Trends in Forest Site and Land Classification in Canada

by

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Abstract

Classification trends during the past 60 years to serve different management needs are reviewed. These trends include the adaptation of European vegetation typology to Canadian conditions, the delineation of regions meaningful to forest management, the classification of forest ecosystems relevant to silviculture and of broader landscapes appropriate for integrated resource management and, finally, prime-site classification combining land features and technologic and socio-economic criteria to serve modern rationalization of management.

Key words: Site classification, land classification, ecosystem classification, vegetation typology, ecological regions, forest ecology, land use planning, Canada.

Résumé

Des tendances de classification pendant les soixantes années passées pour servir des besoins différentes de la gestion sont passées en revue. Celles y comprises l'adaptation de la typologie végétale Européenne, la délimitation des régions significatives pour la gestion forestière, la classification des écosystèmes pertinent pour la silviculture et des plus vaste territoires pour l'aménagement intégrée des ressources et, finalement, la classification des "prime-sites", combinant des facteurs du milieu avec des critères technologique et socio-économique pour servir la rationalization moderne de la gestion.

Mots-clés: Classification des sites, classification du territoire, classification des écosystèmes, typologie végétale, régions écologiques, écologie forestière, aménagement du territoire.

Introduction

Classification is a framework to organize and retrieve information. It allows us to see where a particular experience or item of knowledge is or is not applicable. In forestry, when deciding how to manage any specific piece of land, site classification helps us to consider experience and knowledge already gained from similar sites. Further, the framework can direct future research to any site type that is particularly important.

In Canada, site classification programs have developed to serve differing levels of forest land management under various jurisdictions across a very large nation embracing a very wide range of ecological conditions, usually with only a limited accessibility. Forest site classification in Canada was initially influenced by European work, especially that of plant sociologists and forest mensurationists. Quickly, however, developments in soil science and ecology from both Europe and North America were absorbed, and the concept of ecosystem as a complex of physical environmental features and the supported biota was embraced. New technology was introduced,

including airphoto and satellite image interpretation and data processing by computer. Burger (1972) reviewed Canadian site classification to that date. Here we acknowledge from that period only certain programs, especially the pioneer work of G. A. Hills (1902–1979) in Ontario and V. J. Krajina (1905–) in British Columbia, and we review more recent programs (with selected references), many of which rest largely on the foundations laid by these two men. There are strong similarities between the ecological concepts of Hills and Krajina. Initially, Krajina was a botanist and plant taxonomist; Hills was a soil scientist and soil surveyor. They approached the realm of ecology from different directions, but shared a feel for and belief in orderly classification coupled with substantial experience and observation of natural field conditions. Hills and Krajina have contributed much reasoning and discussion on tree species-site relationships, based on observation across huge natural areas. Wali (1988) and Jacobs (1979) have provided detailed tributes to these men.

Hills' school of site classification stressed the physiographic characteristics of ecosystems, since these are relatively stable and provide the basic control over vegetation development. Nonetheless, Hills' *total site type* embraced both the physiographic and biotic components of ecosystems (Hills and Pierpoint 1960) and later work in Ontario gives more attention quantitatively to the vegetation component (Jones

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V.J. Krajina

et al. 1983a,b). Krajina's school was always rigorous in the analysis of the vegetation component, to identify the local plant community and its place in the classification hierarchy. But the physiographic features of the ecosystem also were part of the classificatory criteria, and their importance in mapping interpretation was always acknowledged (Pojar *et al.* 1987).

The Adaptation of European Vegetation Approaches

Ground vegetation has been considered indicative of site quality. The Finnish school (Cajander 1926) bases "forest types" on species dominance, whereas the Zürich-Montpellier school (Braun-Blanquet 1932) uses fidelity and "characteristic" species for their "plant associations". Environmental description is added to the established type or association. Both approaches have been used and modified in Canada, with a notable trend towards considering vegetation as part of the criteria for an ecosystem classification rather than as the sole classification criterion.

Visits to Canada by Finnish scientists and their descriptions of forest types (Ilvessalo 1928, Kujula 1945) stimulated research, particularly in Quebec. Heimbürger recognized ground vegetation types, observed their close relationship with stand composition and landform position, and discussed growth and yield and logging effects on forest development within the types (Heimbürger 1941). Linteau (1955) extended such work in the boreal forests of northern Quebec, including more soil and physiographic features. To develop even more satisfactory forest site types, Lafond (1958) added tree species to the ground vegetation types and paid more attention to successional stage in his research northward.

Further south, in the floristically richer mixed tolerant hardwood-conifer forest of Quebec, Lafond *et al.* (1964) preferred the Zürich-Montpellier classification method, while Jurdant and Robèrge (1965) integrated this even more closely with soil and physiography into an ecosystem approach. In Newfoundland, Damman (1964) discussed modifications necessary when the Zürich-Montpellier method is applied in the boreal forest, notably the use of combinations of characteristic species rather than single species. For silvicultural purposes he used vegetation and soil profile characteristics as classificatory criteria, thus also moving towards an ecosystem approach, and evaluated the effect of logging and fire on vegetation stability and hence the typology. Damman (1979) discussed the different roles of vegetation in classification and mapping at various scales. Burger (1972) and Grandtner and Vauchamps (1982) give more detail about this earlier work.

Grandtner (1966) Grandtner and Vauchamps (1982) and his students continued classifying by Zürich-Montpellier methods in southern Québec. Numerous associations have been established, related to soil and relief, and complemented with studies of growth and airphoto interpretation. Such research has also been continued outside the university (Gagnon and Marcotte 1980, Majcèn *et al.* 1984).

The Regional Problem

Halliday (1937) delineated forest regions across Canada based on predominance of local forest cover types but without systematic regard to their physiographic position. Rowe (1959) recognized this limitation, but the terms of reference for his revision did not encompass any major conceptual change. Hills and Krajina each stressed the dependence of forest cover on climate, soil moisture and nutrients, and disturbance (i.e., seral stage) when establishing "site regions" in Ontario (Hills 1952, 1960) and "biogeoclimatic subzones" in British Columbia (Krajina 1959, 1965). Their regions are defined primarily by the most stable vegetation occurring on "normal" sites in Ontario and in "zonal ecosystems" in British Columbia, with further description in terms of the vegetation that develops on sites drier or wetter, hotter or colder than

normal. They are considered to be climatic regions effectively controlling forest development.

Loucks (1962) followed Hills' principles when delineating ecoregions in New Brunswick, Nova Scotia and Prince Edward Island, as did Zoltai *et al.* (1967) in Manitoba and Saskatchewan. Damman's (1983) ecoregions for the island of Newfoundland also exhibit relatively constant relationships between species and habitat. A recent group effort, based on the site region concept, produced a map (scale 1:7 000 000) for the whole land mass of Canada and descriptions of so called "ecoclimatic regions" (Ecoregions Working Group 1989). Site regions are being extended beyond Ontario into the USA (Burger 1976, 1989). Kojima (1980) applied Krajina's approach in southwestern Alberta to recognize seven biogeoclimatic zones. In westcentral Alberta, Corns and Annas (1986) delineated ecoregions having a distinctive, mature zonal ecosystem plus edaphic variations. These are similar to the regions of Strong and Leggat (1981) in Alberta, which were also recognized by the vegetation on "modal" sites. In Québec, Jurdant's ecological regions (Ducruc *et al.* 1976; Jurdant *et al.* 1977) reflect both macroclimate effect and characteristic patterns of physiography and geology, as do the regions of Thibault (1985). These regions are generally smaller than the site regions of adjoining Ontario, where distribution patterns of physiography or geology are not distinguishing criteria.

The national sub-committee on bio-physical land classification (Lacate 1969) proposed mapping "land regions", meant to be characterized by a distinctive regional climate as expressed by vegetation, but relying substantially on the recognition of major physiographic formations. The land region, later called "ecoregion", is the highest unit in the four-level bio-physical land classification (presented later). Such ecoregions have been published for Saskatchewan (Harris *et al.* 1983), the Atlantic provinces (Hirvonen 1984) and southern Québec (Thibault 1985) and even broader ecozones have been compiled for the whole of Canada (Wiken 1986).

In New Brunswick, Van Groenewoud (1984) used multivariate analysis of climatic data to establish ten climatic regions, intended as the first division in a forest site classification scheme. Later revision considered also bedrock types, physiographic formations and the vegetation on zonal sites to establish nine so-called "site regions" (Zelazny 1989).

Silviculture and Ecosystem Classification

Site classification based on the height/age relationship (site index) of the existing forest stand has been used in forecasting yield but it is inadequate for silvicultural purposes. At this level, Hills and Krajina each based his classification of ecosystems on selected physiographic and vegetation criteria that are related to soil moisture regime, soil nutrient regime, local climate and forest composition. Hills' techniques emphasized landform and soil features first, with vegetation addressed secondarily; Krajina's priorities were the reverse. We reiterate our opinion that these two pioneers were of one mind in the essential concepts of ecosystem classification. For concepts and techniques we refer you to the following publications for Hills (1950, 1960; Hills and Pierpoint 1960; Burger 1972) and for Krajina (1959, 1965; Pojar *et al.* 1987). Examples of forestry interpretations for Hills' site units in Ontario are Pierpoint (1962) and Lynn and Zoltai (1965) and for Krajina's units in British Columbia are Klinka and Feller (1984) and Klinka and Carter (1990).

A new forest ecosystem classification (FEC) was established in the boreal forest of northeastern Ontario to subdivide the mature natural forest into units for appropriate harvesting and regeneration procedures (Jones *et al.* 1983a,b). This work provided a more quantitative and rigorous analysis of these ecosystems than had hitherto been conducted by Hills' school, and led to a practical key for identifying each ecosystem. The key uses vegetation species first and, where necessary, soil second. Carlton *et al.* (1985) confirmed the indicator value of the vegetation. Some people interpreted this as a move away from Hills' concepts, but this is not the case. Descriptions of the ecosystem classes provide proper information for both the soil and the vegetation components (Jones *et al.* 1983b). Later FEC programs in Ontario cover the northcentral and northwestern parts of the province (Sims *et al.* 1989) and the pine forest of Algonquin Region (Merchant *et al.* 1989). Interpretations of some ecosystem types for silviculture and even as wildlife habitat have already been published (Pierpoint *et al.* 1984; Racey *et al.* 1989; Merchant *et al.* 1989). In Alberta, Corns and Annas (1986) classified ecosystem associations within their ecoregions mentioned earlier. The approach resembles that now in use in Ontario. The ecosystem associations have been interpreted for logging method, site preparation intensity, soil problems, reforestation, productivity, vegetation competition, windthrow and snowshoe hare damage hazard. Similarly in New Brunswick, the latest classification establishes "treatment units" defined by combinations of soil types and vegetation types (Zelazny 1989). There are between 8 and 15 such units per site region and each unit is rated for hazard (windthrow, soil compaction and erosion), natural regeneration of species, site index of species in natural stands and volume production for species in managed stands. In southern Manitoba, a new FEC (Knapik *et al.* 1988) identifies and names sites by their plant association and soil series within a regional framework. Productivity and management interpretations are provided for ecosystem types and specific site variables.

In the current program in Québec, a development of earlier work (Jurdant *et al.* 1977), ecological types are described in terms of physiographic features and vegetation, but with emphasis on tree species rather than subordinate species (Robert *et al.* 1989). The types are being mapped (scale 1:20 000) and interpreted for forest and wildlife management.

In Saskatchewan, forest inventory data from permanent sample plots were combined with soil texture and drainage information to describe 23 common forest ecosystem types, named after dominant tree and ground vegetation species (Kabzems *et al.* 1976). Growth and yield and suitable harvesting procedures for regeneration are discussed.

Integrated Management and Landscape Classification

Timber is only one of the crops considered in integrated resource management. The suitability of forest land in northern Ontario for agricultural development and other land use was investigated early by Hills (1942). Hills' group expanded research in the classification and evaluation of land for agriculture, forestry, wildlife and recreation. Criteria were developed for mapping land units and for evaluating their potential for these different uses, to provide an ecological basis for planning at the human community level (Hills 1961; Hills *et al.* 1970). This research taught administrators and managers that the fundamental resource is land, which can be managed for different uses and will provide different production levels depending on management input. It also

assisted in the development of the cooperative federal-provincial Canada Land Inventory (CLI).

The objectives of the CLI were 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 in the "agricultural" and "forested fringe" area (McCormack 1966). The CLI forest capability mapping units followed physical characteristics of the land, but these characteristics are not shown in a classificatory sense. The Ontario Land Inventory (OLI) was a provincial offshoot from CLI with more classificatory and evaluative detail of the type discussed later by Hills *et al.* (1970). The OLI provided the land resource information on which the provincial Strategic Land Use Plan was based. Meanwhile, in the CLI organization, work was conducted on a further classificatory method beyond simply the productivity ratings shown on the CLI maps (Kowal and Runka 1968). The purpose was to facilitate mapping segments of the land surface for broad land use planning for forestry, agriculture, recreation, wildlife and water yields (Lacate 1969; Jurdant *et al.* 1977). This bio-physical land classification included four levels, i.e., "land region" (discussed earlier), "land district" (e.g., Robitaille 1988), "land system" and "landtype". The land system level (scale 1 : 125 000) was considered the most appropriate for the broad planning (Ducruc and Bérube 1980). With the completion of CLI in 1972, cooperative work in land classification stopped (Thie 1977). However, in 1976 the Canadian Committee on Ecological (Bio-physical) Land Classification (CCELC) was established to encourage among federal and provincial agencies the development and application of a uniform classification approach for resource planning, management and environmental impact assessment (Thie 1977). To emphasize the ecological approach, the prefix "land" was replaced by "eco" in the terminology (Rowe 1979). The strong geomorphic bias remains. Proceedings of CCELC meetings report progress of projects across Canada (e.g., Rubec 1979; Stelfox and Ironside 1988).

Rationalization and Prime-Site Classification

Rational management decisions imply a consideration of alternatives, generally with an economic analysis because more than just the biological productivity of the land is involved. An early, simple example of such decision making, based on ecosystem classification, was provided by Hills and Pierpoint (1960) in Ontario. Since then, management planning techniques have become far more sophisticated and comprehensive, particularly with the advent of computer-based geographic information systems (GIS), but the application principles remain much the same.

A good Canadian example of a modern approach to rationalization is the prime-site management program in Ontario, aimed at the most advantageous allocation of limited management dollars. The primeness of each site (place) in the forest is equated to anticipated management benefit and costs. The prime-site classification involves two parts. First is the so-called prime-land classification based solely on physical land features that are related to productivity; this part is relatively simple and constant. Second is the consideration of a number of technologic and socio-economic criteria such as current forest stand conditions, treatment costs, location relative to transport corridors and mills, and market opportunities. This second part is much more complex and changeable; thus the prime-site classification will be modified, perhaps frequently, as circumstances dictate. Work started in the mid-70s in the Northeastern Region of Ontario

when a so-called "forest land productivity survey" was made. This embraced two concurrent components, i.e., a terrain-unit mapping program and a data collection program linking forest growth rates to specific soil conditions (Heikurinen and Kershaw 1986). For the mapped units, information on management cost and yield value was entered into an economic analysis that also considered location and market factors to provide management priorities (Teskey 1986). Later work, in the Northern Region, used existing soil and land surveys. The map units' boundary locations were digitized and loaded into a GIS data base. The units' original soil/land classes were reallocated to prime-land classification using an algorithm developed through comparison of the classifications' structure and criteria. Then new prime-land maps were drawn. A start has been made in moving from the prime-land classification to the prime-site classification, using the GIS technology and various forest planning models (Greenwood 1987).

Conclusion

Classification is only a means to an end. Jones (1989) gives a comprehensive discussion of requirements to be met if site classification, interpretation (including empirical models, process models, taxonomic models and expert systems) and geographic and land information systems are to lead effectively to forest management decision support systems. We believe that Canadian workers will continue to contribute significantly towards this goal.

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Membership Dues 1990-1991

	National Dues	Section Dues	
Active Membership			
1st and 2nd year after graduation (grad 1990, grad 1989)	\$ 77.00	AL \$8.00	NW \$10.00
Other new members for first year	\$ 77.00	CC \$8.00	OK \$5.00
Married or equivalent, second member only	\$ 77.00	CH \$8.00	OR \$7.00
All other active members	\$108.00	CO \$10.00	OV \$8.00
		CR \$8.00	PA \$8.00
		LW \$13.00	RM \$10.00
Other Memberships		MB \$7.00	SK \$10.00
Members having retired status, prior to 1990-91 who wish to receive the Forestry Chronicle	\$ 34.00	MR \$20.00	SN \$8.00
Members having retired status, prior to 1990-91, who do not wish to receive the Forestry Chronicle	\$ 0.00	ND \$10.00	SO \$30.00
Members granted retirement status subsequent to 1989-90	\$ 34.00	NO \$5.00	VA \$10.00
Student Members	\$ 34.00	NS \$10.00	VI \$5.00
Sustaining Individuals (CIF Members)	\$ 35.00		
Sustaining Corporate	\$225.00		

Upon written application, spousal members of Active Members, may have the dues of one of them reduced by an amount determined annually. Spousal members are members of the same Section who are living together as spouses and using the same mailing address.

The Institute year runs from July 1 to June 30. Applications dated after January 1 will be charged half dues for that Institute year. Applications dated after April 1 will be charged no dues for that Institute year.

Section dues are in addition and range from \$5.00 to \$30.00.