



**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.”**

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1. Introduction

Efforts to document and assess traditional environmental knowledge (TEK) have grown exponentially in recent decades, stimulated by the concomitant rise in its perceived value. This reappraisal is a direct consequence of global environmental and social change as well as manifold threats to the survival and integrity of indigenous peoples and their cultural heritages around the world. The locally-distinctive systems of knowledge, belief and practice held by small-scale indigenous societies or distinctive sociocultural segments within more complex societies contain a wealth of basic and practical information about the natural world, its components and relationships among them. For many impoverished groups, this aboriginal or folk wisdom constitutes the main economic asset that they control. Conservation scientists have emphasized the important contribution that TEK makes to biodiversity conservation and sustainable development. Yet many observers, including local groups themselves, have expressed concerns that slowly accumulated, locally adapted knowledge is disappearing or declining at an alarming rate and therefore pro-active measures are needed to preserve and protect it. Although it is possible to point to a number of policy vehicles enacted at international, national, and lower levels which are aimed at reinforcing or reviving TEK, it remains very unclear and unknown what overall impact, if any, these have really made. The development of TEK indicators represents the most recent chapter in the search for more effective policies. Such indicators are intended to identify and measure key components of TEK and thereby provide a clear and systematic basis for tracking changes over time.

The present study was made in an attempt to contribute something to this exploratory enterprise of developing reliable indicators of TEK. In this report, we describe and justify a robust yet practical methodology for collecting and analyzing data leading to the creation of a locally-appropriate, globally-applicable indicator focused on trends of retention or loss of TEK over time. The proposed index, which we call the VITEK (acronym for “Vitality Index of Traditional Environmental Knowledge”), will be the first of its kind. It will focus on rating the vitality status of TEK (i.e. inferrable trends of retention or loss over time) within selected groups and allow for relative comparisons of that status among groups at different scales of inclusiveness. Another intended feature is to measure the vitality status of different semantic/behavioral domains within the rubric of TEK in order to identify which types of knowledge are most vulnerable to change. The report includes a comprehensive literature review and evaluation of methods that have been used to measure different aspects of traditional knowledge as well as a synthesis of the major findings from studies of TEK variation and change. Using this body of work as precedent, we then formulate a protocol for making a quantitative assessment of the vitality of traditional knowledge at the local level (i.e. community or group of related communities) and representing the trend pattern in a statistical form for comparative purposes. We begin this report by summarizing why TEK is valuable and worthy of protection and how the VITEK can contribute to this goal.

2.0. (Re)Valuation of TEK

Until quite recently, the intellectual capacities and achievements of the people in pre-industrial, nonliterate, small-scale societies were frequently denigrated in

mainstream Euroamerican punditry and public opinion as primitive, arcane, irrational, and inferior in comparison to western science and technology (cf. Hallpike 1979). As a result, there was little interest outside of academic circles given to the study and application of aboriginal cultural knowledges. However, this negative perception has undergone a remarkable revision in the past few decades, especially in regards to TEK - that portion of cultural knowledge most directly associated with the apprehension, exploitation and management of the natural environment. The contemporary discourse of TEK, as expressed in the collective rhetoric and writing of a growing legion of scientists, humanists, activists, policymakers, and indigenous organizations, highlights the practical value and significance of these local knowledge systems for the modern world and hence the need to preserve them for present and future generations (Inglis 1993; Williams and Baines 1993; Grenier 1998; Sillitoe 1998; Berkes 1999; Posey 1999; Sillitoe et al. 2002; Menzies 2006; Zent n.d.a). The recent call for development of cultural-based indicators that are relevant for a better understanding of the state and trends of biocultural diversity represents a new phase in the valuation of TEK.

2.1. The Value(s) of TEK

The actual and potential applications of TEK range across several different fields and endeavors, including science, medicine, agriculture, rural development, environmental protection, political empowerment, cultural identity, and defense of human rights. Local groups sometimes possess more detailed, empirical information and understanding of their surrounding habitat, such as plants, animals, soils, water bodies, weather and the interrelationships of these, than do academy-trained environmental scientists. Scientists conducting botanical and zoological surveys or inventories in the field have often made use of local naturalists to locate, collect and identify new species (Berlin 1984; Schultes 1994a). The folk knowledge and use of plants, animals and fungi is also recognized as a valuable source of information for the discovery and development of new medicines, foods, condiments, cosmetics, pesticides, fibers, and crop germplasm (Elisabetsky 1986; Schultes 1992, 1994a, 1994b; Plotkin 1988; Soejarto and Farnsworth 1989; Schultes and Raffaui 1990; Balick 1990; Cox and Balick 1994; Balick et al. 1996). Under participatory approaches to rural development, TEK is seen as a key resource for facilitating appropriate agricultural innovation, health-care, and commercial enterprise among impoverished groups (Chambers et al. 1989; Moock and Rhoades 1992; Warren et al. 1995; Sillitoe 1998; Sillitoe et al. 2002). The principles of natural resource management embodied in many local production systems are lauded as making a substantial contribution to environmental conservation and sustainable use. A number of biodiversity-sustaining or augmenting practices directly associated with TEK have been identified, including: diversified agroecosystems; selection and propagation of crop varieties or animal breeds; social or religious regulation of exploitation pressure on certain species; the increase of small-scale patchiness; fallow management, forest restoration strategies; refugia protection (e.g. sacred sites, tabooed areas, buffer zones); rotation of hunting-fishing-farming-grazing lands; water management techniques; communal property arrangements (Gadgil et al. 1993; Berkes 1999; Thrupp 1998). Where viable and vigorous systems of TEK are maintained one tends to find stronger indicators of ecosystem health (Inglis 1993; Williams and Baines 1993) and biodiversity conservation projects have generally been more successful when local knowledge was incorporated (Carroll and Meffe 1994).

The casting of indigenous and local groups and their knowledge systems in the role of repositories of valuable ecological information and as human resources for biotechnological development and biodiversity protection has been instrumental in garnering support for indigenous causes but this viewpoint is not without controversy and criticism. It has been severely questioned as exploitative and discriminatory and failing to take into account the interests, rights, priorities and worldviews of the local communities themselves (Shiva 1996; Posey 2004). For this reason more attention has recently been placed on the significance of TEK from an insider's perspective. For many local communities, it is the time-tested basis for decision-making in many areas of daily living, including natural resource management, nutrition, food preparation, health, hygiene, housing, toolmaking, education, community law, and social relations (Warren et al. 1995; Posey 1999). The protection and continued access to such knowledge is looked upon as a necessary condition for guaranteeing resource rights, which in turn is seen as a fundamental pillar of human rights (Posey and Dutfield 1996). By maintaining their traditional knowledges and technologies, people give themselves more options, greater control over their lives, and greater leverage with which to negotiate the process of development and change more on their own terms (Dei et al. 2000). Furthermore, local knowledge serves as a bridge for absorbing new knowledge elements, such as useful techniques and technologies stemming from global science (Bell 1979). In this sense, it may be argued that TEK constitutes a powerful tool for self-determination and political empowerment. The statements of indigenous organizations and representatives recognize the deep integration of TEK with their total way of life and consider their right to keep it to be essential for the maintenance of their culture, language, social organization, economy, spirituality, identity, sovereignty, land, and ultimately their very existence (cf. Posey 1999:555-601).¹

The positive valuation of TEK has gained added force in the last couple of decades as it becomes more apparent that biodiversity and cultural diversity are rapidly declining on a global scale. Studies showing a high degree of spatial correlation between indicators of biodiversity (mainly species richness) and indicators of cultural diversity (mainly numbers of endemic languages) have led to formulation of the concept of biocultural diversity, which sees the two kinds of diversity as interdependent and possibly co-evolved manifestations of the total diversity of life (Maffi 2001; 2005a; Harmon 2002). From a biocultural perspective, the twin losses of biodiversity and cultural diversity are considered to reflect not merely parallel trends but rather interlocking processes. To the extent that TEK shapes and informs people's cognition of the organic world as well as their actions upon it, and is the evolving outcome of the accumulated experiences gained from living in a particular habitat, it may be considered one of the core linkages between biodiversity and cultural diversity. Seen in this light, the continued maintenance and vitality of TEK forms the centerpiece of integrated biocultural approaches to environmental conservation (Carlson and Maffi 2004).

¹ The declarations and documents making specific mention of TEK and appearing in this source include the following: Charter of the Indigenous-Tribal Peoples of the Tropical Forests; Indigenous Peoples' Earth Charter; Statement from the COICA/UNDP Regional Meeting on Intellectual Property Rights and Biodiversity; and Resolutions of the International Workshop on Indigenous Peoples and Development.

2.2. TEK Indicators

In view of the many virtues and benefits of TEK, there is growing concern that it is being lost or eroded in many places due to modernization influences. The impending loss of a valuable resource has stimulated the search for policies aimed at preserving, reinforcing, recording or adapting unique cultural knowledges. These have included a number of general policy statements recognizing the importance of this intellectual heritage, laws established to safeguard the rights of indigenous peoples to their native language and culture, and special programs designed to encourage the continued maintenance or revitalization of traditional knowledge and practices. The development of indicators of traditional knowledge, which may be considered a subset of cultural indicators, represents a relatively new policy direction for conservation science. The concept of indicators is understood here as referring to certain signals or measures that are taken to represent larger and more complex dynamic realities (Hammond et al. 1995). The general function of an indicator is to simplify information about multiple components in order to facilitate communication about states at one point in time and trends over time. Indices are the most highly-aggregated type of indicator and invariably take a quantitative form based on a fixed procedure of measurement. The most common types of indicators are social, economic, and environmental. Cultural indicators represent a recent addition to the field of indicators, but these usually define “culture” in terms of the cultural products of modern global society, such as the arts, literature, and education (Maffi 2005b). It is only in the last few years that there have been attempts to define cultural indicators which refer specifically to indigenous or folk cultures.

Much of the impetus for developing traditional knowledge indicators has come during the last few years following the commitment made by 190 countries at the 2002 Johannesburg World Summit on Sustainable Development, to achieve, by 2010, a significant reduction of the current rate of biodiversity loss at the global, regional and national levels. In order to evaluate in an objective way whether this goal is being met, an integrated strategy was adopted which defined a variegated series of environmental targets and proposed that relevant indicators be developed to measure progress toward each target. The call for indicators included cultural indicators as part of the package based on the consensus opinion that ecosystem assessment needs to be connected directly to human welfare and decision-making. It was felt that these connections need to be explicitly drawn in order to reveal more clearly the long-term human costs of biodiversity loss and habitat destruction and to engage the interest of governments, businesses, and the public (Balmford et al. 2005a). This framework of targets and indicators was later endorsed formally by the 7th Conference of Parties (COP7) of the Convention on Biological Diversity (CBD) in 2004. The COP-CBD has officially adopted the immediate testing of a limited set of indicators and recommended the study and development of others in seven focal areas. Focal area 5 refers to the protection of traditional knowledge, practices and innovations and is based on article 8j of the convention (Balmford et al. 2005b). Another important initiative is being spearheaded by the Food and Agriculture Organization of the United Nations (FAO) and the International Indian Treaty Council (IITC) to develop cultural indicators of indigenous peoples' food and agroecological systems (Woodley 2006). Under these proposals, two general purposes of TEK indicators can be identified: (1) to measure and monitor the states and processes of local cultures and knowledges and (2) to evaluate the results of policies (i.e. whether targets are being achieved). More specifically, we consider that

reliable and standardized quantitative measurements of TEK trends can provide crucial information for answering the following key questions:

- (a) Is knowledge really being eroded, retained or increased?
- (a) How fast is loss/change occurring?
- (b) What areas or groups are most affected?
- (c) What domains of knowledge are most vulnerable?
- (d) What are the causal or conditioning factors?
- (e) Are trends of TEK erosion/change related to trends of biodiversity loss?
- (f) Are TEK preservation/protection policies producing measureable results?
- (g) Which specific policies are working and which are not?

2.3. Uniqueness of the VITEK

The VITEK is specifically designed to fill the need for indicators of traditional knowledge, practices and innovations that contribute to biodiversity conservation and sustainable use and to abide by the criteria for indicator development established by the CBD framework. Although our intention is to define one possible indicator that ideally would be used alongside other indicators to provide a more complete picture of the status and trends of traditional knowledge, we also argue that the VITEK is also unique and different from other such indicators that have been developed or proposed up until now. It is unique in at least three ways: (1) it involves the direct measurement of key domains of TEK itself, rather than relying on measures of proxy variables, (2) it is based on a standardized method for data collection and measurement that is both locally appropriate for diverse cultural and environmental contexts and broadly applicable for global coverage, thus permitting the direct comparison of states and trends across different sites and the aggregation of measures at different spatial scales, and (3) it specifies a precise methodological protocol to follow that is standardized in terms of its basic structural design yet flexible in terms of the specific contents and procedures used in its application (sections 7.0, 7.2).

The direct measurement of TEK is clearly preferable over proxy measures because the relationships of the proxy variables to traditional knowledge, practices and innovations has not been determined with confidence. Under Focal Area 5 of the CBD's 2010 Targets, the only headline indicator which has been formally adopted by the COP-CBD for immediate testing is "Status and trends of linguistic diversity and numbers of speakers of indigenous languages" (decision 30, paragraph 27). Although languages may constitute a useful proxy measure of cultural diversity, the CBD recognizes that this indicator does not amount to a direct measure of traditional knowledge and therefore that more direct measures need to be developed. Accordingly, the Ad-Hoc Open-Ended Inter-Sessional Working Group on Article 8(j) and Related Provisions of the Convention on Biological Diversity proposed several possible options for covering this need, which are classed under four categories: (a) Land-based indicators, (b) People-based indicators, (c) Program- and policy-based indicators, and (d) Culture-based indicators (document UNEP/CBD/WG8J/4/10, 24 November 2005). None of these proposed indicators, however, will provide a direct measure of the status and trends of indigenous and local knowledge. The first two classes, while considered to offer quantifiable indicators, are still proxy measures, and it may be argued that by themselves they do not come any closer to reflecting actual knowledge trends than do

changes in linguistic diversity and the numbers of speakers of indigenous languages. The last two classes include a number of potential qualitative-based indicators for which no clear methodologies have yet been developed and that will make comparisons difficult if not impossible. By contrast, the VITEK assessment method elaborated in this report is aimed at developing an index that directly measures key components of TEK. The index design satisfies the criteria established by the CBD for selection of additional indicators, namely the inclusion of reliable and comparable time-series data, the quantitative measurement of trends, and the aggregation of measures from more than one locality.

The VITEK method that is developed here places considerable emphasis on balancing local appropriateness with global applicability. By this we mean that, on one hand, the specific design of the test instrument used in a particular place is based on local categories and criteria, while on the other hand, the same general framework and procedure for knowledge assessment is applied in multiple settings. The indicator must incorporate both of these (seemingly contradictory) qualities if it is to achieve representative measurement of the statuses and trends of locally-situated, culturally-specific knowledges as well as widespread acceptance and use all over the world. No indicator currently exists, nor has a method been previously designed, that is capable of both providing an appropriate measure of the vitality of TEK in diverse cultural and environmental contexts and of allowing for systematic comparison across local communities, ethnocultural groups, nations, and regions. Although an abundant number of different measures of TEK phenomena have been developed and used previously, these have mostly been realized in single-culture or micro-regional contexts and neither the methods used nor types of measures calculated are automatically applicable to other cultural or environmental situations. For this reason, the few comparative quantitative investigations that have been carried out suffer from lack of direct and systematic comparability (see sections 5 and 6). As well, the attempts to develop entirely self-administered and community-based indicators of traditional and local knowledge also face the same obstacle of incomparability (UICN-CBD-FIIB 2007). Intercultural, inter-environmental comparability is considered a necessary property if the indicator is to achieve global status, capture a broad-based audience, and have policy relevance beyond the local level.

Another shortcoming of alternative proposals for traditional knowledge indicators is the lack of methodological definition for putting them into practice. In the documents that we have reviewed in which prospective indicators are identified and defined, scant attention, if any, is given to explaining the methods and procedures that should be used to produce the measurements. Unless this deficiency is overcome, it is doubtful that they will ever be operable, reliable, or comparable. In section 7, a detailed methodological protocol for collecting data at the local level and calculating the measures comprising the VITEK is elaborated. The overall design of the method consists of two basic phases: 1) data collection, comprising a standardized set of operations for collecting primary data in the field and assigning quantitative values to the field data results, and 2) data analysis, including formulas for calculating the vitality statistics at different scales (local, national, regional, global). The data collection phase is intended for application at the local level and therefore is sensitive to local distinctiveness, while the analytical component is designed for making quantitative comparisons across local groups (as well as larger-scale, aggregated units) and therefore entails common denominator forms of measurement. The feature of comparability

allows for the progressive aggregation of vitality trends according to different scales of spatial inclusiveness, such that the index can be computed by sector, country, region, and so on up to a global measure. The assessment method also has a modular design in order to facilitate the disaggregation of measures for specific domains or subsets (e.g. ethnobotanical knowledge, agroecological knowledge, ethnomedicinal knowledge) of TEK. This feature will permit more focused assessments of which types of traditional knowledge are most vulnerable/resistant to change.

As mentioned above, the indicator method will be potentially applicable for groups characterized by different cultural and environmental situations. We should stress, however, that this includes indigenous as well as nonindigenous groups. Most of the proposed cultural-based indicators for environmental assessment that we have seen are focused on indigenous peoples. Without questioning the extraordinary richness, adaptiveness, and importance value of the native lores held by such groups, we should nevertheless point out that many, if not all, communities which identify themselves as nonindigenous also possess their own folk traditions of understanding and practice which may contribute significantly to biodiversity and ecosystem management. Moreover, nonindigenous people make up a majority of the world's population and occupy a greater portion of the global land surface. Therefore a global indicator that is truly global should not exclude these latter groups. Following this same logic, the indicator should be relevant and equally applicable for vernacular as well as non-vernacular language speakers, native and immigrant, rural and urban, literate and illiterate, stratified and egalitarian, market-integrated and subsistence-oriented, groups. The VITEK fulfills this criterion of global applicability without discrimination.

We should point out that according to the pressure-state-response model of indicator classification, the VITEK would be categorized as a "state" type of indicator, which refers to the quality or state of the environment. We argue that baseline information about the current and changing state of TEK is needed in the first place before it is possible to identify the causes (i.e. pressures) of such states, whether these may be considered negative or positive reinforcements, or to judge the effectiveness of policy actions (i.e. responses). The VITEK measures dynamic states, which is to say trends, through analysis of time-series data. In an initial application, the time-series is accomplished by way of inference based on the recorded knowledge differentials for tested age-groups (see sections 7.3.2, 7.4.1). However, the indicator is easily adaptable for true time-series data collection through the repeated application of the assessment method in the same places at different time periods and comparison of the changes in the trends over time. This in fact would be the best way to use it: as a monitoring device at regular intervals. Furthermore, the optimal use of the VITEK would be as one member of an integrated set of indicators on the environment. As an indicator of TEK vitality, we consider that it provides information about a crucially important domain for ecosystem assessment. Used in conjunction with other environmental, social, and cultural indicators, it can be used not only to track changes in ecosystem health but also to investigate the causal linkages between different variables making up biodiversity and cultural diversity. For example, examination of the changes in the covariation between the VITEK and ecological indicators of biodiversity over time would provide insight into the significance of TEK preservation and loss for biodiversity conservation. In the same vein, the covariation between the VITEK and language-based indicators (e.g., the Index of Linguistic Diversity) would be revealing of the closeness of the relationship between local language and local knowledge and therefore provide a test of

the appropriateness of linguistic trends as a proxy indicator of traditional knowledge, innovations, and practices.

3.0. Potential Uses and User Groups of the VITEK

The VITEK has several potential uses and user groups, from the local on up to the global level. The main ones we can think of are described below. The ability to speak to multiple audiences for different reasons should be considered one of its most valuable assets.

3.1. Local Communities and Organizations

For local communities and the organizations that represent them, the VITEK can provide concise and objective information about the current status and future prospects of their traditional knowledge systems. We believe that the local stakeholders will be the primary beneficiaries of the proposed indicator. Dissemination of the results to the participating groups will help raise their awareness of the healthy/unhealthy state of their cultural heritage and stimulate them to ponder the need for preservation or recuperation initiatives. Many people are vaguely aware that loss or change may be occurring, especially when there is a noticeable gap when younger vs. older persons' knowledges, but they may feel no need to do something about it until they are confronted with concrete facts and figures that show how fast and far this is happening. The modular design of the VITEK test and measure enables disaggregation of the results, showing which types or areas of TEK may be most vulnerable or threatened. Thus remedial or documentary programs instigated by local groups can be focused accordingly. Moreover, the indicator can enhance their ability to communicate their concerns and needs to outside actors, such as policymakers and aid providers. The involvement of community members will be crucial for the site-specific adaptation and application of the VITEK testing instrument (section 7). We also place emphasis on the training of local people to administer the test and analyze the results so that they will be capable of carrying out the assessment on their own, or with minimal involvement of outsiders. This would give them greater access and control over the information produced by it.

Although the VITEK assessment is intended for use and application among any local population, its potential benefits are especially important for indigenous peoples. For such groups, TEK is a vital resource not only for their livelihoods and physical health but also for the maintenance of their self-determination, cultural identity, social cohesion, spiritual wellbeing, and other intangible qualities of life. Many indigenous groups constitute minority and marginalized populations within their countries. The VITEK offers them a crucial piece of information, represented in a universal scientific language (i.e. mathematics) that is comprehensible to others, which they can use to press their claims and defend their interests vis-à-vis state or private institutions.

3.2. Governmental Agencies

For national governments and their agencies, the VITEK will offer a powerful tool for cultural and environmental policy decisions. The index provides a fast and convenient measure for assessing the persistence, loss or change of traditional knowledge in selected subgroups of the national population. This will allow them to better identify groups whose cultural traditions are most endangered and thereby target ethnoeducational support programs to those who are most in need. Used together with ecological indices, the VITEK can help reveal the links between biological and cultural diversity and lead to more integrated environmental conservation programs. Periodic implementation of the VITEK assessment in various localities would permit the monitoring of the states and trends of traditional knowledges over time. This kind of information can be used to evaluate policy performance or progress toward meeting goals. Furthermore, it sheds light on the cultural costs/benefits of development and change processes. Coordinated management of the data generated by the assessment by a governmental agency could make this information available to the key policymakers

3.3. General Public

The VITEK serves the general public interest by providing easily digestible, readily understandable information about trends in cultural diversity and heritage, the plight of small-scale or minority populations and their unique lifestyles in an age of globalization, and the fate of potentially valuable traditional wisdom about the environment. Although many people are aware that global environmental change is one of the major issues confronting humankind in today's world, relatively few people recognize that TEK erosion or change may be an interdependent part of this process. Since public opinion shapes decision-making in democratic societies, the common citizen is also an important stakeholder and consumer of national performance indicators like the VITEK. The indicator will help to publicize whether trends are going in the desired direction or whether policies are working.

3.4. Nongovernmental Organizations

For nongovernmental organizations (NGO's), the VITEK offers a new source of specific and detailed information about the status of cultural knowledge and practices in the places where it is implemented. NGO's collectively comprise a major force and agent of social change throughout the world nowadays. They are heavily involved in the management of development and conservation in numerous countries. Many of them work directly with local groups to strengthen, preserve and innovate TEK and other cultural resources. On one hand, the indicator will expand the information base they rely on to identify problem situations in which TEK is threatened and plan appropriate action programs. On the other hand, by showing where TEK is persistent or resilient, the indicator can help them find prosperous situations which serve as potential models for program planning.

3.5. International Policy Organizations

For multilateral and international organizations that set and guide broad policy directions, the VITEK offers a reliable, comparable, global indicator that directly measures TEK change/continuity at different scales. There are several international organizations currently working to develop cultural indicators, including the CBD, UNEP, UNDP, IUCN and UNESCO, among others. The CBD is particularly important because of its considerable influence on downstream policy at the national level and because it has officially adopted a strategy of indicator development to determine whether policy targets (e.g. biodiversity loss reduction) are being met. There are currently no indicators directly focused on TEK states and trends although there are several which have been proposed and are being studied. The criteria for new indicator development is that they be scientifically robust and reliable, comparable, quantitative, variable in scale, and contain time-series data so as to permit trend analysis. The VITEK meets all of these conditions.

3.6. Scientific Community

For scientific researchers, the VITEK provides a comparative indicator of TEK variation and change which, if analyzed in relation to other social and environmental variables, can be used to test hypotheses about the causes of knowledge loss or persistence or the importance of it for biodiversity conservation. Implementation of the VITEK assessment in various localities and publication or posting of the results would establish an invaluable cross-cultural database that researchers could draw upon to compare and contrast different groups and sites, to distinguish general from specific trends, and to contextualize the results obtained in original field studies. The VITEK might also serve as a source of baseline data prior to undertaking more specialized investigations of aspects of TEK variation and change.

4.0. Conceptual Delimitation of Indigenous and Local Knowledge

The development of a TEK indicator that has global application and can be replicated and understood by different people requires clear definitions of the phenomena that will be recorded and measured. The task of operationalizing the indicator variables and procedures will be dealt with in greater detail in section 7. However, it is also important to delineate some of the basic parameters and properties that have been put forth to define and distinguish the concept of traditional environmental knowledge (TEK). Such parameters must be taken into account when designing the method so that the indicator is robust, reliable and representative.

The task of specifying exactly what is TEK must begin with a consideration of the broader field of indigenous and local knowledge (ILK), of which TEK may be considered a subset (Berkes 1999). This is no simple matter due to the vast enormity and complexity of this phenomenon as well as the variety of interpretations that have been made of it. A recent review of the evolution of the field over the last 50 years reveals that representations of ILK have undergone considerable paradigmatic shifts and these are still being revised with the ongoing accumulation of new studies and the adoption of fresh epistemological perspectives (Zent n.d.a). This dynamic state of

intellectual development is reflected in the proliferation of terminologies used to label it and its subtypes as well as the multitude of different definitions that have been proposed to distinguish it from other knowledge forms (Kloppenburger 1991; Hunn 1993; Gadgil et al. 1993; Dewalt 1994; Antweiler 1998; Grenier 1998; Purcell 1998; Semali and Kincheloe 1999; Ellen and Harris 2000; Sillitoe 2002). No universal or broad consensus has yet emerged about what the correct term or definition should be and this lack of epistemic unity constitutes a problem for meaningful communication, especially if we are to move beyond the level of qualitative description of empirical facts and bodies and their useful applications to the level of quantitative measurement and intercultural comparison (Ellen and Harris 2000; Sillitoe 2002). At the same time, however, it seems only fitting that divergent ideas about it should prevail given that the subject matter itself is synonymous with the notion of intellectual diversity. The fundamental dilemma confronting our attempt to build a culture-based knowledge indicator with wide applicability is how to bridge the epistemological gulf between representations of knowledge that are meaningful at a local or cultural scale and those that are valid at a global or intercultural scale. The former perspective(s) can only be determined by gaining access to local frames of reference and the VITEK method depends on fulfilling this requirement. The latter demands a more abstract and comparative position to the extent that it is possible (see section 7.2). The present section attempts to outline this position and is based on a comprehensive review and reflection of the literature of IK research and its collective findings over several decades.

4.1. Diagnostic Properties of IK

Given the inherent difficulties of defining IK in absolute and universal terms, some investigators have dealt with the definitional problem by listing the general properties that they have in common or are widespread across many such systems. It is important to emphasize that such properties should be understood in relativistic, rather than essentialistic, terms and there is no sharp dichotomy between indigenous and scientific epistemologies (Agrawal 1995). Sillitoe (2002) argues that the relationship between indigenous and scientific, local and global, types of knowledge is better viewed as a continuum of graded differences (see also Brodt 2002). Ellen and Harris (2000) provide a comprehensive list and explanation of IK properties which is summarized below. Some of these descriptions are qualified in reference to the findings of other studies.

1. **Local:** It is rooted to a particular place and set of experiences and is generated by the people living in those places. Thus transferring (or dislocating) parts of it to other contexts necessarily alters its meaning and purpose. This does not mean, however, that such transfer cannot occur. Diffusion of words, symbols, material culture and techniques across cultural boundaries is of course a common event throughout human history. For example, it is believed that agriculture and cultigens spread mainly through such borrowing. Furthermore, local knowledge systems are by no means isolated from external knowledge systems, including western or global science, nor can too sharp boundaries be drawn between them. Agrawal (1995) points out that local and scientific knowledge have been in contact and have exchanged information for centuries. On one hand, the origin of pharmacology can be traced to herbal medicinal traditions that were written down and it has continued to absorb information from folk sources (Balick &

Cox 1996). On the other hand, many local traditions exhibit the ability to incorporate information from global science (Brodt 2002). However, such incorporation still entails translation and reconfiguration according to local situations and cultural criteria. Thus, even though the distinction between local and nonlocal is becoming increasingly blurred in the modern world, we can still speak of its uniqueness in terms of the local blend and the particular real world situations in which it is put to use. In any case, the property of being local is relative to the size and complexity of the reference group.

2. **Oral and Visual Transmission:** It is transmitted orally or through imitation and demonstration, and also may be acquired through personal observations and experience. The mode of transmission is usually informal, based on participation in a range of customary activities, closely tied to the cultural and ecological context(s) in which it occurs, and influenced by the structure and density of social relationships. Writing it down potentially changes some of its fundamental properties, making it more permanent, portable, abstract, formal and decontextualized. However, as with other properties described here, the status of being nonliterary is recognized more as a general tendency rather than as an absolute and exclusive criterion. Some arguably traditional knowledge forms (e.g. Ayurvedic and Chinese medicine) are codified in written texts, local practitioners are increasingly exposed to formal education and book knowledge which they incorporate into their intellectual repertoire, and a number of communities are now recording their ancestral knowledge traditions in registers, databases or pamphlets. In any case, information derived from or stored in written form still tends to be communicated and transmitted through traditional means at the local level.
3. **Practical:** It is the consequence of practical engagement in everyday life and is reinforced by experience, trial and error, and experiment. The lessons learned from these experiences are often accumulated and passed along from one generation to the next. Its persistence over time attests to its positive fitness value because it is constantly being tested in the harsh laboratory of survival (Hunn 1993).
4. **Empirical:** It tends to be empirical and empirico-hypothetical knowledge. While much of the content focus may be on concrete facts and behaviors, all IK systems also include aspects of abstract conceptualization, such as categorical induction, rules-of-thumb (i.e. simplifying procedures), and unique worldviews (e.g. eco-cosmovisions) that affect their understanding of how and why things happen and what is the appropriate behavioral response (cf. Agrawal 1995; Ross 2002; Brodt 2002).
5. **Repetitive:** Repetition is a defining characteristic of tradition, aiding retention and reinforcing ideas. However, replication over time and space is never perfect since new knowledge may be added and on-the-ground experiences and situations vary from generation to generation and individual to individual.
6. **Dynamic:** It is constantly changing, being produced as well as transformed, discovered as well as lost. The fluid, shifting nature of IK is a consequence of its practical responsiveness and integral connection to other variables of the surrounding social and physical environment. When the environmental context undergoes change, some aspect of IK will usually be impacted. This does not mean, however, that all such changes confer practical benefit.
7. **Shared:** It is characteristically shared to a greater degree than other forms of knowledge even though its distribution is uneven (see 8). Certain types of

knowledge are typically more widely disseminated than others (e.g. cultivated vs. wild plants, food plants vs. medicinal plants), leading some observers to make a distinction between common or generalized knowledge and specialized knowledge even though such differences may be relative instead of sharply marked. Uncertain inheritance and open-access, common property attitudes facilitate its exchange within local communities but also make it highly vulnerable to appropriation by outsiders.

8. **Fragmentary:** It is differentially distributed among community members. In some cases, certain individuals are recognized as specialists of certain domains (e.g. healers, mid-wives, boat-builders, weavers) by virtue of social-political-ritual authority, or personal experiences and abilities. In other cases, different types and amounts of “common” knowledge are segmented according to social statuses (e.g. age, gender, class/caste) and the work roles and responsibilities associated with each one (Pfeiffer and Butz 2005). To the extent that knowledge is dependent upon social interaction and communication, it also tends to vary along kinship and residential lines (Boster 1986a).
9. **Functional:** It is organized and oriented toward the pragmatic fulfillment of identifiable goals, ranging from subsistence to health to spiritual well-being. Thus it is often referred to as “know-how” or “knowledge in practice” (Hobart 1993). While some authors argue that ethnobiological taxonomies are motivated by purely intellectual, or non-functional, criteria (Berlin 1992; Atran 1998), others contend that even these components of IK have clearly functional implications if care is taken to investigate what these are (Hunn 1982; Ellen 1986).
10. **Holistic:** It is integrated and situated within broader cultural traditions. Thus separating technical from non-technical, and rational from non-rational, aspects is problematic (Scoones and Thompson 1994).

4.2. Traditional Environmental Knowledge (TEK)

The focus here on traditional environmental knowledge is determined by the specific goal set for the proposed indicator: to measure the change/continuity of knowledge about the natural environment among diverse local groups. The “traditional” label is controversial because it has sometimes been interpreted as the opposite of “modern” or “scientific” phenomena, or as denoting simple, primitive, anachronistic, or irrational (Warren 2004; Ellen & Harris 2000:). We use it in the restricted sense of signifying continuity from the past to the present, but also caution that this does not mean that traditional knowledge and associated practices are totally static and invariant over time (see below). All societies undergo cultural changes through time, incorporating new information and technology, thus making it difficult to separate traditional from non-traditional elements. However, by traditional we wish to emphasize that it is the cumulative result of the collective historical experience of groups and individuals (often over very long periods of time) and that it is usually handed down from previous generations through customary modes of transmission. The notion of traditional also signifies that it is deeply embedded in the local culture and lifestyle in the sense of being embodied in language, classifications, beliefs, values, rituals, social institutions, and daily practices. This integration or interdependency with other aspects of cultural life enhances its qualitative distinctiveness as being specific to a particular people and place.

Environmental knowledge refers to the subset of knowledge dealing with the natural environment and people's relationship to it. This is broadly conceived as encompassing knowledge of biological entities (species, biotopes), abiotic components (e.g. soils, geology, astronomy, climate), the interrelationships among these, and the processes affecting them (including human-made impacts). Because such knowledge depends on direct contact and interaction with nature and is geared toward the practical engagement of it, it is often bound together with resource appropriation, management and utilization behaviours. At the same time, vital aspects of it may be intimately associated with spiritual beliefs, notions of health/disease, social behaviours, and symbolic expressions. Due to its multi-dimensional and interconnected nature, the demarcation of environmental knowledge from other kinds of cultural-based knowledge is somewhat ambiguous and arbitrary, and in many societies implies a conceptual imposition that has no meaning for local members.

5.0. Review of TEK Methodology

An extensive literature review of quantitative and process-oriented studies of TEK was carried out in order to assess the current state of the field and the relevance of this prior work for development of the VITEK. Special attention was given to surveying the principal field and analytical methods used for its study as well as the major findings and conclusions regarding general trends of TEK change or continuity and the factors driving them. A primary goal was to inventory and evaluate the range of methodological options that have been tried and tested previously, their strengths and limitations, and to identify those which are best suited for a quantitatively measured indicator that strives to be both locally appropriate and globally applicable. A careful review of the scope of available data and information tells us what variables should potentially be taken into account and also serves to evaluate what gaps and needs should be addressed by the VITEK. We also wanted to explore the feasibility of developing the indicator from these secondary sources.

5.1. Ethnographic and Theoretical Research Methods

Prior to the mid-1980's, virtually all studies of TEK phenomena were focused on either ethnographic descriptive reports or on ethnobiological theory-building. This phase is characterized by long-term fieldwork, detailed and comprehensive documentation of local environmental knowledge and practice, intimate contact and participant observation of the study community's daily life, in-depth and open-ended interviewing of a few key informants, and mostly qualitative forms of data analysis. The descriptive studies depict particular groups' classification, use and manipulation of biological species and groupings, and is best exemplified by ethnobotanical surveys or monographs of the agricultural cycle. These studies have highlighted the empirical perspicacity, logical organization and ecological rationality of knowledge and use patterns as well as the holistic integration of these with other aspects of the cultural lifestyle. The theoretical investigations are oriented toward the comparative analysis of the linguistic, cognitive and biological properties of ethnobiological classification systems among diverse (mostly rural, nonwestern and nonliterate) groups among whom descriptive studies have been carried out with the purpose of identifying universal or

evolutionary principles of the human apprehension of the biological world. This body of work has revealed that folk peoples who live in close contact with the land typically recognize and classify a large portion of local biodiversity in similar ways (to each other and to scientists), a shared trait that points to a panhuman cognitive ethnobiological faculty (Atran 1990; Berlin 1992). At the same time, the culturally programmed development of this capacity was found to be affected by utilitarian factors and economic orientation. Normal individuals of urban industrialized societies, for example, display more attenuated and structurally simplified inventories, which may indicate that the ability to develop this innate capacity is to some extent determined by environment and lifestyle (Dougherty 1978; Atran et al. 2004).

5.2. Quantitative Approaches

In recent years, there has been a growing trend to use quantitative research approaches, especially in ethnobotanical investigations. The quantitative revolution in ethnobotany and other TEK-related subjects has sought to transform this field into a more rigorous science based on the principles of precision, replication, comparability, prediction, and deduction (Johnson 1978; Phillips and Gentry 1993a). The case studies are distinguished by innovative research methods and their direct applications for conservation and development issues. The research designs rely heavily on formal and replicable data collection procedures, such as structured interviews administered to a population sample, and quantitative analysis and hypothesis testing of the results. Important statistical measures produced through these studies include: a) the percentages of local biodiversity that people name and use (Boom 1987; Prance et al. 1987; Medley and Kalibo 2005), b) the cultural importance values and use preferences of different biological taxa (e.g. species, families, biotopes) (Turner 1988; Stoffle et al. 1990; Phillips and Gentry 1993a, 1993b; Phillips et al. 1994; Byg & Balslev 2001, 2004; Gomez-Beloz 2002; Sheil et al. 2004; Lykke et al. 2004; Gazzaneo et al. 2005; Lawrence et al. 2005; Monteiro et al. 2006; Silva et al. 2006), c) the monetary valuation of wild resources and habitats for local communities (Peters et al. 1989; Campbell et al. 1997; Shackleton et al. 2002; Reyes-García et al. 2006b), d) the actual use frequencies or harvest intensities of certain resources (Campbell et al. 1997; Luoga et al. 2000; Reyes-García et al. 2005a, 2006b), and e) the perceptual, morphological, biological, and ecological characteristics of useful plants (Phillips and Gentry 1993b; Höft et al. 1999; Lawrence et al. 2005; Albuquerque 2006). Such information is useful for understanding the extent to which people are dependent upon locally available natural resources, establishing conservation targets, assessing the ecological impact of use levels on the survival of natural populations, and promoting sustainable development options. Furthermore, the identification of species with high importance value provide useful ecological or socioeconomic indicators for monitoring the effects of conservation and development programs (Kremen et al. 1998).

Another application of ethnobotanical quantification is found in the field of medical treatment. Measures of informant-based consensus and fidelity of use have been employed to rate the local use value of medicinal plant species as a way of identifying the most empirically effective remedies. These candidate species can then be tested for bioactivity and therapeutic effect. This kind of study has two potential applications: a) to identify effective and inexpensive herbal remedies for treating local health problems and b) to discover and develop new pharmaceuticals that may be industrially

manufactured (Friedman et al. 1986; Trotter and Logan 1986; Johns et al. 1994; Frei et al. 1998; Ankli et al. 1999; Lewis 2003; Voeks and Leony 2004; Case et al. 2006; Johnson 2006; Leduc et al. 2006; Monteiro et al. 2006).

In other quantitative studies, variations in knowledge and use habits according to ethnic groups, age, gender, education, wealth, occupation and other social variables have been measured. In some cases, the social distribution of knowledge has been examined to infer processes of change of the knowledge system by showing how different groups and subgroups are affected by surrounding changes in the socioeconomic or biophysical environment. Hypotheses regarding knowledge change and its causes have been tested by correlating knowledge differentials (within and between groups) with dynamic social and environmental variables, many of which are themselves indicators of change. Such investigations are especially relevant for the present objective of indicator development because they afford a more disaggregated, microcontextual and dynamic view of the corpus of knowledge.

5.3. Intracultural Variation

The attention given to TEK variation across space and time draws theoretical inspiration from recent views of culture as a partially shared and socially patterned information pool (cf. Boster 1987b; Keesing 1987; Strauss and Quinn 1997) and as a dynamic network of distinctively positioned perceptions and actions that are constantly being produced and reproduced through ongoing experiences, movements and interactions with other such networks (cf. Wolf 1982; Ingold 1996). The variable, dynamic perspective of TEK effectively supercedes former depictions of it as a collectively homogeneous, static and self-contained phenomenon (Boster 1986b). The justification for a more fine-grained and partitioned concept of the knowledge system follows from the recognition that work roles, social networks and interaction contexts are sufficiently differentiated so as to produce distinct subcultures and subgroups. According to this viewpoint, the social distribution of knowledge is closely bound to social organization which is patterned by age, gender, kinship, marriage, residence, education, occupation, socioeconomic class, ethnic affiliation, trade, religion, and other statuses. These variables constrain and determine people's customary activities, spatial mobility, and access and control of resources, and in that sense directly affect their contact and familiarity with environmental components (Pfeiffer and Butz 2005). Moreover, social relationships constitute pathways for the exchange and flow of information between individuals and groups. One of the key findings in this regard has been that the pattern of social distribution of knowledge within a community closely reflects the pattern of knowledge transmission (Boster 1987b). Thus synchronic variation can be used to infer ongoing processes of diachronic change, including ontogenetic as well as phylogenetic development (Zent and Zent 2000). A focus on dynamic properties therefore requires a shift of the analytical locus from the group to the individual. The determination of individual knowledge variation depends essentially on a two-step procedure: (1) the intersubjective sampling of a person's knowledge of a relevant domain of TEK, usually through a structured questionnaire or interview technique administered on an individual basis to a sample of persons, and (2) the measurement of interinformant patterns of similarity and difference, often through some statistical operation (e.g. cultural consensus analysis, principal components analysis).

5.3.1. Knowledge Sampling

The goal of observing and measuring interinformant cognitive variation imposes the constraint of data comparability on the method chosen which is usually achieved through some process of quantitative data collection and manipulation. In order to comply with the criteria of comparability and replicability, the vast majority of quantitative-based studies of TEK variation and change rely on a controlled data collection format, especially structured or semi-structured interviews. The structured interview type entails the same set of questions or response stimuli being administered to each and every informant in the sample and may take the form of a written questionnaire, for literate populations, or an oral interview schedule, for preliterate populations. This method is transparently quantitative in the sense that the verbatim responses can be submitted directly to statistical analysis without further coding or data manipulation (Martin 1995). The semi-structured interview follows an interview guide, that is, an established list of questions and topics that need to be covered, but actual administration of the interview is more flexible and open-ended, allowing the respondent more freedom to answer *in their own words* and permitting the interviewer to follow up interesting lines of inquiry with spontaneous questions. In other words, it may begin with highly structured queries but is actually intended to elicit more free-ranging, informant-initiated responses. Such responses must then be categorized through an interpretive process controlled by the researcher (i.e. according to some predetermined classification scheme) in order to produce a comparable data set. In consideration of the pros and cons of the two interview formats, we note that the former has the advantage of simple and straightforward coding, which confers a higher level of comparability and thus superior analytical capability, but has the disadvantages of limiting the amount and quality of the information provided, imposing an artificial communicative context onto the data interaction, and restricting the analysis to the categories deemed relevant by the researcher. The latter has the advantages of eliciting more culturally appropriate (i.e. emically valid) information as well as supplying leads for new questions that otherwise might be completely unanticipated by the researcher, but has the disadvantage of requiring a more complicated, time-consuming, and opaque data coding process. While the traditional anthropological field methods of participant observation and informal or unstructured interviewing are not conducive to quantitative treatment, they are still often used alongside more formal methods to get a better sense of locally appropriate topics and questions, build rapport and reduce intrusiveness, enhance communication between researcher and research participants, match people's statements about their behavior with observed behavior, explore rare or unmeasurable knowledge domains, and gain a more holistic understanding of people's daily life and its influence on their knowledge pattern (Zent 1996; Shanley and Rosa 2004; Lawrence et al. 2005; Edwards et al. 2005; Hoffman and Gallaher 2007).

5.3.1.1. Structured Interview Formats

The most common form of structured interviewing is the questionnaire. The questionnaire has been a primary methodological tool in social science research for many years. In anthropology, this method is associated mostly with ethnoscientists, who developed formal interviewing procedures in order to eliminate observer bias and extraneous contextual noise, and therefore elicit only culturally acceptable emic-type information. The formal or controlled elicitation procedure, modeled after structural

linguistics methodology and adhering to a tightly controlled query-response framework for collecting data, rests on the use of standardized question frames ideally posed in the native vernacular. An example of a class inclusion frame would be: “What is the name of a kind of _____?” An example of a use frame would be: “How do they serve us, _____?” (Johnson 1978). The question frame is the basic technique used by researchers of folk biology to elicit plant and animal taxonomies and activity contexts (Metzger and Williams 1966; Berlin et al. 1974; Hunn 1982). The kinds of questions that appear most frequently in the controlled elicitation procedure may be classified as dichotomous (yes/no, true/false), multiple-choice, or fill-in-the-blank (Weller and Romney 1988).

Besides questionnaires, local ecological knowledge can also be revealed through “analytical tools” involving controlled experimental cognitive exercises or games. The basic objective of these tools is to probe the underlying, sometimes unconscious, cognitive organization and content of selected cultural domains. In some cases, the informant may be asked to explain the reasons for his or her choices. Using these mental exercises, the researcher is able to infer the range and extent of an informant’s knowledge as well as the cognitive criteria and biases that shape his or her view of the domain. The most common techniques of this kind include: free listing, paired comparison, triad test, pile sort, rank order test, and psychological projection test (Bernard 1988; Martin 1995).

Free Listing

Free listing is an open-ended interview technique in which the interviewer asks the respondent to name all of the things that he or she can think of on the spot corresponding to a specified cultural domain. The relative position and frequency of mention of a term is thought to reflect its saliency in the culture being studied. In TEK studies, this technique has been most commonly used as an adjunct to the question frame for eliciting the inventory of terms comprising native taxonomies of plants and animals. In that case, the free list query is administered successively and exhaustively at different levels of inclusiveness (e.g. animals, fish, catfish, etc.) to chart the hierarchical structure and composition of the taxonomic system. It can also be used to determine the taxa employed for different use categories (e.g. medicinal plants, diarrhea remedies) or the use values (e.g. food, medicine, construction, etc.) per species (Nolan and Robbins 1999; Ross 2002a; Lykke et al. 2004; Reyes-García et al. 2004; Medley and Kalibo 2005; Ross and Medin 2005; Estomba et al. 2006). One criticism of free listing is that people tend to mention abundant, conspicuous and easily accessible taxa as well as taxa providing goods during the season of investigation, and thus these factors may bias the overall results (Lykke et al. 2004).

Paired Comparison

Paired comparison (or pairwise comparison) involves presenting the respondent with two objects or categories and asking him or her to judge which of each pair is preferred or better according to a given criterion (e.g. firewood) or has a greater amount of some property (e.g. soil fertility). The procedure is carried out successively for all pairs in a given set and the results are tallied to determine the preferred option or to produce a ranking of the array. A paired choice matrix can be constructed to help with this type of analysis. This technique is especially useful for ranking the members of a class that is too large to order easily. In TEK studies, it has been employed to rate the relative

importance value of plant species (Pedersen and Skov 2001; Reyes-García et al. 2004), preferences in relation to use categories (Höft et al. 1999; Maundu et al. 2001; Gausset 2004), and perceptions of activities threatening wild edible plants (Balemie and Kebebew 2006). An interesting variation on the paired comparison method has been developed and used to investigate ecological relationships between plant and animal species (Atran et al. 2002a; Ross 2002a; Ross and Medin 2005).

Triads Test

The triads test entails presenting informants with three things and asking them to choose “which one doesn’t fit” or “which two go together.” The informant may be asked to explain the reasons for his or her choices to explore what criteria for grouping they consider important or the exercise may be directed in relation to some predefined criteria. This is done for all triplet combinations from a set of objects or concepts and the results are analyzed to map degrees of similarity/difference among them. The method is widely used in cognitive research as it sheds light on the internal organization of a cultural domain and its criterial attributes. TEK researchers have made use of triads tests to investigate covert groupings of biotaxa (Berlin et al. 1968), the utilitarian and agronomic significance of weeds, pests and crop varieties (Richards 1980), agronomic and gastronomic criteria for the recognition and classification of plants and arthropods (Nazarea 1991), cognitive prototypes in medicinal plant selection (Casagrande 2002), and residential decision-making (Antweiler 2004). The administration of numerous triads tests can be a lengthy and tedious process for researcher and respondent alike, and therefore for complicated issues or very large cultural domains redundancy-cutting procedures are recommended (Bernard 1988).

Pile Sort

The pile sort, like the triad test, is geared toward organizing objects or categories into groups and thus revealing relationships of similarity/contrast among them. In this case, the informants are handed a set of objects – which may be cards with names written on them, drawings, photos or even biological specimens – and asked to sort them into groups according to whatever criterion they choose. The exercise is repeated successively on each pile of the previous sort until they cannot subdivide the piles any further (or the method can be applied from lower- to higher-inclusive grouping). At each sorting level, the informant may be asked to describe a word or phrase that explains the reason for making each pile (Weller and Romney 1988). The successive pile sort is considered to be especially useful for making interinformant comparisons (Boster 1994). In ethnobiological studies, pile sorts have been used to explore the taxonomic relationships among organisms (Perchonock and Werner 1969; Berlin 1992), covert (i.e. unnamed) categories (Hays 1976), and the intercultural correspondence of taxonomic knowledge (Boster et al. 1986). The method has also been applied in studies of the agroecological knowledge of crops, soils and fertilizer (Rocha 2005) and the folkecology of fish (Ross and Medin 2005).

Rank Order Test

The rank order test involves presenting informants with a list of taxa or categories and asking them to rank them in order according to relative importance or some other scale.

Sometimes this procedure is performed using a Likert scale format in which respondents are asked to specify their level of agreement to a statement about the item in question (Rocha 2005). By administering this technique to a sample of respondents, the average rankings can be calculated per social group or subgroup and then compared between them. Ranking scales produce ordinal data directly, are fast and easy to administer, and are considered easy to understand by informants. The principal use of this method in TEK studies is to rate the importance, use or preference value of biotaxa based on local people's own assessments (Kvist et al. 1995; Ankli et al. 1999; Kristensen & Lykke 2003; Lykke et al. 2004; Lawrence et al. 2005; Albuquerque 2006).

Psychological Projection Tests

Psychological projection tests refer to devices used to infer personality and character orientations, thoughts and values, that may be unconscious and thus not susceptible to direct verbalization by the informant. The best known projective devices are the Rorschach Inkblot Test and Thematic Apperception Test (TAT) and they have been used a good deal in culture-and-personality research (Johnson 1978). In the TEK field, experiments have been conducted to induce one's informants to project (i.e. reveal by indirect means) their ethnoenvironmental understandings through natural element (e.g. tree) drawings, biocultural mapmaking, storytelling, and the interpretation of pictorial representations of environmental scenes. The drawing of so-called "mental maps" by different individuals or focus groups is a common technique used in participatory mapping or ethnocartographic projects (Toledo Maya Cultural Council 1997; Chapin and Threlkeld 2001; Sletto 2002) for it reveals those landscape features which they consider to be most important. Nazarea (1995, 1997; Nazarea et al. 1998) employs a modified TAT, involving photographs depicting local landscapes and human-environment interactions, to investigate sustainability and quality of life judgments by different age, gender, and ethnic groups among farmers-fisherfolk in the Philippines. This class of techniques can provide insight into perceptual biases as well as values and factual knowledge. However, the coding of responses can be somewhat difficult and subjective, and therefore it may not be easily adapted to quantitative and comparative analysis.

5.3.1.2. Sample Selection

Another key constraint that must be taken into account to capture intracultural knowledge variation is data representativity. Interviewing the entire population of a community or larger unit is usually impractical, inefficient, and in some circumstances (e.g. when the sociodemographic composition is highly disproportionate or momentous events that change people's opinions occur before the study is completed) can be less reliable than a careful representative sample (Bernard 1988). The random (or probability) sample, whether simple (i.e. every person has an equal chance of being selected) or systematic (e.g. every nth person or household from a census list is chosen), is generally considered to be the most reliable type because randomization reduces biases and allows for the extension of results to the entire sampling population. However, the proper use of this technique requires a prior idea of the range of variation of the test variables in order to select an adequate sample size. Unfortunately, this critical information is usually unavailable, unless a prior study had already been conducted, and a pilot study of knowledge variation prior to the full study may not be

efficiently possible. In consequence, one can find sampling intensities ranging from 1-100% across the studies reviewed here. Another problem with the probability sample is that it is often the case that some people chosen for the study refuse to participate, are absent during the research period, or do not answer all questions, which may invalidate the assumptions of probabilistic-statistical inference. Therefore in human subjects research, it is often impossible to achieve the ideal sample and flexible adjustments to the sampling design must be made.

The stratified sample attempts to capture all the relevant subgroups of the population and is preferred whenever it is likely that they may be underrepresented by random sampling. This requires a good grasp of all of the independent variables on which to stratify and therefore depends on a fairly detailed population census. Given the typically small size and dispersed distribution of most rural folk populations among whom studies have been carried out, the stratified sample seems to be the preferred choice in studies of TEK variation and change. The relevant social variables used to design such samples have been: age, sex, schooling, occupation, residential history, languages spoken, local group, and kinship group (cf. Boster 1986a; Heckler 2001; Lizarralde 2001; Nazarea 1995; Ohmagari and Berkes 1997; Zent 1999, 2001; Zent and Zent 2004). In most cases, the range of variables selected for stratification is not really justified by reference to a prior socioeconomic survey but instead is simply assumed or dictated by the research problem.

Non-probability sampling may be more effective for some research situations, for example when time and resources are limited or one needs to study a cultural domain characterized by specialist knowledge or experts who are much more knowledgeable than the average person (Bernard 1988). One of these is the purposive sampling technique, also called judgment sampling, which involves the deliberate selection of informants due to their recognized expertise or other qualifications that they possess (Tongco 2007). The experts chosen should be reliable (i.e. consistent across the community), competent (i.e. qualified through reputation or demonstration), and willing and able to communicate their wisdom. The danger of this method is that the researcher exercises uninformed judgment about which informants are duly qualified at the risk of data quality. In order to ensure that the purposive sample is indeed representative and accurate, it is advisable that the selection process count on prior familiarity with the population and culture, consultation with the community leaders or contact persons, or even a survey of community members who are asked individually to name the most appropriate informants and then those people who are most frequently mentioned are chosen. A similar approach is used in snowball sampling, which involves asking an informant to suggest another informant and so on (Atran and Medin 1997; Gazzaneo et al. 2005). Purposive sampling can be used to generate key informants, focus groups, surveys, questionnaires and all of the data instruments discussed above. In TEK studies it has been employed in studies of specific skills, knowledge or practices, comparisons between practices, and case studies of natural resource perception and management (Tongco 2007). The nonrandom sample is frequently used in ethnomedical investigations which focus on specialist or expert healer knowledge (Heinrich et al. 1998; Nolan and Robbins 1999; Leduc et al. 2006). In distributional studies, the sampling of expert knowledge during a preliminary phase serves to establish a baseline of information from which a sample of questions and the answer key can be drawn for interviewing the general population during a later phase.

Opportunistic sampling is the least reliable form of sampling but it may be the only option when time and resources are severely limited, it is impossible to obtain a socioeconomic profile of the study population, the population is highly transient, and/or local cooperation is very uneven (cf. Ohmagari and Berkes 1997; Voeks and Leony 2004). In any case, the sampling procedure should be openly described in order to permit confident comparison.

Whatever the sampling method chosen, the question of adequate sample size or intensity should be addressed but very few of the studies that we reviewed attempt to do so. One way of dealing with this problem in the context of taxonomic richness and use studies is to plot accumulation curves which show the rate of addition of new species or uses in relation to increased sampling effort. Such curves tell us whether the asymptote has been reached, which is the point at which the collection of new data becomes less likely and hence the point at which the sample size is considered to be adequate (Balick and O'Brien 2004; Hoffman and Gallaher 2007). The method is extremely useful for comparative research because comparisons between two or more studies are more reliable if we have some idea of what percentage of the total stock of knowledge is represented in each study (Hoffman and Gallaher 2007). It remains to be seen, however, how accumulation curves can be adapted to the distributional study format where the main concern is not to inventory the entire range of species or uses but instead to compare knowledge differences between subgroups of the same population.

5.3.1.3. Domain Sampling

The concept of representative sampling should also apply to the knowledge system itself. TEK is not a monolithic entity but instead is composed of a number of distinct cultural domains and subdomains of associated meanings and practices. This means that not only should it be expected that knowledge per se will vary across individuals and groups but also that *types* of knowledge will vary as such and therefore this parameter of variation should be taken into account when drawing up the sample (cf. Reyes-García et al. 2005a). However, determining the locally relevant universe of knowledge domains on which to base the sample looms as a formidable task and from a quantitative methodological standpoint poses a very problematic issue.

Some domain distinctions ostensibly have universal significance (e.g. plant versus animal taxonomies) while others display wide intercultural relevance (e.g. edible versus medicinal resources), have a more restricted distribution (e.g. basketry), or appear to be culture-specific. Although cultural domains are ideally supposed to correspond to emic semantic constructs and therefore have psychological reality for native actors (Frake 1962; Conklin 1962; Sturtevant 1964), very few of the recent wave of TEK studies actually attempt to uphold this epistemological standard. Thus it is exceedingly common to find case studies focused on use value without any mention of how the notion of usefulness in a generic sense is locally conceived or the classification of uses into broadly defined categories (e.g. edible, medicinal, construction, handicrafts, firewood, etc.) without having demonstrated that such categories are locally understood. The bias toward researcher-determined categories of significance in quantitative research appears to stem from the need to reduce data complexity, facilitate statistical analysis, and permit comparison of differences within and between groups. But given the recent emphasis on rigorous scientific methodology, it seems rather curious that the

question of representative sampling of the knowledge system has received little attention. In any case, it is a problem that deserves serious consideration for the field of TEK research in general and for the development of the VITEK in particular

The principal ethnoecological knowledge domains which have been tested for variation include: biotaxonomic classification, cultural uses or significance of selected species, ecology (e.g. habitat, behavior, interspecies interaction, reproductive ecology), human impact and sustainability, and survival skills (e.g. subsistence, shelter, mating, childcare) (Atran 1999, 2001; Heckler 2001; Hewlett and Cavalli-Sforza 1986; Lizarralde 2001; Nazarea 1995, 1997; Ohmagari and Berkes 1997; Zent 1999, 2001; Zarger and Stepp 2004; Zent and Zent 2004). The content focus has therefore been trained on essentially practical knowledge that is thought to be important for the material and/or social functioning and reproduction of the cultural group: the ability to discriminate among the multitude of biological species found locally, the identification of useful properties, ecological information that aid in locating, exploiting and managing natural resources, and technological know-how. By contrast, we observe in Atran's (1999, 2001) recent work on the variation and transmission of cultural models of the environment among Maya and Ladino inhabitants of the Petén region of Guatemala that some researchers are now beginning to look at the spiritual, moral, and affective dimensions of TEK in a dynamic, pluralistic context.

5.3.1.4. Stimulus Materials

Ethnoscience methods for controlled interviewing have traditionally relied on exclusively verbal frames or prompts for data elicitation. But this may lead to erroneous results if there are synonyms or disagreement about the correct names for certain taxa, and it may be inadequate for analyzing variations in multilingual contexts unless interlanguage correspondences can be established. For instance, some researchers have noted confusion in their data caused by the inconsistent application of vernacular names to certain taxa as well as the lack of perfect match between folk taxa and botanical species (Kvist et al. 1995; Case et al. 2005; Lawrence et al. 2005).

One way of gaining greater control and precision over the query-response elicitation process is to make use of sensory stimulus materials depicting natural objects or events. In ethnobiological studies, pictorial images (photographs, drawings) and biological specimens (fresh plant collections, herbarium voucher specimens, stuffed animals) are commonly used prompts. However, these may not be appropriate in some contexts. For example, some researchers have reported difficulties of some informants (especially older individuals or groups unfamiliar with such media) to identify taxa from pictures alone (Ross 2002a; Case et al. 2005; Reyes-García et al. 2005a; Cruz García 2006; Monteiro et al. 2006). Botanical specimens consisting of the leaf and fruit or flower may not be useful because some people detect other morphological and ecological characteristics (e.g. stem habit, bark, habitat) or nonvisual cues (e.g. smell, taste) to identify the plant (Jernigan 2006). The "walk in the woods" interview technique provides a more realistic and appropriate context for ethnobotanical interviews as it features living plants in their natural habitat but may lack the control needed for systematic comparison. For more standardized and uniform interviewing, plant trails and plots offer an attractive alternative and are becoming increasingly popular in quantitative studies (Stross 1973; Boster 1986a; Prance et al. 1987; Katz 1989; Kvist et

al. 1995; Dewalt et al. 1999; Zent 1999; 2001; Galeano 2000; Collins and Liukkonen 2002; Zent and Zent 2004; Voeks and Leony 2004; Zarger and Stepp 2004). The advantage of transects is that they are easier to set up and are more efficient in the sense of being able to encompass a wide range of plant species growing in distinct habitats and therefore a greater portion of the culturally relevant local flora can be included in a single, continuous interview. The advantage of doing interviews in precisely measured quadrats is that quantitative vegetation surveys can be accomplished at the same time as folk botanical knowledge is measured and thus the relationships between phyto-ecological variables (e.g. density, frequency, dominance) and knowledge levels can be tested (cf. Phillips and Gentry 1993b). Furthermore, the results are more conducive to rigorous comparison across different study sites and habitat types (cf. Heckler 2001; Zent and Zent 2004). The use of transects or plots is probably not practical for animal identification and we know of no studies in which it is used as such although this method is commonly employed for conducting faunal censuses and behavioral studies. However, some researchers report that informants have less problem identifying animal species from pictures or drawings with the exception of certain bird species (Rosenberg 1998; Ross 2002a).

5.3.2. Measurements of Similarity and Difference

After the raw data is collected, it must be coded and converted into a quantitative, which is to say numerical, form for the purpose of measuring the patterns of similarity/difference of responses among the sample of informants. Statistical analyses can then be performed in order to reveal nonobvious patterns in the data and to test for the significance of relationships between the measured variables. Both the quantitative measurements and the statistical operations used for the study of TEK variation differ a great deal across the studies reviewed here and depend on the field methods used, the type(s) of data collected, and the research questions being asked. Before describing the different techniques, we should make clear that quantitative measurements relevant to the study of knowledge distribution apply to two primary dimensions: (1) items and (2) people. Each one of these can be analyzed at two further levels: (a) individuals and (b) classes. The resulting matrix of data levels thus follows as: (1a) individual objects within a class, (1b) significance classes, (2a) individual informants, and (2b) classes of informants. Examples of these include: (1a) measures of different uses, citations, or importance value per species; (1b) measures of diversity, equitability and consensus per use class or per taxonomic family; (2a) numbers of species known or used and measures of knowledge level per informant; and (2b) measures of consensus, variation and average knowledge score per social group or subgroup (e.g. ethnic group, community, age, gender, etc.). Typically these measures are used in combination and interactively such that the distribution of knowledge about taxa, uses and preferences across informants is used to measure the cultural significance of the taxa while the diversity and importance values of taxa serve as input for measuring interinformant differences in knowledge (cf. Phillips and Gentry 1993a, 1993b; Heinrich et al. 1998).

The degree or amount of knowledge exhibited by informants has been measured at different numerical levels (e.g. ordinal, interval, and ratio scales) and these depend on the type of quantitative manipulation that is used. Three basic types of measurements can be observed and are described below: counting, ranking, and scoring. In order to calculate these measurements, the researcher must have an *a priori* concept of what

constitutes a correct answer. The problem of validation is an important one because most researchers usually enter a research situation without any prior idea of right versus wrong information and often encounter considerable variance in responses across informants, including obvious mistakes (cf. Kvist et al. 1995). Our review revealed that the standard of truth judgment used in quantitative research varies according to the types of data collected as well as the types of measurements being calculated. In some cases, it is simply assumed that any and all supplied answers are valid and true, such as when simple counts are made of the number of taxa or uses known by the informants. In other cases, the answers supplied by informants are scored as correct or incorrect in reference to an answer key constructed on the basis of information given by local experts, focus groups, long-term experience in the community, or even scientific textbooks. A third approach that seems to be gaining ground, judging from the number of recent studies that use it, is to perform statistical analysis of the consensus and variation in response data and calculate relative cultural significance or importance values. These values are then used to calculate individual competence or expertise.

5.3.2.1. Counting

The most elegantly simple and extensively used measures are simple counts. Counting refers to the numerical addition of observed objects or events falling in a certain category, such as ethnobiological inventories, answers to questions about the names, habits and uses of taxonomic groups, or the number of activities or use events recorded per unit of time. Comparison between groups or samples of respondents is facilitated by converting the counts into means or percentages, such the average number of biotaxa named in freelisting interviews or the average proportion of known vs. unknown elements in identification tasks (Chipeniuk 1995; Katz 1989; Nabhan 1998, 2001).

In theoretical ethnobiological research, counts have been employed in several ways: (a) to establish the modal size and range of ethnobiological inventories in order to make inferences about the inherent limits of the pan-human cognitive faculty for biological classification (Berlin 1992), (b) to explore the structural and substantive organization of the taxonomic system (Berlin 1976), (c) to determine the degree of correspondence between folk and scientific classification (Hunn 1975), (d) to compare the plant and animal taxonomic inventories of different groups in order to assess the impact of subsistence mode (e.g. agriculture vs. foraging) or environment (e.g. rural vs. urban) on the development of ethnobiological classification capacity (Brown 1985; Berlin 1992; Ellen 1999), and (e) to assess the relationship between lexical retention and cultural importance (Berlin et al. 1973).

In ethnographic studies, the counting of interview response data has served as a tool for enhancing the descriptive precision of patterns of knowledge or use. The data produced by free listing are often measured by way of simple counts. Counting the number of items listed can provide rough measures of: a) the prominence, importance or consensus of different items for local people, based on their comparative frequencies of mention across the entire sample of respondents, and b) the expertise or depth of knowledge held by different persons, based on comparison of the number of items listed per individual (Quinlan 2005). Another research situation in which counts have been done is in interviews about knowledge and usage of plants found in measured transects or plots. Informants are walked through the transect or plot and asked to identify and

name the plant types and state their uses. The (mean) percentage of plants known or used can be compared across individuals, groups or ecological zones (Boom 1987, Prance et al. 1987; Caniogo and Siebert 1998; DeWalt et al. 1999; Galeano 2000; Zarger and Stepp 2004; Medley and Kalibo 2005). Some researchers have counted the number of plant-animal interactions cited by informants during structured queries and then compared the counts to infer differences in knowledge of ecological relationships (Atran et al. 2002a, Ross 2002a, Marulanda 2005). Counting offers the easiest, simplest, and fastest way of converting qualitative (binary, nominal) data into a quantitative form but also yields the least valuable data for statistical and comparative analysis. For example, in studies of plant use value all of the plant use citations are simply added up without any weight assigned for relative importance (Hoffman and Gallaher 2007). In view of these limitations, counts are often made as a first step in the data analysis and then serve as input for more complex calculations.

5.3.2.2. Ranking

The ranking of data items on an ordinal scale represents another form of quantitative measurement that goes beyond the mere counting of taxonomic inventories or use citations by assigning relative weights to different taxa. The most common application of data ranking in TEK research is to measure the relative preference, importance or conservation value of individual biological species for certain use categories. The ranking of species by cultural use or significance is potentially important for management policies because it affords insight into how and why species are valued, and how these values respond to changes in the surrounding sociocultural and biophysical environments (Lawrence et al. 2005). Two basic forms of ranking can be observed: informant-generated and researcher-generated. The former type involves administering the rank order test or Likert scale interview to a sample of informants for a local inventory of plant taxa. The array of rankings are then converted to a score based on average ranking across the sample of informants (Kvist et al. 1995; Kristensen and Lykke 2003; Lykke et al. 2004; Lawrence et al. 2005). Lawrence et al. (2005) note several advantages with the informant-ranking method: a) it is relatively rapid, b) it allows all taxa to be compared by the respondents themselves (avoids researcher bias), c) it is easy for respondents to understand, d) it permits comparison of the values of different social groups, e) it is much less time-consuming than full inventories. A primary disadvantage of ranking is that the exercise becomes more difficult to perform with larger inventories of items (Lykke et al. 2004).

Researcher-generated rankings have mostly involved the transformation of interval-scale values to an ordinal scale in order to perform nonparametrical statistical analyses due to absence of normality in the data distribution. In some studies of medicinal plant uses, researchers have first calculated use values based on the frequency of citation among a sample of informants and then converted these into an overall ranking to identify promising species for bioassays (Heinrich et al. 1998; Ankile et al. 1999; Leduc et al. 2006). Ross (2002) develops numerical indices of plant-animal interactions (e.g. extent to which individual plants help animals and extent to which animals benefit from all plants) and then arranges these into rankings to facilitate statistical analysis.

5.3.2.3. Scoring

Scoring represents a more refined level of measurement in the sense that the data is enumerated on interval or ratio scales. This usually involves more elaborate data collection and manipulation procedures. Scoring techniques have become especially popular in quantitative ethnobotanical research concerned with developing indices of the cultural significance or importance value of different plant species. A large and growing variety of methods have been used to produce such indices in recent years (Hoffman and Gallaher 2007). These may be differentiated according to whether the scores are assigned entirely by the researcher or are based on judgments supplied by the informant.

Some researchers have assigned scores to distinguish between minor and major uses. For example, Prance et al. (1987) used this technique to quantify the cultural importance of forests for different Amazonian groups (see also Pinedo-Vasquez et al. 1990). Turner (1988) developed a Cultural Significance Index of plants used by Salish groups (Canada), based on a 5-point scale for three variables (frequency, intensity, and exclusivity of use) and subsequent integration of these points into a single overall score. This measure was subsequently employed with modifications in the original formula in other cultural contexts by Stoffle et al. (1990), Todt and Hannon (1998), and Silva et al. (2006). The advantages of research-assigned scoring are that it is relatively efficient, produces a highly differentiated data set, and can be used to reanalyze data from published sources. The main criticism of this approach is that it is biased toward the criteria imposed by the researcher and therefore may not reflect accurately cultural insiders' notions of significance.

Informant-based scoring techniques were explicitly designed to overcome researcher-biased measures of cultural importance. This approach relies on some form of consensus analysis of the pattern of interinformant agreement/disagreement 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 in quantitative TEK research is the informant-indexing technique pioneered by Phillips and Gentry (1993a; 1993b; Phillips 1996). This method quantifies the use value of a plant species based on the overall average frequencies with which a group of informants state particular uses of particular species throughout a series of walking interviews in natural vegetation settings. Interviews may be repeated with the same informants in

order to discriminate consistent/inconsistent information at the individual level. The values obtained per species were then utilized to analyze knowledge variation by age among the study population (mestizos of the Peruvian Amazon). The overall plant use knowledge for each informant was measured as the standardized ratio between the summed use value recorded for him and the summed use value recorded for the entire group of informants. In another paper, Phillips et al. (1994) adapted this method to rate the use value of different forest types, based on the summed use values of all species censused per forest type. The informant-indexing use-value measure has subsequently been utilized or adapted by a sizeable 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 2001a, 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).

Another prominent variant of interinformant consensus measurement that has been used in quantitative TEK research is the cultural consensus model (CCM) innovated by Romney and associates (Romney et al. 1986, 1987). Since its inception two decades ago, Romney's method has been utilized in a wide range of investigations of cultural phenomena, including research on different aspects of TEK variation and change (Boster 1986a; Atran 1999, 2001; Atran and Medin 1997; Atran et al. 2002a; Zent 1999, 2001; Reyes-García 2001; Guest 2002; Ross 2002a; Weller and Baer 2002; Miller et al. 2004; Reyes-García et al. 2003, 2005a, 2006a, 2007; Zent and Zent 2004; Rocha 2005; Ross and Medin 2005). In addition to ethnobotanical topics, the applications include studies of ethnozoological knowledge (e.g. animal habits and management), plant-animal interactions, agroecological knowledge and practices, and cultural notions of illness and curing. Rather than being focused on the valuation of biological resources and resource zones, it is more directly concerned with the structure and distribution of knowledge in a cultural group.

CCM combines mathematical with psychometric techniques, based on factor analysis, and is designed to measure patterns of interinformant agreement/disagreement about selected culturally shared domains. The method requires obtaining a single factor solution (expressed by a first eigenvalue 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 (i.e. consensual) answers (when such answers are unknown beforehand) and (b) rating of the individual knowledge levels, expressed in terms of competence scores. Similar to the Phillips and Gentry technique described above, it measures individual knowledge as a function of the degree to which an individual's answers concord with the "correct" answers derived from the group. However, there are also substantial differences. The Romney consensus method should be considered more rigorous than that of Phillips and Gentry in the following ways: (a) it starts with a matrix comparison of the paired responses of all informants across all questions, (b) it requires that all informants included in the analysis be administered the same set of questions, (c) it distinguishes between right and wrong answers, (d) it accounts for the probability of guessing the right answer, (e) it is able to handle different data formats (true-false, multiple choice, and fill-in-the-blank type questions), and (e) it gives greater weight to the answers provided by presumed cultural experts (i.e. those displaying higher competence score). A valid criticism of CCM is that its applicability is limited to the quantification of consensual based knowledge and of individual departures from that standard, and thus it

is clearly inappropriate for analyzing the evolution of culturally valid specialist type knowledge (Zent and Zent 2004, 2007). Moreover, it is based on a relatively complicated computation process and therefore requires access to a computer and a pertinent computer program (e.g. Anthropac) to perform. A more general criticism of all consensus-derived measures of use-based knowledge (Phillips and Gentry, Romney, and others included) is that they fail to distinguish potential from actual, and present from past, uses, thus inflating current real use levels (Kvist et al. 1995).

Apart from consensus measures, there are some other, less commonly used, techniques on which to base the calculation of TEK scores that should be mentioned here. The “matching with expert” test entails preliminary elicitation of response items from one or more locally recognized expert consultant(s). Individual scores are then determined by proportional agreement with the expert(s) over a structured set of questions (Albuquerque 2006; Caniogo and Siebert 1998). The “matching with science” test uses scientist information as the authority of truth. Individual scores are calculated as the percentage of correct answers given by the respondent (Godoy et al. 1998; Reyes-García et al. 2006a). These methods are much less time- and labor-intensive than consensus-based analysis, but not without their limitations. The expert matching test assumes that one or a few individuals are effectively omniscient or all-knowing standardbearers of the knowledge system, a premise that may not be compatible with the distributional model of cultural knowledge described earlier (section 5.3). The science matching test (dubiously) assumes that traditional knowledge should correlate perfectly with scientific knowledge.

5.3.2.4. Classification and Ordination

Statistical classification and ordination techniques are commonly used to study multivariate ecological relationships (e.g. species distributions in relation to environmental gradients) but in a few cases they have also been used to measure and visualize patterns of interinformant similarity/dissimilarity in regards to their ecological knowledge and practices (Höft et al. 1999). To carry out these types of analyses, a distance or similarity matrix is set up showing the pairwise distance (e.g. Euclidean distance, percentage dissimilarity) or similarity (e.g. correlation, covariance) between all pairs of sample objects (in this case, the objects refer to informants). In classification, the analysis seeks to partition the set of heterogenous objects into relatively homogenous groups based on the calculation of class centers, density, variance, number of members, and distinctiveness of delimitation (Höft et al. 1999). The main form of classification used in TEK-related research is hierarchical cluster analysis, which has been used to compare ethnobiological taxonomies within and between different cultural groups (Berlin et al. 1981; Boster et al. 1986; Boster 1987a; Boster and Johnson 1989; López et al. 1997; Atran 1999).

The basic objective of ordination is to reduce multidimensional data sets to a lower number of dimensions to facilitate analysis. It does this by screening out redundant variables and retaining those characteristics of the data set that contribute most to its variance (i.e. compressing many measurements into a fewer number) (Höft et al. 1999). The statistical procedures for most types of ordination are computation-intensive, especially for large data sets, and hence one of the biggest limitations with this technique is the need for computers. The principal types of ordination applied to

TEK data are principal components analysis (PCA) and nonmetrical multidimensional scaling (NMDS).

In PCA, a multi-dimensional set of observations, usually consisting of correlated variables, is converted into a smaller linear-combination of uncorrelated variables. PCA is generally undertaken to identify patterns of grouping (i.e. similarity) of compressed data points as well as deviations (i.e. dissimilarity) of data points. Höft et al. (1999) propose that PCA applications for ethnobotanical research include: (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. When this type of analysis is performed on people (instead of item or attribute variables), it can be used to calculate the amount of shared knowledge as well as the degree of correlation of each subject's responses with those of the group, i.e. individual scores. In that sense PCA is very similar to CCM but the former uses a correlation matrix for the analysis while the latter is measured with the proportion of identical answers (adjusted to account for guessing or chance) between each pair of informants or with covariance (i.e. correlation of pairwise variances) (Weller and Baer 2002). In some of the studies reviewed here, PCA was employed as a supplement to CCM to test whether the data really conforms to a single underlying model of group consensus (i.e. a single-factor solution) (López et al. 1997; Atran et al. 2002a; Ross 2002a; Ross and Medin 2005).

NMDS arranges multidimensional objects in a low-dimensional space suitable for visualization in two- or three-dimensional graphic displays. The objects are reproduced in the graph to reflect the observed distances among them with the least amount of stress (i.e. deviation from real distance). Besides providing the researcher with a visual display of the clustering and dispersal of the objects in relation to each other, the objective here is to detect meaningful underlying dimensions that allow the researcher to explain observed similarities or dissimilarities between the objects. NMDS has several advantages over linear ordination: (a) it makes no assumptions of linearity, (b) it can be used with ordinal-scale data, and (c) the underlying dimensions of contrast come from the respondents' own judgments or answers. This technique has been used to study intracultural and intercultural variation of concepts of illness (Weller 1983, 1984; Garro 1988), specialist versus nonspecialist ethnomedical knowledge (Garro 1986; Zent and Zent 2007), cross-cultural ethnobiological taxonomic classifications (Boster and D'Ándrade 1989; López et al. 1997), agricultural management style in relation to acculturation (Heckler 2001), and comparison of knowledge about yellow-fin tuna between folk fishermen and fishery scientists (Miller et al. 2004). Unlike factor-based analyses (e.g. CCM and PCA), NMDS is especially useful for comparing specialist and nonspecialist knowledge because it shows data clusters or orderings on the basis of one-to-one or pairwise comparisons rather than one-to-all comparisons.

5.3.2.5. Diversity Indices

Diversity indices are quantitative tools that have been widely used in ecological research to measure species diversity and evenness in a community (Magurran 1988). Begossi (1996) proposes that ecological diversity indices have several potential applications for the study of the relationship between human populations and biodiversity: (a) to evaluate the breadth and intensity of resources used by particular

groups, (b) to facilitate comparisons between different groups in different environments, (c) to assess the adequacy of sampling effort, and (d) to determine the land area needs of a population based on the data of resources used. The literature review revealed that diversity indices have primarily been used in TEK research to characterize plant use inventories, the sole exception being Hardesty's (1975) measure of niche width which is focused on the total breadth and evenness of dietary resources.

The most commonly used indices include: Species richness, Simpson's diversity index, and the Shannon-Wiener diversity index. Species richness (S) refers to the total number of different species present without taking into account proportions or distributions in an area. This is the principal measure of diversity taken to calculate the famous species-area curve (i.e. increase of species per area sampled). A variation on the species-area curve, plotting the number of useful folk taxa or use types against the number of interviews or informants interviewed, has been utilized to evaluate the completeness of the sample and is considered important for quality control when comparing inventories across different groups (Hoffman and Gallaher 2007; see section 5.3.1.2). Simple counts of the inventories of useful plants is a common statistic reported in many ethnobotanical studies and these have been used to proxy the richness of knowledge and use habits among different groups (Figueiredo et al. 1993, 1997; Begossi et al. 2002; Campos and Ehringhaus 2003; Byg and Balslev 2004). S is sometimes calculated per individual and then plotted in the form of rank abundance curves to visualize the equitable/inequitable distribution of knowledge within a community (Benz et al. 2000; Byg and Balslev 2004; Ghimire et al. 2004).

The Simpson diversity index (D) represents the probability that two randomly selected individuals in a habitat belong to the same species. It takes into account the number of species present as well as the abundance of each species. The Shannon-Wiener diversity index (H') measures the uncertainty of predicting to what species an individual, chosen at random from a sample of S species and N individuals, will belong. Similar to the Simpson index, this measurement takes into account both species richness and proportions. When applying these measures to ethnobotanical data, the number of interview citations per taxa is substituted for species abundance. Both of these measures have been used, sometimes side by side within the same study, to compare the diversity of knowledge among different cultural groups as well as the diversity of plants used for different use categories (Benz et al. 2000; Figueiredo et al. 1993, 1997). Begossi et al. (2002) compared H' values between gender and age subgroups in a Caiçara community (Brazil) and was able to identify which subgroups had greater knowledge of diversity. In the same study, the authors also calculated rarefaction curves, a complementary measure to Shannon, to control for different sample size (see also Begossi 1996). The rarefaction method involves rarefying the samples to make them comparable by taking random subsamples of individuals of equal size from the total. Hardesty (1975) uses the Shannon-Wiener formula for calculating niche width according to the criteria of caloric significance, protein contribution, biotopic variation, and seasonal variation.

Similarity indices, such as Jaccard's index and Sorenson's coefficient, represent another set of ecological indices which have been utilized, though more rarely, in ethnobotanical research. The general purpose of these in ecological research is to measure beta (rather than alpha) diversity. Campos and Ehringhaus (2003) calculated the similarity of cultural uses of palms among different communities and the use specificity of species with the Jaccard index. Lozada et al. (2006) also used Jaccard to

measure the overlap of edible and medicinal species between sexes in a single community. In plot-based ethnobotanical inventories, the Sorenson coefficient of floristic similarity was calculated to establish floristic similarity/divergence between communities whose knowledge was being compared (Dewalt et al. 1999; Zent and Zent 2004).

5.4. From Variation to Process

The pattern(s) of TEK variation in space can be directly linked to the process(es) of TEK change over time through another set of methods and measures. Similar to the previous phases of inquiry, we find a great variety of methods being used to reveal the dynamic states and movements of knowledge in relation to historical shifts in the surrounding human and biophysical landscape. In addition to documenting the empirical trends of knowledge in different groups and localities, this body of work also addresses the major question of why knowledge changes or persists and what are the main environmental factors driving change or persistence. There are two basic approaches for documenting cultural knowledge change/continuity through time: a) longitudinal studies and b) cross-sectional studies.

5.4.1. Longitudinal Studies

Longitudinal studies entail the collection and comparison of time-series data, which may be before and after key events or interventions, at periodic intervals, or restudies of previously studied communities. Given the relatively short time constraints on most research projects as well as the lack of similar baseline or prior data sets in most places, it is not surprising that we are able to find few studies of this kind (thus far anyway). The only truly diachronic TEK studies that we are aware of are Zarger and Stepp's (2004) restudy of ethnobotanical acquisition among Mayan children in the community of Majosik' (Chiapas, Mexico), studied 30 years beforehand by Stross (1973), and van Etten's (2006) inventory of maize varieties among highland Guatemalan farmers which he then compared to inventories conducted in the same region by two separate researchers more than 60 years before his fieldwork. Surprisingly, both studies found remarkable persistence, rather than erosion, of knowledge despite several decades of progressive socioeconomic and ecological transformations in the study communities. These findings highlight the fact that TEK persistence rests upon an *active* process of intergenerational transmission that is not always destroyed or debilitated by changes in the surrounding environment (a point that I will return to later). But for most researchers, the only option has been to rely on indirect methods for inferring the transmission process.

5.4.2. Cross-Sectional Studies

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 TEK change or persistence from synchronic data. The basic strategy employed in this case is to study and measure the socially and spatially patterned variation of knowledge and practices within and between groups. A second step is to

examine the correlations of such variations with other social change indicator variables. A third step is to interpret the observed relationships by reference to the larger historical-ecological context. The overwhelming majority of empirical studies of TEK change and process conform to this type.

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 (see below). In studies of the ontogenetic development of knowledge acquisition, the array of individually recorded and scored knowledge types and amounts are indexed 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. This technique is widely used in developmental research on folk biological classification (Stross 1973; Dougherty 1979; Hunn 2002; Zarger 2002; Chase n.d.), naive biological reasoning (Hatano and Inagaki 1999; Keil et al. 1999; Ki-fong Au 1999; Coley 2000) and environmental attitudes (Cohen and Horm-Wingerd 1993; Harvey 1989; Howe et al. 1996; Kahn and Friedman 1995; Kellert 1985; Kellert and Westervelt 1984; Lyons and Breakwell 1994) in children. 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. It should be noted, however, that using age alone as the measuring stick for change can be problematic given that the normal learning curve leading from novice (e.g. child) to expert (e.g. adult) is also time- and age-dependent (Godoy et al. n.d.). For this reason, some researchers have cautioned that the knowledge-on-age trendline in a stable (i.e. nonerosional) situation should reflect gradual increments of change whereas trendlines displaying sharp breaks or noticeable tips are indicative of irreversible change (e.g. erosion) over time (Ross 2002a; Voeks and Leony 2004; Florey 2006). Another way of overcoming the explanatory limitations of age is to include additional change indicator variables in the analysis. Because age overlaps and interacts with other social variables (e.g. education, occupation, language(s) spoken), it can also be used as a control variable to isolate the impact of these on patterns of knowledge variation (Reyes-García et al. 2007). 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). The resulting trend lines over time can be used to identify the most endangered types of knowledge and even to project the estimated extinction dates if present trends continue (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 cropping or wage labor, material possessions, and travel experience (Wester and Yongvanit 1995; Godoy et al. 1998; Zent 1999, 2001; Byg and Sternberg et al. 2001; 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, such as 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, contacts with outsiders, habitat degradation, and nontraditional beliefs and values (Caniago and Siebert 1998; Benz et al. 2000; Ross 2002a; 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). Rocha (2005) attempts to measure traditional/modern attitudes in a systematic way by conducting structured interviews on people's views of community life and regional development and their personal roles in it as well as proper gender roles. Interestingly enough, he finds a strong positive correlation between traditionalism in such attitudes and conservation of traditional agro-ecological knowledge among Peruvian peasants. In some cases, the validity of some of the measures purported to proxy modernization/marginality may be questionable (e.g. housing type, straight-line distance to large towns). Moreover, few studies really attempt to consider a wide range of these indicator variables at the same time and investigate the correlations or interactions between them (but see Godoy et al. 1998; Byg and Balslev 2001a, 2004; Reyes-García et al. 2005a). In our opinion, the most convincing explanations of the impact(s) of environmental variables on TEK change are those that integrate careful measurement of specific variables along with a sensitive and more textured (i.e. qualitative) understanding of the overall context (social, historical, ecological) at the local as well as higher levels (e.g. Lawrence et al. 2005).

Another technique that has been used to adduce change from synchronic data is to gauge the discrepancy between oral statements of potential use and observed behaviors of actual use, based on the logic that usage, or practice-based knowledge, should be impacted before theoretical, or conceptually-based, knowledge but that decline of the former will foreshadow decline of the latter (Godoy et al. 2005; Reyes-García et al. 2005a, 2005b; cf. Kvist et al. 1995; Kremen et al. 1998; Shanley and Rosa 2004). Byg and Balslev (2001b), for example, found a credible gap between individuals' knowledge and uses of *Dyopsis fibrosa* (Arecaceae) as reported in interviews versus the actual use habits by the same individuals as observed by the researchers among villagers in eastern Madagascar. The correct interpretation of this discrepancy, however, still requires a sensitive appreciation of the local dynamics and motives of knowledge change and the contextual factors driving them. For example, Albuquerque (2006), interprets the knowledge of an abundant number of little-used medicinal plant species among rural dwellers of caatinga forest in northeastern Brazil as a strategy of diversification of therapeutic options, rather than passive erosion of knowledge, in response to acculturation pressures. Gazzaneo et al. (2005) report that cultivated and exotic species are the preponderate medicinal plants used by inhabitants of a sugarcane refinery land grant in northeastern Brazil due to extensive vegetational alteration and prohibitions on the exploitation of protected forest reserves. Paying attention to informants' statements about which uses are ancestral but no longer current may provide useful insights in this regard (cf. Figueiredo et al. 1993; DeWalt et al. 1999; Shanley and Rosa 2004).

5.4.3. Statistical Tests of Significance

In the literature review we came across a large number of different statistical procedures and tests that are used to explore the covariate and causal relationships between knowledge or practices and the surrounding environmental variables. The main ones include correlation, contingency tables, t-tests, analysis of variance, and regression, each one of which has variant forms. The conceptual and mathematical description of all of these would add considerable length and take us beyond the scope and purpose of the present review. It will have to suffice to simply advise the interested reader to consult a standard textbook on probabilistic-statistical methods for the social sciences and to point out that the operations chosen depend on the type of data collected and questions being asked. Principal data factors determining the choice of method include whether the data are measured as continuous or discrete values and whether the distribution encountered is normal (i.e. data points are distributed more or less symmetrically around the mean) or not. Some of the authors explicitly ran tests to determine normality or employed normalization techniques to transform their data in order to be able to use the more powerful parametric tests (Heinrich et al. 1998; Byg and Balslev 2001a; Kristensen and Balslev 2003; Voeks and Leony 2004; cf. Höft et al. 1999).

The methods used for testing differences between groups are of particular interest here because irreversible, as opposed to stochastic, change should be reflected at the collective level and because most historical and ecological processes affect entire local populations, or subgroups within populations (e.g. age groups, genders, socioeconomic class), rather than just certain individuals. In order to establish that significant differences between groups exist, it may be necessary to analyze patterns of knowledge variation within them as well. Weller and Baer (2002), for example, discuss various statistical procedures for analyzing within- and between-sample agreement and show how the proportion of shared vs. unique understandings about disease concepts among different cultural groups is directly related to the historical depth of their exposure to the disease in question. In several studies that were reviewed, the authors measured patterns of residual agreement (i.e. observed agreement minus predicted agreement) to explore within- vs. between-group differences. When within-group residual agreement was greater than between-group residual agreement, or if residual agreement is correlated with total observed agreement, this was interpreted as reliable evidence of group differences (see also Boster 1986a; López et al. 1997; Atran et al. 2002a; Ross 2002a; Ross and Medin 2005). The main techniques for testing the alternative hypothesis that groups are different were one-way analysis of variance and t-tests. Where socioeconomic variables could be measured on a continuous scale, regression was the preponderate method of choice. In that case, the test structure was set up with the latter as the explanatory variables and the knowledge score as the dependent variables. To our knowledge, no one has attempted yet to investigate the possible causal or positive feedback effects of TEK shift on other types of sociocultural change (Zent n.d.b). To do so would probably require a nonlinear analytical model as well as more complex statistical procedures than those currently in use (e.g. computer simulation).

5.5. Structure and Process of TEK Transmission

In addition to measuring the change/continuity of knowledge content and distribution over time, there is yet another approach to studying the processual dimensions of TEK that deserves mention. This approach focuses on the social organization, mechanics, and

contexts of intergenerational knowledge transmission, which has come to be recognized as a crucial component for long-term preservation (Nakashima 2005; Zent n.d.b). Several studies have explored the social relationships and channels through which knowledge is passed from individual to individual, and from generation to generation (Hewlett and Cavalli-Sforza 1986; Messer 1975; Murphy 1992; Ohmagari and Berkes 1997; Ruddle and Chesterfield 1977; Wilbert 2002; Zarger 2002). Different data collecting styles have been used to explore these relationships. The studies by Messer (1975), Ruddle and Chesterfield (1977), Murphy (1992), and Wilbert (2000) relied on the traditional anthropological techniques of participant observation and in-depth, informal interviewing of key informants. The results of this approach are richly detailed, normative, qualitative descriptions of the key relationships (e.g. grandmother-granddaughter, father-son, grandfather-grandson, female coresidents) that regulate the flow of different kinds of ethnoecological information (e.g. plant uses, food procurement tasks, phytotherapies) in diverse ethnographic settings. By contrast, Hewlett and Cavalli-Sforza (1986) and Ohmagari and Berkes (1986) used a more rapid appraisal, quantitative survey approach in their studies of Aka hunter-gatherers (Central African Republic) and Cree women (Canada) respectively. The method used there was to administer a highly structured interview schedule to a sample of respondents, asking them if and when (at what age) they had learned an inventory of traditional bush technical and social skills and from whom they had learned it. Analyzing the results statistically, they were able to provide a precise quantitative profile of the knowledge transmission process among the respective groups, specifying the specific category of knowledge, the age when acquired, and who taught it (see also Lozada et al. 2006). A third approach modeled the social networks through which ecological information is exchanged (Atran 1999, 2001; Atran and Medin 1997; Atran et al. 2002a). The method consisted of the following steps: (a) careful selection of a sample of respondents (all mature adults, evenly divided by sex, no one immediately related by kinship or marriage to anyone else in the sample), (b) elicitation of ranked lists of socially significant others, of most frequent interlocutors about forest matters, and of recognized forest experts, and (c) follow-up interviews with the highest and lowest ranked individuals appearing in the lists referred to above, eliciting their respective social interaction and forest expert networks.

Descriptions of the specific mechanisms by which knowledge is passed along or picked up provide unique insights into why TEK is maintained in some places and not in others. Good descriptions of the various “informal” (i.e. extrascholastic) learning modalities by which TEK is acquired can be found in the ethnographic accounts authored by Messer (1975), Ruddle and Chesterfield (1977), Borofsky (1987), Katz (1986, 1989), and Murphy (1992). These studies highlight careful, qualitative, detail-driven, and culturally-sensitive observation of the various forms of knowledge acquisition that appear in normal social and daily intercourse, a feat usually achieved through long term fieldwork and intimate contact with the study community (the main exception being Ruddle and Chesterfield whose fieldwork was relatively brief). The reports by Katz (1986, 1989) on the children of rural Sudanese herders and farmers is especially insightful in this regard. She reports that most environmental learning takes place by accompanying and assisting elders in their agricultural work activities (i.e. peripheral participation, cf. Lave and Wenger 1991) and describes a “pattern of integrated learning,” characteristic of other non-industrialized settings as well (see also Modiano 1973, Ruddle and Chesterfield 1977), consisting of “observation, instruction, imitation, instruction and correction, and supervised or guided practice [that] unfold in

succession (1986:46).” A less nuanced but more quantitative approach to documenting the prevailing local pattern of learning is exemplified in the Ohmagari and Berkes (1997) study. These authors included a multiple choice question about the stages or processes of the learning complex (hands-on experience, learned by observing only, and not learned), based loosely on the typology proposed by Ruddle and Chesterfield (1977), in their structured questionnaire. Obviously this is a quicker and more direct way to answer the question about local learning styles, and the quantitative method allows for statistical analysis, but it is also probably less reliable and in any case should be confirmed by the researcher’s own observations. Finally, Zent (n.d.) examines the impact of acculturation on traditional patterns of ethnobotanical knowledge transmission in relation to observed variation in knowledge content between age and community subgroups of the Joti Amerindians of Venezuela. This study combined structured interviews and statistical analysis of the results along with quantitative time allocation and informal participant observation methods.

5.6. Summary Evaluation of Methods Review

The foregoing review reveals an enormous variety of quantitative methods and measures employed to study the variation and change of TEK in different settings. It was emphasized that the best method to use depends to a large extent on the particular research problem and type of data being collected. A large number of the studies reviewed here in fact make use of a combination of various techniques. For purposes of the VITEK, many different combinations could be selected in theory. However, we consider that this choice needs to be limited in order to satisfy the goal of global applicability. We believe that the best approach for achieving widespread acceptance and sustained implementation is by engaging and empowering local community members to eventually carry out the data collection and analytical process on their own, which is to say a participatory, collaborative approach. As mentioned in section 2.3, the optimal use of the indicator and the assessment test on which it is based would be at regular time intervals (e.g. every 5 or 10 years) to produce true time series measurements. The ideal scenario for making this happen would be by giving the participating communities the training and capacity to manage the assessment on a self-sustaining basis (and use the results for their own purposes in addition to the global assessment). Unfortunately, many of the methods and calculations reviewed above are too complicated and/or laborious to expect that local people would be willing or capable of doing this over the long term without specialized and perhaps recurrent instruction. For these reasons, the best methods from the standpoint of the VITEK will have to be the most simple ones. Further justification of this approach is presented in section 7, which outlines the recommended methodological protocol.

6.0. Observed Trends in TEK Variation and Change

For a number of years, researchers of traditional peoples as well as representatives of indigenous groups and organizations voiced alarm about the rapid decay or extinction of slowly accumulated, locally-adapted ecological knowledge. However, most of these assertions were expressed in vague and generalized terms, supported by anecdotal or impressionistic observations, and were not backed up by hard evidence or precise information about the kinds, degrees, rates and causes of knowledge erosion (Plotkin

1988; Linden 1991; Schultes 1994a). But during the last couple of decades a very substantial body of work relevant to this topic has been carried out, though it is often dispersed among different publications focused more on other issues, resulting in a relatively rich empirical database from which concrete observations of general and specific patterns can be made.

Based on our review of this literature, one of the main overall tendencies that stands out across a broad range of situations is the dynamic complexity of TEK in space and time. At the local level, such complexity is marked by widespread sharing alongside internal variation, simultaneous continuity and change. In a large number of studies, we find descriptions of the local corpus of TEK as consisting of a spectrum of categories, valuations and practices which range from portions that are widely shared by a large fraction of society members to portions that are specific to certain subgroups or even individuals (Benz et al. 1994; Rocha Silva and Andrade 2006). This characteristic reflects the dynamic state of the knowledge system in the sense that access and participation in particular subsets of it depend on active processes of communication, learning, experience and experimentation that vary from individual to individual. In a similar vein, certain elements are regarded to be deeply ancestral, passed down from generation to generation over long time periods, while other elements are recognized as being acquired more recently, such as within the lifetimes of current members (Campos and Ehringhaus 2003). The derivation of the corpus from endogenous as well as exogenous sources highlights the inherently fluid and shifting nature of TEK, which may therefore be conceived as undergoing a continuous regenerative process encompassing a complex mix of replication, loss, addition, and transformation of constituent elements. The particular balance between the collective and the individual, and the old and the new, portions of the knowledge corpus varies considerably from site to site and to some extent provides a measure of its vitality and resilience. Viewed from a global perspective, we are confronted with a complex panorama of both convergent and divergent trends which are conditioned by multiple social and ecological factors. Precisely because our present picture of this reality is so complex and heterogeneous, a simplified and comparative indicator is needed.

6.1. TEK Erosion

The principal convergent process that can be identified from the existing data record is the widespread loss or erosion of TEK in many parts of the contemporary world. Solid empirical, often quantitative, evidence either consistent with or directly confirming the hypothesis of TEK erosion has been documented at numerous sites distributed among many different national, cultural, and eco-geographic contexts. Viewed at a national scale, we find clear indications of this trend occurring in the countries of: Indonesia (Caniago and Siebert 1998), Malaysia (Jarvie and Perumal 1994), Brunei (Voeks and Nyawa 2001), Thailand (Anderson 1986; Wester and Yongvanit 1995), Vietnam (Sowerine 2004), Papua New Guinea (Case et al. 2005), Guinea-Bissau (Frazão-Moreira, A. 2001), South Africa (Shackleton et al. 2002; Malaza 2003), Mozambique (Matavele and Habib 2000), Sudan (Katz 1989), Tanzania (Luoga et al. 2000), Kenya (Sternberg et al. 2001), Madagascar (Byg and Balslev 2001a), Canada (Ohmagari and Berkes 1997), the U.S.A. (Holloway and Alexander 1990; Timbrook 1990; Zepeda and Hill 1995; Nabhan 1998; Nolan and Robbins 1999; Grigorenko et al. 2004; Palmer 2005), Mexico (Benz et al. 2000; Ross 2002a, 2002b;

Ross and Medin 2005), Guatemala (Girón et al. 1991; Comerford 1996; Atran 2001), Honduras (Godoy et al. 1998), Brazil (Milliken et al. 1992; Begossi et al. 1993; Figueiredo et al. 1993; Voeks and Leony 2004; Monteiro et al. 2006; Shanley and Rosa 2004), Bolivia (Reyes-García 2005a, 2007), Peru (Boster 1986a; Phillips and Gentry 1993b; Rocha 2005), Colombia (Galeano 2000; Marulanda 2005), Ecuador (Byg and Balslev 2004), Argentina (Ladio and Lozada 2003, 2004; Estomba et al. 2006), Venezuela (Zent 1999, 2001; 2007; Heckler 2002; Wilbert 2002; Hoffman 2003), the Federated States of Micronesia (Lee et al. 2001), India (Navchoo and Buth 1990; Cruz García 2006), Nepal (Olsen and Helles 1997), Bhutan (Tenzin 2006), and Italy (Edwards et al. 2005). The biogeographic settings where this is happening encompass grasslands, deserts, woody savannas, tropical rain forests, swamp forests, temperate forests, boreal forests, circum-polar zones, high mountains, low mountains, coastal zones, coral atolls, and volcanic islands. The people being affected include indigenous ethnic groups, immigrant groups, mestizo groups, and multi-ethnic populations. The economic types run the gamut from farmers to hunters, collectors, trappers, foragers, fisherfolk, pastoralists, and mixed combinations of these. In sum, the great quantity and diversity of parallel case studies appear to provide empirical confirmation of the hypothesis of TEK erosion at a global scale.

6.2. Explanatory Variables of TEK Variation and Change

A wide variety of change indicator variables have been implicated as causing or correlating with the observed variations and changes in TEK levels. These include: age, gender roles, formal education, parental schooling, language shift, bilingualism, market involvement, imported technology, occupational focus, wealth, land availability, public economic assistance, sedentism, habitat degradation, useful species extinction, distance to forest or town, migration, travel, interethnic contact, availability of western medicines or health clinics, religious belief, and values change. However, the direction and strength of these effects on knowledge vary considerably across the different study sites and with respect to the specific domains or types of knowledge. Furthermore, those types of knowledge which appear to be most vulnerable and endangered in some localities are amazingly robust in other places.

6.2.1. Age

As noted above, age is the most common social variable used to evaluate the diachronic change or continuity of TEK. Significant differences in knowledge according to age group are usually interpreted as indicating change whereas the absence of such differences imply ongoing retention. The erosional process is often manifested locally as a marked gap in the numbers of taxa, uses, preparations, skills, ecological relationships, etc. known by older versus younger generations (Figueiredo et al. 1993, 1997; Phillips and Gentry 1993b; Caniago and Siebert 1998; Zent 1999, 2001; Luoga et al. 2000; Matavele and Habib 2000; Lee et al. 2001; Lizarralde 2001, 2004; Begossi et al. 2002; Heckler 2002; Ross 2002a, 2002b; Amorozo 2004; Voeks and Leony 2004; Case et al. 2005; Estomba et al. 2006; Monteiro et al. 2006). Age alone does not explain why knowledge change takes place so it is frequently analyzed in combination with other social and environmental variables (see section 7.3.2). In several case studies reviewed here, no significant differences between older and younger people's knowledge were

recorded but variable interpretations about whether knowledge decline had occurred or is occurring were made based on correlations with other dynamic variables or other available information (Byg and Balslev 2001a, 2004; Kristensen and Balslev 2003; Kristensen and Lykke 2003; Lykke et al. 2004; Lozada et al. 2006). For example, local informants' statements to the effect that "younger people know and work less than people did in the past" seemed to suggest the possibility that significant changes had already taken place in a more distant earlier time period (cf. Kristensen and Lykke 2003; Byg and Balslev 2004; Lozada et al. 2006). Some of the authors acknowledge that this result may also be explained by limitations in the research design, such as the way that knowledge is defined and measured or the size and composition of the study population sample (Lykke et al. 2004; Lozada et al. 2006).

6.2.2. Gender

Gender is an important social variable linked to dynamic processes of change because knowledge is usually unevenly distributed in accordance with gender-specific work, family and ritual roles and spheres of social interaction, and because socioeconomic development often affects men and women differently (Pfeiffer and Butz 2005). For example, in a number of studies women (especially older women) were found to possess greater knowledge of herbal remedies because they tend to be responsible for family and especially child health care (Begossi et al. 2002; Girón et al. 1991; Kainer and Duryea 1992; Figueiredo et al. 1993; Caniago and Siebert 1998; Nolan and Robbins 1999; Hanazaki et al. 2000; Wilbert 2002; Voeks and Leony 2004; Ross and Medin 2005). Among different rural communities of coastal Brazil, a few women are exceptionally knowledgeable about medicinal plants and therefore are considered key repositories of collective ethnomedical wisdom (Begossi et al. 2002; Voeks and Leony 2004). Caniago and Siebert (1998) report that among the Ransa Dayak of Kalimantan, Indonesia women are more familiar with the medicinal plants found in cultivated and early successional areas while men know more about medicinal species found in primary forest. Elsewhere Voeks (1996) has observed that disturbance species are often sources of ethnomedical innovation (e.g. introduced species) due to loss of primary forests and acculturation. Ross and Medin (2005) demonstrated that Tzotzil Maya (Chiapas, Mexico) women were able to free list more utilitarian plant taxa than men because their residence and work habits were less affected by recent changes. The special role of women for the transmission of knowledge about wild food and medicinal plants is recognized in some societies (Cruz García 2006; Lozada et al. 2006).

6.2.3. Language shift

Local language has been highlighted as crucially important for TEK preservation because much information about the environment is encoded in the lexicon, grammar and discourse (Crystal 2000; Nettle & Romaine 2000; Maffi 2001). Despite this importance, relatively few studies have attempted to measure the impact of language shift on TEK from a quantitative perspective. Where this has been done, the result has invariably been significant. Benz et al. (2000) showed that empirical knowledge about plant use is both more diverse and more evenly shared by the Huastec people of Mexico, who speak an indigenous language, in comparison with mestizo and Spanish-speaking indigenous populations in the Sierra de Manantlán, also in Mexico. The

authors suggest that even though traditional knowledge about plants suffered a decline that accompanied loss of the indigenous language in Manantlán, a considerable amount of such knowledge is able to survive the recent modernization process where it plays an important role in subsistence. In more controlled investigations, Zent (1999, 2001) and Reyes-García et al. (2005a) found that fluency in the national language was negatively correlated with ethnobotanical knowledge among the Piaroa (Venezuela) and Tsimane (Bolivia) groups respectively. Surveys of ethnobiological naming ability among different Native American populations still speaking the indigenous language as their first language and inhabiting a similar desert environment have produced contrasting results. Among the Tohono O’odham of the southwestern U.S., children could name only a small fraction of the common plant and animal species in their local environment that their grandparents could (Nabhan 1998) whereas among the Seri of Sonora, Mexico, youths registered no significant difference from elders in the lexical recognition of culturally salient and ecologically representative animal species (Rosenberg 1998). The differences may be attributable to the fact that O’odham youth no longer participate regularly in collecting expeditions and other subsistence activities and have little “hands-on” experience with their surrounding environment, due mainly to the commanding attention of school and television in their daily lives, while the Seri youth are still actively involved in the traditional activities (cf. Nabhan 1998; Rosenberg 1998). The fact that native ethnobiological names should be lost by indigenous mother tongue speakers seems to suggest that traditional environmental language is one of the linguistic domains that first suffers decay in a context of rapid cultural and ecological change and may be a prelude to more generalized language shift (cf. Hill 2001; Zent n.d.b).

6.2.4. Formal education

The variable of formal education is noteworthy because it often has an effect on the informal learning of TEK but that effect is not uniform from place to place. Several studies reported school achievement or attendance as negatively impacting types of TEK acquisition (Wester and Yongvanit 1995; Zent 1999; Sternberg et al. 2001; Grigorenko et al. 2004; Voeks and Leony 2004; Rocha 2005; Cruz García 2006). In other studies, by contrast, schooling is positively associated with higher knowledge (Byg and Balslev 2004; Reyes-García 2007) or shows no correlation (Godoy et al. 1998; Guest 2002). Where the relationship is negative, it has been explained as due to the fact that time spent in school detracts from the time children can devote to subsistence and other traditional activities or leads to devaluation of traditional knowledge (Sternberg et al. 2001; Cruz García 2006). Where the relationship is positive, it has been interpreted as the result of greater exposure to nonlocal in addition to local knowledge or greater opportunity to interact and share knowledge with others (Reyes-García et al. 2005a; cf. Brodt 2002). While the contrasting results may simply reflect distinct local realities, we should also be aware that reliable comparison across the different case studies is also problematic due to the fact that the research designs differ considerably in terms of the specific domains or subtypes of TEK investigated, the population samples selected, the data elicitation methods used, the ways that knowledge is measured, and the statistical analyses applied. It should also be recognized that schooling interacts with other social change variables, such as residence, literacy, language fluency, occupation, contact with outsiders and personal experiences, and these inter-variable interactions need to be probed or controlled

for to obtain a better understanding of how and where education influences TEK transmission.

6.2.5. Market Integration

Researchers have hypothesized that the transition from a subsistence to a market-based economy would have a negative impact on TEK because integration into external markets entails the specialized extraction or production of fewer goods, the substitution of local natural products and manufactures for imported ones, and the creation of greater socioeconomic heterogeneity, thus undermining the pooling of knowledge and resources (Godoy et al. 2005). Contrary to this generic expectation, where this relationship has been systematically tested the results have been inconsistent. For the Tawahka Amerindians of Honduras, Godoy et al. (1998) observed that integration into the market through the sale of agricultural crops or wage labor was associated with less knowledge of plants and animals and their interactions, but integration into the market through the sale of timber and nontimber forest products was associated with higher knowledge of wildlife. Among Tsimane' Amerindians of lowland Bolivia, Reyes-García et al. (2005a) found that distance between village and market town was correlated with higher agreement about plant uses, but after 50 km. the level of agreement declined. When village-to-town distance was controlled, other canonical market indicators such as cash income and material wealth showed no significant correlation with consensual knowledge. Vadez et al. (2004) examined the effects of markets on Tsimane' farming practices. Although farmers did intensify cash crop production, households and villages more integrated into the market planted more cassava and rice varieties, intercropped more, and put more crops in new fields than more subsistence-focused households.

Another set of studies has addressed the impact of markets on the perceived value of biodiversity for local groups. Among communities affected by the commercialization of timber and nontimber forest products, it has been observed that the market exerts a significant influence on species' quantitative importance values (i.e. more highly ranked species tend to have markets or commercial value) (Pinedo-Vasquez et al. 1990; Shanley and Rosa 2004; Lawrence et al. 2005). At the same time, such valuations differ according to the type and degree of dependence on market activities. Lawrence et al. (2005) compared the valuation of forest plant species among immigrant and indigenous communities in lowland Amazonian Peru. They found that immigrants nominated more species deemed to be valuable than did Indians but the former group placed higher value on commercial timber species while the latter group tend to value more the species used for food, nontimber trade products, and noncommercialized construction materials. In communities with greater access to markets, over-exploitation of the most valuable species and alternative livelihood options contribute to a decrease in the perceived value of the forest. Shanley and Rosa (2004) examined the valuation of local species by Caboclos in a forested area of the lower Amazon, Brazil characterized by the decline of nontimber forest product trade and the rise of commercial logging in recent decades. They found that young people and employees (and their families) of the logging companies place higher value on the commercial timber species while older and economically independent people tend to emphasize nontimber (i.e. technological, medicinal) species.

6.2.6. Western Medicines

Even though a majority of the world's population depends partially or entirely on traditional medicine for most of their health needs (King 1996), western biomedical technology (i.e. pharmaceuticals, vaccinations, health clinics, paramedics, physicians, hospitals) has spread to nearly every corner of the world in the past several decades and constitutes a major agent of biological and sociocultural change. The influence of this factor on TEK change is felt most directly in the domain of ethnomedical knowledge. Some investigators regard medicinal plant knowledge to be especially sensitive and vulnerable to sociocultural change, often with deleterious consequences for the health status of the affected populations because of the costs and difficult access of modern medical care (Phillips and Gentry 1993b; Plotkin 1993; Anyinam 1995; Cox 2000; Vandebroek et al. 2004; Case et al. 2005). While the data record demonstrates that ethnomedical knowledge and practice continues to be important for many rural communities, in a number of areas the rich aboriginal ethnopharmacopoea is nevertheless diminishing from the collective memory as a result of modernization impacts (Furtado et al. 1978; Figueiredo et al. 1993; Phillips and Gentry 1993b; Caniogo and Siebert 1998; Galeano 2000; Matavele and Habib 2000; Ugent 2000; Ghimire et al. 2004; Voeks and Leony 2004; Case et al. 2005; Estomba et al. 2006; Monteiro et al. 2006; Zent and Zent 2007). Local manifestations of this degenerative trend include the intergenerational knowledge gap referred to above (section 6.2.1) as well as the rarity or disappearance of specialist healers in the community (Begossi et al. 2002; Case et al. 2005; Lozada et al. 2006; Monteiro et al. 2006). The role played by western medicines and health clinics in TEK erosion goes beyond merely replacing traditional remedies as health care options since they are also linked with other factors of social and ecological change, including population growth, migration, settlement pattern, trade, religion, and values change (Etkin et al. 1990; Anyinam 1995; Vandebroek et al. 2004). For example, among the Piaroa of the Venezuelan Amazon, the establishment of state-sponsored biomedical programs and services in frontier zones has helped to induce downriver migration, settlement nucleation, interethnic contact and acculturation in a large proportion of the population since the 1970's. This transition is in turn associated with the loss of traditional ethnomedical knowledge among younger members which also reinforces dependence on the healthcare provided by the government (Zent 1993; 1997).

While the intergenerational gap in ethnomedical knowledge referred to above is the more common situation, some local groups display no significant differences between older and younger people and therefore it would appear that their knowledge is not undergoing noticeable decline (Kristensen and Balslev 2003; Kristensen and Lykke 2003; Lykke et al. 2004; Lozada et al. 2006). It is interesting to note, however, that the respective authors cited here invoke different contextual as well as methodological factors to explain the unexpected parity across age groups. The studies by Kristensen and Lykke (Kristensen and Balslev 2003; Kristensen and Lykke 2003; Lykke et al. 2004) were carried out among different communities of the Gourounsi people in the Sahel region of Burkina Faso. Even though the region is characterized by increasing demographic pressure, socioeconomic change and habitat alteration, they found that inventories of medicinal and other useful woody plants do not differ appreciably by age or gender, but do so by community. They wrote that this result may be partially explained by three factors: (1) floristic diversity is relatively low in the Sahel and thus non-specialist knowledge is limited and quickly learned, (2) questions on use-categories

were relatively broad (e.g. the medicinal category was not disaggregated), and (3) the study area is poor and relatively isolated, few people have been to school (Lykke et al. 2004). The study by Lozada et al. (2006) took place in a rural mestizo community in northwestern Patagonia, Argentina. They recognize that the indifference of knowledge distribution by age or sex departs from the pattern observed in other communities within the same region (cf. Ladio and Lozada 2001, 2003; Estomba et al. 2006) and attribute this distinctive result to: (a) the relative homogeneity of knowledge of wild plants in this population, (b) the possibility that significant innovations could have occurred in previous generations but the situation has since become more stable, and (c) the small sample size.

The dynamic status of ethnomedical knowledge is reflected as well in case studies suggesting the historical acquisition of nontraditional herbal remedies in substitution of native ones. For example, in some localities a large proportion of the local ethnopharmacopoea is made up of exotic species or species harvested from anthropogenically disturbed habitats (i.e. cultivated or secondary growth areas) (Albuquerque 2006; Caniago and Siebert 1998; Begossi et al. 2002; Rocha Silva and Andrade 2006; Rossato et al. 1999). In sum, we find different scenarios of ethnomedical TEK change, not all of which can be reduced to a simple unilineal process of loss over time.

6.2.7. Habitat Degradation

The loss of natural habitats or extinction of species due to human activities has been identified as an important cause of TEK variation and change in some studies. Rocha Silva and Andrade (2006) measured and compared the cultural significance indices of useful plants in several communities of northeastern Brazil. They recorded higher indices of introduced versus native plants in relation to degree of deforestation and proximity to urban areas, thus indicating that loss of knowledge about native species was caused in part by deforestation of the Atlantic forest ecosystem. Meanwhile among Caboclo communities who inhabit another region of northern Brazil that is suffering a similar process of deforestation, researchers recorded testimony of older informants who lamented the present day scarcity or disappearance of formerly highly valued plant species and game animals. Thus use decline in this area is mainly being caused not by loss of interest but rather by habitat conversion and local tree extinction (Shanley and Rosa 2004). Among the Gourounsi of Burkina Faso, the use rank profiles of woody plants for villages in areas with much greater human and livestock activity grouped close together on ordination diagrams while villages located in less exploited areas formed another cluster group. This same division was repeated with regard to villagers' perceptions of declining trends of these species, thus confirming that use valuations are influenced by vegetation dynamics related to environmental conditions and human impact (Lykke et al. 2004).

6.2.8. Migration

Immigrant populations are often considered to have less detailed, accurate and adaptive knowledge of their surrounding lands than long-resident indigenous groups. This assumption was put to a test by Atran and colleagues by comparing ecological

knowledge, beliefs and practices for two immigrant groups (Q'eqchi' Maya, Ladino) and one native group (Itza' Maya) in the Petén forest of northern Guatemala (Atran and Medin 1997; Atran 2001; Atran et al. 2002a, 2002b). The results of their research confirm that the native Itza' do indeed exhibit much greater knowledge and awareness of ecological complexity involving animals, plants and people as well as use and management practices favoring forest regeneration in comparison to the immigrant groups. However, they also found that the Spanish-speaking Ladinos are closer to the native Itza' in thought and action than the Q'eqchi'. The researchers suppose that the main reasons that the Ladinos have adapted better to this environment are closer contact with the more knowledgeable Itza' and similarly diffuse patterns of social networking, which allow for more fluid flow and exchange of information across social boundaries. Meanwhile the more conservative and cooperatively-organized Q'eqchi maintain a cultural model of nature and resource management derived from their aboriginal highland heritage. This study demonstrates the variable capacity of immigrant groups to pick up new ecological knowledge rather quickly which is conditioned by patterns of social organization and communication.

The exchange and absorption of folk knowledge between groups in dynamic contact situations has also been explored by comparing the ethnobotanical inventories and use patterns of indigenous versus nonindigenous groups. Some nonindigenous or colonist groups display large inventories of useful plants that compare favorably with the inventories of indigenous groups occupying similar ecoregions (Pinedo-Vasquez et al. 1990; Phillips et al. 1994; Rossato et al. 1999; Galeano 2000; Lawrence et al. 2005). Campos and Ehringhaus (2003) compared the use of palms among two indigenous communities (Yawanawá and Kaxinawá) and two folk communities (rubber tappers and ribeirinhos) in southwestern Amazonia (Brazil) and, as expected, found that the indigenous groups know significantly more about palm uses than the folk groups. However, they also found that substantial percentages (20-30%) of the uses cited by the indigenous groups were considered to be nontraditional uses acquired through contact with the colonists.

6.2.9. Values Change

Several studies have pointed to changing values and beliefs as an important reason for TEK erosion or change. Among tribal and nontribal groups of Western Gats, India the knowledge and consumption of wild food plants is declining mainly because of the social stigma attached to these low-status food types. Both mothers and their children expressed shame at having other people see them collecting wild food plants even though they recognize these foods to be healthy and nutritious (Cruz García 2006). Among the Dusun of northern Borneo, young people consciously avoid learning medicinal species because they believe that this domain of knowledge connects them to the primitive lifestyle of their parents that they are seeking to overcome (Voeks and Nyawa 2001; see also Caniago and Siebert 1998). For the Manus of Papua New Guinea, one of the effects of religious missionization was to discredit the authority and prestige of native healers. This in turn is linked with the loss of specialized ethnomedical knowledge (Case et al. 2005). In the case of the Lacandon Maya of southern Mexico, Ross (2002a) found that younger adults had significantly less intricate knowledge of ecological complexity, expressed in terms of plant-animal interactions, than older adults. He traces this degradation to a clear shift in their social orientation as well as

fundamental differences in their views of the spiritual and ceremonial composition of the world. Estomba et al. (2006) link the decline of native medicinal plant use to corresponding decline of the aboriginal medical cosmovision in a Mapuche community in northwestern Patagonia, Argentina, in noting the low citation of cultural syndrome ailments and the fact that an exotic plant species is the most commonly recognized cure for them.

6.3. TEK Persistence, Transfer and Creation

The preceding sections highlighted the pervasive erosion of TEK in many rural localities around the world and the principal drivers but also emphasized the complex and variable nature of this process and mentioned some examples where this trend is not clearcut. Adding to this complicated picture, there are a few important case studies which have registered the persistence, transfer or even addition of TEK in societies undergoing cultural, economic, and ecological changes. As mentioned earlier, Zarger and Stepp (2004) report finding no significant differences in plant naming ability by age among Tzeltal Mayan children in the community of Mahosik' between 1968 and 1999 despite the fact that numerous sociopolitical, economic and environmental changes had occurred. The authors explain this surprising result by noting that the basic subsistence system and routine activities of children have not changed very much in the 30 year interval between the two studies.

Kristensen and Lykke (2003; see also Kristensen and Balslev 2003; Lykke et al. 2004) found no direct evidence that knowledge of medicinal and other useful woody plants is eroding among the Gourounsi group of the Sahel region of Burkina Faso despite the fact that the region is marked by increasing demographic pressure growth, socioeconomic change and habitat alteration. They attribute this result to the people's strong sense of pride in their traditions and their preference toward using natural resources instead of introduced exotic crops and industrial substitutes.

Byg and Balslev (2004) investigated processes and factors affecting people's knowledge and use of palms among indigenous and nonindigenous residents of the Andean foothills in southeastern Ecuador. This study produced no statistically significant indications that knowledge loss is occurring among the indigenous Shuar although the Shuar's own anecdotal perception is that erosion has taken place among the younger generation. Moreover, they found evidence of knowledge transfer from the Shuar to nonindigenous colonists and among the Shuar themselves. By contrast, they also identify village remoteness, marginality and lack of access to modern goods and services as factors that are associated with more knowledge.

Guest (2002) examined the knowledge of shrimp ecology in a fishing community on the northern coast of Ecuador that has been changing rapidly as a result of road construction and the subsequent influx of people and technology, integration with the national economy, and adoption of shrimp mariculture. He found that the local inhabitants had acquired in a relatively short amount of time new knowledge about shrimp which was not correlated with age, gender, education or years of residence in the community but instead was explained by the length of their experience in shrimp farming.

One of the most complete and sophisticated studies of the TEK erosion/change process up until now was carried out by Reyes-García and colleagues among Tsimane Amerindians of lowland Bolivia, the results of which have been reported in the lead author's dissertation (Reyes-García 2001) and a series of follow-up journal articles (Reyes-García et al. 2003, 2004, 2005a, 2005b, 2006a, 2006b, 2007). In one paper (Reyes-García et al. 2005a), they analyzed the impact of three market-related explanatory variables (village distance to market town, cash income, and household wealth) and three acculturation-related explanatory variables (school grade, father's school grade, and fluency in the national language) on folk knowledge of useful plants, which was measured as a function of agreement among informants. The tests of significance carried out for the different variables produced inconsistent, and therefore inconclusive, results regarding the impact of acculturation or market integration on plant use knowledge. Thus, in reference to the proxy variables of acculturation, schooling was positively correlated with higher consensual knowledge while national language fluency and father's schooling was negatively correlated. With respect to the proxy variables of market integration, distance from a market town was associated with higher knowledge but when distance was controlled, neither income nor wealth showed significant correlation. The authors' interpretation of these results is that schooling may foster greater agreement due to common education and greater interaction with each other while market participation may entail different activities, some of which decrease dependency on the forest (e.g. wage labor) while others increase dependency (sale of forest products). In another paper (Reyes-García et al. 2007), they compared theoretical ethnobotanical knowledge of plant use (i.e. multiple choice test regarding possible uses of particular species) with ethnobotanical skills (i.e. reports of having manufactured items from plants) and found only a weak association between them and higher variation in regards to skills. They also tested for the effects of participation in wage labor and in sales of farm and forest products on these two classes of ecological knowledge and found that the former activity is associated with fewer ethnobotanical skills (but not lower theoretical knowledge) while the latter activity is associated with greater theoretical knowledge and skills. The authors conclude that some but not all market-related activities (in this case wage labor) may erode local ecological knowledge and that practical skill knowledge or actual use will be more vulnerable. In comparing the general results reported in these two papers, we may well conclude that the results obtained about TEK variation and change depend a great deal on what types of knowledge and what explanatory variables are chosen for study and how they are measured.

6.4. Complex Results and Methodological Variance

The body of research on TEK variation, change and continuity reviewed here has advanced our understanding of the current state and trends of TEK in many parts of the world through the reporting of richly detailed empirical data and systematic analysis of the significance of different environmental variables. A main conclusion that can be drawn from a collective reading of this work is that TEK erosion is a widespread trend but also that it is not universal (and therefore not inevitable). Moreover, where the hypothesis of erosion is supported by the available data, the particulars of this process – i.e. rate of decline, types of knowledge being lost, persons affected, and conditioning factors - vary considerably across groups and sites. While the variability of results strongly suggests the culture- and site-specific nature of this process, it should also be

pointed out that this may also be partly due to the different research designs and methods used. The ways that knowledge is defined and measured, the sampling selection, and the variables included in the analysis influence the research outcomes and conclusions. Most individual studies of TEK variation and change are limited to single communities or ethnic groups, or occasionally encompass several communities within the same local area, and are focused on particular, often narrowly defined, knowledge domains to the exclusion of others. There are very few investigations where the same exact method and sampling strategy has been applied to diverse settings and in the few cases where comparative analyses has been attempted it is realized in a post hoc fashion. Clearly the lack of methodological uniformity inhibits comparability and constitutes the main impediment for a more simplified comprehension of the complex empirical reality. It is precisely because of this lack of systematic comparability that we consider that the preexisting data sources cannot be used reliably to develop the TEXVI. Instead, the indicator will require the design of a standardized data instrument and the collection of primary data through its application in different localities.

7.0. Protocol for VITEK Assessment

The VITEK assessment is intended to provide a quantitative measure of the vital status (retention/change) of TEK that is both (potentially) applicable at a global scale and also appropriate and representative of this dynamic process at the local scale. This means that the assessment method design must be sufficiently comprehensive so as to permit replication and comparison across diverse cultural and ecological contexts while at the same time specifically tailored to the local categories, priorities and codes of conduct held in a particular place. A primary conclusion of the literature review is that the development of the global indicator cannot be based on existing data sources because of the lack of uniformity and comparability between them. The differences in topical focus, field methods, sample design, statistical operations, and data sets are simply too great to expect that they can somehow be converted into a single type of measure. The only viable strategy, in our opinion, is to start from scratch as it were and begin the indicator with the collection of primary data in the field. The goal of producing comparable measurements necessitates the elaboration of a standardized methodological framework. In this section, we elaborate a uniform protocol (i.e. steps and procedures) for collecting data in the field and converting them into quantitative measures. Besides comparability and appropriateness, the main criteria used for the VITEK method design are: reliability, robustness, data quantification, aggregability of measures into larger units of analysis, simplicity of use, time efficiency, low cost, and easy reporting. We believe that these parameters offer the best chance for reaching a workable and meaningful indicator that gains a wide level of acceptance and sustained use over time.

Although emphasis is placed on the importance of a uniform protocol, at the same time we are fully cognizant that no two field situations are alike and that some flexibility will have to be incorporated into the research design in order to achieve global applicability. Flexibility is built into the method in two main ways. First, we maintain a flexible approach to the procedures used to collect the baseline data from which test items will eventually be drawn. The protocol is intended for use and application by multiple other actors who have an interest in assessing TEK vitality and change, such as public agencies, conservation organizations, scientific researchers, and

local communities. It should be expected that the specific objectives, means, and criteria of the diverse parties, as well as the situations they encounter, will vary somewhat and therefore exact procedural replication in every place will not be realistic. While we make specific suggestions in regards to the methods that can or should be used to complete different steps, we also allow the field research team some room to either follow them or choose an alternative which will lead to a similar result. We particularly stress the use of participatory rapid appraisal (PRA) techniques, such as focus group discussions and local consultant-generated data sets, because of the general ease, efficiency, emic faithfulness and open-endedness associated with these procedures (Martin 1995). At the same time, we recognize that more sophisticated (and costly) techniques, such as informant-indexing measures (Phillips and Gentry 1993a), cultural consensus analysis (Romney et al. 1986), principal components analysis (Atran et al. 2002a), and quantitative behavioral sampling (Zent 1996), may be used as long as the goal is to produce the same kinds of data. Thus, the method is designed to be flexible in a procedural or tactical sense but without compromising the overall structural design. Second, we admit some flexibility with respect to the data coverage. We propose that a core set of domains or topics of data be documented and tested, but we also recognize that it will not always be possible to include all of these either because of non-applicability (e.g. agricultural knowledge among forager groups, Hunn 1991), cultural privacy sanctions (e.g. taboos on talking openly about ethnomedical practices, Edwards et al. 2005), or absence or reluctance of key informants.

The proposed VITEK protocol is described and justified in the following sections. The purpose here is to lay out the different steps that should be followed to carry out the assessment. These are outlined as follows:

1. Project description and previous informed consent
2. Constructing the Data Register
 - Defining constituent domains of TEK
 - Making an inventory of TEK Items
 - Assigning weights to domains and categorical items
3. Testing Instrument
 - 3.1. Test design
 - 3.2. Sample population selection
 - 3.3. Test administration
 - 3.4. Test evaluation and scoring
4. Vitality Index
 - 4.1. Calculating the Vitality Index
 - 4.2. Significance Tests
 - 4.3. Vitality Index Aggregation and Disaggregation

7.1. Project Description and Previous Informed Consent

The VITEK design contemplates the collection of primary data in the field and therefore its implementation should comply with standard ethical and legal codes of conduct related to such activities. As with other kinds of human subjects research, the first step is to inform the participating or candidate communities about the scope and aims of the research operation and obtain their prior informed consent (PIC). Ideally this should be done by both written and oral forms of communication. A written

statement should be prepared in which the nature, purpose, methods and procedures, estimated chronology, participating individuals or groups, financial support, confidentiality provisions, possible risks, benefits, and foreseeable outcomes of the project are clearly explained. It is highly recommended that the project description also be communicated orally in the context of a public meeting or some other locally acceptable venue, thus giving the local people a chance to raise questions, express their concerns, negotiate the terms of their cooperation, or decline to participate. In situations where all or some community members speak a local language as their first language, a competent translator should be used to enable effective communication. If the community agrees to participate, they should be asked to sign a voluntary PIC form or to provide some other written notification indicating their consent, such as a letter signed by the community leader(s) or various members. PIC should also be obtained in a similar manner from all individual participants whose knowledge is recorded or tested as part of the project. Although the VITEK is not intended for any sort of commercial application, nevertheless it is recommended that the PIC documentation include contractual agreements specifying rights and responsibilities in regards to intellectual property, benefits sharing, information disclosure, access and use of genetic resources, or any other topic having legal implications. In some places, research permits will have to be obtained from local or national governmental authorities. Established procedures for securing the necessary permissions should be duly followed.

Once the necessary permissions are obtained, the local research team in consultation with community leaders and members should devise a plan and schedule for carrying out the assessment process. The protocol described here stresses a participatory approach in all phases of the process and therefore we strongly recommend that one or more members of the community be incorporated into the research team and trained in all methodological aspects, from data collection to analysis, management and reporting of the results. One of the objectives of the initial assessment is to build local capacity for repeating the assessment test at future dates and using this information for their own purposes.

7.2. Constructing the Data Register

The first step toward assessing TEK vitality is to construct a data register or inventory of conceptual categories and items that represent a significant portion of the local body of knowledge. The register will comprise the baseline data from which a testing instrument for measuring TEK status and trends will be developed. The sheer size and complexity of any single knowledge system is so vast that it is likely impossible to achieve a complete inventory of everything everyone knows. Plus the time and cost needed for the assessment should be minimized if the objective of wide application is to be attainable. In view of these limitations, the register will have to consist of a mere sample of key categories and items. The purpose of the register therefore is not to document the full richness and depth of the knowledge system but rather to identify certain representative elements of it upon which the test and measurement will be based. Such elements should serve as key indicators of the larger system of which they are a part.

The basic method for constructing the data register relies primarily on rapid participatory appraisal techniques (Martin 1995; Chambers 1997), especially the

consensual consultation with local group members in the context of collective gatherings (cf. List 2001). Exploratory consulting events can range from larger public meetings to smaller focus group discussions to reviews by a locally designated “council of experts.” Although this technique may not be as systematic or controlled as structured surveys or interviews (see sections 5.3.1 and 5.3.2; e.g. Phillips and Gentry 1993a), we consider that the advantages outweigh the disadvantages given the constraints mentioned above. It is more participatory, interactive, and dynamic in the sense that it permits iterative discussion, feedback and negotiation among the participating consultants. It is relatively fast and efficient in that it bypasses a laborious phase of interviewing numerous individuals and performing complex statistical analysis of their answers. It prioritizes local criteria by letting the consultants themselves to decide directly what categories and items are correct, representative, and relevant. Although this method tends to bring out more generalist as opposed to specialist type knowledge, the latter can be incorporated by supplementing the larger meetings with smaller focus groups of resident experts or even individual interviews with recognized experts if they cannot be brought together. In any case, we recommend that the consultation process consist of triangulation of different meetings with different groups. In particular, separate consensus groups by gender will be needed because of the common tendency of women to defer to men in public arenas in many societies and because the test design depends on this division (see sections 7.2.1, 7.2.2, and 7.3).

7.2.1. Defining Constituent Domains of TEK

Even though TEK is frequently portrayed as holistic and totally integrated with virtually all aspects of daily life, empirical investigations of numerous cultural systems of knowledge and practice over the past half century have quite convincingly demonstrated that it is highly structured and organized (Conklin 1954; 1957; Zent n.d.a). As with other aspects of cultural creation, TEK is structured at cognitive and behavioral levels into distinct domains (or subsets) and these may be further differentiated into smaller subdomains and so on (D’Ándrade 1995). For example, the classification of environmental phenomena can be divided into the domains of plants, animals, rocks, soils, landforms, vegetation types, land use types, and weather patterns (Ellen 1982). The plant domain can, in turn, be further divided into more circumscribed domains according to some shared distinctive feature(s) of meaning, such as: morphological aspect (e.g. tree, vine, herb, etc.), use category (e.g. food plant, medicinal plant, etc.), or habitat (e.g. garden plant, forest plant, etc.). In a similar vein, subsistence practices can be analyzed in terms of distinct activity sets, such as farming, hunting, fishing, food preparation, curing, toolmaking, etc. Even while the boundaries between domains are not always clear and one may point to multiple connections between them (e.g. the dual significance of many plant species as food and medicine, Etkin 1986), it is still possible to discern the reality of different domains in thought and practice. Many of the ethnoscientific methodologies developed for the study of TEK phenomena (described in section 5.3.1.1) are, in fact, based on the implicit assumption that structured domains are psychologically real. The domain structure of the knowledge system is a fundamental property that needs to be taken into account if the assessment is to be representative. However, a complete inventory of all knowledge domains is impractical (if not impossible) due to time and cost constraints and therefore limits will have to be set on the total range of possibilities (see below, same section).

As mentioned above, the primary challenge for developing a globally applicable, locally appropriate indicator is to strike an effective balance between universal and culturally-specific formulations of knowledge. The framework for domain selection will be crucial for achieving this balance. Some cultural domains are purported to be universally recognized (e.g. ethnobiological taxonomies, food taboos) while others are very restricted or culture-specific (e.g. Micronesian navigation techniques). However, this distinction often boils down to differences in the level of abstraction at which the category is defined. Our solution to this problem is to define relevant domains of TEK at two basic scales: cosmopolitan and local. The cosmopolitan scale refers to domain and subdomain categories that are loosely recognizable in many different cultural and ecological contexts around the world based on our reading of the TEK literature. Some of these may be truly universal in the sense of being found everywhere (e.g. plant and animal taxonomies) while others are preponderant but not universal (e.g. soil classification, which may be absent among nonagricultural groups). In any case, it should be understood that the domains identified at this scale are defined according to a global or intercultural frame of reference, are culture-free to the extent that is possible, and therefore are very broadly conceived. At the local scale, we refer to culturally-specific semantic domains and categories as defined and recognized by the local group. The testing and measurement of TEK must be based on emic (i.e. insider) categories of the knowledge system in order to be representative and reliable. It is expected that not all of these categories will be directly comparable across groups nor will there be a perfect one-to-one correspondence to domains defined at the cosmopolitan scale. Therefore a clear procedure for relating one scale to the next is required.

The VITEK method involves preselecting a general set of domains (i.e. the cosmopolitan domains) as a first step and then adapting this set to specific locally recognized domains through consultation with local group members. The process of consultation entails reviewing the list of preselected domains with a sample or group of community members and recording the closest equivalent local term(s) or concept. If no verbal equivalent can be determined, the research team attempts to confirm whether or not the category is somehow salient and understandable for them. In order to balance efficiency with accuracy, we recommend that the consultation process be carried out with one or more focus groups of locally-elected or recognized TEK experts. A more time-consuming alternative would be to conduct the reviews with individuals and then take their consensus opinions. Although we consider that adequate translation from one level to the next is indispensable, we also maintain a flexible position with regard to how this is done.

To allow for the fact that some domains of knowledge and practice are sharply divided along sexual lines, another key aspect of the domain verification and adaptation process is to record which domains are considered to be male- versus female-dominated or are not gender-differentiated. This distinction will be important for constructing appropriate tests for each group. Categorical items within each inclusive domain should also be classified in these terms. To accomplish this task, we recommend that both men and women be included in the initial group consultation process. The results should then be confirmed (or modified) through a second consultation phase involving men-only and women-only focus groups.

The set of cosmopolitan domains is presented in table 7.1. Given the need to establish manageable limits on the size and scope of the indicator, the list gives priority

to those which are most closely related to biodiversity, the appropriation and utilization of natural resources, and culturally significant elements of the environment. These criteria are determined by the VITEK's overall goal of providing a cultural indicator that can be used and integrated with other indicators of biodiversity to advance global environmental assessment and policy-making. Additional criteria for the selection was broad-based (i.e. multi-site) treatment of these topics or related topics in the empirical TEK literature and demonstrated use of structured methodologies for their study. The resulting list is therefore intended to cover some of the major areas of TEK that have been documented by previous work in this field and that reflect the unique relationship between diverse human groups and their habitat, including knowledge and practices dealing with biological entities (plants, animals, biotic communities), ecological relationships, soil, climate, and land. The organization of the list is explicitly hierarchical and consists of four distinct levels. From higher to lower inclusive levels, these are: component, primary domain, secondary domain, and tertiary domain. The terminology given here is arbitrary and merely employed to be able to distinguish clearly one level from the next. This is important because the hierarchical domain structure is maintained throughout all phases of the test design and index calculation (sections 7.3 and 7.4).

The first level of the domain classification made here subscribes to the basic distinction made by Reyes-García et al. (2007) between theoretical knowledge and practical knowledge although we refer to the former as conceptual knowledge and the latter as practical skills. Conceptual knowledge is understood here as “know-what” (i.e. referential knowledge about the world encoded in abstract mental concepts) while practical skills is essentially “know-how” (i.e. performative knowledge embedded and expressed through concrete behavioral activity). While this dichotomy may not correspond to any locally recognized formal classification, we feel it is justified by the generalized findings that ideas do not always match actions and that the learning processes and responses to change involving these two forms are somewhat different (Godoy et al. 2005; section 5.4.2). We have chosen to refer to this level of categorical contrast as “components” to reflect the fact that it is a distinction made entirely by an outside observer and probably has no conscious meaning for local actors whereas we are expecting that the “domains” identified here should often (but not always) have local salience.

Table 7.1. Cosmopolitan Domain List

- I. Conceptual Knowledge
 1. Plant domain
 - a. taxonomic names and identifications
 - b. cultural use or significance
 - i. edible
 - ii. medicinal
 - iii. construction
 - iv. technological
 - v. fuel

- vi. commercial
 - vii. ornamental-artistic
 - viii. spiritual-ritual
 - ix. other
 - c. characteristics (e.g. morphology, behavioral habits, life cycle traits, habitat)
- 2. Animal domain
 - a. taxonomic names and identifications
 - b. cultural use or significance
 - i. edible
 - ii. medicinal
 - iii. labor
 - iv. technological
 - v. fuel
 - vi. commercial
 - vii. ornamental-artistic
 - viii. spiritual-ritual
 - ix. other
 - c. characteristics (e.g. morphology, behavioral habits, life cycle traits, habitat)
- 3. Plant-Animal Relationships
 - a. type of relationship (e.g. food source, shelter, protection, dispersal agent)
 - b. effect of relationship (beneficial/harmful/neutral)
- 4. Biotopes/Landscape units
 - a. names
 - b. characteristics (e.g. elevation, topography, edaphy, architecture, indicator species, disturbance agents, etc.)
 - c. cultural use or significance
- 5. Soil domain
 - a. names
 - b. characteristics (e.g. color, texture, fertility)
 - c. cultural use or significance
 - d. crop suitability
- 6. Climate domain
 - a. elements (e.g. temperature, precipitation, wind)
 - b. seasonal periods and indicators
 - c. seasonal activities
- 7. Ethnogeography
 - a. place names
 - b. location
 - c. cultural use or significance

II. Practical Skills

1. Primary resource production or procurement
 - a. agriculture
 - b. herding
 - c. hunting
 - d. fishing
 - e. collection
2. Food preparation or processing
3. Ethnomedical preparations or applications
4. Craft and tool making
5. Architecture and construction

The intended use and purpose of the list of cosmopolitan domains in the VITEK is twofold: (a) as a guide or parameter for establishing the selection of local domains and (b) as a set of analytical categories for assessing the variable rates of change of different types of knowledge. As a guide for local domain selection in preparation of the test instrument, we present it as a menu of possibilities. The list may have to be reduced according limiting factors of the local situation encountered. Alternatively, the list may be expanded to address other needs or interests, such as broader testing aimed at identifying special needs prior to implementing ethnoeducational programs or more in-depth testing focused on specialized research questions. But for purposes of the indicator development, it is important to include as many of the core set of domains defined here as possible. As an analytical tool, one of the main reasons for adopting this two-step approach is to permit the disaggregation of different domains or types of TEK and their direct comparison across groups and places. This feature of disaggregative comparability enhances the analytical value and power of the indicator. It can be used to identify what types or areas of TEK are more vulnerable or conservative in the face of change and to test more detailed hypotheses regarding the covariation or causal relationships between different knowledge domains and between domains and change indicator variables (e.g. whether knowledge of biotic communities is dependent upon taxonomic knowledge; how market integration affects agricultural knowledge; see section 7.4.3).

7.2.2. Inventory of TEK Items

After the local domains are established, the next step is to make an inventory of the segregate categories or items pertaining to each one. Given time and cost constraints, it is probably not realistic to attempt to do complete inventories. For example, plant and animal taxonomies can each total several hundred and would require specimen collections and extended interviewing, and thus could take a very long time period to carry out. Therefore we recommend that this exercise be limited to compiling a list of culturally salient and representative items with an upper range limit of 50-100 items per domain. These limited inventories would focus on the most important taxa or

categories according to local criteria and they would provide the basic sets of TEK units from which test items are drawn. Once again, we consider that this task is most efficiently carried out, at least initially, in the context of expert focus group discussions although other formats can also serve this purpose. Male and female experts should be consulted separately to come up with gender-specific inventories.

The information collected about each categorical item will vary according to the domain under consideration. For plant and animal domains (I.1. and I.2. in Table 7.1), the local names of taxa can be elicited by the free-listing technique (section 5.3.1.1) with the qualifier that the exercise focus on the organisms that the group (or individual) considers to be most important for their traditional (or current) lifestyle. Every possible effort should also be made to record the scientific name(s) for all of the local taxa in order to clarify their referential ranges and limits. This may require specimen collections (especially in the case of plants), in which case the collaboration of biotaxonomic specialists may be needed, or the use of printed descriptions or illustrated field manuals to make positive identifications. The cultural significance or uses of ethnobiological taxa constitute an important set of subdomains, or secondary domains, that should be incorporated into the VITEK calculation. For plants, nine general use categories, or tertiary domains, have been preselected: edible, medicinal, construction, technological, fuel, commercial, artistic-ornamental, spiritual-ritual, and other. For animals, the general use categories are: edible, medicinal, labor, technological, fuel, commercial, artistic-ornamental, spiritual-ritual, and other. Another related field of information deals with characteristics of each taxon, including morphological traits, behavioral habits, life cycle, and habitats.

Plant-animal relationships (I.3 of Table 7.1) can be investigated by the adapted version of the pairwise comparison technique pioneered by Atran and his associates (1999; 2002). Because the total number of plant-animal pairs could be extremely large (e.g. 50 plants x 50 animals = 2,500 plant-animal pairs), we recommend that this line of inquiry be limited to no more than 20 plants and 20 animals (i.e. 400 possible relationships). For each pair, two basic kinds of information would be elicited: the type of relationship (e.g. Does plant *x* give food/shelter/protection to animal *y*?) and the effect of the relationship (e.g. Does animal *y* harm/hurt/not affect plant *z*?). This set of questions should be asked for the plant as well as the animal in the predicate position.

Named categories of biotopes or landscape units (I.4 of Table 7.1), can be recorded by free-listing but we suspect that the walk-in-the-woods technique (section 5.3.1.3) will produce more reliable and accurate results. However, it may not be feasible to survey all locally known biotopes on the ground, especially those which are distant from the community site, so we recommend that a combination of these techniques be used. Since it may be difficult to establish clear correspondences between locally recognized biotopes and scientific ones in many places, we consider that translation or further description of the local categories is not a vital part of this exercise. Instead, attention should be focused on eliciting the locally recognized characteristics (e.g. elevation, topography, edaphic characteristics, architecture, indicator species, disturbance agents, etc.) and cultural uses or significance of these areas.

Named classes of soil types (I.5. of Table 7.1) can be recorded by free-listing. Given the variability, complexity and specialized nature of scientific classifications of soil (Sillitoe 1996), we do not consider that exact identifications of the local categories

will be feasible but it may be useful to collect samples or take pictures for use in the testing phase. The characteristic properties (e.g. color, texture, fertility, etc.) and uses of soil types can be registered through the use of semi-structured questions. An important line of questioning for application among agricultural groups concerns the suitability of soil types for raising particular crop types. This can be done by rating soil types per selected crop type using a Likert scale format (section 5.3.1.1).

Local categories and concepts with respect to climate (I.6. of Table 7.1) can be explored using semi-structured interviews. This line of questioning would cover aspects such as climatic elements (e.g. temperature, precipitation, wind, cloud cover), seasonal periods and their indicators (e.g. plant phenology, animal movements), and seasonally scheduled cultural activities (e.g. pastoral migrations, cultivation cycle tasks).

Ethnogeographic knowledge (I.7. of Table 7.1) can be explored by experimental mental map-drawing exercises. This technique involves asking people to draw maps of their home territory showing culturally salient features of the landscape. The relevant information elicited by this technique includes place names, their relative locations on the map, and the cultural uses or significance of the represented areas.

A list of traditional skills (II.1. of Table 7.1) can be produced through free listing, semi-structured interviews, informal interviewing, observations of local activities and occupations, or some combination of these. The focus here is on practical subsistence and manufacturing skills involving the direct use and manipulation of natural resources, such as primary resource production/procurement activities, food preparation, curing techniques, and craft and tool making. The category of resource production activities is subdivided into the major biotechnological classes of agriculture, herding, hunting, fishing, and collection. This organization will facilitate comparison between groups with similar economic orientations.

7.2.3. Assigning Weights to Categorical Items

Quantitative TEK research has established that the cultural importance values of different biological species are not equal (Turner 1988; Phillips and Gentry 1993a, 1993b; Hoffman and Gallaher 2007). We make the assumption that this principle also applies to the evaluation of the knowledge and practices associated with such resources. Applying this notion to the VITEK design, we now consider the task of assigning different weights to the individual categorical items that will potentially be included in the vitality assessment. The concept of *cultural importance* refers to a relative judgment about the relationship between an item or set of items and the cultural lifestyle of a group of people at a given place and time (cf. Sheil *et al.* 2004). In this context, *weighing* refers to the measurement of the importance value of the item according to some predetermined scale. Weighted factors are built into the testing instrument at two levels: (1) contribution of the domain to the test composition and (2) selection of categorical items included within the domain.

The method of weighing adopted here essentially designates the local participants as the ultimate judges of value and allows them considerable freedom to use their own criteria for making such judgments. It is argued that such an approach better reflects the needs and priorities of the people themselves and utilizes a more global and

multi-dimensional concept of value. The method also stresses the use of elicitation procedures for extracting value judgements that are appropriate and adaptable to a wide range of cultural contexts – e.g. literate and illiterate, numerate and non-numerate. At the same time, however, we are faced with the limitation that the values must take a quantitative form and be adjusted to a single scale so as to permit aggregation into a single measure.

All domains and subdomains included in the test will be assigned a relative value that is intended to reflect the cultural importance of the domain vis-à-vis all others at the same level (i.e. those included within the same superordinate class). Thus under the category of conceptual knowledge, plant knowledge is rated in comparison to the domains of animal, plant-animal relationships, biotic communities, soils, climate and ethnogeography. Within the plant domain, the subdomain of plant taxonomic knowledge is rated against the uses and characteristics subdomains. In the context of community meetings or focus groups, the participants will be presented with a set of cards representing (by printed word, drawing, picture, or some other symbol) each of the constituent categories within the contrast set and prompted to assign a relative numerical value to each category out of a total of 100 points for the entire set. For illiterate, non-numerate or visually-oriented groups, the “stone-distribution” scoring technique can be used (Sheil et al. 2004). This method involves giving the group of informants 100 stone pebbles, beans, corn kernels or other small objects and asking them to distribute them among the set of cards proportional to their relative importance. A facilitator is present to explain what they are supposed to do, attempt to clarify any doubts or questions that may arise, and encourage active participation by everyone who is present. Some practice runs of the exercise should be performed to ensure that everyone understands the purpose and procedure correctly. In case the exercise generates disagreements, the participants will be encouraged to talk it over and come up with a consensus position. If no consensus can be reached, the exercise should be performed with smaller focus groups (e.g. by age, gender classes) or individuals and then their answers averaged. After the points are assigned, they are converted to a fraction. A hypothetical illustration of how the scoring is calculated is provided in tables 7.2-7.4.

As the result of a series of group consultations, the following scores are obtained:

Table 7.2. Conceptual Knowledge Component Categorical Valuation (Level 2)

Primary Domain	Points	Score
Plant (P)	20	.2
Animal (A)	18	.18
Plant-Animal Relationships (R)	15	.15
Biotopes (B)	15	.15
Soils (S)	12	.12
Climate (C)	10	.1
Ethnogeography (G)	10	.1

Table 7.3. Plant Domain Categorical Valuation (Level 3)

Secondary Domain	Points	Score
Taxonomic Identification (PT)	40	.4
Uses (PU)	40	.4
Characteristics (PC)	20	.2

Table 7.4. Use Subdomain Categorical Valuation (Level 4)

Tertiary Domain	Points	Score
Edible (PUed)	15	.15
Medicinal (PUme)	15	.15
Construction (PUcn)	10	.1
Technological (PUte)	15	.15
Fuel (PUfu)	10	.1
Commercial (PUcm)	15	.15
Ornamental (PUor)	5	.05
Spiritual (PUsp)	8	.08
Other (PUot)	7	.07

The scores obtained at each succeeding level are multiplied by the corresponding score obtained at the immediately preceding higher level to obtain the overall weight of the category. The relative weights per categorical contrast set (i.e. same hierarchical level) and per test component (i.e. conceptual knowledge component) based on tables 7.2-7.4 are depicted in figure 7.1.

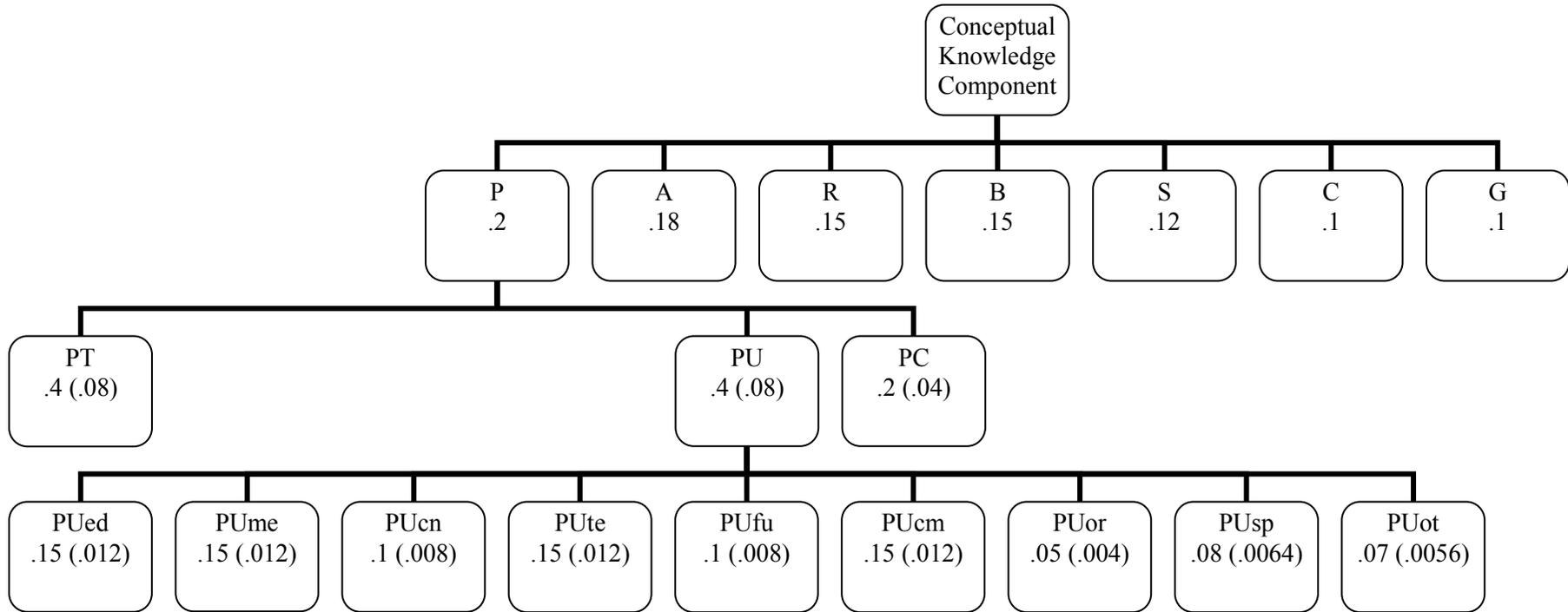


Figure 7.1. Hierarchical Calculation Relative Weights by Domain. The abbreviated letters refer to the domain and subdomain categories appearing in tables 7.2, 7.3, and 7.4. The first number shown below the letter label is the relative weight assigned to the domain within the contrast set (i.e. same hierarchical level), as represented in the tables. The second number shown, which appears in parenthesis, is the relative weight of the domain within the entire set of conceptual knowledge.

Despite the straightforwardness of this technique, it may be anticipated that some groups will experience difficulties in placing different values on the domains contained within a contrast set, especially if all are considered to be equally important or mutually interdependent. In that case, an equal value will be assigned to all categories comprising the set. However, we recommend that the point scoring method at least be tried first in order to give the local participants the opportunity to assign value differentials and thus not to assume ahead of time that they are equal or incomparable.

The second level at which weights are assigned concerns the individual categorical items within a domain. Because the point or stone distribution method does not work effectively for sets containing more than 10 items (Sheil et al. 2004) and some of the domains will be larger than this, we recommend that a simple ranking procedure be used to derive the weight at this level. Lawrence et al. (2005) argue that the ranking exercise is a relatively quick and easily understood method for assigning importance values to an array of items which can then be converted into interval scale data amenable to statistical analysis. The method involves asking the group of local consultants to rank all the items in a category according to their global importance. The inverse value of the rank number is taken for its score (e.g. in a ranking of 10 items, the highest ranked item is assigned a score of 10 points and the lowest ranked item is assigned a score of 1 point) and then the score is converted into a relative value by dividing it by the sum total of scores. The calculation of rank score (RS) and relative weight (RW) can be formulated as:

$$RS_{ij} = (n_{ij} + 1) - r_{ij},$$

where n_{ij} is the number of items in the ranking and r_{ij} is the rank of item i for domain j , and

$$RW_{ij} = \frac{RS_{ij}}{n(n+1)/2}$$

An illustration of this calculation is provided in table 7.5.

Table 7.5. Relative Weight of Domain-specific Categorical Items

Item	Rank	Score	Relative Weight
a	1	10	0.18
b	2	9	0.16
c	3	8	0.15
d	4	7	0.13
e	5	6	0.11
f	6	5	0.09
g	7	4	0.07
h	8	3	0.05
i	9	2	0.04
j	10	1	0.02

The overall purpose of assigning weights to domains and their categorical items is to determine the composition of the test upon which TEK vitality will be evaluated. Thus the relative values obtained at the first level will be used to determine the proportion of questions corresponding to the primary, secondary and tertiary domains that have been selected through the process of local consultation. Meanwhile the relative values obtained at the second level will be used as a weighted factor for determining the selection of individual items that will appear in the test.

7.3. Testing Instrument

7.3.1. Test Design

A standardized test designed to rate the TEK aptitude of individuals in the participating local group will be prepared. The TEK aptitude scores obtained in the test will be used directly for making the vitality assessment (section 7.8). The composition of the test will be based on the results of the local domain and categorical item selection processes as well as the relative weight assignment exercises. Thus questions will be drawn from all of the domains and subdomains defined and selected by the community members as locally recognized and relevant categories of TEK. The weights calculated for the different domains at each level will serve to define the proportion of test questions pertaining to those categories. For example, using the hypothetical results presented in table 7.1, 20% of questions in the conceptual knowledge test component would consist of questions pertaining to the plant primary domain. Of those 20%, 40% (or 8% of the total component) would correspond to questions about the secondary domain of plant uses. Of those 40%, 20% (or 1.6% of the total component) would correspond to questions about the tertiary domain of edible plants.

With respect to the selection of categorical items, the method adopted here calls for a random sample selection of items for inclusion in the test but the chances of selection of any given item should be proportional to its relative weight within the class. Thus, for example, an item with a relative weight of .12 would have a 12% probability of being selected while an item with a relative weight of .04 would have a 4% probability of being selected. This means that the sampling procedure would involve a two-step process: (1) construct a population of items in which the proportional representation of each item is equal to its relative weight and (2) randomly select the number of test items corresponding to the proportional representation of the domain in the entire test component.

Using the procedure described above, separate tests should be drawn up for male and female subjects. To the extent that local domain selection, categorical item inventories, and relative weight assignments differ between the two groups, the tests will also be different. A minimum of three different sample tests per gender group should be constructed in this fashion. From this group, one is randomly selected for each subject taking the test.

In order to exercise greater control over the test answers and thus optimize the time needed to take as well as grade the test, we recommend that the questions comprising the test be phrased as multiple choice or true/false questions. However, we also propose that an "I don't know" response option be allowed for every question to

eliminate (or reduce) the likelihood of guessing. In the practical skills component, the basic question will amount to a self report of knowledge of the skill type (e.g. “Do you know how to do/make _____?” or “Have you done/made _____ in the last month/year/lifetime?”).

A notebook of visual prompts in the form of illustrations, photos or specimen samples (where possible) should be prepared for use in the test. Among oral-based cultural groups, the test should be administered as an interview, preferably by someone from the study community. Among literate groups, it is totally feasible that the entire test can be prepared and administered in a written form, albeit with visual prompts included.

The test will consist minimally of three sections:

(1) Social Data. This section records basic sociodemographic information about the test subject, including his or her name, an identification code for the person, age, gender, community and ethnic group. If the research team wishes to capture other socio-economic variables (e.g. educational achievement of subject, education of parent, language fluency, principal occupation, wealth, marital status, number of children, years living in the place, etc.), that information can be recorded here as well.

(2) TEK Aptitude Test. This section consists of two sections: (a) the conceptual knowledge component and (b) the practical skills component. The two components will be treated separately but equally for scoring purposes. Thus a separate score for each component will be obtained. The two scores can be combined to produce a total score. To avoid participant fatigue, we recommend that the first component consist of no more than 120 questions and the second component be about half that length. A time limit should be set for answering equivalent to one minute per question (e.g. 2 hours for 120 questions). However, this may have to be adjusted according to the test conditions, the need for breaks, and the form of administration, whether oral or visual, communicated directly or through an interpreter.

The conceptual knowledge component of the test is more developed than the practical skills component in large part because knowledge can only be inferred indirectly from the observation of behavior and the measurement of behavioral patterns requires a longer and more sustained investigative process. The test is purposely designed to provide results based on a quick, one-time assessment in order to maximize ease, speed and productivity, and therefore enhance its appeal to a broad audience of potential users. Ideally, the test would be administered periodically among the same group(s) to produce a true time-series based indicator but we still feel that the chances for widespread adoption will hinge upon a fast and efficient, albeit representative and reliable, method. However, time and cost constraints permitting, we propose that the practical knowledge component could be expanded by measuring the actual uses or manipulations of plant and animal taxa by the individuals who have taken the test. This would require a much more intensive data collection effort. The easiest way would be to record self-reports of the diversity and frequency of plant and animal resources harvested by the individual (or the household to which they belong) on a regular basis (e.g. weekly) for an extended period of time (at least a year to capture annual seasonal variations). Scores could be calculated by tabulating the diversity and frequency of taxa harvested per unit time. Individual scores could then be ranked in relation to each or graded in relation to the average score.

(3) Transmission Process. This section is proposed as entirely optional but motivated by our belief that a small amount of data on transmission mechanics can provide a great deal of insight into dynamic processes of change/conservation (see section 5.5). For each subdomain class, two questions would be asked: (1) What method best describes how you learned about these kind of things? (multiple choices being: verbal communication, visual observation of others, active participation in related activities, learned on your own, read about it in book(s), taught at school, other, and do not know), and (2) What person(s) is(are) most responsible for teaching this to you? (multiple choices being: mother; father; grandmother; grandfather; brother; sister; other relative (type: _____); friend; expert; other (describe: _____); do not know). Used in conjunction with the results of the aptitude section, analysis of observed patterns of this data set can reveal proximate mechanisms for explaining why TEK is changing or not.

7.3.2. Sample Population Selection (age, gender, community)

In order to provide a reliable and representative measure of knowledge variation and change, the test should be given to a carefully selected sample of the study population. The preferred sampling strategy for the VITEK is to choose a sample stratified according to the social variables that are included in the analysis. Two main social variables are considered as absolutely necessary for making the assessment: age and gender.

Age is the key variable that will be used to gauge whether significant change has occurred or not. Although the most reliable way to capture trends is to apply the test at regular time intervals and measure the differences between outcomes, that is in a longitudinal sense, the method is also designed to produce an instant assessment of change from cross-sectional data based on age-indexed knowledge differentials. Although age is a continuous variable, our focus will be on segmented age sets of the adult population. The assessment will be based on measuring differences within the adult population in order to minimize the confounding effects of normal learning processes during childhood and adolescence. While it may be expected that the learning phases of different areas of TEK will vary in length and timing as a result of difficulty, aged-based social status and roles, and other factors, the available evidence from ontogenetic studies suggests that the vast majority of nonspecialist knowledge or ability to perform subsistence skills is fully acquired by late adolescence-early adulthood (Stross 1973; Angier 2002; Zarger 2002; Zent and Zent 2004; Reyes-García 2007). Therefore the sample will be drawn from the fraction of the local population that has reached adult age (~15 years old). This fraction will be subdivided into age cohorts of 15 years each, thus producing for most populations four or five demographic strata (15-29, 30-44, 45-59, 60-74, and 75-89 years old) spanning a total of 60-75 years. The method and index calculations are adaptable to other age intervals, meaning that some flexibility is permitted and shorter intervals could be chosen. However, we also consider that the 15-year interval should be the maximum size of the interval in order to preserve enough variation to be able to discern meaningful trends (i.e. at least three points of comparison). Ideally, the segmentation would take place along generational lines but generation is more of a social distinction than a demographic one from a collective point of view and in any case the length of the generation should be calculated on a population-specific basis according to the prevailing demographic structure and life

history data (cf. Howell 1979). Our interest in age distinction is more chronometric, finding a way to index knowledge variation along a temporal scale and therefore we have chosen a fixed interval that can be compared directly across sites. The 15-year interval provides sufficient time-series approximation for spotting trends yet does not inflate the overall sample size beyond manageable limits. Finer distinctions (e.g. 5-year or 10-year cohorts) would enhance trend resolution but also make it more difficult to find equal numbers of willing test participants in all age-gender classes. If the local research team is interested in comparing the knowledge of children with adults, then that cohort could be added as well but it remains to be demonstrated whether such differences actually reflect part of a historical trend of TEK shift or the normal learning curve.

Gender is considered to be a core strata for VITEK sampling because some kinds of knowledge and practices are gender-specific and where they are comparative testing, grading and interpretation must also be conscious of this division. Thus it will be necessary to view trends among men and among women as at least potentially separate phenomena (Pfeiffer and Butz 2005). The sample should count on comparable if not equal numbers of men and women in all age groups. This may not be easy to accomplish, given the tendency in many societies for men to dominate public spaces and contacts with outsiders, but every effort should be made to include members of both sexes in all phases of the assessment process.

If the assessment is targeted on an ethnic population or larger unit composed of several or more distinct local communities, then community becomes another primary strata for sample selection. In that case, we recommend that a random sample be used to select the group of communities that will be included in the assessment. Community is a complex variable consisting of multiple social and environmental variables that alone or in combination may affect the pattern of TEK variation and change. Doing a proper stratified sample in this context would require a long and complicated analysis of all of these variables as well as a preliminary study of the range of knowledge variation between communities. A random sample would be much more efficient but may require a larger sample size. Once the sample communities have been chosen, the within-community sample stratified by age and gender should be selected in the same way as for single-community assessments.

Other social variables that conceivably affect the vitality status of TEK could be added to the sample design if there is special interest in doing so (see section 7.6). However, because these will vary considerably from site to site and accounting for and analyzing this data would add considerably to the cost and complexity of the overall assessment, we consider that this should be optional and decided by the local research team.

The first step toward constructing a stratified sample is to conduct a census of the entire local population. If a current or recent census of the community can be found on site or from secondary sources (e.g. official records, publications), we see no reason why it cannot be used if it is reliable and contains information about the social strata of interest. If other socioeconomic variables are to be incorporated into the analysis, then a socioeconomic survey must accompany the census. In order to permit sufficient analysis of variance, at least 5 individuals from each generation-by-sex group must be chosen, or a total of 40 individuals in all in a group characterized by four adult age groups.

7.3.3. Test Administration

The VITEK test is designed for individual testing and every effort should be made to uphold this standard. If the test is conducted orally, it should be held in a secluded place out of visual and hearing range from third parties. Inside or immediately outside a person's home is probably not the best place. However, some respondents may feel uncomfortable in this type of situation and not able to perform to their optimal capacity. We recommend that the research team discuss this matter with community leaders or in a group meeting to come up with a viable solution. It is also preferable that the test be administered by someone who is native or familiar with the community. If some passerby or onlooker does interfere with a test answer (e.g. by volunteering an unsolicited answer), the administrator should be prepared to put a halt to the interference and substitute a backup question on the spot.

A practice run of the test should be performed with one or two subjects prior to actual administration of the test in order to ensure that all the questions are well formed, the stimulus materials are appropriate, and there are no major problems with other aspects of the design. The practice will also be useful to plan and evaluate the pace and interactive dynamic of the testing process. The design calls for a time limit to take the test. We have suggested approximately one minute per question as sufficient but this can be revised upward or downward by the research team according to their experience. It may be necessary to schedule one or more breaks or provide refreshments to overcome fatigue or boredom. The test should be doable in one sitting and therefore the total length in time should not exceed 2-3 hours. However, the most important thing is that the same limits be applied to everyone taking the test to ensure a fair comparison of the results.

7.3.4. Test Evaluation and Scoring (intracultural comparability)

The results of the aptitude test will be tabulated per component, primary domain, secondary domain, and tertiary domain. A hierarchical coding system will be used in which each question is coded according to the different levels of categorical membership to which it corresponds. Thus a question regarding whether a particular tree species has a commercial use would be coded as conceptual knowledge component, plant primary domain, cultural use secondary domain, and commercial use tertiary domain. The scores for all questions within a given category will be calculated separately and then aggregated successively as one moves up from lower inclusive to higher inclusive hierarchical levels. The codes assigned to the two test components as well as all of their constituent domains and subdomains, and the formulas for calculating the aggregate scores for each one, are given in table 7.6.

The modular structure of the test scoring system is purposely designed to permit disaggregation and aggregation of the test results at various levels. The feature of categorical disaggregation will permit more specific comparisons of scores between individuals and groups in regards to different types of knowledge. The feature of successive aggregation will allow for a more composite view of the global status and trends of TEK between groups. All answers will be scored as either 1 point (for right answers) or 0 points (for wrong or I don't know answers). The confidentiality of all

persons taking the test and their performance will be protected by assigning everyone a personal code. The identities that go with the personal codes and the test scores by coded individual will be stored in separate databases.

Table 7.6. Categorical Codes and Scoring Formulas

Level	Code	Class Description	Calculation Formula
Level 0	ST	Total Score	$ST = SCS + SPS$
Level 1	SCK	Conceptual Knowledge Component Score	$SCK = SCK\ Dpl + SCK\ Dan + SCK\ Dre + SCK\ Dbt + SCK\ Dso + SCK\ Dcl + SCK\ Deg$
	SPS	Practical Skills Component Score	$SPS = SPS\ Drp + SPS\ Dfp + SPS\ Dem + SPS\ Dct + SPS\ Dac$
Level 2	SCK Dpl	Conceptual Knowledge Component, Plant Primary Domain Score	$SCK\ Dpl = SCK\ Dpl\ Ztx + SCK\ Dpl\ Zcu + SCK\ Dpl\ Zch$
	SCK Dan	Conceptual Knowledge Component, Animal Primary Domain Score	$SCK\ Dan = SCK\ Dan\ Ztx + SCK\ Dan\ Zcu + SCK\ Dan\ Zch$
	SCK Dre	Conceptual Knowledge Component, Plant-Animal Relationships Primary Domain Score	$SCK\ Dre = SCK\ Dre\ Zty + SCK\ Dre\ Zef$
	SCK Dbt	Conceptual Knowledge Component, Biotope Primary Domain Score	$SCK\ Dbt = SCK\ Dbt\ Zno + SCK\ Dbt\ Zch + SCK\ Dbt\ Zcu$
	SCK Dso	Conceptual Knowledge Component, Soil Primary Domain Score	$SCK\ Dso = SCK\ Dso\ Zno + SCK\ Dso\ Zch + SCK\ Dso\ Zcu + SCK\ Dso\ Zcs$
	SCK Dcl	Conceptual Knowledge Component, Climate Primary Domain Score	$SCK\ Dcl = SCK\ Dcl\ Zel + SCK\ Dcl\ Zsi + SCK\ Dcl\ Zsa$
	SCK Deg	Conceptual Knowledge Component, Ethnogeography Primary Domain Score	$SCK\ Deg = SCK\ Deg\ Zpn + SCK\ Deg\ Zlo + SCK\ Deg\ Zcu$
	SPS Drp	Practical Skills Component, Resource Production Primary Domain Score	$SPS\ Drp = SPS\ Drp\ Zag + SPS\ Drp\ Zhe + SPS\ Drp\ Zhu + SPS\ Drp\ Zfi + SPS\ Drp\ Zco$
	SPS Dfp	Practical Skills Component, Food Preparation Primary Domain Score	$SPS\ Dfp = SPS\ Dfp\ Z1 + SPS\ Dfp\ Z2 \dots SPS\ Dfp\ Zn$
	SPS Dem	Practical Skills Component, Ethnomedicine Primary Domain Score	$SPS\ Dem = SPS\ Dem\ Z1 + SPS\ Dem\ Z2 \dots SPS\ Dem\ Zn$
	SPS Dct	Practical Skills Component, Craft & Technology	$SPS\ Dct = SPS\ Dct\ Z1 + SPS\ Dct\ Z2 \dots SPS$

		Primary Domain Score	Dct Zn
	SPS Dac	Practical Skills Component, Architecture & Construction Primary Domain Score	SPS Dac = SPS Dac Z1 + SPS Dac Z2 .. SPS Dac Zn
Level 3	SCK Dpl Ztx	Conceptual Knowledge Component, Plant Primary Domain, Taxonomic Secondary Domain Score	SCK Dpl Ztx = \sum CK Dpl Ztx test answers i..n
	SCK Dpl Zcu	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain Score	SCK Dpl Zcu = SCK Dpl Zcu zed + SCK Dpl Zcu zme + SCK Dpl Zcu zcn + SCK Dpl Zcu zte + SCK Dpl Zcu zfu + SCK Dpl Zcu zcm + SCK Dpl Zcu zor + SCK Dpl Zcu zsp + SCK Dpl Zcu zot
	SCK Dpl Zch	Conceptual Knowledge Component, Plant Primary Domain, Characteristics Secondary Domain Score	SCK Dpl Zch = \sum CK Dpl Zch test answers i..n
	SCK Dan Ztx	Conceptual Knowledge Component, Animal Primary Domain, Taxonomic Secondary Domain Score	SCK Dan Ztx = \sum CK Dan Ztx test answers i..n
	SCK Dan Zcu	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain Score	SCK Dan Zcu = SCK Dan Zcu zed + SCK Dan Zcu zme + SCK Dan Zcu zla + SCK Dan Zcu zte + SCK Dan Zcu zfu + SCK Dan Zcu zcm + SCK Dan Zcu zor + SCK Dan Zcu zsp + SCK Dan Zcu zot
	SCK Dan Zch	Conceptual Knowledge Component, Animal Primary Domain, Characteristics Secondary Domain Score	SCK Dan Zch = \sum CK Dan Zch test answers i..n
	SCK Dre Zty	Conceptual Knowledge Component, Plant-Animal Relationships Primary Domain, Type Secondary Domain Score	SCK Dre Zty = \sum CK Dre Zty test answers i..n
	SCK Dre Zef	Conceptual Knowledge Component, Animal Primary Domain, Effect Secondary Domain Score	SCK Dre Zef = \sum CK Dre Zef test answers i..n
	SCK Dbt Zno	Conceptual Knowledge Component, Biotope Primary Domain, Nomenclature Secondary Domain Score	SCK Dbt Zno = \sum CK Dbt Zno test answers i..n
	SCK Dbt Zch	Conceptual Knowledge Component, Biotope Primary Domain, Characteristics Secondary Domain Score	SCK Dbt Zch = \sum CK Dbt Zch test answers i..n

	SCK Dbt Zcu	Conceptual Knowledge Component, Biotope Primary Domain, Cultural Use Secondary Domain Score	$SCK\ Dbt\ Zcu = \sum_{i..n} CK\ Dbt\ Zcu\ test\ answers\ i..n$
	SCK Dso Zno	Conceptual Knowledge Component, Soil Primary Domain, Nomenclature Secondary Domain Score	$SCK\ Dso\ Zno = \sum_{i..n} CK\ Dso\ Zno\ test\ answers\ i..n$
	SCK Dso Zch	Conceptual Knowledge Component, Soil Primary Domain, Characteristics Secondary Domain Score	$SCK\ Dso\ Zch = \sum_{i..n} CK\ Dso\ Zch\ test\ answers\ i..n$
	SCK Dso Zcu	Conceptual Knowledge Component, Soil Primary Domain, Cultural Use Secondary Domain Score	$SCK\ Dso\ Zcu = \sum_{i..n} CK\ Dso\ Zcu\ test\ answers\ i..n$
	SCK Dso Zcs	Conceptual Knowledge Component, Soil Primary Domain, Crop Suitability Secondary Domain Score	$SCK\ Dso\ Zcs = \sum_{i..n} CK\ Dso\ Zcs\ test\ answers\ i..n$
	SCK Dcl Zel	Conceptual Knowledge Component, Climate Primary Domain, Elements Secondary Domain Score	$SCK\ Dcl\ Zel = \sum_{i..n} CK\ Dcl\ Zel\ test\ answers\ i..n$
	SCK Dcl Zsi	Conceptual Knowledge Component, Climate Primary Domain, Seasonal Indicators Secondary Domain Score	$SCK\ Dcl\ Zsi = \sum_{i..n} CK\ Dcl\ Zsi\ test\ answers\ i..n$
	SCK Dcl Zsa	Conceptual Knowledge Component, Climate Primary Domain, Seasonal Activities Secondary Domain Score	$SCK\ Dcl\ Zsa = \sum_{i..n} CK\ Dcl\ Zsa\ test\ answers\ i..n$
	SCK Deg Zpn	Conceptual Knowledge Component, Ethnogeography Primary Domain, Place Names Secondary Domain Score	$SCK\ Deg\ Zpn = \sum_{i..n} CK\ Deg\ Zpn\ test\ answers\ i..n$
	SCK Deg Zlo	Conceptual Knowledge Component, Ethnogeography Primary Domain, Location Secondary Domain Score	$SCK\ Deg\ Zlo = \sum_{i..n} CK\ Deg\ Zlo\ test\ answers\ i..n$
	SCK Deg Zcu	Conceptual Knowledge Component, Ethnogeography Primary Domain, Cultural Use Secondary Domain Score	$SCK\ Deg\ Zcu = \sum_{i..n} CK\ Deg\ Zcu\ test\ answers\ i..n$
	SPS Drp Zag	Practical Skills Component, Resource Production Primary Domain, Agriculture Secondary Domain Score	$SPS\ Drp\ Zag = \sum_{i..n} CPS\ Drp\ Zag\ test\ answers\ i..n$
	SPS Drp Zhe	Practical Skills Component, Resource Production	$SPS\ Drp\ Zhe = \sum_{i..n} PS\ Drp\ Zhe\ test\ answers\ i..n$

		Primary Domain, Herding Secondary Domain Score	
	SPS Drp Zhu	Practical Skills Component, Resource Production Primary Domain, Hunting Secondary Domain Score	$SPS\ Drp\ Zhu = \sum PS\ Drp\ Zhu\ test\ answers\ i..n$
	SPS Drp Zfi	Practical Skills Component, Resource Production Primary Domain, Fishing Secondary Domain Score	$SPS\ Drp\ Zfi = \sum PS\ Drp\ Zfi\ test\ answers\ i..n$
	SPS Drp Zco	Practical Skills Component, Resource Production Primary Domain, Collection Secondary Domain Score	$SPS\ Drp\ Zco = \sum PS\ Drp\ Zco\ test\ answers\ i..n$
	SPS Dfp Z1	Practical Skills Component, Food Preparation Primary Domain, First Secondary Domain (to be defined) Score	$SPS\ Dfp\ Z1 = \sum PS\ Dfp\ Z1\ test\ answers\ i..n$
	SPS Dfp Z2	Practical Skills Component, Food Preparation Primary Domain, Second Secondary Domain (to be defined) Score	$SPS\ Dfp\ Z2 = \sum PS\ Dfp\ Z2\ test\ answers\ i..n$
	SPS Dfp Zn	Practical Skills Component, Food Preparation Primary Domain, Last Secondary Domain (to be defined) Score	$SPS\ Dfp\ Zn = \sum PS\ Dfp\ Zn\ test\ answers\ i..n$
	SPS Dem Z1	Practical Skills Component, Ethnomedicine Primary Domain, First Secondary Domain (to be defined) Score	$SPS\ Dem\ Z1 = \sum PS\ Dem\ Z1\ test\ answers\ i..n$
	SPS Dem Z2	Practical Skills Component, Ethnomedicine Primary Domain, Second Secondary Domain (to be defined) Score	$SPS\ Dem\ Z2 = \sum PS\ Dem\ Z2\ test\ answers\ i..n$
	SPS Dem Zn	Practical Skills Component, Ethnomedicine Primary Domain, Last Secondary Domain (to be defined) Score	$SPS\ Dem\ Zn = \sum PS\ Dem\ Zn\ test\ answers\ i..n$
	SPS Dct Z1	Practical Skills Component, Craft & Technology Primary Domain, First Secondary Domain (to be defined) Score	$SPS\ Dct\ Z1 = \sum PS\ Dct\ Z1\ test\ answers\ i..n$
	SPS Dct Z2	Practical Skills Component, Craft & Technology	$SPS\ Dct\ Z2 = \sum PS\ Dct\ Z2\ test\ answers\ i..n$

		Primary Domain, Second Secondary Domain (to be defined) Score	
	SPS Dct Zn	Practical Skills Component, Craft & Technology Primary Domain, Last Secondary Domain (to be defined) Score	$SPS\ Dct\ Zn = \sum PS\ Dct\ Zn\ test\ answers\ i..n$
	SPS Dac Z1	Practical Skills Component, Architecture & Construction Primary Domain, First Secondary Domain (to be defined) Score	$SPS\ Dac\ Z1 = \sum PS\ Dac\ Z1\ test\ answers\ i..n$
	SPS Dac Z2	Practical Skills Component, Architecture & Construction Primary Domain, Second Secondary Domain (to be defined) Score	$SPS\ Dac\ Z2 = \sum PS\ Dac\ Z2\ test\ answers\ i..n$
	SPS Dac Zn	Practical Skills Component, Architecture & Construction Primary Domain, Last Secondary Domain (to be defined) Score	$SPS\ Dac\ Zn = \sum PS\ Dac\ Zn\ test\ answers\ i..n$
Level 4	SCK Dpl Zcu zed	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Edible Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zed = \sum CK\ Dpl\ Zcu\ zed\ test\ answers\ i..n$
	SCK Dpl Zcu zme	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Medicinal Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zme = \sum CK\ Dpl\ Zcu\ zme\ test\ answers\ i..n$
	SCK Dpl Zcu zcn	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Construction Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zcn = \sum CK\ Dpl\ Zcu\ zcn\ test\ answers\ i..n$
	SCK Dpl Zcu zte	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Technological Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zte = \sum CK\ Dpl\ Zcu\ zte\ test\ answers\ i..n$
	SCK Dpl Zcu zfu	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Fuel Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zfu = \sum CK\ Dpl\ Zcu\ zfu\ test\ answers\ i..n$
	SCK Dpl Zcu zcm	Conceptual Knowledge Component, Plant Primary	$SCK\ Dpl\ Zcu\ zcm = \sum CK\ Dpl\ Zcu\ zcm\ test$

		Domain, Cultural Use Secondary Domain, Commercial Tertiary Domain Score	answers i..n
	SCK Dpl Zcu zor	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Ornamental Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zor = \sum CK\ Dpl\ Zcu\ zor\ test\ answers\ i..n$
	SCK Dpl Zcu zsp	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Spiritual Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zsp = \sum CK\ Dpl\ Zcu\ zsp\ test\ answers\ i..n$
	SCK Dpl Zcu zot	Conceptual Knowledge Component, Plant Primary Domain, Cultural Use Secondary Domain, Other Tertiary Domain Score	$SCK\ Dpl\ Zcu\ zot = \sum CK\ Dpl\ Zcu\ zot\ test\ answers\ i..n$
	SCK Dan Zcu zed	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Edible Tertiary Domain Score	$SCK\ Dan\ Zcu\ zed = \sum CK\ Dan\ Zcu\ zed\ test\ answers\ i..n$
	SCK Dan Zcu zme	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Medicinal Tertiary Domain Score	$SCK\ Dan\ Zcu\ zme = \sum CK\ Dan\ Zcu\ zme\ test\ answers\ i..n$
	SCK Dan Zcu zla	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Labor Tertiary Domain Score	$SCK\ Dan\ Zcu\ zla = \sum CK\ Dan\ Zcu\ zla\ test\ answers\ i..n$
	SCK Dan Zcu zte	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Technological Tertiary Domain Score	$SCK\ Dan\ Zcu\ zte = \sum CK\ Dan\ Zcu\ zte\ test\ answers\ i..n$
	SCK Dan Zcu zfu	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Fuel Tertiary Domain Score	$SCK\ Dan\ Zcu\ zfu = \sum CK\ Dan\ Zcu\ zfu\ test\ answers\ i..n$
	SCK Dan Zcu zcm	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Commercial Tertiary Domain Score	$SCK\ Dan\ Zcu\ zcm = \sum CK\ Dan\ Zcu\ zcm\ test\ answers\ i..n$
	SCK Dan Zcu zor	Conceptual Knowledge Component, Animal Primary	$SCK\ Dan\ Zcu\ zor = \sum CK\ Dan\ Zcu\ zor\ test$

		Domain, Cultural Use Secondary Domain, Ornamental Tertiary Domain Score	answers i..n
	SCK Dan Zcu zsp	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Spiritual Tertiary Domain Score	$SCK\ Dan\ Zcu\ zsp = \sum CK\ Dan\ Zcu\ zsp\ test$ answers i..n
	SCK Dan Zcu zot	Conceptual Knowledge Component, Animal Primary Domain, Cultural Use Secondary Domain, Other Tertiary Domain Score	$SCK\ Dan\ Zcu\ zot = \sum CK\ Dan\ Zcu\ zot\ test$ answers i..n

7.4. Vitality Index of TEK

Vitality is operationalized here as the rate of retention of knowledge between generational groups. A situation in which vitality is strong is indicated by lack of significant change or even increase in TEK aptitude from one generation (i.e. age cohort) to the next. A situation in which vitality is weak or threatened is one in which a significant decrease of aptitude is confirmed. Whereas the rate of retention or change is measured by taking the difference in average aptitude scores between age groups, the significance of this difference is measured by looking at the means or medians in relation to observed variance within and between these groups. Thus the two sets of measures depend on separate but related statistical procedures.

7.4.1. Calculating the Vitality Index

The vitality index (VI) consists of three related measures: the intergenerational rate of retention (*RG*), the cumulative rate of retention (*RC*), and the annual rate of change (*CA*) (Figure 7.2). All of these rely on very simple statistical calculations and can be done by hand or with a pocket calculator. The first step is to calculate the means of the score results for all age/gender groups included in the aptitude test.

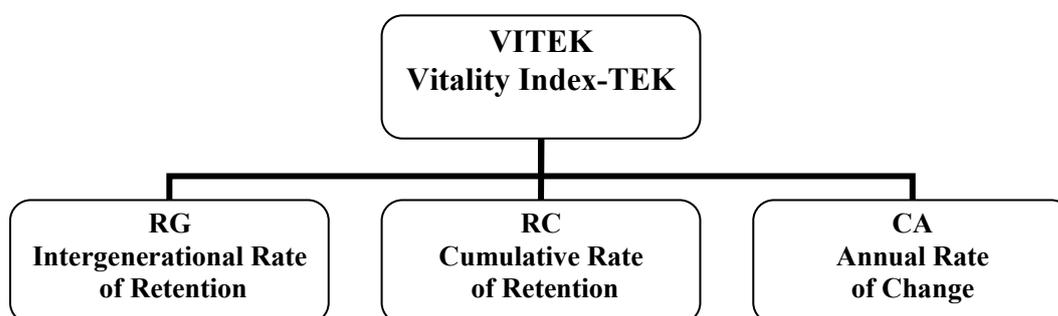


Figure 7.2. VITEK Component Measures

The *RG* indicates the rate of retention between any successive pair of age groups and is calculated as the ratio of the generation mean to that of the generation immediately preceding it. This calculation is given by:

$$RG_t = \bar{g}_t / \bar{g}_r$$

where \bar{g}_t is the mean score of the target age group (i.e. the younger group of the pair) and \bar{g}_r is the mean score of the reference age group (i.e. the next ascending group). The RG_t of the oldest age group is set at 1 based on the logic that no information about the aptitude level of the preceding generation(s) is available and therefore we cannot assume that any differences or changes have occurred in prior time periods.

The rate of retention for men (m) and for women (f) are defined respectively as:

$$RG_{tm} = \bar{g}_{tm} / \bar{g}_{rm}$$

where \bar{g}_{tm} is the mean score of the male target age group and \bar{g}_{rm} is the mean score of the male reference age group, and

$$RG_{tf} = \bar{g}_{tf} / \bar{g}_{rf}$$

where \bar{g}_{tf} is the mean score of the female target age group and \bar{g}_{rf} is the mean score of the female reference age group.

The rate for the combined samples of both men and women (b) is defined as:

$$RG_{tb} = \frac{1}{2} (RG_{tm} + RG_{tf}).$$

The cumulative rate of retention (RC) essentially reflects the proportion of the baseline aptitude level retained by each succeeding age group. The formula used for RC is adapted from that used to calculate the Living Planet Index (Loh et al. 2005) since they have similar purposes (i.e. measuring retention over time based on sample data) although they are measuring different things (i.e. TEK aptitude vs. biological populations). RC is calculated by multiplying the reference RC by 10 raised to the power of the logarithm of the target RG . As with the RG calculation, the RC of the oldest target age group is set at 1. The formula is defined as:

$$RC_t = RC_r 10^{\log(RG_t)}$$

The same statistic can be calculated for men, women, and combined samples.

A composite index expressing the average rate of retention across all age group pairs tested can also be calculated and is defined as:

$$RC_a = \frac{1}{n_t} * \left(\sum_{i=1}^{n_t} RC_t \right).$$

The annual rate of change (CA) expresses the average rate and direction of change per year reflected by the target age group and is given by:

$$CA_t = \frac{RC_t - 1}{yg_t}$$

where yg_t is the length in years of the target age group interval.

This measurement can be calculated for all age groups combined (CA_a) by simple addition, as given by:

$$CA_a = \frac{\sum_{t=1}^{nt} CA_t - 1}{\sum_{t=1}^{nt} yg_t}$$

The same basic measurement can be applied to the male, female, and gender-combined samples.

The composite measure CA_a is especially useful for making direct comparisons of TEK vitality between local populations in space and time. It is adaptable to studies using different age intervals, it gives a single number for the overall population, and it is expressed in a unit of time. As such, it can be used as a reference measure for monitoring trends of TEK retention/change over time through repeated application of the test in the future. If interventive policies aimed at preserving, restoring or innovating TEK are enacted, the impact and performance of these can be directly and unambiguously measured through the CA_a .

A hypothetical example of all of calculations mentioned in this section is presented in table 7.6. The results are plotted on graphs to visualize the prevailing trends (figures 7.3-7.5).

Table 7.6. Vitality Index Calculations by Age/Gender Group

Age/Gender Group	Mean Score	<i>RG</i>	<i>RC</i>	<i>CA</i>	CA_a
Men					-0.01
MG4 (60-74)	75	1.00	1.00	0.000	
MG3 (45-59)	85	1.13	1.13	0.009	
MG2 (30-44)	60	0.71	0.80	-0.013	
MG1 (15-29)	35	0.58	0.47	-0.036	
Women					
FG4 (60-74)	75	1.00	1.00	0.000	-0.0075
FG3 (45-59)	70	0.93	0.93	-0.004	
FG2 (30-44)	70	1.00	0.93	-0.004	
FG1 (15-29)	50	0.71	0.67	-0.022	
Combined					
BG4 (60-74)	75	1.00	1.00	0.000	-0.009
BG3 (45-59)	77.5	1.03	1.03	0.002	
BG2 (30-44)	65	0.84	0.87	-0.009	
BG1 (15-29)	42.5	0.65	0.57	-0.029	

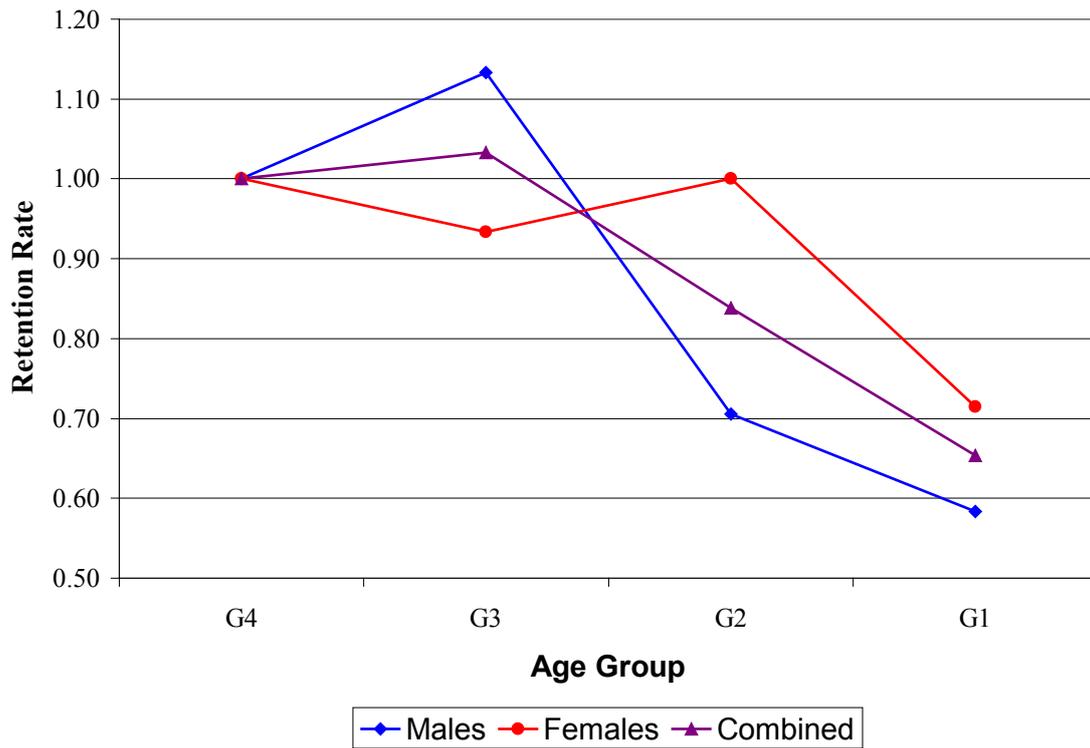


Figure 7.3. Graphic representation of retention rates by age group for male, female, and combined groups.

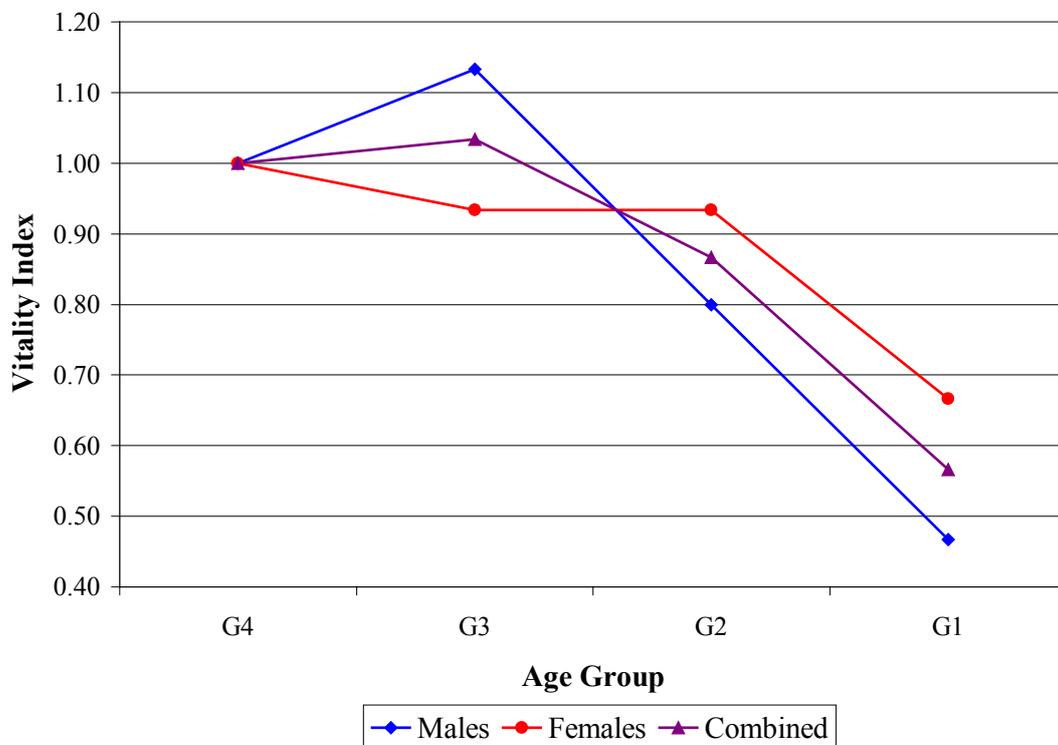


Figure 7.4. Graphic representation of vitality indices by generation for male, female, and combined groups.

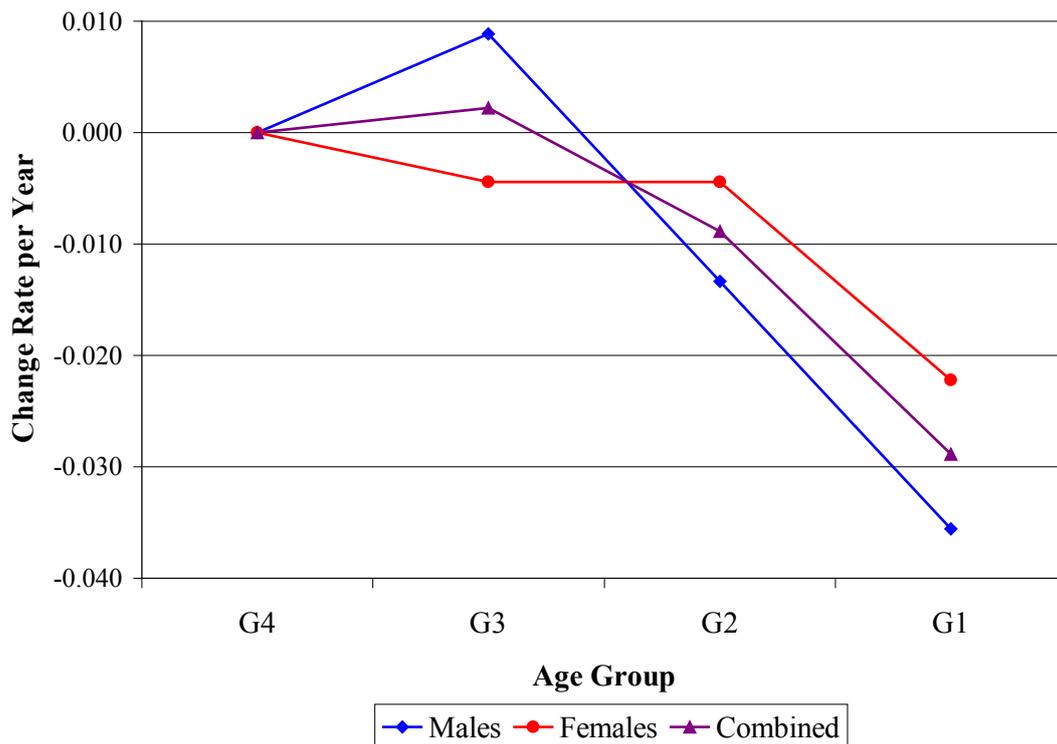


Figure 7.5. Graphic representation of annualized change indices by age group for male, female, and combined groups.

7.4.2. Significance Tests

Significance tests will be used to assess whether the trends calculated by the vitality index signal significant differences (i.e. changes) in knowledge between generations. Given the data characteristics and objectives of the index, we believe that the best measure to use is the Mann-Whitney U (MWU) test. The MWU, also called the two-sample rank-sum test, is a nonparametric statistic which does not assume a normal distribution, does not require equal variances, works well with small sample sizes ($n < 20$), and can be used with interval or ordinal data. The calculations are very simple and can be done by hand. The first step is to convert the continuous measurements reported in the test scores to ordinal measurements. The U statistic is calculated as follows:

$$U = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - \sum_{i=n_1+1}^{n_1+n_2} R_i$$

where samples of size n_1 and n_2 are pooled and R_i are the ranks.

The significance of the U statistic is determined by comparing the obtained value with the value shown for the corresponding sample sizes in a table of critical values. One-tailed tables can be used to test the alternative hypothesis that x values tend to be smaller (i.e. knowledge loss) or larger (i.e. knowledge gain) than y values.

For the composite indices, the preferred test of significance is the Kruskal-Wallis one-way analysis of variance (KW) by ranks. This is a non-parametric method for testing equality of population medians when comparing three or more groups. The method begins by ranking all groups together (i.e. ignoring group membership). The KW statistic is defined as:

$$K = (N-1) \frac{\sum_{i=1}^g n_i (\bar{r}_i - \bar{r})^2}{\sum_{i=1}^g \sum_{j=1}^{n_i} (r_{ij} - \bar{r})^2}$$

where n_g is the number of observations in group g ,
 r_{ij} is the rank (among all observations) of observation j from group i ,
 N is the total number of observations across all groups,

$$\bar{r}_i \text{ is } \sum_{j=1}^{n_i} r_{ij} / n_i$$

\bar{r} is the average of all the r_{ij} equal to $(N+1)/2$.

The P -value is approximated by $P_r (\chi^2_{g-1} \geq K)$.

More complex (and powerful) tests of significance may be called for if other socioeconomic change indicator variables are included as analytical operators. In that case, age and gender can be used as control variables or as sorts for investigating and testing the effects of these additional variables. For example, the association between formal schooling and TEK aptitude could be tested by age or gender group and then compared to the same association for the entire population sample. This would give us a better idea of the impact of schooling on specific subgroups, particularly those displaying a lower rate of retention. The statistical methods employed can vary according to the type of data collected, the scale and precision of measurement, and the hypotheses being tested. Stepwise regression is one of the techniques that has been used to separate the most significant operators in multivariate situations (e.g. Nolan and Robbins 1999; Guest 2002; Byg and Balslev 2004). The Vitality Index based on age and gender serves as an exploratory state measure for identifying dynamic situations where more detailed studies of the pressures and drivers of TEK change are warranted. Because the Vitality Index can be disaggregated at various levels, it also serves as a generator of hypotheses concerning the impact of different environmental factors on different areas of TEK.

7.4.3. Vitality Index Aggregation and Disaggregation

The Vitality Index measures (RG , RC , CA) can be aggregated according to different scales of inclusiveness, from the local community on up to the entire globe, depending on data availability of course. For example, if the index is calculated separately for different communities belonging to the same ethnic unit, these community indices can be combined to produce an ethnic index. Several ethnic indices can be aggregated to

form a provincial index and provincial indices can be put together to calculate a country index. Country indices can be aggregated to make a macro-regional index and all of these together would comprise the global index. Instead of aggregating according to spatial-political units, the aggregation could be determined by eco-regions (e.g. landscapes, regions, continents) or levels of demographic density. There is really no limit on its capacity for aggregation other than comparability of method and data across all of the sites included. The same basic formulas for calculating the Vitality Index described in section 7.9 can be used at any scale except that the calculation involves taking the mean index value of all the individual indices included from the lower scale. The mean vitality index is calculated by the following equation:

$$\overline{VI}_t = \frac{1}{n_t} \sum_{i=1}^{n_t} VI_{it}$$

where VI is used to represent any of the measures RG , RC , or CA and n_t is the number of samples included

The same basic formula can be used to calculate the mean vitality index by scale for males (\overline{VI}_{tm}), females (\overline{VI}_{tf}), and all generational groups (\overline{VI}_a) as depicted below.

For males:

$$\overline{VI}_{tm} = \frac{1}{n_t} \sum_{i=1}^{n_t} VI_{itm}$$

For females:

$$\overline{VI}_{tf} = \frac{1}{n_t} \sum_{i=1}^{n_t} VI_{itf}$$

For all generational groups:

$$\overline{VI}_a = \frac{1}{n_t} \sum_{i=1}^{na} VI_{ia}$$

Aggregate measures can in turn be disaggregated according to the TEK domains and categories that are included in the test across different sites. This feature is especially important for identifying generalized trends of TEK constancy/change with respect to particular areas or kinds of knowledge or for testing hypothesis about the impacts of specific environmental drivers. For example, this technique could be used to assess the vitality/loss of traditional agricultural practices in different populations of a province, country or region. The vitality of ethnobotanical and ethnozoological knowledge of communities living in areas experiencing high (or low) rates of deforestation and biodiversity loss during the lives of their members could actually be measured. The effects of free (vs. protectionist) trade policies on the TEK-dependent livelihoods of women could be assessed. In sum, this combination of aggregative and

disaggregative properties creates in effect a powerful tool for empirically documenting the complex, variable and dynamic trends of TEK at different scales of inclusiveness.

8. VITEK Pilot Study

A pilot implementation study has been planned to make a practical test of the VITEK assessment methodology in real-life field situations. The main purpose of the pilot study is to evaluate the feasibility, practicality, efficiency, and reliability of the method defined in section 7 of this report. This type of exercise will be useful for identifying and correcting any errors, weaknesses or problems with the different operations that make up the protocol. The first phases of the pilot study will be financed with annual research funds that are granted to the project's PI by his home institution, the Instituto Venezolano de Investigaciones Científicas (IVIC). Application for additional funding will be made to the Ley Orgánica de Ciencia, Tecnología e Innovación (LOCTI) program sponsored by the Ministerio del Poder Popular para Ciencia y Tecnología, República Bolivariana de Venezuela.

Ideally, the pilot study should be done among a sample of diverse groups located in different ecoregions in different countries. However, due mainly to economic and logistical constraints as well as prior commitments, we are proposing to do a first phase of testing entirely in Venezuela, which is the country of residence of the project's PI. The plan is to implement it among four different biocultural groups that represent a range of variation in terms of bio-ecological setting, economic orientation, ethnic composition, degree of acculturation, and linguistic situation. The four groups tentatively chosen for the study include: (1) the Yabarana, (2) the Jotí, (3) the communities of Cuyagua and Chuao, and (4) the communities of Apure and Acequias. Besides the fact that they encompass a considerable range of socioecological variation, a primary criterion used for their selection is that the PI of this report or members of his research group at IVIC have had previous contacts and/or field experience with all of them, which should facilitate access and receptivity. A brief description of each group is provided below.

- 1) The Yabarana are an indigenous group living in the Manapiare and Parucito River Basins of Amazonas State. The Yabarana population comprises approximately 300 persons distributed in seven ethnically mixed communities (besides Yabarana, these are mainly Piaroa, Panare, Yekuana and mestizo). The local environment consists of a mosaic of seasonally flooded savanna, lowland tropical forest, premontane forest, tepuy table mountains, blackwater rivers and creeks, and lagoons. The main economic activities include shifting cultivation, fishing, hunting, collection of nontimber forest products, cattle ranching, and occasional placer gold mining. According to written as well as oral history, the land area currently occupied by the Yabarana is considered to be their ancestral territory but both the population as well as their geographical range has been reduced during the last three centuries of colonization and state expansion. The Yabarana suffered demographic and economic shocks during the rubber boom period: some subgroups were coerced into debt-peonage extractive labor while others fled the collection zones and hid from the rubber bosses and their gangs. Other indigenous and nonindigenous groups have moved into this region, especially during the past 50 years, and the Yabarana have experienced a high

degree of interethnic marriage and diffusion of foreign cultural elements. One result of this history of cultural and biological assimilation is that the Yabarana language is no longer spoken actively by the majority of the population; the main languages spoken in Yabarana communities today being Spanish and Piaroa. Despite these changes, the Yabarana maintain a strong sense of ethnic identity and have formed a tribal organization which has undertaken activities aimed at recuperating some of their lands occupied by outsiders and revitalizing their cultural and linguistic traditions.

- 2) The Jotĩ are an indigenous group numbering about 800 individuals among 25 communities located in the Upper Cuchivero watershed in Bolívar State, and the Asita, Iguana, and Upper Parucito River basins in Amazonas State. The local environment is mainly tropical forest that varies in terms of structure and composition along an altitudinal gradient from basimontane to premontane to montane levels. The Jotĩ were totally isolated and uncontacted by the western world until the 1970's due to the difficult access and rugged mountainous terrain of their home territory. At that time, they were very nomadic and subsisted mainly by hunting-gathering but also practiced an incipient form of shifting cultivation. In the last three decades, some of them have expanded their contacts with neighboring indigenous groups and foreign missionaries, acquired western trade goods and tools, and been exposed to foreign cultural beliefs and practices. However, not all local groups are equally affected by these changes. Some groups continue to live a traditional nomadic lifestyle and have virtually no contact with nonJotĩ and even those who have settled around current or former mission bases still have very limited contact and interaction with outsiders and continue to depend heavily on foraging and trekking activities for their livelihood. As a result, the Jotĩ are rightly considered to be one of the least acculturated indigenous groups living in Venezuela today. Most members of their group are monolingual speakers of the Jotĩ language and relatively few people have learned Spanish as a second language.
- 3) The residents of Chuao and Cuyagua municipalities constitute a *criollo* (i.e. mestizo) population of mixed Indian, African, and European ancestry occupying a coastal habitat. These communities are located in fluvial valleys on the northern coast of Aragua State, bordered on the north by the Caribbean Sea and on the south by the Cordillera de la Costa (coastal mountain range). Besides the sea, beach and littoral scrublands, this region encompasses humid premontane forest, low montane forest, and dry tropical forest life zones. Chuao and Cuyagua were founded as colonial plantation settlements in the XVIth and XVIIth centuries respectively in an area occupied by Carib and Arawakan Indians. African slaves were brought in from the XVIIIth century on to supply labor for agricultural works, mainly cocoa, indigo and coffee production, and intermarried over the years with the Indian population. This area was only accessible by boat or foot travel until the 1960's and, partly as a consequence of its relative isolation, the inhabitants developed a distinctive regional expressive culture characterized by syncretic religious beliefs, cycle of Catholic-based fiestas, *cofradía* (brotherhood) organizations, herbal- and faith-based healing, and African-rooted music and dance. The main economic activities practiced in both localities are: commercial silviculture dominated by cocoa or coffee, family subsistence gardens, maritime fishing, tourism-related businesses, construction, and government-sector jobs. A fairly large number of young adults have moved to cities in the northern states in order to perform wage labor, and send periodic

remittances home to older as well as younger relatives still living in the communities. Everyone in both communities speaks Spanish as their mother tongue.

- 4) The agricultural peasant communities of Apure and Acequias, located in the Sierra Nevada of Mérida State, comprise a mestizo group with European and Indian biological and cultural roots. The local environment corresponds to high mountain ecosystems between 2,000 and 4,000 m asl, including cloud forest, subparamo, and paramo life zones, in addition to substantial human-altered expanses. This region was originally inhabited by the once numerous but now-extinct Timoto-Cuica Indian group but it was converted into a major wheat- and dairy-producing region by the colonial authorities beginning in the XVIIth century. Over a period of centuries, the native population and culture either declined or merged with incoming European settlers. Today the region's inhabitants resemble in many respects other peasants throughout the Andean mountain region of Venezuela except that they are notorious for their cultural conservatism and insularity. Agriculture continues to be the economic mainstay, of which different types of crop farming are practiced (e.g. maize, wheat, potato, carrots, dairy - varying mainly according to altitude and topography) for home consumption as well as for sale. Numerous wild plant species are also collected for medicinal and technological purposes. No one in this area speaks an Indian language anymore, although a number of indigenous words still survive, especially the names of plants, animals, and places.

Community members will have an active role for implementation of the proposed methodology. First, they will be responsible for determining the specific content of the local corpus of TEK that they consider to be valid, viable, and valuable (section 7.2). Second, certain members will be trained to administer the testing instrument, to code the data collected, and to report the results to designated data managers (section 7.3). Following implementation of the methodology and collection of data, indices will be produced for all four groups (section 7.4). Based on the results of this experience, the methodology will be critically evaluated and necessary modifications will be made at that time.

A summary of the sequential operations that will be taken in each locality and the estimated time it will take to complete each one is provided in table 8.1 while the projected chronogram for the entire pilot study is shown in table 8.2 below.

Table 8.1. Pilot Study Sequential Description of Activities and Timeline

Study Phase	Description of Activities	Estimated Timeline
1. Project Introduction and Previous Informed Consent	Members of the research team will travel to the proposed participating communities in order to explain the nature and purpose of the project and to secure their consent to participate. If consent is given, a written agreement specifying the terms and	1 month

	conditions of the project activity will be drawn up and signed by the different parties.	
2. Research Permit Process	Applications for the necessary permits for carrying out the project are prepared and submitted. Such permits include: approval by the Bioethics Committee of the sponsoring institution (Instituto Venezolano de Investigaciones Científicas), genetic resources access contract granted by the Ministry of Popular Power for the Environment and Natural and Renewable Resources, and the Ministry of Popular Power for Indigenous Peoples (applicable in the case of indigenous communities), among others.	2-3 months
3. TEK Domain Definition	The predefined set of cosmopolitan TEK domains (see table 7.1) is adapted and translated into a corresponding set of local TEK domains through a process of consensual consultation with local group members in the context of collective gatherings. Separate consulting sessions are held for male and female participants.	1 month
4. Data Register Compilation	A select inventory of the categories or items (50–100 total for practicality's sake) pertaining to each local TEK domain will be elicited from each gender group. Using culturally appropriate scoring methods, both the list of local domains as well as the constituent items comprising each one are then weighted based on local participants' assessment of their cultural importance.	1 month

5. TEK aptitude Test Design/Construction	Stimulus materials (e.g. photographs, specimen samples, drawings) for the test are prepared. Using a random or proportional sampling method, test items are drawn from each local domain based on the compiled data register. A minimum of three different sample tests per gender group are prepared.	1 month
6. Sample Selection	Based on a review of available community census materials, a sample of subjects will be selected to take the test. The sample will be stratified primarily by age and gender.	< 1 week
7. Test Administration	Local community workers (LCWs) are trained to administer the aptitude test through supervised trial runs and to record the results in an aggregate database. After the training is complete, the LCWs proceed with administering the test to the sample of community participants.	2 months
8. VITEK statistical calculation	The respective statistical measures defined in section 7.4 are computed. The LCWs are taught to perform the calculations on their own.	1 week
9. Analysis and Reporting at Local Level	The results of each individual assessment are presented in oral and written forms to the participating source communities.	2 weeks
10. Global Analysis and Reporting	The results of the entire pilot study are analyzed and written up as a technical report that describes the substantive results of TEK vitality in the four study groups as well as the evaluation of the assessment methodology and any recommendations for its	2 months

	modification. The report will be disseminated to institutional sponsors (Terralingua, The Christensen Fund, and in-country organizations).	
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Table 8.2. Pilot Study Chronogram

Dates	Phases, Groups 1 & 2	Phases, Groups 3 & 4
08/2008		1
09/2008	1	2
10/2008	2	2
11/2008	2	3
12/2008	2	4
01/2009	3	5
02/2009	4	6 & 7
03/2009	5	7
04/2009	6 & 7	8 & 9
05/2009	7	
06/2009	8 & 9	
07/2009	10	10
08/2009	10	10

9. Plans for Publication of Results

In addition to reporting the results of this study in the present report, and with the goal of expanding the communication of these results to a wider audience, the preparation of scholarly articles that will be submitted for publication to peer-reviewed journals are being planned. The first paper that will be prepared will entail an evaluation of the hypothesis that TEK erosion is a global trend in the contemporary world, including a literature review of different case studies that provide empirical evidence for or against the hypothesis and discussion of the different social and environmental factors that have been identified as affecting the prevailing trend(s). It will be based in large part on section 6 of the present report. The journals being considered for this submission are *Journal of Ethnobiology* or *Human Ecology*. The second planned paper is a review article of the burgeoning field of research known as Quantitative Ethnobiology, focusing on methodological innovations, ethnographic aspects and theoretical implications, which will probably be submitted to the journal *Annual Review of Anthropology*. This paper will rely heavily on the review and evaluation of methods and findings discussed in section 5 of the present report. Finally, after the pilot study is carried out, an article describing the VITEK protocol (see section 7) and the results of its application will be prepared and submitted to either *Field Methods* or *Ecological Indicators*.

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