Forest Site Classification in Canada

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This review deals with the development and present status of forest site classification in Canada. The presentation of theories and results closely follows the phraseology and terminology of individual authors without actual quotations. I have added my comments only to clarify situations or to suggest the relative merit of various approaches.

To facilitate personal correspondence, the appendix lists those authors who have been mentioned in this review and are still active in site classification, as well as the institutes and addresses where they are employed.

I wish to express my sincere appreciation to my colleagues Moss, A. N. Boissonneau, C. Fierpoint and J. R. M. Williams for their many constructive comments on earlier drafts of this review.

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With a few exceptions, only published reports are discussed here, although many others are in files of provincial and national government agencies and of private companies, and as theses in universities.

II. Studies emphasizing Ground Vegetation Types

A number of studies in site classification in various parts of Canada were initiated after Ilvesalo’s visit to North America in 1927 (Ilvesalo, 1929) and that of Kujula and Cajander, Jr. in 1931 to Canada (Kujula, 1945). Ilvesalo (1929) established a number of forest site types, using Cajander’s method and related height and diameter growth of some tree species to these types.

Ab-Yberg (1932) discussed the need and value of Cajander’s site classification for agriculture. For the Province of Quebec, he proposed four forest regions, subdivided into two zones and belts, and he recognized five major classes of forest site types (shrub, grass-herb, moist moss, wet moss and dry moss-fichen forest types), which could be further subdivided by crown density classes. Rousseau (1932) showed the relation of yield to some of Ab-Yberg’s major site classes, Bellefeuille (1932), working in greater detail, presented the first complete description of forest site types, named after the most frequent and abundant species.

At the Petawawa Forest Experiment Station in Ontario, Heimburger (1936) studied vegetation-soil relationships and recognized nine upland and four lowland forest types, using Cajander’s (1926) and Sukachev’s (1928, 1932) principles of classification which he had discussed in an earlier work (Heimburger, 1934). On the Lake Edward experimental area northeast of Montreal, Heimburger (1941) made a similar study in tolerant hardwood-spruce forests approaching the climax stage and occurring on shallow glacial till over bedrock. Under these relatively stable conditions he recognized four upland forest site types (C. R. G. O. R. A.)
Corpus, Viburnum-Oxalis and Viburnum) which were associated with four main cover types (conifer, conifer-broadleaf, broadleaf-conifer and broadleaved) and also with the four main physiographic site types (defined by depth of material and slope position)

At Pecawawa, Sivas (1938) found no close relationship between yield of pure stands of Populus tremuloides and Populus grandidentata of three age classes and Heimburger’s site types, although height-diameter curves for 60-year-old stands on four site types fell into two distinct groups. On the other hand, in more elaborate studies at Lake Edward, Ray (1943, 1956) found that 90% of the study area was covered by three of Heimburger’s four types and that yield, increment, height growth, species distribution and defect were well related to these site types.

Looke (1942 a, b; 1954) mapped Heimburger’s forest site types on aerial photographs by interpreting observable features on the photos such as cover type, crown density and topographic position, and by using knowledge of the location of the site types along slopes.

In second growth stands of Pseudotsuga menziesii in British Columbia, Washington and Oregon, Spilsbury and Smith (1947) recognized five plant associations (based on purely floristic characteristics) determined by Cajander’s methodology. They published curves showing height/age, volume/age, trees per acre/age and basal area/age relationships which are fairly distinct for the five associations studied.

In the montane and sub-alpine regions of British Columbia, Illingworth and Arlidge (1960) recognized nine forest site types in Pinus contorta and five types in Picea glauca-Abies lasiocarpa stands by the fluvial composition of the ground vegetation and named these types mainly after the "selective" species. Soil moisture and elevation were also described. These authors warned that a major disturbance in Pinus stands, e.g., by logging or fire, is followed by xerophyllumous and light demanding species which give the site the appearance of a type of lower productivity. They stressed, however, that the original site types can still be recognized by many characteristic elements of the ground vegetation which are retained, although with reduced vigour. Although significantly different relations among the types were found for height/age, volume/age, basal area/age and stems per acre/ D.B.H., the authors considered that their vegetation types were of greater importance as a guide to silviculture rather than as an indicator of site productivity.

Linteau (1953, 1955) extended Heimburger’s (1941) pioneering work over a much larger area, comprising the main watersheds of the boreal forests in the Province of Quebec north of the St. Lawrence River up to 52° N, between longitude 58° to 75° W. Linteau described ground vegetation...
types and associated soil and physiographic features and related these to heights of average dominant *Picea* and *Abies* trees, 50 years old. For each of the 18 ground-vegetation types, he listed the species, life form, combined estimate of abundance and cover, and sociability. These types were arranged in six groups, herb, herb moss, moss and dwarf shrub, peat moss and dwarf shrub, lichen and dwarf shrub. Each of these types occurs on one of seven moisture classes ranging from somewhat dry to wet which closely resemble Hills' (1950) moisture regime classes, being based on texture, structure, depth of gley and topographic position.

Linteau (1955) wondered how a knowledge of soil and physiography could add to his site classification by ground-vegetation types in cases of severe disturbance such as a fire. He expressed uncertainty about the value of physiography, by pointing out that different ground-vegetation types may occur on very similar combinations of soil permeability and moisture regime (as described by Hills, 1950) and that these vegetation types are associated with quite different forest cover types. He thus implied that physiographic types were not defined sufficiently narrowly to allow correlation with individual ground-vegetation types.

The answer would not be more narrowly defined physiographic classes, but instead, the recognition that vegetation development varies even within physiographic classes. The physiography, while creating environments which characterize the ecological events take place. Thus, any one physiographic site type, a number of cover types may occur depending on chance and stage of succession. Within the limits set by the physiography, the cover type has a profound influence on the type of ground-vegetation. The evaluation of physiographic types would lead to potential productivity classes, where ground-vegetation types could be considered potential productivity classes and silvicultural treatments classes.

For mapping ground-vegetation types on air photographs, Linteau considered a knowledge of landform desirable and a careful ground control necessary particularly for the better quality classes 1 and 11 on moraines and outwash. This ground control would thus seriously limit the advantage of using aerial photographs in mapping programs.

In a 31-year-old plantation of *Picea glauca* on old farmland, Gagnon and MacArthur (1959) found good relationships between three ground-vegetation types (*Calliergon, Calliergon-Polytrichum* and *Cladonia-Polytrichum*) and height growth, volume growth, basal area and survival. Hatcher (1961) used Linteau's (1955) site types in studies of northern vegetation, and of growth and yield of Abies balsamea and *Picea mariana*.

Lafond (1958, 1960, 1964) extended previous site classification studies by Heimburger and Linteau to include the boreal forest of the Province of Quebec up to approximately 55° N and also the forests of southern Quebec. In the boreal forest, Lafond (1964) found Cajander's method quite adequate for describing forest types. In southern Quebec he preferred Braun-Blanquet's approach because Cajander's methodology, in his opinion, did not sufficiently consider forest succession and because the flora in Quebec, particularly in the southern part, is richer than in Scandinavia.

Lafond's (1960, 1964) forest type is defined by the dominant tree species and characteristic ground-vegetation, and has a certain volume production of wood, rate of growth, origin and development which are important for forest inventory, management, silviculture and exploitation. His forest type is a practical unit does not necessarily pretend to correspond to natural units of plant sociology. Forest types with similar dominant tree composition have been grouped into associations, which seem to be major forest cover types.

Lafond's forest types do not include all the subassociation of a transitional stage as in Cajander's forest types. Instead, several types may occupy any one location at different times. For example, as a stand develops from a pioneer mixture of *Betula, Populus* and *Picea* to an almost pure stand of 120-year-old *Picea mariana*, the ground-vegetation type may change concurrently from an *Aralia-Cornus* type to the *Calliergon* type of the climax stand. All these types, however, have the same indicator value for productivity, namely, site class II. A ground fire can also change the ground-vegetation type, for example, under *Pinus banksiana* from a *Cladonia-Kalmia* type to a *Cladonia-Vaccinium* type.

Rinfret (1964) has discussed the mapping of Lafond's forest types on aerial photographs. He concluded that a knowledge of the distribution of geologic formations, surface deposits and species requirements is essential for photo interpretation. A number of plan-shots have been made in forests of southern Quebec with emphasis on application in forestry (Grandtnner, 1960; Lafond et al., 1964; Jardant and Roberge, 1965). They were based on somewhat modified methods of Braun-Blanquet rather than on Finnish methods and included soil descriptions, detailed information on growth and yield in relation to forest types, management and yield factors and silvicultural treatments and some maps.

Some forest ground-vegetation types in southern Quebec were arranged into a system by Grandtnner (1966), who used data from the literature and 244 of his own descriptions. Within the class of the deciduous and semi-deciduous forest (*Acereto-Quercetum americanae*) he dealt with two orders which occur on upland sites, namely, the *Acereto-silicietum* and the *Querceto-rubetum* which is not yet adequately described. Within these two orders he recognized three alliances and seven associations, three of which were further subdivided into nine sub-associations. The 13 groups of vegetation at the level of association or sub-association were related to soil types and microclimates. For each of these groups, descriptions are given of physiology, floristic composition, structure, place in the successional trend, soil characteristics, distribution and their value for forestry.

For the central part of the island of Newfoundland, Dammann (1964) developed a forest site classification useful for silviculture. Types were characterized primarily by vegetation. He described modifications of the *Zürich-Montpellier* School's methodology for application in the boreal forest. Many associations could not be defined in terms of characteristic species since it was impossible to test the fidelity of a species over a variety of sites. A much broader use was made of differential species in combination with characteristic species. He also used dominance of a few species, although he recognized that dominance can result from a sudden disturbance from which a species which is not dominant and dominant species often have a wide sociological amplitude. Further, Dammann pointed out that it will not add to the clarity of the distinction between vegetation units if, in order to stay in agreement with the original concepts of the *Zürich-Montpellier* School, differential and characteristic species are used to define these units when the dominance of another species is the primary and most obvious characteristic.

For two areas on the island of Newfoundland, Page (1970, 1970) found rather large variations in height growth and basal area of *Picea mariana* and *Abies balsamea* within many of the 22 forest types established by Dammann. Page concluded that for these areas, any site potential evaluation or capacity classification should take into account site factors such as drainage and exposure which affect forest growth.

Hustich (1949, 1950, 1951, 1957) explored the Labrador Peninsula and the Hudson Bay Lowlands and described vegetation types according to Cajander's (1926) principles. From south to north he recognized four main physiographic regions (Hustich, 1949), namely, northern spruce, tundra, forest tundra and taiga. Their vegetation types were then subdivided into 18 sections. He established 10 provisional forest types. His forest type was a group of forests which were floristically, ecologically and synthetically very sim-
III. Studies Emphasizing Physiography

A. The Ontario Classification System

The site classification system developed in the Ontario Department of Lands and Forests by Hills and his colleagues during the past 27 years is the most comprehensive one in Canada.

The purpose of the system is to describe, classify, and evaluate the potential productivity of land in the Province of Ontario. Initially, the system was oriented towards forestry, but it has been broadened to provide an ecological basis for land-use planning, including uses other than timber production.

A hierarchical taxonomic system has been developed in which physiographic characteristics of ecosystems are used as a stable framework within which the more variable soil profile and vegetation developments can be studied. Interpretation of aerial photographs is a vital technique in the mapping of often inaccessible parts of this province, which covers an area as large as France and Spain together. A system has been devised to rate the productive capability of taxonomic and of mapping units for various uses.

1. Taxonomic Classification

Forest and multiple land-use management deal with the growing of various "crops" on various kinds of land. It requires the management of an ecosystem, the whole local biological production system, which Hills (1953, 1954) has called "total site characteristics".

The general approach used in the classification of total site is based on the principle that, although site includes all environmental features, it may be classified by a single feature or by any combination of features (Hills, 1953). Since ecosystems are dynamic systems, phycographic features have been chosen to constitute the logical frame of reference, because these features remain most stable and most easily recognizable in a world of constant change (Hills, 1952). For universal use, three features have been chosen, namely, (i) ecoclimate regime (temperature and humidity), (ii) soil moisture regime, and (iii) nutrient regime (Hills, 1952, 1953). These features directly affect plant growth and were called "available features". Ecoclimate deals with the variations in the atmosphere of local areas between ground surface and tree tops. Soil moisture regime refers to the moisture supply during a complete vegetation cycle, and nutrient regime refers in a similar manner to available nutrients.

The three "potential features", which govern the limits of the three "available features" include relief (slope, aspect, relative mass elevation, relative position of local bodies of water and land masses), pore distribution pattern (combination of texture and structure of materials), and potentially effective chemical elements (mineral composition and weatherability of materials).

The relative levels of each of these features are estimated on an 11 digit scale covering the complete continuum from extremely low (0) to extremely high (9) as follows:

0 1 2 3 4 5 6 7 8 9

Thus, the moisture regime scale ranges from extremely dry (0) to saturated (9), in a manner similar to Bushnell's (1942) proposal for the soil catena. Pore pattern, formerly called permeability, ranges from extremely open (6) to extremely restricted (9). The 11 classes can be grouped into broad classes; for example, for moisture regimes: dry (0-2), moist (2-3), moist (4-5), and wet (7-9). Farrar (1962) discussed the use of factor gradients in the Ontario classification system.

As an important reference point in these continua, Hills (1945, 1950) applied the term "normal" as used by Mar-
Figure 2

The site regions of Ontario according to Hills (1960, revision in Pierpoint 1964)
THE CHARACTERISTIC FORESTS OF THE SITE REGIONS OF ONTARIO

THE MAJOR PHYSIOGRAPHIC SITE CLASSES

--- ECOCLIMATE ---

<table>
<thead>
<tr>
<th>HOTTER</th>
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<th>COLDER</th>
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<td>FRESH</td>
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--- SOIL ---

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<tr>
<td>Hudson Bay</td>
<td>E. hudsoniana - Poplar</td>
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<tr>
<td>2E James Bay</td>
<td>L. americanus - Birch</td>
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<tr>
<td>Lake Abitibi</td>
<td>B. spicata - Balsam</td>
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<tr>
<td>Lake Timagami</td>
<td>P. resinosa</td>
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<tr>
<td>Georgian Bay</td>
<td>B. lutea</td>
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<tr>
<td>Lakes Simcoe - Rideau</td>
<td>T. pilosula</td>
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<tr>
<td>Lakes Erie - Ontario</td>
<td>T. pilosula</td>
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<table>
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<td>3W Lake Nipigon</td>
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<td>4W Pigeon River</td>
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<th>Southwestern Ontario</th>
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<tr>
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<tr>
<td>4S Wasagama Lake</td>
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<tr>
<td>5S Lake of the Woods</td>
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</tbody>
</table>

Table 1 The characteristic forests of the site regions of Ontario according to Hills (1960; unpublished revision 1966).

Species characteristic of regional forests are hyphenated, e.g. OAK-HICKORY
Additional species are characteristic of specific sites.
but (1927) in his concept of normal soil profile development. Hills defined "normal" as a standard reference point instead of as an average of existing conditions or as the optimal condition. A "normal physiographic site" has a normal moisture regime, no forest cover, and normal ecoclimates. The primary landform reference of this is a gently undulating, well-drained loam with no significant deficiencies or excesses of nutrients and not exposed, protected or in a forest pocket. On such a site, vegetation development reflects most truly, or most strongly, the cold humid macro- or region climate. In the 11 digit scale, the normal for forest pattern, the loam is a 4, the normal for moisture regime is a 2 rather than a 4, because more classes were needed in the moist and wet part of the range. Later, however, when the dry part of the moisture scale needed further refinement, symbols such as 1, 1.5, 0, and 0 — were added (for example, Love and Williams, 1968).

On any one physiographic site, vegetation is not stable but develops from a pioneer stage through intermediate stages to a climax or least disturbed stage. The same pioneer vegetation type may occur over a considerable range of physiographic site types, whereas a climax vegetation has a more restricted range.

Since there must be a fitting of forest to physiographic sites, it is argued that neither physiographic site type nor biotic types can be established a priori, but that both groups of features must be classified concurrently. He considered this the key to the greater success, that is, usefulness of his proposed system of site classification compared to other systems. Forest types are often established a priori on the assumption that similar forests must have similar environmental conditions such an assumption does not take into account the compensation of factors. Hills maintains further that an a priori classification of climate, soil or landform is not adequate either since these are based on only one portion of the total productivity complex.

The above principles were used in the development of a hierarchical physiographic classification system comprising four levels, namely, site region, landscape, physiographic site type and site condition.

"Site regions" are regions within which specific plant successions occur upon specific landform positions. Or, conversely, similar landforms (relief and geologic materials) within different site regions will support different plant successions. This is a reflection of differences in regional climates (Hills and Pierpoint, 1960).

The distribution of sites in Ontario is based on the relationship between the most stable vegetation type on the normal physiographic site type and also on such relationships for eight important deviations from the normal (Fig. 2, Table 1). The nine physiographic classes are combinations of three soil moisture regime classes with three ecoclimatic classes (Hills, 1952, 1960 a, b, 1961). Thus site regions are not characterized merely by the presence or absence of species but by the physiographic niche in which species are found. Conceptually, the site region was developed from a soil region (Hills, 1945) and soil site region (Hills, 1950) to a site region based more fully on physiography-vegetation relationships. Initially, the more obvious effect of temperature was recognized (Hills, 1952), and later also the effect of precipitation (Hills, 1958, 1959 a, 1965).

A site region is an area in which similar responses may be expected from similar forest practices within similar combinations of forest type, ecoclimate and landform (Hills, 1958) and it is also considered to be a biological productivity region of specific potentials (Hills, 1961). These regions differ from the forest regions of Halliday (1937) and Rowe (1939) which are areal descriptions of present forest cover unrelated to landform positions. Continued reference to these forest regions as ecorions is considered unjustified (Hills, 1960 a).

A "landtype" is an actual area of land within a particular site region and is defined and named in terms of taxonomic classes of geologic materials which occur within the normal rooting depth of forest trees (Hills and Pierpoint, 1960). These geologic material classes have relatively narrow ranges in texture and petrography and are named after places where they have been recognized regionally near the type area. Such landtypes are limited only within a site region. An example of a landtype is Sherborne over Hemerly, being very low base (granitic) silty sand over very low base (granitic) bedrock in the specific site region 5 E (Fig. 2). To be useful for large areas, the texture and petrography classes are usually broader, than those based in occasional cations in agricultural soil surveys (Hills et al., 1970). This modern definition of landtype was developed from one mainly based on Vetch's (1957) concept, in which landtypes referred to a combination of topography and material representing any range of soil conditions which occurs repeatedly over an area (Hills and Morwick, 1944). Using this older definition, Brown (1953, 1956) showed the significance of landtypes for forest management including soil location.

The "physiographic site type" is a subdivision of the landtype and is defined by narrow ranges in (i) depth of geologic materials occurring in the rooting zone, (ii) soil moisture regime, and (iii) local climate (Hills and Pierpoint, 1960). An example of a physiographic site type is a dry shallow (30–100 cm) very low base silty sand over very low base bedrock with a normal macro-climate (Hills and Pierpoint, 1960). Physiography-vegetation relationships studied at this level provide the basis for the establishment of site regions and the classification of significant landtypes. This is the level of the ecosystem which the forester has to manage. This unit is used as a basis for rating potential productivity.

"Site condition", the fourth level of classification, refers to the upper soil horizons, particularly of the organic and raised organic mineral horizons (Hills et al., 1960; Hills and Pierpoint, 1960). Variations in site condition within any one physiographic site type reflect differences in history of forest growth and disturbances, and influence both the actual forest production and the competition of undesired vegetation during forest establishment (Hills and Pierpoint, 1960). Criteria for the classification of site condition have not yet been fully developed. Agricultural soil surveys which emphasize soil profile condition and soil genesis operate at the general level of site condition.

The biotic features of ecosystems include the forest cover types (tree species only) and groundvegetation types. The positions of forest cover types in successional trends have been studied in relation to physiographic site types (Hills et al., 1960; Pierpoint, 1962; Lynn and Zoltai, 1965). Groundvegetation is regarded as an indicator of site condition when considered in conjunction with physiographic site type and tree cover at a particular time. Groundvegetation thus aids in assessing the actual productivity and the effects which particular silvicultural treatments might have (Hills and Pierpoint, 1960). General descriptions of groundvegetation have been included in some studies (Hills et al., 1960; Pierpoint, 1962; Lynn and Zoltai, 1965). A short summary of the Ontario site classification system has also been given by Pierpoint (1964).

2. Site Mapping

The classification system provides the taxonomic units within which knowledge can be organized, but land areas are not always sufficiently homogeneous to allow for the mapping of single taxonomic units especially at small scales. A number of mapping units were therefore developed in the Ontario site classification system.

A "landtype component" is a pattern of physiographic site types within a landtype (Hills and Pierpoint, 1960; Hills, 1965). It is usually made up of a landtype and variations in moisture regime or depth over bedrock. They have been mapped at a scale of 1: 50 000 (Pierpoint, 1962; Lynn and Zoltai, 1965). At this scale the vegetation can be divided into "forest components" and the combination of physio-
graphic unit and forest unit is called the “ecological unit” which is of a size suitable for forestry operations.

“Landtype patterns” have been mapped at a scale of 1:125,000 (Burger, 1972) to show areal mosaics of landtypes. This scale is also suitable to map ranges in depth classes.

To provide an ecological basis for land-use planning at the community level without detailed mapping, two kinds of units were introduced to show patterns of physiographic sites at a scale of 1:125,000.

“Landunit” (Hills et al., 1970), initially introduced as landtype landscapes (Hills, 1963), are at least 10 square kilometers. Three or more of their many features are used for their mapping, namely, elevation, surface geology, and depth over bedrock. Each landunit is unique and is given a number to facilitate the separate listing of other features such as topography and bedrock, moisture pattern and profile development. The larger water bodies are mapped as “water units.”

The larger “landscape units” (Hills et al., 1970), comprising several “land units” and “water units,” are at least 40 square kilometers and must be large enough to support a local community or other community based on renewable resources. Each landscape unit is given a place name and detailed descriptions are made including social and economic considerations. These larger units are more suitable for regional planning for fish, wildlife, and recreation than the smaller land units.

Land classification maps showing land units and landscape units at a scale of 1:250,000 have been published by the Ontario Land Inventory of the Ontario Department of Lands and Forests for an area of about 252,000 square kilometers or about 60% of the more productive part of the province south of Site Regions 2 and 2. (See Fig. 2.)

A “site district” is a subdivision of a site region based on a characteristic pattern of physiographic features such as relief units of bedrock, parent materials, etc. (Hills, 1954, 1959). It has been used as a scale of 1:40,000 to 1:100,000.

The mapping program at all scales relies heavily on the interpretation of aerial photographs, based on a field knowledge of ecology, bedrock geology and the influence of glacial history on the distribution of parent soil materials (Burger, 1957, 1967).

3. Site Evaluation

The purpose of forest site evaluation is to rate (1) the potential forest production of each physiographic site type, and (2) the effort required to obtain the potential production (Hills and Pierpoint, 1960).

Because data on timber production for various physiographic sites are lacking, a comparative evaluation system of production classes from 1 (the best) to 5 (the poorest) has been employed. These classes may express for each tree species the relative gross marketable volume and the quality of dominant trees (Hills and Pierpoint, 1960) or any other suitable measure. The potential production of a physiographic site type refers to the best production of that species observed on a number of places belonging to that site type. Potential production does not refer to levels which might be reached by fertilization, drainage or other site improvement techniques.

The degree of effort required to obtain a desired crop depends upon the present competition potential, as governed by the type of forest present, the physiographic conditions, and the characteristics of the desired vegetation. The required effort is therefore evaluated within total site type or site district. The comparative scale of five classes has been established and can be defined later in terms of operations or costs when data become available (Hills and Pierpoint, 1960).

The production classes and degree of effort classes are integrated in a timber use capability rating either for individual tree species or for general forestry use (Hills and Pierpoint, 1960). Similar ratings can be made for other uses such as agriculture, wildlife, fish, recreation or multiple use (Hills et al., 1960; Hills, 1963). A relative scale for use capability rating from A (the best) to G (the poorest) may apply to various groups of crops but the criteria for placing physiographic land units in class A for agriculture differ somewhat from those used to designate class A land for timber or wildlife. The scale for rating in this interpretive classification are regional, not universal.

For purposes of land use planning, techniques have been developed to rate broad areas, such as land units and landscape units, for a number of crops and for multiple use; a three-letter map symbol indicates the proportionate distribution of use-capability classes for such areas (Hills, 1961). Forest use-capability maps have been published by the Ontario Land Inventory for the same area as the previously mentioned series of land classification maps.

B. Other Studies emphasizing Physiography

1. Taxonomic Classification

Louds (1962) used principles of the Ontario system for the recognition and descriptions of ecoregions in New Brunswick, Nova Scotia and Prince Edward Island. Differences in tree composition and groundvegetation of stable forests on similar physiographic site types — defined by texture, mineralogy of materials and relief — were used to recognize and characterize regions. His ecoregions, which is similar to Hills’ (1952) site region, although smaller, is a geographical unit within which ecological relationships between species and (physiographic) sites are essentially similar, and within which silvicultural treatments give comparable results. His ecoregions are not necessarily continuous, but often consist of several separate areas. Subdivisions of these ecoregions, called site districts, are similar to those used in Ontario. For broad comparisons, ecoregions were grouped into forest zones by dominant tree species.

Louds distinguished seven forest zones, namely, Acer saccharum-Fraxinus, Acer saccharum-Tsuga-Pinus, Acer saccharum-Betula alleghanensis-Abies, Picea rubens-Tsuga-Pinus, Picea-Abies coast, Abies-Pinus-Betula and Picea taiga, and a total of 13 ecoregions and 53 site districts. For each of these units, descriptions are given of forest cover, groundvegetation, soils, bedrock, topography and climate.

Ecologically-significant site regions have also been established tentatively for Manitoba and Saskatchewan (Zoltai et al., 1967). The thirteen regions are based on similarity in forest development and growth on similar sites and are a continuation of the site regions of Ontario (Hills, 1966 a).

Rowe (1962) maintained that the “site region” criterion — similar vegetation development on similar landform — does not seem definable in terms of its definition since it would imply climatic homogeneity. However, he considered the site region quite useful as a practical geographic unit. It should be pointed out that the recognition of a number of units within a continuum scale, for example, soil moisture or site regions, only sets limits to a range of conditions for each class or region but does not imply homogeneity.

For the description of forest-site relationships Lacate et al. (1965) subdivided the moisture regime classes on the basis of presence or absence of frozen ground at 30-150 cm depth.

In a review of forest land classification in Alberta, based mainly on unpublished reports, Duffy (1964 b) described various programs, all of which use some type of physiographic site classification and aerial photo interpretation. He concluded that in these exploratory studies an initial classification based on soil parent materials and soil drainage is adequate. Groundvegetation was not mentioned as a basis for site classification.
2. Site Mapping

For purposes of mapping, Loeve (1942b) established broad physiographic units for an area in Saskatchewan. For airphoto interpretation he provided a key in which broad cover types (coniferous, broadleaved and mixedwood) and related vegetation types were classified to map larger areas such as plateau, glacial slope, delta, lacustrine, lowland and fluvial.

Gimbarzevsky (1964, 1966) applied physiographic classification and mapping from aerial photographs for an area of 8000 km² in the Cordilleran and Interior Plains in Western Canada. The main objectives were to establish management units based on land capability, to delineate areas for summer and winter logging, to select highly productive sites for intensification of silvicultural practices and to classify soil engineering conditions for planning and construction of main forest roads. He discussed the use of small-scale photos (1:40,000 and 1:60,000) for mapping landforms and surficial geologic deposits and the use of large-scale photos (1:3560 or 1:15,840) for more detailed mapping of topography, moisture regime and depth to bedrock. Gimbarzevsky (1968) also demonstrated on a series of aerial photographs the technique of evaluating land capability for wood production as used in the Canada Land Inventory, which is discussed in a later section of this review.

In British Columbia, Lacate (1963) used the concepts of the hierarchical site classification system developed in Ontario by Willis and Pierpoint, 1951; Hills and Pierpoint, 1960 in combination with terminology of the Australian reconnaissance land survey (Christian, 1958). The latter was designed to deal with very large areas of land about which little or no scientific information was available and which has not any long-term traditional form of land use except hunting and gathering of native food. The Australian survey had little or no taxonomy of ecological types which establish mapping units, and instead recognized geomorphic units within which ecological relationships are described and land use, developmental possibilities and technical problems are assessed. For a research forest of about 40 km², Lacate used two of these Australian mapping units, namely, a "domain unit" and a "land association".

The smaller mapping unit used by Lacate (1963), the "land unit", is a relatively small segment of the land surface with characteristic topographic form and depth of parent material, with which are associated distinctive types of soils and vegetation. An example is a smooth upper slope composed of gravelly sandy loam eluvium being shallow over bedrock and dry. These units can be represented on air photos at scales 1:12,000 or 1:16,000. They are similar to Hills' physiographic site type in lack of description of ecolimics and perigrophy of parent material. To a limited extent, different vegetation and soil profile types can occur in the same type of land unit, either in different places at the same time or at the same place at different times due to modifications by fire, wind, soil creep, logging or development in the absence of such disturbances. However, Lacate (1966) later defined a "land unit" differently as a combination of a soil series and a vegetation type which has a specific physiographic position on a defined landform. Although Lacate still considered this land unit to correspond to Hills' physiographic site it actually resembles more Hills' total site type (Hills and Pierpoint, 1960) which is a combination of a physiographic site type, a vegetation type and the surface soil conditions.

Lacate's larger mapping unit, the "land association", is a mosaic of land units and may be recognized on the basis of characteristic topography, dominance of certain types of land units, parent material, depth over bedrock, etc. Airphotos at a scale of 1:60,000 are considered most suitable for point in the classification system. Lacate's larger mapping unit includes one or more soil ecoregions: the latter comprise a group of soils developed from one kind of parent material but which differ due to relief and drainage (Anonymous, 1951). Thus defined, this land association is comparable to the "land units" of Hills et al. (1970). In a later proposal, Lacate (1966) restricted a land association to an area of land composed of all units belonging to one class; this definition is similar to Hills' "landtype".

3. Site Evaluation

A number of quantitative studies have been made in which forest production has been related to physiographic site classes. In the boreal forest north of Lake Superior and in the northern Clay Belt of Ontario and Quebec, growth and yield of stands of Pinus banksiana, Picea mariana, Picea glauca, Abies balsamea, Betula papyrifera and Populus tremuloides have been related to groupings of soil moisture regime and parent soil (ponderosa pine groups) classes (Bedell and Maclean, 1952; Maclean and Bedell, 1955). For each grouping, species of ground vegetation were listed together with values for dominance, sociability and frequency.

In an extensive province-wide survey to obtain defect factors for the main commercial tree species in Ontario, Macawiski, Badlam and Turner (1958) claimed that, in general, moisture regime appeared to have a much greater effect on site index, especially Pinus banksiana and Picea mariana than in broadleaved species. In Pinus, percent defect decreased from dry (moisture regime 0) to somewhat fresh (1) to fresh (2-3). In Picea, defect was higher on dry and fresh sites than on moist and wet sites; the trend, however, showed little change between classes 0 and 1, more than compensated for the greater amount of defect.

In three site regions in northern Ontario, Chruscielicki (1963) studied height and diameter growth of Pinus banksiana 43 to 97 years old. Growth was well correlated with five soil moisture regime classes, three soil texture classes, two physiographic classes and three site regions.

A survey of coniferous forest stands and plantations of Pinus resinosa and Picea glauca on deep sands in Sine Region E in southern Ontario (Fig. 2). Love and Williams (1961) constructed yield tables for three potential production classes consisting of groupings of moisture regime classes, ranging from somewhat dry (10) to very moist (6) according to Hills' scale.

In addition to these studies which related tree growth to physiographic sites in Ontario and Quebec, a number of studies have been made in western Canada.

In Manitoba, Halliday (1953) found in a preliminary investigation on 17 sample plots a fairly good relationship between height and volume growth of Populus, Picea glauca, Picea mariana and Pinus banksiana and four forest site groups on a moisture gradient (meso-hygrophyte, mesophytic transition, mesophytic and mesophytic) and with growth in both classes. In a similar study in Saskatchewan of Pinus banksiana growth on six sites defined by pore pattern and moisture regime (Hills, 1950, 1952) and by cation exchange capacity of the B horizons as a measure of nutrient regime.

In Alberta, site productivity of very dense stands of Pinus contorta var. latifolia has been assessed by Smothers (1956). These stands, though growing on well-drained sites, have a tendency to stagnate at an early age with very limited annual growth, uniformly small crowns and little crown differentiation. Seven physiographic site types were recognized on the basis of moisture regime and kind and depth of parent soil mate-
rials. Basal area per acre was closely related to sites, but height was affected more by number of stems per acre than by site. In the lower foothills of the Rocky Mountains in Alberta, Horr and Lea (1961) studied habitat relationships, subvegetative characteristics and growth and yield of *Pinus ponderosa* within seven moisture regime classes. The relative importance of species of the groundvegetation was indicated by constancy classes. In an area of the mixedwood forest of Alberta, Duffy (1965) studied the growth of *Pinus glabra* on combinations of five moisture regime classes and eight parent materials from mollis land to clay loam and muskeg. The maximum dominant height yield of white spruce for this species at 80 years was better correlated with moisture regime than with the parent material types, the best spruce growing on well-drained sites.

4. Canada Land Inventory, a National Land Evaluation

The Canada Land Inventory is a cooperative program of the federal and provincial governments to assess land use capability for agriculture, forestry, recreation and wildlife, to describe present land use and to assess social and economic factors relative to land use (Canada Land Inventory, 1965). It deals with the "settled" areas of Canada, about 6.8 million km² of "agricultural" land and forested fringe area which affects the income and level of employment of rural residents (McCormack, 1966). The program is primarily an evaluation of productive capacities of the land, an interpretive classification without a basic taxonomic classification. This program has not dealt with large productive forest areas more remote from agricultural land areas. For rating the capability of land for forestry, seven classes were established, based on the capability to produce a certain species or group of species. Each class represents a range in productivity of well-stocked stands, based on the mean annual increment per acre to rotation age in gross merchantable volume to a minimum diameter of 10 cm exclusive of thinnings, bark and branch wood. This rating is given for the species which is best adapted to the site.

The mapping units delineated on aerial photographs follow the physical characteristics of the land. The mapping symbols do not describe the land features but rather the land capability. The capability rating of each unit is based on all known or inferred information about the unit, including subsoil, soil profile, depth, moisture, fertility, landform, climate and vegetation, but no consideration is given to location, access, distance to markets, size of unit, ownership, present uses, or possible improvements such as through fertilization or drainage (McCormack, 1967). It should be noted that the capability ratings also ignored the degree of effort needed to achieve potential production and are therefore similar to the original Ontario production classes instead of the Ontario capability classes. In addition to the capability class, the map symbol also registers the type of land feature which restricts growth, such as climate, soil moisture, depth of rooting zone, fertility, etc., and also one or two tree species on which the rating is based (McCormack, 1968).

For each province, general descriptions have been made of the range of climate and soils occurring within each capability class (McCormack, 1967). For Manitoba, Saskatchewan and Quebec (McCormack, 1967), and for Ontario (Boissonneault et al, 1969), the ranges of soils within a capability class have been described within site regions or ecoregions. The field work for this Canada Land Inventory terminated early in 1970 and map production is close to completion.

To handle the large amount of data (about 10,000 maps), a computer system is being developed. Maps at a scale of 1:1,500,000 are to be used for the computer storage and retrieval system, whereas maps at the 1:250,000 scale will be printed for publication (McCormack, 1966; Tomlinson, 1967; Rowe and McCormack, 1968).

IV. Agricultural Soil Surveys

Agricultural soil surveys are being conducted in Canada as part of programs of the federal and provincial governments, research councils and universities. The program is coordinated by the Canada Soil Survey Committee (Can. Dept., 1970). A brief outline of the principles of the agricultural soil classification and definitions of the units most relevant to our discussion is necessary.

The taxonomic soil classification system does not use an initial stratification based on climate — such as the site regions in Ontario — but it is based exclusively on soil profile characteristics, ranging from those which reflect major processes of soil formation at the level of the soil order (leptosols, podsol, etc.), great soil group and subgroup to those which influence local water and nutrient availability and tillage at the level of the soil series, type and phase.

The principal unit of soil classification is the soil series, which is a group of soils developed from a particular kind of parent material. A series is defined as a group of soils having the same number and arrangement of horizons, whose color, texture, structure, consistency, thickness, reaction and composition, or a combination of these are within a defined range. Soil series may be subdivided into soil types on the basis of significant variations in the properties of the plow layer (Can. Dept. Agr., 1970), usually texture of the surface soil. Each series is given a geographic name, usually taken from an area where it occurs most commonly. Each soil series usually represents a particular drainage class within a parent material type.

Some of the agricultural soil surveys included forested areas and some have been tested for forestry purposes. In an initial investigation of soils on 36 km² forested area in the mountains of Alberta with altitudes ranging from 1500 to 2600 m, Crowsey (1951) used the great soil group and subgroup as broad mapping units which were subdivided into calcareous and non-calcareous materials. Duffy (1962) investigated the usefulness of three soil series on heavy loam, silt loam and sandy loam for forest-uses evaluation. From a total of 13 plots, he found that dominant height and basal area of *Pinus contorta* was related to soil texture. To predict growth better, he recommended a subdivision of soil series by criteria which affect available soil moisture. In a later study, Duffy (1964a) established 158 plots on the same three parent materials and concluded from multiple regression analyses that mean height of ten dominant trees was the best single trait of productivity to be predicted with higher precision than basal area, total volume or merchantable volume. The important site factors were depth to free carbonate, slope position and slope grade, thickness of A₁ pH of the clay B horizon (B₁) and percent silt and clay of B₁, × thickness of B₁. In a soil survey report covering about 7700 km² in southeastern Mani toba (Smith et al., 1964), Jameson and Cayford rated the productivity and regeneration of 13 tree species on 36 soil series.

The concepts and principles of the agricultural soil surveys have also been assessed for forestry (Hills, 1958; Hills et al., 1970). Hills objected to the concept of the soil as an independent body and rather considered it as only a part of a larger productivity system. He noted that since soil profile characteristics and not parent material or climate are used to establish soil series, a specific series may be found in several climatic regions, owing to variations in combinations of parent materials, relief and vegetation compensating for differences in the regional climate. In his opinion, the use of great soil subgroups, such as brown forest or grey brown podsol, is not suitable, particularly on the artesian lands, coarse textured soils, since the genetic soil characteristics vary considerably over short distances. He proposed the need for establishing separate mapping and taxonomic units since many mapped areas (mapping units) are not a single soil type but patterns of types. Furthermore, for
forestry a knowledge of the water profile to a depth greater than the standard one meter soil auger is required.

In spite of these criticisms, Hills et al. (1970) considered the concept of different useful concepts in land classification to describe soil profiles within mapping units rather than to provide the mapping unit itself.

V. Studies combining several approaches

Analyses of groundvegetation, forest cover types, soils and physiography have been combined in various manners to classify land for a number of purposes.

In British Columbia, Krajina and his students studied ecosystems from the floristic and physiographic point of view. The basic phytoecosystem, an intrinsic part of the biosphere, should be defined to Krajina (1962) be presented as a plant association in the sense of the Zürich-Montpellier School, but liberated from the dogmatic requirements of the plant association. He further stated that the classification by plant communities becomes ecological only when biocoenoses are characterized not only by biont but also by their environment and especially by their soil characteristics. Krajina's (1933, 1934) methodology was modified in certain cases by Bell (1965) and Petersen (1965).

In British Columbia have been characterized by the climatic vegetation climax which develops on a mesic or xeric habitat (Krajina, 1965). This approach is similar to the establishment of site regions in Ontario, although Krajina's physiographic site is less well defined. Krajina (1959, 1965) recognized 11 zones, of which five were subdivided into a dry and wet subzone on the basis of precipitation; an alpine zone was subdivided into two alitudinal subzones. The 11 zones were grouped into seven "regions", according to Köppen's system. For each zone, region and subzone, Krajina provided data on climate, soil, tree cover and groundvegetation. No maps of these bioclimatic zones or regions have been published.

Within Krajina's subzones, Orloci (1965) distinguished "land types" (rock outcrop, glacial drift, flood plain, etc.), each of which can support a number of "plant associations" indicating gradients in soil moisture. Bell (1965) divided these plant associations into "forest types", which he defined as a plant-environmental ecosystem occupying a particular, often physiographically-defined portion of the land surface. Such forest types may be classified by the presence, absence or combination of one or more of the following: physiography, soil, age and soil moisture. Bell (1965) recognized as many as 40 soil types in the British Columbia coastal region. Each soil type is described by a number of properties, including its fertility, productivity, potential productivity, and the degree of effort required to obtain that productivity. The application of these ideas was demonstrated with a series of small maps (Jurdant, 1965b). He concluded that forest land classification and mapping with the aid of aerial photographs are possible only when relationships between soil and vegetation are systematically studied within a geomorphic framework and that a forest classification based solely on plant communities (either forest types or plant associations) is inadequate because they cannot be identified on air photos with a great deal of subjectivity.

A further combination and integration of physiography, soil, and vegetation is being attempted in an ambitious program called the bio-profile project by the Indian Forestry Service. The aim of this program is to classify ecologically-significant segments of the land surface, rapidly at a small scale, to satisfy the need for an initial overview of forest land and associated wildland resources and to serve as an ecological basis for land use planning. Extensive use of air photos is planned and emphasis is placed on the relationship between soil, vegetation and water (Lacate, 1966, 1969; Jurdant, 1968, 1969; Kowal and Runka, 1968). This program is separate from the national agricultural soil survey, but liaisons have been established. Jurdant (1968, 1969) recommended that the classification and mapping of vegetation of soil and of
physiography in such a bio-physical survey can be conducted concurrently by a team of specialists, not by separate mapping programs to be integrated at a later date. Furthermore, this will be factual and stable for a significant period of time, unaffected by change due to evaporation and they should include physiography, meaning texture, petrography and depth of the surficial geological materials, type of underlying bedrock, soil moisture regime and regional climate.

The latest proposals (Lacate, 1969) for this biophysical land classification include four levels of mapping, namely, land region (scale of 1:1,500,000 to 3,000,000); land district (1:500,000 to 1,000,000); land system (1:125,000 to 250,000); and land type (1:10,000 to 20,000).

The “land region” will be characterized by a distinctive regional climate as expressed by vegetation. Because climatic data are lacking and because it is not clear which climatic data are significant for various management uses, it is proposed (Lacate, 1969) that investigators rely on major physiographic formations to obtain a useful framework of regional differences. It will thus mainly be a geomorphological approach as in the Canadian reconnaissance land survey (Christian, 1958), without indicating how significant relations between vegetation and physiography will be used as indicators of regional climates. It seems that Hills’ approach as developed for Ontario and that of Krajina in British Columbia, in which normal sites and most stable vegetation, not just key species, could be well applied to many other regions, as has been shown by Louden (1962) and Zolotai et al. (1967).

The land region will be subdivided into “land districts” (Lacate, 1969), to be characterized by a distinctive pattern of relief, geology, geomorphology and associated regional vegetation as in Hills’ (1954) site districts.

Within each land district, “land systems” similar to the Australian land system (Christian, 1958) will be defined as areas with a recurring pattern of landforms, soils and vegetation. An example would be a rolling, shallow to flat, dry, low-lying gravelly mosaic of bedrock, characterized by Podzol soils and a Betula alleghaniensis-Alnus incana forest cover. The land system is the main unit proposed for mapping forest land (Lacate, 1969). Its physiographic components resemble Hills’ landscape unit.

The smallest unit, called the “landtype”, will be an area of land on a particular parent material with a combination of topography (corresponding to the series of agricultural soil surveys) and consequent vegetation. An example would be “a well-drained portion of a gravelly outwash terrace with an Orthic Dystric Brunisol supporting lodgepole pine — *Picea glauca* var. *piceaster* vegetation”. The landtype will be the basic unit for which specific use capability ratings will be made (Lacate, 1969). It thus seems similar to the total site type or the somewhat broader ecological unit used in Ontario (Hills and Pierpoint, 1960); the physiographic components of this “landtype” would be similar to Ontario’s “physiographic site type”. The landtype as used in Ontario has a broader meaning, at the level of a catena rather than of a soil series.

Pilot projects of this bio-physical land classification program are in progress in British Columbia, Manitoba, Quebec, Newfoundland and Nova Scotia (Lacate, 1969). Considerable effort will be required to obtain uniform application of concepts and terminology. For example, in a preliminary report (Jurdant et al., 1969), the concepts of land regions and land district have been applied to rather small areas.

Rowe (in Kowall and Runka, 1968) pointed out that the problem of integrating vegetation with the land inventory is difficult, because there is neither a generally accepted method of description nor a framework of vegetation classification in Canada and because the vegetation changes rapidly with disturbances, resulting in variable vegetation cover on essentially similar kinds of land.

It thus appears that the bio-physical classification may develop on a physiographic basis to cover large areas of land and that physiographic classes may be established on the basis of relations between physiography and vegetation. The fullest integration of physiography, soil, forest cover and groundvegetation is planned at the “landtype” level. It should be kept in mind that data on stand composition have already been collected in forest inventories which are revised every ten years in most areas in Canada.

VI. Summary and Conclusions

This review presents site classification in Canada as it developed from unrelated studies on small areas of land for the purpose of describing ecosystems and demonstrating their relevance for silviculture and timber production to large, well-organized provincial and nation-wide programs aimed at describing land and assessing its productive capacity for various uses including forestry.

A number of major trends have developed in site classification in Canada. In the first investigations, Phytosociological methods were applied, in attempts to show the relevance of “forest types” (groundvegetation types) as indicators of site productivity and as a basis for silviculture (Ab Yserb, 1952; Bellefeuille, 1932; Halliday, 1935; Heimburcher, 1936; Sisam, 1938). These investigations took place when foresters used only covertypes as a basis for silviculture operations. They were made for the boreal forests (Lafond, 1964), but in floristically richer areas such as southern Quebec, the Zürich-Montpellier methods proved more useful (Grandner, 1960; Lafond, 1964; Jurdant and Roberge, 1965). After the Second World War the technique of aerial photo interpretation became an important tool in forest site mapping and it became necessary to relate “forest types” to land use. Two methods were developed (Losee, 1942 a, 1954; Linten, 1955; Rains, 1964; Jurdant, 1964 a). In studies of groundvegetation types, the trend is now away from pure principles of plant sociology to more applied ecological classification, which includes physiographic and soil features (Kajtana, 1965; Lemeux, 1963; Dumoulin, 1964; Jurdant, 1964 b; Lafond, 1964). The plant ecological approach to forest site classification is still strongly developed in Quebec, particularly at Laval University.

In the meantime a physiographic site classification system was being developed in Ontario. Hills, who had worked on agricultural soil surveys (Hills and Morwick, 1944; Hills, Richards and Morwick, 1944) found their emphasis on soils alone inadequate for forestry purposes. He regarded soil as only one of the many more basic forest ecosystem. Groundvegetation was not suitable for province-wide mapping programs because of a lack of background knowledge and because of its unstable character. Instead, the physiography (soil and climate) was chosen as the basic framework for a taxonomic site classification system within which the more variable vegetation and surface soil characteristics could be fitted (Hills, 1950, 1953, 1958, 1960 a, b). The criteria for establishing physiographic units is based on ecological relationships, not merely on the occurrence of morphological landforms. A hierarchical classification was developed with four main levels of taxonomic units, namely, site regions, landtypes, physiographic site types and site conditions. For mapping purposes, mapping units were recognized by patterns of landform and vegetation. See several studies (Pierpoint, 1962; Hills, 1963; Lynn and Zolat, 1965). Extensive use is made of techniques of photo interpretation (Burg, 1957, 1967). The physiographic units proved useful for rating use capability comprising potential productive capacity and effort required to obtain that productivity. Scales were designed to rate capabilities of taxonomic and mapping units and combinations of the other single uses such as recreation, wildlife, agriculture and for multiple use (Hills and Pierpoint, 1960; Hills et al., 1960; Hills, 1961).
Various aspects of the physiographic site classification developed in Ontario were applied in a number of studies throughout Canada, such as the development of the region (Loudie, 1962; Zoltai et al., 1967), photo interpretation and mapping (Gimbarzevsky, 1964, 1966, 1968; Lacate, 1965) and site evaluation (Bedell and MacLean, 1952; Smithers, 1956; Morawski et al., 1958; Chriscelwicz, 1963; Jameson, 1963, 1964, 1965; Duffy, 1965). The technique of mapping “land units” and “landscape units” and rating their potential capabilities contributed substantially to the development of the Canada Land Inventory, a national-wide program of rating land capability in and around agricultural areas (Canada Land Inventory, 1965; McCormack, 1966).

The relative value of agricultural soil surveys has been discussed by a number of authors (Crossley, 1951; Hills, 1958; Hills et al., 1970; Duffy, 1962, 1964 a; Burger, 1967). Some objections deal with the concept of the soil as an independent body, the variability of genetic soil profile characteristics and their dependance on vegetation, the need to map patterns instead of single taxonomic units, the lack of emphasis on deeper layers in the soil profile, and the inadequate photo interpretation in mapping.

Methods based mainly on groundvegetation or physiography or soil have been combined in experiments in mapping of selected areas (Jurdant, 1964 b; Spilsbury et al., 1965; Sprout et al., 1966). The most recent development is the bio-physical land classification of the federal government in which physiography is used as the broad classification within which groundvegetation and soil types will be fitted (Lacate, 1966, 1969; Jurdant, 1968; 1969; Kowal and Runke, 1968). This program does not include Ontario where classification and mapping of physiography already cover about 60 % of the productive land area.

The value of the various approaches may be summarized as follows. The physiographic classification system is the most useful system to describe and map stable features of small as well as very large areas; aerial photo interpretation is a valuable technique. Physiographic units can be rated for their potential productivity. Groundvegetation types, soil series and soil phases are more variable, more dependent on development within the tree layer, and more closely related to actual production. The groundvegetation type in combination with a physiographic unit is particularly useful for silviculture as a treatment type and to rate actual production.

Following a synopsis of forest types and forest ecosystems (Fustich, 1960), a group of prominent Canadian researchers (Rowe et al., 1960) representing the various approaches of site classification agreed that a common platform for the different schools of forest site classification could and should be found. They agreed that a forest ecosystem is a geographic unit comprising forest organisms as well as the physiographic factors of soil and climate. Furthermore, the ecosystem provides an opportunity to focus attention on bio-physical relationships which influence its productive capacity. And finally, forest ecosystems should be studied within a geographic framework with due regard to regional differences to allow the development and application of general principles.

To be of optimum use to forest or land management in Canada, site classification should be based on a knowledge of ecological relationships, it should be useful for manipulating and evaluating the productivity of ecosystems, and it should provide the basis for making an inventory of the land resources. A clear distinction should thus be made between taxonomic units and mapping units. Reference areas should be chosen primarily to establish development of the concept and to add to the often very limited knowledge of vegetation-physiography relationships. The importance of quality wood production requires a better characterization of nutrient and moisture supply and requirements in ecosystems. The value of groundvegetation as indicators of these supplies requires studies on vegetation-soil-physiography (eco-system) relationships. The several groups active in site classification should agree on terminology.

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Br. — Branch
Chron. — Chronicle
Dep. — Department
Ed. — Editor
For. — Forestry, foresteriæ
J. — Journal
Prov. — Province
Publ. — Publication
Res. — Research
Silv. — Silviculture
Sci. — Science
Univ. — University


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