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Site index model approach for drained peatland forest stands

Pituusboniteettisovellus ojitusalueiden metsille

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The site index system presented is intended as support for the idea of developing a more hierarchical and integrated forest classification system in Finland. The data used were obtained from stands growing on old permanent experimental plots laid out in drainage areas in southern Finland. The model, describing the post-drainage development of stand dominant height as a function of drainage age (time elapsed since drainage), is based on successive measurement data (465 observations), collected from 89 plots, each representing a single stand. The site indices H40dr are post-drainage dominant height values 40 years since drainage, given in 2-meter classes. Post-drainage dominant height is defined as the difference between the current dominant height and the dominant height at the time of drainage. In classification work, one needs to know (or measure) the two aforementioned height characteristics, together with age since drainage. If the dominant height at the time of drainage is not known, it can be estimated from a function presented herein and based on current dominant height and drainage age. The mean annual volume increments at 40 years since drainage (MAI40) are also presented. There is still a need for examining separately the accuracy of the model with new data from spruce-, pine-, and birch-dominated stands, collected for numerical constructions of site index curves. Therefore, the site index model and its characteristics must be seen more as outlines than as a final system for practical application. A well-functioning ditch network is a default when applying the site index curves.

Key words: drainage, growth and yield, site classification

INTRODUCTION

The area of drained peatland forest in Finland accounts for more than 20% of the country's productive forest land. The evaluation of these forests for future use, i.e. long-term forecasting of timber yield and allowable cut, is of great importance for Finnish forestry. A detailed and well-developed site classification system will be of valuable help in reducing the uncertainty in such forecasts.

The need for developing the whole forest site classification system in Finland, comprising both peatland and upland sites, has been pointed out earlier (Reinikainen & Lehtinen 1994). This is necessitated by the increasing intensiveness in forest management, e.g. the need for quantitative site variables in growth models and criteria for multiple-use forest planning.

In Finland, the classification systems for practical peatland forestry purposes are based on plant communities as introduced by Cajander (1913). The systems developed for the classification of undrained peatlands (e.g. Huikari 1952, Huikari et al. 1964, Heikurainen 1968) as well as drained peatlands (e.g. Sarasto 1961, Laine 1989, Laine & Vasander 1990), form a very important basis for the improvement of the site classification system as a whole, i.e. for creating a more hierarchical site evaluation system embodying vegetation, soil and foliage analysis data (Tamminen 1993, 1994). The weaknesses of the existing peatland site classification systems are in their subjectiveness and the lack of quantitative assessment of site quality in terms of absolute measure per unit area. Thus, these classification systems serve more the purpose of relatively ranking sites rather than of estimating their potential productivity capacities (Hånell 1988).

A complementary classification based on stand characteristics, however, may lead to more accurate estimates of site quality, usually expressed in terms of maximum attainable mean annual volume increment (MAI). For drained peatland forests, the post-drainage yield potential, in absolute terms of cubic metres per hectare, and years since drainage, are logical variables describing site quality. Being a component of stand volume, stand height is naturally positively correlated to the potential stand yield. This relationship is utilised in the most common site classification system for upland forests, the site index (height-age) classification system. As a continous variable, the site index is especially suitable for stand growth and yield modelling.

The use of site indices is restricted only to forested sites. They are, in principle, not intended to be used with mixed stands. The dominant height-age model suitable for upland sites is problematic when dealing with drained peatland stands. The differences in initial growing stocks at the time of drainage and the estimation of a reasonable average total age cause difficulties. Penttilä (1984) suggested two alternatives for developing a classification system for growing stocks on drained peatland forests. One was to apply the existing site index models for upland sites (e.g. Vuokila & Väliaho 1980, Gustavsen 1980) and then to test the corresponding growth models. The other was to search for new criteria in place of stand age as the basis for a site index system, e.g. some diameter variable.

Despite the problem connected to the age variable, site index systems for upland forests have been used as site-describing variables in a few peatland studies. For example Perala (1971) used the site index for describing the increment and yield in black spruce stands on virgin mires in Minnesota. Konstantinov (1979) presented post-drainage height development curves according to drainage age in different fertility classes in the former Soviet Union (see Paavilainen & Päivänen 1995). Also, in Norway peatland forests belonging to so-called productive land are classified according to the site index (H40) for upland forests. To ensure a better site index estimation, the "economic" age of the stand, determined from sample trees, can be used. The economic age is determined as a corrected age according to normal annual ring width (see Tveite & Braastad 1981). This solution serves perhaps as an alternative more in the case of undrained peatland forests than in the case of drained peatland forests.

The site-index classification for drained forested peatlands must be based on data collected from peatland forests in order to lead to satisfactory assessment of site quality. In Finland, site index curves have so far been presented only for birch (*Betula pubescens* Ehrh.) stands growing on drainage areas in northern central Finland (Saramäki 1977). Recently, Gustavsen et al. (Gustavsen, H.G., Heinonen, R., Paavilainen, E. & Reinikainen, A. unpublished data) used a three-variable model for determining the site quality classes for predicting volume increment and yield. Site quality, expressed as post-drainage yield at 40 years since drainage, was determined on the basis of drainage age, current dominant height, and initial volume at the time of drainage. The weakness of this system is in that three variables give a more complicated expression form (many tables or graphs) than the traditional height-age model. An improvement would be to use initial dominant height as a substitute for initial volume at the time of drainage in the model.

The aim of this study is to provide an outline of an alternative method for classifying drained peatland sites by presenting a site index system based on post-drainage dominant height and drainage age. Post-drainage dominant height is defined as the difference between the current dominant height and the dominant height at the time of drainage. Drainage age is defined as the time elapsed since drainage. The site index (H40dr) is defined as the post-drainage dominant height at 40 years since drainage.

DATA

The data for this study were collected from permanent sample plots in stands growing on drained peatlands in southern Finland (Fig. 1). A description of the sample plot data has been given by Paarlahti (1988). The sample plots were established during the years 1911–1982 by the Finnish Forest Research Institute, and the growing stocks have been remeasured several times at varying time intervals. On average, the sample plot stands have been thinned 2–3 times. No fertilizations have been done on the plots.

For this study, data from 89 plots (= stands) located in 14 study areas (Fig. 1) were subjectively selected from a total number of 329 plots. A broad distribution with respect to different site types and geografical location was aimed at in the selection of the sample plots. Forty-two plots were located in pine (*Pinus sylvestris* L.) dominated stands, 27 plots in spruce (*Picea abies* (L.) Karst.) dominated stands, 17 plots in birch (*Betula pubescens* Ehrh.) dominated stands, and 13 plots were located in stands with mixed stands of spruce, birch and pine (about equal percentages of the three species). Twenty original mire site types (according to Heikurainen 1968) were represented in the data.

The stand dominant heights at different remeasuring times were estimated from sample trees on each plot. Stand dominant height was defined as the mean height of the 100 thickest trees per hectare. The final data comprised 465 stand-level observations of both drainage age and post-drainage dominant height. The variation and means of the post-drainage dominant height of the drainage age classes in the study areas are presented in Table 1.

On average, five successive height observations in each stand were available and the drainage age covered an average time interval of 30–35 years. The drainage age was greater than 40 years in 49 stands. Only these stands were used for estimating the mean annual post-drainage volume growth (MAI40), giving the average productivity in the post-drainage site index classes (H40dr-classes).

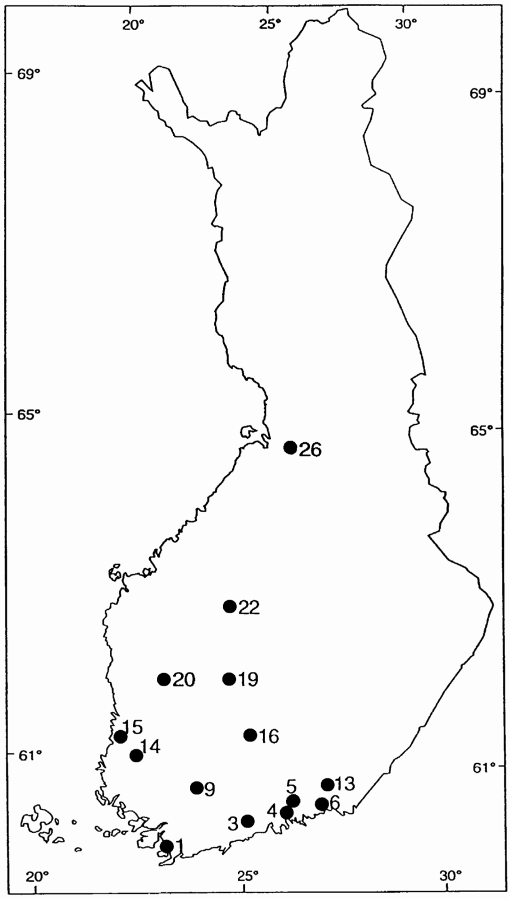

Fig. 1. Location of study areas. 1. Bromarv, Solböle, 3. Tuusula, Ruotsinkylä, 4. Pernaja, 5. Lapinjärvi, 6. Kymi, 9. Forssa, 13. Sippola, 14. Kauttua, 15. Eurajoki, 16. Padasjoki, 19. Vilppula, 20. Häädetjärvi, 22. Karstula, 26. Muhos.

Kuva 1. Koealueiden sijainti.

METHODS

The basic idea of the study was to construct a site index system based on two variables; i.e. the drainage age and the post-drainage dominant height. The system thus offers a possibility for classifying drained peatland forests with different initial dominant heights using the same model. A second advantage is in the use of quantitative and continous variables, which are easy to determine objectively.

Primarily site index curves are defined for classification purposes. The site index found for a certain stand will, to a certain extent, express the growth conditions of that particular locality. In some cases, curves are also defined for other purposes, e.g. to predict the future growth of trees or stands of a specified height. According to Strand (1964), it should be kept clearly in mind that a curve set that is very efficient for one purpose is not necessarily efficient for another. Therefore, there ought to be a close connection between the use of site index curves and their method of construction. Curves prepared for classification use should be established in such a way that the classification error is as small as possible. This is an entirely different problem from that of predicting growth.

Height curves were derived from the entire data (89 stands with 465 observations) using a method introduced by Strand (1964), and especially developed for numerical construction of site index curves for classification purpose. The following flexible height-age function was used:

$$\text{Hdomdr} = (\text{Hdom} - \text{Hdom}\,0) = \left[\frac{\text{Tdr}}{\text{B}0 + \text{B}1 \times \text{Tdr}}\right]^{n} \quad (1)$$

where Hdomdr = post-drainage stand dominant height at different times since drainage, Hdom = current dominant height at different times since

Table 1. The range and mean (in brackets) of post-drainage dominant height by drainage age classes and the study areas (see Fig. 1).

Taulukko 1. Ojituksenjälkeisen valtapituuden vaihteluvälit ja keskiarvot (suluissa) ojitusikäluokissa koealuettain (ks. Kuva 1).

	Drainage age, years since drainage *Ojitusikä, v*					
	10	20	30	40	50	All
Study area *Koealue*	Post-drainage dominant height, m *Ojituksenjälkeisen valtapituus, m*					
1	1.5–7.0 (4.1)	4.0–12.0 (8.0)	10.0–14.0 (12.0)			1.5–14.0 (7.2)
3	1.5–6.0 (3.6)	7.0–12.0 (9.6)	12.0–12.0 (12.0)			1.5–12.0 (7.4)
4	0.5–12.0 (3.9)	3.0–10.0 (6.9)				0.5–12.0 (5.1)
5	0.5–9.0 (4.2)	2.5–14.0 (9.3)	7.5–17.0 (12.9)	12.0–20.0 (16.0)		0.5–20.0 (11.3)
6	0.5–8.0 (3.1)	3.0–9.0 (6.0)	5.0–11.0 (8.5)			0.5–11.0 (5.3)
9		5.0-9.0 (6.9)	6.5-14.0 (10.7)	11.0-15.5 (12.6)		5.0–15.5 (10.8)
13	0.5–6.0 (2.5)	0.5–9.0 (5.1)	5.0–11.0 (8.0)			0.5–11.0 (5.1)
14	7.0–8.0 (7.5)	6.0–10.0 (6.9)	7.5–14.0 (10.7)	9.8–16.5 (13.6)	11.0–18.0 (15.2)	6.0–18.0 (12.2)
15	12.0–12.0 (12.0)	2.5–14.0 (9.1)	6.0–16.0 (12.4)	7.0–22.0 (14.8)	9.5–24.0 (17.2)	2.5–24.0 (13.8)
16	0.5–6.0 (2.9)	2.5–8.0 (5.6)	5.0–7.5 (6.2)			0.5–8.0 (4.2)
19			14.0–15.0 (14.5)	16.0–17.0 (16.5)	18.0–18.0 (18.0)	14.0–18.0 (16.0)
20			15.0–15.0 (15.0)	16.0–17.0 (16.5)		15.0–17.0 (16.0)
22				9.0–12.0 (10.3)		9.0–12.0 (10.3)
26	2.0–7.0 (4.5)	8.0–8.0 (8.0)	10.0–10.0 (10.0)	11.0–12.0 (11.5)	12.0–14.0 (13.5)	2.0–14.0 (10.5)
All *Kaikki*	0.5–12.0 (3.8)	0.5–14.0 (7.8)	5.0–17.0 (11.1)	7.0–22.0 (14.3)	9.5–24.0 (16.4)	0.5–24.0 (10.5)

drainage, Hdom0 = dominant height at the time of drainage, Tdr = drainage age (years since drainage) and B0 and B1 are the parameters to be estimated. The value of the exponent n determines the shape of the site index curves; e.g. a value of n = 3 gives a more S-shaped curve set than n = 2 or n = 1.

The basic assumption in the method is that a set of index curves can be described by a linear relationship between the coefficients B0 and B1. The set of curves is given by a straight line in a graph, where the values of B0 are on the horizontal and of B1 on the vertical axis:

$$B1 = u \times B0 + v \qquad (2)$$

The method may be characterised as an iterative method, where different values of the exponent n and of the relationships (parameters u and v) between the coefficients B0 and B1 are employed in seeking the best solution; i.e. that the total classification error will be as small as possible (see Strand 1967, p. 291–294).

The problem is to find one estimate of u and one of v. The value of B0 will change from plot to plot being a "site parameter". Estimates of u and v may be found in different ways, according to the principle used for measurement of the "goodness of fit" (classification error) of the site index curves. In the least squares sense, the total classification error was measured by the total sum of squares of the differences (residuals) between the observed actual post-drainage dominant height curves and the site index curves.

To assist in obtaining hints about the relationships for the coefficients and the exponent, a mean height/age curve was smoothed to the mean values of the data. The result was a slight sigmoidial curve as a function of time. By comparing graphically the different solutions given by Eq. 1 to the mean curve, guidelines could be obtained for the selection of the initial values of the exponent n and of the parameters u and v in Eq. 2. Many pairs of values of u and v were tried for different values of n, each pair containing one value of u and one of v. For each pair, an estimate of B0 was found for every sample plot and the total sum of squares was computed. The best result (the least square sum) was obtained by setting n = 1, u = 0.002 and v = 0.015 (Eqs 1 and 2).

The total sum of squares of the height residuals for this final solution was 586 m^2, while e.g. the sum of squares for the "best" result using a more S-shaped curve model (n=2) was clearly greater (627 m^2).

For example, when one wishes to derive the curve for the site index H40dr = 20, the values of Hdomdr = 20 and of Tdr = 40 must be set into Eq. 1 and values of B0 and B1 can then be calculated as follows:

$$20.00 = \frac{40}{B0 + (0.002 \times B0 + 0.015) \times 40} \qquad (3)$$

which results B0 = 1.296 and B1 = 0.002 × 1.296 + 0.015 = 0.0176. Corresponding values of B0 and B1 could in this way be calculated for all the desired site index classes.

The site index refers to the inherent production capacity of a piece of land, and it is usually expressed in absolute terms of attainable mean annual volume increment (MAI), either at a fixed age or at the age when MAI culminates. In a complete classification system, the productive capacity is estimated from a functional relationship between MAI and site index.

In this study, site productivity was expressed as the post-drainage mean annual stand volume increment at 40 years since drainage (MAI40, $m^3ha^{-1}a^{-1}$, o.b.) calculated on basis of the measurement data from 49 permanent sample plots. This is one of three common methods of estimating MAI for establishing relationship with site index (Eriksson 1977). The two other methods would be to use yield tables or inventory data.

Ordinary linear regression analysis was used to build a model Hdom0 = f(Hdom,Tdr) for estimating the dominant height of the stand at the time of drainage from current dominant height and drainage age. All data (465 observations) were used in the parameter estimation.

RESULTS

Site index curves

The site index curves for classifying forest stands growing on drained peatlands in southern Finland are presented in Fig. 2. The curves represent site index class limit values for post-drainage dominant

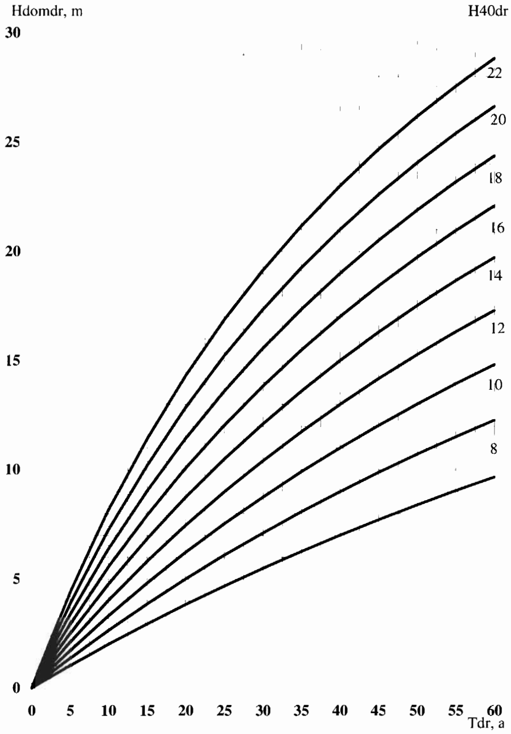

Fig. 2. Site index classes (H40dr) for forest stands growing on drained peatlands in southern Finland based on post-drainage dominant height (Hdomdr) and time since drainage (Tdr). Post-drainage dominant height is defined as the difference between the current dominant height and the dominant height at the time of drainage.

Kuva 2. Ojitettujen metsiköiden pituusboniteettiluokat (H40dr) Etelä-Suomessa ojituksen jälkeisen valtapituuden (Hdomoj) ja ojitusiän (Tdr) mukaan. Ojituksenjälkeinen valtapituus on nykyhetken ja ojitushetken valtapituuksien erotus.

height of eight site index classes (2 m class range) at different points in time since drainage. The corresponding numerical values are given in Table 2 and the values of B0 and B1, allowing calculation of numerical results for nineteen site index classes (1 m class range) are given in Table 3.

The number of site index classes and their width of 2 m were decided on the basis of the material. A site index class range smaller than 2 m was not reasonable, because of the relatively small differences between the curves, especially in cases of more recently drained sites (Fig. 3), and also because of the great variation in mean annual volume increment within the site classes (Fig. 4).

The following equation gives an estimate of the stand dominant height at the time of drainage (Hdom0, m) for measured current dominant height (Hdom, m) and drainage age (Tdr, a), if information about the initial height is missing:

$$\text{Hdom0} = 1.46 + 0.62 \times \text{Hdom} - 0.23 \times \text{Tdr} \quad (4)$$

with $R^2 = 0.58$ and standard error of estimate = 2.41.

The average correspondences between the original mire types and the site index classes H40dr are presented in Table 4.

Site index and site productivity

The relationship between site index and the site productivity (MAI40, $m^3ha^{-1}a^{-1}$, o.b.) is presented

Table 2. Class limit values of post-drainage dominant height according to drainage age (years since drainage) for site index classes H40dr = 8–22.

Taulukko 2. Ojituksenjälkeisen valtapituuden raja-arvot ojitusiän (vuosia ojituksesta) mukaan pituusboniteettiluokissa H40dr = 8–22.

Drainage age	H40dr, m								
	8	10	12	14	16	18	20	22	
Ojitusikä	7	9	11	13	15	17	19	21	23
5	1.0	1.4	1.7	2.1	2.5	2.9	3.4	3.9	4.4
10	2.0	2.6	3.3	4.0	4.8	5.5	6.4	7.2	8.2
15	2.9	3.9	4.8	5.8	6.8	7.9	9.0	10.2	11.4
20	3.8	5.0	6.2	7.5	8.7	10.1	11.4	12.6	14.3
25	4.7	6.1	7.5	9.0	10.5	12.0	13.6	15.2	16.9
30	5.5	7.1	8.8	10.4	12.1	13.8	15.6	17.3	19.1
35	6.3	8.1	9.9	11.8	13.6	15.5	17.0	19.3	21.2
40	7.0	9.0	11.0	13.0	15.0	17.0	19.0	21.0	23.0
45	7.7	9.9	12.0	14.2	16.3	18.4	20.5	22.6	24.7
50	8.4	10.7	13.0	15.3	17.5	19.7	21.9	24.1	26.2
55	9.0	11.5	13.9	16.3	18.7	20.9	23.2	25.4	27.6
60	9.8	12.3	14.8	17.3	19.7	22.1	24.4	26.6	28.8

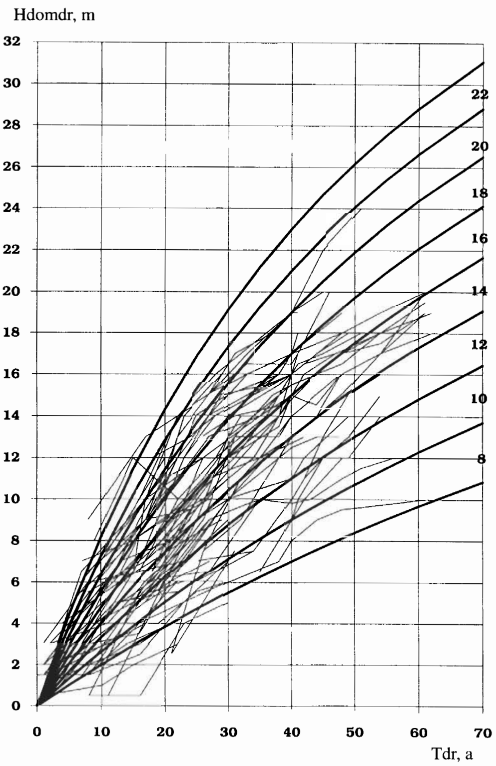

Fig. 3. The actual post-drainage dominant height development on the sample plots (89 in number) in the site index curve system.

Kuva 3. Koealoittaisen valtapituuden kehitys ojitusiän mukaan pituusboniteettikäyrästössä.

Table 3. The values of the parameters B0 and B1 in Equation 1 for different site index classes.

Taulukko 3. Yhtälön 1 parametrien B0 ja B1 arvot eri pituusboniteettiluokille.

H40dr	B0	B1
23	1.0548	0.0171
22	1.1279	0.0172
21	1.2081	0.0174
20	1.2963	0.0176
19	1.3938	0.0178
18	1.5020	0.0180
17	1.6231	0.0182
16	1.7592	0.0185
15	1.9136	0.0188
14	2.0899	0.0192
13	2.2934	0.0196
12	2.5308	0.0200
11	2.8114	0.0206
10	3.1481	0.0213
9	3.5597	0.0221
8	4.0741	0.0231
7	4.7354	0.0245
6	5.6173	0.0262

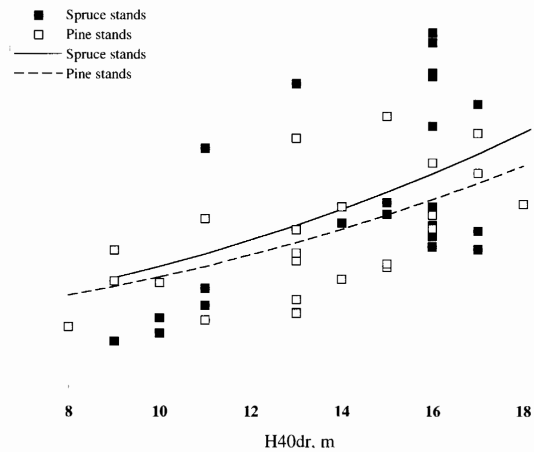

Fig. 4. Relationship between mean annual volume increment at 40 years since drainage (MAI40) and site index (H40dr).

Kuva 4. Ojituksen jälkeisen keskikasvun (0–40 v; MAI40) riippuvuus pituusboniteetista.

in Fig. 4. The standard deviation of MAI40 was higher for spruce-dominated stands (s.d. = 2.8 $m^3ha^{-1}a^{-1}$) than for pine-dominated stands (s.d. = 1.85). Also the mean values of the post-drainage mean annual volume increment (6.0 $m^3ha^{-1}a^{-1}$) and the site index H40dr (14.8 m) were higher for the spruce-dominated mires than for the pine-dominated stands (4.7 $m^3ha^{-1}a^{-1}$ and 13.4 m).

The corresponding functional relationship between MAI40 and H40dr is for spruce-dominated stands:

$$MAI40 = 1.850 + 0.018 \times H40dr^2 \quad (5)$$

and for pine-dominated stands:

$$MAI40 = 1.828 + 0.015 \times H40dr^2 \quad (6)$$

Table 4. The approximate correspondence between the original mire site types (Heikurainen 1968) and the site indices (H40dr) in the material.

Taulukko 4. Alkuperäisten suotyyppien (Heikurainen 1968) ja pituusboniteettiluokkien (H40dr) keskinäinen rinnastuminen aineistossa.

Original mire site type *Alkuperäinen suotyyppi*	H40dr
LhK, RhSR	18–17
MK, VLR	16
VSK, RhK, PK, PsR	16–15
KgK, VSR, LkSR, VSN, RhSN	15–14
PsK, KR, KgR	14–13
RaR, IR, TR, LkN	12–10

DISCUSSION

Reliability of the results

The post-drainage height curves could be evaluated only against the modelling data (Fig. 3). Systematic errors (over-estimation) were detected only in the drainage age interval of 0–10 years when smoothing Eq. 1 to the basic data. This bias was not eliminated by using a more S-shaped alternative (n = 2 or 3). The differences between the site index curves in this age interval are, however, very small and the classification is therefore inaccurate. For drainage age higher than 10 years the site index model is unbiased. This, however, does not mean that classification according to the site index curves will definitely be unbiased in an application situation.

According to Fig. 3, the site index curves seem to be well based by the actual post-drainage dominant height developments in the material up to drainage age of 50 years. The data represent site indices H40dr from about 8 metres to 20 metres. Only the site classes H40dr = 22 and 20 have a weak basis.

The final model was adjusted to the whole data neglecting the fact that the site index curves should be principally species-specific. A data set sorted according to 3 dominant tree species would have decreased the number of stands in each stratum too much. The examination of successive site index values and separate systematic errors from the residuals ($Hdomoj - \widehat{Hdomoj}$) of pine-, spruce- and birch-dominated stands indicated that the accuracy of the model may be increased if species-specific site index curves are developed. The bias was –0.4 m for pine-dominated stands and +0.4 m for both the spruce- and the birch-dominated stands; i.e. the model gives a slight over-estimation for the pine- and an under-estimation for spruce- and birch-dominated stands. In mixed stands, the model was almost unbiased.

There is considerable variation in the post-drainage mean annual volume increment (MAI40) according to site index classes (Fig. 4). There are also problems connected to the use of post-drainage volume increment as a reliable estimate of the total timber production potential of the site. The site indices and the corresponding mean volume increments in Figure 4 may merely express the rate of response to drainage rather than the inherent site productivity. The problem in using growth data as the basis for the classification has been discussed by Hökkä (1994), but further investigations are still needed. For example, we need intensified growth and yield studies of virgin mire stands in order to take into account the effect of the pre-drainage yield on the inherent site productivity. At the same time problems arise if we want to classify stands with different initial growing stocks at the time of drainage with the same site index curves.

Comparison to other investigations

The range of the site indices of this study is very similar to that of Scots pine stands in the investigation by Konstatinov (1979). In his study, post-drainage heights at the drainage age of 40 years were from 10 metres to 22 metres for six fertility classes (Ia, I, II, III, IV, V). These fertility classes were determined by the stand height-age models used for both upland and peatland forests in Russia.

A comparison with upland site index systems is of no use, because of the differences in the basic input characteristics; e.g. post-drainage dominant height is not the same as dominant height in the upland height-age system.

Eriksson (1977) concluded that a yield table based on wide, representative material would perhaps provide the best basis for assessing the productivity of each site index class. He reported standard deviations from 0.24 to 1.36 $m^3ha^{-1}a^{-1}$ for MAI according to site index classes for Scots pine stands growing on upland sites in Sweden. Eriksson suggested the incorporation of different site characteristics in the analysis in order to strengthen the relationship between site index and MAI. This is in analogy with the estimation by Tamminen (1993) of site index for pine and spruce stands in southern Finland using site properties.

Similary, great variation in upland stands, with respect to stand increment, has also been reported by Tveite & Braastad (1981) for site index classes concerning pine, spruce and birch stands in Norway. The mean values of MAI were, therefore, given with an accuracy of 0.5 $m^3ha^{-1}a^{-1}$.

Application

Due to the problems discussed above and the preliminary nature of the study, one should be careful when applying the results in practice. The work is presented more as an outline of a new approach than as a well-developed complete classification system.

A fundamental assumption when using the site index curve classification is that the ditch system is in good condition. Otherwise, the classification of the growing stock will not give a correct picture of the real post-drainage productivity of the site. Because of the greater variation in the mean annual volume increment in this study (Fig. 4) than in earlier investigations of upland stands, the accuracy of 1 $m^3ha^{-1}a^{-1}$ is perhaps reasonable for the estimate of MAI40 in the site index classes intended for drained peatland forests.

When necessary, the values of the parametres B0 and B1 in Table 3 for the site index classes H40dr = 22, 20, 18, 16, 14, 10, 8 give the corresponding mean site index class values. For practical application, however, the limit values and the corresponding curves in Table 2 and Fig. 2 are more useable.

Conclusions

The difference in post-drainage volume growth between pine- and spruce-dominated stands and also the slight systematic errors of the site index model connected to the dominating tree species, indicated that separate species-specific site index curves are also needed for drained peatland forest.

A future task is, therefore, to test the site index curves with independent data. The permanent SINKA plots (Peatland Inventory Growth Plots), established in 1984–1988 (Penttilä & Honkanen 1986, Mielikäinen & Gustavsen 1992), are a potential source of suitable data for testing and developing the site index curves.

Another alternative is to make additional measurements on the permanent plots used and to examine in detail their original field measurements in order to get new and more data for further numerical constructions of species-specific site index curves. Evaluation of the influence of the dominant tree species and of the climatic and geographical conditions, etc., on the post-drainage stand height development, may provide a better basis for site index curves intended for practical use.

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TIIVISTELMÄ:

Pituusboniteettisovellus ojitusalueiden metsille

Tutkimuksen tarkoituksena on täydentää metsäojitusalueiden uudentyyppiseen integroituun luokitteluun pyrkivää tutkimustyötä esittämällä valtapituusboniteettikäyrästö luontaisesti syntyneille ojitetuille suometsiköille Etelä-Suomessa. Työn ensisijainen tarkoitus on antaa uusi lähestymistapa ojitettujen suokasvupaikkojen luokitteluun. Aineisto koostuu Metsäntutkimuslaitoksen suontutkimusosaston vanhoista kestokoealoista. Tutkimuksessa on laadittu ojituksenjälkeisen valtapituuden kehitysyhtälö, joka perustuu 465 havaintoon 89 kestokoealasta, joista kukin edustaa yhtä metsikköä. Valtapituuskehitystä (Hdomdr(Tdr)) selitetään metsikön ojitusiällä (Tdr). Pituusboniteettiluokat, H40dr-arvot (22, 20, 18...) ovat indeksilukuja, jotka ilmaisevat metsikön ojituksen jälkeisen valtapituuden 40 vuoden ojitusiällä 2 m:n luokkia käyttäen. Ojituksenjälkeinen valtapituus (Hdomdr) on nykyhetken ja ojitushetken valtapituuksien (Hdom ja Hdom0) erotus, joka ojitusiän funktiona antaa boniteettiarvot käyrästöstä tai taulukosta. Jos valtapituutta ojitushetkellä ei tunneta, se voidaan laskea laaditusta yhtälöstä nykyhetken valtapituuden ja ojitusiän avulla. Esitettyjen boniteettiluokkien puuntuotoskyky (keskikasvu, $m^3ha^{-1}a^{-1}$) perustuu osa- aineistoon (49 metsikköä), jossa ojitusikä oli vähintään 40 vuotta. Luokkien sisäisen suuren hajonnan vuoksi pituusboniteettiluokkien edustama tuotoskyky on syytä esittää vain 1 m^3:n tarkkuudella. Valtapituusbonitointi esitetyn käyrästön avulla ei kuitenkaan ole käyttökelpoinen kaikissa ojitetuissa metsiköissä Etelä-Suomessa. Mallin tärkein edellytys on, että ojaverkosto on kunnossa. Lannoitettuja metsiköitä ja viljelymetsiköitä ei voida luokitella näiden käyrien avulla. Käyrästöä ei ole testattu riippumattomissa aineistoissa, ja sen vuoksi sitä on pidettävä vain alustavana. Selviä systemaattisia virheitä ei esiintynyt perusaineiston tasoituksessa ojitusiän ollessa yli 10 vuotta. Alle 10 vuoden ikäjaksossa malli yliarvioi systemaatisesti valtapituuden. Puulajittaiset indeksiluvut ja valtapituuden poikkeamat ja keskikasvut osoittavat että pääpuulajeille todennäköisesti pitäisi kehittää omia käyrästöjä. Tämä rajoittaa tällä hetkellä työn tulosten soveltamista. Jatkossa on tärkeää testata käyrästöä esimerkiksi mitattujen suometsien pysyvien kasvukoealojen (SINKA-koealojen) aineistojen avulla.

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