FRM514:QUANTITATIVE ECOLOGY

LECTURE NOTE

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NATURE OF VEGETATION

Vegetation is the plant cover of the earth and comprises all plant species growing in a very great diversity of assemblages. Before attempting of analyze and understand the structure of vegetation, in term of the distribution and abundance of the individual species, it is necessary to discuss certain features of the nature of vegetation.

When one comes to make a really close examination of an area of ground, in particular by laying small quadrates are closely scrutirizing the make-up of the vegetation therein. It is then realized that a simple classification of vegetation into plant communities can scarely by realistic.

For instance, if one lays a sequence of contiguous (toughing) quadrate along a transept (straight) line across a bracken dominate zone, starting andenclosing well away. From the bracket it is extremely difficult to delimit the bracken may be so dense as to entirely suppress all other spp by its shade in the summer and the density of its litter at other times of the year. On either side the density of the bracken becomes less and less; but it will be found quite impossible to say exactly when the transept away. From the area of dense bracken, many quadrates will contain isolated braken stems and some quadrats may contain more than one.

For many years, plant ecologists were divided in their opinion as to whether vegetation consists of a series of district communities or whether vegetation types grade into one another, i.e. vegetation is a continuum.

Those ecologists who favoured the community idea of vegetation recognized that boundaries of communities are indistrict.

They coined the word ecotone to describe the area of the boundary and the ecotonois considered to be a district vegetation type in itself. Very often the ecotone is found to be more species rich than either of communities it separates and this is ascribed to the fact that not only does the ecotone contain species of both adjacent communities. In other words, the ecotone could be recognized as a community. In other words, the ecotone could be recognized as a community itself.

Purpose of vegetation analysis

There are basically two reasons for surveying and analyzing vegetation. One of these is for description are mapping purposes, and other reason is for what we shall call ecological purpose. Since the prime objective of ecological enquiring is to determine the factors, both biotic and abiotic which control the occurrence and distribution of plant spp the phase for ecological purpose will mean the use of vegetation analysis to investigate spp-spp and spp environment relationship.

Based on the scale of the work in the fields, it is convinent to classify the various aims of vegetation analysis into three categories.

Large scale vegetation survey

This kind of survey is made when interest centres on describing are mapping the vegetation of a large area. At this level of working, distrinct communities may be recognized and the aim is almost in variably a description and classification of community types. For this kind of work methods of pytosocology are particular useful, and it is employ.

Small scale survey

At this level of working it is usually very difficult to adhere to the community concept. This is used restricted area, containing different vegetation types, where the objective could either be mapping of ecological purposes.

Qualitative description of vegetation

A qualitative habitat description uses subject description instead of numbers. A quality description habitats most obvious features e.g. you can talk about the high forest or the low closed scrub.

Qualitative description have many uses

1) To placer a plant or animal or event in a known easily understood setting, for example you could say that you saw congo clauless often tracks in a swamp forest or in marantaceac forest.
2) To produce a preliminary stratification of an area by vegetation type, prior to systematic sampling of animal density or plant communities.
3) To look for trends in the way animals uses different habitat types, for examples from animal survey which do not include detailed vegetation analysis.
4) To give people a common set of terms to use when discussing the different parts of the forest. This allows for more efficient communication between colleagues e.g. you can say that the patrol will being in the secondary forest near the road, pass through logged forest and end near the clearing.
5) To allow protected area staff to describe in general terms, to any person, the types of habitats that can be found in the area. This is important if protected area staff are going to communicate easily with vistors and other interested people. For example, you can say that most of the forest found in the part is tall and relatively open, with a sparse under stored. However, the weather area are characterized by many palm trees and a denser under storey.

Descriptive factors used in qualitative habitat Descriptions

1. Dominant or most common tree Spp.- some forest types can be adequately described by listing the 1-3 most common trees found in that forest, for e.g. the "dlibertiodendron dewevrei forest" of central Africa when there are no species that are found much more commonly than any other, the forest can be called a mixed forest.
2. Indicator spp. - certain spp. at trees, called "indicator spp" can be indicate growing conditions or past disturbance to the forest.
3. Average canopy height"- A relatively tall forest may grow next to a relatively short forest. Although the cause of the difference in canopy height may be differences in soil or water conditions, the descriptions at the forest types can remain 'high forest' and ' low' closed scrub', beers the difference in canopy height provides the most obvious difference between them.
4. Open or closed canopy: some forest exhibit a 'closed canopy' meaning that these are almost no spaces between the leaves of neighbouring canopy trees. An "open canopy refers to a forest where many spaces (gaps) in the canopy allow patches of sunlight to reach the under – storey or the ground.
5. Average tree size – some forests, such as swamp forests or young secondary forests, are made up one small tree, (i.e. small trunk diameter). By contrast, other forests have greater proportions at large trees.
6. Under – storey density: Some forest possess a thick, dense larger it ground vegetation, shrubs and small trees, while others are relatively tree of under –storey vegetation.

Quantitative Classification

A quantitative classification of a habitat is a numerical description of that habitat's features. Generally, quantitative habitat descriptions are more detailed than qualitative habitat descriptions. For example, you can say quantitatively that 23% of the trees in the primary mixed forest are in the family (aesatpiniaceae, where the mean density of the tree is 579 trees/ha, and the mean trunk diameter (including only trees greater than 10cm in diameter) is 32cm.

Quantitative studies are extremely useful for many reassess and can provide the kinds of detailed information that are needed to make effective, realistic management decisions. These includes

- ✓ Determine which Spp. are common, and which ones are rare in only given area.
- ✓ Quality spp. composition in different habitat types, and hence refine and improve subjective vegetation classifications.
- ✓ Quality the density of fruit trees that provide important foods for animals.
- ✓ Help determine if a timber species or other part product is being exploited sustainably.
- ✓ Assess how long it takes old farmland to return to mature forest.
- ✓ Map the distribution of important forest types.
- ✓ Provide a record from which all future changes can be assesses.
- ✓ Provide the means to make detailed comparisons with other forests.
- ✓ Investigate links between vegetation and animal numbers or movements.

INFORMATION THAT CAN BE OBTAINED FROM A QUANTITATIVE STUDY

1) **Forest Structure**

The physical structure is one of the most obivious ways to describe a forest, and is important because it can help determine the types of species present. In particular, the quantity of sunlight that reaches the forest floor can strongly influence the species composition of the trees and other plants. Which in turn, can be influence which animal species are found there in addition certain animal spp. may be restricted to forests with specific physical xtics. For example, vegetation that is dense enough to hide in or trees that is strong enough to climb in.

2) **Average canopy height**

The true height of a forest's canopy is difficult to measure, standing beneath of a guessing its height is not a reliable method, even though it is perhaps the most commonly used. If tree/canopy height is important for your study: it is best to measure all heights. Another way to estimate the average canopy height is to use a tape measure to measure the lengths of numerous fallen canopy trees, and the take the mean, or average of those measurements.

3) Canopy cover

Canopy cover gives a measure of the amount of light penetrate through to different layers of the forest. As a rule, undisturbed forest have high canopy cover and there is only sparse ground vegetation in their gloomy under – storey. Secondary or disturbed forests tend to have incomplete canopy cover and dense ground vegetation – many methods have been used to estimate canopy cover. Some researchers have used photographs taken vertically with either a standard or fish – eye lens, and estimate the proportion of their picture are covered by sky.

DESCRIPTION OF VEGETATION

A lot of attention had been directed in the past towards the description of vegetation. The object of such description is to enable people to have a mental picture of an are its vegetation and allow comparison and ultimate classification of different units of vegetation.

Before any serious or dealer work can be carried out in an area. It is necessary to know what specie are present, what is their distribution and what is the relative abundance, what each spices .thus floristic composition simply expressed as a list of species, life form composition and structure of vegetation are a necessary basis of all ecological work.

LIFE–FORM

It is a term to describe the vegetation (morphological form of the plant body. Life systems are based on differences in gross morphological features. Features used in establishing life –from classes insoluble deciduous leaves versus evergreen leafless, broad versus needle leaves, size of leaves, degree of protection afforded the permeating tissue, succulence, and duration of life cycle (annual, biennale, or perennial).

There is a deer between life form and climates. For example, broad –leaved evergreen trees clearly dominate in the hot humid tropic whereas broad –leaved deciles trees prevail in temperature climates with cold winters and warm summers, and succulent cacti dominate American deserts.

Many life-form systems have been developed. The most successful and widely used system in describing the classifying lie-form is that of C. Raunkiuer (19003, 1909, 1928, and 1934). The arranged the life form of species in a natural series in which the main criterion was the height of the permuting bud (the tips of shoots which renew growth after a dominant season, either cold or drought). Raunkiaer's classes were based on the degree of protection afforded the bud as the position of the bud relative to the soil surface. They applied to autotrophic, vascular, self supporting plants.

Raunkiae'r established the following types.

(I) Phanerophytes- the parenting buds or shoot apices borne on <u>aerial shoots</u>. Thy are any tall plants visible all the year round, which up in the at least 25cm up. This includes all trees, lianas and virtually all shrubs in the strictly structural classification.

(a) evergreen phanerophytes cout bud scales

(b) evergreen phanerophytes with bud scales

(c) dewdrops phanerophytes with bud scales

(ii) Nana phanerophytes (<2m in height)

Micro phanerophytes (2-8m)

Meson phaneropytes (8-30m)

Mega phanerophytes (7.30m)

(2) Chamaphytes – preempting bids or shoot apices borne very close to the ground. The are low growing plant that are visible all year round which carry the 8 pernnialbude any where from the ground to about 25cm up. They are capable of handling round environments than phanerphytes because of their low stature (they are exposed to less wind and some ground warming). Examples include the small shrubs found in the tundra unmated.

(i) Suffruticose chamaephytes – characterized by more or less erect aerial shoots which die away in part at the onset of an unfavorable season. Preempting buds arise in the lower portions of the react systems where are exposed to the environment.

(ii). Passive chamaephtes- similar to the last group but at the on set of adverse conditions the weakened erect axes fall over and buds arise along the horizontal stems where at ground level they obtain some protection from the environment .

(iii). Active chamacphytes – the vegetative shoots are persistently orientated along the ground usually rooting their length.

(3) Hemicryptophtes preempting buds at ground_level, able conditions. Stilton's many or many not be present. They are after hidden by litter in the rough season which portents them. This induces many forbs, perennial grassed, and ferns.

(i) Proto hemicroyptoytes- lower most leaves on stem are less perfectly develop than the upper ones, the preempting buds arise at ground level.

(ii) Partial rosette plants- the best developed leaves form a rosette at the base of the aerial shoot, but some leaves as present on the aerial stems

(4) Cryptophytes-perrenating bulbs below ground level or surbmerged in water. Die back to under ground structures: such as bulbs, corms, or rhizomes, during the challenging times of the year. They would include a lot of forbs in the strictly structural classification. Example include lilies, onions, garlic, potatoes.

(5) Therophytes- Annual species which complete a life history from a seed to during the favorable season of the year, the life span can be as short as a few weeks and they are characterized of dry regions. Annual grasses would be an example. Using the life form as a basis for comparison;

(1) It is possible to compare areas which are widely separated geographically and do not contain species common to both.

(2) It is a useful measure for comparison on a geographical scale and shows the number of species within each life form group.

(3) In general the life form spectrum is not of great significance in comparing adjacent areas of vegetation but is of value in the realm of plant geography.

Quantitative assessment of abundance vegetation is a major component of forest ecosystem.

The composition, diversity and structure of vegetation are important factor for assessing biological diversity of forest ecosystems. The composition and structure of vegetation can serve as bio-indicators for environmental changes to ecosystems, changes in vegetation and in underlying environmental factors can serve as indicators of the status of other organisms based on our current knowledge of the ecological niches of numerous plant spp.

Two main objectives of the vegetation assessment are to;

1 characterizes the current state of the forest ecosystem on the basis of the composition of the vegetation.

2 monitor of the vegetation changes due to natural and an propogenic environmental factors.

Abundance of species can be expressed in several ways ranging from a direct count of the number of individuals in an area (density) to the no of times the species occur (frequency) or area covered (cover) or the dry weight of vegetable material produced in a given area (biomass/yield).

Since the realization that a large degree of error is inherent in subjective evaluation of abundance, ecologists have become increasingly conscious of the nessesity of using quantitative measures to describe vegetation.

DENSITY

This is a count of number of times of individual within an area. It is usual to count the no of individuals within a series of randomly distributed quadrants, calculating the average number of individuals relative to the size of quadrant used, from the total sample.

The method is accurate, allows for direct comparison of different areas and different species and is an absolute measure of the abundance of a plant.

The disadvantage of the method is usually associated with the time involved in counting very large number of individuals. This can be circumvented by counting within small quadrant but these always remains those cases where the individual can not be picked out with any great degree of certainty e.g grasses or sedges.

In some instances a convenient unit of vegetation used instead of the complete individual, Thus tillers, flowering culms, erect shoots, or whole clumps could be suitable reflection of the density of a species where these approaches fail, it is necessary to find an alternative approach.

$$R.D = \frac{\text{Number of individuals of a species} \times 100}{\text{Total Number of individual of all species}}$$

COVER

This is defined as the proportion of the ground occupied by perpendicular projection on to the aerial parts of individuals of the species under consideration. It is infact an estimation of the area covered by given species usually expressed as a percentage of the total area and estimated from a number of sample points. The cover value can be obtained either by a visual estimate, a certain percentage of the total area of a quadrant being covered by a given species or measured by taking a number of points from the sample area and determining at those points which species if any is covering the surface of the ground. Visual estimates are subject to personal bias and should be avoided where possible despite their relative speed and ease of use.

Measures of cover are conveniently obtained using a frame of pins. The pins are lowered one at a time and the species touch by each pin is then recorded. The final number of 'hits' from a number of sample 'frames' is then expressed as a percentage cover for all species in an area will always exceeds 100% since in closed vegetation, leaves of several different species frequently overlap one another at a particular point. If absolute measures of percentage cover are required, it is important to use optical method which will give a reliable measure of the cover of a species.

Percentage cover is a good measure of plant abundance and is very widely used in grassland where it is impossible to define one individual starts and another ends.

The main disadvantage of the method is the rather tedious and show sample involved. This can make the measure impractical in a large scale survey. The difficulty in accurately observing the point of the needle in tall vegetation does lead to some error and these is a definite limits to the practicability of the method.

the main error involved in this measure of abundance (apart from small personal errors which are inevitably present and only of any consequence in tall vegetation) is the exaggerations of the estimate percentage error when a large diameter pin is used.

FREQUENCY

The frequency of a species is a measure of the chance of finding it with any one trow of a quadrant in a given area. Thus if a species has a frequency of 10% then measure should occur once in every ten quadrants examined. Them measures is obtained by nothing whether a species is present or not in a series of randomly placed quadrants for e.g if 86 quadrants out of a total of 200 contain a given species. The frequency is 86 X 100 = 43%

200

Two convenient forms of frequency are used- **Shoot frequency** and **rooted frequency.** The shoot frequency is obtained by including as ‘present’ all parts of the foliage that overlaps into a quadrant rooted frequency measure only include a species as present when it is actually rooted within the area of the area of the quadrant. The only advantage of frequency as a measure of abundance lies in the ease and rapidity with which an area can be sampled. The error involved in estimating frequency compared with cover or density is negligible, but the final frequency figure obtained is dependent on several factors, which considerably offset the advantages of speed and facility.

(a) Effect of quadrant size

Frequency is dependent on quadrant size and it is important to state the size of frequency. Consequently if data are to be compared from different sample plotg, it is essential to use the same quadrant size throughout.

(b) The effect of plant size

Both species have the same density but using the size of the quadrant shown, species B will have a high and species A, a low percentage frequency . if rooted frequency value. It is essential that the type of frequency measure used is clearly stated.

(c) The effect of spatial distribution of individual.

With the same number of individuals present in each case and using the same size of quadrant, widely different values will be obtained.

YIELD

As a measure of abundance, yield has not been used very widely in ecological work. It is determined by chippings, drying and weighing them, so that for each species present a figure for dry weigh is available. Under field conditions, it is very time consuming to sort out chipping into the component species and accordingly. Its use as a measure of   is limited where a series of culture experiments or a series of field trials are being undertaken, the yield offers a reliable and absolute measure of both and vigour of a species.

PERFORMANCE

In some instance, it is necessary to know how well a plant is growing in a particular area and a measure of some suitable character can often be made, which reflects the relative vigour or performance as it is termed, of an individual. Suitable measures include leaf length, leaf width or a ratio of the two, these measures being related to leaf area (the area available for photosynthesis) or flower number, length of flowering spike, number of seeds per capsule reflecting the reproductive capacity of an individual. The choice of character depends entirely on the species under investigation, but suitable and gives a good measure of performance.

It is obvious that as the sample size is increased a better of the mean of the population is obtained, but to reduce the standard, the number of samples has to be increased greatly and in general. It is recommended to take as large a sample as time will permit. The calculation of a series of mean values as the sample size is increased rarely acts a guide and even if the fluctuations are reduced markedly at a given sample size it does not mean that the fluctuations have ceased altogether.

Similar considerations can be applied to quadrat density, frequency of percentage cover.

Size or shape of quadrat if the distribution of individuals in a population is completely random than the size of quadrat used is immaterial except from the stand point of convenience.

The most suitable quadrat on theoretical grounds being the smallest possible, relative to the type of vegetation and to their practicability of the enumeration of such a quadrat size.

The shape of a quadrat has almost by tradition been a square but some advantages are obtained by the use of rectangular quadrats, the variance between rectangular strips being less between squares of the same area.

One common erroe associated with quadrat work is in the ‘edge effect’ frequently a decision has to be taken whether a species is ‘in’ or ‘out’ of a quadrat.

REGULAR AND SPACED SAMPLE

In majority of cases samples of a population taken at random with their resultant standard error are of considerably more use than samples taken at regular intervals. However, there are same exceptions to the general rule.

Where the data about the of a species along an environmental gradient are required, it is worthwhile to sample systematically along a transect in order to record the of a species in relation to position. Similar considerations apply to isonomes and to the grid analysis of pattern.

PARTIAL RANDOM SAMPLING

If an area appears heterogeneous, the sampling method is to sub divided the area into a convenient number of equal sized areas and to take random samples within each sub-division. If the area proves to be uniform after all then the data can be clumped together, but on the other hand if the area is variable then information available which is relative to each sub-division of the plot and is accordingly of considerable interest. The use of partial random samples would be equally applicable to the hypothetical relationship between the distribution of a species and topography and the approach in general is ideally suited for sample plots which contain in slight variation of surface topography.

TRANSECT AND ISONOMES STUDIES

Transects are of considerable importance in the description of vegetative change along a environmental gradient or in relation to some marked feature of topography.

The method simply consist of laying out a line running across the zones to be sampled and then placing quadrats at known intervals along the line. Various measures can be employed in the description of a transect, density or frequency determinations being made of intervals along the line and cover determination most conveniently made by using a frame of pins orientated at right angles to the transect at fixed intervals.

The data is suitably represented, either by means of a graph or a histogram of a species plotted against position on the transect.

Another use of transect studies is in the description of   representing stages of a succession.

In general the use of a transect is of greater importance where the variation of vegetation in response to a changing environmental factor is well marked. If the change is only slight it is then necessary to layout a number of sample plots at intervals along a transect and make a detailed analysis by means of random quadrat within each plot. By this means slight trends in the density of a species down a slope may be detected and if factors which are measured at the same time.

An analogous approach to variation in the spatial distribution of a species in a sample plot can be made by the use of the isonome method which consists of laying out a grid of contagious quadrat over a sample area and recording. For each quadrat the   of the species to be considered. For each species separately, the density distribution is then reproduced on squared paper and those squares with approximately equal   values joined by a series of lines, giving a contoured distribution of species.

This method can be extended to suitable measurements of the environmental so that the distribution of a species in an area can be related to the distribution of other species or to environmental factors. The isonome method is in general a very convenient way of depicting relationships between species or between a species and some environmental factor. Clearly the method is only applicable where the distribution of species varies quite markedly.

PLOTLESS SAMPLING

In theory the point quadrat is a method of plotless sampling although it is usually used in association with a certain square quadrat or line transect.

The procedure starts with the selection of random points by the tossing of a quadrat stick, plotless sampling is particularly useful in first vegetation where minimal area is difficult to calculate and contain practical difficulties are encountered in sampling relatively large areas for tree

a) Closest individual method – A measurable is taken from the sampling point to the nearest individual and procedure repeated.

b) Nearest neighbour method – The distance from the first individual in method (a) to its nearest neighbour. By these methods the density of trees or the reciprocal of density, mean area (the mean distance between individuals) can be determined.

c) Random pairs method – extending from method (a) the nearest individual to the sample point is used and a 90^0 exclusion angle erected on either side of it. The distance from this individual to the nearest one situated outside the exclusion angle ismeasured.

d) Point – centered quarter method – from the sampling point, lines are erected at right angles to give four quarters in which the distance from the sample point to the nearest individual is measured giving four measures at each point. In this case the mean of all distances has been shown to be equal to the square root of the mean area.

The importance of sampling a plat community is to obtain the maximum amount of information from one set of samples, if the sampling procedure is incorrect, then the derived conclusions may be invalid. Each sampling procedure should be thought out in relation to a specific problem, the information required being borne in mind.

SAMPLING METHODS

Random sampling – It is usually necessary to distribute a set of quadrat in an area in such a way that the position of each quadrat is independent of all the other quadrats and is also independent of any prominent feature of the area.

The most satisfactorily way of obtaining a random sample from an area is to layout two lines at right angles to each other to serve as axes, each line is then marked by a convenient number of division. A series of random numbers taken from tables (or rarely by drawing a set of each time from a pack of cards) then are used as pairs of co-ordination to locate each quadrat in turn. It is often quicker to work all the random points by a series of pegs before enumerating the quadrats, each peg marking a corner of the quadrat.

Size of sample necessary – Each case has to be decided independently. Considered against the amount of sampling involved to reach a certain level of accuracy. The method consists of taking a sample of 5 quadrats of readings calculating a mean value.

The number of samples is then increased to 10, 15, 20 and a fresh mean is calculated each time. A graph relating mean value to the sample size is constructed and the point (i.e. the sample size) at which the mean value cease to fluctuate is easily determined.