Plant cover estimate in long-term monitoring

– how to assess its precision

Master's thesis 20 p

(examensarbete)

by

Stina Lundström

Department of Environmental Assessment
Swedish University of Agricultural Sciences (SLU)
Box 7050 SE 75007 Uppsala
Supervisor: Sven Bråkenhielm

2000 Rapport 2000:8

Contents

Abstract

This study will deal mainly with the problem of assessing precision within the framework of the Swedish Integrated Monitoring Programme (IM). Data for the study were collected partly during the early part of the programme that started in 1982, partly during the field season in July 1999. The aspect of variation in species detection on a given sample plot was not considered in this study. Data are judged with reference to a general proposal that Swedish environmental monitoring should, with 95% significance, be able to demonstrate a change in any variable of minimum 20% during 5 years. The mean difference, in absolute values, between any two cover estimates was less than 5% in 95 per cent of the occasions. In relative values the mean difference was larger, i. e. 14% with species covering twenty per cent or more and 34% with species that cover less than one per cent. It is recommended not to consider relative changes when the cover is small, e.g. 10 per cent and less, because of the extreme values that may ensue from such calculations. The variation between estimates produced only a small effect on community sensitivity, "Ellenberg", indices. Of sixteen species specially studied, the intrapersonal difference was significantly lower than the interpersonal one only for *Pleurozium schreberi*. Of three high-cover species only *Vaccinium myrtillus* showed a significant difference between series of paired observations. There was a comparatively high correlation between cover estimates in the field and cover measured on photographs.

Introduction

For repeated observation, e. g. in long-term monitoring, cover estimate has proven a fast and effective way of quantifying plants without destroying them (Bråkenhielm and Qinghong, 1995a). However, the visual cover estimate has an inherent subjectivity which has alerted some scientists to study it (Ericson, 1975; Sykes *et al*., 1983; Kennedy and Addison, 1987; Tonteri, 1990). In order to be able to assess the precision, i. e. repeatability, of a cover estimate the actual variation in that or those persons involved must be considered. For assessing accuracy, i.e. the proximity to true cover, an exact measure of the cover must be obtained, e.g. via a photograph. However, as a rule it is practically impossible to measure all species on a photograph due to frequent overlap of foliage. Therefore, in practice one has to resort to some sort of estimate in repeated, non-destructive observation of plants. This study will deal mainly with the problem of assessing precision within the framework of the Swedish Integrated Monitoring Programme (Naturvårdsverket, 1993).

Integrated Monitoring (IM) was initiated in the early 80´s as a means of measuring the impact of changes in air pollution on the ecosystem following the ratification of the UN-ECE convention on Long-Range-Transboundary air Pollution of 1979 (Bernes, 1990). This is accomplished by long-term monitoring of the main physical, chemical and biological processes in natural ecosystems uninfluenced by recent management. The IM sites are situated along air pollution gradients in order to represent various degrees of impact. The biological subprogram mainly involves plant species and communities as indicators of chemical change and as components of biological diversity. For both these purposes the precision in the quantitative assessment of plants is crucial.

According to a guideline once proposed by the Swedish Environmental Protection Agency, SEPA (Naturvårdsverket, 1993) the methods applied in environmental monitoring should, with 95% significance, be able to detect a change of more than 20% during 5 years. If the variation in the method is greater than 20% the result is not satisfying.

Few studies on the quality of cover estimate data have been published compared with the vast amount of papers based on the method. The problem has been dealt with in various ways. Ericson (1975) studied the differences in vegetation cover estimate between observers (interpersonal comparison) as well as for one observer on different occasions (intrapersonal comparison). The interpersonal comparison showed small variation from the mean value in the highest class (cover 55-96%). In the highest and the lowest cover classes (≤5.5%), the intrapersonal variation was much lower than the interpersonal one. For species in the intermediate cover classes, the intrapersonal variation was almost as wide as the interpersonal comparison. According to Ericson a difference of up to ±60 % from the mean value is a realistic and acceptable result when using more then one observer.

Like Ericson, Sykes *et al*. (1983) examined the intra- and interpersonal differences. They used quadrats of different sizes: 4 m^2, 50 m^2 and 200 m^2 in the test. The interpersonal differences were significant on all occasions, irrespective of species and quadrat size. The smallest range of interpersonal difference was 17% on the 4 m^2 and the largest 88% on the 200 m^2 quadrat. In the intrapersonal difference test, half the test runs differed significantly. The estimates were usually less than 5% and seldom more than 10% apart. The highest variation occurred in species with around 50% cover and the smallest with around 0% and 100% cover.

In order to determine the precision Kennedy and Addison (1987) had one observer repeat the same set of sample plots nine times during a period of eleven days. The largest relative errors appeared in the species with the lowest mean cover. For the eight species with the lowest cover the mean difference was 63% of the mean cover. For the eight species with the highest cover the mean difference was only 12%. Despite some large errors, the nine samples repeated after each other were very similar – according to Sorensen's index 88-96% similarity. The precision increased initially as the observer grew more familiar with the vegetation. According to Kennedy and Addison, temporal changes in vegetation need to be larger than 20% not to be attributed to estimate errors or annual fluctuation. They concluded that 10% error depended on the estimate.

Tonteri (1990) showed that the coefficient of variation, which is related to the mean difference, was largest in species with small cover and smallest in species with large cover. The result indicated that the observers had different scale ranges. The ranges also seemed to be different for different species, indicating that calibration, if used, should be done separately for each species.

Aims

The aims of this study are

- to assess the quality of visual plant cover estimate under the conditions at hand in Integrated Monitoring
- to quantify the inter- and intrapersonal precision in cover estimates
- to recommend measures for maximising the precision of cover estimate

The aspect of variation in species detection on a given sample plot was not considered in this study.

Sites and Methods

Sites

Data for the study were collected partly during the early part of the IM programme that started in 1982, partly during the field season in July 1999. The early observations were done at 18 sites distributed all over the country (figure 1). Most of them were forest sites, some open wetland and some alpine heath. The later study was done in July 1999 at the four current IM sites in Sweden: Gammtratten, Kindla, Gårdsjön and Aneboda. The sites are shortly described in table 1. See further http://info1.ma.slu.se/IM/Sweden/PMKIMinfo.html.

Table 1. Swedish Integrated Monitoring (IM) sites.

Site	County (län)	Community	Lat.	Long.	Area ha	Zone	Dominant plant community
Gammtratten	V.-norrland	Örnsköldsvik	63°51´	18°07´	45	mid. boreal	spruce-Vaccinium myrtillus
Kindla	Örebro	Lindesberg	59°45´	14°54´	19	S boreal	spruce-Vaccinium myrtillus
Gårdsjön	V. Götal.	Stenungsund	58°03´	12°01´	3.7	boreonem.	spruce-Vaccinium myrtillus
Aneboda	Kronob.	Växjö	57°07´	14°32´	20	boreonem.	spruce-Vaccinium myrtillus

Methods

Visual cover estimate

At each site there were one or two so called intensive plots in representative and homogenous plant communities (Bråkenhielm, 1993). The plots were 40 x 40 m in size. On each plot 16 or 32 subplots 0.5 x 0.5 m were distributed in a restricted random fashion so that each 10 x 10 m quadrat received one or two permanently marked subplots (figure 2). On each subplot all species of vascular plants, bryophytes and lichens were registered and their covers estimated visually as per cent of the area inside a frame. The cover of a species or a layer on a plot was defined as the net area of the projection onto the ground of all living above-ground parts of the species or the layer. The cover of repeated layers of the same species was not considered. Only those parts of the plant that were inside the vertical projection of the frame were included either they were rooted inside or not. Also living plant parts covered with litter were included

Figure 1. IM sites in Sweden with vegetation monitoring. Sites monitored currently (•) and earlier (∘).

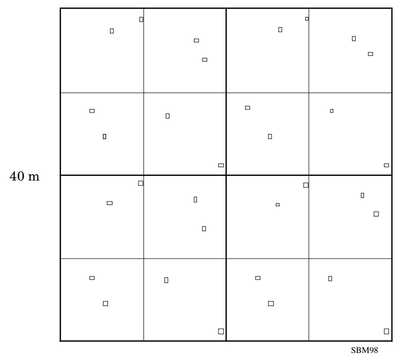


Figure 2. Distribution of subplots on a 40x40 m plot.

On the test occasions two or more observers estimated the cover of all or a limited number of subplots. On some intensive plots the estimates were repeated once, twice or thrice. All observations on the same plot were performed within a few days. In all, the tests were performed at 13 sites on between 3 and 32 subplots with up to 27 species. At Gammtratten 1999 two observers, SBM and SLM, together estimated the cover five times (table 2).

The observers had different experience of cover estimate. Most of them had done estimates for several years, a few were beginners. The study was performed under as realistic conditions as possible. At most occasions the ordinary observer in the area estimated parallel with the "calibrator", the person responsible for the IM vegetation programme. The calibrator, who was the same person all the time, had a long experience of estimating cover.

Table 2. Sites, years, comparisons of observers two by two, number of plots and species on which the analysis is based in the paper. SBM is the "calibrator", i. e. the person responsible for the IM vegetation subprogram, and ALN etc. are observers, responsible for the observations at one or two sites. SLM is the author of this report.

Site	Year	Comparison /observers	Number of subplots	Number of species estimated
Aneboda	99	ALN/SBM	22	20
Aneboda	99	ALN/SLM	21	17
Aneboda	99	SBM/SLM	17	16
Berg	86	ALN/SBM	3	16
Berg	91	ALN/SBM	5	13
Berg	88	ALN/SBM	3	10
Bohult	86	SRE/SBM	5	23
Dalby	86	GSP/SBM	19	4
Gammtratten	99	SBM1/SBM2	32	27
Gammtratten	99	SBM1/SLM1	32	25
Gammtratten	99	SBM1/SLM2	32	26
Gammtratten	99	SBM1/SLM3	19	26
Gammtratten	99	SBM2/SLM1	32	26
Gammtratten	99	SBM2/SLM2	32	27
Gammtratten	99	SBM2/SLM3	19	27
Gammtratten	99	SLM1/SLM2	32	28
Gammtratten	99	SLM1/SLM3	19	28
Gammtratten	99	SLM2/SLM3	19	28
Gårdsjön	99	HEG/SBM	10	17
Gårdsjön	99	HEG/SLM	10	17
Gårdsjön	99	SBM/SLM	10	16
Kindla	99	SBM/SLM	32	23
N Kvill	85	SRE/SBM	4	12
N Kvill	86	SRE/SBM	6	17
Sandnäset	91	RJU/SBM	3	17
Stormyran	88	ÅHA/SBM	4	8
Svartedalen	91	SHU/SBM	3	12
Svartedalen	84	AEB/SBM	4	16
Tiveden	85	AEB/SBM	3	13
Tyresta	91	BEK/SBM	3	13
		Sum	455	568

In the IM vegetation subprogram the four corner subplots on each intensive plot were photographed. Some of the photographs from nine sites and different community types were scanned and transmitted to computer where the cover of the uppermost species was measured. Both manual and automatic delineation of the leaves were applied, in the latter case after deciding a threshold level of brightness of the species to be measured. Covers of some species estimated in the field on one hand and in computer on the other were compared (Liu Qinghong 1997, pers. comm.). Those field estimates were done by different observers.

Analysis

In the analysis of this study, the means of the cover of all subplots on the intensive plot were used. The reason for applying means rather than primary values from one plot is that the mean is generally used in the analysis of data in the IM programme.

Two main sources of variation or error were considered in the present study. One is the variation in estimates between persons, the *interpersonal* variation, the other the variation within the same person, the *intrapersonal* one. Both are highly relevant to quantify. The main exercise with intrapersonal comparison was performed in 1999 and it is from that year that most data are derived (table 2: Gammtratten).

Another source of variation is that originating from the difficulty with which the cover of a species can be estimated. Species differ greatly in their leaf size, shoot morphology and spatial structure as well as in their relative sizes. It is assumed that also an experienced observer notes greater variation in the observation of *"difficult"* species than with others.

The difference between cover estimates of the same plant species on the same plot, the "error" can be expressed in various ways, two of which were used in this study. The *absolute* difference is simply the difference between two or more values. Its size is directly useful to know since the real cover is a basic characteristic of the vegetation, among other things constituting the various vegetation indices. The *relative* difference is the difference between two values expressed as percentage of the estimated cover. It gives the size of the error of a species in relation to its real cover. The relative difference could be suitable when comparing species in different cover classes. It was used by Kennedy and Addison (1987). Relative differences between observations were calculated as the percentage mean difference of the mean cover per comparison following the formula:

$$\textit{relative difference (\%)} = (|A-B| \,/\, mean_{AB}) \times 100$$

where A and B represent the cover (mean of several plots or primary value) of the same species estimated twice, either by two observers on the same occasion or by the same observer on two occasions. $Mean_{AB}$ is the mean of A and B. In the subtraction the sign is ignored.

The species were grouped into four classes according to their mean cover at each comparison:

1) < 1%, 2) 1,0-4,9%, 3) 5,0-19,9%, 4) ≥ 20%

The relative and absolute differences were calculated for the comparisons between field and photographs as well.

In the IM programme vegetation cover is used to find out whether there is biological indication of changes in the ecosystem over the years as a result of reduction in pollutant emissions. To this end various indices are applied. The Ellenberg N-index is supposed to react on change in soil nitrogen and the Ellenberg R-index on soil pH. Not all species have an N- and an R-indicator value. The indices are calculated

$$\textit{community R-index} = \sum[(C_z/C_{\Sigma}) \times R]$$
$$\textit{community N-index} = \sum[(C_z/C_{\Sigma}) \times N]$$

where C_z is the cover of one of the species at the site and C_{Σ} is the sum of the covers of all species with an R- and an N-value respectively. N and R are the indicator values for species z. After all individual species indices have been calculated they are summed into a community index. When calculating the N- and R-indices in vegetation monitoring, the mean cover of each species on the subplots is used (Bråkenhielm and Qinghong 1995b).

Results

Difference between estimates – absolute values

The estimated covers of the species were less than 1% in the majority of the cases. On some occasions they were between 1 and 5% and on a few they were over 5% (figure 3). As a consequence, the differences in estimates were mostly less than 1%. In 95 % of the occasions the differences between the estimated covers were less than 5%, in several cases even 0%.

At Gammtratten, where SBM and SLM estimated the cover five times (table 3), *Vaccinium myrtillus* and *Pleurozium schreberi* were the only species with a cover over 20%. The mean cover of *Barbilophozia lycopodioides* was under 10%. These three species represent different types with regard to spatial structure.

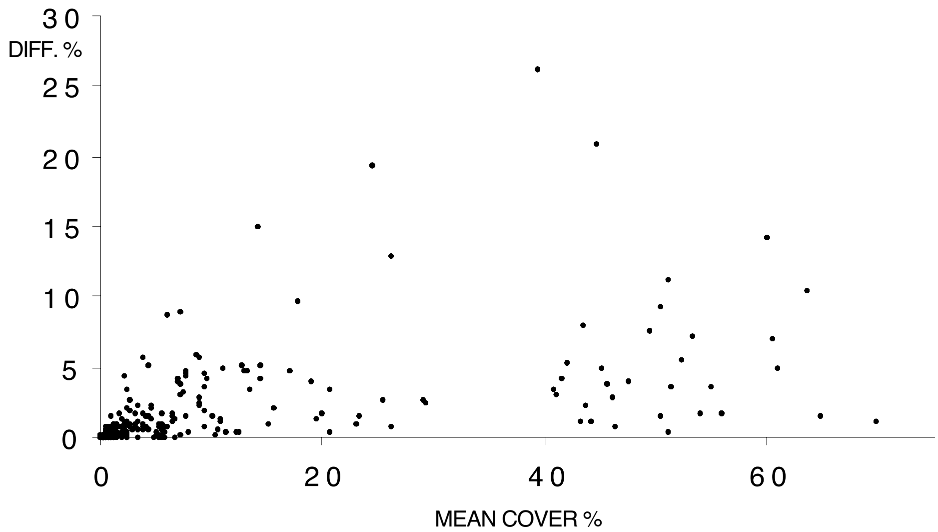
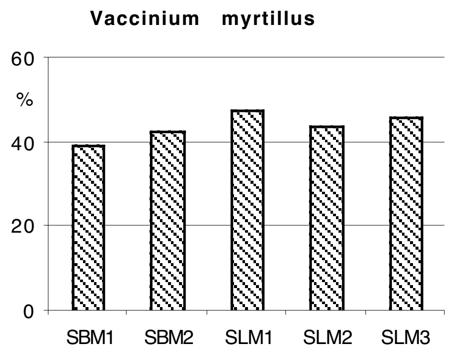


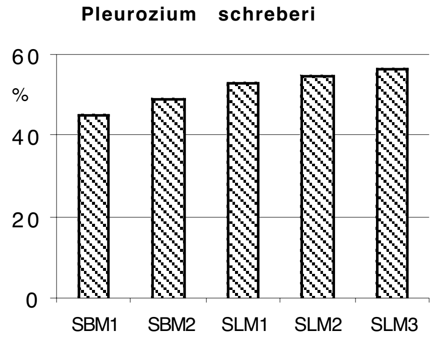
Figure 3. Mean cover of two paired estimates of a species in relation to the difference between them. In all 568 single estimates. In 338 pairs of estimates the mean cover was less than 1%. On 104 occasions the estimates were equal and on 438 occasions the difference was under 5%. (Data according to table 2)

The estimated covers for *Vaccinium myrtillus* were between 39.4% for observer SBM1 and 47.4% for observer SLM1 (table 3, figure 4). The mean cover for all five observations of *Vaccinium myrtillus* was 43.8% ± 13.9% (95% confidence interval) and the mean difference was 5.9% ± 1.5%. At seven out of ten comparisons one was significantly higher then the other (table 4) (Repeated measure ANOVA Df: 18,4; F-value: 11.57; p-value: <0.0001). SBM1/SLM1 had the largest absolute difference and SBM2/SLM3 the lowest (table 5).

Table 3. Mean cover of 16 species estimated repeatedly by two observers SBM and SLM on two and three occasions respectively. SBM1 = observer SBM, occasion 1 etc. Note that SLM3 only observed 19 out of the 32 subplots. (Data according to table 2: Gammtratten.) SD = standard deviation.

	n=32		n=32		n=32		n=32		n=19			Mean
Species	SBM1 Mean	SBM1 SD	SBM2 Mean	SBM2 SD	SLM1 Mean	SLM1 SD	SLM2 Mean	SLM2 SD	SLM3 Mean	SLM3 SD	All Mean	of SD
Pleurozium sch.	45.5	28.5	49,3	26.0	53.1	26.3	54.9	26.9	56.7	24.0	51.9	26.3
Vaccinium myrtillus	39.4	16.3	42,7	17.8	47.4	16.4	43.6	16.6	44.7	12.7	43.6	16.0
Dicranum sp.	6.0	6.5	5,5	5.0	11.6	13.1	7.4	10.4	7.2	10.5	7.5	9.1
Barbilophozia lycop.	5.6	7.5	5,2	7.4	5.4	7.3	5.2	9.8	10.0	13.7	6.3	9.1
Hylocomium sple.	5.8	8.9	6,3	9.5	4.8	6.9	4.9	7.6	9.0	14.1	6.2	9.4
Vaccinium vitis-idaea	2.3	1.2	2,3	1.6	2.4	1.8	2.4	1.8	2.0	1.1	2.3	1.5
Deschampsia flex.	1.2	0.8	1,4	1.6	1.5	2.5	1.2	0.8	1.2	1.0	1.3	1.4
Polytrichum com.	1.0	2.1	1,6	3.0	1.2	2.0	1.1	2.3	1.1	2.3	1.2	2.3
Empetrum herma.	0.6	0.8	0,9	1.2	0.6	1.0	0.7	1.2	0.4	0.8	0.6	1.0
Ptilium crista-cast.	0.5	1.2	0,7	1.7	0.8	2.7	0.5	1.3	0.6	1.6	0.6	1.7
Juniperus com.	0.6	3.5	0,8	3.6	0.3	1.8	0.6	2.8	0.7	2.8	0.6	2.9
Melampyrum prat.	0.7	0.8	0,7	0.7	0.4	0.5	0.6	0.5	0.6	0.5	0.6	0.6
Cladina rangiferina	0.2	0.5	0,3	0.6	0.5	0.9	0.5	0.7	0.4	0.5	0.4	0.6
Sorbus aucuparia	0.3	1.3	0,3	1.4	0.2	1.1	0.5	2.3	0.5	1.7	0.4	1.6
Cladina arbuscula	0.3	0.6	0,4	0.6	0.4	0.5	0.3	0.5	0.3	0.5	0.3	0.5
Calluna vulgaris	0.1	0.6	0,2	0.7	0.3	1.4	0.1	0.6	0.1	0.2	0.2	0.7
SUM	110	-	119	-	131	-	125	-	135	-	124	-





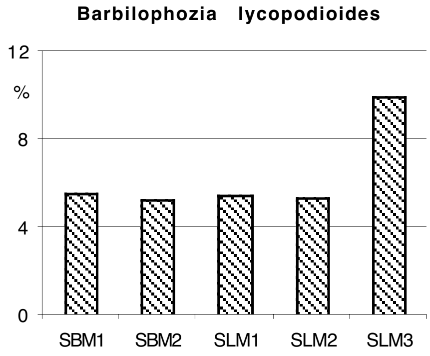


Figure 4. Mean cover of three species with different shoot morphology, estimated repeatedly by observer SBM and SLM on two and three occasions respectively. (Data according to table 2: Gammtratten.)

Table 4. Fisher's PLSD for *Vaccinium myrtillus*. Significance level 5%.

Comparisons	Mean difference
SBM1/ SBM2	-3.00 *
SBM1/ SLM1	-9.84 ***
SBM1/ SLM2	-5.11 *
SBM1/ SLM3	-3.74 *
SBM2/ SLM1	-6.84 ***
SBM2/ SLM2	-2.11
SBM2/ SLM3	-0.74
SLM1/ SLM2	4.74 *
SLM1/ SLM2	6.11 ***
SLM1/ SLM3	1.37

For *Pleurozium schreberi*, the lowest estimated cover was 45.5% (SBM1) and the highest was 56.7% (SLM3) (table 3, figure 4). The mean cover for all five observations of *Pleurozium schreberi* was 51.9% ± 8.0% and the mean absolute difference was 11.4% ± 7.3%. SBM1/SLM2 had the largest absolute difference and SLM1/SLM3 had the lowest (table 5).

There was no significant difference between the observations. (Repeated measure ANOVA Df: 18,4; F-value: 2.04; p-value: 0.10 > 0.05).

For *Barbilophozia lycopodioides* the estimated mean covers were between 5.2% for SBM2 and SLM2 and 10.0% for SLM3 (table 3, figure 4). The mean cover for all five observations of *Barbilophozia lycopodioides* was 6.3% ± 2.8% and the mean difference was 3.4% ± 1.3%. SBM2/SLM3 had the largest absolute difference and SLM1/SLM2 and SBM2/SLM2 had the lowest (table 5). There was no significant difference between the observations. (Repeated measure ANOVA Df: 18,4; F-value: 1.91 p-value: 0.12 > 0.05).

Inter- and intrapersonal comparison

Of all sixteen species, the intrapersonal difference was significantly lower than the interpersonal one only for *Pleurozium schreberi* (table 5).

Table 5. Intra- and interpersonal differences in mean cover estimates of 16 species. In the two right columns the smallest mean difference in each pair is marked by bold text. The intrapersonal difference was significantly lower than the interpersonal difference only for *Pleurozium schreberi* . (Data according to table 2: Gammtratten.)

	n=32	n=32	n=19	n=19	n=32	n=32	n=19	n=32	n=32	n=19	Mean difference	
	SBM1/ SBM2	SLM1/SLM2	SLM1/SLM3	SLM2/SLM3	SBM1/ SLM1	SBM1/ SLM2	SBM1/ SLM3	SBM2/ SLM1	SBM2/ SLM2	SBM2/ SLM3	intra	inter
	Intrapersonal comparison				Interpersonal comparison							
Pleurozium schreberi	3.8	1.8	1.7	4.1	7.6	9.4	5.3	3.8	5.6	4.2	**2.9**	6.0
Vaccinium myrtillus	3.3	3.9	6.1	1.4	8.0	4.2	3.7	4.7	0.8	0.7	3.7	3.7
Dicranum sp.	0.5	4.3	4.5	0.2	5.7	1.4	1.2	6.1	1.9	1.7	**2.4**	3.0
Barbilophozia lycopodioides	0.3	0.1	3.5	2.8	0.2	0.2	3.7	0.2	0.1	4.2	1.7	**1.4**
Hylocomium splendens	0.5	0.1	4.9	4.3	0.9	0.8	3.4	1.4	1.3	3.6	2.5	**1.9**
Vaccinium vitis-idaea	0.1	0.0	0.1	0.5	0.2	0.1	0.1	0.1	0.1	0.3	0.2	**0.1**
Deschampsia flexuosa	0.2	0.4	0.5	0.1	0.3	0.0	0.1	0.2	0.2	0.3	0.3	**0.2**
Polytrichum commune	0.6	0.1	0.2	0.1	0.2	0.1	0.3	0.3	0.4	0.4	**0.2**	0.3
Empetrum hermaphroditum	0.2	0.0	0.2	0.3	0.0	0.0	0.1	0.2	0.2	0.3	0.2	**0.1**
Ptilium crista-castrensis	0.2	0.3	0.2	0.2	0.3	0.0	0.2	0.1	0.2	0.1	0.2	**0.1**
Juniperus communis	0.1	0.3	0.2	0.3	0.3	0.1	0.4	0.4	0.2	0.6	**0.2**	0.3
Melampyrum pratense	0.0	0.2	0.2	0.0	0.3	0.1	0.2	0.3	0.1	0.2	**0.1**	0.2
Cladina rangiferina	0.1	0.1	0.3	0.1	0.3	0.3	0.1	0.2	0.2	0.1	**0.1**	0.2
Sorbus aucuparia	0.0	0.3	0.1	0.4	0.0	0.2	0.0	0.1	0.2	0.1	0.2	**0.1**
Cladina arbuscula	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Calluna vulgaris	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	**0.0**	0.1

Indices

In a comparison between the observations done in Gammtratten 1999 the different cover estimates gave only slightly different Ellenberg index values. The values for the R-index varied from 2.22 to 2.30 and the N-index from 2.83 to 2.87 (figure 5).

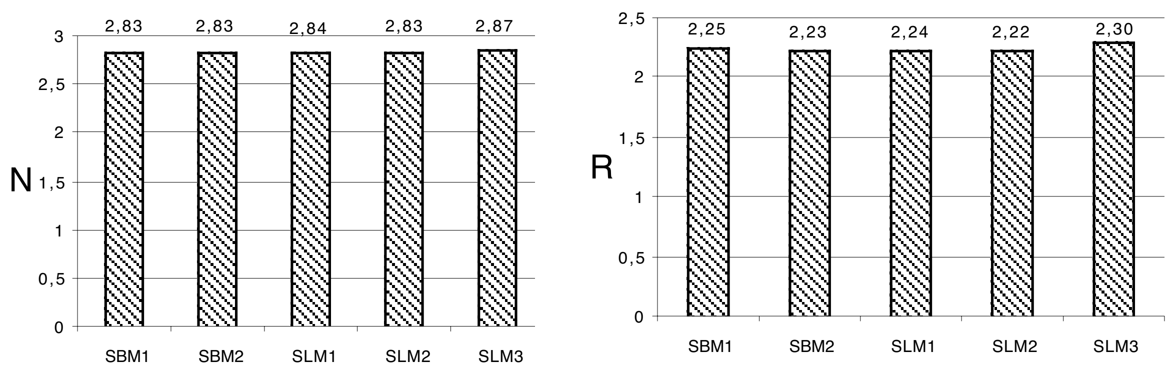


Figure 5. The five observations at Gammtratten resulted in slightly different values of Ellenberg R- and N-indices.

Difference between estimates – relative values

The overall relative difference between estimates, interpersonal as well as intrapersonal, was smallest for those species that had the highest estimated cover and largest for the species with the smallest estimated covers (figure 6, table 6).

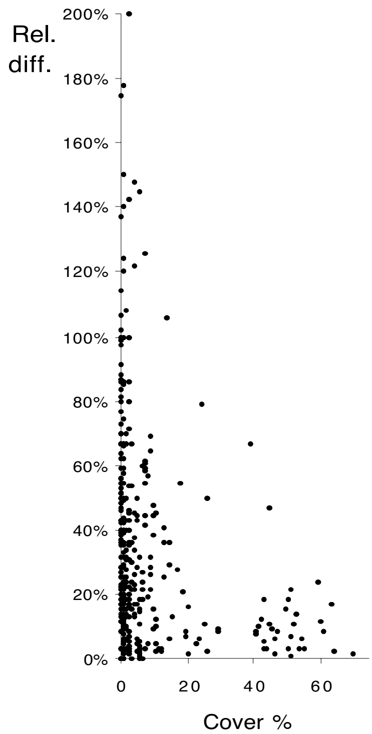


Figure 6. Mean cover of the two estimates in each pair in relation to the relative difference between them. In all 568 single estimates.

When only looking at the intrapersonal comparison the result was somewhat better, the species with the largest estimated mean cover, had a much smaller error. The largest difference was still found in the species with a mean cover under 1%. When the calibrator estimated the same site at different occasions the result was even better, the mean difference was between 7% and 21%. The comparisons in cover class 3 had the lowest error. (Table 6)

Table 6. Relative differences in cover estimates between two persons and with the same person on different occasions. Relative difference is the absolute difference as percentage of the mean cover. The classes are; 1) < 1%, 2) 1,0-4,9%, 3) 5,0-19,9%, 4) ≥ 20%. n = number of comparisons of means of one species in an area.

Mean cover class	Absolute difference of mean cover	Relative difference % of mean cover	CV % of mean cover	Max/ Min of rel. diff.	n
		Inter- and intrapersonal			
1	0.10	34	97	178/0	338
2	0.74	33	107	200/0	117
3	2.56	28	105	144/0	71
4	5.51	14	124	79/1	42
		Interpersonal			
1	0.11	33	101	178/0	259
2	0.81	35	103	200/0	104
3	2.58	27	110	144/0	60
4	6.16	15	119	79/1	34
		Intrapersonal			
1	0.08	35	85	137/0	79
2	0.21	14	92	43/1	13
3	2.50	32	82	60/1	11
4	3.09	7	43	12/3	8
		Intrapersonal – calibrator only			
1	0.06	21	98	69/3	20
2	0.27	21	99	43/3	3
3	0.39	7	45	11/5	3
4	3.52	8	7	8/8	2

Comparison between field estimate and photograph

An approximation of the *"true"* cover of a species in a community may be achieved by measuring cover on photographs by computer software. The size of the difference between the "truth" and the subjective estimate is illustrated by data derived from another study within the IM. The overall R^2-value was 0.7 which should be regarded as relatively high (figure 7).

On the other hand the relative differences were higher than those derived from estimates only (table 6 and 7). For the cover class 4 it was 39% and for class 2 and 3 higher. None of the species compared had a cover under 1%

From a few subplots estimates from both photograph, calibrator and ordinary observer were compared (figure 8). Except for one occasion the estimates coincided remarkably well.

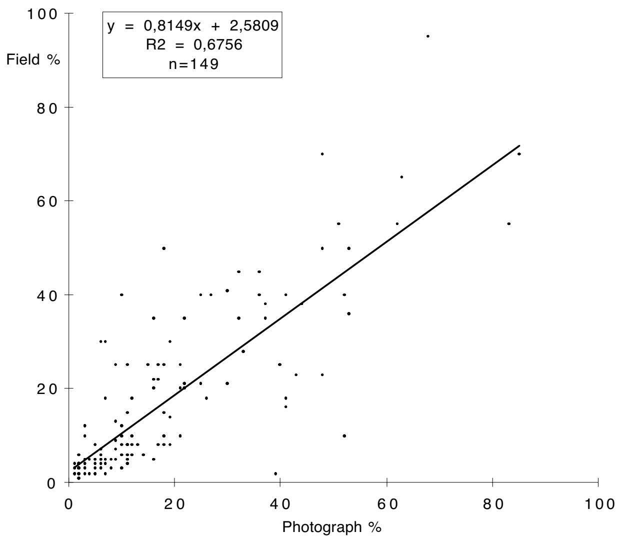


Figure 7. Agreement between cover estimate at a photograph and in field for 149 comparisons.

Table 7. Difference of cover estimated from a photograph and in field. For explanation see table 6.

Mean cover class	Absolute difference	Relative difference % of mean cover	CV % of mean cover	Max/ Min of rel. diff.	n
1	-	-	-	-	-
2	1.56	52	63	120/0	39
3	5.13	48	75	133/0	64
4	12.67	39	96	180/2	46

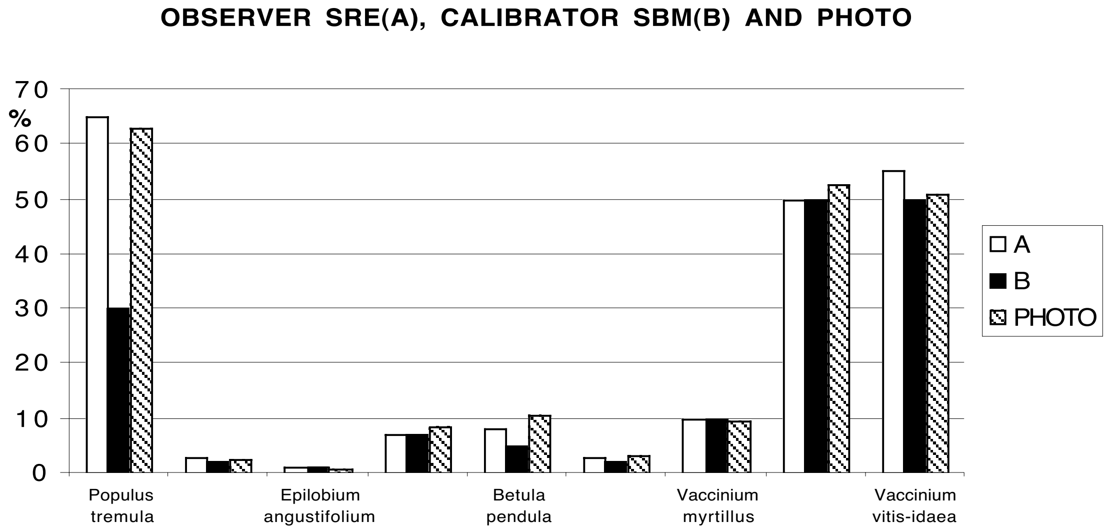


Figure 8. Comparison between cover measured in computer and estimated in the field by observer SRE and calibrator SBM on two subplots. The cover of each species came from only one subplot. (Data according to table 2: Bohult 1986, N Kvill 1986.)

Discussion and conclusions

It is not a matter of course what should be the sensitivity of a variable in environmental monitoring. Therefore I take as a starting point a proposal by the Swedish Environmental Protection Agency (SEPA) in 1993, according to which the IM monitoring programme should use methods that could, with 95% significance, detects changes in variables of more than 20% during five years. Applied to vegetation cover monitoring it could mean capacity to detect 20% change both in absolute and relative values. As regards absolute values this study demonstrates that in 95% of all paired observations the error attributed to personal variation is less than 5%. Thus the standard proposed by SEPA is easily met with.

On the other hand, when relative values are considered, the size of the personal variation depends on the absolute level of cover of the species involved. With covers over 20% the mean relative difference was 14% and with covers under 1% it was 34%. Therefore the method meets the SEPA requirement with high cover species, but not with low cover ones. The easily understood reason is that the relative difference, when cover goes from 1 to 2% the change is 67%, whereas when it goes from 50 to 51% it is only 2%. Therefore the method calculating with relative values does not have the same precision in all cover classes and the demands cannot be the same over the whole scale. However, the result in this study was much better than that reported by Ericson (1976). For high cover species it was rather comparable to that reported by Addison & Kennedy (1987).

The studies reported by Ericson (1979) and Sykes et al. (1983) showed that the error was smaller in comparison within the same person (intrapersonal) than between persons (interpersonal). In this study only one of the species specially analysed, *Pleurozium schreberi*, gave significantly lower intrapersonal values than interpersonal ones. One reason could be that the main comparison, performed in 1999, was done by the same two observers. There the more experienced "calibrator" trained intensively the less experienced observer immediately before the test observations. This case demonstrates, among other things, that intensive training could be effective in order to minimise personal differences.

Some species, due to their shoot morphology and spatial position in the community, are easy to estimate, others more difficult. In this study the estimates differed significantly regarding *Vaccinium myrtillus*, but not *Barbilophozia lycopodioides* and *Pleurozium schreberi*. This was unexpected since in the field *Vaccinium myrtillus* occupied the upper layer and had easily discernible leaves. *Barbilophozia* also had leaves easily seen, but they grew partly hidden and in shadow in the bottom layer. *Pleurozium* was also partly hidden and frequently occurred in single shoots or small groups interspersed with other mosses and with vasculars, making it a "difficult" species. One reason for the large variation in *Vaccinium* could be that its dominant position gave an impression of higher cover than it actually had.

Ericson (1979) pointed out that the capacity to identify a species and know its various stages of development influences the cover estimate performance. A person who is uncertain in this respect tends either to miss the species completely or to underestimate its cover. In the present study these aspects were not included.

Although cover was measured on scanned photographs in computer this ”truth” can not be regarded as absolute since there apparently are shortcomings of the method applied. Especially for species with numerous small leaves, the edge effect errors may be large. This calls for further development of the photo method. Probably the best approach would be to use digital camera and a programme that identifies the number of pixels in a field of specific colour or light. Great care must be taken in the specification of these fields so that similar species are not mixed with each other or the same species is not regarded as different ones.

To increase the reliability of field data some important points should be kept in mind. First the observer must have good knowledge of the species to be encountered. Second the observer must clearly know how cover is defined and how to proceed when estimating the cover. This is best achieved by personal instruction and training where the apprentice is confronted with various communities under different light and weather conditions. When one observer is replaced by another the new observer should also be calibrated to the previous one. It is recommendable that the observer is regularly calibrated not only to a person, but also to test figures with exactly measured cover. Such pictures are easily made in a computer. There should be a large number of them – one or two hundred – so that the observer does not subconsciously learn all the correct answers (Bråkenhielm and Qinghong, 1995a).

In long-term vegetation monitoring, as in all other monitoring, it is recommendable always to be able to state the precision of the method. It is helpful for the executor of monitoring if the level of precision required is determined beforehand. Then it will be easier to design an adequate method and, at the evaluation of data, see whether a change is real or within the error of the method.

Acknowledgements

I would like to thank my supervisor Sven Bråkenhielm for all I have learnt during the field work and for his support and patience during my struggle with the writing. I also thank Ulf Grandin for his comments and constructive criticism on the manuscript.

References

Written sources

Bernes, C. 1990. Environmental monitoring in Sweden. Monitor 1990. Swedish Environmental Protection Agency informs.

Bråkenhielm, S. 1993. Fältinstruktion för observatörer inom PMK-vegetation 1993. SLU, enheten för miljöövervakning. (Unpublished)

Bråkenhielm, S. and Qinghong, L. 1995a. Comparison of field methods in vegetation monitoring. Water, Air and Soil Pollution 79:75-87.

Bråkenhielm, S. and Qinghong, L. 1995b. Impact of sulphur and nitrogen deposition on plant species assemblages in natural vegetation. Water, Air and Soil Pollution 85: 1581-1586.

Ericson, L. 1975. Metodstudier vid vegetationsanalys. SNV VINA Rapport. (Unpublished)

Kennedy, K. A. and Addison, P. A. 1987. Some considerations for the use of visual estimates of plant cover in biomonitoring. Journal of Ecology 75:151-157.

Kleemola, S. and Forsius, M. (eds) 1999. 8th Annual Report 1999. UN-ECE Convention on Long-Range Transboundary Air Pollution. ICP Integrated Monitoring of Air Pollution Effects on Ecosystems. The Finnish Environment 325.

Leps, J. and Hadincová, V. 1992. How reliable are our vegetation analyses? Journal of Vegetation Sciences 3:119-124.

Naturvårdsverket 1993. Svensk nationell miljöövervakning. Rapport 4275.

Sykes, J. M., Horril, A. D., and Mountford, M. D. 1983. Use of visual cover assessments as quantitative estimators of some British woodland taxa. Journal of Ecology 71:437-450.

Tonteri, T. 1990. Inter-observer variation in forest vegetation cover assessments. Silva Fennica. Vol. 24, 2:189-196.

Internet source

http://info1.ma.slu.se/IM/Sweden/PMKIMinfo.html, 22 July 2000.