A Comparison of Sampling Methods in Dense Herbaceous Pasture

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Highlight: *Several methods of vegetation sampling were compared in a very homogeneous herbaceous vegetation: Needle points, double metre points, bayonet points, line transects, area measurements, and harvesting with sorting and weighing. Consistent curvilinear relationships were found between species frequencies, interceptions, and biomasses obtained by several methods. These constant relationships allow the estimation of yields from the double metre points by simple and fast observations. The shape of the curves suggests some ecological relationship between the vegetation attributes analyzed.*

Many problems arise in quantitative sampling of dense herbaceous vegetations because of difficulties in delineating individuals or tillers and because of entanglement of species. The main problem is optimalization of time and resources to attain sufficient accuracy. Another question is the kind of relations which exist between estimates obtained by different methods.

Many methods of measuring and surveying vegetation have been reviewed by Brown (1954). They differ by the attributes sampled, sampling techniques, sample numbers, and types of lay-out. Field observations may consist of species lists, frequency (in sub-units), cover (total or by species), density, weight (by species), etc. Sampling methods include areas of various sizes and shapes, lines or belt transects, and points. Point observations have been made by crosswire sighting tube (Winkworth and Goodall, 1962) or with vertical, oblique, or horizontal point frame pins (Warren-Wilson, 1959; 1963). Parker (1951) and Long (1958) have used lines and areas for locating sampling units. Methods have been compared by Hédin and Lefebvre (1951), mountier and Radcliffe (1964), and others.

Optimalization of sample numbers with time has been discussed by Hyder et al. (1965) and Fisser and Van Dyne (1966). The distribution of samples may be entirely subjective (i.e. as applied by some phytosociologists), stratified (Gounot, 1960), at random, or regular. Numerous combinations at different levels of these lay-outs have also been used (Boudet and Bayens, 1963).

The present paper evaluates different sampling methods by very detailed observations on dense natural herbaceous pasture in Central France.

The Experimental Area

The 0.4 hectare, very homogeneous experimental plot is situated on a basaltic plateau, West of Cantal in the Massif Central of France, at 950 m altitude. The climate is mesothermic with a short summer growing season. Precipitation (rain and snow) totals 1600 mm annually, and is regularly distributed all around the year. The soil is deep, brown, mull moder humus, very loamy (45%) and slightly stony; pH is 5.5. The vegetation consists mainly of perennial grasses and forbs. The three dominant species are *Festuca rubra, Agrostis vulgaris* and *Trifolium repens.* The area was grazed 6 months a year with a stocking rate of 1-1.5 animal units/hectare/year. For more details, see Daget and Poissonet (1965).

Experimental Procedure

Methods Compared.

The following sampling methods were compared:

1) *Needle points*—Points were defined using a very thin needle, accurately located by a special frame (Long et al., 1972). The number of hits for each species was recorded at each point. This method gives the most accurate point estimates but is time-consuming; it is used as the "reference method" for further comparisons. 8 x 160 points were located at 2.5 cm intervals along 4 m lines.

2) Double metre points—Points were defined by vertical sighting on the edges of a 2 m ruler (Daget and Poissonet, 1971). This method is much faster than the previous one: 12 x 100 points were recorded at 4 cm intervals.

3) Bayonet points—Points were defined by the edge of the blade or a "bayonet" (Poissonet et al., 1972), which is convenient in tall herbage. Two hundred eighty-nine points were located randomly, 289 regularly, 256 regularly in 4 subplots of 64 1 x 1 m squares, or 0.5 x 0.5 m squares.

4) Line transects—Species presence was recorded in 25 cm segments of 4 lines of 64 m each.

5) Areas with species ranking—Species presence and their orders (De Vries and De Boer, 1959) were done at regular intervals of (a) "handfuls" (145 units) which were harvested, (b) 0.5 x 0.5 m squares (256), (c) 0.25 m^2 squares (12),

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(d) 0.25 m^2 rectangles (12), (e) 0.25 m^2 circles (12).

6) Harvesting of areas with sorting —Forty plots of 1 x 0.25 m were harvested, and dry weights were determined after sorting into species categories. Location of plots corresponded to that of the points in methods 1 and 2.

All methods were tested in the same area within 5 days to reduce variation due to plant growth, and the time spent for each method was recorded (Table 1). Observations were made by four teams of two operators each (one observer + one recorder). Between-team variance was checked by analysis of variance on a latin square design.

Definitions

Relative frequency of a species is the percentage of sampling units that contain that species. When the sampling unit approaches a point and the number of sampling units is great, relative frequency approaches cover (Godron, 1968). *Contribution of frequency* is the frequency of a species expressed as percent of the sum of frequencies of all species. As relative frequency approaches cover, contribution of frequency approaches relative cover. Similarly, *contribution of interception* is the percentage of hits of any one species from the total number of hits of the vegetation; it indicates "relative species volume." A widened meaning of the preceding definition may be applied when the sampling units are lines or areas; the order (DeVries and DeBoer, 1959) is considered as equivalent to the number of hits. *Relative biomass* is the dry weight of a *species category* expressed by percent of the whole herbage. *Species rank* refers to decreasing relative frequency, contribution of frequency, or contribution of interception and may also be expressed as percentage of the total number of species, either for a single species (r) or species category (r'). Cumulative values of the other measures are presented in order of decreasing rank.

Results

When the species relative frequencies obtained by the different methods are plotted against those obtained by the most accurate reference method, their values tend to fall on curves of the Lorenz type (Poissonet, 1969) (Fig. 1). The double metre method is closest to the reference method, and the overestimation of relative frequencies increases from it, through bayonet points, line transects, and handfuls to area sampling. A similar family of curves, but with a tendency to underestimation, is obtained when cumulated contributions of frequency or interception from different methods are plotted against those from the reference method. Obviously, the more rigorous point methods give considerably better estimates of species relative frequencies or contributions of frequency and interception than other methods; on the other hand, their success is more observer-dependent.

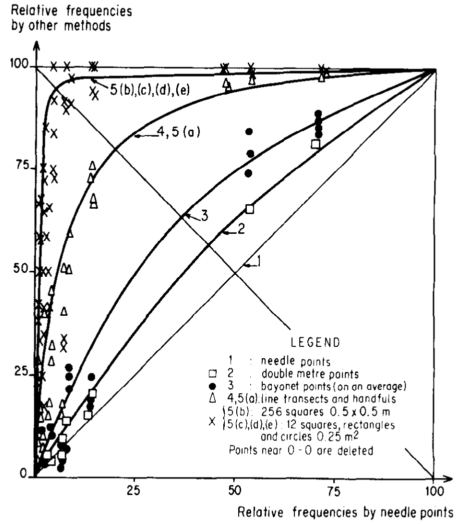

Fig. 1. *Relations between relative frequencies as measured by needle points (the "reference method") and other methods.*

By all methods, cumulated contributions of frequency are related to cumulated contributions of interception by a concave curve which is a characteristic of each method (Fig. 2), but the underestimation of the latter by the former is greater with area units than with points. When cumulated contributions of frequency or interception are plotted against species rank (r), most point methods follow the same curve; but line and area methods diverge from it (Fig. 3).

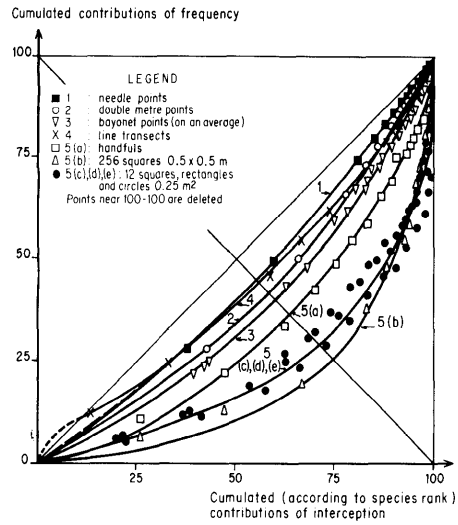

Fig. 2. *Relations between cumulated contributions of frequency and interception in various sampling methods.*

Species relative biomasses show frequently a fairly good linear relationship (x = y) with contributions of interception as measured by point methods, even when cumulated values are plotted (Fig. 4). This enables a direct estimate of relative biomasses from contributions of interception, with an accuracy depending to some extent on the observer. The relationships between relative frequency and contribution of frequency to biomass are less satisfactory.

The relations between relative biomasses and contributions of interception as determined by line transects and area methods are clearly non-linear (Fig. 5). Thus, when only a few "fodder value categories" are considered these methods do not allow a reliable estimation of relative biomasses from interception data.

Table 1. Sample number and time (man hours) spent for all the methods.

Sampling units	Sample number	Time
1) Needle points	1280	16
2) Double metre points	1200	18
3) Bayonet points		
(a) at random	289	12
(b) regular	289	16
(c) regular in 4 subplots	256	12
(d) regular in 4 other subplots	256	12
4) Line transects	1024	16
5) (a) Handfuls with harvest	145	16
5) (b) Squares	256	32
5) (c, d, e) Squares, rectangles and circles	12	3
6) Harvest	40	300

Discussion

These relationships allow fast sampling for yield estimation and species group composition by simple methods; this is their main practical value. The following approach of estimating the distribution of biomasses between categories and species is suggested:

a) Record species frequencies by one of the faster point methods (double metre or bayonet) or by segment or area methods, and calculate contributions of frequency.

b) Calculate contributions of inter-

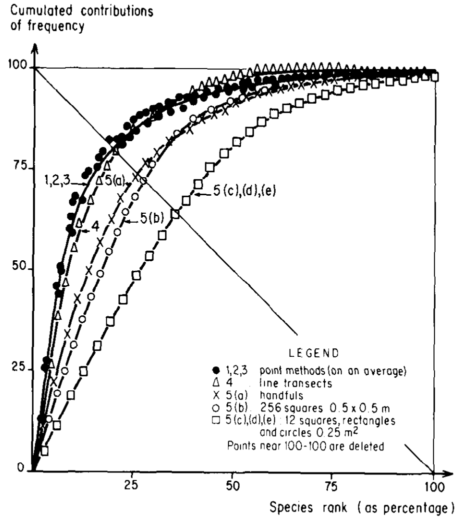

Fig. 3. *Relations between cumulated contributions of frequency and species rank expressed as percentage in various sampling methods.*

ception from contributions of frequency, using the characteristic curve of the method used (Fig. 2).

c) If a line or area method has been used, calculate the corresponding values for point method from the curves obtained.

d) Sum contributions of interception over species in each category; the sum equals the relative biomass of the category (Fig. 4).

As to the distribution of biomasses between individual species in each category, we may assume that it is proportional to the distribution of contributions of interception (by point methods) in the same way as the distribution between categories. Insofar as this assumption is correct, biomass of each species may be calculated from its contribution of interception and the total biomass.

In this experiment, several types of measurements were carried out on the same very homogenous vegetation at a single site. Care was also taken in the reference method to record hits only by the very sharp tip of a very thin needle. This may explain the clear-cut relationships found between the needle point reference method and other sampling techniques and the lack of such relationships experienced by other investigators (Mountier and Radcliffe, 1964).

The relationship found between interception, biomass, cover, and rank recorded by different methods may be expressed in a family of 3-dimensional curves. The generality of such curves tends to support the hypothesis of a basic ecological significance of these relationships, at least in the type of vegetation studied. This will be discussed in detail elsewhere.

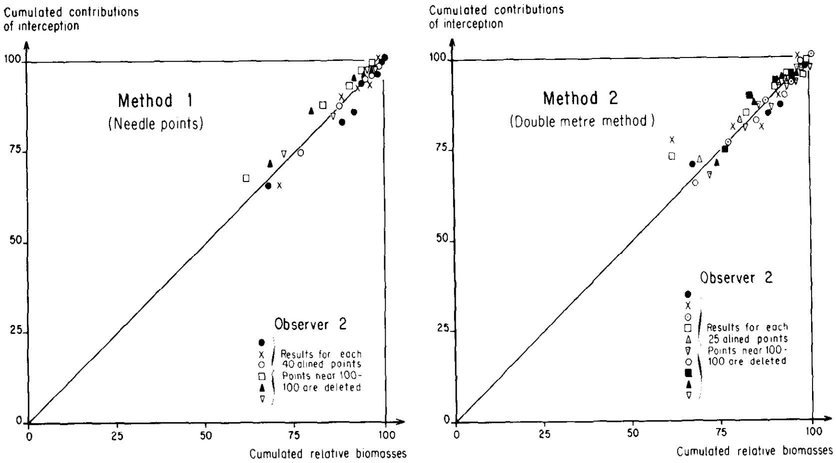

Fig. 4. *Relations between relative biomasses and contributions of interception, for species categories, with needle and double metre points.*

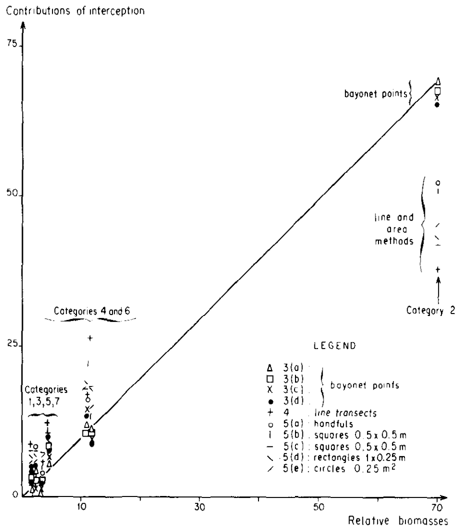

Fig. 5. *Relations between relative biomasses and contributions of interception, for species categories, with bayonet points, line and area methods.*

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