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Contents

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6

Local communities and natural resources: ethnobiology in practice

LAURA ZANOTTI, DENISE M. GLOVER, AND JENNIFER SEPEZ

INTRODUCTION

This chapter focuses on methods specific to the field of ethnobiology. Literally, ethnobiology is the study of the logic of life (the *logos* of *bios*) among a group of people (*ethnos*) (Glover 2005: 24). Ethnobiologists examine the knowledge systems that social and cultural communities have developed to explain the natural world. Ethnobiology is also a multidisciplinary field, which means that ethnobiologists use a variety of interdisciplinary methodologies and theories. Ethnobiologists often occupy multiple roles as social and natural scientists. Finally, ethnobiology is at the same time a positivist and interpretative field of inquiry. Scholars conducting ethnobiological research employ a wide range of quantitative and qualitative techniques.

The history of the field has been split into several phases to account for the different schools of thought that have dominated ethnobiology over the years (Ellen 2006; Nazarea 2006; Hunn 2007). The initial phase was a period where researchers were conducting "salvage" ethnobiology in an attempt to document local biological knowledge of economically and medically useful plant species (Ellen 2006: S2; Hunn 2007). Phase two began in the 1950s but peaked in the 1960s and 1970s with the rise of cognitive anthropology. Inspired by linguistic studies of the Prague School (circa 1920s), cognitive anthropologists sought to document and classify folk biological knowledge in order to understand how different cultural groups conceptualize their environment (Nazarea 2006). In this strand, ethnoscientists were

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primarily concerned with methodologies that could be utilized to elicit local categories while at the same time searching for non-local, cross-cultural grids with which to compare cultural groups. From a theoretical perspective, much of the work generated from this phase focused on demonstrating why it is "notable that nonliterates know so much about nature" (Berlin 1992: 5). Conklin's agroecological study (1954) of the Hanunóo (Philippines), and Hunn's (1977) and Berlin, Breedlove, and Raven's (1974) on Tzeltal Maya classification are all exemplary of this period.

In the late 1970s and 1980s ethnobiologists expanded the previous focus on economic botany and taxonomic research to incorporate traditional ecological knowledge and local research management practices (Alcorn 1990; Denevan 1992; Nazarea 2006). An interest in indigenous knowledge and management was a reaction to the delocalizing impacts of modernization (Appadurai 1996) and state-making policies (Dove 2006: 195). Ethnobiologists discussed the complexity of local classification systems, observing that gender, ethnicity, kinship, and other notions of hierarchy play a role in the acquisition and transmission of ethnobiological knowledge (Ellen 2006). Ethnobiological research has also moved toward more process-oriented approaches. For instance, ethnobiologists "now study the processes of cultivation and domestication; the management of useful plant and animal populations; the process of traditional knowledge acquisition and organization" and so on (Salick *et al.* 2003: 2). Furthermore, an applied, activist approach to ethnobiology brought ethnobiology research to the forefront of international discussions about indigenous rights, intellectual property rights, and community-conservation issues.

Since its early phases, ethnobiology has flourished and expanded. Ethnobiology currently encompasses many different strands of research ranging from its classic taxonomic focus to more interpretative approaches. This chapter details the methods that ethnobiologists have developed to examine ethnobiology in contemporary societies and their associated place-based environmental knowledge. The theoretical shifts in ethnobiological research have corresponded with methodological expansion. This chapter outlines some of the classic methodologies used by ethnobiologists since its nascent years as well as some more recent developments, including participatory strategies. The goal of the chapter is to give researchers an overview of the many methods ethnobiologists employ, and how to discern which method is appropriate for which research design. The methods are discussed more or less in the historical order in which they were developed.

METHODS

Collection of voucher specimens

Identification of flora and fauna and the preservation of specimens are important in ethnobiological studies to document and establish reference points. Such documentation makes scientific revisions and redefinitions possible, and generally acts to provide a permanent and material archive that can be accessed in future work (Bye 1986: v). For these purposes, the collection and construction of voucher specimens is necessary. Proper processing of specimens entails advanced planning and preparation, including careful selection of collection sites, appropriate handling and processing of specimens, and having proper permits to collect and transport materials (Martin 2004: 28–65). When obtaining specimens, a field notebook is essential allowing data-gathering information to be recorded, such as location coordinates, description of local habitat, description of organism, cultural uses if known, conditions under which collection took place (e.g., season), and other related information. Bye (1986) stresses that diagnostic features of identification (such as inflorescence in plants) must be included in any sample; if they are not present at the initial time of collection then an additional collection should be made when these characteristics are present. In addition to field collection data, biological identification, notation of local name(s), and collector's name and cataloguing number should be included with each specimen (Bye 1986; Martin 2004). Proper processing is essential so as to preserve the biological materials; see Martin (2004: 28–65) for a thorough description of these for botanical materials. Specimens should be deposited in appropriate institutions both within the country of research and in the researcher's country of residence (if different); these institutions usually handle the mounting or further preservation of materials according to standard protocols. If you are working in an international setting, you will need to coordinate with researchers (and preferably a reputable institution) about how to obtain the proper permits for collection and/or transfer of specimens between countries.

Flora and fauna identification and classification

Species identification establishes a point of reference and must be included with a voucher specimen. Generally ethnobiologists rely on Linnaean classification, since this is a *lingua franca* of the scientific community worldwide that also allows for cross-cultural comparisons.

Determination of such identity will usually need to be made by a trained biologist; this can be done on-site with a local biologist or through transporting specimens to taxonomic specialists. In addition, local systems of identification are often of particular interest to ethnobiologists, in large part because of what they can reveal about local conceptualizations of the natural world.

One of the more difficult aspects of identification can be making sense of the variety of terms used within a local community among informants (and between adjacent communities). In some cases, linguistic analysis is necessary to determine whether terms are mere phonological variations, linguistic borrowings, or related cognates (sharing linguistic heritage). If you are not trained in the skills needed to make these distinctions, you can enlist the expertise of a linguist. In any case, it is important to either work with specimens (live, dried, or stuffed) or photographs when inquiring about the correspondence between an actual organism and the name(s) for it, since assumptions of identification can be wrong without an objective reference point.

In some instances, the ethnotaxonomy of a sociolinguistic group may not be in line with taxonomic distinctions recognized in Western science. When there are more distinctions recognized in some part of an ethnotaxonomy than that in Western taxonomy, the term over-differentiation is used to describe the contrast; under-differentiation is used to describe the reverse situation (Berlin 1973: 267–8; Berlin 1992). Generally speaking, over-differentiation tends to occur among organisms that are culturally significant for utilitarian or cognitive reasons (although *size* may increase cultural salience among *faunal* taxa – see Hunn 1999). Berlin notes that there is particularly striking agreement (as high as 60 percent) in the taxonomies of folk systems and those recognized in Western science, especially at the level of folk generic (see Berlin 1992).

Largely, however, ethnobiological studies that focus on classification do rely on a variety of lexical elicitation methods (and analysis of the lexical data gathered). One useful method employed to elicit classificatory schema is the frames and slots approach, adopted from structural linguistics. This approach is based on the idea that "one can get at the meaning of items through the way items are distributed in different [linguistic] environments [or frames]" (D'Andrade 1995: 59). The "frame" generally constitutes a nearly complete phrase with a "slot" omitted that the respondent needs to fill in to make the phrase true. Hence in the construction "_____ is a kind of vegetable," the slot can be filled in by any number of items (broccoli, bean, etc.) to

make the phrase/sentence culturally true. One can use this technique to generate a list of items in a cultural domain and examine the taxonomical relationship of set inclusion. Metzger and Williams (1966) pioneered an extension of this technique now known as free listing (described below), where the researcher simply asks "What kinds of vegetables are there?" or uses a similarly direct line of questioning to elicit a list of terms.

Cultural consensus analysis

In the 1980s cognitive anthropologists developed cultural consensus analysis to determine shared cultural beliefs and analyze amount of shared knowledge among informants (Romney and Weller 1984; Romney, Weller, and Batchelder 1986; Romney, Batchelder, and Weller 1987; Reyes-García *et al.* 2004; Weller 2007: 339). Romney, Weller, Batchelder, and other associates developed cultural consensus theory (CCT), cultural consensus models (CCM), and other aggregative analysis methods that anthropologists and other scholars use today (Romney and Weller 1984; Romney 1999; Reyes-García *et al.* 2004). Cultural consensus analysis is particular useful in ethnographic contexts since it "estimate[s] the culturally correct answers and the cultural knowledge or accuracy of informants" (Weller 2007: 340). This allows the researcher to aggregate the "culturally best" responses, estimate the culturally correct answers, and establish the amount of cultural competence an individual has in a certain domain or topic (Dressler *et al.* 2005: 335; Weller 2007). Cultural consensus analysis is an excellent method to ascertain shared cultural beliefs and determine informant reliability in a cultural domain or topic, and is used in ethnobiological research.

Cultural consensus analysis operates best with systematic data collection methods, such as open-ended questionnaires with a short or single response, dichotomous questions, multiple choice questions, and fill in the bank questions (see Bernard 2002: 280–97; Miller *et al.* 2004; Reyes-García *et al.* 2004; Weller 2007). Cultural consensus analysis has a formal and informal method for analyzing data (see Weller 2007: 343–348). The informal methods uses reliability analysis and the formal model relies on a mathematical model found only in ANTHROPAC and UCINET software. Cultural consensus models are "a family of formally derived mathematical models that simultaneously provide an estimate of the cultural competence or knowledge of each informant and an estimate of the correct answer to each question asked" (Romney *et al.* 1996: 4701).

In the formal and informal method, the researcher should collect the information on an individual basis (not in focus groups) so that responses from one individual are independent of those from other interviewees (Weller 2007: 341). In addition, the questions should cover just one topic or domain at a time (Weller 2007: 341). The analysis does not work unless there is a high degree of agreement in the responses so that a consultant's competence can be tested against the "consensus" (Weller 2007: 341). As such, during data collection it is best to sample at least thirty individuals for reliable results, although there are always exceptions to the rule (Weller 2007: 355).

Cultural consensus analysis can be applied to any type of question that deals with the relationships among plants, animals, and people. For often cited examples of cultural consensus analysis, see Boster's (1986) study of manioc varieties, Miller *et al.*'s (2004) analysis of yellow fin tuna fisheries, Reyes-García *et al.*'s (2004, 2005) work with Tsminane plant knowledge, Atran *et al.*'s (1999) examination of plant classification, Garro's (1986) work on folk medicine in Mexico and Romney *et al.*'s many other publications. Also, refer to Weller (2007) for an excellent overview of cultural consensus and frequently asked questions associated with working with cultural consensus theories and models.

Ethnosemantics

Ethnosemantics is the study of categories of meaning within a cultural group with a focus on lexical contrasts, particularly in systems of classification. This type of examination got its start in anthropological kinship studies (and linguistics before that) but quickly spread to other areas of ethnoscientific inquiry. The key in ethnosemantics is to identify a cultural domain, to elicit terms of identification and classification from within that domain, and then to discover the distinguishing features of each term. Terms are elicited using free listing as well as through careful observation of conversation and social interactions. Besides qualitative inquiry, where a researcher can inquire directly what the various features of categories are (by asking what the difference between an aunt and an uncle is, for example), a number of more quantitative methods can be utilized. These techniques include pile sorts and triads, which are explained below, followed by analytical tools such as multi-dimensional scaling (MDS), PROFIT analysis, QAP (matrix correlation analysis), and cluster analysis. The following subsections detail additional data collection methods that are common for ethnosemantics.

Free listing

As highlighted previously, a focus on eliciting explicit cultural information via lexicon is central to many of the methods employed in ethnobiological work. Free listing is a technique in which an informant is asked to freely list (that is, no specific order of listing is requested) terms for a cultural domain. The format of elicitation is along the lines of "Tell me [list] all the names of _____" where a particular domain is identified.[1] Lists can be elicited either orally or in written form, depending on circumstances and time constraints. Generally speaking, if one is trying to arrive at an understanding of larger cultural tendencies, it is wise to get as broad a sampling as possible and therefore elicit as many free lists as one can. The technique of successive free listing is a way of further fleshing out connections between items, informants, and related cultural domains not targeted in the initial free-listing tasks (Ryan, Nolan, and Yoder 2000). For example, after asking a respondent to list all the names of locally occurring medicinal plants, one could then ask for the uses, parts used, preparation, and healing properties of each plant listed.

After acquiring the lists, statistical techniques can be used to analyze the cultural consensus that exists between informants (Weller and Romney 1988) as well as salience levels for items listed (Smith 1993); such levels of salience calculate the rank order of items listed (those listed first have a higher ranking of salience, being the ones remembered first by informants) as well as how often items appear on informants' lists.

Potential drawbacks with free listing include a focus on lexical items where substantive information may be overlooked (see Ellen 1999). Relatedly, Quinlan (2005) remarks that other methods of extended interviewing may in fact yield more detailed and fuller inventories than those obtained through free listing. The fact that free lists can be quantified is helpful, although the statistical reliability of free lists is dubious (Weller and Romney 1988). Furthermore, Miranda *et al.* (2007) argue that visual stimuli present during the course of free listing can have an influence on the inventory of items obtained.

[1] Note that free listing technically does not entail constraining the respondent's time frame, although sometimes such a limit is used (responses are restricted to 3–4 minutes long, for example). In these cases, the term used to describe this technique is a restricted list task (Sutrop 2001: 264).

Pile sorts and triads

Pile sorting and triad comparisons are techniques that have had much longevity within ethnoscience and cognitive anthropology. Although quite different in execution, there is an underlying similarity between these techniques in the shared goal of assessing categorical or semantic relations between items within a cultural domain. With both procedures, items can be previously obtained either through free listing tasks or through other informed decisions made by ethnographer and/or informant. Similar statistical analyses are used for both techniques, such as MDS where relations between items are projected into Euclidian space. In order to be able to effectively process data obtained through pile sorting and triads, statistical software is usually necessary. ANTHROPAC and UCINET, developed by Steve Borgatti and produced by Analytic Technologies, are the software packages most widely used by ethnobiologists (see www.analytictech.com for further information on these products).

Pile Sorting

In pile sorting, the basic idea is to ask respondents to organize a set of items (actual specimens, photos of specimens, or names written down) into piles based on whatever criteria the respondent feels is relevant but so that the items in each pile "belong together." In a constrained form of pile sorting, the researcher would request that a particular number of piles be made. In an unrestricted task, the respondent can make as many or as few (although there needs to be more than one) piles as he/she wishes. A number of variations are possible in the basic pile sorting task, including allowing items to be sorted into more than one pile (this requires having "copies" of items available), and conducting successive piles sorts. The ethnographer can record the information (which items were sorted into which piles – and even when in the sorting process) and subsequently use MDS or other techniques to identify aspects that seem to be significant in the cognitive orientation of the respondent. The ethnographer also usually asks the respondent to explain why he/she made the piles as such (generally after all sorting tasks have been completed), so there is overt and direct discussion about the piles between the ethnographer and respondent.

Weller and Romney (1988) note that there can be significant differences between what are known as "single sort" and "multiple sort" tasks. With a single sort task, the respondent sorts only once,

while with multiple sorting the respondent sorts and re-sorts as many times as desired, using a different criterion each time. In addition, successive pile sorts can be used to elicit taxonomies. In this procedure, respondents are asked to first make piles and then to either combine or split the piles (or both – but not at the same time) for as many times as is appropriate. The aim of this approach is to generate a taxonomic tree that shows the relations of set inclusion between groupings of items.

The advantages of pile sorting include being able to process many items simultaneously (over 100 items at once), the relative ease at which the task is understood, and the ability to use with non-literate subjects. Disadvantages include the difficulty of comparing across respondents, and the need for 20–30 respondents (unless you use an extensive number of items, in which case fewer respondents is fine). Finally, in successive pile sorts there may be an imposition of a taxonomic hierarchy that is not appropriate for the items being considered (although see Berlin 1992).

Triads

In the comparative/contrastive technique known as triads, items are presented to respondents in groups of three, with a request given either to choose the one that is the "most different" or to order the items from having the most to the least amount of a particular characteristic. Generally a number of iterations are randomly generated (most expediently with the use of a computer) to compare a list of items ($N < 12$) in sets of three. The basic idea of this technique is that one can identify salient aspects in making similarity judgments between the given items, especially after submitting the data to tools of analysis; by running the results through MDS, for example, one can discover which items cluster together into groups and how "cognitively distant or close" items may be.

Triads are most useful when dealing with small numbers of items and with few informants. The more items one has, the more triads will be generated. For example, a list of 21 items would produce 1330 triads (Weller and Romney 1988). One way to use more than 10–12 items and reduce the number of triads is to utilize a balanced, incomplete block (BIB) design (Weller and Romney 1988; Ross, Barrientos, and Esquit-Choy 2005). This type of design eliminates the number of times *pairs* of items are presented in triadic comparisons and significantly reduces the overall number of triads that informants have to compare. If adopting a BIB design, one may need to increase the number of informants in order to stabilize the results.

Generally speaking, triads are easy to explain and to administer. Additionally, one can use either an oral or a written format. The drawbacks include not being able to compare long lists of items, boring respondents with a repetitive task, and the possibility of missing or incomplete data (respondents not marking any item in a set of three as being different). This last point may be mitigated by allowing for a "no judgment" option (cited in Ross, Barrientos, and Esquit-Choy 2005), but too many of such choices may have an adverse effect on the overall results of comparison (see Case Studies).

Situated knowledge: interviews, surveys, and questionnaires

Several different types of qualitative and quantitative interview techniques exist to situate traditional and local environmental knowledge within the sociocultural context. These range from structured to more unstructured data collection methods. This section, therefore, offers a brief overview of the techniques that an ethnobiologist might consider.

Interviews are divided into three categories: unstructured, semi-structured, and structured. Unstructured interviews can take place anywhere and are unscheduled, open-ended interviews where the researcher engages in informal conversation with the interviewee (Bernard 2002: 204). These types of interviews are useful at the beginning of a project in order to gain rapport, build friendships, and learn about the complexities of community life (Johnson 1992; Bernard 2002: 206). Informal interviews are also valid as a primary method to explore human–environment relationships, natural resource management techniques, and other topics of interest to ethnobiologists.

On the other hand, semi-structured interviews have "much of the freewheeling quality of unstructured interviewing and requires the same skills" but are based on an "interview guide" (Bernard 2002: 205). For example, Hunn *et al.* (2003) used informal, guided interviews to discuss gull egg harvests with the Huna Tlingit to document local harvest techniques and knowledge about gull populations in Glacier Bay National Park and Reserve, Alaska. The project members "encouraged interviewees to elaborate on their experiences, perspectives, and opinions" (Hunn *et al.* 2003: S85). The result was a rich

dataset from 43 community members, which was used to help with sustainable resource management in Glacier Bay National Park and Reserve.

Structured interviews utilize a standardized list of questions that "control the input that triggers people's responses so that their output can be reliably compared" (Bernard 2002: 240). Structured interviews include survey instruments, such as questionnaires. These methods are best when the researcher has "clear and circumscribed" objectives (Johannes, Freeman, and Hamilton 2000: 266). Structured interviews contain open-ended questions, forced-choice (fixed response) questions, a combination of the two types of questions, or multiple types of one or the other (Bernard 2002: 254). Forced-choice questionnaires are extremely common in cultural consensus analysis. For example, Reyes-García *et al.* (2004) used three different types of forced-choice questionnaires accompanied by an initial free listing exercise to test adult Tsminane ethnobotanical knowledge. In the multiple choice component of their questionnaire, Reyes-García *et al.* (2004: 140) generated a list of plants and asked each Tsminane consultant about each one in a multiple-choice format: "For example, we asked, 'Can you tell me if X [name of plant] can be used as firewood?'(yes/no), 'to build a house?' (yes/no), 'to eat?' (yes/no), 'to cure?' (yes/no), 'to make a canoe?' (yes/no), and 'to make a tool?' (yes/no)." The researcher should pay close attention to word choice and what type of questionnaire is most appropriate for the subject in order to reduce response error (Bernard 2002: 256). See Bernard (2002: 256–265) and Fowler (2002) for excellent discussions on writing questionnaires.

Each unstructured and structured method has benefits and drawbacks. For instance, Ferguson and Messier (1997) drafted and then used a questionnaire in their preliminary research with a Baffin Island Inuit community. The researchers were documenting indigenous knowledge about caribou populations and initially thought that a questionnaire would be the best interview technique. However, the questionnaire was abandoned "in favor of a standard, yet flexible interview protocol" (Ferguson and Messier 1997: 18) after pre-testing revealed it was an inadequate survey tool. On the other hand, questionnaires are imperative for cultural consensus analysis and gathering specific types of standardized quantitative ethnobiological data that can not otherwise be collected. Many researchers chose to employ both structured and unstructured methods to improve informant reliability, sampling techniques, and the quality of the dataset.

Photo elicitation and interpretation

One very specific form of interviewing is photo elicitation. Harper (2002: 14) defines photo elicitation as, "the simple idea of inserting a photograph into a research interview." The premise of this research method is that visual images (e.g., photos, drawings, graphics, etc.) elicit different types of memories, sensations and information than verbal ones (Whyte 1984; Johnson and Griffith 1998; Harper 2002: 14; Stewart, Liebert, and Larkin 2004). Photo elicitation arguably reduces fatigue in longer, non-photo based interviews and often evokes more substantive and comprehensive material from the informant (Collier 1967; Collier and Collier 1986; Ziller 1990: 36). This method is common in visual sociology, leisure studies, cognitive psychology, and cognitive anthropology (Taylor *et al.* 1995; Banks 2001; Stewart, Liebert, and Larkin 2004). Photo elicitation is also a method used for analyzing human–environmental relationships in visual mediums, and can also be employed in consensus analysis for communities that are illiterate or have low literacy levels (Johnson and Griffith 1998: 215; Atran *et al.* 2002: 428).

Photo elicitation techniques offer ethnobiologists a "bridge between worlds that are more culturally distinct" (Harper 2002: 21). This method: (1) helps to identify local classifications of the biophysical environment; (2) determines different attitudes and values about the landscape; and (3) elicits stories about the landscape. The first step to photo elicitation is to determine what photos to use that best suit the research objective. The researcher can bring photos from the research site, historical photos, aerial photos, photos of scanned biotic material, or other types of graphic materials depending on the research task at hand. For example, Aswani and Lauer (2006: 267) used aerial photo interpretation as one method to identify the local "hierarchical cognition of the seascape" in the Solomon Islands.

Alternatively, researchers can also distribute cameras and ask community members to record their own experiences of a specific task or event and bring these photos to the interview, or ask the interviewee to bring photos that they might already have on hand. The same technique applies to videos (Worth and Adair 1972). This approach to photo elicitation can empower the consultant since they are providing the content for the interview (Clark-Ibáñez 2004: 1512). Once the photos are displayed, an "interview guide approach" (Stewart, Liebert, and Larkin 2004: 319) helps lead the interviewees through the photo-elicitation process. Photo elicitation functions best

when combined with other methodologies that have a longer-standing history in ethnobiological studies.

Participatory mapping and plant trails

Participatory mapping is a method where a researcher actively collaborates with a local community to map different parts of the community's landscape (Brody 1981; Feld and Basso 1996). This method is an effective tool for: (1) analyzing community based resource management practices; (2) documenting key features, ecotypes, and subsistence areas within and surrounding a community; (3) documenting cultural sites (Chapin and Threlkeld 2001); (4) attributing stories, names, emotions and memories to contemporary, historical, and ancestral locations; (5) documenting political claims to land rights; and (6) "reaffirming historical and cultural links" (Smith *et al.* 2003: 357). This method is particularly useful to analyze how a community perceives, thinks about, and interacts within a landscape. In addition, mapping biographies are special types of interviews that solicit information on plants used and known within living memory of community members (Freeman 1976; Berkes *et al.* 1995). The researcher can employ this type of interviewing technique before, during or after the participatory mapping exercises.

Participation can take many forms in participatory mapping. For instance, a community may determine the context and content of research, guiding researchers to collect information according to the community's needs (Herlihy and Knapp 2003: 303). This is a common practice when a community is interested in mapping their lands for legal reasons, but also applies in other cases as well (Chapin, Lamb, and Threlkeld 2005). The researcher and community might jointly select community members as field assistants and train them in specific mapping techniques (Smith 2003: 334). On the other hand, individuals within the community might volunteer as consultants for the proposed project. In each case, the researcher should consult with the local community to determine the extent to which the community wishes to participate.

Several different mapping techniques exist to "transform cognitive spatial knowledge into map and descriptive forms" (Herlihy and Knapp 2003: 303). These techniques range from the simple to the highly technical. Hand-drawn or sketch mapping is a simple activity that the researcher can use to elicit knowledge or generate cognitive

maps to uncover what features and areas are salient to the community (e.g., see Brody 1981; D'Antona, Cak, and Vanwey 2008). This technique is often the first step to identify what other mapping procedures to use, but also can stand on its own as a method (Chapin and Threlkeld 2001: 9). Remotely sensed data, such as aerial photography and satellite sensor imagery are other mapping options (Aplin 2003: 295). Aerial photographs taken from different time periods, if available and accessible, can elicit stories about changes in the landscape. Satellite images, digital terrain maps, 3-D maps and GIS technologies are newer forms of spatial analysis but some of the most prevalent in participatory mapping techniques (Chapin, Lamb, and Threlkeld 2005; Fox *et al.* 2008; Rhoades and Nazarea 2009). In this scenario, researchers and consultants use hand-held GPS devices to mark key features and points of interest to create participatory community maps of the designated area.

Finally, plant trails are a mapping method where a researcher marks specific plants on a predetermined route in the village. This marked trail is a representative sample of plants in the village and serves to measure an individual's ethnobiological knowledge (Stross 1970; Zarger and Stepp 2004; Wyndham 2004; Voeks 2007; Hunn 2008). On the trail, the researcher is careful to intentionally mark plants that have "cultural significance and abundance" (Zarger and Stepp 2004: 415) to the community, however, the composition and emphasis of the plant trail can vary depending on the research question at hand (e.g., Voeks 2007: 9). A number of consultants are asked to identify the marked plants on the trail and, often, to discuss other knowledge associated with the identified plants (Zarger and Stepp 2004). For another application of the plant trail methodology please refer to the vast literature on household garden surveys and suite of associated methodologies (Stoler 1975; Boster 1986; Vogl, Vogl-Lukasser, and Purl 2004)

In all cases, maps can be dangerous and contain within them sensitive cultural information so make sure to take into consideration the implications of the work (Fox *et al.* 2008: 204).

ETHNOBIOLOGY IN PRACTICE: THREE CASE STUDIES

This section presents three case studies where in each instance the researchers decided to implement one or more aspects of ethnobiological research in their project design.

Medicinal plant classifications and Tibetan doctors

Glover's focus on classification and ethnosemantics (2005) highlights the way in which a variety of classificatory schema were utilized, for varying purposes, by doctors of Tibetan medicine in Rgyalthang, Yunnan Province, PRC. Some of these schema have important textual precedent, which led Glover to investigate the relationships between categories of *materia medica* in various medical texts and in relation to the larger system of Tibetan medicine (Glover 2005; Glover forthcoming). Glover used a variety of interview techniques (open-ended, semi-structured and structured) as well as free listing and pile sorting tasks (with some modifications). Semi-structured interviews often focused on explanation of a particular topic of relevance – how names and characteristics of medicinal plants are learned throughout the course of a doctor's education, for example. Structured interviews with pre-determined list of questions could be especially helpful when time constraints were an issue.

Restraints were put on the free listing tasks, where Glover asked five area doctors to list the top 30 most useful or most important plants in their practice. She next utilized photographs to confirm with each doctor the identity of all names given in each list. Glover then chose the plants that occurred in all lists ($N = 19$) and asked respondents to sort these plant names, written in Tibetan on pieces of paper, together in whatever manner they thought the plants should be grouped. Glover explained that more than one pile was needed, names could be sorted into multiple piles and provided blank slips of paper for the purpose of copying names if needed. One doctor performed successive pile sorts, while the others did not. While statistically too small a sample size for consensus analysis, patterns did emerge from the pile sorts that were easily discernable. There was some variation of placement within each pile and some of the piles highlighted different aspects of categorization. The most common type of pile was one that grouped plants according to the disorder(s) that they treat. Free listing and pile sorting did not appear to be an arduous or troublesome task for the doctors, although it did seem a bit strange at first. The abstraction of using chits of paper (rather than actual specimens) may have in fact been the oddest part of the task, but did not seem especially problematic.

Finally, Glover deposited voucher specimens from her fieldwork at the Kunming Institute of Botany in China, the University of Washington, and the Missouri Botanical Garden.

Makah, ethnobiology, and present-day subsistence practices

The Makah Tribe is a Northwest Native American group on the Makah reservation in Neah Bay, Washington State. The Makah tribe has a long tradition of subsisting on the local terrestrial and marine resources, and community members have strong place-attachments to the ecoscape around Neah Bay (Sepez 2001: 1). From 1997 to 1999 Sepez (2001) conducted an analysis of the present-day subsistence practice of the Makah, focusing on the impact political histories have had on Makah foraging strategies, traditional environmental knowledge associated with these practices, and the sociocultural and economic valuation attributed to the subsistence complex. Sepez decided to constrain her research to the subsistence practices of hunting, fishing, and shellfish collecting and document local ethnobiological knowledge associated with harvesting animal resources. She combined more customary qualitative ethnographic methods with statistical analysis of a random sample survey administered to 15 percent of the households.

In this instance, qualitative methods and quantitative methods complemented one another to cross-check data and generated a portrait of hunting, fishing, and shellfish collecting practices. Participant observation afforded Sepez (2001: 35) the opportunity, for example, to "participate in and observe river and ocean fishing, clam digging and other shellfish gathering ... and my favorite activity of all, octopus hunting" along with other subsistence activities. Coinciding with these observations and events, Sepez also collected statistical data on subsistence harvesting. The survey, a structured interview technique, was initially tested and then approved by the Makah Cultural and Research Center. The survey included questions about household composition, subsistence harvests for specific animal resources, resource-sharing practices, and other questions associated with local natural resource management and use.

At the time of research, 99 percent of households surveyed participated in subsistence activities, indicating the continued importance, and preference, the Makah have for subsistence foods despite access to non-native food (Sepez 2001: 327). In addition, the social and cultural interactions that resulted from subsistence activities placed added value on foraging practices beyond merely a dietary need. In this case, the local perception of and preference for subsistence activities would have been difficult to document without a combined quantitative and qualitative approach to ethnobiological knowledge.

Place-making, ethnoecology, and the Kayapó

The Kayapó are a central Brazilian indigenous group who live in a series of federally demarcated protected areas, which are located in the states of Mato Grosso and Pará, Brazil. The Kayapó were able to successfully demarcate most of their territory in the latter half of the twentieth century, and their protected area network was further consolidated in the twenty-first century. In her 2007 study, Zanotti examined the impact that protected area status had on Kayapó livelihoods in Aukre village. Zanotti incorporated an ethnoecological component into the research design to examine Aukre's place-making strategies, place-attachments, and local understandings of the landscape. In this case, ethnoecological methods provided an analytical framework for collecting and analyzing local knowledge and place-attachments.

Zanotti employed two methodologies in the ethnoecology portion of her research. First, she drew upon participatory mapping techniques and mapping biographies to better understand the local use of the landscape. Zanotti asked consultants to guide her to places in the landscape that were important to them and their community. On foot and by canoe, community members pointed out fishing spots, old wasp ritual areas, hunting trails, fruit trees, seasonal bridges, and other areas of interest. Zanotti recorded these areas with a GPS unit, hand-sketched maps, and jotted down notes as she went. She followed the informal participatory walks with semi-structured interviews with different consultants. In these interviews, Zanotti questioned about the different parts of the landscape that the community members had pointed out to her, why they were important to the interviewee, and what meaning they had for the community in general. The combination of these methods provided a suite of cartographic data, visual materials, and verbal responses. To conclude the study, Zanotti analyzed the data to identify the salient aspects of the landscape that were critical for the Kayapó (see Zanotti 2008).

CONCLUSION

This chapter outlines the methods a researcher can choose from when undertaking ethnobiological research. Because ethnobiology is a multi- and interdisciplinary field, the methods ethnobiologists use include both qualitative and quantitative approaches. Ethnobiology has emerged as a complex field within anthropology, and arguably environmental sciences, that is well equipped to answer several different types of research questions. Ethnobiology offers several valuable methodologies to analyze the human dimensions of natural resource management (Ellen 2006), and also has the explanatory potential to evaluate the impact of rapid change in socioenvironmental systems. Finally, this chapter is merely the first step to understanding the several rich methodologies available to ethnobiologists. We urge those interested in pursuing ethnobiological research to consult the references we have cited to continue to build their research design.

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