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# Inter-observer variation in forest vegetation cover assessments

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*TIIVISTELMÄ: HAVAINNOITSIJAN AIHEUTTAMA VAIHTELU METSÄKASVILLISUUDEN KUVAAMISESSA*

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Differences in vegetation cover estimation by field biologists of the 8th National Forest Inventory were tested. Eleven observers estimated the canopy coverages of six forest taxa in 25 sample plots, located in one stand. The experiment was arranged after the field work. The coverage of *Vaccinium vitis-idaea* and the ground layer appeared to be the most difficult to estimate. The mean of the highest estimator was about double that of the lowest one. The least abundant species and the sample plots with the smallest coverages had the largest estimation errors. The most important compositional gradient of the data was natural, even though the test was made in a homogeneous area. However, the effect of the observer could be recognized. The differences between observers could be caused by the differences both in visual estimation level and in placing the sampling frame. The results suggest that tests should always be made when several observers are used in vegetation surveys. If calibration is used, it should be made separately for each species.

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Tutkimuksessa testattiin valtakunnan metsien 8. inventoinnin kenttäbiologien kasvillisuuden peittävyysarvioiden eroja. Yksitoista havainnoitsijaa arvioi kuuden metsäkasvilajin tai lajiryhmän peittävyyden kenttäkauden jälkeen 25 näytealalta yhdestä männiköstä. Puolukan ja pohjakerroksen peittävyyksien arvioinnissa olivat suurimmat havainnoitsijakohtaiset erot. Suurimpia arvoja saaneiden havainnoitsijoiden keskiarvot olivat noin kaksi kertaa niin suuria kuin pienimpiä arvoja saaneiden. Niukimpien lajien ja pienten näytealoittaisten peittävyyksien estimointivirheet olivat suurimpia. Aineiston päävaihtelusuunta oli luonnollinen, näytealojen kasvillisuuden vaihtelusta aiheutuva, vaikka koe tehtiin homogeenisella alueella. Kuitenkin havainnoitsijasta aiheutuva vaihtelu oli tunnistettavissa. Havainnoitsijoiden väliset erot voivat johtua sekä visuaalisen arviointitason eroista että näytealan paikallistamiseroista. Usean henkilön kerätessä kasvillisuusaineistoa havainnoitsijoiden väliset erot tulisi aina testata. Havainnoitsijoittaisten korjauskertoimien tulisi tulosten perusteella olla lajikohtaisia.

Keywords: forest vegetation, vegetation survey, canopy-coverage estimation. ODC 182.5 + 524.63

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# 1. Introduction

The visual canopy-coverage estimation method is commonly used in extensive vegetation surveys because it is both quantitative and quick to carry out. The problem of subjectivity always exists when vegetation data are collected by visual methods and several observers. Subjectivity is often discussed, but surprisingly seldom tested. The problem is important especially when the results of extensive vegetation surveys are analysed and short ecological gradients, where the changes occur in species abundance ratio rather than in species exchange, are being studied. Gradients caused by succession or air pollution are examples of this kind of variation.

During this century two large forest vegetation data sets have been collected in Finland. The first one is the material of the 3rd National Forest Inventory (NFI), collected in 1951–1953 by 42 observers (Kujala 1964). The second one is the material from the permanent sample plots of the 8th National Forest Inventory collected in 1985–1986 by 13 observers (see Reinikainen and Nousiainen 1988). As the vegetation of the permanent sample plots is to be surveyed at 10-year intervals, the observers performing the next survey will probably not be the same as those in 1985–1986. It is therefore highly important to determine the extent to which a change in observers affects the results. In addition to inter-observer variation, annual random fluctuations in vegetation can also affect the results (Kennedy and Addison 1987).

The aim of this study is to determine the estimation differences between the biologists of the 8th National Forest Inventory, and to discuss the problem of subjectivity in vegetation analysis in general. The biases caused by the estimation scale and the abundance of the species will also be discussed.

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# 2. Material and methods

Eleven observers were tested between October 22nd and 29th, 1985, 1–2 weeks after they had finished an intensive period of field work lasting for 4.5 months. During the field period each observer had at least ten opportunities to compare his/her skills with those of some of the others.

The test was performed in Tuusula, Ruotsinkylä, 25 km north of Helsinki. The test area was about 30 x 50 meters in size, and was located in a mature stand dominated by *Pinus sylvestris*. The site was of the Vaccinium type, and has been slightly disturbed by trampling. There were no visible gradients in the vegetation. The field and ground layer vegetation consisted of about 30 species. The coverage of litter was about 13 %.

There were five lines with five sample plots on each running through the test area. The center point of each sample plot was marked, and the observers placed the 2 m$^2$ sampling frame (Fig. 1) according to their own discretion as in the 8th NFI. The observers were asked not to discuss the work with each other.



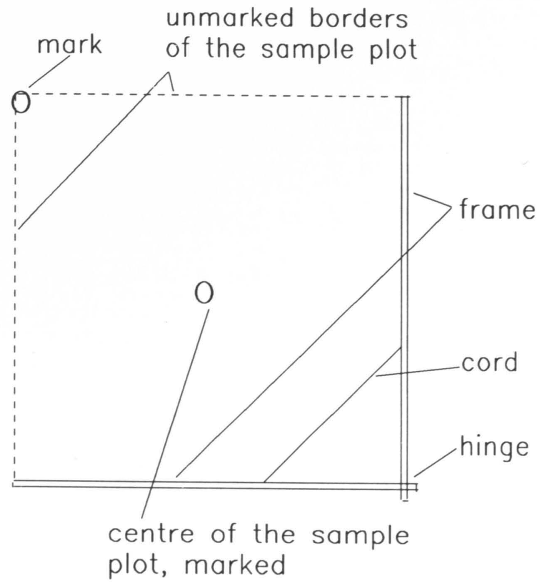


Fig. 1. The sample plot used in the test. The length of the side is 1.4 m, and the area is 2 m$^2$.

Each observer estimated the percentage cover of *Vaccinium vitis-idaea* L., *Deschampsia flexuosa* (L.) Trin., *Dicranum polysetum* Sw., *Dicranum spp.* Hedw., *Polytrichum juniperinum* Hedw. and the total coverage of the ground layer on the same 25 sample plots. The scale consisted of classes of 0.1, 0.2, 0.5, 0.7, 1, 2, 5, 7, 10, 15, 20, 25, 30, 40, ... 90, 93, 95, 97, 98 and 99 per cent.

The differences between the observers were tested with the Kruskal-Wallis one-way variance analysis for each species. The mean coverages and the coefficients of variation of the sampling area were calculated for each species. The relationship between mean coverage and the coefficient of variation of each sample plot was evaluated by means of regression analysis in order to determine whether the abundance affected the error of the estimate.

Correspondence analysis (CA) was done with CANOCO (Ter Braak 1987) in order to compare the effect of the observer on other variation components in the data set. The same sample plots observed by several observers were treated as separate samples in the analysis. *Polytrichum juniperinum* was excluded from the analysis because it occurred on only three sample plots and could be considered an outlier species. A Kruskal-Wallis one-way variance analysis was performed.

# 3. Results

The coverage estimates of *Vaccinium vitis-idaea* and the ground layer indicated statistically significant inter-observer variation (Fig. 2). The mean of the highest estimator was about twice that of the lowest one. The standard deviations and the coefficients of variation of the observers' estimates differed considerably, indicating that the observers had different scale ranges. The same observer did not seem to systematically underestimate or overestimate different species, except observer B, who seemed to estimate high values for most of the taxa.

The proportional variation of the estimation level of the observers was largest for the least, and smallest for the most

Table 1. Means ($\bar{x}$) and coefficients of variation (C.V.) of the means of percentage cover estimates of different plant species made by eleven observers.

| Species or species group | $\bar{x}$ (%) | C.V. |
|---|---|---|
| *Polytrichum juniperinum* | 0.4 | 0.37 |
| *Vaccinium vitis-idaea* | 12.7 | 0.31 |
| *Deschampsia flexuosa* | 23.2 | 0.27 |
| *Dicranum polysetum* | 23.9 | 0.23 |
| *Dicranum* spp. | 25.0 | 0.22 |
| Ground layer | 63.4 | 0.15 |

abundant species (Table 1). The abundance also affected the variation in the coverage estimates within each species (Fig. 3). The smaller the coverage of the plant, the larger was the coefficient of variation.

The first CA axis (eigenvalue 0.23, length of gradient 3.5 S.D.) was interpreted to be a natural moss – grass axis, which is also a light – shade gradient (Fig. 4). There were no significant differences between the sample scores of the different observers (H = 14.37 n.s., df = 10). The second CA axis (eigenvalue 0.04, length of gradient 3.8 S.D.) was much weaker than the first, and was characterized by the effect of the observers (Fig. 4). The sample scores of the

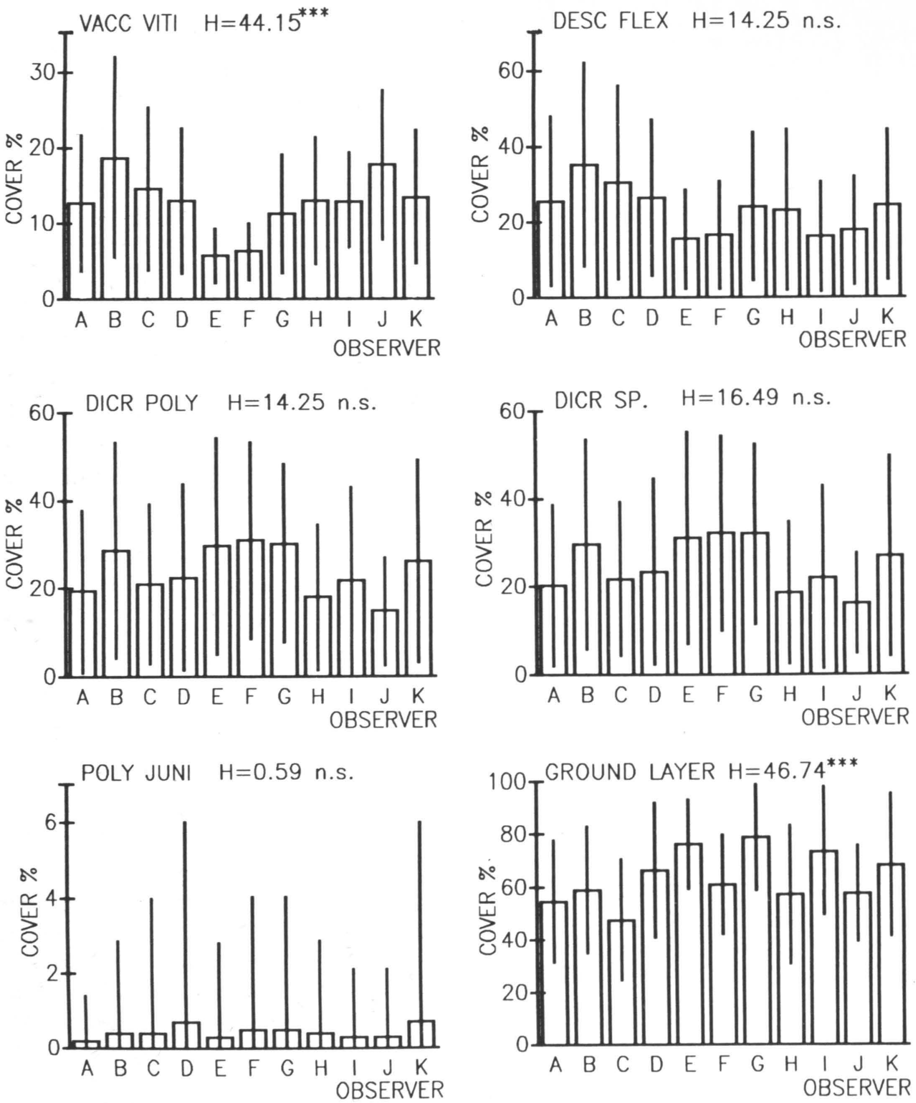


Fig. 2. Means and standard deviations of the projection coverage estimates made by several observers. The species or species groups are: *Vaccinium vitis-idaea, Deschampsia flexuosa, Dicranum polysetum, Dicranum* spp., *Polytrichum juniperinum* and ground layer. The result of Kruskal-Wallis one-way variance analysis (H) is given above each figure.



observers differed (H = 57.19***, df = 10). There were highly significant differences between the sample scores of the plots within both axes (H = 232.61***, df = 24, and H = 157.99***, df = 24). Differences in the coverage estimates of *Vaccinium vitis-idaea* and the ground layer characterized the second axis. The sample scores of the observers varied more than those of the plots.

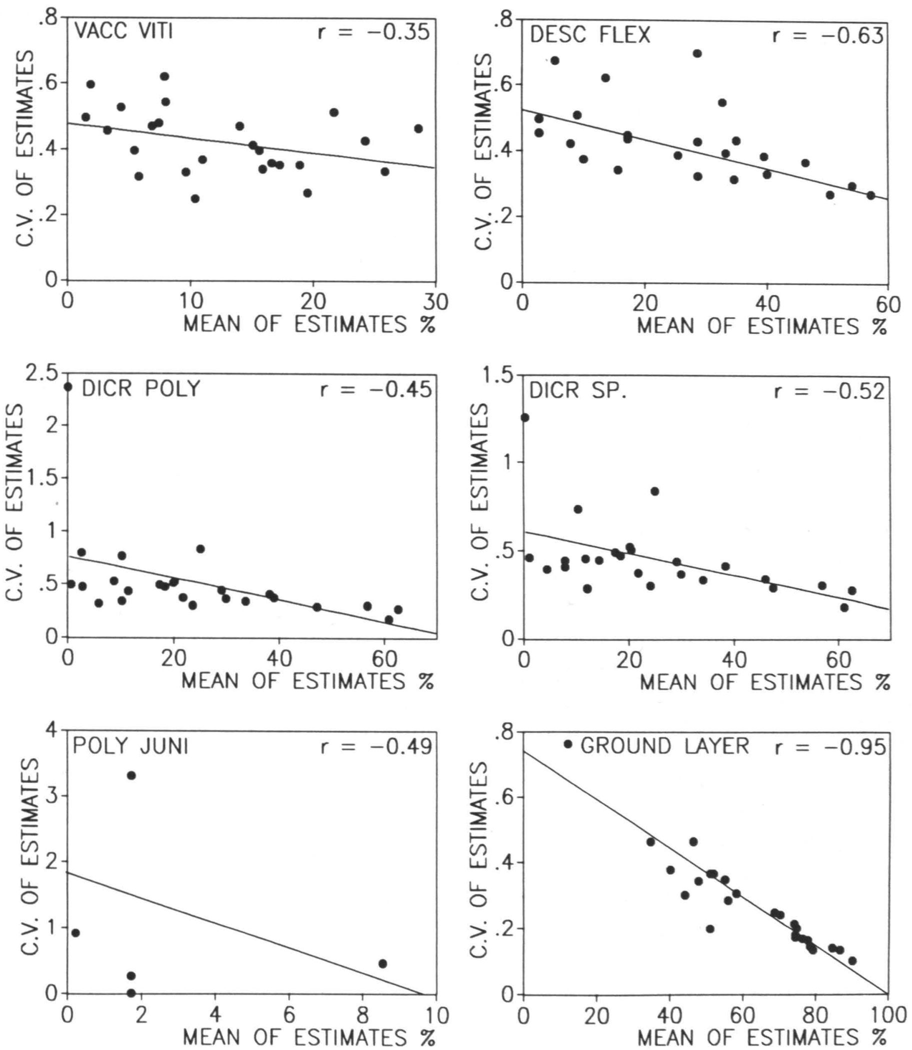


Fig. 3. Regression between the mean and the coefficient of variation of the coverage estimates of each sample plot. Each dot denotes one sample plot. r = regression coefficient. Species are the same as in Figure 2.

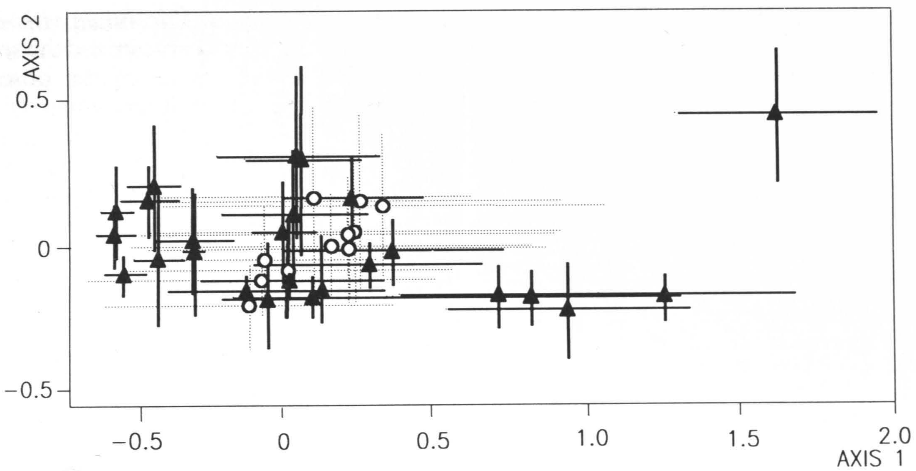


Fig. 4. Means and standard deviations of sample scores of each observer (circles) and of each sample plot (triangles) in a correspondence analysis (CA).

## 4. Discussion

These results are to a great extent similar to those reported by Sykes et al. (1983). The variation caused by the observers is about as large. The size of the estimates differ within all the estimation objects, but the errors are of varying magnitude.

According to Clymo (1980) and Hope-Simpson (1940), differences commonly exist between the reliabilities in estimating the coverages of different species, for instance when two species are very similar. This could have been the case e.g. with *Dicranum* species in this study.

It is often postulated that the variance in estimation levels depends on the habitus of the plant: the coverage of *Deschampsia flexuosa* could be more difficult to estimate than that of the whole ground layer. According to Kennedy and Addison (1987), some morphological features, e.g. leafy creeping stems and variable leaf size, are difficult to estimate. Small species with a low coverage are also difficult to find. *Polytrichum juniperinum* could be such a species in this data set. Species which are easily seen but have limited distribution are easiest to estimate (Kennedy and Addison 1987).

There are two main causes of the differences in coverage estimation. The most discussed one is the difference between the observers' visual estimation levels, and the second is the difference in placing the sampling frame in the field. These differences can be random or systematic. The second reason is most likely in the case of species that occur in patches, e.g. *Vaccinium vitis-idaea*. This could explain the large differences in estimation levels, even though this species belongs to the easy-to-see group. This would suggest that the sample plot size commonly used in Finnish vegetation surveys is too small.

These results support the view of Sykes et al. (1983). If calibration is used, the correction coefficients should be calculated separately for each species, because individual observers have different biases for different species. For example, observers E and F estimated the smallest mean coverages for *Vaccinium vitis-idaea* and *Deschampsia flexuosa,* but the largest ones for *Dicranum polysetum* and *Dicranum spp*.

Even though a scale with narrower classes for smaller coverages was used, the results of this study agree with Kennedy and Addison's (1987) observation that the species with lowest mean coverages have the largest errors (Table 1). However, Sykes et al. (1983) came to an opposite conclusion: the coverage has the largest error in the 50 % coverage region, and smaller errors in the extremes. Fig. 3 shows that the abundance has an effect on the proportional error of the estimates, but there are differences between the species. It seems that, in the case of *Vaccinium vitis-idaea,* the abundance has the smallest and in the ground layer the largest effect on the variation in estimation accuracy. However, the dependence does not seem to be non-linear as Sykes et al. (1983) have observed.

There are also some theoretical problems associated with the use of coverage classes. Floyd and Anderson (1987) have demonstrated that the canopy coverage method overestimates the coverages of least abundant species. The real frequency distribution of small and rare species is negative exponential, but it is assumed that the coverage values are uniformly distributed around the midpoint of each coverage class.

Jukola-Sulonen and Salemaa (1985) also found out that observers tend to underestimate large and overestimate small coverages. When the coverage is around 50 %, the observer has an equal chance to either underestimate or overestimate the abundance – if we do not take into account the argument of Floyd and Anderson (1987). If the coverages are very small or very large, the observer has a possibility to make only small errors towards the extremes, but larger ones towards the midpoint of the scale.

Constant class width causes larger proportional error of the estimate accuracy in classes of lower abundance than in classes of higher one. The method utilizing all possible coverage values between 0 and 100 could be more suitable because the coverages could be used as true continuous variables where there would be no bias caused by the discreteness of the scale and the different sizes of the coverage classes.

The differences between the observers are considerable. However, the vegetation data set of the 8th NFI can be used as well as the data from some other large vegetation data sets. The most important gradient of the test material is the natural shading gradient, even though the test was done in a small, homogeneous area. Even in the second CA axis which best explains the effect of the observers, the means of the sample scores of the sample plots differed more than those of the observers.

All the observers were known to be skilled in identifying plant species. There is thus no need to omit out any observers as Kujala (1964) did when analysing the data of the 3rd NFI. Hope-Simpson (1940) suggested that, in the case of large inventories, many tests should be made during the course of the field work. The differences between the observers could be even greater without training during the field period. According to Smith (1944) and Kennedy and Addison (1987), training reduces the effect of the observer. Thus the error variance could be bigger at the beginning of the field period than later on. The effect of the observers can also be reduced by applying a transformation in the data analysis.

Inter-observer variation considerably affects the interpretation of vegetational change on the permanent sample plots. In this study error caused by the observer was about 15–40 % of the coverage. Sykes et al. (1983) and Kennedy and Addison (1987) noticed that there also were about 10 % errors in sequential measurements obtained by same observers. According to Kennedy and Addison (1987), occasional between-year and within-year variation of the vegetation causes a 10 % uncertainty in vegetation monitoring. So the changes in vegetation have to be quite large to be ecologically interpreted in case of individual sample plots of the 8th NFI.

The variation caused by the observer is always present in the visual coverage assessment method. Multivariate methods can effectively reduce the noise in the data, but the effect of the observer should be considered when data sets of large vegetation inventories are analysed.

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