SUMMARY

ON RELATIONSHIP BETWEEN STAND DENSITY ON TREE SIZE

Two Japanese models regarding the within-stand competition have been reviewed on the basis of the relevant literature. Computations showed consistency with the results obtained elsewhere in the world. It is concluded that also in Finnish conditions the 3/2 th power model may have great potentials in describing the effects of stand density on tree size.

DISTRIBUTION OF VEGETATION ON MESIC FOREST SITES IN RELATION TO SOME CHARACTERISTICS OF THE TREE STAND AND SOIL FERTILITY

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Vegetation data collected from a random sample of forest stands representing mesic upland forest sites in selected areas in southern Finland are analyzed and classified using two-way indicator species analysis (TWINSPAN). The tree stand and soil fertility characteristics are analyzed using the LISRREL measurement model in order to construct latent variables for describing the site factors. The site factor scores are treated as continuous dependent variables and the vegetation units as independent class variables in order to test statistically the mensurational fitness of the produced vegetation units.

The results are in agreement with the main division of mesic forest sites in the Finnish forest site type classification system: vegetation units which can be related to the Osmulis-Myyrillius site type are clearly separated from the remaining units, and the fertility factor indicates a statistically significant difference. The Myyllius site type seems to be edaphically comparatively uniform; the vegetational differences are caused mainly by the tree stand factor. On the other hand, the Osmulis-Myyrillius site type seems to be markedly heterogeneous; variation in the soil characteristics is clearly reflected in the vegetation composition, particularly in species' richness and in the abundances of exacting herbs, grasses and bryophytes.

1. INTRODUCTION

The Finnish forest site type classification is primarily based on A.K. Cajander's theory on forest site types (Cajander 1909, 1926, 1949, Cajander & Ilvesalo 1921 etc.). Cajander described two main types of mesic forest sites in southern Finland: the Myyllius site type (MT) and the Osmulis-Myyrillius site type (OMT) (e.g. Cajander & Ilvesalo 1921). Mesic forest sites are confined mainly to moraine soils. The moisture content of the soil is relatively high. A comparatively thick, well-developed humus layer has more or less the characteristics of raw humus. In undisturbed, mature forest stands, the dominant tree species is Norway spruce (Picea abies), but also Scots pine (Pinus sylvestris) may occur as a forest-forming tree. The Myyllius site type is characterized by an abundant and more or less continuous moss cover and by a predominance of Vaccinium myrillus, usually accompanied by Vaccinium vitis-idaea. The Osmulis-Myyrillius site type represents a continuous transition between the preceding type and the grass herb forest class (grass- and herb-rich forests). Vaccinium myrillus is also fairly abundant in this type, but due to the more luxuriant character of the vegetation, i.e. occurrence of relatively exacting herbs and grasses such as Oxalis acetosella, Melica nutans, Carex digitata etc., the Osmulis-Myyrillius site type can rather easily be identified in the field (cf. e.g. Ilvesalo 1922, Cajander 1926).

The main emphasis in the Finnish forest site type classification is on classifying poten-
2. MATERIAL AND MEASUREMENTS

The material consists of 106 sample plots, each 16 × 16 m in size, located in the districts of Lammi, Kuokkala and Mäntä (Fig. 1) in the southern boreal vegetation zone (Ahti & al. 1968). The material was collected in 1982. In the field, the sample plots were located randomly using the center points of the coordinate quadrats of selected sheets of the basic ordnance survey map (1:20,000). Only sample plots representing closed forest stands were taken into account in the vegetation analysis.

Six subsamples, 2 × 2 m in size, were located in the corners (4) and in the centre (2) of each of the sample plots. The vegetation growing on stones, stumps, logs etc. was disregarded. The coverage of the species was investigated using direct estimation of percentage cover. In the material of the present paper, only sample plots representing mesic upland forest sites (MT and OMT) were included. Thus the material used in the present work was reduced to a total of 80 sample plots.

The nomenclature of the plant species follows Hámet-Ahti & al. (1980) (vascular plants) and Koponen & al. (1977) (Bryophyta).

The material concerning the site characteristics was collected from the same sample plots. The ecological data used in the present work consist of the following variables:

1. Characteristics of the tree stand
   - basal area (m²/ha/tree species)
   - dominant age of the stand
2. Characteristics of the soil
   - dry weight of humus (kg/ha)
   - pH (H₂O) in humus layer
   - total nitrogen content (% dry humus)
   - total calcium content (% dry humus)

Information about the measurement methods are given by Tamminen (1982).

The present study was carried out with the co-operation of the Department of Forest Soil Science, the Finnish Forest Research Institute, and was supported by the Academy of Finland. Mr. Pekka Tamminen of the Finnish Forest Research Institute provided the author with the measurements concerning the tree stand and the soil characteristics. Computing work was carried out by the author at the University of Joensuu. The author is also responsible for the vegetation data, which were collected with the assistance of Mr. Jorma Kurkosen. Valuable comments on the manuscript were given by Prof. Eino Mäkiläinen, Prof. Matti Leikola, Dr. Erkki Lipas, Mr. Hannu Mannasukko and Mr. Jari Oksanen. Mr. John Demore kindly checked the language. The author is grateful to all the above-mentioned, as well as to all the other contributors to the study.
3. METHODS

3.1. Vegetation analysis

The mean coverages of different plant species were calculated for each sample plot. The data were analyzed using two-way indicator species analysis (TWINSPAN, Hill 1979), which results dichotomous hierarchical clustering of both samples and species. The data are first ordinated using a reciprocal averaging algorithm (Hill 1973). The samples are initially divided into two clusters by breaking the ordination axis near its midpoint. The sample division is refined by a reclassification in which species with a maximum value are used to indicate the poles of the ordination axis. The division process is then repeated on the two sample subsets to give four clusters and so on, until the maximum level of division is reached. A corresponding species classification is produced, and the sample and species hierarchical classifications are used to produce an arranged data matrix. The method in its basic form is essentially qualitative. The quantitative information is retained by computing it on a relatively crude scale of quantitative equivalents, so called "pseudospecics" (Hill 97). The data are scaled using special cut levels, which are equivalent to commonly used ordinal scales of coverage. In this study, the cut levels were defined following the Hult-Sernander scale (e.g. Du Rietz 1921), which is based on successive halving of the quadrats; the coverage classes therefore make up a geometric series.

3.2. Analysis of the site characteristics

The LISREL measurement model (see Jöreskog & Sörbom 1981) specifies how the latent variables or hypothetical constructs are measured in terms of observed variables and is used to describe the measurement properties (validities and reliabilities) of the observed variables. Provided that the goodness of fit and the coefficient of determination are acceptable, a set of observed variables can be substituted by a linear combination of the variables (Lawley & Maxwell 1971, Jöreskog & Sörbom 1981).

Latent variables $\xi$ were constructed to describe the effects of the site factors on the understorey vegetation. The measurement model specifying how these hypothetical constructs are measured in terms of the observed variables can be defined as follows:

\[ x = \Lambda \xi + \delta, \]

where $x$ is the measured ecological characteristics, $\Lambda$ is the regression matrix of $x$ on $\xi$, and $\delta$ is the vector of the measurement errors of $x$.

Finally, factor scores regression coefficients representing the estimated regression of $\xi$ on all the observed variables were computed (for formula, see Lawley & Maxwell 1971, p. 109). The coefficient matrix, say, $A$, was used to compute the estimated factor scores $\xi$ for each observation (sample plot) with observed scores $x$ by the means of the formula

\[ \xi = Ax. \]

Computed factor scores were then used as dependent continuous variables instead of the observed variables characterizing the tree stand and the soil.

The estimation of model parameters is essentially that of fitting the covariance structure implied by the specification of parameter matrices to the sample covariance matrix (see Jöreskog 1973). This was done automatically using the programme LISREL V (Jöreskog & Sörbom 1981).

3.3. Analysis of the relationships between site and vegetation

In statistical analysis, the vegetation units produced by TWINSPAN were treated as independent class variables and site characteristics as continuous dependent variables. One-way analysis of variance with a posteriori contrast tests of the group means were used when examining the relationships between the vegetation pattern and site factors. In the multiple range tests, the LSD (least-significant difference) procedure was used. This is essentially a Student's $t$ test between group means, and is exact for unequal group sizes. The computations were carried out using the programme package SPSS (Nie & al. 1975).

4. VEGETATION ANALYSIS

The results of two-way indicator species analysis are summarized in the arranged data matrix (Table 1). The names of the species are abbreviated; the correct names are given in Table 2. The ordinal numbers of the sample plots are given in the upper margin; e.g. the first column represents sample plot number 61. The binary codes in the lower margin represent the sample divisions produced by TWINSPAN; the binary codes in the right margin represent corresponding divisions of species. The table is divided into fields by lines which follow the hierarchical classification of the samples and species.

The maximum level of divisions was defined as 4; the minimum group size for each division was defined as 10. The maximum number of species was limited in the program specification; in the final tabulation, the 60 most abundant species are presented. However, all the species present in the original data matrix were used in the computations and could appear as indicators. The coverages of different species in the tabulation follow Hult-Sernander scale.

The first division divides the data into two major subsets: sample plots representing herb-rich sites (1) and sample plots representing more heath-like sites (0). The most significant indicators in the first division are Vaccinium vitis-idaea, Diuramum polyctenum and Pleurozium schreberi. Calamagrostis arundinacea is also fairly abundant. Only a few occurrences of exacting herbs and grasses can be found. The number of species is compa

1. (00): The unit represents markedly xerophilous and light-demanding vegetation, characterized by an abundance of Vaccinium vitis-idaea, Diuramum polyctenum and Pleurozium schreberi. Calamagrostis arundinacea is also fairly abundant. Only a few occurrences of exacting herbs and grasses can be found. The number of species is compa
Table 1. Hierarchical classification of sample plots and species (TWINSpan).

<table>
<thead>
<tr>
<th>Species</th>
<th>TWINSpan Group</th>
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<tbody>
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<td>...</td>
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</table>

Table 2. Key to species.

<table>
<thead>
<tr>
<th>Species</th>
<th>TWINSpan Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
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</tr>
</tbody>
</table>

 relative low. Dominance by dwarf-shrubs and common forest mosses prevails. In the Finnish forest site type system, this group may be regarded as a transition type between the Myrtillus site type and the Vaccinium site type.

2. (0100): The unit is clearly of more mesic character than the preceding one. In the Finnish forest site type system, the group clearly represents the Myrtillus site type. However, the unit resembles the preceding one in that there are relatively high abundances of certain light-demanding and xerophilous species (e.g. Calamagrostis arundinacea and Juniperus communis). A significantly lower abundance of Deschampsia flexuosa and the absence of Polystichum commune are noticeable differences in comparison with the subsequent units. The general character of the vegetation resembles relatively dry and open forest.

3. (0101 and 011): An abundance of Vaccinium myrtillus, Pleurozium schreberi, Hylorchium sphondylium and Diancurn majus characterizes this unit. Frequent occurrences of e.g. Polystichum commune and Orthilia secunda and, on the other hand, a low number of occurrences of light-demanding and xerophilous species, imply a rather moist and mesic loving vegetation. The number of occurrences of herbs, grasses and mosses typical of rich sites is low, except in subset (011), which is included into this unit due to the small group size. In general, the unit represents the typical Myrtillus site type, as described by Ca-jander. The vegetationally somewhat deviating subset (011) reflects the gradual transition between the Myrtillus type and the Oxalis-Myrtillus type.

4. (000): The comparatively mesophilous vegetation characterizing this unit indicates that it represents a rather moist site. Poa nemoralis, Dryopteris carthusiana, Gymnocarpium dryopteris, Orthilia secunda and seedlings of Betula pubescens occur rather frequently. The abundance of Polystichum commune and Sparganium spp. indicates that paludification has taken place at least to some degree. Herbs and grasses occur significantly more frequently than in the preceding units; also Oxalis acetosella is more abundant. For this reason, the unit would be assigned to the Oxalis-Myrtillus site type in the Finnish forest site type system.

5. (001): This unit is characterized by an abundance of Vaccinium myrtillus and Pleurozium schreberi, which is associated with relatively well represented herb and grass vegetation. However,
5. ANALYSIS OF THE SITE FACTORS

The most important environmental factors affecting the forest floor vegetation are the supply of light, microclimate (i.e. humidity and temperature), the moisture content of the soil and the edaphical conditions of the site. Not only the supply of light, but also the microclimate are closely connected to the characteristics of the tree stand. In Fennoscandian coniferous forests especially, the dominance of Norway spruce (Picea abies) plays a decisive role in determining these factors (e.g. Cajander & Ivessalo 1921, Brenner 1921, Sarvas 1951, Telivaara 1952, Sirén 1955 etc.). The basal area is a reasonably good variable in estimating the density of the tree stand (e.g. Vuokila 1980). Consequently, both the total basal area of the tree stand and the basal area of Norway spruce individuals in the stand are incorporated in the model describing the properties of the tree stand. In addition, the dominant age is considered to indicate the maturity of the tree stand and is incorporated as a measure of the successional stage.

The correlations between the tree stand measures can be seen in Table 3. Since the forest stands where deciduous trees are pre-dominant are omitted from the material, the low dominance of Norway spruce implies a high dominance of Scots pine. Dominant age appears to correlate negatively with the two measures of basal area; young spruce stands in particular, seem to be denser than old ones. This may arise as a result of selective cuttings carried out in older stands approaching the regeneration stage. It should, however, be noted that only mature and middle-aged stands are included in the study material. Thus the range of the axis is short and the distribution somewhat skewed. Hence the product-moment correlations between age and the measures of basal areas can be biased.

In order to substitute the mutually connected effects of the observed variables by a single effect via the latent variable $\xi_1$, which is later called the tree stand factor, a measurement model was specified following the general formula (1). The results are presented in Table 4. The model includes only two parameter matrices: lambda $\lambda$ is a vector of factor loadings, i.e. the regression matrix of the tree stand measures on $\xi_1$, and theta delta is a vector of error variances. The squared multiple correlations (R square) for x-variables represent their reliabilities. The coefficient of determination for the x-variables jointly is a generalized measure of the reliability for the whole measurement model (see Jöreskog & Sörbom 1981). The t-values are calculated by dividing each parameter estimate by its standard error, and is used to test whether the true parameter is zero. Parameters whose t-values are larger than two in magnitude are normally judged to be different from zero (Jöreskog & Sörbom 1981).

The coefficient of determination is remarkably high, 0.701, indicating that the measurement model is reasonable. It can be seen from the t-values that most of the parameters are considerably significant. Factor loadings of the tree stand measures represent the magnitude of their effects on $\xi_1$. Here it is seen that the density of Norway spruce has a strong positive effect on the latent variable.

The reliability of the parameter is also very high (0.626). The positive effect of the total density is also considerably high, but the error variance is fairly large (0.675). The dominant age affects $\xi_2$ negatively; this effect may, however, be biased. In addition, the error variance is considerably large. The factor scores regressions show the weight of each variable on computed scores of the tree stand factor. The tree stand factor may thus be interpreted in such a way that high factor scores represent mainly a high dominance of Norway spruce and also somewhat higher density of the tree stand. The dominant age is also possibly lower than in the stands characterized by low factor scores, the main attributes of which are high dominance of pine
and lower density. Consequently, high factor scores represent a low illumination level as well as relatively high and constant moisture conditions on the forest floor. Low factor scores represent a rather high illumination level and more xeric conditions.

As regards the edaphical conditions, the properties of the humus layer are a good measure of the nutrient supply in the rhizospheric horizon of the plants (e.g. Aaltonen 1940, Hinneberg 1972). Therefore, attention has been paid to the amount of humus material and its chemical properties, instead of to the underlying mineral soil. It has previously been demonstrated that the pH value of the soil and the total contents of nitrogen and calcium reflect the fertility and the productive capacity of the site rather reliably (e.g. Valmari 1921). Accordingly, variables measuring the corresponding characteristics in the humus layer are incorporated in a measurement model. The amount of humus material is omitted from the model, but is used independently in further comparisons.

Correlations between the measured soil characteristics indicate strong mutual connections (Table 3). The acidity of the soil is associated with the calcium content, which affects the availability of nutrients for plants. The strong positive correlation between the nitrogen and the calcium content is probably due to the fact that the rate of nitrogen mineralization is dependent on the calcium content (e.g. Mälkönen 1982).

The parameters of the measurement model are presented in Table 5. The formulation of the model is equivalent to the model for the tree stand factor. The squared multiple correlations, as well as the t-values, indicate high reliabilities of the x-variables. The coefficient of determination is very high, 0.842, indicating that the measurement model is good. The latent variable $x_2$ can be considered to reflect the overall fertility of the site quite well. As regards the factor scores regressions, the calcium content has the highest weight, whereas the weight of the nitrogen content is rather low. High factor scores may be interpreted to indicate high site fertility, whereas low factor scores are associated with less fertile sites. Computed factor scores are treated as a dependent variable, which is later called the fertility factor.

Consequently, two latent variables (i.e. the tree stand factor and the soil fertility factor) and one observed variable (the amount of humus material) are used in further comparisons. It should be noted that the two latent variables were calculated separately, i.e. the correlation between $x_1$ and $x_2$ were fixed to be zero (cf. Jøreskog & Sörbom 1981).

### Table 5. Parameter estimates of measurement model for soil fertility. FCR = factor scores regressions.

<table>
<thead>
<tr>
<th>Variable - Huone</th>
<th>Lambda x</th>
<th>t-values</th>
<th>Theta $x$</th>
<th>t-values</th>
<th>R square</th>
<th>FCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH of humus - humusen pH</td>
<td>0.799</td>
<td>8.110</td>
<td>0.362</td>
<td>3.526</td>
<td>0.638</td>
<td>0.349</td>
</tr>
<tr>
<td>Nitrogen content - Typpiptieinuus</td>
<td>0.568</td>
<td>5.785</td>
<td>0.677</td>
<td>6.492</td>
<td>0.323</td>
<td>0.133</td>
</tr>
<tr>
<td>Calcium content - Kalkeiptieinuus</td>
<td>0.869</td>
<td>8.818</td>
<td>0.245</td>
<td>2.198</td>
<td>0.755</td>
<td>0.561</td>
</tr>
<tr>
<td>Total coefficient of determination</td>
<td>0.842</td>
<td></td>
<td></td>
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</tbody>
</table>

### 6. RELATIONSHIPS BETWEEN SITE FACTORS AND VEGETATION UNITS

Computed scores for the tree stand factor and the fertility factor, as well as the observed amounts of humus, were allocated according to the division of the sample plots into vegetation units (1–7). The differences between vegetation units were tested statistically in order to examine the ecological character of different vegetation types and to give some information about the dependency of the vegetation pattern on the measured environmental characteristics. The results of the analyses of variance and the multiple range tests are given in Tables 6–7. An asterisk (*) denotes pairs of groups which differ significantly at the 0.05 level. An (o) denotes pairs of groups which differ significantly at the 0.10 level.

The results concerning the tree stand factor are presented in Table 6. The lowest scores are observed in units 1 and 2; they differ significantly from all the other units. The fact that the vegetation of these units is characterized by light-demanding, relatively xerophilous plants fits well to the ecological interpretation of the tree stand factor. Vegetation unit 3 seems to represent a spruce-dominated, dense stand of the Myrtillus type, whereas unit 2 resembles a more pine-dominated and open stand of the same site type. Vegetation units 3–7 seem to closely resemble each other: they represent largely spruce-dominated, relatively dense and closed forest stands. The differences between units 5 and 7, although not statistically significant, give support to the interpretation of the vegetation analysis: the general character of the vegetation in unit 7 indicates moister and more shady conditions than that of unit 6.

The results concerning the fertility factor are presented in Table 7. The differences are very clear and largely in agreement with the forest site type theory: vegetation units related to the Oxalis-Myrtillus type site represent statistically more fertile sites than those related to the Myrtillus site type. As regards units 1–3, only a slight difference between units 2 and 3 can be found. The lower fertility in unit 3 may be a result of the accumulation of raw humus, which often takes place in spruce-dominated, dense stands (cf. Aaltonen 1940, Sirén 1955). As far as vegetation units 4–7 are concerned, the fertility index increases in accordance with the ordination produced by TWINSPLAN (cf. Table 7. Distribution of fertility factor scores in different vegetation units.

<table>
<thead>
<tr>
<th>Group Mean</th>
<th>Ryhmä</th>
<th>Keskitaso</th>
<th>1.</th>
<th>2.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>7.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>-3.653</td>
<td>3.</td>
<td>2.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>3.070</td>
<td>3.</td>
<td>2.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>8.483</td>
<td>3.</td>
<td>2.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>1.849</td>
<td>3.</td>
<td>2.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>10.621</td>
<td>3.</td>
<td>2.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>10.073</td>
<td>3.</td>
<td>2.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>15.060</td>
<td>3.</td>
<td>2.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
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</tr>
</tbody>
</table>

### Table 6. Distribution of tree stand factor scores in different vegetation units.

| Multiple range test (LSD) - Keskitaso monicertaaila (LSD-test) |
|---------------------------|-------------------|-------------------|-------------------|
| Group Mean | Ryhmä Keskitaso | 1. | 2. | 4. | 5. | 6. | 7. |
| 1. | -3.653 | 3. | 2. | 4. | 5. | 6. | 7. |
| 2. | 3.070 | 3. | 2. | 4. | 5. | 6. | 7. |
| 4. | 8.483 | 3. | 2. | 4. | 5. | 6. | 7. |
| 2. | 1.849 | 3. | 2. | 4. | 5. | 6. | 7. |
| 6. | 10.621 | 3. | 2. | 4. | 5. | 6. | 7. |
| 5. | 10.073 | 3. | 2. | 4. | 5. | 6. | 7. |
| 7. | 15.060 | 3. | 2. | 4. | 5. | 6. | 7. |

### Analysis of variance – Variansi analyysi

| F-ratio - F-table | 4.748*** |

### Table 7. Distribution of fertility factor scores in different vegetation units.

| Multiple range test (LSD) - Keskitaso monicertaaila (LSD-test) |
|---------------------------|-------------------|-------------------|-------------------|
| Group Mean | Ryhmä Keskitaso | 1. | 2. | 4. | 5. | 6. | 7. |
| 1. | 1.785 | 3. | 2. | 4. | 5. | 6. | 7. |
| 2. | 1.820 | 3. | 2. | 4. | 5. | 6. | 7. |
| 4. | 1.898 | 3. | 2. | 4. | 5. | 6. | 7. |
| 2. | 2.011 | 3. | 2. | 4. | 5. | 6. | 7. |
| 6. | 2.034 | 3. | 2. | 4. | 5. | 6. | 7. |
| 5. | 2.145 | 3. | 2. | 4. | 5. | 6. | 7. |

### Analysis of variance – Variansi analyysi

| F-ratio - F-table | 12.483*** |
Table 1. In other words, the order of the samples, as well as the arranged species list, reflects the overall fertility of the site remarkably well; the abundance of exacting herbs, grasses and bryophytes increases in accordance with the site fertility. The fertility of the sites assigned to unit 4 can be related to that of unit 2; the low fertility of the former may be connected to the effects of paludification. Vegetation units 5-7 seem to make up somewhat different fertility classes, although their limits are gradual.

As regards the amount of humus material, analysis of variance indicates no statistically significant differences. The multiple range test, however, indicates that the amount of humus is somewhat higher on sites assigned to unit 3 than in, for example, those assigned to unit 5. The difference may be interpreted by examining the differences in vegetation composition: the somewhat more luxuriant vegetation in unit 5 indicates a faster rate of litter decomposition as well as a faster carbon and nutrient cycle, whereas in unit 3 the accumulation of raw humus has apparently taken place.

7. DISCUSSION

7.1. Methods

Divise classification methods have seldom been used in forest vegetation research. Jeglum & al. (1982) and Jones & al. (1982) applied TWINSPLAN for the classification of Canadian forest ecosystems. In Finland, Paikaninen (1982) has used association analysis (Williams & Lambert 1960, Podani 1979) for the numerical classification of southern Finnish forest types. Due to its polythetic nature and the effective use of quantitative information, TWINSPLAN can be regarded as the most appropriate method for divisive classification, particularly when the vegetation consists of many constant plant species (Gauch 1982). In its emphasis on indicator species, TWINSPLAN resembles the approach used in practical determination of the Finnish forest site types. The method emphasizes specific, relative abundances of different species rather than absolute coverage values. The use of the Hult-Sernander scale as the pseudospecies cut levels also emphasizes the differences at low abundance levels: lower coverages are scaled more accurately than high ones. Hence it follows that the differences between the coverages of abundant, but less informative common forest plants, affect the classification less than the abundance relationships between indicator plants often characterized by a relatively scanty occurrence. However, the sensitivity of TWINSPLAN also makes its sensitive to random (ecologically insignificant) variation in species' abundances. Therefore, the divisions of small groups at low classification levels especially, must be interpreted with care; in many cases it would be useful to analyze the vegetation data by more than one numerical methods simultaneously (cf. Jones & al. 1982).

TWINSPLAN reconciles the practical need to form vegetation classes for forest mensurational purposes with the reality of vegetation continua by using ordination to classify both the samples and the species. In this application of TWINSPLAN, the classification of both samples and species seems to reflect the overall fertility of the site considerably well. The common character of the variation in the vegetation pattern, as well as in fertility characteristics, can be seen in the results: abundances of different species change gradually along the vegetation continuum, thus reflecting the gradual change in site quality. Generally speaking, a correspondingly arranged matrix of species and units, based on a larger and more representative material, would probably be a more suitable tool for site evaluation than qualitative descriptions of vegetation in defined, distinct site classes.

From the viewpoint of classification, it is interesting to compare these results with the application of TWINSPLAN for Canadian boreal forest vegetation presented by Jones & al. (1982). Although Jones & al. used only presence/absence data instead of coverage classes, their main division of the samples is equivalent to the first division presented in this study: it subdivides the population into those plots with a reasonably well represented herb and grass vegetation from those plots with a poor to non-existent herb and grass vegetation. The method Jones & al. used for treating the soil data was based on the classification and ordination of site properties, independently of vegetation classification, and is thus not comparable with the results presented here. However, if the main emphasis is on evaluating the mensurational fitness of forest vegetation classes, the two-stage method presented here is probably more valid and unambiguous than indirect comparisons between separate classifications.

Confirmatory factor analysis constitutes by measurement models has many applications in ecomometrics and in the social and behavioral sciences (see e.g. Jöreskog 1969, Goldberger 1972, Jöreskog & Sörbom 1981). In the present study, confirmatory factor analysis is applied for the treatment of ecological data.

The fertility of the soil can be regarded as an observable, hypothetical latent variable, which affects the biological productivity of the site (cf. Aaltonen 1940). All measurable soil characteristics, i.e. nutrient contents, acidity, moisture etc., reflect the overall fertility jointly, and often their effects are cumulative or complementary. In the present study, the measurement model for the overall fertility was extremely simple, consisting only of three observed variables and a latent one. The model was specified under the assumption that the pH of the soil and the nitrogen and calcium contents are valid and adequate measures of fertility. The characteristics of the tree stand also form a complex of variables, the effects of which are not easy to examine separately. Although the model presented for the tree stand factor seems to describe well some of the essential characters of the tree stand, it needs further development and testing in a less uniform material. The validity of the models could be improved by incorporating additional variables characterizing the properties of the soil and the tree stratum.

In practical evaluation of the site quality, the main emphasis is on determining the biological productivity of the site. The major difficulty is encountered in the treatment of a great number of site factors, which affect the site productivity jointly. Confirmatory factor analysis provides a statistical tool for the analysis of the covariance structure between the site factors. The method also provides tools for examining the fit of the model and deciding where the lack of fit is. Thus it enables stepwise improvement of the model (cf. Jöreskog & Sörbom 1981).

7.2. Results

The results presented here emphasize the role of exacting herbs and grasses as indicator species, whereas quantitative differences in the abundances of constant forest plants, such as Vaccinium myrtillus and common forest mosses, are less informative. As discussed by e.g. Werger & Maarel (1978), there is a shift in the ecological indicator value of a given species. Near the margins of their distribution area, species are more specific environmental indicators than in the more central parts of their distribution area. Near the centre of a species' distribution area, ecological amplitude of the plant fits well to the combination of the governing environmental factors, and thus it is strongly competitive to other species. Towards the margins, the environmen-
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1–16; this differs from the variation ob-
served in the sample subset assigned to the 
Oxalis-Myrtilus site type is insignificantly small.
SELOSTE
TUOREIDEN KANGASMETSINEN KASVILLIITUEDEN JAKAUTUMINEN SUhteessa ERAISHIN PUUSTON JA MAAPERÄN TUNNUKSIN

Työssä tarkastellaan Etelä-Suomen tuoreiden ja lehtomailta ennen karsintaa metsätyypikuvassa ilmenee vaihteleva ja siihen vaikuttava tekijöitä sekä eräiden monimuotojen metsätyypien soveltuavuutta kasvupaikkakulloista tuesta koskevan tutkimuksen. Kerätyn petittyösaainetiston pohjalta suoritettiin piintakasvillisuuden lajiasteiden ja näytealojen yhteenkuvin kutkimalla ja käytöllä. Tutkimus on suunniteltu ja suoritettu valtakunnallisilla ja kansallislaitoslailla, ja osa näitä tutkimuksia on julkaisemassa ja kirjoitettavissa olevissa tutkimuksissa.


FLIGHT PERIODS OF SOME BIRCH TIMBER INSECTS
KARI LÖYTNYIEMI
Selostus
KOIVUPUUHYÖnteisten Lentoaajoista
Suunutti tiedotuskirje 1.12.1983

FLIGHT PERIODS OF BIRCH TIMBER INSECTS

Flight periods of birch timber insects were observed by means of window flight traps baited with freshly cut birch (Betula spp.) logs in five locations in Finland from 1972 to 1976. Only a few species were caught during the study. In general, these species were on the wing during midsummer, although flight periods of some of them were relatively long. Scolytus rufobrunnus caused harmful staining of wood within a month from attack, but the damage by the wood-boring pests remained negligible throughout the first storage season.

INTRODUCTION
Flight periods of insects attacking green birch (Betula spp.) timber, or moribund trees, have not been intensely studied in Finland, nor in neighbouring countries in corresponding conditions. Information on this would, however, be useful for timber protection purposes. Insect boring may especially degrade valuable saw and veneer logs during leaf seasoning (cf. Hakkila et al. 1970) but is harmful also in birch pulpwod, promoting deterioration (Pekkala and Uusvaara 1980). This study was therefore designed to provide basic information on flight periods of common occurring insects attacking freshly cut birch logs in Finland.

MATERIAL AND METHODS

Window flight traps (Chapman and Kinghorn 1955) were used for flight monitoring. The traps, two in each location, were baited with birch logs cut monthly from early April to early September. Betula pendula was used as bait in South Finland but B. pubescens in the north. In addition to the flight observations, actual attack on the bark logs was inspected. Data on weather conditions during the 1972-1975 study seasons have been presented previously (Uusvaara and Löytöniemi 1977).