10.1 Interpretation of nitrogen, phosphorus, magnesium, and potassium status for **Douglas-fir stands** in the Alex Fraser Research Forest. For foliar nutrients see Appendix 9.1.

Plot	Polygon	Site series	N	P	Mg	K
GF01	P008	ICHmk3/05fd	Severly deficient	Adequate	Possible slight-moderate deficiency	Moderate-severe deficiency
GF02	P005	ICHmk3/01zn	Severly deficient	Adequate	Little, if any deficiency	Moderate-severe deficiency
GF05	P155	ICHmk3/01zn	Severly deficient	Adequate	No deficiency	Slightly-moderately deficient
GF06	P132	ICHmk3/01zn	Severly deficient	Adequate	Little, if any deficiency	Moderate-severe deficiency
GF09	P337	ICHmk3/05fd	Very severly deficient	Adequate	Possible slight-moderate deficiency	Moderate-severe deficiency
GF11	P038	ICHmk3/01zn	Severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient
GF18	S160	SBSdw1/01dr	Severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient
GF19	S297	SBSdw1/03ck	Very severly deficient	Adequate	Possible slight-moderate deficiency	Moderate-severe deficiency
GF21	S295	SBSdw1/01zn	Severly deficient	Adequate	Little, if any deficiency	Slightly-moderately deficient
GF42	S083	SBSdw1/03sk	Severly deficient	Adequate	Possible slight-moderate deficiency	Possibly slightly deficient
GF43	S054	SBSdw1/01dr	Severly deficient	Adequate	Possible slight-moderate deficiency	Possibly slightly deficient
GF56	P485	ICHmk3/06gr	Slight moderate deficiency	Adequate	Possible slight-moderate deficiency	Moderate-severe deficiency
GF57	P559	ICHmk3/06sl	Severly deficient	Adequate	Possible slight-moderate deficiency	Possibly slightly deficient
GF58	P485	ICHmk3/01zn	Slight moderate deficiency	Adequate	Possible slight-moderate deficiency	Possibly slightly deficient
GF59	P383	ICHmk3/01zn	Severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient
GF66	S322	SBSdw1/01zn	Severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient
GF67	S160	SBSdw1/01zn	Severly deficient	Adequate	Possible slight-moderate deficiency	Slightly-moderately deficient
KF26	614	IDFdk3/SBPSmk/01dr	Very severly deficient	Adequate	Possible slight-moderate deficiency	Moderate-severe deficiency
KF29	602	IDFdk3/SBPSmk/01ny	Severly deficient	Adequate	Little, if any deficiency	Moderate-severe deficiency
KF30	402	IDFdk3/LD	Slight moderate deficiency	Adequate	Little, if any deficiency	Possibly slightly deficient
KF32	402	IDFdk3/01dr	Severly deficient	Adequate	Little, if any deficiency	Slightly-moderately deficient
KF33	108	IDFxm/04sk	Severly deficient	Adequate	No deficiency	Moderate-severe deficiency
KF34	109	IDFxm/04sk	Very severly deficient	Adequate	No deficiency	Moderate-severe deficiency
KF35	108	IDFxm/06gr	Severly deficient	Adequate	No deficiency	Possibly slightly deficient
KF36	107	IDFxm/04ck	Severly deficient	Adequate	No deficiency	Moderate-severe deficiency
KF37	110	IDFxm/04ck	Severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient
KF38	105	IDFxm/01dr	Very severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient
KF39	108	IDFxm/01zn	Severly deficient	Adequate	No deficiency	Possibly slightly deficient
KF48	341	IDFdk3/01zn	Severly deficient	Adequate	Little, if any deficiency	Moderate-severe deficiency
KF49	345	IDFdk3/01zn	Very severly deficient	Adequate	Little, if any deficiency	Moderate-severe deficiency
KF50	345	IDFdk3/07fd	Severly deficient	Adequate	No deficiency	Possibly slightly deficient
KF51	218	IDFxm/IDFdk3/01zn	Severly deficient	Adequate	Little, if any deficiency	Moderate-severe deficiency
KF52	220	IDFxm/IDFdk3/04ck	Very severly deficient	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
KF53	217	IDFxm/IDFdk3/07gr	Severly deficient	Adequate	Little, if any deficiency	Moderate-severe deficiency
KF55	384	IDFdk3/01zn	Severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient
KF60	105	IDFxm/01zn	Severly deficient	Adequate	No deficiency	Possibly slightly deficient
KF61	108	IDFxm/01zn	Severly deficient	Adequate	Little, if any deficiency	Slightly-moderately deficient
KF62	108	IDFxm/01zn	Severly deficient	Adequate	Little, if any deficiency	Possibly slightly deficient

Appendix 10.2 Interpretation of nitrogen, phosphorus, magnesium, and potassium status for **lodgepole pine stands** in the Alex Fraser Research Forest. For foliar nutrients see Appendix 9.2.

Plot	Polygon	Site series	N	P	Mg	K
GF03	P154	ICHmk3/07fd	Slight moderate deficiency	Slightly deficient	Little, if any deficiency	Moderate-severe deficiency
GF04	P150	ICHmk3/01wt	Slight moderate deficiency	Slightly deficient	Moderate-severly deficient	Possibly slightly deficient
GF07	P104	ICHmk3/06fd	Severly deficient	Slightly deficient	Little, if any deficiency	Moderate-severe deficiency
GF08	P038	ICHmk3/01wt	Slight moderate deficiency	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF10	P038	ICHmk3/01zn	Severly deficient	Slightly deficient	Possible slight-moderate deficiency	Possibly slightly deficient
GF12	S144	SBSdw1/01dr	Severly deficient	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF14	S147	SBSdw1/07fd	Very severly deficient	Moderately deficient	No deficiency	Very severly deficient
GF15	S148	SBSdw1/01ny	Severly deficient	Moderately deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF16	S158	SBSdw1/07fd	Severly deficient	Slightly deficient	No deficiency	Very severly deficient
GF17	S160	SBSdw1/01zn	Very severly deficient	Moderately deficient	Possible slight-moderate deficiency	Very severly deficient
GF20	S297	SBSdw1/03ck	Severly deficient	Adequate	Possible slight-moderate deficiency	Moderate-severe deficiency
GF22	S295	SBSdw1/01dr	Severly deficient	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF23	S292	SBSdw1/01cs	Severly deficient	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF24	S293	SBSdw1/01dr	Very severly deficient	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF40	S054	SBSdw1/01dr	Severly deficient	Moderately deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF41	S083	SBSdw1/03sk	Slight moderate deficiency	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF44	S054	SBSdw1/01zn	Severly deficient	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF45	S116	SBSdw1/03ck	Severly deficient	Adequate	Possible slight-moderate deficiency	Moderate-severe deficiency
GF46	S113	SBSdw1/01zn	Very severly deficient	Moderately deficient	Moderate-severly deficient	Very severly deficient
GF47	S190	SBSdw1/03sk	Very severly deficient	Slightly deficient	Possible slight-moderate deficiency	Moderate-severe deficiency
GF64	P412	ICHmk3/01zn	Slight moderate deficiency	Adequate	No deficiency	Possibly slightly deficient
GF65	P038	ICHmk3/01zn	Slight moderate deficiency	Adequate	Possible slight-moderate deficiency	Slightly-moderately deficient
KF25	614	IDFdk3/SBPSmk/01dr	Very severly deficient	Moderately deficient	Little, if any deficiency	Very severly deficient
KF27	614	IDFdk3/SBPSmk/07fd	Slight moderate deficiency	Slightly deficient	No deficiency	Moderate-severe deficiency
KF28	602	IDFdk3/SBPSmk/01dr	Severly deficient	Slightly deficient	No deficiency	Moderate-severe deficiency
KF31	402	IDFdk3/01dr	Severly deficient	Slightly deficient	No deficiency	Moderate-severe deficiency
KF54	384	IDFdk3/01zn	Severly deficient	Slightly deficient	No deficiency	Moderate-severe deficiency
KF63	397	IDFdk3/01zn	Very severly deficient	Slightly deficient	No deficiency	Very severly deficient