Canopy-Coverage Method Compares Pasture and Prairie

PAUL G. JANTZEN

BIOLOGY STUDENTS LIVING IN REGIONS where the grazing of livestock is of economic importance might find relevance in studies that illustrate the degeneration of grassland. For the second year, at Hillsboro (Kan.) High School, we have used the canopy-coverage method of vegetational analysis to compare a low-grade, overgrazed pasture with a nearby high-quality prairie. This activity introduces students to several useful concepts: the measurement and expression of plant population density; the purpose and practice of random sampling; the determination of possible cause-and-effect relationships; and the development of problems that call for further investigation. In the process the students are introduced to a variety of plants and are made aware of problems in grassland management.

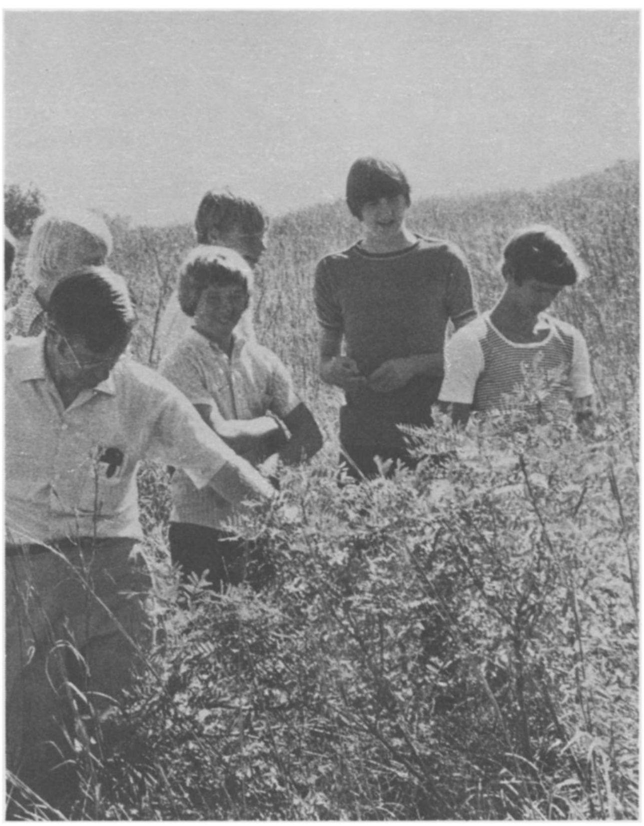

Fig. 1. The author points out prairie plant species in the grasslands on public hunting grounds in Marion County, Kansas.

The study is flexible. At several points decisions can be made by the working teams, by the class as a whole, or by the instructor. The study can be conducted by a large class or a single person. The comparison can be made not only between over-grazed and well-managed pastures but between burned-over and unburned grasslands, prairies and the understorey of forests, or even abandoned lots and well-groomed lawns.

The two areas analyzed by our high-school biology classes in October 1972 are in Marion County, Kansas, which lies between two physiographic regions: the Flint Hills and the Great Bend Prairie. The pasture is dissected by an intermittent stream and was being grazed by dairy cattle. The prairie, about 1 km away, is designated by the Kansas Forestry, Fish, and Game Commission as public hunting land. The areas appear to be similar in geology, elevation, slope, and ground-water supply. Both study areas are about a 10-minute bus trip from the high-school building; this allows 30–35 minutes' field work without extending our 55-minute class period.

Preparation for Field Work

The entire study may be done in about seven days, but independent investigation of problems arising from the study could extend to several weeks. We introduce the study with a written handout, which states the purposes of the study and describes the procedure. The class is divided into teams of 2–4 students each.

After a short discussion of the necessity of random sampling, we devise a method of determining the location of sample plots. This may be done by teams, by the class, or by the instructor. By one method we used, each team cuts numbers from an old calendar, places them in a paper bag or some other container, and thoroughly mixes the numbers. For each plot,

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two numbers are drawn. The first number indicates how many steps to move in a certain direction from a given point. The second number indicates how many steps to move to the right (or left) at a right angle to the first direction. All positions are determined from the same reference point, such as a shrub, a corner fence post, or a driven stake. (On fenced land, post-to-post intervals may replace steps as the basic unit of distance.)

This procedure assumes relative homogeneity of vegetation. In places where vegetation is patchy, more representative data may be obtained (i) by controlling the number of plots falling in different homogeneous vegetation units through systematic rather than random sampling or (ii) by greatly increasing the number of sample plots.

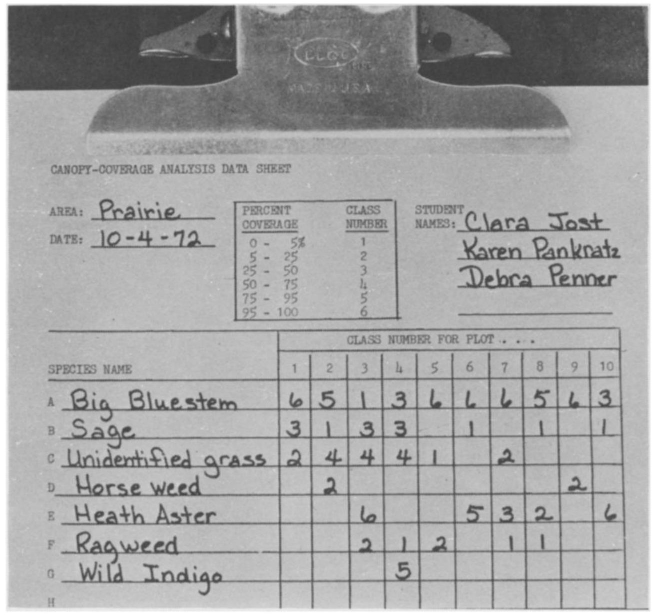
On the second day, students are taken to both study areas, in turn, for identification of the most common plants (fig. 1). This can well be supplemented with pressed specimens or slides, which may be reviewed in the laboratory.

Data-Collection and Calculations

We spend our third and fourth days in the field: one day in the pasture, the other on the prairie. Each team collects data from at least 10 plots in each area. The general combination of techniques used in the canopy-coverage method was described by R. F. Daubenmire (1959: "A Canopy-Coverage Method of Vegetational Analysis," *Northwest Science* 33[1]: 43–64). Daubenmire's paper thoroughly discusses the rationale of these techniques. A rectangular frame (ours are 20 cm by 40 cm) of 4-mm wire is placed

Fig. 2. Students record the percentage of the framed area covered by each plant species in a low-grade pasture. (Wire frame retouched to make it visible.)

briefly at randomly determined locations (fig. 2). Each species of plant included in or overhanging the frame is recorded, along with the class number, which indicates that species' percentage of coverage of the framed area according to the scheme included at the top of each student's data sheet (fig. 3). If students are unable to recognize a species, they ask the instructor for the identification or take a sample.



CANOPY-COVERAGE ANALYSIS DATA SHEET

AREA: Prairie
DATE: 10-4-72

PERCENT COVERAGE	CLASS NUMBER
0 - 5%	1
5 - 25	2
25 - 50	3
50 - 75	4
75 - 95	5
95 - 100	6

STUDENT NAMES: Clara Jost, Karen Panknatz, Debra Penner

	SPECIES NAME	CLASS NUMBER FOR PLOT . . . 1	2	3	4	5	6	7	8	9	10
A	Big Bluestem	6	5	1	3	6	6	6	5	6	3
B	Sage	3	1	3	3		1		1		1
C	Unidentified grass	2	4	4	4	1		2			
D	Horse weed		2							2	
E	Heath Aster			6			5	3	2		6
F	Ragweed			2	1	2		1	1		
G	Wild Indigo				5						
H											

Fig. 3. Data sheet, which includes the class number recorded for each range of coverage by the various plant species.

Each sample is assigned a letter, which is written on masking tape and attached to the sample. Thereafter, that species is referred to by letter and is identified at a later time if it is present in significant quantity. Separate data sheets are provided for each of the two study areas.

One or two class periods are required to complete calculations. The time required depends on whether each team collects and interprets its own data or all teams pool their data. (Although the pooling of data provides a better statistical sampling, it is more time-consuming and makes the final summary more remote from each student's experience.) To facilitate calculation, we use a special form (fig. 4) in which, for each species, the number of plots in each class is multiplied by the midpoint of that class. These products are averaged to produce the percentage of coverage of the area by that species. A table summarizing the data from both study areas completes the mathematical task (see table).

Formation of Hypotheses

On the last day, either as a class or in teams, students reexamine their techniques and search out reasons for the differences in canopy-coverage by various species in the two study areas. The following statements are used to guide the inquiry:

1. Tell why it is important to use a system of random sampling to determine placement of sample plots.

2. Describe the system of sampling you used and explain why the system is really random.

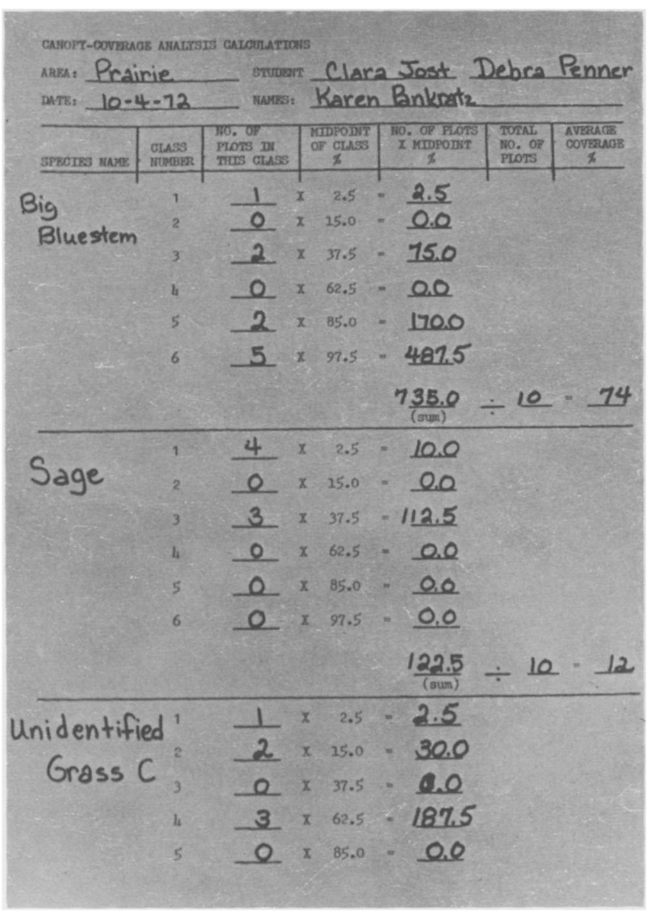
3. Determine possible reasons for differences in population density in the two areas for several individual species. Consider their growth requirements, growth habits, and palatability to livestock. Use direct observation and library references to arrive at your tentative hypotheses.

4. Propose experiments that might confirm or nullify your hypotheses.

Responses to the last two items provide many opportunities to test hypotheses experimentally.

Interpretation of Results

Much of our interpretation is based on the work of a veteran student of grasslands, John E. Weaver (1954: *North American Prairie,* Johnsen Publishing Co., Lincoln, Neb.). Weaver says that the deterioration of prairie is due largely to the preference by livestock for certain plant species. Under heavy grazing the most desirable forage species, such as the bluestem grasses and the legumes, are weakened and


CANOPY-COVERAGE ANALYSIS CALCULATIONS

AREA: Prairie STUDENT NAMES: Clara Jost Debra Penner Karen Bankratz

DATE: 10-4-72

SPECIES NAME	CLASS NUMBER	NO. OF PLOTS IN THIS CLASS	MIDPOINT OF CLASS %	NO. OF PLOTS X MIDPOINT %	TOTAL NO. OF PLOTS	AVERAGE COVERAGE %
Big Bluestem	1	1	x 2.5	= 2.5		
	2	0	x 15.0	= 0.0		
	3	2	x 37.5	= 75.0		
	4	0	x 62.5	= 0.0		
	5	2	x 85.0	= 170.0		
	6	5	x 97.5	= 487.5		
				735.0 (sum)	÷ 10	= 74
Sage	1	4	x 2.5	= 10.0		
	2	0	x 15.0	= 0.0		
	3	3	x 37.5	= 112.5		
	4	0	x 62.5	= 0.0		
	5	0	x 85.0	= 0.0		
	6	0	x 97.5	= 0.0		
				122.5 (sum)	÷ 10	= 12
Unidentified Grass C	1	1	x 2.5	= 2.5		
	2	2	x 15.0	= 30.0		
	3	0	x 37.5	= 0.0		
	4	3	x 62.5	= 187.5		
	5	0	x 85.0	= 0.0		

Fig. 4. Calculation sheet, used to determine the average percentage of canopy-coverage by each species.

Summary of canopy-coverage by selected species in a prairie and a pasture in Marion County, Kansas, in October 1972.

Species	*Percentage of Coverage* PRAIRIE	PASTURE
All grasses	70	54
Big bluestem	32	0
Scribner's panicum	1	0
Switchgrass	1	0
Three-awn	0	1
Unidentified grasses	36	53
Sage	9	3
Wild indigo	5	0
Goldenrod	2	0
Buckbrush	2	0
Ragweed	2	11
Osage orange	2	3
Heath aster	1	4
Sumpweed	0	12
Buffalo bur	0	5
Dandelion	0	5
Cocklebur	0	2
Yarrow	0	1
Spurge	0	1

decrease in population density. As the decreasers disappear the unpalatable plants have more water and light available, and they increase. The increasers include less desirable grasses and unpalatable forbs, such as yarrow, heath aster, and ironweed. As bluestems and legumes weaken and die and livestock trample the soil, bare patches appear and become colonized by invader species, such as ragweed, thistles, vervain, spurge, and three-awn grass. Weaver lists many species that appear as decreasers, increasers, and invaders in degenerating prairies of North America.

Accompanying these shifts in plant population is a decreased quantity of humus, increased erosion, loss of nutrients, elevated soil temperature, and increased numbers of rodents and grasshoppers.

Even the growth habits of some grasses, when coupled with grazing, contribute to the degeneration of prairies. Grasses differ from other seed plants in having a meristematic region at the base of the leaf. If part of the leaf is cut off, the leaf continues to grow. In some grasses, such as bluegrass, bluegrama, and buffalo grass, foliage originates at the soil surface, and the plants are resistant to grazing damage. In other grasses, like the bluestems and switchgrass, foliage develops far enough above the soil to be vulnerable to damage by grazing or short mowing.

In our region, the most useful forage grasses are those that are sensitive to short grazing. Therefore practices that contribute to the degeneration of prairie include grazing too many animals for available forage; grazing before the important species have developed enough growth to withstand injury; extending the grazing season so late that the grasses are unable to store sufficient food reserves to withstand the winter and develop new growth in spring; and undesirable locations of water, shelter, shade, and salt,

(Concluded on p. 340)

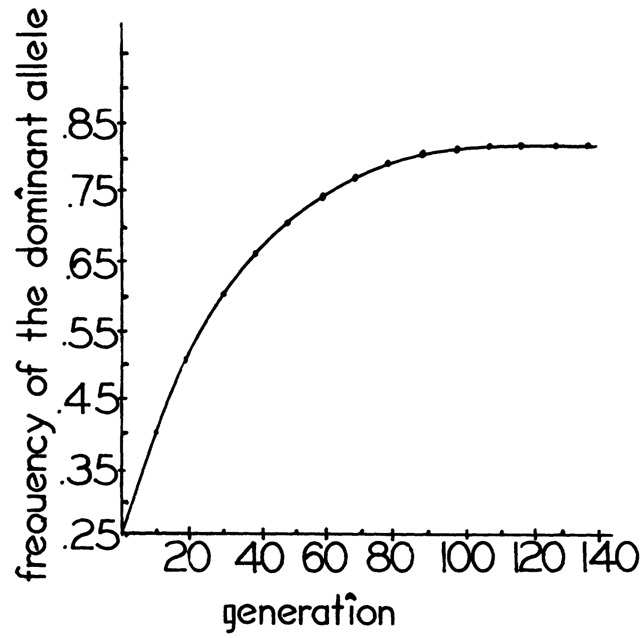


Fig. 3. Alteration in frequency of the dominant allele when a constant environmental selective pressure of 15% is exerted against the homozygous recessive condition.

reconstituted population, the latter being made up of parents and offspring as described below.

A modified program using the computerized model enables the teacher to illustrate why even fairly rigorous selection against a recessive allele is not sufficient to totally remove that allele from the population even after a great many generations. The original program could be used, for example, to print out the frequency of *A* over a period of 100 or 200 generations; but that would require an excessive amount of time and paper, even for the computer. However, much of the print-out is omitted, in the modified program, and the student can observe the long-term effects of selection on a print-out obtained in 10 minutes or so. Fig. 2 illustrates the kind of print-out obtained in this program. Note that the print statements of earlier versions are omitted, along with the calculation data that are used for determining the new frequency for *A*. Note also that one is able to select the interval for printing a new gene-frequency, such as every 10th generation.

In the original program for natural selection, the student will obtain data suggesting a straight-line graph if extrapolated from only 10 or 15 generations. If the second natural-selection version is used and a larger number of generations is observed, a graph of the data quickly shows what might have been an error if the extrapolation had been carried out (fig. 3).

Other Advantages

The Time-Shared Basic system has been valuable in the teaching of evolutionary processes in my classes in other ways. (i) It has enabled the student to omit much of the "garbage" that had been a major stumbling-block to his understanding of evolution—what it is not, as well as what it is. (ii) Much of the time required for the manual operation of the exercise has now been eliminated in favor of more profitable discussion of results that are immediately available. (iii) The use of the computer has not only stimulated interest but has produced data, valuable for discussion, that otherwise might not have been generated.

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with a resulting unevenness in the distribution of grazing and trampling.

Many of the factors students may suggest as being operative in changing the population density of specific species can be rephrased into testable hypotheses. When this happens, perhaps the process of biologic education has begun.

Acknowledgments.—The canopy-coverage method of vegetational analysis was introduced to me by Thomas Eddy, of Kansas State Teachers College, at the 1971 National Science Foundation Summer Institute in Environmental Biology. The photos are by Chuck Grunau and Randy Rediker, students.

Awards in Science Education

The National Science Teachers Association is accepting nominations for its annual distinguished-service awards in science-teaching. Criteria include one or more of the following: sustained leadership and scholarly endeavor, efforts to enlist public support of science education, direct contributions to curricular improvements, and personal excellence in science-teaching. Nomination forms, returnable by 1 January, may be obtained from the executive secretary, NSTA, 1201 16th St., N.W., Washington, D.C. 20036.

NSTA's first Robert H. Carleton Award—in the name of the long-time, soon-to-retire executive secretary of the association—has been given to Stanley E. Williamson, chairman of science education at Oregon State College and a past president of NSTA.

Harmful Water Projects

"Disasters of Water Development," a 15-page pamphlet describing several dam, canal, and channelization projects considered harmful to the environment, is available free from the National Wildlife Federation, 1412 16th St., N.W., Washington, D.C.