Suo 36 (2): 33—44, 1985

JOHN K. JEGLUM

THE STATUS OF PEATLAND SITE CLASSIFICATION FOR FORESTRY IN ONTARIO

METSÄTALOUDELLISEN SUOKASVUPAIKKALUOKITTELUN NYKYTILANNE ONTARIOSSA

Jeglum, J. K. 1985: The status of peatland site classification for forestry in Ontario, (Metsätaloudellisen suokasvupaikkaluokittelun nykytilanne Ontariossa). — Suo 36: 33—44, Helsinki.

Wetland site classification for forestry in Ontario is reviewed. The main units of a physiognomic-dominance scheme are portrayed in an environmental model, and research and inventory work using this approach is reviewed. Some common wetland terms used in Ontario are defined and discussed. The results of the Forest Ecosystem Classification (FEC) program are presented, for those operational groups that include peatland forests. Recent analyses of wooded peatlands in Ontario have revealed the relationships of the FEC types to the earlier defined wetland units. Some quantitative data are given to characterize tree growth, site, and vegetation. Recent silvicultural, remote sensing and inventory applications which utilize the main wetland units are reviewed.

J. K. Jeglum, Great Lakes Forest Research Centre, Canadian Forestry Service, P. O. Box 490, Sault Ste. Marie, Ontario, Canada P6A 5M7.

INTRODUCTION

The boreal forest region in northern Ontario has much in common with the boreal region that encompasses almost all of Finland. Both of these regions have cool summers and cold, snowy winters, bedrock controlled topographies, glacially created landforms, numerous lakes and rivers, and, of particular interest to peatland workers, abundant peatlands. Biologically there are many similarities, in terms of circumboreal genera and species of plants and animals.

The climate in boreal Ontario, as in Finland, favors accumulation of peat in the lower parts of the landscape which are wet and poorly drained. Heat sum and mean annual temperature range from 1350 degree-days and 2.0 degrees C at the southern edge of the boreal forest (Wawa), to about 650 degrees-days and —5.5 degrees C close to the tree line and Hudson Bay (Winsik). Annual precipitation ranges from about 500 mm in the northwest to about 800 mm in the eastern boreal of Ontario, with locally higher amounts associated with higher hills and bluffs in the southern part of the boreal. The climate is somewhat more continental in the north and west part of Ontario than it is in the most continental, eastern regions of Finland.

The objective of this paper is to report on the status of peatland and wetland classification for forestry in Ontario. Classifications are always purposive, and designed for certain needs. The main needs and uses of the forest manager are related to inventory and planning, harvesting and regeneration silviculture.

EARLY CLASSIFICATIONS FOR FORESTRY

The earliest peatland site classifications for forestry in Ontario were those developed by paper companies that had considerable amounts of forested peatlands on their limits. Spruce Falls Power and Paper Company, whose limits in the Clay Belt of northern Ontario include a high proportion of black spruce (*Picea mariana*)[1] dominated swamps, used peatland classes such as 'spruce slope', 'spruce flat', 'spruce swamp' and 'stagnant spruce' (Jeglum et al. 1983). This sequence is unidimensional, and has been interpreted by foresters as related primarily to the moisture gradient. However, each of these categories actually encompasses a range of nutrient conditions. Hence, this classification did not

[1] In this paper vascular plant nomenclature is according to Scoggan (1978/1979), and bryophytes according to Ireland et al. (1980).

distinguish very clearly differences that could be related to both of the two major gradients in wetlands — moisture and nutrient regime.

Forest site classification work was begun intensively by G. A. Hills in the early 1950s. He and his colleagues developed an approach that is called the Ontario Site Classification System (e.g., Hills 1960, Hills and Pierpoint 1960, Jones 1984). Although a holistic ecosystem approach was advocated, much of the work by Hills and his associates emphasized the physiographic features of the landscape. Not too much was produced on vegetational classifications, or on the detailed classification of peatlands or wetlands.

One exception to this was the classification work of MacLean and Bedell (1955), who used the Hills approach for the Northern Clay Belt. They recognized two general types of peatlands — 'wet swamp' and 'very wet swamp'. Also, a transitional type on slopes with peat usually less than 30 cm was recognized. The above types were for forested types only, and would encompass what are now termed 'transitional upland', 'swamp', 'treed bog', and some 'treed fen' (described in the next section). The primary emphasis was again on topographic location and the wetness of the soil, even though each of the types included a variety of soil types and inferred nutrient regimes (Fig. 2 in MacLean and Bedell 1955). These authors recognized also some vegetation types of wetlands, but these were not used as a basis for summarizing productivity information and they were not specifically recommended for management purposes.

There has been considerable influence on wetland classification in Ontario by Scandinavian workers. Many Finnish scientists have also visited and worked in Ontario (e.g. Kujala 1945, Hustich 1957, Kalela 1962a, 1962b, Ahti and Hepburn 1967), and have given stimulus for site work in Ontario which was and still is influenced by Cajanderian concepts. Sjörs (1961, 1963) carried out ecological studies in the Hudson Bay Lowland, and introduced the Swedish concepts and terms of 'ombrotrophic bog' and 'minerotrophic fen'.

PHYSIOGNOMIC-DOMINANCE CLASSIFICATION

The first comprehensive attempt to classify wetlands in Ontario with an orientation towards forestry uses was done by Jeglum et. al. (1974). Four main categories of wetlands were recognized — marsh, swamp, fen and bog — and defined using both biotic and abiotic features of the ecosystem (Jeglum et al. 1974, Zoltai et al. 1975). Subdivisions of the main units were based on physiognomy and dominance of the vegetation. Although some dominants of the field and ground layers were catalogued, no attempt was made at the time to define detailed floristic associations or indicators of various levels of nutrient regime.

The terms for the four main units were chosen by concensus as the most commonly used ones representing rather widespread units in Canada (Zoltai et al. 1975). 'Marsh' is similar to the 'reedswamp' of British usage. 'Swamp' is well established in North American literature for well-wooded, minerotrophic wetland. 'Fen' has been adopted from the influence of Sjörs (1961, 1963) in Ontario. 'Bog' is now used in the sense of ombrotrophic bog (Sjörs 1961, 1963), although initially a somewhat broader definition was used (Jeglum et al. 1974). There is a transition between open fen and well-forested swamp where it is sparsely or semi-forested. Often trees occur on mounds or hummocks slightly raised above the main mire surface. I have called this transition 'treed fen', comparable to the 'composite' Finnish types which are between their forested and open peatlands.

The physiognomic-dominance scheme was used as the basis for describing chemical contents in peat for a composite sample of the upper 50 cm (Stanek and Jeglum 1977). Although the lower units had relatively heterogeneous values, the analysis revealed some general relationships among the higher units of the classification.

The main units, and a few of the main physiognomic subdivisions of them, are portrayed in a simple environmental model (Fig. 1). In the model the main axes are moisture regime, and a complex factor gradient consisting of the trophic gradient and ending with flooding (*'luhta'*) influence. In the model one can recognize certain spatial sequences that are to be found in the landscape. One sequence found along open flowage systems and water courses is marsh — meadow marsh — thicket swamp — hardwood swamp. These types occur in areas of considerable fluctuation of water levels and flooding disturbances, and may or may not be underlayed by organic soils, depending on how recently they have originated, and how much mineral deposition or erosive influence there has been. Another moisture sequence is fen pool — open fen —

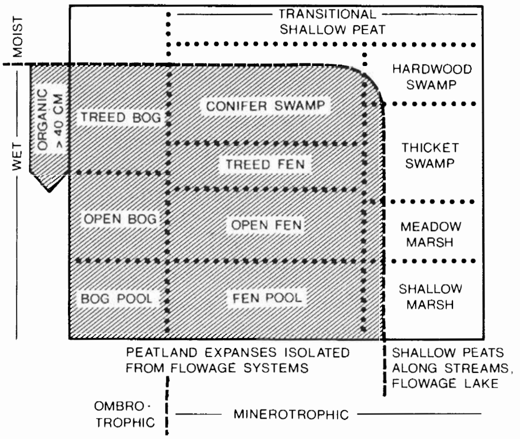

Fig. 1. A conceptual edaphic model of the main units of wetlands in Ontario.

Kuva 1. Ontarion märkien maiden pääryhmiä kuvaava käsitteellis-maaperällinen malli.

treed fen — conifer swamp. This is on minerotrophic sites, over organic soil. A third sequence is bog pool — open bog — treed bog, also over organic soil.

The physiognomic-dominance approach has been useful for standardizing, on a broad level, some main mire units and terms. In a general way these broad units are related to main gradients of moisture, trophic status, and the flooding effect (Fig. 1). Also, they are useful for air photo interpetation purposes, in which the general appearance of the vegetation provides the main basis for the images recorded.

The physiognomic-dominance approach has been used as the basic classification framework for ecological survey work in the coastal zone of the Hudson Bay Lowland (Jeglum and Cowell 1982, Sims et al. 1982a, 1982b, Wickware et al. 1980, 1984). It has also been used as the basis for interpreting wetland types from conventional air photos (Jeglum and Boissonneau 1977) and from satellite data (Boissonneau and Jeglum 1976; Pala 1983, 1984). A modification of this classification is being used in the peat inventory work being done in Ontario (Telford 1982).

TERMINOLOGICAL CONSIDERATIONS

'Wetland' is the term used in Canada by one group of scientists for land having the water table at, near, or above the ground surface (up to 2 m depth), or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soil, hydrophyllic vegetation, and various kinds of biological activity adapted to poorly aerated, wet environments (e.g., Tarnocai 1980). Another group of scientists uses the term mire, which includes shallow-peatland sites with 'peat-forming' plants. The wetland definition thus seems to encompass certain conditions where there is not enough peat depth yet to be peatland, but where peat-forming plants are not present or abundant, such as certain marshes and swamps. Thus, wetland is slightly broader than the concept 'mire'.

The occurrence of 'organic soil' is superimposed on the environmental model (Fig. 1), to conceptualize the relation of organic terrain and wetland. In Canada, organic soil as a material is defined as that which has 17 % or more carbon by weight (ca. 30 % organic matter) (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978). In order for a soil to be an organic soil, there must be at least 40 cm of organic material over mineral. This applies when the organic matter is moderately or highly decomposed (mesisol or humisol). However, when the organic matter is mainly poorly decomposed (fibrisol) then 60 cm depth is required. These are quite artificial limits which do not coincide with any natural ecosystem limits. They are similar to the 30 cm peat depth used in Finland as a practical limit for separating peatlands having shallow peats from those having deeper peats (e.g. KgR, and KgK, and KgRhK from true *räme* and *korpi* peatland types, Heikurainen and Pakarinen 1982). In Ontario the depth limit of 40 cm was accepted to conform with the current practice and usage of Canadian soil taxonomists. This approach contrasts with the practice in Finland and elsewhere to use the ecosystem to define mire, i.e., by the presence of peat-forming plants.

The Canadian concept of 'organic material' encompasses approximately the two terms favored by Andrejko et al. (1983) for organic rich material — 'carbonaceous' and 'peat'. These authors prefer to define 'peat' materials as having 75 % or more organic content (by a standard loss on ignition technique), 'carbonaceous' as having 25 to 75 % organic, and 'mineral' as having less than 25 % organic. These definitions suggest that one should be careful in using the terms 'peatland' and 'organic terrain', and that the latter is the broader concept encompassing both peat and carbonaceous deposits. In boreal regions, though, probably the majority of organic matter accumulation is peat, and it may make little difference if one uses peatland or organic terrain since they will in practice be almost equivalent.

An important contribution by the Ontario Site System is the moisture regime classification (Ontario Institute of Pedology 1978, Pierpoint 1978, Jones et al. 1983b). Moisture regime consists of 11 classes, grouped into 4 main moisture classes: dry (Θ); fresh (1, 2 and 3); moist (4, 5 and 6); and wet (7, 8 and 9). These classes have been recently defined in table form, in terms of soil texture and depth to mottles or to gley horizon in the soil profile (Ontario Institute of Pedology 1978, Jones et al. 1983b). In addition, the limit between mineral and organic soil, 40 cm of organic, has been chosen (Jones et al. 1983b) to separate moist (less than 40 cm) from wet (equal to or greater than 40 cm). Hence all organic soils are categorized as wet, and all mineral soils as moist, fresh or dry. This convention may not be too accurate in some cases. Certain organic soils may actually be moist or fresh, and certain mineral soils may actually be quite wet with water level close to or at the surface. Hence, the moisture regime system is the weakest in the wet organic and very moist transitional sites, and it differs with the definition of wetlands used by Tarnocai (1980). It may in fact be better to apply another system of moisture classification to wetlands based on the relative proportions of the hummock (dry), intermediate (moist), and flark (wet) levels (e.g., Eurola, Hicks, and Kaakinen 1984).

Fig. 2. A typical topographic sequence in the Clay Belt in the eastern mid-boreal, showing a clay ridge covered by trembling aspen (left) grading into black spruce on organic soil (right).

Kuva 2. Tyypillinen näkymä Clay Belt -alueen itäisestä keski-boreaalisesta osasta. Vasemmalla savikolla kasvava haavikko (Populus tremuloides) vaihettuu oikeanpuoleiseen eloperäisellä maalla kasvavaan mustakuusikkoon (Picea mariana).

FOREST ECOSYSTEM CLASSIFICATION

The most important recent classification work in Ontario for forestry is the Forest Ecosystem Classification (FEC) for the Clay Belt in the mid-boreal of eastern Ontario (Pierpoint 1981, Jeglum et al. 1983a, Jones et al. 1983a, 1983b, Jones 1984, Pierpoint et al. 1984). The purpose of this work was to provide a practical forest site classification for forest management in the Clay Belt. The classification encompassed both uplands and forested peatlands, represented in Figures 1 and 2.

The program was aimed specifically at the forest manager, and was carried out at the request of and in cooperation with the Northern Region of the Ministry of Natural Resources. The main requirements defined by this agency were that the classification serve current purposes and needs of practical field forestry, emphasizing regeneration silviculture; that it be simple and rapid to apply in the field; and that it consist of a limited number, e.g. 10 to 15, practical management-orientated groups. Early in the program, a thorough survey was conducted among all practicing foresters in the Clay Belt to determine their perceived needs and requirements, and what they felt to be important site factors and types. It was determined that managers were most interested in information pertaining to regeneration silviculture. They wanted the classification to help them to make decisions such as the appropriate cutting system, the most desirable season of harvest, the most suitable site preparation method following harvesting, the most suitable species and type of stock per type, the potential for using natural regeneration systems, anticipated tending requirements, and so on.

The classification was based on 250 forested stand samples, located on both mineral and organic soils, sampled intensively for vegetation, soils and site, less intensively for forest composition and growth. A TWINSPAN analysis (Hill 1979b) of the vegetation, using presence and absence only, was used to derive 23 vegetation types (VTs). Soils and site data were analyzed in various ways. Discriminant analyses were done for subsets of stands on mineral soil and organic soil. TWINSPAN was also used to derive a classification of 14 soil types (STs), but this was not an essential part of the classification.

It was decided at this point to merge the vegetational and site type data. Twenty-three VTs were too many for the practical operational groups. Hence, some of the VTs were combined if they had similar soils and vegetation. In other cases VTs were divided into two or sometimes three units, based on the selection of important boundaries of soil or site features found to be important in the discriminant analysis, important to some aspect of forest management, and easy to recognize in the field. In this way, 14 operational groups (OGs), two of which are rather poor and often unmerchantable, were recognized.

The classification features a key which can be used to key out a site in the field rapidly to one of the 23 VTs, and then to one of the 14 OGs. It is cautioned that the key should be applied only in forested sites in the Clay Belt; it may not be valid outside this biogeoclimatic area. It is also cautioned that the key does not always work optimally in its dichotomous splits, and there are misclassifications at certain levels of the divisions, particularly the higher level ones. Three reasons account for this: (1) To make it easy for the field man to use the key, only a maximum of seven species were allowed at any one division. (2) Only presence/absence data was used. (3) The data contained much heterogeneity, because it was for the whole range of upland and lowland forests. It is advised that after a VT has been keyed out, the actual stand be compared with the description for the type in the guide (Jones et al. 1983b) to check whether it fits. Nonetheless, the key does give a tool for identifying VTs and OGs, rapidly and relatively accurately, in the field. The main strength is that it gives the same identification no matter who uses it, so long as the user can identify all the diagnostic plant species and the diagnostic site features.

The OGs, VTs and STs have been described for some key vegetation and soil properties (Jones et al. 1983b). One of the methods for portraying variation of many of these properties was the DECORANA ordination (Hill 1979a). In this work it was the vegetational types which were ordinated. Schematic lines were drawn on the resulting two-dimensional ordination to show the grouping of types into OGs. Lines often passed through VTs, and this was because the soil boundaries that were used to separate OGs often subdivided the VTs.

One of the main boundaries chosen to subdivide VTs was the 40 cm depth of organic material (e.g., see Fig. 2). The VTs with less than 40 cm of organic, and on moist soils transitional between organic and fresh mineral soil sites, were grouped (Jones et al. 1983b) into one of three OGs:

1. OG8 **Feathermoss-sphagnum** -- "Black spruce-feathermoss *Sphagnum* on moist fine loamy-clayey soil with 20 to 39 cm organic matter." (see Fig. 3)
2. OG9 **Conifer-herb/moss rich** -- "Conifer mixed-herb rich on moist fine loamy-clayey."
3. OG10 **Hardwood-alnus** (*Alnus rugosa*) -- "Hardwood-*Alnus*-herb rich on moist fine loamy-clayey soils with thick black organic-mineral forest humus."

These units correspond to a sequence of increasing fertility, approximately the horizontal line of variation in moist forest across the top of Figure 1. They are roughly comparable, at least in the moistest levels (moisture class 6) to the KgR, RhKgK and LhK types of the Finnish system (Heikurainen and Pakarinen 1982).

The types with equal or greater than 40 cm depth of organic matter were in one of four OGs:

1. OG14 **Chamaedaphne** -- "Black spruce-*Chamaedaphne* on wet poorly decomposed organic soil with thick surface fibric horizon." (see Fig. 4)

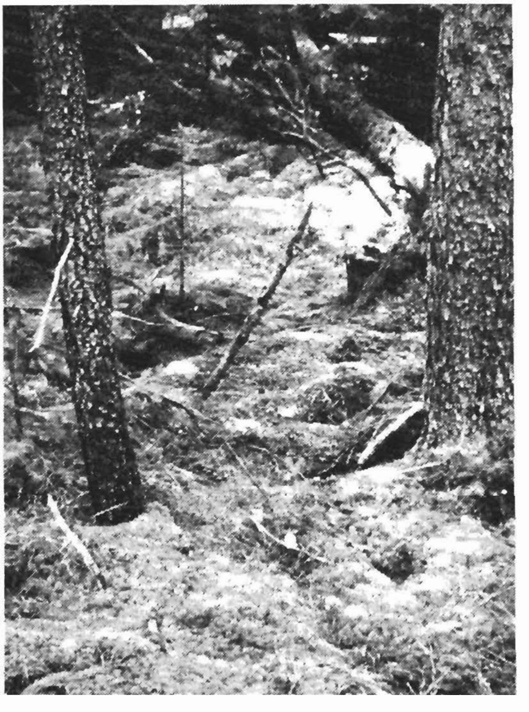

Fig. 3. OG8, FEATHERMOSS-SPHAGNUM, one of the more common transitional types in the Clay Belt, which has between 20 and 40 cm of organic.

Kuva 3. OG8 (seinäsammal — rahkasammal), yksi yleisimmistä vaihettumistyypeistä Clay Belt -alueella. Orgaanisen kerroksen paksuus 20—40 cm.

Fig. 4. Low shrub treed bog, one of the types included in OG14, CHAMAEDAPHNE, which is on 40 cm or more of organic.

Kuva 4. Vaiveroräme — eräs OG14 sisällytetty suotyyppi. Orgaanisen kerroksen paksuus yli 40 cm.

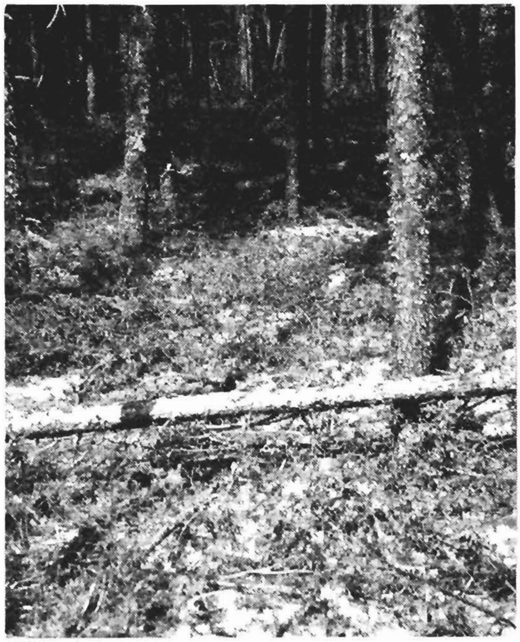

Fig. 5. OG11, LEDUM swamp, which is on 40 cm or more of organic.

Kuva 5. OG11 — suopursuräme — orgaanisen kerroksen paksuus yli 40 cm.

2. OG11 **Ledum** -- "Black spruce-*Ledum* on wet moderately decomposed organic soil with thick surface fibric horizon." (see Fig. 5)
3. OG12 **Alnus-herb poor** -- "Black spruce-*Alnus* herb poor on wet moderately decomposed organic soil with thick surface fibric horizon."
4. OG13 **Alnus-herb rich** -- "Black spruce and/or white cedar (*Thuja occidentalis*) /tamarack (*Larix laricina*)-*Alnus*- herb rich on wet well decomposed organic soil with thin surface fibric horizon." (Jones et al. 1983b) (Fig. 6)

These units correspond to the horizontal line of variation from treed bog to conifer swamp in Figure 1. They correlate with increasing fertility and are roughly comparable to the RaR, IR, KR, MK, RhK sequence of types of Heikurainen and Pakarinen (1982).

Fig. 6. OG13, ALNUS-HERB RICH swamp, which is on 40 cm or more of organic.

Kuva 6. OG13, suomalaista ravinteista nevakorpea vastaava suotyyppi (Alnus-Herb rich), jossa orgaanisen kerroksen paksuus yli 40 cm.

In the FEC data, no thicket swamps were sampled, even though they could be a productive type if they were drained and forested. As well, the FEC data contained some stands that could be regarded as treed fen (see Fig. 1). These fens, some of which were moderately rich, combined with treed bog types in the TWINSPAN classification, to make up OG14 (Jones et al. 1983b). Hence, the key to OG14 contains several indicators of moderately rich and poor fen conditions as well as poor treed bog species. This should be corrected, because moderately rich fens are more fertile than bogs, and warrant separation for forestry purposes.

Another problem with the FEC classification is that the VTs were made up of both mineral soil and peatland site types, in the VTs that split at the artificial limit of 40 cm of peat. This makes it difficult to understand the vegetational variation specifically within the organic soil segment.

Recently, I have combined the FEC organic soil data set with additional stands from other surveys in the Clay Belt. An analysis has been done of the wooded segment. This consisted of 95 stands which had more than 30 % cover of woody vegetation over 2 m tall. This criteria was chosen to delimit the 'drier' forested segment, to be comparable to the forested segment of the Finnish classification. A TWINSPAN classification (Hill 1979b) and DECORANA ordination (Hill 1979a) were done with standard default options.

A thorough description of the results is not in the scope of this paper. However, the orientation of the main units are portrayed in the DECORANA ordinaton (Figure 7). Across the top from left to right is the low shrub treed bog type of OG14, OG11, OG12, and OG13. The bottom sequence from left to right again begins with low shrub treed bog, and progresses in the following sequence:

1. Species poor treed fen (in OG14 of the original FEC key).
2. Species rich treed fen (in OG14 of the original FEC key).
3. Thicket and *Larix/Alnus* swamp (not sampled in the FEC data, but keying out to OG13 or OG12).

These units correspond to a sequence of increasing floristic richness in the Finnish system from ombrotrophic to eutrophic. It is difficult to say without more detailed classification of the Ontario material what vegetational types may be comparable in the Finnish system.

Some mean values for black spruce growth and site conditions are given for the main units of wooded peatlands (Table 1). The sequence of main swamp units from poor to rich shows, in general, increasing nutrient regime as indicated by increasing water pH, moist peat pH, and water calcium, and decreasing depth of the fibric layer (von Post 1 to 4). Site index increases in the same way. The sequence of treed fen to thicket shows similar trends. Although depth to groundwater is a very crude measure, being taken only at the time of sampling and representing the 'average' depth, nonetheless the top sequence has generally deeper depths than the bottom sequence.

Some quantitative values for selected species are presented for the main units in Table 2. In both the swamp and the treed fen-

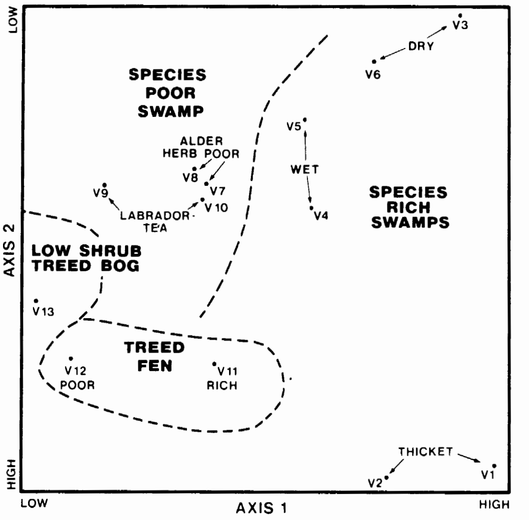

Fig. 7. A DECORANA ordination of the main vegetation types of wooded peatlands in the Clay Belt.

Kuva 7. Clay Belt -alueen metsäisten suotyyppien pääryhmien DECORANA-ordinaatio.

thicket sequence the mean number of species increases from species poor to species rich types. The species distribution patterns show a similar species rich condition, with many of the same preferential species, in **Alnus-herb rich** and in species rich treed fen. The analysis also showed floristic and quantitative differences between the main units — swamp, treed fen and treed bog.

The plan for the future is to more thoroughly characterize the wooded segment, the semiwooded segment, and the open wetlands in the Clay Belt. Similar detailed study of wetlands will be undertaken in other ecological regions. Already, a new FEC program has been initiated in the North Central Region of Ontario (Sims and Wickware 1984), and this will again include forested peatlands.

SILVICULTURAL APPLICATIONS OF THE PEATLAND SITE TYPES

The status of peatland forestry in Ontario has been more thoroughly considered elsewhere (Haavisto 1979, Jeglum et al. 1983). In this section I will consider recent applications using the FEC organic soil and transitional site OGs.

The OGs and VTs of FEC have been available for forestry use for about two years, and they have been already been used as the basis for classification in other inventory and research work. Thus far, the FEC has been used

Table 1. Mean values[a] for some black spruce growth and site measures — main units of wooded peatlands.

Taulukko 1. Muutamia keskimääräisiä metsäisten soiden pääryhmien kasvualustan tunnuksia ja mustakuusen kasvulukuja.

	SWAMP SEQUENCE				TREED FEN — THICKET		
	Poor ⟶ Rich				Poor ⟶ Rich		
FEC OG No.:	OG14	OG11	OG12	OG13	OG14	OG14	—
Name:	**Low Shrub Treed Bog**[b]	**Ledum**	**Alnus-Herb Poor**	**Alnus-Herb-Rich**	**Herb-Poor Treed Fen**[b]	**Herb-Rich Treed Fen**[b]	**Alnus Thicket, Larix/Alnus**
No. of plots	4	23	18	28	3	8	11
Site index, 50 years (m)[c]	2.0	3.9	5.1	4.9	2.0	4.7	5.8
Mean depth to ground-water (cm)	36	32	23	28	23	22	17
pH, groundwater	3.8	5.4	5.3	6.4	5.7	5.6	5.6
pH, moist-peat	3.4	4.1	4.6	6.2	5.2	4.5	5.0
Calcium, groundwater (mg/l)	4.1	10.8	6.9	16.8	5.7	11.7	6.8
Depth of surface fibric (von Post 1—4) (cm)	22	15	16	9	—	13	—

[a] The means are all winsorized and represent the shortest, most reliable confidence interval (Dixon and Turkey 1968).
[b] In the original FEC analysis, these types were all included in OG14, **Chamaedaphne.**
[c] Obtained using the formula of Payandeh (1978).

mainly at the OG level, much less at the VT or ST levels. However, the VTs could become more important in making decisions regarding seedbed, potential competition and finer distinctions of fertility.

The most important use of FEC is that it has provided a new language which people can use to reliably convey information about results of certain treatments, either operational or research. Now when a forester talks about planting paperpots on 'lowlands' he can be more precise and define what OG. The FEC program included numerous training sessions, so now most foresters are quite clear about the concept for various sites. Furthermore, the field guide (Jones et al. 1983b) gives rather detailed keys and descriptions as aids for identifying the OGs.

Foresters from both government and private industry, as well as researchers, attended training sessions. It is encouraging that some of the forestry companies that are entering into the new Forest Management Agreements with the province of Ontario are using the FEC OGs in their schedules for silvicultural prescriptions. Individual OMNR Districts are also developing and refining prescriptions.

A committee has been established for the Northern Region to develop silvicultural guidelines for the OGs. These guidelines should be useful for general improvement of prescriptions, and for orientating new foresters to generally agreed upon practices. Hence experience is passed on and not lost when foresters move out of regions.

Even though the foresters were most interested in having the classification for purposes of regeneration silviculture, the FEC OGs have also provided a framework for indicating relative productivity. This is shown by the mean black spruce site indices for the treed bog-swamp and treed bog-treed fen-thicket sequence (Table 1). It is clear therefore that the OGs also have relationships to black spruce productivity, which in turn is determined by underlying gradients of soil nutrient regime. However, undoubtedly the mean site indices would be higher if excess moisture were removed by forest drainage.

Other interpretations have been applied to the FEC. A recent publication provides prescribed burn guidelines according to the OGs (Wearn et al. 1983). It is known generally that certain of the OGs have more advance growth than others. Data from the FEC survey (Groot 1984) revealed that stocking of black spruce advance growth average 60 % or more for OG8, OG11, and OG14, and levels of 40 to 60 % were attained in OG12 and OG13.

(Note: 'Stocking' is the percentage occurrence of seedling or sapling size black spruce in 2 m x 2 m quadrats, a common method for assessing regeneration in Canada.)

Table 2. Some species measures in the main units of wooded peatlands. Mean cover percent, followed by constancy in scale 1—10 (in brackets). + ≤ 0.5 %.

Taulukko 2. Muutamia metsäisten suotyyppiryhmien kasvilajeja. Prosenttinen keskimääräinen peittävyys ja konstanssi (1—10, suluissa) on esitetty lajeittain. + ≤ 0.5 %.

	SWAMP SEQUENCE				TREED FEN — THICKET		
	Poor →			Rich	Poor →		Rich
	Low Shrub Treed Bog	**Ledum**	**Alnus-Herb Poor**	**Alnus-Herb Rich**	**Herb Poor Treed Fen**	**Herb Rich Treed Fen**	**Alnus Thicket, Larix/ Alnus**
No. of plots	4	23	18	28	3	8	11
Mean no. species	20	25	31	47	23	44	41
Picea mariana	59(10)	57(10)	43(10)	35(10)	46(10)	43(9)	2(8)
Thuja occidentalis	0(0)	+(1)	8(2)	25(4)	0(0)	0(0)	0(0)
Larix laricina	1(3)	+(2)	+(1)	3(3)	0(0)	11(5)	29(6)
Chamaedaphne calyculata	29(10)	3(7)	1(6)	+(2)	22(10)	9(9)	4(6)
Ledum groenlandicum	35(10)	32(10)	8(10)	7(8)	22(10)	24(9)	2(8)
Alnus rugosa	0(0)	1(4)	21(9)	21(10)	2(10)	7(5)	71(10)
Lonicera villosa	0(0)	+(2)	+(3)	1(6)	0(0)	1(10)	1(7)
Salix pedicellaris	0(0)	0(0)	0(0)	0(0)	1(7)	1(8)	+(2)
Calamagrostis canadensis	0(0)	0(0)	+(1)	1(6)	0(0)	2(9)	6(7)
Potentilla palustris	0(0)	0(0)	+(1)	+(1)	0(0)	1(8)	1(7)
Linnaea borealis	0(0)	+(4)	1(5)	1(9)	0(0)	1(5)	1(5)
Eriophorum spissum	1(5)	0(0)	0(0)	0(0)	+(3)	0(0)	0(0)
Rubus pubescens	1(0)	+(2)	1(3)	2(9)	0(0)	1(6)	11(10)
Sphagnum fuscum	22(10)	12(7)	1(3)	1(3)	3(3)	11(6)	0(0)
Sphagnum angustifolium	30(3)	1(4)	7(7)	2(2)	39(10)	43(9)	0(0)
Pleurozium schreberi	36(10)	37(10)	19(10)	16(10)	19(10)	6(9)	2(4)
Sphagnum girgensohnii	0(0)	10(5)	17(8)	7(5)	3(3)	5(6)	27(7)
Hylocomium splendens	0(0)	2(4)	1(7)	14(9)	0(0)	1(4)	0(0)

Of course this varies depending on stage of stand development, density of the canopy, stand basal area, amount of *Sphagnum* on the forest floor, and other factors (Groot 1984). Arnup (1984) has recently published on techniques for mapping and interpreting the distribution of black spruce advance regeneration.

The OGs have important implications for soil fragility, as this relates to season of harvesting and site damage. An area of 5,000 ha of summer harvested cutover in the Clay Belt was surveyed, using the FEC OGs (McColm 1983). In this area 18 % was fresh upland (OGs 6 and 7), 13 % transitional (OGs 8 to 10), and 69 % organic soil (OG11 to OG13). Over 40 % of the surveyed cutover had been rendered 'untreatable' and unregenerated mainly because of lowland site damage. Site damage was attributed to the use of inappropriate logging equipment during the frost free season. (Another untreatable condition was where heavy residual hardwood was left in highgraded stands.) Only 34 % of the total cut was judged available for planting.

It was concluded that minimal consideration was being given to site preparation and forest renewal (McColm 1983). If significant improvements are to be made, current logging strategy, including road location, equipment selection and season of harvest, must be changed. Specific recommendations were made for improvements.

Advance growth can be utilized by identifying those sites that have enough of it in precut inspections, and modifying harvesting procedures to preserve it. In the above survey, approximately 16 % of the cut was regenerating naturally to acceptable conifer regeneration (McColm 1983). It was felt that this could be increased if sites were protected and if modified harvesting were considered. Other ways to preserve it are harvesting in winter, full tree harvesting to minimize slash, and using low ground presure harvesting and skidding machines. Some cutting has been tried to simulate the horse logging strip thinning method that yielded regenerated all-aged stands. This type of careful logging to preserve advance growth in combination with drainage could become a viable method, but special machines and methods would have to be developed. Most importantly there would have to be changes in attitude and approach from the large scale clearcutting which now prevails.

INVENTORY AND REMOTE SENSING

Foresters are very interested in the development of guidelines for recognizing wetland (and upland) types on air photos (e.g. Jeglum and Boissonneau 1977, Day 1983, Arnup 1984). If air photo interpretation can be increased and field sampling decreased, costs will decrease greatly. As well, areas difficult to access could be mapped. One component in the FEC program was to study the mapping of the OGs in several study areas (Arnup 1984, Wickware et al. 1984). As well, the OG types have been mapped in various operational activities such as timber cruises, precut inventories, postcut inventories (e.g., Day 1983, McColm 1983). The usual application is to use the stand polygons already identified in the Forest Resource Inventory maps (scale 1:15840). Stands are subsampled and points classified on ground transects to the OG level. Often a stand polygon may consist of more than one OG, so a decision is made as to which OG will best characterize it, considering the proportions of OGs and the limitations on management options for the OGs represented. Foresters often classify a stand according to the OG with the most limiting conditions (e.g. Day 1983). Wickware et al. (1984) used TWINSPAN to classify mapped polygon types, using as attributes the percentage of the various FEC OGs represented in the polygons. This approach has been useful to reveal what types of groupings one can get in the stand polygons. Arnup (1984) concludes that large scale color photography shows promise for evaluating site features related to predicting advance growth stocking levels.

There is interest in extending the FEC to map whole management units (Day 1983). If this were done, it could provide a useful tool for long range planning. With such a map one could plan in more detail such things as distribution of summer versus winter cut area, planting stock requirements by species and stock types, site preparation and tending requirements, and budgeting, based on a much better knowledge of the forest than was previously the case. The FEC system was also judged to hold potential for other planning activities, such as locating roads and potential gravel deposits (Day 1983). There has also been discussion of the possibility of incorporating the FEC into the provincial Forest Resource Inventory, for areas being reinventoried in the Northern Region. McColm (1983) noted that roads are currently not located with regard to specific sites.

Finally, recent work has focused on the interpretation of forested peatland site types from satellite imagery at the Ontario Centre for Remote Sensing. This work holds potential for recognition of categories of forest which may be useful in the provincial inventory program.

LITERATURE

Ahti, T., and Hepburn, R. L. 1967: Preliminary studies on woodland caribou range, especially on lichen stands, in Ontario. — Ont. Dep. Lands and Forests Res. Pap. (Wildlife) No. 74: 1—134.

Andrejko, M. J. Fiene, F., and Cohen, A. D. 1983: Comparison of ashing techniques for determination of the inorganic content of peats. — In: P. M. Jarrett (ed.), Testing of peats and organic soils, ASTM 820, Amer. Soc. for Test. Mater., — pp. 5—20., Ann Arbor, Mich.

Arnup, R. W. 1984: Techniques for mapping and interpreting the distribution of black spruce advance regeneration, Northern Region, Clay Belt. — Ont. Min. Nat. Res. Int. Rep., Timmins, Ontario. 46 pp.

Boissonneau, A. N., and Jeglum, J. K. 1976: A regional level of wetlands mapping for the Northern Clay Section of Ontario. — In: G. E. Thompson (ed.), Third Canadian Symposium on Remote Sensing, — pp. 349—353, Edmonton, Alta.

Canada Soil Survey Committee: Subcommittee on Soil Classification. 1978: The Canadian system of soil classification. — Can. Dep. Agric., Ottawa, Ont. Publ. 1646. 164 pp.

Day, Q. 1983: Application of F.E.C. to forest management, Cochrane Districht. — Meeting of the Northern Region Technical Committee, Ont. Min. Nat. Resour., Cochrane Dist., Ont. Typescript, 8 pp.

Dixon, W. J., and Tukey, J. W. 1968: Approximate behaviour of the distribution of winsorized t (Trimmins/Winsorization 2). — Technometrics 10: 83—98.

Eurola, S., Hicks, S., and Kaakinen,. 1984. A key to the Finnish mire types. — In: Gore, A. J. P. (ed.), European mires, pp. 11—117, Academic Press.

Groot, A. 1984: Stand and site conditions associated with abundance of black spruce advance growth in the Northern Clay Section of Ontario. — Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Info. Rep. O—X—358. 15 pp.

Haavisto, V. F. 1979: Some considerations for regenerating black spruce on peatland in the Northern Clay Section, Ontario. — Can. Dep. Environ., Can. For. Serv., Info. Rep. O—X—295. 32 pp.

Heikurainen, L., and Pakarinen, P. 1982: Mire vegetation and site types. — In: Laine, J. (ed.), Peatlands and their utilization in Finland, — pp. 14—23. Helsinki.

Hill, M. O. 1979a: DECORANA — A FORTRAN program for detrended correspondence analysis and reciprocal averaging. — Cornell Univ., Ithaca, N. Y. 52 pp.

Hill, M. O. 1979b: TWINSPAN — A FORTRAN program for arranging multi-variate data in an ordered two-way table by classification of the individuals and attributes. — Cornell Univ., Ithaca, N. Y., 90 pp.

Hills, G. A. 1960: Regional site research. — For. Chron. 36: 401—423.

Hills, G. A., and Pierpoint, G. 1960: Forest site evaluation in Ontario. — Ont. Dep. Lands and Forests, Res. Br., Res. Rep. 42. 66 pp.

Hustich, I. 1957: On the phytogeography of the Hudson Bay Lowland. — Acta Geogr. 16 (1): 1—48.

Ireland, R. R., Bird, C. D., Brassard, G. R. and Vitt, D. H. 1980: Checklist of the mosses of Canada. — Natl. Mus. Can., Publ. Bot. No. 8. 75 pp.

Jeglum, J. K., and Boissonneau, A. N. 1977: Air photo interpretation of wetlands, Northern Clay Section, Ontario. — Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Report O—X—269. 44 pp. + Appends.

Jeglum, J. K., and Cowell, D. W. 1982: Wetland ecosystems near Kinoje Lakes, southern interior Hudson Bay Lowland. — Nat. can. 109: 621—635.

Jeglum, J. K., Haavisto, V. F., and Boissonneau, A. N. 1974: Toward a wetland classification for Ontario. — Can. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O—X—215, 54 pp. + Appends.

Jeglum, J. K., Arnup, R. W., Jones, R. K., Pierpoint, G., and Wickware, G. M. 1983a: Forest ecosystem classification in Ontario's Clay Belt: A case study. — In: Proc. Artif. Regen. Conif. in the Upper Gt. Lakes Reg. — pp. 11—128, Green Bay, Wis.

Jeglum, J. K., Haavisto, V. F., and Groot, A. 1983a: Peatland forestry in Ontario: An overview. — In: J. D. Sheppard, J. Musial, and T. E. Tibbetts (ed.), Symposium 82: A Symp. on Peat and Peatlands, — pp. 127—167, Shippagan, New Brunswick.

Jones, R. K. 1984: Site classification in Ontario. — In: — (ed.), Forest land classification: Experiences, problems, perspectives, 17 pp., Madison, Wis.

Jones, R. K., Pierpoint, G., Wickware, G. M., and Jeglum, J. K. 1983a: A classification and ordination of forest ecosystems in the Great Claybelt of northeastern Ontario, — In: R. W. Wein, R. R. Riewe, and I. R. Methven (ed.), Resources and dynamics of the boreal zone, — pp. 83—96, Thunder Bay, Ont.

Jones, R. K., Pierpoint, G., Wickware, G. M., Jeglum, J. K., Arnup, R. W., and Bowles, J. M. 1983b: Field guide to forest ecosystem classification for the Clay Belt, Site Region 3E. — Ont. Min. Nat. Resour., Maple, Ont. 123 pp.

Kalela, A. 1962a: A comparison of forest regions in northern Ontario and Quebec with those in Finland — In: W. K. W. Baldwin (ed.), Report on botanical excursion to the boreal forest region in northern Quebec and Ontario, — pp. 68—72, Can. Dep. N. Aff. Nat. Resour., and Natl. Mus. Can., Ottawa, Ont.

Kalela, A. 1962b: Notes on the forest and peatland vegetation in the Canadian Clay Belt region and adjacent areas. I. — Commun. Inst. For. Fenniae. 55 (33): 1—14.

Kujala, V. 1945: Waldvegetationsuntersuchungen in Kanada mit besonderer Berucksichtigung der Anbaumöglichkeiten kanadischer Holzarten auf naturlichen Waldboden in Finnland. — Ann. Acad. Sci. Fenn. Ser. A, IV, 7. 434 pp.

MacLean, D. W., and Bedell, G. H. D. 1955: Northern Clay Belt growth and yield survey. — Can. Dep. North. Aff. Natl. Resour., For. Br., For. Res. Div., Tech. Note No. 20. 27 pp.

McColm, R. G. 1983: Postcut classification of recent cutover, 1978—82: Summary of results. — Ont. Min. Nat. Resour., Cochrane Dist. Ont. 13 pp.

Ontario Institute of Pedology. 1978: Field manual for describing soils, 2nd ed. — Ont. Inst. Pedol., Publ. No. 82—1. Univ. Guelph, Guelph, Ont. pp.

Pala, S. 1983: A method for peat inventory based on landsat data and computerized mapping. — In: J. D. Sheppard, J. Musial, and T. E. Tibbetts (ed.), Symposium on Peat and Peatlands, — pp. 266—290, Shippagan, New Brunswick.

Pala, S. 1984: A landsat-based method for the survey and inventory of peat resources over extensive regions. — In: R. A. Robertson (ed.), Remote sensing in Peat and terrain resource surveys, — pp. 156—168, Aberdeen, Scotland.

Payandeh, B. 1978. A site index formula for peatland black spruce in northern Ontario. For. Chron. 54: 39—41.

Pierpoint, G. 1978: The recognition and classification of soil moisture regime in the Ontario physiographic site classification system. — In: R. K. Jones (ed.) Proceedings Soil Moisture Regime Workshop, Ontario Institute of Pedology, Publ. No. 79—3, — pp. 31—59, Guelph, Ont.

Pierpoint, G. 1981: Site types in the boreal mixedwood forest, — In: Whitney, R. D., and McClain, K. M. (ed.), Boreal mixedwood symposium, — p. 10—16, Thunder Bay, Ont.

Pierpoint, G., Jones, R. K., Jeglum, J. K., Wickware, G. M., and Arnup, R, 1984: Characteristics and management implications of ecosystems with boreal hardwood components in the Great Clay Belt, northern Ontario, Canada. — In: Stone, E. (ed.), Proc. Sixth N. Amer. For. Soils Conf., — pp. 17—28, Knoxville, Tenn.

Scoggan, H. J. 1978/1979: The flora of Canada. — Publ. Bot., Natl. Mus. Can. No. 7 (1—4). 1711 pp.

Sims. R. A., Cowell, D. W., and Wickware, G. M. 1982b: Use of vegetational physiognomy in classifying treed peatland near southern James Bay, Ontario . — Nat. can. 109: 611—619.

Sims, R. A., Cowell, D. W., and Wickware, G. M. 1982a: Classification of fens near southern James Bay, Ontario, using vegetational physiognomy. — Can. J. Bot. 60: 2608—2623.

Sims, R. A., and Wickware, G. M. 1984: Forest ecosystem classification (FEC) in the North Region of Ontario. — Can. Dep. Environ., Can. For. Serv., For. Newsl., Summer 1984: 5—7.

Sjörs, H. 1961: Forest and peatland at Hawley Lake, northern Ontario. — Natl. Mus. Can. Bull. 171: 1—31.

Sjörs, H. 1963: Bogs and fens in Attawapiskat River, northern Ontario. — Natl. Mus. Can. Bull. 186: 45—133.

Stanek, W., and Jeglum, J. K. 1977: Comparisons of peatland types using macro-nutrient contents of peat. — Vegetatio 33: 163—173.

Tarnocai, C. 1980: Canadian wetland registry, — In: Proceedings of a Workshop on Canadian Wetlands, Ecol. Land Class. Ser. No. 12, — pp. 9—38, Lands Directorate, Ottawa, Ont.

Tellford, P. 1982: Peatland resource evaluation program, province of Ontario. — In: Morgan, S. M., and Pollett, F. C., Proc, Peatland Inventory Methodology Workshop, — pp. 51—53, Ottawa, Ont.

Wearn, V. H., Springer, E. A., and Lesage, A. J. 1983, Forest managers' photo guide to prescribed burn planning. — Ont. Min. Nat. Resour., Kapuskasing District, Ont. 72. pp.

Wickware, G. M., Sims, R. A., Ross, R. K., Cowell, D. W.

1980: The application of remote sensing techniques for an ecological land survey of the snow goose colong at Cape Henrietta Maria, Hudson Bay. — In: 6th Canadian Symposium on Remote Sensing, — pp. 387—395, Halifax, Nova Scotia.

Wickware, G. M. Arnup, R. W. Jones, R. K., Pierpoint, G., and Jeglum J. K. 1984: Application of multivariable analysis techniques in mapping forest ecosystems: An example from the Great Clay Belt, Ontario. — In: Stone, E. (ed.), Proc. Sixth N. Amer. For. Soils Conf., Poster and abstract, — p. 435, Knoxville, Tenn.

Zoltai, S. C., Pollett, F. C., Jeglum, J. K., and Adams, G. D. 1975: Developing a wetland classification for Canada. — In: Bernier, B., and Winget, C. H. (ed.), Proc. Fourth N. Amer. For. Soils Conf., — pp. 497—511, Quebec City, Que.

TIIVISTELMÄ

METSÄTALOUDELLISEN SUOKASVUPAIKKALUOKITTELUN NYKYTILANNE ONTARIOSSA

Havumetsävyöhykkeeseen kuuluva osa Ontariota muistuttaa luonnonmaantieteeltään — mukaan lukien soiden runsaus — paljolti Suomea. Ontarion havumetsävyöhykkeessä vuotuinen sademäärä kasvaa lännestä itään siirryttäessä n. 500:sta 800 mm:iin. Ilmasto on kuitenkin jonkin verran mantereisempi kuin Suomessa. Tutkimustyö kasvupaikkojen luokituksen kehittämiseksi metsätalouden tarpeita varten alkoi jo 1950-luvulla G. A. Hills'in johdolla. Varhaisimmat suometsien kasvupaikkaluokittelut ottivat lähinnä huomioon vesitalouden, mutta eivät juurikaan kiinnittäneet huomiota trofiatasoihin tai kasvillisuusluokkiin. Pohjois-Ontariossa on työskennellyt useita pohjoismaisia tutkijoita, joiden työllä on ollut oma vaikutuksensa nykyiseen suokasvupaikkojen luokitteluun.

Ontarion märkien maiden ensimmäisissä luokitteluyrityksissä käytettiin kasvillisuuden fysiognomiaan ja lajien vallitsevuuteen perustuvaa lähestymistapaa. Tässä luokittelussa pääluokkia ovat "marsh" (tulvasuo tai -niitty), "swamp" (minerotrofinen korpi tai räme), "fen" (minerotrofinen suo, yleensä neva tai letto) ja "bog" (ombrotrofinen suo, räme — neva). Nämä pääluokat ja eräitä niiden alaluokkia on kuvattu edafiseen malliin, jossa vaihtelusuuntina ovat toisaalta vesitalous ja toisaalta kompleksitekijä ravinteisuus-tulvaisuus (Kuva 1). Ko. luokittelua on käytetty kuvattaessa turpeen ravinteisuutta, Hudson-lahden alangon ekologisissa kartoituksissa, ilma- ja satelliittikuvien tulkinnassa ja turvevarojen inventoinneissa.

Kanadassa eräät tutkijat käyttävät nimitystä "wetland" toiset taasen nimitystä "mire". "Wetland" on käsitteenä jonkin verran laajempi kuin "mire", joka lähinnä vastaa meikäläistä suo-käsitettä. Käsillä olevassa artikkelissa tarkastellaan Kanadassa käytössä olevia käsitteitä "peat" (turve), "peatland" (suo), "organic soil" (orgaaninen maa), "organic terrain" (orgaanisen maa-aineksen peitossa oleva alue) ja "moisture regime" (maan kosteusolot).

Metsäekosysteemien luokittelu (Forest Ecosystem Classification, FEC) -projekti on luonut perustan markkinakelpoista puustoa kasvavien alueiden luokittelemiseksi käytännön metsätalouden tarpeita varten Ontarion Clay Belt -alueella. Luokittelussa on muodostettu 14 käytännön metsätaloudessa käytettävää ryhmää (Operational group), joista 3 edustaa kosteita, ohutturpeisia (alle 40 cm) ja 4 orgaanisen maan (organic soil, yli 40 cm) kasvupaikkoja. Jatkotutkimuksissa on tarkennettu päätyyppiryhmien "swamp", "treed bog", "treed fen" ja "thicket" välisiä eroja. Näitä on lyhyesti luonnehdittu kasvupaikkaindeksinä (50 vuoden iällä), kasvupaikan tunnuksilla ja kasvillisuudella.

Märkien maiden kasvupaikkaluokituksen sovellutusaloja ovat:

- yhteisen kielen luominen metsäammattimiehille
- luokituksen luominen sekä ennen puunkorjuuta että sen jälkeen suoritettavia metsäninventointeja varten
- luoda systeemi kasvupaikan tuotoskyvyn, sopivan uudistamismenetelmän, pintakasvillisuuden mahdollisen kilpailun ja erilaisten korjuumenetelmien mahdollisesti aiheuttamien vahinkojen arvioimiseksi ja ennakoimiseksi
- parantaa päätöksentekoa silloin kun harkitaan
  - metsäautotien sijaintia
  - korjuumenetelmää ja -koneita
  - korjuuajankohtaa
- luoda pohjaa metsänhoidollisia toimenpideohjeita varten.

Märkien maiden päätyyppiryhmien tulkinta- ja erottelumahdollisuuksia selvitetään perinteisiltä ilmakuvilta ja satelliittikuvien tulostuksista käynnissä olevissa tutkimuksissa.