Study of Plant Distribution on School Grounds[1]

Stanley A. Cain
Departments of Botany and Conservation,
The University of Michigan,
Ann Arbor, Michigan

Plant and animal distribution has occupied the attention of naturalists through much of history. "What grows where, and why?" has always been an important question for man whether the culture was primitive or civilized, ancient or modern. Food, medicine, clothing, materials for shelter and construction, and many of the amenities of life, whether simple or sophisticated, are derived from plants and animals. It has always been important that someone knew where certain kinds of plants or animals could be found and gathered or captured, what kinds of places and conditions they lived in, and whether they could be transplanted and cultivated or domesticated.

Biogeography and ecology have ancient roots in human needs. The more esoteric concerns that grew out of biosystematics and some aspects of modern ecology have continued the interest in plant and animal distribution not only on a grand scale but also in terms of patterns of local occurrence. It is obvious that school grounds offer laboratory conditions only for certain studies concerning local distribution. It is not necessary that a portion of the grounds be in any sense wild, or that they be forested. A lawn, a playing field, an abandoned field or neglected weed patch, the edges of a road or a path will do for some purposes.

What is it? The first question is inescapable, "What is it?" We need names for purposes of discrimination and convenience. The problem of identity should never be avoided. A distinctive thing, process or relationship needs a name if we are to think and communicate clearly. Common names will do, if we use them consistently, or symbols like "a" "b" and "c," until we discover what others have already decided to call something. Teachers, and in some cases students, should consult local, state or regional floras for correct names, common or scientific, of plant species encountered on school grounds. Many states have weed manuals which should be helpful. Land grant colleges and agricultural experiment stations have botanists who can be consulted for identifications. This requires sending them a dried plant specimen, preferably in flower.

Where is it? The next question, "Where is it?" arises naturally if the school ground or any other small section of the earth is inspected carefully, for no one species is found everywhere. Each one is found

---

[1] Part of the "Open Meeting of National Committee for Natural Areas for Schools" of the Nature Conservancy, AAAS, New York, 27 Dec. 1960.

somewhere, and a little observation reveals certain correlations between the observed locations and the observed conditions of those places. There are two phenomena here: 1) that of place, and 2) that of the condition of the place.

The first phenomenon can be dealt with by observation and a general description of where something occurs, or it can be handled by the use of appropriate coordinates. Occurrence can be mapped. To some extent it can be dealt with by the phenomenon of "presence or absence" in a series of sample plots such as quadrates, strips, line intersects, etc., but in this case we need to know where the samples were taken, so the matter of coordinates is not avoided.

The second phenomenon can be studied in an approximtae way by observing the conditions of the station, that is, of the place where something occurs. Incidentally, it seems better to reserve the word "habitat" for the conditions at a place, and use a word such as "station" merely to indicate location. Just by observation much can be judged about exposure to sunlight and consequently about heat, and by using simple relative classes the soil can be said to be coarse, medium or fine, wet, moist or dry, loose or compact, etc. Many schools will have the means of measuring some of the conditions of the environment that make one habitat different from another. If the staff and students of the physical sciences can be interested in a project of the biologists to study plant distribution, the combined instruments and techniques of several departments can produce a comprehensive description of the various living conditions on the school grounds that can be correlated with the occurrence of the different kinds of plants.

Correlations don't tell you "why" Let us suppose for a moment that we know where certain species grow on the school grounds and that we know several things about the conditions of life of the different habitats. We still can't answer the toughest question of ecology, "Why does something grow where it does and why isn't it found elsewhere?"

In the first place we should never forget chance. A species may be absent from a certain place by pure chance. It simply never got there. Absence doesn't prove anything. Since we are speculating about comparatively small space, it is likely that reproductive structures of most species of plants get about pretty generally over the entire surface. But distribution of propagules isn't enough; conditions have to be right for their germination and the subsequent establishment of new plants. Failures one year and successes another are to be expected along with the simple chance that a propagule reaches a given spot.

However, there will be dozens, hundreds or many thousands of individuals of the different species. If all the plants that belong to a given species seem to be limited to the compacted soil of paths, or to moist and shady spots, for example, then it is likely that the species is pretty well adapted to such conditions. Still it doesn't follow that a species couldn't grow well, or even better, in places where it doesn't occur. A species may be absent from a place because it is unable to withstand the competition of species that are even better adapted to the site, even though it would do better there if it had a chance. Simple correlations don't tell you why plants grow where they do. A high positive correlation does not mean that two phenomena necessarily stand in a cause-and-effect relationship.

It seems to me that interesting and important biological questions are beginning to emerge. What is tolerance? What is the nature of competition? What is the nature of interactions between organisms? When does a group of individuals of different species form a community, rather than a mere aggregation? An interesting question for students is, What is a weed? It is pertinent because many plants of school grounds are weeds. The correlative question is, "What biological characteristics do weeds have, i.e., what makes them weedy"? These matters lead naturally to experimentation. Part of it can be done outdoors; part of it is better brought into the laboratory. This is a point worth learning—the advantage of moving from the field to the laboratory and from the laboratory to the field in order to explore better the biological questions which arise.

Something about the narrowness or breadth of plant tolerance for different conditions can be learned on the school grounds by planting different species in different places. Seeds can be used or vegetative parts of perennial plants can be transplanted. They can be inserted into the pre-existing vegetation where they are faced with competition or they can be given a better chance by clearing small areas for them. To do it both ways tells us more than to do it one way alone, for we get a hint about competition. One thing to look for in transplant studies is the relative vigor of growth of similar plants in dissimilar places. Some species of the poorest sites may do very much better on better sites; others may not, with or without competition from plants naturally there.

More information about the limitations placed on plant occurrence may be gained in the classroom, laboratory or greenhouse by contriving experiments to test the success of plants over a range of conditions. The best way to do this, perhaps, is to attempt to vary one factor at a time, such as light intensity, moisture, or soil texture. It is not my purpose, however, to pursue this line of suggestions, but another.

Composition and structure. In looking about the school grounds we have discovered that some species are found in one place and others in another. We will soon discover that several of the species normally occur together and others do not. Whether or not they have similar ecological tolerances over a wide range of conditions, they at least have tolerances whose ranges overlap and which, under the local conditions, allow them to grow together. The different groupings on the school grounds, let's call them communities, are probably not completely discrete. Some species will be found predominantly in one place, say in the lawn, but a few members will be found in other places also.

The composition of a piece of vegetation is simply a question of the species that compose it. But we can also recognize what has been called "typical composition." To know what is typical requires comparison of different, similar stands of vegetation. Some species may be only accidentally present in one or a few stands. Others may be comparatively scarce but typical because they are usually present in the community type. Still others are obviously important for a variety of reasons. Some may be very numerous. Some may not be numerous but are conspicuous. Others may occur in patches, whereas some are regularly distributed through the community. The local distribution may be random, or it may be more clumped or more regularly distributed than random.

Several of these features lead us to a consideration of the structure of vegetation as distinct from its composition. They can all be investigated on a school grounds.

Number. It isn't feasible to count all the members of a species and is seldom worth much effort in any case, but on small sample areas the determination of density—the number per unit of area—will reveal some unexpected results. The members of some species will be much more numerous than others, more numerous than they appear to be. The converse will be true of others. Judgment may have been influenced by size of individuals or by their conspicuousness for one reason or another, such as color, flowering and fruiting, or the shape of leaves. An examination of number can lead in several directions.

When a few small sample plots have been used to determine density, the results can be expanded to the entire piece of similar vegetation. Impressively large numbers may occur for some species—millions of individuals in one lawn, for example. This is a good time to get the students interested in application of mathematics. Suppose, for example, that instead of one set of small sample plots having been used to determine density (from which an average density has been determined and a range of densities from one plot to another) that different teams of students take independent series of samples. Questions will arise which will send the students to the school's mathematicians for help. The results of the different sets of counts aren't the same. Which result is right? Which is more nearly right? What are the limits within which the average densities can vary if the differences are due to chance? What probable error does the mean density have? Something about the reliability of data, or its unreliability, is good to learn. Many people have never learned this. Nor have they learned, in many connections, that their individual observations form no adequate basis for generalization about a large population.

One runs into an interesting biological problem in an effort to find out something about number. What is an individual? What do you count? Many species present no problem, but all those that reproduce or spread vegetatively by stolons, rhizomes and rootstocks are only more or less individual at a given time.

Pattern of occurrence. Some species are more or less everywhere. Some species are more or less clumped. Some species are more or less associated, one occurring where another does to a higher degree than would be expected by chance. These matters can be studied. Once more let us lay out a series of small sample plots. In each plot merely observe whether a species is present or absent. Some species may occur in every sample plot. The ecologist would say they are 100% frequent. (Notice that frequence in this connection doesn't refer to density, but merely to how many of the sample plots contained at least one plant of the species.) At the other extreme some species may have been observed to be present in the vegetation (suppose we are examining a lawn) but didn't happen to get included in any of the sample plots. We might investigate that question. How many sample plots would have to be taken in order for all species to have been sampled? Would it be permissible to place the sample plots so that every species was sampled? If one selected the location of the sample plots would it "mess up" the results for other species? What is a random sample? How little work can you do and still get results sufficiently accurate for your needs?

So far we haven't said anything about the size of the sample plots other than to suggest that they be small. An interesting exercise would be to compare density and frequency data from series of sample plots that differ in size. A parallel study might compare results from sample plot series differing in number of plots. Increasing the number of the plots may have no effect beyond improving the accuracy of the estimates of number and frequency, but a change in sample plot size (area) may radically alter frequency data. Why? If the size of the sample plot is reduced to a point, there is no difference between density and frequency data. Why? If sample plots are too large, there is no discrimination between frequencies that is useful. Why? You may find that one species has a much higher average density but has a lower frequency than another species. How can that be? Some species may have clumped distributions because of their manner of reproduction. How do plants multiply? How do they get around? How do they pre-empt space? This brings us to another matter, life-form and the "control" of a community.

Life-form and coverage. Life-form has been handled in several different ways for different purposes and I wouldn't suggest going very far along this line, but a point or two can be made regarding its role in determining community structure. For example, the life-form of grasses is usually very different from that of most other herbs. Height, branching type, leaf size and shape, position of vegetative reproductive structures, annual or perennial duration, deciduous or evergreen leaf persistence and such matters enter life-form classifications. In almost all kinds of vegetation the different species belong to a few if not several different life-forms. This influences structure in one obvious way; it usually results in layers in the vegetation. One of the results of such differences is that the coverage of a species may not be correlated with either density or frequency.

Coverage is usually estimated as the ground shaded by the foliage of plants, assuming an overhead light casts the plant's shadow directly onto the ground. Coverage is rather easy to estimate, if difficult to measure, for low-growing plants. It is important because it suggests the competitive ability of the plants which have high coverage. They must shade adversely many other plants, and it can be assumed, since they have grown so well, comparatively, that they get a lion's share of soil moisture and nutrients. Species of high relative coverage in a community often are spoken of as "dominants." This term implies more than "predominance." It suggests control of the community. If the vegetation being studied is structured in more than one layer, dominance can be considered separately for each layer, yet the superior layer has some degree of dominance over those which are lower.

The question of wider distribution. Teachers may wish, or may be stimulated by students, to extend consideration of plant distribution beyond local occurrence. The wider areas of occurrence can be looked up in appropriate manuals. Weeds may be of especial interest because many of them are exotic and their distribution has been facilitated by man. In other words they have been imported by man, mostly inadvertently. This may give an added opportunity for inter-disciplinary cooperation. The historians may help out by suggesting routes of human movement and times and means of conveyance of weed seeds from Europe, Asia, and elsewhere to the United States and, ultimately, to the local area of the particular school.

The generation of student interest. Any of the preceding suggestions for fuller use of school grounds, including any more natural areas than have been discussed here, require interested teachers and, in most cases, interested administrators. Granted favorable circumstances, several things can be done to promote student interest. Perhaps a student biology or natural science club could become interested in some of the ramifications of study and action that lead off from the school grounds and class work. A herbarium could be started and added to by class after class. Student and class records could be kept so as to accumulate over the years and provide student interest in comparative data. Correspondence might be initiated between classes in different schools (even in different states) which are undertaking related projects. Photographic and other records will, over time, allow for study and discussion of change. The dynamism of vegetation is something worth learning about, in any case.

Conclusion. There are several possibilities for biological studies on school grounds that seldom are exploited. Natural areas, that is areas undisturbed by man, are not necessary for such studies. Some of these studies, although biological in nature or emphasis, may be of interest to other subjects of the curriculum and in favorable schools would profit by cooperation of the physical sciences and mathematics. I believe, also, that some of these experiences can have general meaning, especially those that raise questions about the limitations of data for generalization and the nature of competition.

ELECTRICAL EXPLOSIONS USED TO SHAPE METALS

Underwater electrical explosions are used in a new process to mold hard-to-form metals such as titanium, stainless steel and tungsten.

The new process, described as "capacitor discharge electrospark forming," is under development at General Electric Company's General Engineering Laboratory. It makes possible the saving of millions of dollars a year in the working of these difficult metals.

In the process the metal to be shaped is placed in a die underwater. A built-up of electrical energy produces an explosion that directs high-intensity shock waves against the metal to be formed. The impact of the shock wave causes the metal to take the shape of the die immediately. Removal of air from the die is necessary to prevent irregularities on the metal's surface.

The need for TNT, dynamite or other chemical explosives in forming the metals is eliminated by the process. Electrical potentials up to 35,000 volts are used now, but eventually 100,000 volts or more will be used.

Manufacturing aircraft and missile parts will be greatly simplified by this process. Metals thus far successfully shaped include niobium (or columbium), molybdenum and certain beryllium alloys in addition to titanium, tungsten and stainless steel.

The fact that the forming is done at room temperature without preheating is a considerable advantage. Metal pieces up to ten inches in diameter and one-sixteenth of an inch thick have been processed in this manner. It is expected that missile sections ten feet or more in diameter and one inch in thickness can be formed by the process.