Application of the Braun-Blanquet Cover-Abundance Scale for Vegetation Analysis in Land Development Studies

DOUGLAS A. WIKUM[1]
Stone & Webster Engineering Corporation,
245 Summer Street
Boston, Massachusetts 02107

and

G. FREDERICK SHANHOLTZER[2]
Dames & Moore
6 Commerce Drive
Cranford, New Jersey 07016

ABSTRACT / To document environmental impact predictions for land development, as required by United States government regulatory agencies, vegetation studies are conducted using a variety of methods. Density measurement (stem counts) is one method that is frequently used. However, density measurement of shrub and herbaceous vegetation is time-consuming and costly. As an alternative, the Braun-Blanquet cover-abundance scale was used to analyze vegetation in several ecological studies. Results from one of these studies show that the Braun-Blanquet method requires only one third to one fifth the field time required for the density method. Furthermore, cover-abundance ratings are better suited than density values to elucidate graphically species-environment relationships. For extensive surveys this method provides sufficiently accurate baseline data to allow environmental impact assessment as required by regulatory agencies.

Introduction

The United States' National Environmental Policy Act of 1969 and similar state regulations and guidelines require environmental impact assessment for industrial, commercial, residential, and recreational developments. Among a number of land perturbations, the removal of vegetation during construction frequently creates the greatest impacts. To document impact predictions, vegetation studies employing a variety of methods are conducted.

The principal objectives of these studies are to:

1) determine the extent, structure, and composition of plant community, habitat, or vegetation cover types;
2) document the presence or absence of endangered or threatened plant species;
3) describe vegetation-environment relationships;
4) detect existing natural and man-induced environmental perturbations;
5) describe successional trends and patterns.

KEY WORDS: Environmental impact assessment, Density measurement, Braun-Blanquet cover-abundance scale, Vegetation analysis, Biogeography.

[1]Present address: Department of Biology, University of Wisconsin-Stout Menomonie, Wisconsin 54751

[2]Present address: Envirosphere Company, 19 Rector Street, New York, New York 10006

Baseline information gathered in meeting these objectives is used to assess the environmental impact of the construction and operation of proposed developments on existing vegetation and associated fauna. Four broad categories of methods are used to accomplish the stated objectives. The methods, listed in order of increasing quantification, are: 1) tabulation of a species list, 2) estimation of relative abundance, 3) estimation of foliar coverage, and 4) density measurement (stem counts). Frequency is also used, but is usually calculated from abundance, coverage, or density data.

Biologists who design and conduct land development studies work under definite cost and time constraints. Consequently, the selection of efficient, cost-effective methods that meet objectives is vitally important.

Table 1 contains a summary of the methods used to study shrubby and herbaceous vegetation at 15 proposed industrial sites in seven states. It is based on a survey of environmental reports that were readily available to us, and were assumed to be representative of studies of this type. Stem counts were made at 14 out of the 15 sites for shrubs and at 11 out of 15 sites for herbs. The number of stems counted varied considerably, from a desert where plant density was low to an eastern deciduous forest where in a 400 ha site, 26,823 stems of herbaceous plants were counted in 133 1 m^2 quadrats. Counting this many stems requires considerable time and, consequently, is expensive. Foliar coverage estimates were made in conjunction with stem counts at 12 sites for shrubs and 10 sites for herbs. This practice further increases the cost of vegetation studies.

0264-152X/78/0002-0323 $1.40

Table 1 Frequency of methods used to study shrubby and herbaceous vegetation at 15 potential industrial sites

Method	Frequency	
	Shrubs	Herbs
Species list	1	2
Relative abundance	0	2
Percentage foliar cover	12	10
Density measurement (stem counts)	14	11

Use of the Braun-Blanquet Method

To overcome some of the limitations of counting stems, we have used the Braun-Blanquet cover-abundance scale (Braun-Blanquet 1932, 1964), as shown in Table 2, to estimate species importance in studies of herbaceous and shrubby vegetation. Cover was determined from estimates of vertical plant shoot-area projection as a percentage of quadrat area (Mueller-Dombois and Ellenberg 1974). Only the index designating the appropriate cover-range was recorded in the field. Solitary species, conventionally assigned an "r," were combined with those assigned a "+" (cross) rating in our studies.

We have used the Braun-Blanquet cover-abundance scale in a variety of land development studies in a number of states. Studies include potential sites for power plants, dredge material disposal sites, a sewage pipeline corridor, and a proposed dam. Data collected at Hart Island, in Long Island Sound, are presented here to illustrate some of the applications of the Braun-Blanquet scale. In all studies, sampling was conducted at regular or subjectively determined intervals along transects. At Hart Island, herbaceous vegetation was studied in 1 × 2 m, and shrubby vegetation in 2 × 5 m, quadrats. Quadrat sizes at other sites ranged up to 5 × 5 m for shrubs.

Table 2 Braun-Blanquet cover-abundance scale

Braun-Blanquet scale	Range of cover (%)
5	75–100
4	50–75
3	25–50
2	5–25
1	<5; numerous individuals
+	<5; few individuals

Application of Data

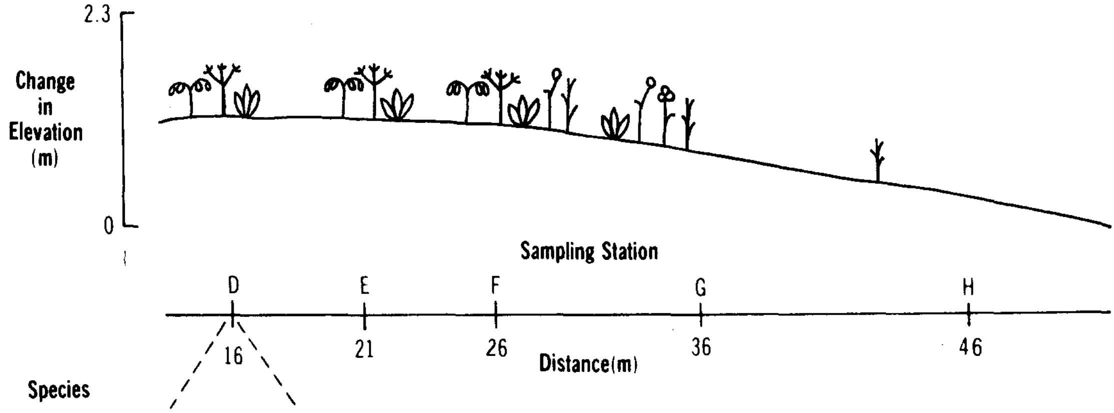
Description of vegetation-environment relationships is one objective of vegetation studies that is often poorly met. In practice, vegetation and environmental information is frequently included in separate sections of reports, without any discussion of their ecological relationships. To overcome this problem, we used profile diagrams to elucidate graphically the vegetation-environment relationships. The use of cover-abundance ratings in profile diagrams allows one to visualize simultaneously species importance, community composition and structure, and vegetation-topographic relationships. A profile diagram of a transect through a 1.2 ha salt marsh on Hart Island (Fig. 1) illustrates this fact. This diagram is patterned after those developed by Richmond and Mueller-Dombois (1972) in their studies on coastal ecosystems of Oahu, Hawaii. The transect line for the Hart Island Study is marked off in sampling stations at specified intervals. The plant profile symbols along the transect represent plant species that occurred at each sampling station. The cover-abundance index for each species appears to the right of the species name, directly below the plant profile symbol selected for that species. For example, *Spartina alterniflora* (cord grass) has a + (cross) rating (<5% cover with few individuals) at sampling stations F and G and a rating of 5 (75–100% cover) at station H.

To further illustrate ecological relationships, soil types can also be included in the profile diagrams. Plant species can be listed by stratum when applicable. In addition, the density or abundance of dominant, rare or endangered, or selected fauna present along sampling transects can be included in the profile diagrams. Thus, profile diagrams can be used to combine a variety of information to focus on ecological relationships.

The fact that data collected using Braun-Blanquet cover-abundance estimates are recorded on a scale with indices that are not additive, suggests that the data are

Table 3 Conversion of Braun-Blanquet cover-abundance scale to midpoint of cover range

Braun-Blanquet scale	Range of cover (%)	Midpoint of cover range (%)
5	75–100	87.5
4	50–75	62.5
3	25–50	37.5
2	5–25	15.0
1	<5	2.5
+	<5	0.1



Species					
Suaeda linearis	2	+	+		
Salicornia europaea	1	3	+		
Limonium nashii	2	3	+	1	
Distichlis spicata			5	5	
Spartina patens				+	
Spartina alterniflora			+	+	5

Figure 1. Profile diagram showing plant cover-abundance ratings along transect through a salt marsh on Hart Island, Long Island Sound, New York State.

not amenable to further analysis. However, following conversion of the Braun-Blanquet scale to midpoint coverage, as shown in Table 3, data can be synthesized and analyzed by essentially the same methods as stem counts. The midpoint coverage values are those of Mueller-Dombois and Ellenberg (1974). The lowest two values are arbitrarily defined.

A summary of absolute and relative values of species importance in the salt marsh on Hart Island (Table 4) serves as an example for application of midpoint cover data. Parameters shown here for each of the 11 species present are: 1) plots of occurrence, 2) percent frequency, 3) total cover, 4) average cover, 5) relative frequency, 6) relative cover, and 7) importance value based on the sum of relative frequency and relative cover. Dominance (based on cover) of *Spartina alterniflora* in the salt marsh is clearly shown. Because absolute data, shown here as average cover, are based on a percentage, uniform comparison can be made among as well as within development sites. The presence, if any, of endangered or threatened plant species and their relative and absolute coverage values can be gleaned from these tables and their environmental relationships from profile diagrams.

Species diversity and evenness need not be based solely on density (Whittaker 1972), but can also be calculated from midpoint coverage as shown in Table 5 for herbaceous species in four community types on Hart Island. Among the four, the Old Field Community Type has the highest species richness, diversity, and evenness. The low evenness index for the Common Reed Community Type indicates plant cover is not well apportioned among species.

Table 4 Summary of salt marsh vegetation analysis for 18 1 × 2 m quadrats sampled on Hart Island, Long Island Sound, New York

Species	Plots of occurrence	Percent frequency	Total cover (%)	Average cover (%)	Relative frequency (%)	Relative cover (%)	Importance value
Spartina alterniflora	11	61.1	790.1	43.9	25.6	58.8	84.8
Salicornia europaea	8	44.4	47.8	2.7	18.6	3.6	22.2
Limonium nashii	7	38.9	72.7	4.0	16.3	5.4	21.7
Suaeda linearis	6	33.3	55.3	3.1	14.0	4.1	18.1
Distichlis Spicata	2	11.1	175.0	9.7	4.7	13.0	17.7
Ammophila breviligulata	2	11.1	75.0	4.2	4.7	5.6	10.2
Humulus japonicus	2	11.1	65.0	3.6	4.7	4.8	9.5
Convolvulus arvensis	2	11.1	62.6	3.5	4.7	4.7	9.3
Daucus carota	1	5.6	0.1	0	2.3	0	2.3
Digitaria sanguinalis	1	5.6	0.1	0	2.3	0	2.3
Spartina patens	1	5.6	0.1	0	2.3	0	2.3

The Braun-Blanquet scale is also adaptable to assessment of existing environmental perturbations. By comparing plant coverage values in disturbed areas with those in undisturbed areas having similar species composition, gross estimates of reduction in plant cover can be made. We believe this method also has good potential for estimating species importance of mosses, lichens, ferns, emergent, and even submergent aquatic vegetation. It can also be used for trees, but cover-abundance estimates are more difficult for this stratum.

By using classification or ordination procedures, midpoint cover data can also be used to identify plant communities or to verify community types tentatively identified during qualitative surveys or from aerial photographs. If a classificatory approach is desired, a computer program, PHYTO, developed by Moore (Moore and others 1970) and another by Ceska and Roemer (1971) may be used instead of hand sorting to construct Braun-Blanquet phytosociological tables. Frenkel and Harrison (1974) assessed the merits of several classificatory methods and concluded the Braun-Blanquet and information analysis methods are equally well suited for examining plant-environment relationships. Smartt and others (1974) have shown that the Braun-Blanquet method is improved by arcsin transformation of data prior to analysis.

Table 5 Species diversity and evenness of herbaceous vegetation in major community types on Hart Island, Long Island Sound, New York

Community type	Diversity index*			Number of species	Evenness index*	
	Simpson	Shannon	Brillouin		Shannon	Brillouin
Old field	0.89	4.11	3.36	50	0.71	0.64
Salt marsh	0.63	2.07	1.77	11	0.60	0.24
Young hardwood	0.69	1.92	1.58	11	0.55	0.40
Common reed	0.42	1.17	1.06	10	0.35	0.18

*See Simpson, 1949; Shannon and Weaver, 1963; Brillouin, 1956.

Wikum and Wali (1974) have demonstrated the feasibility of ordinating midpoint coverage values to establish abstract community types. Frequently used ordination methods include principal component analysis and Bray-Curtis (polar) ordination.

Detailed evaluations of ordination procedures have been made by Gauch and Whittaker (1972) and Orloci (1975). The Cornell Ecology Program Series, developed in the Department of Ecology and Systematics, Cornell University, Ithaca, New York, contains computer programs dealing mainly with ordinations. Additional information on both classification and ordination can be found in *Handbook of Vegetation Science,* Part V., *Ordination and Classification of Communities* (Whittaker 1973).

Evaluation of Time and Cost Requirements

A comparison of time and cost requirements between cover-abundance estimates and stem counts for analysis of salt marsh vegetation at Hart Island is shown in Table 6. It took 30 minutes to estimate and record cover-abundance values in 18 1 × 2 m quadrats; whereas, it took three hours to cut, sort, and count stems, and record data in 12¼ × ¼ m quadrats. The stem count method took six times longer, yet included only $\frac{1}{24}$th of the area sampled by the cover-abundance method. Because of the floristic simplicity of the salt marsh, the magnitude of difference in time required for the two methods is greater than in other community types studied. Therefore, depending on the physiognomy and species richness of the vegetation at the sites studied, we estimated that the cover-abundance method required one third to one fifth the field time necessary for stem counts. This means that three to five times as many plots could be sampled for the same cost. Furthermore, because cover-abundance quadrats are usually larger than stem-count quadrats, more than three to five times the area could be sampled for the same cost.

Time and cost for synthesis and analysis of data (whether by hand or by computer) is essentially the same for the two methods. Therefore, these are not important criteria for selecting one method over the other.

Evaluation of Cover-Abundance Scale Method

It is not possible to make a completely objective evaluation of the adequacy of cover-abundance data for assessing environmental impact. However, when compared with conventional methods in terms of stated objectives the evaluation becomes less subjective.

Table 6 **Comparison of time and cost requirements for study of salt marsh vegetation at Hart Island, Long Island Sound, New York, by stem counts versus cover-abundance estimates**

Field data collection time	Method	
	Cover-abundance	Stem counts
Man hours	0.5*	3**
Cost***	$8.50	$51.00

*Based on 18 1 × 2 m quadrats

**Based on 12 ¼ × ¼ m quadrats

***Based on rate of $17.00/hr

Conventional methods presently used for environmental impact assessments (Table 1) have several obvious limitations. For example, listing of species, a qualitative method, provides no quantitative data upon which an impact assessment can be made. With qualitative data, equal importance is given to all species present, thus species richness becomes the major factor in comparison among sites (Smartt and others 1974). Use of the Braun-Blanquet cover-abundance scale adds only slightly more field time to qualitative studies and results can be analyzed mathematically (Moore and others 1970).

Estimation of relative abundance is a comparatively rapid method. However, the method is highly subjective and results are not comparable among sites. In nearly the same time, Braun-Blanquet cover-abundance estimates can be made, obviating the inadequacies mentioned above for relative abundance estimates.

Use of coverage estimates without carefully defined class intervals frequently causes investigators to strive for greater numerical precision than humanly possible. This method also lacks uniformity. In contrast, the Braun-Blanquet cover-abundance scale has unequal class intervals, which aids in estimation of coverage values. The lower end of the scale is proportioned to reduce overestimates of frequently occurring but not abundant species, or those with small coverage values (Mueller-Dombois and Ellenberg 1974).

As stated previously, stem counts require considerable field time. Therefore, in practice, small sampling plots are used. Quadrat size is not as critical for coverage-abundance estimates as for stem counts. In fact, cover-abundance estimates can be estimated effectively in quadrats much larger than would be economically feasible for stem counts. This offers the advantage of increasing the size of the sampling area without increasing time and cost requirements. Also, the likelihood that plant species and individuals of a species will be sampled is increased.

Examination of existing environmental reports containing stem count data reveals that, although this method also meets objectives as stated earlier, the data are not used for environmental impact assessment at the same level of resolution at which they were collected. Furthermore, the data are generally not used effectively to show vegetation-environment relationships. Moreover, because of variability in stem size among species, stem count data tend to overemphasize the ecological significance of small plants and underemphasize that of large ones. Therefore, the question must be asked, "Is the time and effort required to collect stem count data justifiable to obtain the required accuracy for extensive vegetation surveys?" To be certain, no one method satisfies the requirements for all types of studies.

Sample Size Determination

Determination of the number of plots necessary to adequately sample an area is important, but difficult. Methods frequently used to determine sample size include 1) strictly arbitrary decisions based on previous experience, 2) species area curves, and 3) statistical methods. None of these three assure the detection of protected (endangered and threatened) plant species which, by their very nature, are frequently rare. Therefore, thorough searches of study areas are required to verify their presence or absence. To simultaneously ensure an acceptable sampling intensity and detection of protected plant species the following three-step method using the Braun-Blanquet cover-abundance scale is proposed.

First, plant community types are identified from aerial photographs and brief walking surveys. Second, presampling surveys are conducted in each plant community type to resolve taxonomic problems and compile a list of plant species present in each type. This is done one or more times a year in accordance with study objectives and phenological changes in plant species composition (for example, spring flora, midsummer flora, and late summer flora). Finally, stratified sampling using the Braun-Blanquet cover-abundance scale is conducted in plots slightly larger than would normally be used for stem counts. Stratified sampling is suggested because it provides better overall comparative accuracy than either random or systematic sampling (Smartt and Grainger 1974). Sampling is continued in each community type until an arbitrary number of plant species is reached, for example, 90 percent of those present during presampling. In this way, 100 percent of the plant species observed are reported and sampling intensity in each community type is reported. Like all methods for sample size determination, this one also requires that a decision be made by the investigator or regulatory agency regarding an acceptable level of sampling intensity.

Conclusions

Based on results of our studies, we found that for extensive surveys the Braun-Blanquet cover-abundance method meets objectives of vegetation analysis as previously stated for establishing a baseline from which environmental impact can be assessed. Moreover, this method is readily adaptable to a number of data reduction and analytical techniques.

Similar conclusions concerning existing or potential environmental perturbations can be drawn using either the Braun-Blanquet cover-abundance scale or stem counts pursuant to United States government regulatory requirements and basic technical objectives. However, by using the cover-abundance method, a greater area may be sampled in less time, for less money. Furthermore, the use of cover-abundance methodology does not reduce the level of information gained, but, in fact, adds distributional as well as structural considerations, which are important for faunal habitat assessment. If the Braun-Blanquet or similar scale (for example, Domin-Krajina or Daubermire) were widely adopted, the results of many studies would be comparable.

When evaluated in terms of the amount of ecological information gained per unit of time expended, use of the Braun-Blanquet cover-abundance scale for surveys of herbaceous and shrubby vegetation provides a reasonable compromise between qualitative surveys and stem counts. Any method that adds to the understanding of ecological relationships and also reduces costs is most desirable.

ACKNOWLEDGMENTS

Our sincere thanks to the Power Authority of the State of New York for permission to use data collected during studies conducted at Hart Island. We also thank Paul Orser, Stone and Webster Engineering Corporation, Boston, and Mohan Wali, University of North Dakota, for reviewing the manuscript.

Literature Cited

Braun-Blanquet, J. 1932. Plant sociology (Transl. G. D. Fuller and H. S. Conrad). McGraw-Hill, New York. 539 pp.

———. 1964. Pflanzensociologie: Grundzuge der Vegetationskunde. 3te aufl. Springer-Verlag, Wein. 865 pp.

Brillouin, L. 1956. Science and information theory. Academic Press. New York. 320 pp.

Ceska, A., and H. Roemer. 1971. A computer program for identifying species-releve groups in vegetation studies. Vegetatio 23:255–277.

Frenkel, R. E., and C. M. Harrison. 1974. An assessment of the usefulness of phytosciological and numerical classificatory methods for the community biogeographer. J. Biogeography 1:27–56.

Gauch, H. G., and R. H. Whittaker. 1972. Comparison of ordination techniques. Ecology 53:868–875.

Moore, John J., S. J. P. Fitzsimons, E. Lamber, and J. White. 1970. A comparison and evaluation of some phytosociological techniques. Vegetatio 20:1–20.

Mueller-Dombois, Dieter, and Heinz Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547 pp.

Orloci, L. 1975. Multivariate analysis in vegetation research. Dr. W. Junk, The Hague. 276 pp.

Richmond, T. de A., and D. Mueller-Dombois. 1972. Coastline ecosystems on Oahu, Hawaii. Vegetatio 25:367–400.

Shannon, C. E. and W. Weaver. 1963. The mathematical theory of communication. University of Illinois Press. Urbana. 117 pp.

Simpson, E. H. 1949. Measurement of diversity. Nature 163:688.

Smartt, P. F. M., S. E. Meacock, and J. M. Lambert. 1974. Investigations into the properties of quantitative vegetational data. 1. Pilot study. J. Ecology 62:735–759.

Smartt, P. F. M., and J. E. A. Grainger. 1974. Sampling for vegetation survey: some aspects of the behavior of unrestricted, restricted, and stratified techniques. J. Biogeography 1:193–206.

Whittaker, R. H. 1972. Evolution and measurement of species diversity. Taxon 21:213–251.

Whittaker, R. H. (ed.). 1973. Handbook of vegetation science: Part. V. Ordination and classification of communities. Dr. W. Junk N. V. The Hague. 738 pp.

Wikum, D. A., and M. K. Wali. 1974. Analysis of a North Dakota gallery forest: vegetation in relation to topographic and soil gradients. Ecol. Monogr. 44:441–464.