Selected Guidelines for

Ethnobotanical Research: A Field Manual

Edited by Miguel N. Alexiades

with assistance from Jennie Wood Sheldon

NYBG

Scientific Publications Department
THE NEW YORK BOTANICAL GARDEN
Bronx, New York 10458-5126 U.S.A.
(718) 817-8721 • FAX (718) 817-8842
E-mail: scipubs@nybg.org

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Behavioral Orientations toward Ethnobotanical Quantification

Stanford Zent
Instituto Venezolano de Investigaciones Científicas

Selected Guidelines for Ethnobotanical Research: A Field Manual, 199–239
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Introduction

Ecological anthropology and ethnobotany are kindred scientific endeavors. The former concerns the study of the biological and cultural relationships between human communities and their natural environment. Plants make up a huge, often dominant, part of human-occupied and -managed ecosystems, hence the obvious affinity to ethnobotany. Despite the common interests, there has been relatively little interchange of theory and method between the two fields. Many of the methods currently employed in ecological anthropology are applicable and indeed useful for ethnobotanical research. Consequently, this chapter is devoted to outlining different anthropological methodologies of potential utility for the ethnobotanical researcher. The methodologies discussed here share an explicit behavioral research orientation that emphasizes the direct observation and measurement of behavioral interactions between people and plants. The behavioral focus addresses an imbalance seen in much of current ethnobotany. Whereas the field of ethnobotany has readily incorporated rigorous linguistic and cognitive-based ethnoscientific methodologies developed by anthropologists (see Berlin et al., 1974), the behavioral methodologies used by ethnobotanists are primarily descriptive and confined to laundry lists of plants and their respective uses. A behavioral approach to ethnobotany stresses systematic sampling of people's behavior with plants, quantitative data collection, and hypothesis testing through statistical analysis, leading to more microscopic and empirical as well as more macroscopic and theoretical understandings of ethnic-botanical relationships. Moreover, the quantitative study of human behavior with respect to plants is designed to capture the complexities and patterning of such behavior within the wider cultural ecological context.

It is argued here that one of the primary applications of a behavioral orientation to ethnobotany is the development of behavior-based quantitative definitions of the significance of plants in different cultural contexts. Quantitative modeling of the cultural significance or use value of plants is a recent trend in ethnobotanical research (Adu-Tutu et al., 1979; Johns et al., 1990; Phillips & Gentry, 1993a,b; Prance et al., 1987; Turner, 1988; Phillips, Chapter 9, this volume), although most of this work has focused on the quantification of *knowledge* or *ideas* about plant use or significance rather than on *actual use* patterns. The concept of activity significance, a behavioral quantitative formulation of plant significance, will be introduced in the following pages as a necessary complement to the previous quantitative treatments of cultural significance.

Epistemology of the Etic Behavioral Research Paradigm

Inasmuch as ethnobotany is concerned with the relationship between humans and plants it differs from the more conventional plant sciences precisely because of its focus on the human element. It follows that the principal objects of ethnobotanical study, human beings, are different from those in the nonhuman botanical fields because they are conscious subjects, with thoughts of their own that may be communicated via human language and behavior to the researcher. The dual nature of humans as both subjects and objects of scientific inquiry requires that certain ontological and epistemological distinctions be made explicit. The fundamental distinctions discussed here are mental versus behavioral and emic versus etic.

Mental versus Behavioral Distinction

Human biocultural activity can be divided into two broad classes of phenomena: (1) behavioral activity, which refers to physical body motions and the environmental effects of such motions, and (2) mental activity, which designates the thoughts and feelings experienced within the mind. In practical terms, behavioral and mental processes, connected through the central nervous system, are closely intertwined and to some extent interdependent, but ontologically they are separate and require that we use different kinds of research operations in order to make scientific statements about them. To describe human mental experiences, the operations must fulfill the criteria of intersubjectivity—that is, provide access to what people are thinking about. By contrast, descriptions of body motions and their environmental effects are entirely possible from an external vantage point (Harris, 1979: 30–31).

Emic versus Etic Distinction

An epistemological distinction can be drawn between the cognitive systems of the observed and those of the observer, commonly referred to as emic and etic world views, respectively (Pike, 1967). An emic point of view corresponds to the perceptions, nomenclature, classifications, knowledge, beliefs, rules, and ethics of the local plant world as defined by a native of the local cultural community. Emic knowledge allows a native person to behave in culturally appropriate and meaningful ways in different cultural contexts. An etic perspective denotes the conceptual categories and organization of the ethnobotanical environment according to the researcher, who often is an alien of the local culture and whose conceptual system ideally derives from the language and rules of science. The distinction between emic and etic kinds of plant knowledge has been most systematically treated by Berlin (1973, 1992). An important finding of his research is that there is a high level of correspondence between folk (i.e., emic) generic biological taxa and scientific (i.e., etic) biological species. However, folk generics are distinguished on the basis of perceptually salient clusters of morphological and behavioral traits, whereas scientific species are theoretically defined by the criteria of biological reproduction and evolution (Mayr, 1982).

The Emic Research Perspective

Emic and etic epistemologies have led to different and often competing paradigms for the study of human culture, each with specific implications for ethnobotanical theory and method. An emic approach to culture, which includes ethnoscientific (Sturtevant, 1964) and interpretivistic (Geertz, 1973) schools in anthropology, seeks to describe and explain cultural patterns in terms of native categories and semantic structures. Proponents of this approach subscribe to a theory of culture as a symbolic system, as a set of ideational rules for culturally appropriate behavior (Goodenough, 1964) or as a complex web of inherited public meanings embodied in symbols and communicated through social discourse and symbolic activity (Geertz, 1973). According to these formulations, the locus of culture is the collective consciousness of the cultural community, and culture (read symbol) logically precedes and determines behavior. The objective of emic research is to understand the culture in its own unique terms as a necessary first step toward subsequent generalization. Ellen (1986) has been the most forceful proponent of this approach in the field of ethnobiology, declaring that plant and animal classifications can be fully understood only in their proper social and situational contexts.

Emic methodology relies heavily on interviews with key informants from the native culture (see Alexiades, Chapter 3, this volume). Informant statements are analyzed with an eye toward discovering both conscious and unconscious structures of cultural behavior. The result, however, is often a normative or ideal description of the culture—a description of how it ought to be rather than how it really is, since natives tend to think in terms of the rules rather than the exceptions (Johnson 1978: 28; Kaplan & Manners, 1972: 22). Moreover, emic approaches have been criticized for relying too much on a few supposedly omniscient informants while ignoring intracultural variations in cultural knowledge (Pelto & Pelto, 1975; see Boster, 1986, for an informed discussion of this issue in ethnobiological research). Recent studies in ethnobotany (Adu-Tutu et al., 1979; Kainer & Duryea, 1992; Phillips & Gentry, 1993b) have overcome some of these problems by paying attention to social variables affecting plant knowledge, systematically sampling the informant pool, and making statistical comparisons of informant responses.

The Etic Research Perspective

The etic position begins with the premise that people do not always follow the rules that culture sets for them, and hence it is better to study what people actually do rather than what they say they do. The clear emphasis here is on the study of behavioral patterns, although the investigation of mental phenomena also falls within the scope of this perspective. The etic-oriented investigator describes and explains the culture on the basis of his own observations of the behavior (including verbal behavior) of the study population and according to the semantic framework provided by science. Culture is defined etically as the learned repertory of both symbols and behavior, but the principle objective here is to classify aspects of culture in terms that permit systematic comparisons with other cultures and generalizations of cultural patterns and processes according to some theoretical program (Harris, 1979). An illustration of the etic approach to ethnobotany is found in biobehavioral perspectives of ethnopharmacology, which seek to investigate the biodynamic relationships between plant use, pharmacology, and physiological import (Etkin, 1988).

Etic data collection depends on the eyewitness observation of behavioral events, often of individual behavior, by the researcher or the recording of informant recall of such events. The task of the researcher is to segment the behavior stream into significant observable units and chains of related units (see Harris, 1964, for an explicit method). Behavioral units are frequently coded according to some preconceived scheme and quantitatively measured. The perceptual, memory, and recording limitations of a single observer limit the amount of information that can be recorded at one time, although multiple observers or mechanical aids such as cameras or tape recorders are sometimes used to help make up the deficit. The objectivity of human observers, no matter how loyal to scientific principles, has also been questioned, since scientists are no less influenced and prejudiced by their own cultural and political systems than are folk people (Dumont, 1978: 45–47). This problem points out the need for explicit, detailed reporting of research methods and conditions and for improvement in the standardization of conceptual definitions and data collection techniques.

Complementarity of Emic and Etic Approaches

The differences in emic and etic research strategies have been emphasized here, but it is also important to recognize that the two strategies are not mutually exclusive; rather they occupy two ends of a methodological continuum, and the researcher should employ both emic and etic methods whenever they advance the research objectives. The classic anthropological methodologies of interviewing—recording the responses of informants to queries about cultural topics—and participant observation—observing and recording cultural activities while participating in those activities—go hand in hand and still form the crux of ethnographic (including ethnobotanical) fieldwork.

It is absurd to think that etic data collection can proceed efficiently and accurately without some access to the emic frame of reference. First, the ethnobotanist quite often enters an unfamiliar world, and, at least at first, he or she may completely miss or misinterpret behavioral patterns if unable to speak with someone who is familiar with them. For example, early in my fieldwork with the Piaroa of Venezuela, I observed a particular task that entailed prolonged kneading of the gummy mesocarp of the fruit of *Couma macrocarpa* Barb. Rodr. The kneading process, it appeared, served to expel the seeds contained therein, and these were later gathered up, parched on a stone griddle, and eaten. I initially classified this behavior as food processing (i.e., extracting edible seeds). Later, after I had become more conversant in the local vernacular, I was told that the kneaded gum is saved and used to trap birds, so I was forced to reclassify the previous recorded kneading bouts as a combination of food processing and gum trap manufacture. Second, not infrequently, the native botanist possesses a more fine-grained knowledge of the local flora than does the Western botanist, and therefore the emic knowledge system constitutes a potential source of etic botanical information. The classic example in this case is the Hanunóo of the Philippines, who were found to discriminate more plant categories and more attributes for categorization than Western systematists for the same inventory of plants (Conklin, 1954). Third, the researcher cannot always be present to witness significant behavioral events and must rely on the participants to tell what happened after the fact, or native assistants from the study community may be trained in the research methodology and employed as data collectors (Stone et al., 1990). Fourth, participants' verbal descriptions provide cues for what to look for and what to expect in the observation of complex scenes (Pelto & Pelto, 1978). The advantage of being able to communicate with the local people, whether through learning the language or using an interpreter, cannot be overstated. The important point for the etic researcher is that emic statements be translated into etic terms through effective language translation and be compared against the researcher's own observations.

In like manner, emic-oriented research can be enhanced by etic data collection. The researcher may lack the cultural and linguistic knowledge necessary for accurate comprehension of data supplied by informants (Etkin, 1988), and therefore direct observations of human–plant interactions may be needed to interpret and clarify informant statements about such interactions. Furthermore, the accuracy and completeness of verbal accounts of ethnobotanical events can be distorted by memory limitations, lack of interest, distrust, secrecy, or a host of other reasons and therefore should be verified, whenever possible, by empirical observations by the researcher. Finally, owing to the complex nature of the ethnobotanical research domain, where the focus is the relationship between different kinds of phenomena, human and natural, semiotic and physical, social and biological, the ethnobotanical researcher trained primarily in one discipline, be it anthropology or botany or geography or another, is often obliged to solicit the scientific expertise of specialists in other fields.

Methodological Considerations in Etic Behavioral Research

The etic behavioral research orientation stresses systematic and replicable collection of empirical data, problem-oriented studies that focus on the relationships between particular cultural or ecological variables, and hypothesis testing through probabilisticstatistical analysis. There are two important methodological issues to consider when doing behavioral research: (1) defining useful behavioral units and (2) ensuring representativeness of observations (Pelto & Pelto, 1978: 104).

Defining Behavioral Units

The behavioral researcher is faced with the problem of transforming the stream of observed behavior into units that are useful for description and analysis. The recording of different behavioral units should be done according to an explicitly defined code, and it is recommended that the code be compatible (and hence comparable) with the behavioral codes used in other studies (see Johnson & Johnson, 1989, for a proposal). Quantitative measurement of behavioral units is another fundamental aspect of the behavioral methodology, deemed necessary in order to achieve more precise, reliable, comparable, and statistically testable data sets (Johnson, 1978).

Ensuring Representativeness

Because ethnobotanical behavior (like knowledge) is likely to vary within a given population, the researcher must consider how to sample a representative portion of behavior. In small populations, the sample population may reach 100% of the empirical or overall population, but these situations are rare. The random sample is the most reliable sample from a statistical point of view; the haphazard sample is the least reliable. The sample type selected, however, often is a compromise between the theoretical goals, the size and diversity of the empirical population, fieldwork conditions, and time, cost, and personnel constraints of the researcher. Three common sample techniques used by human behavioral researchers are (1) the systematic sample—every *n*th house on a map or name in a register, (2) the stratified sample—encompassing all the relevant subgroups (e.g., male and female, rich and poor, urban and rural) of a heterogeneous population proportional to their total numbers, and (3) the cluster sample—dividing the research site into equivalent geographical compartments and subcompartments (e.g., counties, towns, blocks). One of the main causes of deviation from randomness or representativeness is the simple refusal of people to participate in the research. Another sampling problem frequently encountered is the difficulty (and danger) of attempting to observe closely members of the opposite sex of the host community. In such cases, male researchers may have to focus their data collection on men, and female researchers, on women. These are unavoidable hazards of doing research among human beings, and it is strongly advised that the researcher adapt the sampling method to local norms and desires rather than attempt to impose a method that may turn out to alienate host support and cooperation. In any case, it is important that the researcher report honestly and fully any deviations that occur in the sampling process, since these may affect the confidence in statistical outcomes.

Etic Behavioral Research Methodologies

Various behavioral methodologies developed and used by anthropologists and cultural geographers to investigate human-ecological relationships may serve the more circumscribed research interests of the ethnobotanist. Four major methodological orientations of potential application to ethnobotanical research are identified and reviewed here: spatial distribution analysis; human activity studies; resource accounting; and input-output analysis. These four methods are summarized in Table I and discussed in detail below. Such methodologies are highly relevant for developing a quantitative behavioral notion of the cultural or economic significance of plants. The behavioral approach offers a more direct form of quantifying plant utility, since human–plant interactions are measured in terms of real actions and not just words. Furthermore, a statistical understanding of people's use of and impact on plants provides a necessary control for assessing mere verbal descriptions of their relationships with plants.

Another important application of the behavioral methodologies discussed here is that they enable systematic investigation of the dynamic relationships between ethnobotanical variables and other cultural and ecological variables of the environment. Thus, it may be necessary to look at impinging social or economic factors in order to explain the origin or function of a particular ethnobotanical practice (e.g., why locally made baskets are important commodities in the local exchange system among the Yekuana Amerindians of Venezuela even though basketmaking knowledge and raw plant materials are evenly distributed; see Hames & Hames, 1976). In a similar vein, plant use strategies interact closely with other economic activities in integrated resource production systems. For example, many shifting cultivators in tropical regions manage and exploit old fallows as hunting grounds, since game are attracted to the many plant foods found in these areas (Nations & Nigh, 1980; Posey, 1983). A better understanding of the systemic context of plant use may in turn lead to a better understanding of the causality and functioning of that use (Johns et al., 1990).

Spatial Distribution Analysis

Quantitative analysis of the spatial relationships between human and plant communities represents an important aspect of behavioral ethnobotanical research. Three aspects of spatial distribution analysis are discussed here: landscape mapping, estimating resource production, and spatial patterning of plant resource use.

Landscape Mapping

Landscape mapping ranges in scale, from whole culture areas or ecotypes through the land range of a community to planting zones within a single garden, and in level of mapping technique, from space-based remote sensing through aerial photography to ground survey. The scale and level chosen are directly dependent on the research problem. In most community-based studies where remote and macroscale data are used these must be interpreted against microscale data collected on the ground during fieldwork (a process referred to as "ground truthing"), and in general a "multistage" approach (i.e., integrating different levels of data acquisition) is recommended. The increasing availability and sophistication of Geographic Information Systems (GIS) computer programs (e.g., ARC/INFO, IDRISI) has facilitated this type of research by permitting fast, accurate overlay and integration of multiple spatially referenced data sets and statistical analysis based on the correlation of spatial distributions (Aronoff, 1991; Conant, 1990).

(text continued on page 215)

Table I. Summary of four etic behavioral research methods

Method	General description and purpose	Kinds of information	Uses of information	Advantages	Disadvantages
Spatial distribution analysis	Describe and explain spatial relationships between human and plant communities	See below	Various descriptive and analytical operations dealing with spatial relationships between human and plant communities		
Landscape mapping					
Remote sensing	Record surface features of geographical areas via distant mechanical devices	Aerial photos, radar, Landsat or SPOT images	Macroscale analysis of synchronic or diachronic relationships between people and plants	Enables researcher to extend scope of analysis to wider area	Very costly, need special data analysis skills and equipment
Ground mapping	Map relevant natural and man-made features of local habitation and resource exploitation areas using on-the-ground techniques	Original small-scale maps of the field study site	Microscale analysis of spatial parameters of resource production, productivity, & procurement	Easy to learn, captures detail	Very time-consuming
Extrapolating resource production	Extrapolate household or community resource production from sample counts of resource production and areal measurements of production areas	Measurements and calculations of crop yields and field areas	Estimate crop production or land use intensities in fallow cultivation systems	Fast way to measure total resource production	Indirect measure of production, does not account for crop yield or loss
Spatial distribution of	Quantify differential botani-	Integration of land-	Determine resource ranges and areas, co-	Facilitates various analytical	Requires accurate knowledge of the

	areal measurements of production areas				
Spatial distribution of resource production and productivity	Quantify differential botanical resource activities, outputs, and productivities according to geographical coordinate information	Integration of landscape mapping, human activity, and resource output data	Determine resource ranges and areas, covariation of plant resource production and productivity with space-related variables (e.g., distance, biotope)	Facilitates various analytical operations relating to the spatial dimension of plant use	Requires accurate knowledge of the spatial location of resource activities and outputs; a good landscape map is a prerequisite
Human activity studies	Record the time spent at various plant-related behaviors through systematic observation techniques; compare the time spent at different activities	Quantitative record of how long certain activities last or how time is allocated	Statistical description and analysis of activity patterns of a community; necessary component of input-output studies		
Time and motion studies (continuous behavior sampling)	Record the duration of specific activities and subactivities by continuous observation from start to finish of the activity sequence	Database of continuous time measurements according to specific tasks	Assess the amount of time it takes to perform certain tasks; can be used to estimate time allocation	Detailed record of complete activity sequences; relatively noninvasive	Difficulty of recording groups of people; very time-consuming for researcher
Time allocation studies (state behavior sampling)	Measure the allocation of time across a range of activities by systematic scan sampling of people's behavior	Database of discrete time measurements for a range of activities that may be cross-referenced with other spatial, temporal, and social variables	Describe the pattern of time investment in work and other activities; test the covariation of time allocation with other spatial, temporal, and social variables	Representative, accurate, and comprehensive record of a group's activities; can be economical of researcher's time	Can be quite invasive; underrecords duration of complete activities; overrecords group activities; inefficient among small and dispersed populations

Table I. Summary of four etic behavioral research methods (*continued*)

Method	General description and purpose	Kinds of information	Uses of information	Advantages	Disadvantages
Resource accounting	Keep records of resource types and amounts procured or utilized by the study community during a given period	Quantitative database of resource inventories	Derive measures of the importance of different plant species and the level of exploitation pressure on these resources; necessary component of input-output studies		
Dietary survey	Measure food intake using a variety of specific techniques	Quantitative database of food consumption habits	Assess nutritional composition and adequacy of the diet		
Weighed inventory	Weigh beginning food inventories, food imports, and ending food inventories			Economical for researcher and relatively nonintrusive for subjects	Need to control for waste amounts, exports, and consumer numbers
Dietary recall	Ask subjects to list all types and quantities of food eaten during the previous time period			Easy to administer and allows population representativeness	Highly susceptible to memory or reporting errors
Food frequency	Record the number of [illegible]			Quick way to document food	Gives no quantity information about

	eaten during the previous time period			population representativeness	porting errors
Food frequency	Record the number of times a food is consumed during a given time period			Quick way to document food consumption patterns for a large group of people	Gives no quantity information about food amounts eaten within meals
Weighed intake	Weigh food at time of serving and waste amounts left over			Most accurate and precise way to measure actual food consumption	Time consuming for researcher and very intrusive for subjects
Marketing survey	Measure monetary income realized from certain activities or resource types	Account of economic return or monetary value of resources or activities	Assess income levels of people, economic performance and potential of resource types		
Ethnopharmacological survey	Observe medicinal plant uses and biomedical effects	Preclinical observations or test results of plant consumption or use and their effects	Test the efficacy of treating ailments according to local use patterns; may precede biochemical analysis or clinical testing		
Input-output analysis	Cost-benefit type of analysis of different activities using time allocation and resource accounting data	Integration of time allocation and resource accounting data; descriptive or analytical statistics	Describe or explain the interactive relationships between populations and resources		

Table I. Summary of four etic behavioral research methods (*continued*)

Method	General description and purpose	Kinds of information	Uses of information	Advantages	Disadvantages
Rational choice models	Assess economic production decisions within an environment of constraints and encouragements	Covariation of production strategies and socioeconomic variables; formal models (e.g., production function, decision trees)	Determine the influence of socioeconomic variables on production decisions; frequent tool of analysts of technological and social change	Useful in complex, differentiated social environments	primarily used in the study of agrarian situations
Optimal foraging analysis	Test optimizing assumptions of observed foraging behavior by way of mathematical maximization models	Mathematical modeling and hypothesis testing	Determine the optimal diet or resource patch mix	Theoretically and methodologically sophisticated; statistical hypothesis testing	Confined to hunting-gathering populations; requires rigorous time allocation and resource accounting data collection
Linear program analysis	Manipulate goal and constraint variables of mathematical maximization models to determine the limiting factors in an empirical situation	Mathematical modeling and hypothesis testing	Determine the degree to which empirical situations depart from optimizing assumptions	Computer analysis and simulation encouraged; mathematical-statistical hypothesis testing	Difficult to incorporate nonnumerical variables (e.g., risk, taste) into the model

REMOTE SENSING Remote sensing refers to the operation of using distant mechanical sensors (e.g., cameras, radar) to record variations in the way earth surface features reflect and emit electromagnetic energy. The primary data of remote sensing are pictorial or numerical type images taken of geographical areas of the world, such as aerial photographs or Landsat images. These images are analyzed using various viewing and interpretation devices (for pictorial data) or computers (for numerical sensor data) in order to extract information about the type, extent, location, and condition of the various resources over the area being studied (Lillesand & Kiefer, 1979: 2; see also Colwell, 1983).

The significance of remote sensing for ethnobotanical research lies in the fact that it permits the simultaneous mapping of human population and plant community distributions, which in turn sheds light on human–plant interactions. Pertinent study topics include the synchronic-spatial correlations between floristic types or even specific plant resources and human activity patterns and the diachronic impact of human activity on vegetation. Examples of remote sensing applications in ethnobotanical and related research include the interdependent relationship between cattle, grasslands, and goat herding in western Kenya (Conant, 1990); the pattern and extent of deforestation in the Amazon (Skole & Tucker, 1993); the distribution, interrelation, and evolution of land use types in a complex agricultural system in the Philippines (Conklin, 1980).

Remote images are usually acquired from conventional aircraft and from satellites such as the Landsat and SPOT series of spacecraft. For the individual researcher in the United States interested in consulting satellite images, many of these materials can be purchased from the U.S. Geological Survey at Denver, Colorado, or the private EOSAT company (formerly a division of NASA) located in Beltsville, Maryland (O. Huber, pers. comm.). The main problems with this research technique are the very high cost of producing or purchasing remote images, the technical requirements of interpreting the images, and the technical limits of the images themselves (e.g., cloud cover interferes with passive images; radar-sensed images are not collected on a regular basis; Conant, 1990).

GROUND MAPPING Ethnobotanists have traditionally carried out small-scale, intensive studies of the plant knowledge and use of a single community or group of related communities. Local maps depicting resource locations and areas and land use types are instrumental for quantitative ethnobotanical research because they facilitate various analytical operations relating to the study of plant resource production and productivity, spatial patterns of resource procurement and activity, and population–resource relationships.

Small-scale maps are usually produced using conventional ground-mapping techniques. Remote images are potentially useful here (see Conklin, 1980; Vogt, 1974), but they work best in combination with ground mapping because ethnobotanically significant microenvironmental variation does not appear on some maps and must be surveyed on the ground. Elementary surveying techniques (McCormac, 1985; Spier, 1970) can be used to produce accurate maps depicting relevant features of the field study site, including residential structures, trails or roads, prominent natural features (e.g., streams), and resource areas. The essential tools of this work include a Brunton or Suunto compass for determining directions; tape measure, pedometer, measuring wheel or rangefinder for determining distances; topographic map for reference; and grid paper and ruler for plotting data. Areal extents of resource regions, such as agricultural plots, are determined by the common perimeter method, which entails taking directional readings with a compass and measuring the distance between different points lying along the perimeter of the plot. The biggest drawback of this work is that surveying and map making are very time-consuming. However, the growing availability and affordability of global positioning system (gps) instruments and supporting computer software are helping to reduce the workload of this task.

Extrapolating Resource Production through Spatial Analysis

In agrobotanical studies, the quantification of field areas has been a key technique for extrapolating crop production amounts (Ruddle, 1974; cf. Ruthenberg, 1980). The standard methodology is to count or weigh crop portions in carefully measured areas and then multiply these figures by the total area under crop. The resulting figures give a rough estimate of crop production; further measurements must be introduced to estimate losses due to pests, intrafield variations in crop yield, or crop amounts actually harvested. Measurement of field areas has also been useful for calculating the intensity of land rotation under fallow cultivation systems (Ruthenberg, 1980). In another application of this technique, areal measures of crop production under polycultures versus monocultures were taken to determine the differential land use efficiencies of the two farming systems (Natarajan & Willey, 1980).

Spatial Distribution of Resource Production and Productivity

The determination of the spatial distribution of plant resource production and productivity is an important function of small-scale mapping in ethnobotanical research. Most people inhabit heterogeneous environments made up of different biotopes or microenvironments distinguished according to soil, vegetation, climate, and faunal characteristics. The local environment comprises a network of resource patches (i.e., clumped resource areas) in the sense that the different biotopic areas vary according to resource items, resource productivities, and distances from the settlement. At least some of these biotopes are usually man-made (e.g., gardens, secondary forests, rice paddies). Settlement pattern is to some extent conditioned by the distribution and use patterns of vegetational resource patches within a territory (see Balée, 1988; Fuentes, 1980). Seen in this light, such information might be of interest to the ethnobotanist whose research aim is to investigate the impact of the botanical environment on human sociocultural behavior.

Resource production and productivity can be calculated in terms of specific localities within the resource range, specific biotopes, or simple distance from the settlement site (Ellen, 1982: 160–168). A knowledge of simple locality is theoretically uninteresting in itself but is useful to the extent that locality is an index for other information such as area, distance, habitat, elevation, and so on. An excellent example of measuring resource production by biotope is found in Nietschmann's (1973) study of the Miskito of eastern Nicaragua. He recorded all meat biomass captured in over 40 different biotopes (many of which comprised distinct vegetational associations) over the course of a year. A more indirect approach to measuring biotopic resource productivity is to conduct censuses of the plant resources in sample plots located in different biotopes and compute the respective resource densities (Unruh & Alcorn, 1987; Unruh & Flores Paitán, 1987;

Zent, 1995). Ohtsuka (1977) studied the intensity of resource appropriation by distance among the Oriomo of New Guinea by dividing the territory of the study community into a grid of 1-km^2 blocks and recording the number of visits to each block according to different activity types.

Human Activity Studies

The observation of human activities is the most direct and simplest method for collecting data about people's interactions with plants. Anthropologists have developed and employed a number of quantitative observational techniques for studying human activity patterns that are quite useful for the ethnobotanist who seeks a quantitative understanding of people's plant-related behavior. Numerous research scenarios are conceivable: a study of the economic potential of indigenous crafts in which it may be important to know the labor costs of making different artifacts, a time series analysis of the processing techniques used to detoxify certain plant foods (Uhl & Murphy, 1981), an assessment of agricultural crop scheduling decisions (Stone et al., 1990), a study of energy expenditure of different tasks in a production system (Montgomery & Johnson, 1976).

Time Currency

Time is the most common currency or unit used by researchers for measuring human activity, although important alternative currencies include energy and money (Johnson, 1978). Time has been the favored currency because of its universal relevance, simple measurability, wide comparability across cultures, and convertibility into other currencies. The significance of time as an index of ecological behavior stems from the fact that it is a limited, and hence strategic, resource to be allocated among alternative behavioral options with different outcomes and consequences for satisfaction of biological needs. Thus, the decision to invest time in one behavior rather than another reflects an economic choice for optimizing somatic effort to produce benefit. A relevant example would be the decision to switch from a Musa- to a Manihot-dominated horticultural system by downriver Yanoama living next to mission settlements in the Upper Orinoco River of Venezuela. The shift to the more land-productive, yet labor-expensive, manioc cultivation appears to have been motivated by the rising costs of foraging for forest foods under the more sedentary lifestyle (Colchester, 1984). Two kinds of time studies of human activities are discussed here: time and motion studies and time allocation studies.

Time and Motion Studies

Time and motion studies refer to operations in which the researcher records and times an individual or group engaged in a specific cultural activity, say, cutting a patch of forest or weaving a basket, usually from start to finish of the activity sequence. The time of said activity is measured in relation to a second variable, such as resource amount harvested or area worked, in order to be able to project how much time it takes to accomplish certain task amounts. This technique has been used to break down work investment in different phases of garden labor (Conklin, 1975; Rappaport, 1968) and food processing (Uhl & Murphy, 1981; Zent, 1992). It is equally useful for the study of other ethnobotanical events, say, preparing herbal medicines or tapping rubber.

Time and motion studies have been adapted to experiments testing variables of the work situation, such as differences in technology used. Carneiro (1979) compared the work efficiency of steel versus stone axe technology in the task of chopping down trees by Yanomami woodcutters. The results of this study showed that the time needed to fell a tree using a stone axe was 10 times as great as the time it took to fell a comparable tree with a steel axe. The inevitable conclusions are that steel probably intensified horticultural patterns among tropical forest swidden farmers and, inversely, that the foraging lifestyle was a more attractive alternative during the stone age (Colchester, 1984; Zent, 1992). Experimental time and motion studies of this kind are useful for examining past relationships, and, combined with paleobiological investigations, they offer interesting possibilities for reconstructing resource utilization patterns in prehistory.

Time Allocation Studies

More recent time allocation studies, also referred to as behavior sampling, utilize more sophisticated methodologies for sampling and measuring human activity patterns. The focus here is on the distribution of time across a range of activities rather than the duration of particular activities. Some of these methods emphasize strictly observational procedures as they were originally developed for the behavioral study of nonverbal animals (see Altmann, 1974). Applied to the study of human conduct, methods of behavior sampling have been modified somewhat to take advantage of the verbal capacities of human subjects. Many time allocation studies in fact utilize a combination of direct observations of behavior and informant recording or recall of behavior.

A variety of observational methods have been proposed, and the one chosen depends on the theoretical questions, sample size requirements, length of time available for the study, complexity of the study population, and constraints of the field situation. Hames (1992: 211–212) proposed a fourfold typology of time allocation methods based on cross-cutting combinations of two dimensional features: the duration of the observation and the number of persons under observation. The dimension of duration contrasts state with continuous observations. A state observation is the recording of a single moment in time (akin to a snapshot photograph), whereas a continuous observation refers to observation over a length of time (a roll of videotape). Thus in a study of basket making, the data of state observations would take the form of a frequency distribution indicating the number of times the different tasks that make up the basketmaking process (e.g., collecting raw material, drying fiber, cutting fiber, dyeing fiber, weaving) were recorded, whereas the data of continuous observations would consist of a record of blocks of time spent in the different stages. The dimension of person-number distinguishes between individual and group observations. In individual sampling, also referred to as focal person observation, the observer records the behavior of a single individual. Group sampling, otherwise known as scan sampling, implies that the observer records the behavior of all persons coinhabiting an activity space. Thus, the four observational possibilities are group state behaviors, individual state behaviors, group continuous behaviors, and individual continuous behaviors.

Group State Behavior Sampling The observation of group state behaviors, also known as instantaneous scan sampling, spot-checks, and point sampling, is the time-sampling method most frequently used by students of human behavior (Borgerhoff Mulder &

Caro, 1985; Gross et al., 1979; cf. Gross, 1984; Hames, 1978; Johnson, 1975; Rogoff, 1978). The basic technique consists of series of observations at randomly selected time points of random or stratified samples of individuals of the study population. Time is usually randomized according to hour or half-hour slots and, in studies where time constraints limit the total days available for making observations, by day as well. The theoretical minimum period for carrying out such a study is one year in order to capture a full annual cycle of activity. The subject sample can be randomized (or stratified) by household or hamlet, and the sequence of individuals to be observed within a particular observation scan should also be randomized. The observer records the activity being performed by the subject at the moment he or she is first sighted. Borgerhoff Mulder and Caro (1985) suggest a binary code for recording and classifying behavior: (1) physical description of body movements (e.g., gathering leaves) and (2) description by consequence, amounting to a functional description (e.g., food preparation) (see also Hames, 1992). Other helpful information that should be recorded in the spot observation (besides the time, subject identification, and activity) include the date, location, weather, coparticipant(s) of the activity, and whether the subject sights the observer first (since this may cause the subject to alter his or her behavior). If someone selected for observation at a certain time is absent from view, the recorder either attempts to locate the missing person within a certain time frame or asks persons who are present where the missing person is and what he or she is likely to be doing. These "substitute" observations should be verified through follow-up interviews with the person in question when he or she shows up (Hames, 1992; Johnson, 1975). The accumulation of spot observations over a period of time (preferably a year) builds up a copious and fairly reliable quantitative data base reflecting the division of labor (and leisure) across temporal variables (e.g., hour, season) and social variables (e.g., sex, age, social class). Drawbacks of this approach include inefficiency when dealing with small and dispersed populations (Stone et al., 1990), biases related to subject's reactions to being observed and to observer reliability (Borgerhoff Mulder & Caro, 1985), bias toward overrecording group activities (Hawkes et al., 1987), unrecording of duration of complete activities and transitions and linkages between behaviors (Hames, 1992), and the lack of standard codes for classifying behaviors (but see Johnson & Johnson, 1989). Furthermore, a method that requires the researcher to search out people unannounced, indeed when they are least expecting it, can be quite invasive. Therefore the method should be adapted to the local norms of social conduct (e.g., nightly visits may not be appropriate) and used only after clearly explaining the procedure and obtaining permission from one's subjects (see also Alexiades, Chapter 1, this volume).

Individual State Behavior Sampling Focal person observation is a more intensive method for recording subject behavior. The observer follows a single individual and continuously records his or her every move or, alternatively, records the subject's behaviors at given intervals, every 5 or 10 or 30 minutes. This methodology provides the most accurate and detailed accounting of time use but requires enormous investments of time by the researcher to build up a decent sample size and is extremely intrusive for the subject. The most appropriate scenario for employment of this method would be dispersed, solitary activities (e.g., plant collecting) or complex behaviors (e.g., interpersonal transactions).

Continuous Behavior Sampling The method of continuous scan is analogous to the methodologies used in time and motion studies. Although this method is probably the least invasive of time allocation data collection techniques, a major problem with it is the difficulty of observing and recording all the activities of a group of performers at the same time as well as the implied high time costs for the researcher.

Resource Accounting

Resource accounting refers to the recording of resource types and amounts acquired or utilized during a specified period. This methodology is designed to produce a numerical account of the resource outputs observed among the study community. This kind of information is of obvious interest to the ethnobotanical researcher who wishes to formulate measures of the importance of different plant species to the local population and of the level of exploitation pressure on these resources. In turn, such measures facilitate comparison of plant use across cultures.

Although the method of resource accounting sounds fairly straightforward, there are actually variable procedures for counting resources. Since resources are defined in reference to particular needs, which may be defined by the research focus (e.g., food, fuel, shelter, medicine, commercial), there are different levels and currencies of resource accounting. Thus, resources may be counted at the level of resources simply acquired or at the level of resources utilized for a specific purpose. Different currencies may be used: weight, cash value, energy or nutritional value. Johnson (1978: 92) considers weight or size of the resource item harvested to be the more universal and versatile currency since it can easily be converted to other currencies.

Counting and Sampling Resource Amounts

The general technique of measuring resource outputs emphasizes counting, weighing, and sampling whenever possible. A common procedure used by researchers is to measure all resources brought back to the house or village. If the researcher must be absent, or harvests are hidden or consumed away from home, local assistants may be hired to do the counting or weighing. Another rather common technique is to interview people about their harvests of the day and estimate the amounts on the basis of their descriptions of resource names and amounts harvested and average weight or size values of the resource(s) as determined by a sample of actual weighing bouts.

Another solution for eliminating missing counts or weights is to systematically select, ideally by random sample, the days when resource harvests will be measured (Flowers, 1983). Systematic sampling of resource acquisitions is more economical than trying to achieve a total accounting, and, since the researcher can dedicate time more fully to the task on those days, may produce more accurate results. A sampling procedure is also useful for estimating total resource amounts consumed away from the house or village. Certain subjects and days can be chosen for focal following during which the resource amounts consumed on the spot are duly recorded. Another problem of representativeness in resource accounting studies is the length of study. Most authors recommend a year, but this may fall short especially in studies of wild plant resources. According to my accounts of wild fruit collection by the Piaroa of the Upper Cuao River, the fruiting schedule of some tree species (e.g., *Jessenia* *bataua* (Mart.) Burret, *Platonia insignis* Mart.) is more on the order of every 2 or 3 years.

Resource Data Collected

A typical resource account record should include, besides the resource type and amount, the date, name of person(s) who made the harvest, harvest location, and settlement location (if this is subject to change). Specimen collections are highly recommended in order to provide positive identification of the plant species (see Alexiades, Chapter 4, this volume). Some knowledge of local use patterns of resources also makes for more accurate and precise accounting records. For example, if a resource has more than one component part and more than one use, the researcher should attempt to separate measurement of the different portions. This can be done most efficiently by taking sample measurements. The same advice applies to measuring usable versus nonusable portions. For example, the fruit of *Couma macrocarpa* Barb. Rodr. can be broken down into four parts: skin (garbage), meat/juice (eaten raw), seed (eaten parched), and gum (used to trap birds). A comparison of the edible portions of fruit among different wild species shows some significant differences: *Couma macrocarpa,* 43.75%; *Jessenia bataua,* 43%; *Dacryodes* spp., 37.5%; and *P. insignis,* 14%. Thus in a study highlighting the dietary significance of wild plants, sample measurements of the component weights of all species encountered should be taken. The date of resource collection is useful for charting seasonal patterns of resource production, while the personal data on resource harvesters may reveal social patterns of resource production (e.g., composition of work groups or division of labor by sex or age). The data on harvest location provide useful information about spatial patterns of resource appropriation. Also under this section, it should be noted whether the resource was obtained by exchange or gift and, if by either, who and where was the source. Finally, it may prove useful to keep track of the resource destination, whether for immediate or delayed use, for local consumption or export.

Types of Resource Accounting Studies

Some studies have a more specialized focus and are interested only in particular domains of resources, in which case the accounting methods must be tailored to the domain in question. The methods most apt to interest the ethnobotanical researcher include dietary surveys, marketing or economic income surveys, and ethnopharmacological surveys.

Dietary Survey In dietary surveys, the researcher attempts to measure food intake and possibly to assess the nutritional composition and adequacy of the diet. Dietary surveys are relevant to the ethnobotanist to the extent that the dietary or nutritional significance of plants is being studied. Dietary surveys are either long-term (i.e., longitudinal surveys) or short-term (called prevalence or point prevalence surveys) (Jelliffe, 1966). Food intake can be measured in several ways, each with its pros and cons (Gibson 1990; Thompson et al., 1994). Some of the most common techniques—including weighed inventory, dietary recall, food frequency, and weighed intake methods—are briefly described below. Although these methods are specifically designed to measure food resources, they could just as easily be applied to other resource categories, such as medicines, building thatch, or charcoal.

The weighed inventory, or larder, technique entails weighing of all food at the study site at the beginning of the study, of all food brought into the site during the study, and of all food remaining at the end of the study. This technique is economical for the researcher and relatively nonintrusive for the subjects, but quantity data must be adjusted to account for waste and a close watch must be kept on consumer numbers and food exports.

The dietary recall, or history, method consists of a written or pictured questionnaire or interview in which a person is asked to report all types and quantities of foods eaten during a previous time period (usually 24 hours). This method is also fairly easy to administrate and enables population representativeness, but it is hindered by inaccurate or distorted memory or reporting.

Food frequency studies record the number of times a food is consumed during a given time period. The advantage of this method is that it represents food consumption patterns for large numbers of people relatively quickly, but it gives no quantity information about food in any particular meal.

The weighed intake method involves the weighing or measuring of foods at the time of preparation or time of serving and of waste amounts left over after meals. This is the only method in which the food amounts actually eaten are weighed and therefore yields the most accurate and precise accounting of consumption. However, the method is very time-consuming and can be extremely bothersome to subject families. Intrusiveness can be minimized by weighing the food immediately before or after it is prepared, not at mealtime as it is being eaten. Thus it may be necessary to estimate by sight the size portions that are consumed by individual family members. Depending on the research objectives and constraints, it may be useful to combine the different food-weighing methods—for example, 24-hour recall reports and weighed intake.

The nutritional survey is a dietary survey in which recorded food amounts per consumer are converted to corresponding values of dietary compounds and elements considered essential to human nutrition (e.g., calories, proteins, lipids, vitamins, minerals). A primary purpose of this type of study is to assess the nutritional adequacy of the diet. Nutritional values are assigned to food amounts using published food composition tables (McCance, 1991; Wu Leung & Flores, 1961; Wu Leung et al., 1972) or computer databases of nutritional assessment (e.g., USDA Nutrient Data Base for Standard Reference; see also Frank & Irving, 1992). With lesser known foods it may be necessary to collect samples and do your own laboratory analysis of their nutritional contents (Dufour, 1988; Murphy et al., 1991). Complete nutritional surveys require additional kinds of data: anthropometric measurements, clinical characteristics, biochemical data (e.g., hemoglobin), parasitological data, and health histories.

Marketing Survey The marketing, or economic income, survey is designed to measure the monetary income realized by individuals or household groups from certain activities or resource types over a specified time period, usually a year. Articles by Padoch et al. (1985) on market-oriented agroforestry by peasants of the Peruvian Amazon and by Romanoff (1992) on lowland Bolivian rubber tappers exemplify this type of survey. Another method of economic analysis entails recording the respective market values of various plant species and then estimating the real or potential market yield of a given land area and use on the basis of its yield of commercial plants (Peters et al., 1989).

ETHNOPHARMACOLOGICAL SURVEY Studies of ethnopharmacologies, focused on the therapeutic and pharmacological properties of plants, include observation, interviewing about indigenous medicinal uses, and bioassays. Biomedical researchers have conducted preclinical tests of the physiological effects of local patterns of medicinal plant consumption or application (Hansson et al., 1986; Kristiansson et al., 1987). I am unaware, however, of any studies that provide quantitative descriptions of behavioral interactions with medicinal plants in a folk context, although it would seem that quantitative behavioral observational techniques should be highly relevant for biomedically oriented ethnobotanical investigations.

Input-Output Analysis

Input-output analysis encompasses a variety of research methodologies whose primary concern is to describe or explain the interactive relationships between populations and resources in human-managed ecosystems. Included under this rubric are rational choice (economic decision making) models, optimal foraging models, and linear programming analysis. These analytical techniques are all derived from mathematical optimization theory and are methodologies of data analysis properly speaking instead of data collection. A general goal here is to specify the ecological and economic (and sometimes social) factors that influence or determine resource decisions. Most studies of this genre attempt to understand human resource behavior in microeconomic terms, and, accordingly, the basic analytical technique amounts to a cost-benefit analysis of different behaviors as computed by resource output units divided by labor input units (e.g., resource weight produced per manhour; kilocalories produced per kilocalorie expended; cash received per cash invested). The collection of quantitative time allocation and resource accounting data are therefore prerequisites of input-output analysis.

Input-output analysis may be relevant for the ethnobotanist or economic botanist who wants to assess the efficiency or profitability of exploiting a given plant resource or of pursuing a given production strategy. Uhl and Murphy (1981) used input-output analysis to rate the energetic productivity of slash-and-burn farming at San Carlos, Río Negro, Venezuela. The results of this study indicated that a two-crop swidden cycle achieves the most efficient return on labor and is largely consistent with actual practice.

Rational Choice Models

Rational choice models have been applied mostly to the study of farmer production decisions (Barlett, 1980). The models attempt to assess the degree to which individuals or households follow economic maximization strategies within an environment of constraints and encouragements. A pertinent example is Barlett's (1977) study of agricultural decisions and socioeconomic differences in a rural community in Costa Rica.

Optimal Foraging Analysis

Optimal foraging analysis combines sophisticated mathematical maximization models with Darwinian theory in the analysis of foraging behavior (Winterhalder & Smith, 1981). The models enable the researcher to predict the optimal diet—the inventory of resources exploited at optimum profitability (i.e., maximum caloric yield per caloric cost)—and the optimal patch selection—the mix of resource areas foraged at optimum profitability—in a given environment. The models are operationalized by assigning a goal (e.g., labor minimization or energy maximization), a currency (usually energetic return), a set of constraints (e.g., technology available), and a set of options (e.g., the menu of resources or patches to be exploited). Hawkes et al. (1982) employed this approach to analyze the composition of plant and animal food resources exploited by Aché hunter-gatherers of Paraguay. This study showed that the Aché diet, though dominated by hunted animal foods, includes a few plant foods because the harvest rates of the latter are high enough to merit their inclusion in the optimal diet.

Linear Programming Analysis

Linear programming analysis uses many of the same mathematical maximization formulas as optimal foraging theory. The explicit purpose of linear program modeling is to manipulate goal and constraint variables in order to see what factors are most limiting in an empirical situation and to assess the degree to which empirical situations depart from optimizing assumptions. Using this approach, Johnson and Behrens (1982) determined that Machiguenga (Peru) food production decisions, which do not achieve optimal nutritional or energetic efficiency, apparently are modified by the qualitative factors of security, drudgery, diversity, and taste.

The Concept of Plant Activity Significance

The four behavioral methodologies reviewed here directly support the development of a biobehavioral approach to ethnobotany (see Etkin, 1988). These methods can be used to specify the biological and behavioral parameters of an ethnobotanical situation in order to generate and test hypothesis about human–plant interactions within the context of a broad vision of human ecology. The spatial parameters of plant use can reveal information about land use and territorial organization. The measurement of activity patterns with respect to plants is relevant to the description and evaluation of resource utilization strategies. The accounting of plant resource outputs details patterns of resource significance and exploitation pressure. Input-output analysis is a valuable tool for explaining why specific plant uses are practiced or why they are sustained or changed over time.

In addition to these general applications, the reviewed behavioral methodologies are specifically relevant for the development of a quantitative behavioral notion of the cultural or economic significance of plants. Previous formulations of this concept have been either nonbehavioral (Phillips & Gentry, 1993a,b), nonquantitative (Berlin et al., 1973), or both (Hunn, 1982). I propose the concept of **activity significance** as a behavior-based approach for quantifying the cultural significance of plants. The activity significance of a plant is defined as the set of all observed behavioral interactions between the human community and the plant. Because of the strong quantitative orientation of behavioral research, the concept of activity significance is naturally conducive to quantitative description. The methodologies described above provide the basic parameters of an activity significance—that is, spatial significance, input significance, output significance, and input-output significance.

The proposed concept of activity significance is illustrated in Figure 1, Plant Activity Significance Data Sheet. The example contains actual field data on the plant *Couma macrocarpa* for one calendar year resulting from my fieldwork with the Piaroa of the

PLANT ACTIVITY SIGNIFICANCE DATA SHEET

I. General Data

1. Plant Code or Number ID: fpw01
2. Etic Name: *Couma macrocarpa Barb. Rodr.*
3. Emic Name: up^{h}æ
4. Study Site: Upper Cuao River, Depto. Atures, Estado Amazonas, Venezuela
5. Geographical Coordinates: (5°25' to 5°45'N 66°30' to 67°W)
6. Ecological Setting: evergreen basimontane-submontane-montane forest
7. Altitudinal Range: 250-1200 m.a.s.l.
8. Ethnic Group: Piaroa
9. Study Period: 07-01-85 to 06-30-86
10. Project Name: Ethnoecology of Traditional Piaroa Subsistence

II. Quantitative Data

1. Spatial Significance

a. Resource Location (fruit output only):

i. kwẽrãwẽ lagoon (5°35'N 66°46'W - Cuao riverside) 111.24 kg
ii. caño æčɨ (5°34'N 66°52'W - Cuao tributary) 218.22 kg
iii. upper poñoto (5°25'N 66°54'W - headwater stream) 2.6 kg
iv. caño baboto (5°38'N 66°48'W - headwater stream) 33.94 kg
v. caño mærækænæ (5°37'N 66°46'W - headwater stream) 52 kg
vi. caño ærõto (5°36'N 66°50'W - Cuao tributary) 53.74 kg
vii. lower kænæruoto (5°37'N 66°45'W - Cuao tributary) 138.72 kg

b. Distance Interval from Settlement (fruit output only):

i. 0-2 km 371.97 kg
ii. 2-4 km 224.69 kg
iii. 4-6 km 13.8 kg
iv. > 6 km 0

c. Biotope (fruit output only):

i. garden 0
ii. old garden 0
iii. secondary forest 0
iv. fluvial forest 544.68 kg
v. interfluvial forest 65.78 kg
vi. saxicolous 0

Figure 1. First page of Plant Activity Significance Data Sheet.

Upper Cuao River. *Couma macrocarpa* is one of the most important wild plant species exploited by the Piaroa.

The data sheet presented in the figure is one possibility of what a plant activity significance can look like. The design of the data sheet, in representation of the general outlines and details of

2. Input Significance

a. Time (fruit only):

i. total acquisition time 103.9 hrs
- search/travel time --
- seed collection/prep time (cultivated) NA
- planting time (cultivated) NA
- weeding-pruning time (cultivated) NA
- harvest/collection time --
- transport time --

ii. processing time
- preparing beverage: 11.5 hrs
- kneading gum: 158.94 hrs
- parching seed: 13.75 hrs

3. Output Significance

a. Raw Harvest Amount:

i. fruit: 610.46 kg

period:

07/85	134.51 kg
08/85	291.26 kg
09/85	181.09 kg
05/86	1.6 kg
06/86	2 kg

use allocation:

food (fruit nectar)	256.39 kg
(seed)	≤10.68 kg
birdtrap (gum)	54.48 kg

ii. sap: 0.7 kg

use allocation: paint mixer 0.7 kg

iii. wood: 2 blocks

use allocation:

woodwork (bench)	1 large block
(blowgun mouthpiece)	1 small block

4. Input/Output Significance

a. raw fruit: 5.88 kg/manhour
b. edible fruit: 2.22 kg/manhour
c. edible seed: ≤.09 kg/manhour
d. benchmaking: 1 bench/12.5 manhours
e. gum: .21 kg/manhour

Figure 1 *(continued).* Second page of Plant Activity Significance Data Sheet.

the activity significance, is expected to vary according to the plant type, ecological and human setting, and research priorities and goals. For example, the reader will notice that much of the quantitative data given under spatial, input, and output domains refer to the harvest of *C. macrocarpa* fruit. The focus on fruit reflects my main interest in studying the Piaroa subsistence pattern. However, the same method for data organization could be applied to any other plant use or interaction type. Under the input domain, total data on acquisition time are reported. Since I did not use the focal person method of studying time allocation data, I am unable to break down time investment into the different acquisition phases of searching, collecting, and transporting. By contrast, a study focusing on foraging behavior might well want to capture that sort of data. My accounting of the quantity of *C. macrocarpa* wood harvested is also rather crude. I did not weigh blocks of wood because this aspect of resource exploitation did not form a priority of my research. In a study dealing with timber utilization, however, that type of data might be considered more noteworthy, in which case finer measurements of wood extraction would be called for. The important point is that the data sheet reflects the activity significance of the plant within the parameters and constraints of my research. Given the considerable cost of time to the researcher to collect this kind of data, it is necessary to focus on certain aspects of the activity significance of the plants (those central to the research objectives) or work in teams. Thus the individual researcher can collect only a limited subset of the total activity significance of a plant, but it is advised that it be an adequately sampled, systematically observed, correctly measured, and problem-relevant subset.

The value of compiling plant quantitative activity significance data is that it enables access to statistical details and patterns of the relationship between people and the plant that are unavailable or difficult to see in emic or qualitative descriptions. For example, the fruit production was dominated by fluvial forest trees, although several informants stated that interfluvial forest trees bear equally well (the data at least show that some interfluvial forest trees do bear fruit, but not at the same level of production as fluvial forest trees). The edible seeds of *C. macrocarpa* were mentioned as a common food, and on numerous occasions I observed the seeds being consumed. But about half the time (though I did not measure this), the seeds were thrown out and not utilized. The low overall productivity of seeds, as reported under input/output significance (<0.09 kg/manhour), may explain why this resource is deliberately wasted. Meanwhile, the cost of gum manufacture (0.21 kg/manhour), also shown under input/output significance, should be included in calculations of the profitability of trapping birds by gum traps. The distance interval data, under spatial significance, shed light not only on resource range but also on settlement pattern. We see that over 60% (371.97 kg) of *C. macrocarpa* fruit is harvested within 2 km of the settlement, whereas about 98% (596.66 kg) of the fruit is harvested within 4 km. But this rather limited range belies a multiple and mobile residence pattern. *Couma macrocarpa* is considered so important that Piaroa expressly change their settlement site, switching among mature settlements, old houses, and makeshift camphouses in order to be close to ripening tree stands and to be able to process the gum while in the vicinity. To the extent that people desire to stay within a certain distance (4 km) of *C. macrocarpa* during its fruiting season, one can surmise that this plant exerts a constraint on Upper Cuao settlement patterns. Emic information supplied by native informants often backs up the quantitative behavioral information. For example, Upper Cuao informants openly mentioned the habit of changing residence to afford easy access to *C. macrocarpa* fruit. But this anecdote merely shows the importance of investigating the correspondence between emic and etic type data; activity significance data can be used to evaluate the behavioral accuracy of the emic significance of a plant.

Finally, quantitative behavioral data lead to a more precise knowledge of the cultural or practical significance of plant taxa in the sense that they indicate the weighted significance of the respective taxa inhabiting a given significance domain. That is to say, the exact proportional significance of a taxon within the domain is knowable. For instance, my data (not shown on Figure 1) specify that *C. macrocarpa* fruit makes up 4.94% of all vegetable food weight and 49.35% of all wild vegetable food weight (Zent, 1992) in the Piaroa diet. Converted to caloric or nutritional values, such information provides a precise, absolute, and unambiguous etic sense of the dietary significance of this particular plant among the Upper Cuao Piaroa. These figures can be compared in rather straightforward fashion with the harvest weight amounts of other vegetable foods in order to gauge degrees of significance difference in the food domain. As a demonstration, we can compare the relative food weight significances of four wild plant species, in which we see the dominance of *C.*

Table II. Comparison of wild fruit raw harvest amounts

Plant species	Harvest amount (kg)
Couma macrocarpa	610.46
Scheelea sp.	161.70
Pouteria sp.	157.50
Jessenia bataua	94.18

macrocarpa (shown in Table II). The reasons for this rank ordering of food significance might be investigated by comparing the spatial distributions or resource efficiencies (i.e., input/output) of the different plant species. Comparisons of this kind can also be made for particular species in different cultural contexts, for example a survey of the food significance of *C. macrocarpa* in Venezuela or throughout the Amazon region.

Suggested Readings

The epistemologies of emic and etic research orientations are discussed by Harris (1964, 1979), Johnson (1978), Kaplan and Manners (1972), and Pelto and Pelto (1978). The basic principles of remote sensing are covered by Lillesand and Kiefer (1979) and ethnobotanical applications of remote mapping by Conant (1990) and Vogt (1974). Land surveying and mapping methods are explained by McCormac (1985) and Spier (1970). Time allocation methods are described and debated by Borgerhoff Mulder & Caro (1985), Gross (1984), Hames (1992), and Johnson (1978). Johnson (1978) briefly discusses resource accounting or outputs and input-output analysis.

Acknowledgments

I would like to thank Miguel Alexiades, Egleé López Zent, two anonymous reviewers, and the participants of Brent Berlin's Seminar in Ethnobiology at the University of Georgia for their critical observations of earlier manuscript versions. A special thanks goes to Barbara Price for suggesting that I write this paper.

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