CHAPTER 9

INVENTORIES OF VEGETATION, WILD BERRIES AND MUSHROOMS

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9.1 BASIC PRINCIPLES

Analysis of the vegetation cover is an important part of plant ecology, and the monitoring of temporal changes in the abundance of different plant species is important in relation to the biodiversity aspects, for example. In addition, floristic mapping produces information on species ranges and the abundance of rare plant species. The abundance and occurrence of understorey plant species has also been used as an indicator of site fertility. Assessment of the vegetation forms a part of some national forest inventories, as on the permanent sample plots of the National Forest Inventory (NFI) in Finland.

The aims of specific inventories of wild berries and mushrooms differ from those of other vegetation inventories, however, as interest may be focused on only the part of the population, those berries that are important for picking. Important aspects are then the prediction of annual yields and the time of ripening and the analysis of regional variability in yields.

9.2 VEGETATION INVENTORIES

9.2.1 Approaches to the description of vegetation

Vegetation science examines the relationship between the occurrence or abundance of plant species and environmental factors (Lawesson 2000). Different concepts can help us to understand variations and changes in vegetation patterns. The nature of vegetation stands can be seen as continuous or discontinuous, leading to two contrasting views (Whittaker 1962): 1) the continuum concept, in which variations in vegetation in response to environmental factors are continuous, and 2) the

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community-unit theory, in which the occurrence of vegetation is expected to follow natural groups of species. There are more or less discontinuities between vegetation stands, and these form integrated plant communities (c.f. Austin and Smith 1989).

Certain countries have long traditions in vegetation surveys, and there are many different approaches and theories for the description of vegetation. According to ∅kland (1990), vegetation classifications usually include three phases: 1) the analytic phase, in which homogenous stands are selected, one or more sample plots are defined in each stand and the vegetation of these plots is analysed, 2) the synthetic phase, in which the results are tabulated according to the similarities and differences in species composition between the plots, and 3) the syntaxonomic phase, in which the plots are arranged into plant communities according to the tradition followed.

The Central European tradition of classifying vegetation into plant communities follows the Braun-Blanquet system, whereas in the Nordic countries attention is paid most to the quantitative differences in species abundances. Other approaches include the Anglo-American school, which uses a classification of vegetation types according to the dominance by one or more species (Whittaker 1978). In Russia, Sukachew (1928) recognised ecological series of plant units somewhat similar to those used in Finland (Whittaker 1978).

The basic ideas of the Braun-Blanquet approach are the following (Braun-Blanquet 1932, Kent and Coker 1992):

1. The floristic composition of plant communities is used to classify types of vegetation. In the field, sample plots (relevés) are located subjectively in homogeneous vegetation stands, and a minimum area for each is determined by studying the number of plant species, first within a small area and then increasing the plot area until the number no longer increases.

2. Species abundance is estimated using a simple class scale which links shoot frequency with coverage. The classes are the following: one or a few individuals, occasional and less than 5% of total plot area , abundant and with very low cover or less abundant but with higher cover (in any case less than 5%), very abundant and less than 5% cover, 5-12.5%, 12.5-25%, 25-50%, 50-75% and 75-100% of cover (∅kland 1990).

3. Diagnostic species whose ecological properties are the most effective indicators of the vegetation stands are used to organize the data into a hierarchy of plant communities. The fundamental unit of this classification is the plant association, which has a characteristic species combination.

Statistical methods play only a minor role in the Braun-Blanquet approach. More information about this method can be found in the textbooks of Whittaker (1978), ∅kland (1990) and Kent and Coker (1992), for example.

The Nordic approach also includes similar basic phases of classification to those of the Braun-Blanquet approach, but the main emphasis is on quantitative differences in species abundance (Salemaa et al. 1999). The abundance of a plant species is usually estimated using coverage or frequencies. Coverage estimates are classified to form scales (see 9.2.2). Vegetation data are usually collected from a large number of small sample plots, and a fixed sampling design has been employed more recently.

Gradient based approaches to vegetation monitoring are emphasised in the Nordic countries. The term ecological gradient can be defined as a gradual change in any ecological factor (∅kland 1990), i.e. it is assumed that biotic and abiotic conditions vary along continuous gradients to form a complex gradient. In such a case vegetation and site classifications can be made simultaneously and lead to a non-hierarchical, multidimensional classification of sample plots along gradient axes (∅kland 1990).

The site-type approach has been used in Finland for the classification of forest site types. The Finnish botanist A.K. Cajander developed a system in which the species of the ground and field layers are used as indicators of site properties (Cajander 1909, 1913). Site types are characterized by dominant, constant, differential and characteristic species, and a range of these types including all successional stages and parallel types is used in each region. A corresponding approach has also been adopted to the characterization of Finnish mires (Ruuhijärvi 1960).

9.2.2 Recording of abundance

The abundance of a species is recorded using either qualitative or quantitative characteristics (∅kland 1990). A typical qualitative measure is presence/absence (∅kland 1990, see also Ståhl 2002), while quantitative indicators include cover estimation, frequency in sub-plots and point frequency. Plant biomass has also been used as a measure of abundance, but since this requires harvesting of the plants, it cannot usually be employed on a large scale or on permanent plots (Salemaa et al. 1999).

In the case of cover estimation, the percentage plant cover or various cover and cover-abundance scales can be used. These values are usually assessed visually in the field. It is also possible to use automatic image analysis methods, e.g. digitized photographs, for vegetation analysis, but their usefulness is dependent on the vertical structure of the vegetation (Vanha-Majamaa et al. 2000). It is also worth noting that detection is related to the size of the plant(s) and the resolution of the images.

Cover estimates are usually subjective, vary between observers and include considerable sampling error (Lawesson 2000). A historical example of a cover scale used in the Nordic countries is Norrlin's abundance-density scale, which is based on shoot densities measured in 10 grades (Pakarinen 1984). The values 1-7 are related to the average distances between plant specimens, the whereas the highest values (8-10) are defined by the mixture of other species (Pakarinen 1984). A corresponding classification is Hult's five-grade scale and its later modifications.

The first application of direct coverage estimation was the use of decimal cover classes 1-10 (0.1, 0.2, …, 1.0) by Kujala (1936). Nowadays, direct percentage cover is the main method used to assess the abundance of plant species in Finland, although some rounding off of percentages higher than 5% may take place. A scale of 0.1, 0.2, 0.5, 0.7, 1, 2, 5, 7, 10, 15, 20, 25 , 30, 40, …, 90, 93, 95, 97, 98, 99 and 100% is used in the NFI, for example (Tonteri 1990). Cover classes are also used to speed up fieldwork.

The description of abundance in terms of frequency requires recording of the occurrence of the plant species in subplots. Correspondingly, in the case of point frequency a regular or random arrangement of pins is placed on a sample plot and the touch frequency of each species is calculated to provide a measure of abundance (∅kland 1990). Methods which include the measurement of frequencies are more time-consuming than ones based on cover estimation.

9.2.3 Sampling methods for vegetation analysis

Vegetation studies are usually carried out by means of sampling. According to ∅kland (1990), there are three main steps in the sampling of vegetation:

1. Placement of sample units
2. Determination of plot size and shape
3. Determination of the number of sample plots.

Selective (subjective) sampling is a widely used method in conjunction with the Braun-Blanquet approach. The statistical properties of this method are poor, however, and statistical tests of species abundance or areal estimates are not always valid (∅kland 1990). The representation of rare species and vegetation types can be guaranteed, however, since these aspects can be emphasized when selecting the plots. The time required for plot selection is also minimal.

Random sampling meets the statistical prerequisites and is therefore a good choice for the estimation of species abundance and the definition of site types. The extremes on the gradient, e.g. rare species and vegetation types, may not be found, however, and redundant information will be collected. The sample may also be statistically clustered and the designation of plots is time-consuming (∅kland 1990). Therefore modifications of basic random sampling are often recommended (Jongman et al. 1987). The use of different methods of stratified (restricted) random sampling at least means that the selection of plots in the field is more effective.

Systematic sampling is also widely used in vegetation studies (Jongman et al. 1987). Sampling can be done on two-dimensional or one-dimensional grids, the latter being called transects (∅kland 1990). These transects can be open or closed depending on whether all the plots defined are chosen for the sample or not. In an open transect some plots may be rejected, but in a closed transect all the plots are measured. Systematic sampling can produce accurate coverage of a given area. An example of systematic sample design including open transects and different levels of subplot is presented in Figure 9.1.(∅kland and Eilertsen 1993).

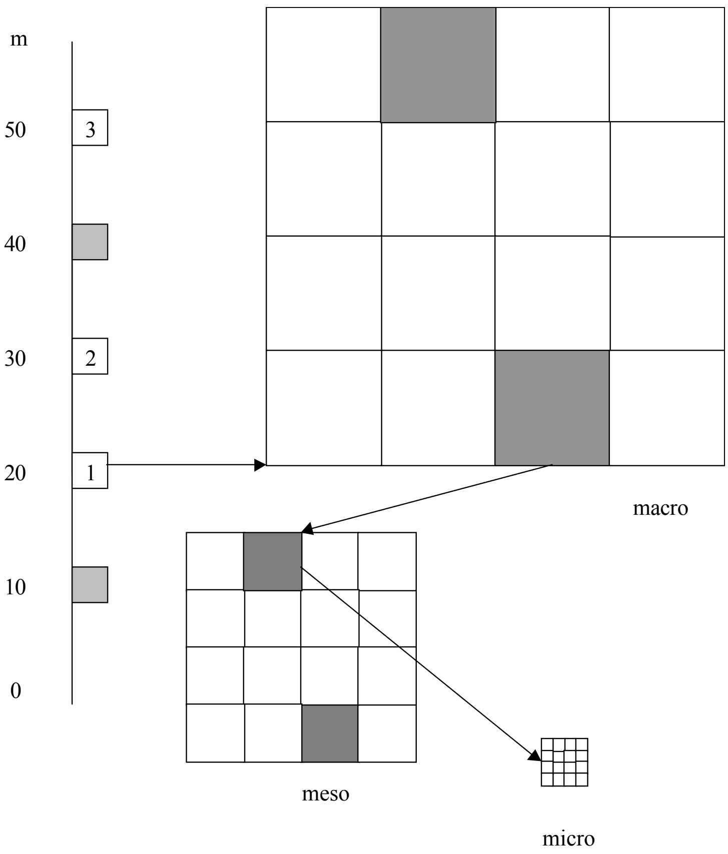

Figure 9.1 A sampling design for analysing boreal forest vegetation, according to ∅kland and Eilertsen (1993). The location of open transects is given on the left. Putative macro-level sample plots are delimited every tenth metre along the transect and are accepted or rejected according to given criteria. These macro plots, each 16 m^2, are then divided into 16 subplots of 1 m^2 each and two are chosen at random as meso-level plots and further divided into 16 subplots, each of size 0.0625 m^2, two of which (in corresponding locations to the meso plots) are taken as micro plots and again divided into 16 subplots. Finally, the presence/absence of each species is recorded in each subplot at the meso and micro-levels.

The sample units in vegetation surveys have traditionally been square in shape, although other alternatives such as circular or rectangular plots have been used. Measurement of a square plot is easy and it can also be easily divided into subplots. The benefit of a rectangular plot lies in the ability to describe homogeneous vegetation in a clustered plant distribution, whereas a circle has only a minor edge effect compared with other shapes (Lawesson 2000).

The optimal size of plot depends on the homogeneity of the plant communities and the representativeness of the plots (∅kland 1990). The homogeneity of plant species can be defined as the existence of an equal number of individuals in all parts of the area. Correspondingly, the species in a plant community should be homogeneously distributed. Finally, ecological homogeneity can be defined by specifying a range of variation along each complex gradient that should not be exceeded within in an individual plot (for more details, see ∅kland 1990).

The requirement of homogeneous sample plots inevitably leads to a small size, since variation on the most important gradients should be greater between plots than within them. Small-scale changes in the vegetation may not be detected on large plots, whereas these will more probably have a species composition which reliably reflects the environmental conditions. This is referred to as the representativeness of plots (∅kland 1990).

Since there is no exact way to determine the optimal plot size it has to be decided separately in each case (see Jalonen et al. 1998, Salemaa et al. 1999). Some Finnish examples of the sizes (and number) of plots in one forest stand include ten to forty plots of 0.25 m^2 (Kujala 1936), 20 quadrats of 1 m^2 in an area of 30 x 40 m (Jalas 1962), three quadrats of either 2 or 4 m^2 Hinneri (1972) and 5-15 sample plots of size 0.25 m^2 on mires (Heikurainen 1953). Considerably larger plots of size 100 m^2 have also been used for cover estimation, however (Kujala 1964), having originally been established by the NFI for tree measurement purposes.

The number of plots required is dependent on the following aspects (∅kland 1990): the expected variation in ecological conditions and vegetation in the area, the method used for defining the sample plots, plot size, the desired representation of gradients and vegetation types and the time available for the fieldwork. The sample should also ensure further data analysis and yield data that can lead to an understanding of the ecological demands of individual species.

Various aspects of sampling design in vegetation surveys have been emphasized, e.g. in the textbook of Lawesson (2000), where traditions and current aspects are considered separately for each of the Nordic country. Other reviews are those presented by Knapp (1984), Pakarinen (1984), Kenkel (1989), ∅kland (1990), Kent and Coker (1992) and Elzinga et al. (2001).

9.3 EXAMPLES OF VEGETATION SURVEYS

Floristic mapping has long traditions in Finland. The earliest flora was published in 1673, by Til-Landz (see Lawesson 2000), and large-scale mapping of plant species has been undertaken by Hulten (1950), by Jalas and Suominen for the ‘Atlas Florae Europaea’ (1967) and by Lahti et al. (1995) for a series of digital maps depicting the distribution of 1604 vascular species in Finland.

The project “Atlas of the Vascular Plants of Finland (Kurtto and Lahti 1985) divided Finland into 10x10 km quadrats which each included 100 quadrats of 1x1 km. The aim was to examine the distribution of vascular plants using as many of the smaller quadrats as possible. Nowadays 2 401 small quadrats located in 249 larger quadrats are being investigated, which means that 6.5% of the country’s land area is being examined intensively

Information on forest site types has been collected as a part of the Finnish NFI since 1921, when the first inventory was started (Ilvessalo 1927), and the third inventory, in 1951-53, assessed the vegetation on 12 000 circular plots of size 100 m^2 situated on survey lines running from south-west to north-east. Kujala (1964) published frequency maps for 189 plants included in the floristic data for this 3rd National Forest Inventory. During the 8th inventory, in 1985-1986, 3 000 permanent plots were established (Reinikainen et al. 1998), located systematically within Finland, and these were re-examined in 1995. The radius of the original plot of trees was 10 m, and the vegetation was examined on four sub-plots of size size 2 m^2 located systematically along the diameter of the plot in a south-north direction. Percentage cover was used as a quantitative measure for vegetation assessment.

Although special attention has been paid to the statistical representativeness of the NFI vegetation data (see Reinikainen et al. 1998), the sampling design has not been optimal for vegetation surveys, since it was a compromise between the inventories of the tree stock and the plants. The results of the national inventories concerning changes in the frequencies and abundances of forest and mire plants were published in the textbook by Reinikainen et al. (2001). Mäkipää and Heikkinen (2003) studied large-scale changes in the abundance of terricolous bryophytes and macrolichens in Finland, and Tonteri (1990) and Korpela (2005), for instance, have analysed the NFI vegetation data.

Pan-European monitoring of forest vegetation was launched in the EU/ICP Forest Level II Programme (Manual on methods… 1998). The Level II network in Finland consists of 31 sample areas: 27 on mineral soil sites and 4 on peatlands. As a pilot study, alternative methods for the long-term monitoring of forest vegetation were tested on 9 Finnish Level II plots in 1998 (Salemaa et al. 1999), comparing the Nordic percentage cover method and the Braun-Blanquet method. The sampling design is presented in Figure 9.2. Percentage cover was used on the small quadrats (0.25, 1 and 2 m^2) and the Braun-Blanquet scale on the larger plots (25 and 900 m^2). The results showed that there are considerable differences in the mean coverages obtained by these approaches. The average number of species increased with quadrat size ($0.25 < 1 < 2 < 25 < 900$ m^2), although in most cases it did not increase essentially after 16 quadrats (size 1 m^2 or 2 m^2) (Salemaa et al. 1999).

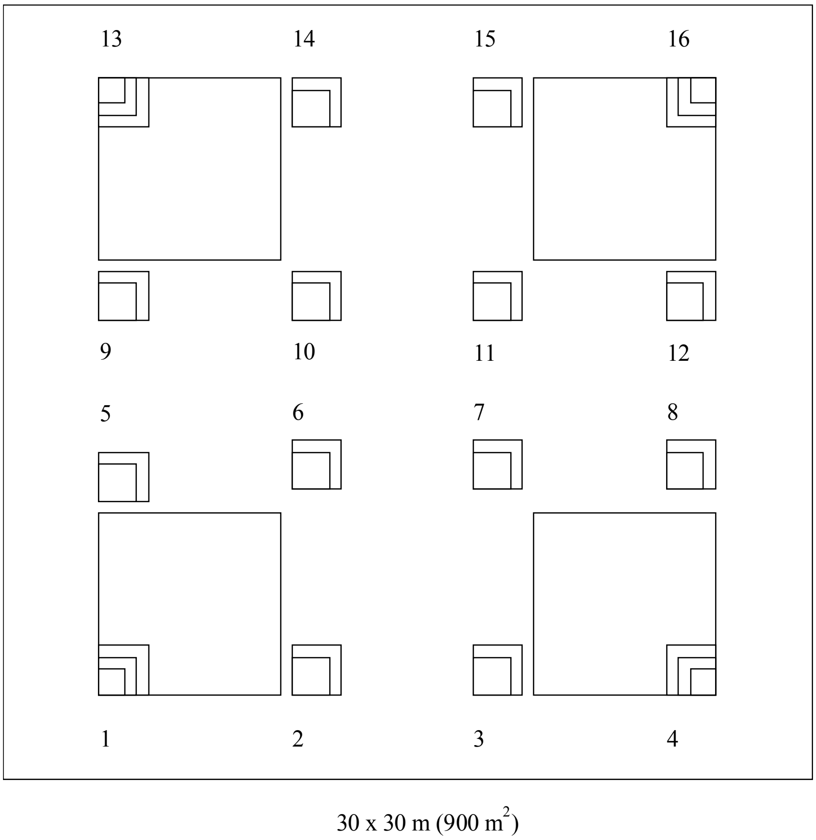

Figure 9.2 The sampling design used in a pilot study for the Finnish Eu/ICP Level II programme (Salemaa et al. 1999). For quadrat sizes, see text. In the final design a total of 16 quadrats sized 2 m^2 were marked out systematically. The occurrence of a species is also recorded outside the quadrats for areas of 400 m^2 (common sample area).

9.4 INVENTORIES OF MUSHROOMS AND WILD BERRIES

In general, berry species and macrofungi can be surveyed in the same way as vascular plants (see previous chapter). If the object of interest is non-wood forest products, however, i.e. edible wild berries and mushrooms picked for household use or trade, the methodology and aims may differ from those of a basic vegetation inventory. The regional economic importance of some species, e.g. the mushroom <u>Boletus edulis</u> in Northern Karelia, Finland, may be very high. Inventories of mushrooms and wild berries have been conducted in the Nordic countries, Russia and Poland, for instance (Eriksson et al. 1979, Kalinowski 1999, Kukuev 1999, Salo 1999), most of the studies being concerned with one municipality (Jaakkola

1983, Raatikainen and Raatikainen 1983), although national surveys have also been carried out in Sweden and Finland (Eriksson et al. 1979, Salo 1999).

The main aim of inventories of non-wood forest products is to study the yields of these and their ripening. Thus the abundance of berry plant species as such is not of great importance, as it is also for them to produce berries. In addition, there are very marked annual and regional variations in yields due to site conditions, pests and climate (Solantie 1983). It is also possible that unripe berries and very small mushrooms may be picked by people or eaten by animals before they are counted. Therefore, inventories and forecasting systems for these products must include permanent plots which are checked several times during the growing season. There also exist both empirical and expert models for the prediction of yields (Ihalainen et al. 2002, 2003).

The date of flowering and the numbers of unripe and ripe berries are recorded during the growing season (Salo 1999), and in some cases the biomass is also estimated (Laakso et al. 1990). Correspondingly, the numbers of edible mushrooms, identified by species, are usually recorded.

The sizes and numbers of sample plots have varied in different inventories of wild berries and mushrooms. In the case of cowberries (Vaccinium vitis-idaea), the size of the plot has been as small as 0.25 m^2 (also 4 and 10 m^2), whereas cloudberries (Rubus chamaemorus) have been examined on plots of size 1- 20 000 m^2 (Raatikainen and Pöntinen 1983). Saastamoinen (1982) proposed the use of circular 1 m^2 sample plots which could be measured quickly using a rake, while according to Veijalainen (1982) plot size has varied between 8-1 500 m^2 in the case of mushrooms, the optimum size being about 100 m^2.

The sampling design used in inventories of wild berries and mushrooms has also varied. Jaakkola (1983) used a systematic line inventory in which the sample quadrats were located in clusters, while in Sweden the NFI sampling design was used to define circular plots arranged in clusters, inside which wild berries were assessed on circular sub-plots (Eriksson et al. 1979). Correspondingly, in the sampling design of the 7th NFI was used eastern Finland to establish permanent plots for the monitoring of wild berries and mushrooms (Salo 1993; Figure 9.3). Three plots were located in each original NFI cluster. The location of sample plots may also be random if the area to be examined is small, e.g. one stand.

The current national system for forecasting wild berry and mushrooms yields in Finland is based on 2 200 permanent plots in 440 forest compartments (Salo 1999). Each stand possesses 5 experimental plots of 1 m^2 located subjectively in the most productive part of the stand. This network was established in 1997 and is monitored three times a year. The fieldwork is carried out by researchers at the Finnish Forest Research Institute, staff from schools of agriculture and forestry, qualified natural product advisers and members of the 4H organisation (Salo 1999). The drawback with the system is the subjective placement of plots, which means that the statistical properties of the results are questionable, and may also lead to excessively optimistic yield forecasts.

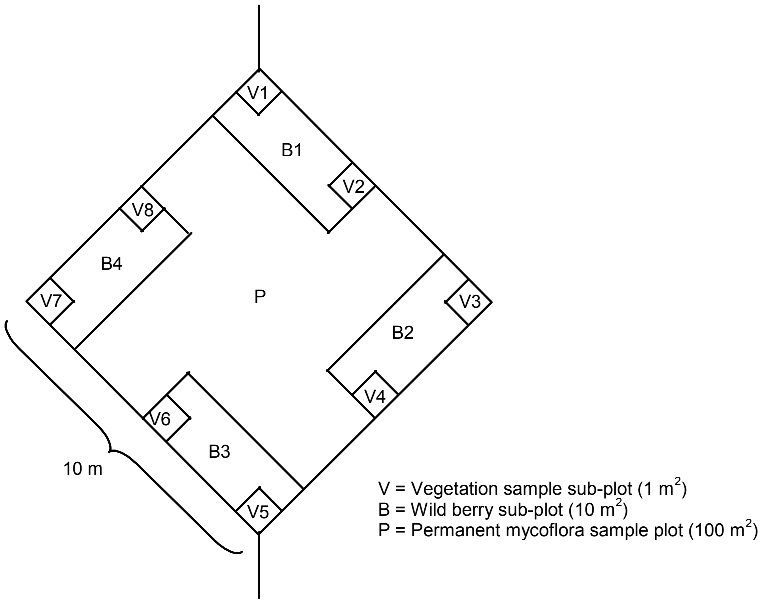

Figure 9.3 Layout of an NFI-based permanent plot (100 m^2) and location of the wild berry sub-plots, which formed one berry sample plot (40 m^2) (Salo 1993). The permanent plot also included vegetation sampling sub-plots.

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