Mushrooms in Forests and Woodlands

Resource Management, Values and Local Livelihoods

Edited by

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CHAPTER 4

Ethnobiological Methods for Ethnomycological Research: Quantitative Approaches

Stanford Zent and Egleé L. Zent

INTRODUCTION

In the last 20 to 25 years there has been a growing trend of using quantitative methods and designs in ethnobiological research. The quantitative revolution in ethnobiology has helped to boost its appeal among students and budding researchers as well as its status within the greater scientific community. The benefits of a quantitative approach include: greater methodological rigour; explicit attention to sampling; more reliable data sets; enhanced analytical capabilities; and higher confidence in the research results and conclusions (cf. Phillips 1996; Höft et al, 1999). Moreover, this development has played a big role in expanding the investigative scope of ethnobiological research. In the past, most field studies in ethnobiology had a descriptive focus; they were occupied with compiling lists of locally known or used plants and animals, making collections of specimens and recording their cultural names, classifications, uses and manipulations (Phillips, 1996; Peters, 1996). By contrast, recent research has had a more analytical orientation, characterized by the careful measurement of selected bio-cultural variables, the statistical representation and analysis of data, the testing of hypotheses about relationships between variables, and occasionally the formulation of models depicting current states or trends of ethnobiological knowledge/behaviour and their causes or conditioning factors. This approach to research has not only advanced our understanding of the specific relationships and importance of the biological world for different cultural groups but also given us a better grasp of how these relationships are patterned or otherwise affected by the larger social and natural environments in which they are situated.

To date, quantitative methods have been employed mainly to study the cultural significance of different plants and animals, ethnomedical practices, agroecological management techniques, beliefs about animal–plant interactions, the economic importance of certain resources and habitats, or the ecological impacts of land and resource use. Another area of application relates to the social dimensions of ethnobiological knowledge systems, such as the distribution and exchange of knowledge within and across communities or societies, and the dynamics of persistence or change of knowledge over time. In some cases, the research findings have been directly used to support (or critique) resource management and conservation initiatives. This points to another important merit of quantitative ethnobiology: its applied significance for conservation and development policy issues.

Ethnomycological studies stand to benefit from the adoption of quantitative methods in the same general ways mentioned above and therefore the prospective researcher is encouraged to consider such methods for his/her own individual project. A major consideration in selecting which method(s) to use is to evaluate how relevant the data set will be in relation to the research problem or question(s) (Alexiades, 1996). If the focus of investigation is on the cultural perception and classification of fungi in a given society then perhaps a qualitative approach is more relevant (see Chapter 3) whereas a quantitative approach has excelled when the research is aimed at questions of process, such as the variation and/or change of knowledge/practices. In this chapter, we review a variety of methods that can be used to study different aspects or dimensions of the dynamic interactions between people and fungi. The chapter is divided into four sections: (1) valuation, a survey of different techniques for estimating the cultural significance or use value of biotaxa; (2) variation and change, dealing with measures of knowledge variation among individuals, social sub-groups and communities, and the inference of knowledge variation or transformation over time; (3) transmission, including methods for studying intergenerational and intercultural

Figure 4.1 *Training younger Jotï in the collection of ethnobiological data. Kayamá (Venezuela, December 2005)*

Photograph: Stanford Zent

knowledge transmission; and (4) behaviour, looking at the systematic observation of behavioural activities and their material consequences.

VALUATION

One of the primary applications of quantitative methods in ethnobiological research has been to compare and contrast the cultural value and significance of different folk taxa. It is not uncommon to find that rural (and some urban) societies around the world recognize and use hundreds of biological species in their daily lives. However, it is also true that not all plants/animals/fungi are treated equally by a given cultural group. Through a combination of formal interviewing and statistical analysis, ethnobiologists have been able to offer a more exact and detailed appreciation of the relative cultural importance value of each and every taxon, as measured by a single metric yet also based on the native point of view (Phillips and Gentry, 1993a, 1993b; Phillips, 1996). Moreover, the mathematical sense of value has been extended to encompass other biological units, such as families, life forms and ecosystem types (Phillips et al, 1994). This type of exercise has been instrumental for testing hypotheses about the relationships between eco-cultural characteristics (e.g. abundance, size, habitat, management, exotic/native species) and usefulness (Phillips et al, 1993a; La Torre-Cuadros and Islebe, 2003; Rocha Silva and Andrade, 2006). Alternatively, the biological content of different use categories has been analysed in terms of the richness of species diversity that fulfil this function (Figueiredo et al, 1997; Galeano, 2000). That a large number species are deemed useful for a particular use category is sometimes interpreted as evidence of the importance of that use category (Rossato et al, 1999; Galeano, 2000). Such measurements also have practical applications, such as identifying which species are more important from a cultural standpoint and thereby establishing conservation priorities or targets that are more relevant from a local perspective (Stoffle et al, 1990; Phillips and Gentry, 1993a, 1993b). Furthermore, it has proved to offer a valuable tool for assessing knowledge variation within and between communities as well as trends of knowledge change, as we describe in the section on Variation and Change.

Quantitative appraisals of the cultural importance value of folk taxa have generally relied on rather brief and simple structured interviews in which the key starting question is ‘How do you use X?’ or its semantic equivalent. The same standardized interview is conducted with a group of people from the study community, preferably a sample of systematic design (e.g. random, stratified or purposive; see Chapter 3). After the basic interview data have been recorded, the total sum of answers are tabulated and added up or otherwise converted into numerical form using a more complex procedure in order to rate and distinguish the use value of different taxa relative to one another. Quite a few different cultural importance/significance indices have been developed, which vary in terms of field methods, information incorporated and formulas of calculation (see Silva et al, 2006; Hoffman and Gallaher, 2007; Garibay-Orijel, et al 2007; Tardío and Pardo-de-Santayana, 2008 for selective reviews). Phillips (1996) categorizes these indices into three broad classes: uses totalled, researcher score and informant consensus.

The 'uses totalled' methodology

The 'uses totalled' methodology entails the simple addition of use citations per taxonomic category (e.g. Toledo et al, 1995). This operation can be carried out in two ways, which may be done separately or in combination:

- the total number of times that a particular use of the folk taxon is cited among the entire sample of respondents; and
- the total number of different uses that are attributed to the given taxon.

A variation of this approach has been employed to rate the usefulness of the forest by asking informants to state the uses of all plant species recorded in measured forest plots and then calculating the percentage of useful plants per unit area (Baleé, 1986, 1987; Boom, 1987, 1990; Bennett, 1992). This relative measure has in turn been utilized to compare the usefulness of local biodiversity across different cultural groups, subcultural groups or forest types (Prance et al, 1987; Caniago and Siebert, 1998; DeWalt et al, 1999; Galeano, 2000). The uses totalled method is easier and faster to carry out than the others but also yields less valuable information about the data set. For example, all use citations are counted equally and there is no recognition of relative differences in the degree of usage. Under this procedure, a rarely used species with more than one use could conceivably score higher than a frequently used species with only one use. Common species known and used by many people are automatically favoured over those species/uses which fall into the more restricted domain of specialist knowledge, regardless of how many people depend on and place value on the latter (cf. Silva et al 2006). In view of such distortions, simple counts are often made as a first step in the data analysis and then serve as input for more complex operations. Lawrence et al (2005) recommend conducting a rank order test of the relative importance of the inventory of taxa cited as being useful. The overall rank of each taxon per use category is calculated as the average ranking across the sample of informants.

The 'researcher score' method

In the 'researcher score' method the researcher assigns a score or quantitative value to the list of different folk taxa, which takes into account how extensively and intensively it is used. The precise method for calculating this score varies somewhat from study to study, from a simple distinction between major and minor uses to more elaborate formulas which encompass more variables. Prance et al (1987) used the former technique to quantify the cultural importance of forests for different Amazonian groups (see also Pinedo-Vasquez et al, 1990). They allowed a score of 1.0 for each major use and 0.5 for each minor use and added up the total for six general use categories (edible, construction, technology, remedy, commerce and other) per species and per family. Nancy Turner (1988) invented a Cultural Significance Index (CSI) of plants used by Salish groups (Canada), which is calculated as the product of three countable variables (quality, intensity, and exclusivity of use). Turner's CSI method has served subsequently as a model for other researchers who have elaborated on the original formula. Stoffle et al (1990) added the parts of a plant used for each purpose as well as the variable of 'contemporary use' into the CSI formula. Silva et al (2006) revised the list of constituent variables to species management, use preference and use frequency, changed the scale per variable to a binary scoring system, and incorporated a correction factor to the formula. The correction factor adjusts the score according to the informant consensus value (defined as the number of informants that cite a given species or the number of informants that cite the most cited species).

Pieroni (2001) developed a compound index, called the Cultural Food Significance Index (CFSI), for rating the variable importance of edible plants, which also included eight mushroom species in the analysis. This index aggregates a larger number (seven) of eco-cultural factors than any of the previous measures, and these refer specifically to this resource type: frequency of mention, perceived availability, frequency of use, taste score appreciation, plant parts used, multifunctional food use and food-medicinal role.

Garibay-Orijel et al (2007) adapted the CFSI specifically for the quantification of the cultural significance of edible mushrooms in their study of traditional mycological knowledge among the Ixtlan Zapotecs of Oaxaca (Mexico). Their index, labelled Edible Mushrooms Cultural Significance Index (EMCSI), incorporates eight scored variables: frequency of mention, perceived abundance, use frequency, taste, multifunctional food use, knowledge transmission, health and economy. The computations can be expressed in terms of each individual sub-index score or these can be added together to get the overall EMCSI. The results obtained for the different sub-indices were analysed by using multivariate ordination and grouping techniques (see section on Variation and Change) in order to reveal which variables combine and contrast to structure the Ixtlan Zapotecs' perceptions and behaviour with respect to different species of mushrooms. Garibay-Orijel et al (2007) consider that their index has several advantages. Firstly, the notion of cultural significance is divided into several domains, showing the relative position of species among a cultural significance gradient. Secondly, it is replicable yet flexible and can be used for cross-cultural comparison (ibid:16). The main criticism of these approaches is that they are subjective and biased toward the criteria imposed by the researcher, and therefore may not reflect accurately cultural insiders' notions of significance (Phillips, 1996; Hoffman and Gallaher, 2007).

Informant consensus

Informant consensus-based scoring techniques were explicitly designed to overcome researcher-biased measures of cultural importance. This approach relies on measuring the pattern of group consensus (i.e. level and distribution of agreement or disagreement across informants) in regards to a given data set. Different methods and formulas for calculating consensus were applied to investigate the medical efficacy of herbal remedies in different cultural contexts (Adu-Tutu et al, 1979; Friedman et al, 1986; Trotter and Logan, 1986; Johns et al, 1990; Varghese et al, 1993).

Trotter and Logan (1986) measured consensus by way of an Informant Agreement Ratio (IAR), formulated as the total number of cases of an ailment in a sample minus the number of separate remedies cited for the ailment, divided by the total cases of the ailment minus 1. Friedman et al (1986) computed efficacy as a function of rank order priority (ROP), calculated as the product of fidelity level (FL = ratio between the number of informants who gave the use of a species for the same treatment and the total number of informants who mentioned the plant for any use) and relative popularity level (RPL = ratio of the number of diseases treated by a particular plant and the number of informants). Johns et al (1990) used a log-linear model to calculate the interaction effect for each remedy cited in a sample as a measure of its degree of confirmation.

Probably the most well-known and influential consensus-based method used to quantify cultural importance or use value in ethnobiological research is the informant-indexing technique pioneered by Phillips and Gentry (1993a; 1993b; Phillips 1996). This method determines the use value (*UV*) of a species as a function of the overall average frequencies with which a group of informants state particular uses of particular species throughout a series of walking interviews in natural settings. Interviews may be repeated with the same informants in order to distinguish between consistent and inconsistent information, major and minor uses, and mistakes and true answers at the individual level. The use value of each species (*s*) for each informant (*i*), UV_{is}, is calculated as the sum of the number of uses mentioned in each interview event by the informant divided by the number of such events for species (*s*) with informant (*i*). The total use value for each species, UV_s, is the sum of all UV_{is} divided by the number of informants interviewed for species. The informant-indexing use-value measure has subsequently been utilized or adapted by a large number of ethnobotanical researchers (Figueiredo et al, 1993, 1997; Kvist et al, 1995; Kremen et al, 1998; Rossato et al, 1999; Galeano, 2000; Luoga et al, 2000; Byg and Balslev, 2001, 2004; Gomez-Beloz, 2002; Kristensen and Lykke, 2003; La Torre-Cuadros and Islebe, 2003; Lykke et al, 2004; Gazzaneo et al, 2005; Monteiro et al, 2006).

Although informant-based techniques strive to be more objective and to better reflect the study population's general knowledge and use of biological species, a valid criticism of this approach is that the major use categories themselves still tend to be defined by the researcher (Zent, 2009). Furthermore, the operation of assigning continuous quantitative values (by the researcher) to what are in fact discrete qualitative judgments of value (by the local people), no matter how rigorous or sophisticated these mathematical procedures may look, nonetheless represents a grave distortion of the folk point of view. Thus the numerical values that are produced in any given case should be looked upon as very approximate and relative measures at best.

VARIATION AND CHANGE

The assessment of variation and change in traditional ecological knowledge/practices is another prominent theme of recent ethnobiological research in which the use of quantitative research methods has made a crucial difference. The focus on intra-cultural variation takes into account the fact that cultural knowledge is unevenly distributed within a given community and is patterned by age, gender, kinship, marriage, residence, education, occupation, socioeconomic class, ethnic affiliation, trade, religion and other social statuses (Boster, 1987; see Figure 4.2).

These variables constrain and determine people's customary activities, spatial mobility, and access and control of resources; thus they directly affect people's contact and familiarity with environmental components (Pfeiffer and Butz, 2005). Moreover,

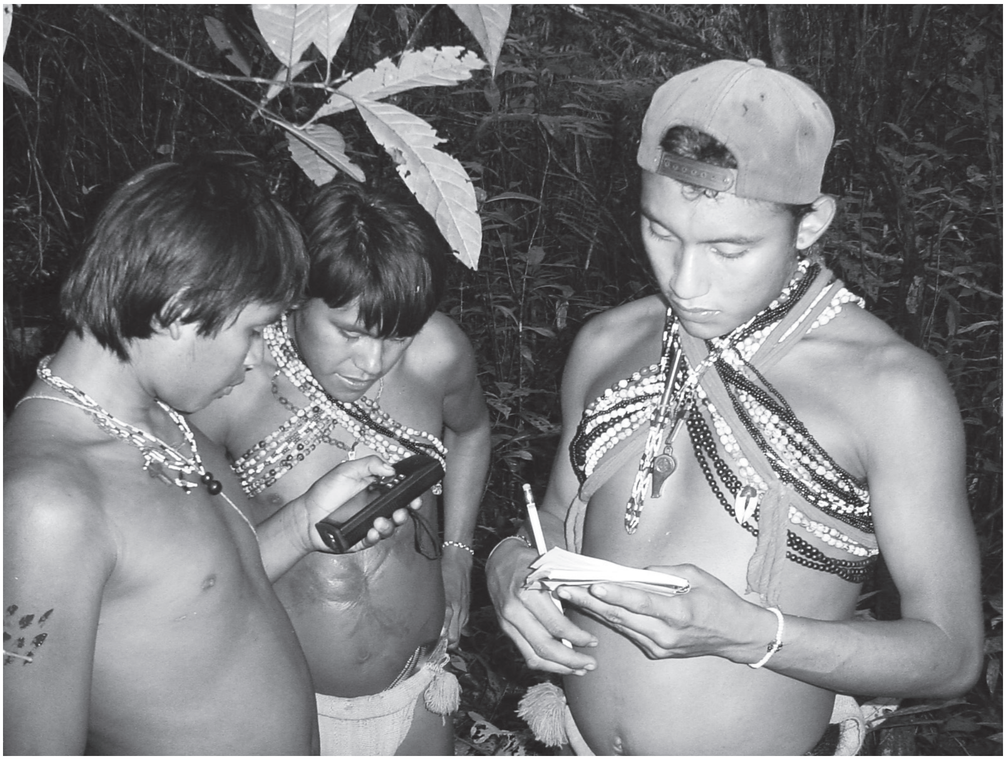

Figure 4.2 *Training Joti boys in the collection of ethno-ecological data and taking GPS readings (Kayama, Venezuela, June 2003)*

Photograph: Yheicar Bernal

social relationships constitute channels for the exchange and flow of information between individuals and groups. Hence the pattern of social distribution of knowledge within a community closely reflects the pattern of knowledge transmission (Boster, 1987). Intra-cultural variation of knowledge is closely associated with the dynamic process of culture change over time just as genetic variation within a population is the source of biological evolution (Pelto and Pelto, 1975). Through diffusion and experimentation, new forms of knowledge – such as local names, cognitive categories, use values, recipes and skills – are constantly being introduced. Old and new forms coexist and compete with each other and eventually those which confer adaptive advantage are propagated at the expense of others. Thus synchronic variation can be used to infer ongoing processes of change over time, including ontogenetic development (i.e. life-cycle of the individual to maturity) as well as phylogenetic development (i.e. evolutionary transition of the society/tribe) (Zent and Zent, 2000).

A focus on the distributive and dynamic properties of knowledge dictates a shift of the analytical locus from the group to the individual. The characterization of individual knowledge variation depends essentially on two basic operations: the inter-subjective sampling of individual knowledge, and the measurement of inter-informant patterns of similarity and difference. The sampling of knowledge in an individual sense means that interviews or observations are conducted with one person at a time and their responses are recorded separately and independently of those recorded from other individuals. Furthermore, the goal of assessing cognitive variation requires that the recorded data are directly comparable across individuals. This criterion is usually achieved by adopting a standardized data collection method. Most studies of ethnobiological variation and change rely on structured interviews or questionnaires because these are relatively easy to code and the results are directly comparable (i.e. do not require interpretation). After the raw data is collected and coded, it must be submitted to an appropriate statistical analysis of variance for the purpose of producing precise measurements of the patterns of similarity/difference of responses among the sample of persons interviewed.

A wide variety of statistical procedures can be used to quantify individual knowledge and to analyse patterns of variation within a sample population. The optimum choice of method will depend on the field methods used, the type(s) of data collected and the research questions being asked.

'Matching and scoring' methods

The most elegant and extensively used measures are simple counts or percentage comparisons between different subgroups (based on age, gender, occupation, etc.) as determined by the average number of biotaxa named in free-listing interviews or the average proportion of known vs. unknown elements in identification tasks (Chipeniuk, 1995; Katz, 1989; Nabhan, 1998, 2001). One of the hidden assumptions of this method is that the researcher has already has an idea of what constitutes a true vs. false answer. In many cases, all answers supplied by one's informants are simply accepted as valid without further evaluation. One alternative is the 'matching with expert' test. This entails preliminary elicitation of response items from one or more locally recognized experts. Individual scores are then determined by proportional agreement with the expert(s) over a structured set of questions (Albuquerque, 2006; Caniago and Siebert, 1998; Zent, 2009). The 'matching with science' procedure has a similar test design but uses published scientific information as the answer key against which local respondent's answers are scored (Godoy et al, 1998; Reyes-García et al, 2006). These methods have been questioned on the grounds that the knowledge of average persons should not be expected to match the knowledge of so-called experts (especially given the distributional culture concept stated in the introduction to this section) just as the knowledge of folk peoples will probably not coincide perfectly with that of scientists.

Consensus analysis

An alternative approach to quantifying knowledge differentials at the individual level is by carrying out group consensus analysis. The cultural consensus model (CCM) developed by Kimball Romney and associates (Romney et al, 1986, 1987) is one of the most popular forms of quantitative consensus analysis used in social science research in recent years and it has also been employed previously in several important studies of ethnobiological variation and change (Atran, 1999, 2001; Atran and Medin, 1997; Boster, 1986; Zent, 1999, 2001, Zent and Zent, 2004). CCM is a mathematical technique, based on factor analysis, designed to measure patterns of inter-informant agreement (or levels of disagreement) about selected culturally shared domains. The method requires obtaining a single factor solution (expressed by a first eigenvalue at least three times greater than the second eigenvalue), which indicates that a group consensus model exists. Having established that consensus configures the domain, it permits: (a) determination of the correct answers when such answers are unknown beforehand and (b) rating of the individual knowledge levels, expressed in terms of estimated competence scores. According to the computational formulas used, correct answers are usually the most popular answers but greater weight is given to individuals who display greater competence and lesser weight is given to individuals who display lower competence. The individual competence scores are essentially measured as a function of the degree to which an individual's answers concord or agree with the 'correct' answers derived from the group. Phillips and Gentry (1993b) adapted their informant-indexing technique for measuring the cultural use value of different plant species (a plant-centric measure; see the Valuation section of this chapter) to the analysis of botanical knowledge differences by age in their study population (an anthropocentric measure). The overall plant use knowledge for each informant was measured as the standardized ratio between the total use value recorded for him/her and the total use value recorded for the entire group of informants. This technique amounts to a kind of inter-informant consensus analysis in the sense that the average number of plant uses known by an individual is compared to the average number of plant uses expressed by the population.

Classification and ordination

Classification and ordination represent another set of techniques that can be used to represent and measure the variation of knowledge within a given community or cultural group.

Classification, also known as cluster analysis, is an exploratory mathematical technique which has the aim of sorting an array of heterogeneous objects into a smaller number of homogeneously defined groups or clusters. Applied to the analysis of interpersonal differences of cultural knowledge, it can be used to identify subgroups in a population based on the calculation of degrees of shared understandings among individuals. Hierarchical cluster analysis provides an idea of the stepwise distance of these groupings in relation to one another through divisive (i.e., progressive splitting) or agglomerative (i.e. progressive merging) graphic displays (Höft et al, 1999).

Ordination is a statistical method that orders objects characterized by values on multiple variables (i.e. multivariate objects) along gradients so that similar objects are near each other and dissimilar objects are further apart. These relationships between the objects, on each of several axes (one for each variable), are then characterized numerically and/or graphically. While ordination has been used mainly for studying community ecology (e.g. floristic composition in relation to environmental gradients), it can also be applied to ethnobiological research by incorporating people as one of the object variables (for example, a People × Species data matrix). Höft et al (1999) propose that the applications of ordination for examining human-biotic relationships include the following: (a) revealing whether certain groups of people value the same species in the same ways, (b) spotting individuals who respond differently from the majority, and (c) grouping species according to the use values assigned by people.

The main types of ordination applied to ethnobiological data thus far are principal components analysis (PCA) and non-metrical multidimensional scaling (NMDS). In addition to segmenting and ordering the social universe according to patterns of shared (or non-shared) knowledge or behaviour, these techniques also afford insight into how knowledge is structured and distributed within a community. Different from consensus-based measures, which rate an individual's knowledge in reference to a single linear scale determined by the average collective response (i.e. one-to-all comparisons), classification and ordination produce aggregate measures of the degree of conformity of an individual to all other individuals in the sample (i.e. one-to-one comparisons).

Variation over time

The observed pattern(s) of ethnobiological variation in space can be used as input for inferring the processes of change of the ethnobiological system over time. This requires some additional analytical steps such as considering how different groups and subgroups are affected by surrounding changes in the socioeconomic or biophysical environment. Beyond simply measuring the historical shifts or trends, this body of work also addresses the major questions of why knowledge changes or persists and what are the main environmental factors driving this process. There are two basic approaches for documenting cultural knowledge change/continuity through time: longitudinal studies and cross-sectional studies.

The longitudinal study

The most simple, straightforward and accurate way to measure change is by carrying out a longitudinal study. This entails the collection and comparison of time-series data – i.e. similar type of data, using similar methods, at the same site(s) at two or more different time periods. A variation of this approach is the community restudy, which involves going back to a community that was studied sometime in the past, usually by somebody else. The observed changes in ethnobiological knowledge and practices can then be related to more general socio-cultural and ecological changes that also took place during this interval to get some idea of the causal factors and mechanisms involved. The requirements of this approach are that reliable and comparable baseline data are available or that data collection can be sustained over a relatively long time span. Due to the difficulty of meeting these conditions, it is not surprising that there are few precedents of this kind in ethnobiological research (Zarger and Stepp, 2004; van Etten, 2006). Thus for most researchers, the only option is to rely on indirect methods for inferring the transmission process.

The cross-sectional study

Cross-sectional (or transversal) studies refer to data collecting operations at one point in time. However, several creative techniques have been devised for inferring diachronic processes of ethnobiological loss, change or persistence from synchronic data. After the patterns of variation within and between study groups are measured, the next step is to examine the correlations of such variations with other social and environmental variables which are indexed to time (thus permitting an explanation of past events) or are themselves relevant indicator variables of change in a more general sense. A third step is to interpret the observed relationships by reference to the larger historical-ecological context. The overwhelming majority of empirical studies of ethnobiological knowledge change and process conform to this type.

People's age stands out as the social variable most commonly used to chart the slope of knowledge change in dynamic contexts, probably because it is universal and directly indexed to time. In studies of the ontogenetic development of knowledge acquisition, the array of individually recorded and scored knowledge types and amounts are ordered according to the person's age and the resulting knowledge-by-age trend lines are read as site-specific models of the age-dependent learning process (e.g. Stross, 1973; Dougherty, 1979; Hunn, 2002; Zarger, 2002; Hatano and Inagaki, 1999; Keil et al, 1999; Ki-fong Au, 1999; Coley, 2000) Age-on-knowledge curves are also frequently employed to infer the diachronic evolution of TEK amount and content in groups over time (Hewlett and Cavalli-Sforza, 1986; Ohmagari and Berkes, 1997; Rosenberg, 1998; Zent, 1999, 2001; Lizarralde, 2001, 2004; Heckler, 2002; Byg and Balslev, 2004; Zent and Zent, 2004). In that case, the difference(s) between older versus younger people's knowledge levels is measured and thought to approximate the degree of change (whether loss or increase) that has occurred in that time interval. Some researchers have pointed out that the knowledge-on-age trend-line in a stable (i.e. 'non-erosional') situation where knowledge is not being lost, should reflect gradual increments of change, whereas trend-lines displaying sharp breaks or noticeable tips are indicative of irreversible change (e.g. erosion of local knowledge) over time (Ross, 2002; Voeks and Leony, 2004; Florey, 2009). An alternative approach is to confine the sample population to adults beginning with the age level at which intellectual maturity is thought to be reached. Accordingly, the difference between knowledge levels of younger versus older generation adults is represented as an approximate measure of the direction and rate of knowledge change (Voeks and Leony, 2004; Caniago and Siebert, 1998; Lee et al, 2001).

Besides age, we were able to observe a number of other social variables that are treated as proxies or indicators of acculturation. Some of these are obviously direct markers of modernization and are easily measured on an individual basis, like years of school education completed, literacy, fluency in the national language, amount of income obtained from cash copping or wage labor, material possessions and travel experience (Wester and Yongvanit, 1995; Godoy et al, 1998; Zent, 1999, 2001; Sternberg et al, 2001; Byg and Balslev, 2004; Voeks and Leony, 2004; Reyes-García et al, 2005a, 2007). Others are more indirect or qualitatively described change indicators that are assumed to affect entire communities: availability of modern services (e.g. schools, health clinics, communications and transportation, nontraditional housing, indoor plumbing); changes in settlement pattern; introduction of exogenous technology, economic orientation (e.g. commercial vs. subsistence activity); proximity to roads or urban areas; contact with outsiders; habitat degradation; and non-traditional beliefs and values (Caniago and Siebert, 1998; Benz et al, 2000; Ross, 2002; Ghimire et al, 2004; Shanley and Rosa, 2004; Zarger and Stepp, 2004; Lawrence et al, 2005; Reyes-García et al, 2005a, 2005b; Ross and Medin, 2005; Cruz-García, 2006). In addition to measuring the co-variation between ethnobiological variables and the socioecological change indicator variables mentioned above, it may be necessary to take into consideration qualitative aspects of the socio-historical context, not only at the local level but also at regional, national and international scales (Lawrence et al, 2005).

TRANSMISSION

The transmission of knowledge represents another dynamic property or dimension of ethnobiological systems that has begun to attract more attention from researchers in recent years. The study of patterns of transmission can shed considerable light on how and why changes take place, including not only the erosion of traditional knowledge but also the acquisition of new forms. For example, Zent (2009) examined the impact of intercultural contact and missionary activities on the trans-generational continuity (or change) of ethnobotanical knowledge among the Jodï people of Venezuela. Several important social and economic transformations associated with the missionary process were identified as having a detrimental impact on the acquisition of such knowledge among younger people:

- more sedentary settlement patterns;
- substitution of traditional with nontraditional activities;
- more time spent in agricultural tasks as opposed to foraging;
- decreased amount of time that children and adults spend together;
- diminished consumption and use of wild natural resources;
- positive valuation of allotochtonous knowledge (derived from outside influences) over autochtonous (locally derived) knowledge.

By contrast, Campos and Ehringhaus (2003) observed that 20 to 30 per cent of the particular uses of palms by indigenous groups of southwestern Amazonia (Brazil) were non-traditional uses adopted from their non-indigenous neighbours. The two cases mentioned here illustrate two main types of transmission: from generation to generation and from group to group.

Inter-generational, or vertical, transmission is extremely important: this is how a society's traditional knowledge and practices are reproduced and perpetuated over time. The transmission process can be analysed in terms of a few key elements:

- Social channels: the social relationships of individuals (e.g. parent-child, older sibling-younger sibling, expert-novice) between whom knowledge is passed.
- Situational contexts: the combination of physical, social, symbolic and intentional elements that frame the dynamic learning events.
- Learning/teaching strategies: to the modes of communication and psycho-behavioural operations used to convey/capture information.

Different data collecting styles have been used to explore these phenomena.

One style relies on the traditional anthropological methods of participant observation and in-depth, informal interviewing of key informants. This group of studies is characterized by normative, anecdotal and qualitative ethnographies of how young people are socialized in different ethno-ecological domains (e.g. plant uses, food procurement tasks, phytotherapies), with culturally sensitive descriptions of the routine acquisition mechanisms (e.g. peripheral participation, observation, imitation, informal instruction, supervised practice) and the key social relationships (e.g. grandmother–granddaughter, father–son, grandfather–grandson, female co-residents) (Messer, 1975; Ruddle and Chesterfield, 1977; Katz, 1986, 1989; Lave and Wenger, 1991; Murphy, 1992; Wilbert, 2002).

A second approach to data collecting makes use of structured questionnaires or interviews administered to a sample of respondents and statistical analysis of the results. The interview schedule consists of questions about whether the person knows or performs certain traditional practices (e.g. wild plant gathering, craft-making, bush skills), their age when first learned, the person who taught it and their relationship to the respondent, and in some cases where and how learned. This exercise produces a descriptive statistical profile of the knowledge transmission process, specifying according to the category of knowledge: average age (range) when acquired, most common personal sources, and typical locations and methods of acquisition (Hewlitt and Cavalli-Sforza, 1986; Ohmagari and Berkes, 1997; Lozada et al, 2006).

A third approach to studying ethnoecological knowledge transmission can be identified as social network analysis. The specific method used for this type of analysis by Scott Atran in his study of Mayan and Ladino groups in the Petén region of Guatemala involves two basic steps of data collection: (a) elicitation of ranked lists of socially significant others, of most frequent interlocutors about forest matters, and of recognized forest experts, and (b) follow-up interviews with the highest and lowest ranked individuals appearing in the aforementioned lists, eliciting their respective social interaction and forest expert networks. The results of this exercise are then added up and projected graphically to model the density, diffuseness and directionality of putative knowledge exchanges within the social group (Atran, 1999, 2001; Atran et al, 2002).

The investigation of intercultural knowledge transmission helps to bring out the creative, adaptive and historical aspects of ethnobiological systems. One way in which this topic can be investigated is by means of controlled comparisons of resource inventories and their use values across two or more cultural groups who occupy a contiguous space or are in direct contact with each other, especially where at least one of these groups is indigenous and another is immigrant (Campos and Ehringhaus, 2003; Byg and Balslev, 2004). The sharing of cognate names for the same species by ethnolinguistically-distinct groups, particularly when their languages are not genetically related, is a telling indication of ethnobiological contact and diffusion in the past (Austerlitz, 1968; Svanberg, 2009). Atran (1999, 2001), in the study mentioned above, extends network analysis to investigate the flow of ethnoecological information between distinct ethnic communities inhabiting the same region. Although we are not aware of any research which specifically deals with the question of ethnomycological knowledge transmission, given the rapidly shifting nature of fungi use as food, medicinal and commercial resource in many places around the world, this appears to offer a particularly apt domain for investigating transmission issues.

Figure 4.3 *Training Joti research participants in the collection of ethno-ecological data (Kayama, Venezuela, June 2003)*

Photograph: Stanford Zent

BEHAVIOUR

Observational studies of human behaviour can open another window onto people's relationship to fungi and therefore provide a necessary complement to cognitive research (see Figure 4.3 and Chapter 3). Informant statements and recollections about cultural practices tend to present a normative picture and gloss over the exceptions, whereas a focus on the behaviour of different individuals helps to capture more diversity and complexity. People do not always do what they say they do. Actually observing what they do provides a corrective control on their statements (Zent, 1996). Moreover, people do not always say everything they do. Paying attention to the latter is useful for filling in missing information and obtaining further details. Some forms of knowledge are embodied in behaviour (physical movements) and not necessarily conscious or verbalized. Our ability to detect and apprehend such knowledge, often referred to as skills or 'know-how', may depend entirely on the opportunity to witness it in live action. The listing of folk taxonomies, perceptual properties and use categories by way of standardized elicitation formats tends to convey fragmented and formalized representations of cultural knowledge removed from their normal natural and social contexts (Ellen, 1986). A broadly conceived method that integrates both cognitive and behavioural data is able to provide a more holistic grasp of the knowledge system. Participant observation involves not simply taking up residence in the study community but also taking an active part in the social and economic activities that make up community life. Going along on foraging or trading expeditions, helping out in the kitchen, sharing the meals and participation in other activities is a good way to build rapport and familiarity with local people, and also gives the researcher first-hand experience of the subject.

Many different methods have been developed for recording people's social and ecological behaviour in natural settings, including qualitative as well as quantitative approaches. The choice of method used depends on the research topic and specific questions being studied. If the goal is a detailed ethnographic description, then participant observation of the full range of activities involving mushrooms – from collecting to processing, consuming and marketing – is a standard technique. Observational ability, style and language will vary from person to person, but it is recommended that field notes are taken as soon as possible and at the lowest level of abstraction (Pelto and Pelto, 1978). Attention should be given to both the ecological and social context of the activity. Besides the description of the focal activity itself, records of behavioural events often include relevant information about the date and time, the actors and their respective roles, the social relationships between participants, the sequence of constituent activities that make up the entire event, the timing of these sequences, the tools and/or materials used, the place or habitat, weather, and material outcome of the activity (Johnson, 1978). The full meaning and significance of an activity often goes beyond what meets the eye at one moment in time and therefore the researcher might have to conduct follow-up inquiries or relate the observed event to other types of data (Pelto and Pelto, 1978). In order to avoid bias and unreliability in behavioural data collection, a reasonable sampling strategy should be developed with the aim of distributing observational events among different people, locations and seasons. This ideal of maximizing data representativity is valid whether the study has a qualitative or quantitative orientation.

The study of behaviour through field observation lends itself easily to quantitative data collection and analysis (cf. Altmann, 1974). As a general research strategy, quantitative measurement has several advantages: increased reliability, comparability, theoretical precision and statistical power (Johnson, 1978:43–45). At the same time, the quantitative study of behaviour must confront several methodological challenges: (a) sampling design, (b) coding of behaviour, and (c) currency type or counting units. The sample design should seek to maximize coverage of the socioeconomic diversity of the study population, the range of different activities and seasonal variations while at the same time minimize the time and cost for the researcher as well as the intrusiveness and disruption for the study group. The recording of different behaviours should be done according to an explicitly defined code that is somewhat compatible and thus comparable with the categories used in other studies. Units of measurement depend on what dimension of behaviour is being looked at, but the main rule of thumb is to use the most universal measure possible – such as the time spent in different behavioural categories (in minutes or hours) or the gross weight of particular products (in grams or kilograms) – to allow for convertibility to other derived measures (such as market values) if the need arises.

Ethnomycological researchers may want to consider the potential applications of quantitative data for examining certain aspects of the procurement or allocation process. For example, the measurement of time or energy inputs and production outputs would be crucial components of a micro-economic cost-benefit analysis (Montoya et al, 2008). This in turn would permit the inferential exploration of decision-making processes such as why to pursue one resource strategy versus another. Other topics that require a quantitative approach include: the significance of mushroom hunting as a part of the total activity budget, the proportional contribution of this resource type to the local diet, the comparison of harvest amounts across different sites or time periods, and the impact of cash cropping on local subsistence habits. A quantitative approach permits the statistical integration and comparison of different data sets, leading to more sophisticated analysis and hypothesis testing. For example, a comparative analysis of mushroom production levels, market prices and export figures over time could provide information for exploring the relationships between the mushroom trade, ecological pressures and social impacts (cf. Winkler, 2008; Yang et al, 2008).

Useful field methods for producing quantitative descriptions of ethnoecological behaviour can be conveniently grouped into three primary dimensions: spatial relationships, human activities and resource production (Zent, 1996), which are discussed below.

Spatial relationships

The spatial dimension encompasses measurements of geographic data and information. Relevant information includes the mapping of resource distributions, foraging routes and exchange circuits, which in turn can be used to calculate land areas exploited or distances travelled. At a local scale, this type of data can be recorded easily and efficiently by using a portable GPS (Global Positioning System), which computes the precise geographic coordinates of resource or activity locations (Figure 4.4).

The productivity of a species in a given area can also be extrapolated by taking sample measurements of yield per unit of land area and then multiplying by the total resource catchment area. Samils et al (2008) analysed yield in spatial terms (kg/ha per year) in combination with market price (EUR/kg) to compare income generation from truffle plantations with income earned from cereal production in rural Spain. They found that truffle cultivation was far superior in economic potential and therefore offers a more profitable land use option for farmers. Further discussion on economic valuation methods is given in Chapter 5.

Human activity

Activities are usually measured in terms of time units although energy expenditure or monetary value could also be used according to the nature of the research problem. The sampling of activity patterns can be divided into two main techniques: (1) continuous observation, observing an activity, or sequence of activities, over a specified time frame; and (2) state observation, recording the activity which occurs at a single moment in time (Hames, 1992). The former, sometimes called time-motion study, entails recording the time it takes to carry out a specified cultural activity. The time of the activity is

Figure 4.4 *Ara taking a GPS reading while collecting ethnoecological data (Jkalo Ijkuana, Venezuela, May 2002)*

Photograph: Stanford Zent

sometimes measured in relation to a second variable, such as the amount of resource harvested or area worked, in order to calculate the efficiency or time cost per unit of product output. Although the timing operation is usually performed by the researcher who participates or follows along in the activity, it is also feasible to train the local actors to do this work themselves. Another alternative for timing organized activities outside the home is to record exit and arrival times. Depending on the activity type and the analytical objectives, it may be necessary to delineate and time separately the different key operations or phases of the total activity sequence. For example, in order to test hypotheses under optimal foraging theory, it may be necessary to separate search time, pursuit/handling time per resource type and transport time for all resources (see Hill and Kaplan, 1992). The spot check or instantaneous scan sampling methods are the most common types of state observations used in human behavioural research. The basic technique consists of recording the activities of a sample of different individuals of the study population at randomly or systematically selected time points. The repeated application of this method over a reasonable time period (e.g. one year, in order to capture seasonal variations) produces a frequency distribution of the number of observed events per activity category, which in turn allows the researcher to calculate the proportional allocation of time to different types of behaviour, such as work vs. leisure, collecting vs. marketing (Johnson, 1975).

Another important dimension has to do with person-number, distinguishing individual vs. group observations. Observations on focal individuals involve closely following and recording the movements and actions of chosen individuals even in the context of group activities. Such focal person observations can be carried out in a continuous fashion – timing the start and finish times of different behaviours – or using a point sampling method – noting the person's behaviour at set intervals (every 5, 10, 30, etc. minutes). Similar focal observations of (sub)groups can also be done but obviously it is more difficult to effectively monitor several individuals at the same time especially if the activities imply physical separations beyond immediate view.

Resource production

Resource production (or consumption) can be estimated by measuring sampled quantities over a specified temporal or spatial frame and then extrapolating the results according to the parameter and scale most pertinent to the research objective (e.g. per hour, day, week, year, person, household, village, region, person–day). This kind of measure is very useful for assessing economic productivity, consumption habits and ecological impact. Although resources can be counted by way of different currencies, Johnson (1978) recommends that the quantity of the raw product itself is the most versatile measurement and can easily be converted into other currencies (e.g. local market value). Many different sampling procedures have been used and only a few examples can be mentioned here. The best method would be to count and weigh all the resources that are brought back to the house or village during the entire research period. But since it is extremely difficult to achieve complete coverage, more accurate results may actually be obtained by sampling certain days and/or certain households/producers. In our own research, we have trained and hired local people to do this job, with reasonably good results. Alternatively, people can be asked to recall all of the resource items and approximate amounts (according to their own measuring units) they collect or harvest during the day; the reported amounts can then be converted into estimated weights based on a sample of actual weighing events per resource item. One technique used in consumption studies is to count or weigh all the resources of a certain class at the start of the study period, all amounts introduced during the period and the amounts remaining at the end, in order to calculate how much was actually consumed. The same basic method can be adapted to studying product exchange in a market setting. If the researcher wants a more detailed picture of exchange, then the focus of observation may be on the transactions themselves, noting the content (e.g. species type) and frequency or volume of the transactions as well as relevant variables of the vendor and consumer populations (e.g. sex, ethnic background, education, occupation). For example, Montoya et al (2008) made weekly visits to a mushroom dealer's store in central Mexico over a four month period and recorded the species sold, price per kilo paid, amount of each species bought in the store that day, the number of people who came to sell mushrooms and the criteria used by the dealer for choosing which mushrooms to buy.

CONCLUSION

Although the main focus in this chapter has been on quantitative ethnobiological techniques, we should also emphasize that these are meant to complement, rather than substitute, qualitative methods of data collection and analysis (see Chapter 3). It is quite possible that some sort of qualitative assessment of cultural categories, meanings and behaviours will have to be undertaken before any counting can even begin. For example, it doesn't make much sense to tally up use value citations mentioned in individual interviews if you haven't accurately translated the emically-valid use categories. In our opinion, the most interesting case studies are those that manage to integrate different types of data and methods. In any case, it is worthwhile to recognize the special value of quantitative data and mathematical analysis, especially in regard to revealing the distributive and dynamic parameters of human–fungi relationships. How important is a particular species for a cultural group? Which sub-groups or individuals know about it and which ones don't? Is this knowledge being retained, lost or transformed from one generation to the next? How is this knowledge or skill set being passed on? Are traditional forms of learning/teaching being affected by formal schooling and other socio-cultural changes? How much of a particular resource is actually being harvested or consumed or sold? Are species being harvested at a sustainable level? These are just a few of the questions that are best answered by way of supporting mathematical data and evidence. They are also questions with deep implications for ecological or cultural management problems. Quantitative data collection and analysis are not always easy to do but the benefits clearly outweigh the costs.

REFERENCES

Adu-Tutu, M., Afful, Y., Asante-Appiah, K., Lieberman, D., Hall, J. B. and Elvin-Weis, M. (1979) 'Chewing stick usage in southern Ghana', *Economic Botany* 33, pp320–328

Albuquerque, U. P. (2006) 'Re-examining hypotheses concerning the use and knowledge of medicinal plants: a study in the Caatinga vegetation of NE Brazil', *Journal of Ethnobiology and Ethnomedicine* 2(30)

Alexiades, M. N. (1996) 'Introduction to Quantitative Methods in Ethnobotanical Fieldwork', in M. N. Alexiades (ed) *Selected Guidelines for Ethnobotanical Research: A Field Manual*, Advances in Economic Botany, vol 10. The New York Botanical Garden, New York, pp167–169

Altmann, J. (1974) 'The observational study of behavior', *Behavior* 48, pp1–41

Atran, S. (1999) 'Managing the Maya Commons: The Value of Local Knowledge', in V. D. Nazarea (ed) *Ethnoecology: Situated Knowledge/Located Lives*, University of Arizona Press, Tucson, pp190–214

Atran, S. (2001) 'The Vanishing Landscape of the Peten Maya Lowlands', in L. Maffi (ed) *On Biocultural Diversity: Linking Language, Knowledge, and the Environment*, Smithsonian Institution Press, Washington, D.C., pp157–174

Atran, S. and Medin, D. (1997) 'Knowledge and Action: Cultural Models of Nature and Resource Management in Mesoamerica', in M. H. Bazerman, D. M. Messick, A. E. Tenbrunsel and K. A. Wade-Benzoni (eds) *Environment, Ethics, and Behavior: The psychology of environmental valuation and degradation*, The New Lexington Press, San Francisco, pp171–208

Atran, S., Medin, D., Ross, N., Lynch, E., Vapnarsky, V., Ucan Ek', E., Coley, J., Timura, C. and Baran, M. (2002) 'Folkecology, cultural epidemiology, and the spirit of the commons', *Current Anthropology* 43, pp421–450

Austerlitz, R. (1968) 'Native Seal Nomenclatures in South-Sahalin', in J. K. Yamagiwa (ed) *Papers of the CIC Far Eastern Language Institute*, Panel on Far Eastern Language Institutes of the Committee on Institutional Cooperation, Ann Arbor, MI, pp133–141

Baleé, W. (1986) 'Análise preliminar de inventário florestal e a etnobotânica Kaápor (Maranhão)', *Boletim do Museu Paraense Emílio Goeldi*, vol 2, no 2, pp141–167

Baleé, W. (1987) 'A etnobotânica quantitativa dos índios Tembé (Rio Gurupi, Pará)', *Boletim do Museu Paraense Emílio Goeldi, Botânica*, vol 3, no 1, pp29–50

Bennett, B. C. (1992) 'Plants and People of the Amazonian Rainforests', *BioScience* 42, pp599–607

Benz, B. F., Cevallos E. J., Santana M. F., Jesus Rosales A., and Graf, S. (2000) 'Losing knowledge about plant use in the Sierra de Manantlan Biosphere Reserve, Mexico', *Economic Botany* 54, pp183–191

Boom, B. (1987) 'Ethnobotany of the Chacobó Indians, Beni, Bolivia', *Advances in Economic Botany* 4, pp1–68

Boom, B. (1990) 'Useful plants of the Panare Indians of the Venezuelan Guayana', *Advances in Economic Botany* 8, pp57–76

Boster, J. S. (1986) 'Exchange of Varieties and Information Between Aguaruna Manioc Cultivators', *American Anthropologist*, vol 88, no 2, pp428–436

Boster, J. S. (1987) 'Introduction', *Behavioral Scientist*, vol 31, no 2, pp150–162

Byg, A. and Balslev, H. (2001) 'Diversity and use of palms in Zahamena, eastern Madagascar', *Biodiversity and Conservation* 10, pp951–970

Byg, A. and Balslev, H. (2004) 'Factors affecting local knowledge of palms in Nangaritza Valley, southeastern Ecuador', *Journal of Ethnobiology*, vol 24, no 2, pp255–278

Campos, M. T. and Ehringhaus, C. (2003) 'Plant Virtues are in the Eyes of the Beholders: A comparison of known palm uses among indigenous and folk communities of Southwestern Amazonia', *Economic Botany*, vol 57, no 3, pp324–344

Caniago, I. and Siebert, S. F. (1998) 'Medicinal plant economy, knowledge and conservation in Kalimantan, Indonesia', *Economic Botany* 52, pp229–250

Chipeniuk, R. (1995) 'Childhood Foraging as a Means of Acquiring Competent Human Cognition about Biodiversity', *Environment and Behavior*, vol 27, no 4, pp490–512

Coley, J. D. (2000) 'On the Importance of Comparative Research: The Case of Folkbiology', *Child Development*, vol 71, no 1, pp82–90

Cruz García, G. S. (2006) 'The mother–child nexus. Knowledge and valuation of wild food plants in Wayanad, Western Ghats, India', *Journal of Ethnobiology and Ethnomedicine* 2, pp39.

DeWalt, S., Bourdy, G., Chavez de Michel, L. R. and Quenevo, C. (1999) 'Ethnobotany of the Tacana: Quantitative inventories of two permanent plots of Northwestern Bolivia', *Economic Botany* 53, pp237–260

Dougherty, J. W. D. (1979) 'Learning Names for Plants and Plants for Names', *Anthropological Linguistics* 21, pp298–315

Ellen, R. F. (1986) 'Ethnobiology, Cognition, and the Structure of Prehension: Some General Theoretical Notes', *Journal of Ethnobiology* 6, pp83–98

Figueiredo, G. M., Leitão-Filho, H. F. and Begossi, A. (1993) 'Ethnobotany of Atlantic forest coastal communities: diversity of plant uses in Gamboa (Itacuruça Island, Brazil)', *Human Ecology* 21, pp419–430

Figueiredo, G. M., Leitão-Filho, H. F. and Begossi, A. (1997) 'Ethnobotany of Atlantic forest coastal communities: II. Diversity of plant uses at Sepetiba Bay (Brazil)', *Human Ecology*, vol 25, no 2, pp353–360

Florey, M. (2009) 'Sustaining indigenous languages and indigenous knowledge: developing community training approaches for the 21st century', in P. Bates, M. Chiba, S. Kube and D. Nakashima (eds) *Learning and Knowing in Indigenous Societies Today*, UNESCO, Paris, pp25–37

Friedman, J., Yaniv, Z., Dafni, A. and Palewitch, D. (1986) 'A Preliminary Classification of the Healing Potential of Medicinal Plants, Based on a Rational Analysis of an Ethnopharmacological Field Survey among Bedouins in the Negev Desert, Israel', *Journal of Ethnopharmacology* 16, pp275–287

Galeano, G. (2000) 'Forest use at the Pacific coast of Chocó, Colombia: a quantitative approach', *Economic Botany* 54, pp358–376

Garibay-Orijel, R., Caballero, J., Estrada-Torres, A. and Cifuentes, J. (2007) 'Understanding cultural significance, the edible mushrooms case', *Journal of Ethnobiology and Ethnomedicine*, vol 3, no 4, pp1–18

Gazzaneo, L. R., Lucena, R. F. P. and Albuquerque, U.P. (2005) 'Knowledge and use of medicinal plants by local specialists in a region of Atlantic Forest in the state of Pernambuco (Northeastern Brazil)', *Journal of Ethnobiology and Ethnomedicine*, vol 1, no 9

Ghimire, S. K., McKey, D. and Aumeeruddy Thomas, Y. (2004) 'Heterogeneity in Ethnoecological Knowledge and Management of Medicinal Plants in the Himalayas of Nepal: Implications for Conservation', *Ecology and Society*, vol 9, no 3, art 6

Godoy, R., Brokaw, N., Wilkie, D., Colón, D., Palermo, A., Lye, S. and Wei, S. (1998) 'On trade and cognition: Markets and the loss of folk knowledge among the Tawahka Indians', *Journal of Anthropological Research*, 54, pp219–233

Gomez-Beloz, A. (2002) 'Plant Use Knowledge of the Winikina Warao: The Case for Questionnaires in Ethnobotany', *Economic Botany*, vol 56, no 3, pp231–241

Hames, R. B. (1992) 'Time Allocation', in E. Smith and B. Winterhalder (eds) *Evolutionary Ecology and Human Behavior*, Aldine de Gruyter, New York, pp203–235

Hatano, G. and Inagaki, K. (1999) 'A Developmental Perspective on Informal Biology', in D. Medin and S. Atran (eds) *Folkbiology*, MIT Press, Cambridge, MA, pp321–354

Heckler, S. (2002) 'Traditional Ethnobotanical Knowledge Loss and Gender among the Piaroa', in J. R. Stepp, F. S. Wyndham and R. K. Zarger (eds) *Ethnobiology and Biocultural Diversity: Proceedings of the Seventh International Congress of Ethnobiology*. International Society of Ethnobiology. University of Georgia Press, Athens, GA, pp532–548

Hewlett, B. S. and Cavalli-Sforza, L. L. (1986) 'Cultural transmission among Aka Pygmies', *American Anthropologist*, vol 88, no 4, pp922–934

Hill, K. and Kaplan, H. (1992) 'Food Acquisition', in E. A. Smith and B. Winterhalder (eds) *Evolutionary Ecology and Human Behavior*, Aldine de Gruyter, New York

Hoffman, B. and Gallaher, T. (2007) 'Relative Cultural Importance Indices in Quantitative Ethnobotany', *Ethnobotany Research and Applications*, vol 5, no 1, pp185–199

Höft, M., Barik, S. and Lykke, A. (1999) 'Quantitative Ethnobotany: Applications of Multivariate and Statistical Analyses in Ethnobotany', *People and Plants Working Paper* 6, UNESCO, Paris

Hunn, E. (2002) 'Evidence for the Precocious Acquisition of Plant Knowledge by Zapotec Children', in J. R. Stepp, F. S. Wyndham and R. K. Zarger (eds) *Ethnobiology and Biocultural Diversity: Proceedings of the Seventh International Congress of Ethnobiology*. International Society of Ethnobiology. University of Georgia Press, Athens, GA, pp604–613

Johns, T., Kokwaro, J. O. and Kimanani, E. K. (1990) 'Herbal Remedies of the Luo of Siaya District, Kenya: Establishing Quantitative Criteria for Consensus', *Economic Botany*, vol 44, no 3, pp369–381

Johnson, A. W. (1975) 'Time Allocation in a Machiguenga Community', *Ethnology*, vol 14, no 3, pp301–310

Johnson, A. W. (1978) *Quantification in Cultural Anthropology. An Introduction to Research Design*. Stanford University Press, Stanford

Katz, C. (1986) 'Children and the Environment: Work, Play and Learning in Rural Sudan', *Children's Environments Quarterly*, vol 3, no 4, pp43–51

Katz, C. (1989) 'Herders, gatherers and foragers: The emerging botanies of children in rural Sudan', *Children's Environments Quarterly*, vol 6, no 1, pp46–53

Keil, F. C., Levin, D. T., Richman, B.A. and Gutheil, G. (1999) 'Mechanism and Explanation in the Development of Biological Thought: The Case of Disease', in D. Medin and S. Atran (eds) *Folkbiology*, MIT Press, Cambridge, MA, p285–320

Ki-fong Au, T. and Romo, L. F. (1999) 'Mechanical Causality in Children's "Folkbiology"', in D. Medin and S. Atran (eds) *Folkbiology*, MIT Press, Cambridge, MA, pp355–401

Kremen, C., Raymond, I. and Lance, K. (1998) 'An Interdisciplinary Tool for Monitoring Conservation Impacts in Madagascar', *Conservation Biology* 12, pp549–563

Kristensen, M. and Lykke, A. M. (2003) 'Informant-based valuation of use and conservation preferences of savanna trees in Burkina Faso', *Economic Botany* 57, pp203–217

Kvist, L. P., Andersen, M. K., Hesselsoe, M. and Vanclay, J. K. (1995) 'Estimating use-values and relative importance of Amazonian flood plain trees and forests to local inhabitants', *Commonwealth Forestry Review* 74, pp293–300

La Torre-Cuadros, M. A. and Islebe, G. A. (2003) 'Traditional ecological knowledge and use of vegetation in southeastern Mexico: A case study from Solferino, Quintana Roo', *Biodiversity and Conservation* 12, pp2455–2476

Lave, J. and Wenger, E. (1991) *Situated Learning: Legitimate peripheral participation*, Cambridge University Press, Cambridge

Lawrence, A., Phillips, O. L., Ismodes, A. R., López, M., Rose, S., Word, D. and Farfan, J. (2005) 'Local values for harvested forest plants in Madre de Dios, Peru: Towards a more contextualised interpretation of quantitative ethnobotanical data', *Biodiversity and Conservation* 14, pp45–79

Lee, R. A., Balick, M. J., Lee Ling, D., Sohl, F., Brosi, B. J. and Raynor, W. (2001) 'Cultural Dynamism and Change – An Example from the Federated States of Micronesia', *Economic Botany*, vol 55, no 1, pp9–13

Lizarralde, M. (2001) 'Biodiversity and loss of indigenous languages and knowledge in South America', in L. Maffi (ed) *On Biocultural Diversity: Linking Language, Knowledge, and the Environment*, Smithsonian Institution Press, pp265–281

Lizarralde, M. (2004) 'Indigenous Knowledge and Conservation of the Rain Forest: Ethnobotany of the Barí of Venezuela', in T. Carlson and L. Maffi (ed) 'Ethnobotany and Conservation of Biocultural Diversity', *Advances in Economic Botany* 15, pp113–131

Lozada, M., Ladio, A. and Weigandt, M. (2006) 'Cultural Transmission of Ethnobotanical Knowledge in a Rural Community of Northwestern Patagonia, Argentina', *Economic Botany*, vol 60, no 4, pp374–385

Luoga, E. J., Witkowski, E. T. F. and Balkwill, K. (2000) 'Differential utilization and ethnobotany of trees in Kitulanghalo Forest Reserve and surrounding communal lands, eastern Tanzania', *Economic Botany* 54, pp328–343

Lykke, A. M., Kristensen, M. K. and Ganaba, S. (2004) 'Valuation of local use and dynamics of 56 woody species in the Sahel', *Biodiversity and Conservation* 13, 1961–1990

Messer, E. (1975) 'Zapotec Plant Knowledge: Classification, Uses, and Communication about Plants in Mitla, Oaxaca, Mexico', PhD Dissertation, University of Michigan, Ann Arbor

Monteiro, J. M., de Albuquerque, U. P., de Freitas Lins-Neto, E. M., de Araújo, E. L. and de Amorim, E. L. C. (2006) 'Use patterns and knowledge of medicinal species among two rural communities in Brazil's semi-arid northeastern region', *Journal of Ethnopharmacology* 105, pp173–186

Montoya, A., Hernández, N., Mapes, C., Kong, A. and Estrada-Torres, A. (2008) 'The Collection and Sale of Wild Mushrooms in a Community of Tlaxcala, Mexico', *Economic Botany*, vol 62, no 3, pp413–424

Murphy, I. I. (1992) '"And I, in my turn, will pass it on": Indigenous education among the Kayapó Amerindians of central Brazil', PhD dissertation, University of Pittsburgh.

Nabhan, G. (1998) 'Passing on a Sense of Place and Traditional Ecological Knowledge between Generations: A Primer for Native American Museum Educators and Community-Based Cultural Education Projects', *People and Plants Handbook* 4, pp30–33

Nabhan, G. (2001) 'Cultural Perceptions of Ecological Interactions: An "Endangered People's" Contribution to the Conservation of Biological and Linguistic Diversity', in L. Maffi (ed) *On Biocultural Diversity: Linking Language, Knowledge, and the Environment*, Smithsonian Institution Press, Washington, DC, pp145–156.

Ohmagari, K. and Berkes, F. (1997) 'Transmission of Indigenous Knowledge and Bush Skills Among the Western James Bay Cree Women of Subarctic Canada', *Human Ecology*, vol 25, no 2, pp197–222

Pelto, P. J. and Pelto, G. H. (1975) 'Intra-cultural diversity: some theoretical issues', *American Ethnologist* 2, pp1–18

Pelto, P. J. and Pelto, G. H. (1978) *Anthropological Research. The Structure of Inquiry* (2nd edition) Cambridge University Press, Cambridge

Peters, C. M. (1996) 'Beyond Nomenclature and Use: A Review of Ecological Methods for Ethnobotanists', in M. N. Alexiades (ed) *Selected Guidelines for Ethnobotanical Research: A Field Manual*, Advances in Economic Botany, vol. 10. The New York Botanical Garden, New York, pp241–276

Pfeiffer, J. M. and Butz, R. J. (2005) 'Assessing Cultural and Ecological Variation in Ethnobiological Research: The Importance of Gender', *Journal of Ethnobiology*, vol 25, no 2, pp240–278

Phillips, O. (1996) 'Some Quantitative Methods for Analyzing Ethnobotanical Knowledge', in M. N. Alexiades (ed) *Selected Guidelines for Ethnobotanical Research: A Field Manual*, Advances in Economic Botany, vol 10, The New York Botanical Garden, New York, pp171–197

Phillips, O. and Gentry, A. H. (1993a) 'The Useful Plants of Tambopata, Peru: I. Statistical Hypothesis Tests with a New Quantitative Technique', *Economic Botany*, vol 47, no 1, pp15–32

Phillips, O. and Gentry, A. H. (1993b) 'The Useful Plants of Tambopata, Peru: II. Additional Hypothesis Testing in Quantitative Ethnobotany', *Economic Botany*, vol 47, no 1, pp33–43

Phillips, O., Gentry, A. H., Reynel, C., Wilkin, P. and Gálvez-Durand, C. (1994) 'Quantitative Ethnobotany and Amazonian Conservation', *Conservation Biology* 8, pp225–248

Pieroni, A. (2001) 'Evaluation of the cultural significance of wild food botanicals traditionally consumed in Northwestern Tuscany, Italy', *Journal of Ethnobiology*, vol 21, no 1, pp89–104

Pinedo-Vasquez, M., Zarin, D., Zipp, P. and Chota-Inuma, J. (1990) 'Use Values of Tree Species in a communal forest reserve in Northeast Peru', *Conservation Biology* 4, pp405–416

Prance, G., Baleé, W., Boom, B. and Carneiro, R. (1987) 'Quantitative Ethnobotany and the Case for Conservation in Amazonia', *Conservation Biology*, vol 1, no 4, pp296–310

Reyes-García, V., Vadez, V., Byron, E., Apaza, L., Leonard, W. R., Pérez, E. and Wilkie, D. (2005a) 'Market Economy and the Loss of Folk Knowledge of Plant Uses: Estimates from the Tsimane of the Bolivian Amazon', *Current Anthropology*, vol 46, no 4, pp651–656

Reyes-García, V., Vadez, V., Huanca, T., Leonard, W.R. and Wilkie, D. (2005b) 'Knowledge and consumption of wild plants: A comparative study in two Tsimane' villages in the Bolivian Amazon', *Ethnobotanical Research Applications* 3, pp201–207

Reyes-García, V., Vadez, V., Tanner, S., McDade, T., Huanca, T. and Leonard, W. R. (2006) Evaluating indices of traditional ecological knowledges: A methodological contribution, *Journal of Ethnobiology and Ethnomedicine* 2, p21

Reyes-García, V., Vadez, V., Huanca, T., Leonard, W. R. and McDade, T. (2007) 'Economic Development and Local Ecological Knowledge: A Deadlock? Quantitative Research from a Native Amazonian Society', *Human Ecology*, vol 35, no 3, pp371–377

Rocha Silva, A. J. and Cavalcante Andrade, L. H. (2006) 'Cultural Significance of Plants in Communities Located in the Coastal Forest Zone of the State of Pernambuco, Brazil', *Human Ecology*, vol 34, no 3, pp447–465

Romney, A. K., Weller, S. C. and Batchelder, W. H. (1986) 'Culture as Consensus: A Theory of Culture and Informant Accuracy', *American Anthropologist*, vol 88, no 2, pp313–318

Romney, A. K., Batchelder, W. H. and Weller, S. C. (1987) 'Recent Applications of Cultural Consensus Theory', *American Behavioral Scientist*, vol 31, no 2, pp163–177

Rosenberg, J. (1998) 'Documenting and Revitalizing Traditional Ecological Knowledge: Seri Survey', *People and Plants Handbook* 4, pp34–35

Ross, N. (2002) 'Cognitive aspects of intergenerational change: Mental models, cultural change, and environmental behavior among the Lacandon Maya of southern Mexico', *Human Organization* 61, pp125–138

Ross, N. and Medin, D. L. (2005) 'Ethnography and Experiments: Cultural Models and Expertise Effects Elicited with Experimental Research Techniques', *Field Methods*, vol 17, no 2

Rossato, S. C., Leitão-Filho, H. D. F. and Begossi, A. (1999) 'Ethnobotany of Caiçaras of the Atlantic forest coast (Brazil)', *Economic Botany* 53, pp387–395

Ruddle, K. and Chesterfield, R. (1977) *Education for Traditional Food Procurement in the Orinoco Delta*, Ibero-Americana 53, University of California Press, Berkeley

Samils, N., Olivera, A., Danell, E., Alexander, S. J., Fischer, C. and Colinas, C. (2008) 'The Socioeconomic Impact of Truffle Cultivation in Rural Spain', *Economic Botany*, vol 62, no 3, pp331–342

Shanley, P. and Rosa, N. A. (2004) 'Eroding knowledge: An ethnobotanical inventory in Eastern Amazonia's logging frontier', *Economic Botany* 58, pp135–160

Silva, V. A., Cavalcante Andrade L. H. and Albuquerque, U. P. (2006) 'Revising the Cultural Significance Index: The Case of the Fulni-ô in Northeastern Brazil', *Field Methods*, vol 18, no 1, pp98–108

Sternberg, R. J., Nokes, C., P. Wenzel Geissler, Prince, R., Okatcha, F., Bundy, D .A. and Grigorenko, E. L. (2001) 'The relationship between academic and practical intelligence: a case study in Kenya', *Intelligence* 29, pp401–418

Stoffle, R. W., Halmo, D. B., Evans, M. J. and Olmsted, J. E. (1990) 'Calculating the Cultural Significance of American Indian Plants: Paiute and Shoshone Ethnobotany at Yucca Mountain, Nevada', *American Anthropologist* 92, pp416–432

Stross, B. (1973) 'Acquisition of Botanical Terminology by Tzeltal Children', in M. S. Edmonson (ed) *Meaning in Mayan Languages*, Mouton, The Hague, pp107–141

Svanberg, I. (2009) 'Plant Knowledge as Indicator of Historical Cultural Contacts', in A. Pieroni and I. Vendebroek (eds) *Traveling Cultures and Plants: The Ethnobiology and Ethnopharmacy of Human Migrations*, Studies in Environmental Anthropology and Ethnobiology, vol 7 (paperback edition) Berghahn Books, New York, pp227–244

Tardío, J. and Pardo-de-Santayana, M. (2008) 'Cultural Importance Indices: A Comparative Analysis Based on the Useful Wild Plants of Southern Cantabria (Northern Spain)', *Economic Botany*, vol 62, no 1, pp24–39

Toledo, V. M., Batis, A. I., Bacerra, R., Martinez, E. and Ramos, C. (1995) 'La selva util: etnobotánica cuantitativa de los grupos indígenas del trópico húmedo de México', *Interciencia* 20, pp177–187

Trotter, R. T. and Logan, M. H. (1986) 'Informant Consensus: A New Approach for Identifying Potentially Effective Medicinal Plants', in N. L. Etkin (ed) *Plants in Indigenous Medicine & Diet: Biobehavioral Aproaches*, Redgrave Publishing Co., New York, pp91–112

Turner, N. J. (1988) '"The Importance of a Rose": Evaluating the Cultural Significance of Plants in Thompson and Lillooet Interior Salish', *American Anthropologist* 90, pp272–290

Van Etten, J. (2006) 'Changes in farmers' knowledge of maize diversity in highland Guatemala, 1927/37–2004', *Journal of Ethnobiology and Ethnomedicine* 2 (29)

Varghese, E., Jain, S. K., and Bose, N. (1993) 'A quantitative approach to establish efficacy of herbal remedies: A case study on the Carias', *Ethnobotany* 5, pp149–154

Voeks, R. A. and Leony, A. (2004) 'Forgetting the Forest: Assessing Medicinal Plant Erosion in Eastern Brazil', *Economic Botany* 58 (Supplement) S294–S306

Wester, L. and Yongvanit, S. (1995) 'Biological diversity and community lore in northeastern Thailand', *Journal of Ethnobiology* 15, pp71–87

Wilbert, W. (2002) 'The Transfer of Phytomedical Knowledge among the Warao', in J. R. Stepp, F. S. Wyndham and R. K. Zarger (eds) *Ethnobiology and Biocultural Diversity: Proceedings of the*

Seventh International Congress of Ethnobiology, International Society of Ethnobiology, University of Georgia Press, Athens, GA, pp336–350

Winkler, D. (2008) 'Yartsa Gunba (*Cordyceps sinensis*) and the Fungal Commodification of Tibet's Rural Economy', *Economic Botany*, vol 62, no 3, pp291–305

Yang, X., He, J., Li, C., Ma, J., Yang, Y. and Xu, J. (2008) 'Matsuke Trade in Yunnan Province, China: An Overview', *Economic Botany*, vol 62, no 3, pp269–277

Zarger, R. (2002) 'Acquisition and Transmission of Subsistence Knowledge by Q'eqchi' Maya in Belize', in J. R. Stepp, F. S. Wyndham and R. K. Zarger (eds) *Ethnobiology and Biocultural Diversity: Proceedings of the Seventh International Congress of Ethnobiology*, University of Georgia Press, Athens, GA, pp593–603

Zarger, R. K. and Stepp, J. R. (2004) 'Persistence of botanical knowledge among Tzeltal Maya children', *Current Anthropology*, vol 45, no 3, pp413–418

Zent, S. (1996) 'Behavioral Orientations toward Ethnobotanical Quantification', in M. N. Alexiades (ed) *Selected Guidelines for Ethnobotanical Research: A Field Manual*, Advances in Economic Botany, vol 10. The New York Botanical Garden, New York, pp199–239

Zent, S. (1999) 'The Quandary of Conserving Ethnobotanical Knowledge: A Piaroa Example', in T. Gragson and B. Blount (eds) *Ethnoecology: Knowledge, Resources, Rights*, University of Georgia Press, Athens, GA, pp90–124

Zent, S. (2001) 'Acculturation and Ethnobotanical Knowledge Loss among the Piaroa of Venezuela: Demonstration of a Quantitative Method for the Empirical Study of TEK Change', in L. Maffi (ed) *On Biocultural Diversity: Linking Language, Knowledge, and the Environment*, Smithsonian Institution Press, Washington, DC, pp190–211

Zent, S. (2009) *Final Report on Indicator No. 2: Methodology for Developing a Vitality Index of Traditional Environmental Knowledge (VITEK) for the Project 'Global Indicators of the Status and Trends of Linguistic Diversity and Traditional Knowledge'*, www.terralingua.org/projects/vitek/ch5.htm

Zent, S. and Zent, E. L. (2000) 'Inferring Processes of Ethnobotanical Knowledge Acquisition from Patterns of Knowledge Acquisition', Paper presented at the VII International Congress of Ethnobiology, Athens, GA, 23–27 October 2000

Zent, S. and Zent, E. L. (2004) 'Ethnobotanical Convergence, Divergence, and Change Among the Hoti', in T. Carlson and L. Maffi (ed) *Ethnobotany and Conservation of Biocultural Diversity*, Advances in Economic Botany, vol 15, The New York Botanical Garden, New York, pp37–78