TRADITIONAL ECOLOGICAL KNOWLEDGE

CONCEPTS AND CASES

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PREFACE

In December 1989, the United Nations General Assembly called for a global meeting that would devise strategies to halt and reverse the effects of environmental degradation. In response to this request, the United Nations Conference on Environment and Development (UNCED), commonly known as the Earth Summit, was held in June 1992 in Rio de Janeiro.

The Earth Summit produced agreements on basic principles for sustainability and established specific requirements for assuring a more secure and sustainable future. The principles are enshrined in the Rio Declaration and the requirements in Agenda 21, a comprehensive and far reaching program of action for assuring sustainability.

Critical to the successful implementation of Agenda 21 is the recognition of the contribution of indigenous peoples and their knowledge to the quest for a sustainable future. There are numerous references to indigenous knowledge, or what is commonly known as traditional ecological knowledge (TEK), in the Rio Declaration, the agreements, and Agenda 21, including:

- Principle 22 of the Rio Declaration
- Preamble, Articles 8 and 10 of the Convention on Biological Diversity
- "Forest Principles"
- Chapter 26 of Agenda 21

TEK refers to the knowledge base acquired by indigenous and local peoples over many hundreds of years through direct contact with the environment. It includes an intimate and detailed knowledge of plants, animals, and natural phenomena, the development and use of appropriate technologies for hunting, fishing, trapping, agriculture, and forestry, and a holistic knowledge, or "world view" which parallels the scientific discipline of ecology.

In September 1991, recognizing the importance of TEK in planning and decision-making for sustainable development, UNESCO Canada Man and the Biosphere Programme (MAB) and the Canadian Environmental Assessment Research Council (CEARC) jointly sponsored the International Workshop on Indigenous Knowledge and Community Based Resource Management. More than 50 indigenous people and specialists participated in this two-day workshop. The workshop recommended that an international program be established to promote and advance the concept and use of TEK in planning and decision-making.

The Program was initially developed under the auspices of the UNESCO Canada/MAB program, and it is recognized under the UN Decade for Cultural Development. The International Program has now been formally established under the leadership of the Honourable James Bourque P.C., Chair, Traditional Ecological Knowledge at the Canadian Museum of Nature in Ottawa, Canada.

The goal of the Program is to promote and advance the recognition, understanding and use of TEK in policy and decision-making for sustainable development.

Program objectives are:

- to foster and support research into the nature, scope, use and preservation of TEK;
- to promote the development and implementation of a Code of Ethics and Practice regarding the acquisition and use of TEK;

- to facilitate the communication, and exchange, of ideas, information, experiences and practices associated with TEK;
- to promote the understanding and use of TEK through the formal, non-formal and informal education systems;
- to ensure that both traditional ecological knowledge and western-based science are employed in a complementary manner in planning and decision-making.

The papers in this volume were selected from presentations made in a number of special sessions on TEK, which were held as part of the Common Property Conference, the second annual meeting of the International Association for the Study of Common Property. The meetings were attended by indigenous peoples and specialists in the subject from around the world.

The papers selected for this volume represent a wide range of perspectives on the nature of TEK. They explore the underlying concepts, provide case studies, and confirm once again the importance and, as yet, unrealized potential of TEK in resource and environmental management. The papers reinforce the conviction that TEK can make a major contribution to the delivery of Agenda 21 and to sustainable development. The papers also reinforce the point that indigenous and local peoples have themselves lived in harmony with their environments for many hundreds of years, a relationship which is evident in many of their activities today.

The International Program seeks to encourage the use of this knowledge at the community level, in all resource sectors, as a very real and essential contribution to the local, regional and national economy.

In many cases, it is a matter of survival.

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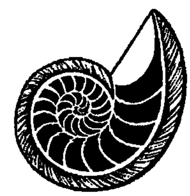
The papers making up the volume were for the most part delivered at the Common Property Conference — the Second Annual Meeting of the International Association for the Study of Common Property, University of Manitoba, Winnipeg, Manitoba, September 1991. The Keynote Address which forms Chapter 2 of the volume was delivered to the International Workshop on Indigenous Knowledge and Community Based Resource Management chaired by Jim Bourque, Government of the Northwest Territories, and Chairman, Northern Working Group, UNESCO Canada Man and the Biosphere Program. The workshop was held in association with the Common Property Conference.

The papers were selected by an editorial committee comprised of Fikret Berkes, University of Manitoba, Rick Riewe, University of Alberta, Carl Hrenchuk, Canadian Council of Ministers of the Environment, Patrice LeBlanc, Canadian Environmental Assessment Research Council, and Julian Inglis, International Program on Traditional Ecological Knowledge.

Copy editing was the responsibility of Joan Haire, who took on the time consuming task of shaping the individual contributions into a coherent collection of essays. Credit for the final product must go to her. Editing assistance was also provided by Carl Hrenchuk.

1. Traditional Ecological Knowledge in Perspective

Fikret Berkes



"Ecosystems sustain themselves in a dynamic balance based on cycles and fluctuations, which are nonlinear processes... Ecological awareness, then, will arise only when we combine our rational knowledge with an intuition for the nonlinear nature of our environment. Such intuitive wisdom is characteristic of traditional, non-literate cultures, especially of American Indian cultures, in which life was organized around a highly refined awareness of the environment" (Capra 1982:41).

Traditional ecological knowledge (TEK) represents experience acquired over thousands of years of direct human contact with the environment. Although the term TEK came into widespread use in the 1980s, the practice of TEK is as old as ancient hunter-gatherer cultures. In addition to ecology, the study of traditional knowledge is valued in a number of fields. For example, in agriculture, pharmacology and botany (ethnobotany), research into traditional knowledge has a rich history. In fact, in comparison to these fields, the study of indigenous knowledge in ecology is relatively recent.

The earliest systematic studies of TEK were done by anthropologists. Ecological knowledge as studied by ethnoecology (an approach that focuses on the conceptions of ecological relationships held by a people or a culture), may be considered a subset of ethnoscience (folk science), defined by Hardesty (1977:291) as "the study of systems of knowledge developed by a given culture to classify the objects, activities, and events of its universe." Pioneering work by Conklin (1957) and others documented that traditional peoples such as Philippines horticulturalists often possessed exceptionally detailed knowledge of local plants and animals and their natural history, recognizing in one case some

1,600 plant species. Other kinds of indigenous environmental knowledge were acknowledged by scientific experts. For example, Arctic ecologist Pruitt has been using Inuit (Eskimo) terminology for types of snow for decades.

> Boreal ecologists deal with aspects of nature, particularly snow and ice phenomena, for which there are no precise English words. Consequently our writings and speech are larded with Inuit, Athapaskan, Lappish and Tungus words, not in any attempt to be erudite but to aid in the precision in our speech and thoughts (Pruitt 1978:6).

There has been growing recognition of the capabilities of ancient agriculturalists, water engineers and architects (for example, Fathy 1986). Increased appreciation of ethnoscience, ancient and contemporary, paved the way for the acceptability of the validity of traditional knowledge in a variety of fields. Ancient ways of knowing started to receive currency in several disciplines, including ecology. Various works showed that many indigenous groups in diverse geographical areas from the Arctic to the Amazon (for example, Posey 1985) had their own systems of managing resources. Thus, the feasibility of applying TEK to contemporary resource management problems in various parts of the world was gradually recognized. As stated in Our Common Future:

> Tribal and indigenous peoples'... lifestyles can offer modern societies many lessons in the management of resources in complex forest, mountain and dryland ecosystem (WCED 1987:12).
>
> These communities are the repositories of vast accumulations of traditional knowledge and experience that link humanity with its ancient origins. Their disappearance is a loss for the larger society, which could learn a great deal from their traditional skills in sustainably managing very complex ecological systems (WCED 1987:114-115).

Professionals in applied ecology and resource management fields such as fisheries, wildlife and forestry have been slow to take up the challenge of TEK. The reasons for this are as complex as they are perplexing (Freeman 1989). With the recognition of the value of TEK, the growth of the field has been rapid, however. It should be noted though that most of these contributions have come from interdisciplinary scholars rather than from ecology and resource management professionals.

Book-length works include studies in the transmission of TEK (Ruddle and Chesterfield 1977); community-based TEK research approaches (Johnson 1992); application of TEK to development (Brokensha et al. 1980) and to resource management (Klee 1980); detailed biological/ecological evaluation of fisheries TEK systems in Oceania (Johannes 1981); traditional conservation (Moruata et al. 1982; McNeely and Pitt 1985); traditional coastal resource management systems (Lasserre and Ruddle 1983); TEK of northern ecosystems (Freeman and Carbyn 1988), dryland ecosystems (Niamir 1990) and tropical forest ecosystems (Posey and Balee 1989); environmental philosophy and indigenous knowledge (Knutdson and Suzuki 1992); volumes of selected topics (Johannes 1989) and studies of traditional marine resource management systems in Asia and the Pacific (Ruddle and Johannes 1989; Freeman et al. 1991).

A recent volume (Warren et al. 1993) contains an authoritative summary of the various indigenous knowledge fields from a development perspective. Some of the material summarized in it is based on the work done at the Center for Indigenous Knowledge for Agriculture and Rural Development (CIKARD), Iowa State University, which published the newsletter *CIKARD News*. As of 1993, this newsletter has been superseded by the *Indigenous Knowledge and Development*

Monitor, the newsletter of the Global Network of Indigenous Knowledge Resource Centers, based in The Hague, The Netherlands.

Defining Traditional Ecological Knowledge

There is no universally accepted definition of traditional ecological knowledge (TEK) in the literature. The term is, by necessity, ambiguous since the words *traditional* and *ecological knowledge* are themselves ambiguous. In the dictionary sense, *traditional* usually refers to cultural continuity transmitted in the form of social attitudes, beliefs, principles and conventions of behaviour and practice derived from historical experience. However, societies change through time, constantly adopting new practices and technologies, and making it difficult to define just how much and what kind of change would affect the labelling of a practice as *traditional.*

Because of this, many scholars prefer to avoid using the term *traditional*. As well, some purists find the term unacceptable or inappropriate when referring to societies such as Native northern groups whose lifestyles have changed considerably over the years. For this reason, some prefer the term, *indigenous ecological knowledge*, which helps avoid the debate about tradition, and explicitly puts the emphasis on indigenous people.

The term *ecological knowledge* poses definitional problems of its own. If ecology is defined narrowly as a branch of biology in the domain of western science, then strictly speaking there can be no TEK; most traditional peoples are not scientists. If ecological knowledge is defined broadly to refer to the knowledge, however acquired, of relationships of living beings with one another and with their environment, then the term TEK becomes tenable. It is what Levi-Strauss (1963) has called the "science du concret", native knowledge of the natural milieu.

In this context, *ecological knowledge* is not the term of preference for traditional or indigenous peoples themselves. In the Canadian North, for example, native peoples often refer to their *knowledge of the land* rather than to ecological knowledge. *Land*, however, is more than the physical landscape; it includes the living environment. Interestingly, in the history of scientific ecology, *land* was also often used in the sense of *ecosystem* (Leopold 1949).

To arrive at a definition of TEK, it is necessary to sift through the various meanings and elements of TEK as emphasized in the major works on this subject (for example, Lasserre and Ruddle 1982; Ruddle and Johannes 1989; Freeman and Carbyn 1988). Putting together the most salient attributes of TEK from these sources, one may arrive at a working definition:

> TEK is a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Further, TEK is an attribute of societies with historical continuity in resource use practices; by and large, these are non-industrial or less technologically advanced societies, many of them indigenous or tribal.

Western Science and TEK

There are both similarities and differences between traditional science and western science. Bronowski considers the practice of science (including magic) as a fundamental characteristic of human societies: "...to me the most interesting thing about man is that he is an animal who practices art and science and, in every known society, practices both together" (Bronowski 1978:9). Thus, one can probably say that both western science and TEK (and art) are the result of the same general intellectual process of creating order out of disorder.

There are also major differences, however, between the two kinds of science, some of them substantive and some perceptual. Johannes (1989:5) observes that "the attitudes of many biological scientists and natural resource managers to traditional knowledge has frequently been dismissive." Accomplishments of traditional societies in such fields as agriculture cannot be denied; most domesticated species predate western science. Nevertheless, the existence of curiosity-driven inquiry among traditional peoples has been questioned by those who regard the knowledge of other cultures as *pre-logical* or *irrational*, thus playing down the validity of TEK.

Opinions differ, but there is a great deal of evidence that traditional people do possess scientific curiosity, and that traditional knowledge does not merely encompass matters of immediate practical interest. Levi-Strauss (1962) has argued this point on the grounds that ancient societies could not have acquired such technological skills as those involved in the making of water-tight pots without a curiosity-driven scientific attitude and a desire for knowledge for its own sake. As Levi-Strauss (1962:3) states it, "the universe is an object of thought at least as much as it is a means of satisfying needs." As Harvey Feit (personal communication) paraphrased it, "moose are not only good to eat, they are good to think."

In general, TEK differs from scientific ecological knowledge in a number of substantive ways:

1. TEK is mainly qualitative (as opposed to quantitative);
2. TEK has an intuitive component (as opposed to being purely rational);
3. TEK is holistic (as opposed to reductionist);
4. In TEK, mind and matter are considered together (as opposed to a separation of mind and matter);
5. TEK is moral (as opposed to supposedly value-free);
6. TEK is spiritual (as opposed to mechanistic);
7. TEK is based on empirical observations and accumulation of facts by trial-and-error (as opposed to experimentation and systematic, deliberate accumulation of fact);
8. TEK is based on data generated by resource users themselves (as opposed to that by a specialized cadre of researchers);
9. TEK is based on diachronic data, i.e., long time-series on information on one locality (as opposed to synchronic data, i.e., short time-series over a large area).

There are exceptions, as always, to the above generalizations. For example, there is evidence from Feit's (1987) work with subarctic beaver trappers that TEK can be quantitative; Berkes' (1977) work shows that Cree fishermen of the subarctic are perfectly adept at carrying out controlled field experiments. As well, of course, scientific ecology can and often does use holistic approaches, and occasionally produces diachronic data.

In contrast to scientific ecology, TEK does not aim to control nature, and is not primarily concerned with principles of general interest and applicability (i.e., theory). TEK is limited in its capacity to verify predictions, and it is markedly slower than scientific ecology in terms of the speed at which knowledge is accumulated. A major way in which TEK may be further distinguished from scientific ecology concerns the large social context of TEK. TEK is not merely a system of knowledge and practice; it is an integrated system of knowledge, practice and beliefs. The social context of TEK includes the following dimensions:

a) Symbolic meaning through oral history, place names and spiritual relationships (Levi-Strauss 1962; Tanner 1979; Hrenchuk, this volume);

b) A distinct cosmology or world view; a conceptualization of the environment that is different from that of Western science of which ecology is a part (Tanner 1979; Freeman and Carbyn 1988; Johannes 1989; Nakashima, this volume);

c) Relations based on reciprocity and obligations towards both community members and other beings (Fienup-Riordan 1990), and communal resource management institutions based on shared knowledge and meaning (Berkes 1989).

Some of the dimensions of the social context of TEK are captured in the following quote from Caring for the Earth:

> Hunting, fishing, trapping, gathering or herding continue to be major sources of food, raw materials and income. Moreover, they provide native communities with a perception of themselves as distinct cultures, confirming continuity with their past and unity with the natural world. Such activities reinforce spiritual values, an ethic of sharing, and a commitment to stewardship of the land, based on a perspective of many generations (IUCN/ UNCEP/ WWF 1991: 61).

Practical Significance of TEK

It follows from these considerations that the preservation of TEK is important for social and cultural reasons. For the group in question, TEK is a tangible aspect of a way of life that may be considered valuable (for example, Wavey, this volume). For the rest of the world, there are also tangible and practical reasons why TEK is so important, quite apart from the ethical imperative of preserving cultural diversity. The following list is adapted from the IUCN Programme on Traditional Knowledge for Conservation (IUCN 1986):

1. Traditional knowledge for new biological and ecological insights. New scientific knowledge can be derived from perceptive investigations of traditional environmental knowledge systems, as in the case of life cycles of tropical reef fish (Johannes 1981).

2. Traditional knowledge for resource management. Much traditional knowledge is relevant for contemporary natural resource management, in such areas as wetlands. "Rules of thumb" developed by ancient resource managers and enforced by social and cultural means, are in many ways as good as Western scientific prescriptions (Gadgil and Berkes 1991).

3. Traditional knowledge for protected areas and for conservation education. Protected areas may be set up so as to allow resident communities to continue their traditional lifestyles, with the benefits of conservation accruing to them. Especially where the local community jointly manages such a protected area, the use of traditional knowledge for conservation education is likely to be very effective (Gadgil et al., in press).

4. Traditional knowledge for development planning. The use of traditional knowledge may benefit development agencies in providing more realistic evaluations of

environment, natural resources and production systems. Involvement of the local people in the planning process improves the chance of success of development (Warren et al. 1993).

5. Traditional knowledge for environmental assessment. People who are dependent on local resources for their livelihood are often able to assess the true costs and benefits of development better than any evaluator coming from the outside. Their time-tested, in-depth knowledge of the local area is, in any case, an essential part of any impact assessment (Johannes, this volume).

In addition to these practical uses for TEK, it is also significant, as Carl Hrenchuk (personal communication) has pointed out, that a newfound awareness of TEK in mainstream western society can enhance our appreciation of the cultures that hold this knowledge. As well, the recording of such knowledge is significant in the political realm as a tool for social change. For example, the TEK of northern Canadian indigenous peoples as recorded by Nakashima, Hrenchuk and Tobias in this volume provides insight into the life of the people of these communities, and makes southern governments take this knowledge more seriously.

In the past, western science alone provided biological and ecological insights, the knowledge base for resource management, conservation, development planning and environmental assessment. At this stage of the development of TEK, it is possible to say that indigenous peoples and the knowledge held by them do have something to contribute to each of the above areas. But traditional knowledge is complementary to western science, not a replacement for it (Knudtson and Suzuki, 1992).

However, just what TEK can contribute and how is yet to be operationalized. As well, the question remains as to how scientific knowledge and TEK can be integrated — and whether such integration is desirable in the first place. Rooted in different world views and unequal in political power base, these two systems of knowledge are certainly not easy to combine. Serious attempts at integration inevitably come up against the question of power-sharing in decision-making. Many of the chapters in this volume are contributions towards exploring and resolving these issues.

Overview of this volume

In Chapter 2, Chief Wavey of the Fox Lake First Nation, northern Manitoba, sets the stage for traditional ecological knowledge discussions by presenting an indigenous peoples' point of view. Chief Wavey's chapter, based on the keynote address which he delivered to the International Workshop on Indigenous Knowledge and Community-based Resource Management, makes explicit the political nature of the issue which is at the heart of any discussion of TEK. Chapter 3 by Ruddle addresses the key issue of how knowledge is transmitted from one generation to the next, based on his classic study of indigenous peoples in the Orinoco Delta of South America. Johannes (Chapter 4) provides perspectives on the use of traditional knowledge for a very practical and current issue: environmental impact assessment. Doubleday in Chapter 5 explores TEK as alternative collective wisdom relevant to a variety of matters at a time when existing norms, values and laws are increasingly called into question.

Chapters by Lalonde (Chapter 6) and McDonald and Fleming (Chapter 7) deal with development-related issues. Lalonde discusses the relevance of African indigenous knowledge to environment and development issues of today. McDonald and Fleming describe community-based economic development and resource management in the Hudson Bay Inuit (Eskimo) community of Sanikiluaq in northern Canada. Chapters by Hrenchuk (Chapter 8) and Tobias (Chapter 9) deal with the indigenous worldview, and illustrate two major emerging approaches for the documentation of traditional knowledge. Hrenchuk describes how a community of northern Manitoba Cree Indians in subarctic Canada utilizes an extensive territory for their hunting needs. Tobias deals with a Metis community in northern Saskatchewan, and a wildlife harvesting study which debunked popular planning myths.

Chapters by Nakashima (Chapter 10), Usher (Chapter 11), Binder and Hanbidge (Chapter 12) and Eythorsson (Chapter 13) all deal with the relationship of indigenous peoples with the state in the management of resources. Nakashima explains the traditional knowledge of Sanikiluaq Inuit concerning eider ducks, and how this knowledge is an appropriate basis for the joint government-local native people co-management of eider. Usher presents a co-management study of two major caribou herds in the Canadian Arctic, which is one of the earliest co-management agreements involving indigenous peoples in North America. Binder and Hanbidge provide a second co-management case study of a land claims settlement in the Canadian Arctic. Eythorsson describes the Sami fisherman of northern Norway and explains why local knowledge and local norms provide the necessary supplement to scientific knowledge for resource co-management.

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2. International Workshop on Indigenous Knowledge and Community-based Resource Management: Keynote Address

Chief Robert Wavey

Recently, academics, scientific researchers and others have "discovered" that the knowledge which indigenous people hold of the earth, its ecosystems, the wildlife, fisheries, forests and other integrated living systems is extensive and extremely accurate. On the eve of the 500th anniversary of Christopher Columbus having stumbled upon North America, it is appropriate to provide comments from the perspective of an indigenous person in North America on what the concept of "discovery" means to us.

At the time Europeans first contacted Aboriginal peoples, the quality of our environment was such that our communities had access to ample supplies of clean water, timber and wood, berries and medicinal plants, beaver, muskrat, moose, caribou, geese and other wildlife.

The laws and customs of First Nations guided the sharing and management of resources, and ensured that our people could continue to enjoy, on a sustained basis, the resources which provided the needs of our families. These laws and customs are based on generations of observation and knowledge. Our laws and customs respecting land and resources also form the binding foundation of Aboriginal nations and systems of governance.

Europeans came to a resource-rich continent after millennia of management and stewardship of that continent by Aboriginal people. After 500 years of continuous exploitation and development, guided by science and technological discovery, non-aboriginal management systems have created an era of unprecedented opportunity for widespread ecological catastrophe.

As was the case with Columbus, "discovery" is in the eye of the beholder. It may be more accurate to state that the dominant European-based society, after 500 years, has finally stopped ignoring our traditional knowledge, laws and customs.

As indigenous people, we spend a great deal of our time, through all seasons of the year, travelling over, drinking, eating, smelling and living with the ecological system which surrounds us. Aboriginal people often notice very minor changes in quality, odour and vitality long before it becomes obvious to government enforcement agencies, scientists or other observers of the same ecological system.

Governments have begun to view indigenous people and their knowledge of the land as an early warning system for environmental change, perhaps in much the same way as miners once viewed canaries. The difference is that a canary does not know why it died, or what was wrong; indigenous people do. The canary can not propose solutions or provide an example of lifestyles and ethics to restore ecological balance; indigenous people can. The canary does not foretell environmental change, but indigenous people accurately predict ecological disturbance, based on multi-generational accumulations of knowledge and experience.

Soon after contact with Europeans, indigenous people recognized that the foreign way of touching, using, and thinking about the earth would ultimately lead to ecological destruction and to an uncertain future for all people. Aboriginal leaders warned of the ecological consequences. In the words of Chief Seattle:

> We know that the white man does not understand our ways. One portion of the land is the same to him as the next, for he is a stranger who comes in the night and takes from the land whatever he needs.
>
> The earth is not his brother, but his enemy, and when he has conquered it, he moves on. He leaves his father's graves behind, and he does not care. He kidnaps the earth from his children, and he does not care. His father's grave, and his children's birthright are forgotten. He treats his mother, the earth, and his brother, the sky as things to be bought, plundered, sold like sheep or bright beads. His appetite will devour the earth and leave behind only a desert.
>
> But in your perishing you will shine brightly, fired by the strength of the God who brought you to this land for some special purpose, gave you dominion over this land and over the red man. That destiny is a mystery to us, for we do not understand when the buffalo are all slaughtered, the wild horses tamed, the secret corners of the forest heavy with the scent of many men, and the view of the ripe hills blotted by talking wires. Where is the thicket? Gone. Where is the eagle? Gone. The end of the living and the beginning of the survival.

Chief Seattle spoke these words in 1854.

The United Nations World Commission on Environment and Development found in 1987 that:

> Social discrimination, cultural barriers, and the exclusion of [indigenous peoples] from national political processes makes these groups vulnerable and subject to exploitation... They become the victims of what could be described as cultural extinction ... .

In Canada, the process of acquiring Aboriginal lands for agriculture, forestry, mining and settlements was rooted in an official policy of cultural extermination which continued for several generations. In concert with the churches, Aboriginal children were removed from our communities year after year for the entire school season. We were prevented from speaking our languages and we were prevented from practising our ceremonies in respect for Mother Earth and our ancestors. Separating the children from the grandparents and elders resulted in many of our people losing touch with traditional resource uses and knowledge of the land.

The Government of Canada did not succeed. The traditions, cultures, languages, institutions and beliefs of our people live on and grow stronger every day.

Two important things have kept the Aboriginal people of Canada strong and together. The first is our tremendous sense of community and family. Our traditional means of teaching — with the grandparents teaching the young while the parents provide for the family — remains today within our communities; it has ensured that the young people recover, restore and revitalize their traditions, their languages and their way of life. The second is that *most Aboriginal people in Canada still have the land.* Without the land, our knowledge of the land and the respect that we hold for the land, our communities and our way of life would not exist because *the land and the people are one.* A land base and extensive traditional ecological knowledge has ensured the cultural survival of Aboriginal people in Canada.

The boreal forest in Manitoba is almost roadless and is home to more than 33,000 treaty Aboriginal people living in some 30 communities. To Manitoba's northern people, there are no frontiers, wilderness or empty lands; the forest is the First Nations homeland. Manitoba's boreal forest region is almost completely interconnected by trails, rivers, lakes and portages. The region also contains hundreds of spring, summer and winter hunting, fishing, gathering and trapping encampments. The boreal forest provides considerable direct economic value to the communities, values which are largely invisible to resource developers, managers and politicians. In addition to the teaching of skills, each elder maintains continuity and links to the community resource area by transferring a highly detailed oral "map" and inventory of resource values and land use locations. These individual and family maps knit together into a rich and complete mosaic which provides integrated knowledge of the ecosystems within the community's traditional resource area.

Therefore, major ecological disturbances such as hydroelectric development and large-scale forestry activities have profound cultural impacts by obliterating the reference points and actual resources that these maps are intended to share. Resource developments convert highly valued and sought-after family and community knowledge into memories. The UN World Commission describes the disappearance of indigenous cultures as "a loss for the larger society, which could learn a great deal from their traditional skills in managing very complex ecological systems." The same is true for the loss of traditional ecological knowledge.

If the concept of ecosystems includes those habitats extensively modified by humans, then traditional ecological knowledge is used by everybody every day of their lives; many are just not aware of it. In the cities of the world, for example, urban survival knowledge is a form of traditional knowledge. People must use their adaptive instincts to survive on the streets, in the school yards, in the factories and in the office towers. Urban families accumulate "street smarts" which change to meet the times. Detailed knowledge of the urban environment is essential for survival.

There is a major difference between traditional ecological knowledge, which is an instinctive adaptation taking place within a few short years, and the body of traditional ecological knowledge, which is accumulated for specific lands and handed down over many generations. For example, many resource developers and government planners often assume that Aboriginal people are highly adaptive and can survive the abrupt relocations and changes in the resource base caused by hydroelectric development. Traditional ecological knowledge related to current areas of land use, occupancy and habitation is often incorrectly assumed to allow for an instant knowledge of new or altered hunting and gathering locations. This attitude was evident during the diversion of the Churchill River and the extensive damming of the Nelson River system in northern Manitoba. Although forcibly relocated Aboriginal people may survive in the end, their well-being will be affected for many generations while the patterns of experience and observations develop into detailed knowledge of the altered localized ecology.

When the international pulp and paper giant REPAP announced the purchase of a Forest Management Licence covering 108,000 square kilometres of northern Manitoba, an area the size of Guatemala, the Chiefs of northern Manitoba were determined to protect the traditional resource areas of the First Nations affected by documenting the oral and land use maps of resource users in the REPAP cutting area.

Earlier experience with the massive hydroelectric projects in northern Manitoba had proven that non-aboriginal developers and government considered impacts to Aboriginal land uses too general to quantify accurately using existing techniques. As a result, they were effectively ignored. The Chiefs were determined in the REPAP case to combine traditional ecological knowledge with science by developing an independent capacity to document detailed land use, managing the considerable map data with an automated geographic information system (GIS), and overlaying this data with maps of the REPAP cutting plans.

Under Manitoba's Environment Act, a joint Federal-Provincial Review of the REPAP forestry expansion and bleached kraft proposals is a mandatory requirement. The terms of reference for the environmental impact statement include a detailed assessment of the impacts of logging and roads on Aboriginal land use. However, the Chief of Northern Manitoba has refused to provide this information directly to consultants working for REPAP. Such land use information is the private property of the resource users and the community. It is strictly confidential and may be released only with the consent of the resource user and community involved.

Through its Natural Resources Secretariat, the Council of Manitoba Northern Chiefs, the Manitoba Keewatinowi Okimakanak (MKO), negotiated an agreement-in-principle to have MKO First Nations conduct the land use mapping which was related to the environmental assessment process. Partly as a result of the REPAP agreement, MKO installed a geographic information system (GIS) supported by a system to display and analyze remotely-sensed images to ensure that First Nations benefit in future from the information collected as part of the assessment of forestry impacts.

The MKO GIS Development Project achieved several important objectives. Firstly, the proprietary nature of much of the resource and land use information of individuals was protected. Use, occupancy and habitation maps are often used during land entitlement selection and settlement, mitigation program assessment and other claims negotiations. In addition, impacts could be created by making specific details of land use public through publishing maps of prime hunting and fishing sites, gravesites and former community locations. Second, control of the raw land-use information allows the communities to optimize the acknowledged value of this information through skills development, contracted projects, employment and other means. And finally, MKO now has a comprehensive, computer-based geographic information system to incorporate existing and future land use mapping data, allow overlay and comparison of resource inventories and economic activity, and enable effective modelling of possible alternative patterns of development.

Maintaining complete indigenous control of traditional land use information is a cornerstone in developing a link between traditional ecological knowledge and science. This ensures that indigenous people develop the skills and capacity to benefit from the growing interest in traditional ecological knowledge. Development of the capacity for indigenous people to independently respond to and directly participate in the resource management activities arising from the application of traditional ecological knowledge is also required.

For example, biologists and chemists working in field analysis acknowledge that a human being can often detect changes in taste, water, tissue and other substances, at levels below that of contemporary testing equipment. Aboriginal resource harvesters near the Ruttan copper-zinc mine in northern Manitoba have refused to drink water and eat fish and beaver from lakes which are not related to the licensed discharges from the mill. These changes in taste have developed over the past two years. A recent field sampling program designed by the MKO and Environmental Protection Laboratories identified sample sites and sample types on the basis of interviews with the principal resource harvesters. The field sampling technicians confirmed the significance of the 13 sampling sites suggested by an 83 year-old Cree trapper and others using the area. Work is now underway to develop a permanent First Nations capacity to link traditional ecological knowledge-based environmental monitoring with a sampling and laboratory analysis program directed and operated by Aboriginal people in northern Manitoba.

I have often been asked for some positive examples of First Nations management of natural resources. The question implies that First Nations management is something that is either new or developing through agreements with governments. First Nations in Canada have never surrendered the role of managing the natural resources protected by Aboriginal rights. In fact, the use of resources by Aboriginal people and the stewardship of resources have always been tied together. Many specific sites have been continuously used by our communities for generations, indicating the success of the existing direct management and continued stewardship by the communities.

Although government seeks to regulate lands and natural resources, the ability of government to manage these vast lands directly has always been limited. The government ability to actually manage resources is even more limited now with reductions in budgets and changes in government priorities.

When government and corporate managers fly into remote regions to set up camps for fieldwork, watching them pass overhead are a good number of Aboriginal faces turned to the sky. Aboriginal people watch as exploration camps are built, cut lines made, hydro sites selected, timber harvested and resource roads constructed.

The people retain a record of what the land and the resources have provided for generations, and Aboriginal people are the first to see the changes. The Aboriginal resource users are the principal managers of resources who also bear the burden of the long term impacts. Aboriginal people must develop unique strategies for adjusting to and accommodating these impacts to continue our direct use of the lands and resources.

First Nations intend to ensure a quality of the environment so that our traditional pursuits are maintained. First Nations recognize that influence over decisions concerning natural resources management and the quality of the environment is directly tied to the social, cultural and economic future of Aboriginal people. Ultimately the difference between poverty and prosperity is determined in large measure by the extent to which Aboriginal people directly manage and control the nature, scale and type of development within our traditional lands.

Traditional resource management structures can continue to provide effective stewardship for lands and ecosystems which are not significantly disrupted by development and all the related ecological pressures. The need for linking non-traditional, science-based environmental technologies and management approaches with traditional ecological knowledge increases in relation to the extent of ecological disruption. This is particularly apparent, for example, when identifying problems related to hazardous wastes and industrial pollution. However, an identified need for applying science-based environmental technologies to a disrupted ecosystem does not mean that traditional ecological knowledge and Aboriginal stewardship should be replaced with science-based, non-aboriginal government authority. Traditional ecological knowledge is an important cornerstone of Aboriginal self-government. I agree with the UN World Commission findings that:

> ... the recognition of traditional rights must go hand in hand with measures to protect the local institutions that enforce responsibility in resource use. And this recognition must also give local communities a decisive voice in the decisions about resource use in their area.

In Canada, the entrenchment of Aboriginal and treaty rights in the Constitution, as well as the recent reinforcement of resource rights by the Supreme Court of Canada, provides for a mandatory role for First Nations in the management of natural resources. The role remains unfulfilled.

For science to effectively support traditional ecological knowledge and indigenous resource management in Canada and elsewhere, you must place the highest priority on supporting the development of permanent technical, scientific and support capacity under the control and direction of indigenous peoples. There is no question that increased access to traditional ecological knowledge will allow non-indigenous managers a means for refining and focusing environmental regulation and management. However, I am concerned that science-based management approaches will use the improved ecological database not to focus on development-related ecological impacts, but to impose additional regulations and restrictions on the resource uses of indigenous peoples.

Science has never been neutral in relation to indigenous peoples, lands, resources and development. The struggle to control lands and resources to facilitate development is the principal feature of the relationship between indigenous peoples and governments worldwide. Science is based on discovery, and has provided the foundation for the industrialization of the earth and the concentration of wealth in the hands of those nations with the greatest scientific capacity. Traditional ecological knowledge is not another frontier for science to discover.

When you contemplate the linking of traditional ecological knowledge and science in order to support the healing of Mother Earth, I ask you to resist seeking to discover. I urge you instead to accept what is obvious.

Traditional ecological knowledge is based on mutual well-being and sharing. In our severely disrupted global environments, traditional ecological knowledge is now essential for our mutual survival. The benefits of traditional ecological knowledge can be shared when there is respect, understanding, the recognition of traditional rights, and the recognition of existing indigenous stewardship of many regions of the earth.

3. The Transmission of Traditional Ecological Knowledge

Kenneth Ruddle

Although knowledge is the foundation of social life, the sociology of knowledge, and particularly its transmission between or among generations, remains a neglected field. This is extraordinary in view of the fundamental socio-cultural importance of the process. Similarly, although children and young people actively participate in economic activities of households in the Third World, little is known of their contribution to community life nor of the socialization and the transmission of knowledge to them, nor of the related processes through which they eventually become fully productive adult members of society.

In rural subsistence communities in particular, traditional knowledge is a central concern for the regulation and balance of exploitative pressures that permit an ecosystem to maintain stability and regenerative capacity. But almost without exception, most ethnographers, if they discuss childhood at all, have little to say about how traditional knowledge of specific skills is transmitted. The impression conveyed is that skills are transmitted and acquired in a disorganized, unstructured and highly individualistic manner. Studies of the ecology of human subsistence and food procurement neglect the processes through which information concerning either the preservation of the system's integrity or its modification are transmitted from one generation to the next.

Because continuity from one generation to the next is implicit in the concepts of culture and society, the ethnographic literature concerned with generational transmission of information tends to deal with questions of how children are incorporated into their groups in only very broad analytical terms of cultural and social systems. Such analysis is more informative about the totality of what children learn than about how they acquire traditional ecological knowledge of specific tasks and skills.

However, it is clear from the persistence of social and cultural forms that learning at such general levels is not only structured but also culturally specific; there is no reason to suppose that the acquisition of particular traditional economic and ecological skills is any less so. The scanty data on the subject bear this out. For example, Raum (1940) identified the ages when Chaga boys are shown which banana leaves are best for fodder; Wagley (1957) described Guatemalan Indian boys receiving miniature hoes; and Mead (1930) detailed the experience of Manus children piloting adult canoes. The typical way in which the organization of subsistence training has been mentioned briefly is exemplified by the works of Holmberg (1950), Levine and Levine (1963), Read (1960), (Ruddle and Chesterfield 1977), and Whiting (1941), among others.

The often fragmented and cursory data on subsistence-level societies throughout the world obtained by researchers from a wide range of disciplines yield remarkably consistent generalizations about certain structural and processual characteristics of the transmission of traditional knowledge. These may be summarized as follows (Ruddle and Chesterfield 1977):

(1) There exist specific age divisions for task training in economic activities.

(2) Different tasks are taught by adults in a similar and systematic manner.

(3) Within a particular task complex (for example, gill-netting in fisheries) individual tasks are taught in a sequence ranging from simple to complex.

(4) Tasks are gender and age specific, and are taught by members of the appropriate sex.

(5) Tasks are site specific, and are taught in the types of locations where they are to be performed.

(6) Fixed periods are specifically set aside for teaching.

(7) Tasks are taught by particular kinsfolk, usually one of the learner's parents.

(8) A form of reward or punishment is associated with certain tasks or task complexes.

Just as traditional knowledge and its transmission shape society and culture, culture and society shape knowledge; these are reciprocal phenomena. Thus, vastly differing constructions of knowledge and processes of transmission as well as the social uses to which knowledge is put occur worldwide. To exemplify this, I use contrasting cases from Venezuela and Polynesia in the second part of this paper

Finally, a caveat is required here. It should be asked if the topic we are examining is really *ecological knowledge* or *environmental knowledge,* which includes the social environment. The former term implies an awareness in a given society of the systemic interactions among the components of an environment, an ethnoecological construct. In the absence of such a concept, and with the substitution of a unifying matrix imposed by an outside investigator, which might erroneously assume local systems thinking, the topic is really *traditional environmental knowledge,* in its broadest sense.

The Key Socio-cultural Role of Traditional Knowledge Transmission[1]

In addition to its practical aspects of ensuring sustained resource management, the transmission of traditional knowledge has fundamental socio-cultural importance to any society. During knowledge transmission over several generations, social institutions are gradually crystallized; routine or habitual ways of doing things gradually become the customary way that things are done. For children, a community's customary way eventually becomes the given-received social world, an analog of the biological-physical world with which it overlaps.

In the process of transmitting knowledge to a new generation, the transmitter's sense of reality is strengthened. The social world, which is embodied in traditional knowledge, becomes enlarged during transmission. But, of course, each new generation of receivers of knowledge understands the history and context of its society's institutions only by increasingly attenuated hearsay. The rationale underlying custom, tradition, normative and actual behavior, and rules and regulations must therefore be provided to learners by teachers through consistent and comprehensive legitimation.

The process of knowledge transmission leads logically to that of institutionalization, since the logic of institutions and that of the linkages among them emerges not from the institutions per se, but from the way in which they are treated by conscious reflection by those that operate within them, especially during the process of knowledge transmission. When such reflection is common to the various operators, it provides a logical framework for an institution. This logic also emerges from the reciprocity that occurs among operators of different systems, for example, as among fishermen and farmers, women and men, and different age sets. Continual acts of reciprocity establish the collective consciousness of a logical framework for linked resource systems and their accompanying institutions.

Therefore, knowledge assumes a pivotal role in any community; integration of an institutional order is understandable only in terms of the knowledge that its members have and share. However, this does not necessarily imply complex indigenous theoretical constructs about the character of institutions, although this is also important. The primary knowledge is pre-theoretical knowledge: "the sum total of 'what everybody knows' about a social world" (Berger and Luckmann 1984:83). At this level, "every institution has a body of transmitted 'recipe knowledge' (Schutz 1960) ...that supplies the institutionally appropriate rules of conduct."(Berger and Luckmann 1984:83).

Such knowledge underlies the dynamics of institutionalized conduct and defines the areas of such conduct, as well as both defining and constructing the roles to be played in the context of such institutions. By definition, such knowledge also controls and predicts conduct by the operators within a resource system. Since such knowledge comprises a body of generally valid truths about reality, any deviance from the social order is a departure from reality — a deviance that could be variously interpreted as depravity, a symptom of mental illness, ignorance, criminality, willfulness, or a sign of a power struggle aimed at the eventual usurpation of authority. That leads to the need for social controls to handle deviance and to ensure compliance with social norms. There is a need to control deviance by ensuring compliance under the threat of sanctions.

Thus, a society's stock of knowledge, when either put into operation or reflected upon, becomes the local world; it becomes co-extensive with *the knowable,* and provides the framework through which that which is "not yet known will come to be known in the future" (Berger and Luckmann 1984:83), that is the acceptance or the rejection of innovation. In these terms, knowledge is the key dialectic of society, since knowledge about society both captures everyday social reality and continuously reproduces it.

A body of knowledge develops over generations to refer to the various activities involved in a given resource system, and takes on a linguistic form. For example, consider fishing:

(1) Vocabularies define species, habitats, weather patterns, sea conditions, seasons, fish behavior, and the like.

(2) A collection of "recipes" must be learned in order to fish both correctly and with consistent success.

(3) Knowledge is also a channeling and controlling force that underlies fishing institutions.

(4) In the persistence and crystallization of fishing institutions, knowledge becomes the objective description of the activity/institution.

(5) An objective arena/field/ethnoscience of fishing develops in parallel with the activity of fishing.

This body of knowledge is transmitted to the next generation as an *objective truth* during socialization, and then it is internalized as *subjective reality.* This transmission yields and gives identity to a specific type of person, a fisherman, whose principal social universe is constituted by that body of knowledge. As a consequence, to be an active fisherman implies that there exists a social world defined and controlled by a discrete body of arcane knowledge about fishing.

Only a fraction of an individual's experience is consciously retained and thus makes sense. What is retained and shared by persons pursuing a common activity such as fishing becomes codified, usually in specific linguistic terms, and it can then be transmitted coherently to the next generation.

"The transmission of the meaning of an institution is based on the social recognition of that institution as a 'permanent' solution to a 'permanent' problem." (Berger and Luckmann 1984:87). Therefore, potential "actors of institutional actions must be *systematically* acquainted with these meanings. This necessitates some form of *educational process*" (Berger and Luckmann 1984; second emphasis added) to structure the transmission of any given body of knowledge, such as traditional ecological knowledge of fishing.

The Structure of Traditional Knowledge Transmission in a Mixed Peasant Economy in the Orinoco Delta, Venezuela

The traditional system of knowledge transmission examined on Guara Island, in the Orinoco Delta of Venezuela (Ruddle and Chesterfield 1977), is highly structured and systematic, with either individual or small group instruction. Emphasis is placed on learning by doing through repeated practice over time rather than by simple observation and replication. Regardless of the complex of tasks to be taught, a teacher's first step is to familiarize the learner verbally and visually with the physical elements of the appropriate location. The entire complex is demonstrated over a period of time. Proceeding additively and sequentially from simple to complicated steps, the complex is divided into individual procedures that repeat those already mastered. Finally, an entire task complex is learned, with only occasional verbal correction needed. When competent, the learner is allowed to help the teacher, and to experiment and use his or her own initiative. Gradually, the role of the teacher is eliminated.

In terms of the framework for the transmission of traditional knowledge described above, the system on Guara Island fits as follows:

(1) Age
The learning of tasks is age-specific (Table 1)[2]. Learning to recognize the names and characteristics of the more common items of the biota is the earliest ecological knowledge transmitted. Between two and five years of age, when a child is becoming mobile and learning to speak, the child begins to become familiar with foodstuffs and other materials used to satisfy household needs. Older children are mobile and verbal enough to be taught tasks which are prerequisites to livelihood activities, complexes of knowledge associated with household maintenance and the preparation and processing of food. Children are taken to the fields for the first time to observe cultivation techniques. Now ready for formalized instruction in food production activities, eight-year-old boys are taught to use implements and to use techniques which require a minimum of physical strength or skill. Gradually, more demanding task complexes are mastered, until, finally, boys of 11 to 14 years are prepared in complexes which are either exceedingly difficult to perform or are undertaken in dangerous locations.

(2) Gender
Labour is divided according to gender and age as are the skills taught to a child. Both sexes are instructed in household and preparatory tasks (Table 1). With the exception of the use of the bush knife, in which boys are given special instruction, the training of both sexes is similar. While eight-year-old boys begin intensive training in cultivation and complementary activities, girls continue to perfect skills related to household maintenance in addition to receiving instruction in those aspects of cultivation for which women are responsible. Though girls learn to sow and plant, to select seeds, and to care for the dooryard garden, other aspects of cultivation, animal husbandry, fishing, and hunting are taught only to boys. Plant and animal identification, harvesting for the pot, small-scale fishing, and the care of animals are learned by both sexes, mostly during early childhood.

(3) Sequencing
Task complexes are taught sequentially (Table 2)[2]. The simpler and more familiar parts of a task are taught first. The ability to identify food plants by name and characteristic is among the earliest skills developed. Once a plant's characteristics are known, children are trained to procure it from easily accessible sites using implements of an appropriate size. As strength and skill increase, training is provided for the acquisition of a greater quantity of food, for entrance into more dangerous locations such as backswamps, and for greater discriminatory capabilities.

Both task complexes and individual tasks are taught sequentially, building on skills already developed, until an entire complex of tasks has been mastered. Age and strength as well as skill and experience determine advancement to successive levels.

(4) Location
Children are taught to take advantage of the seasonal range and local diversity of food resources with the objective of ensuring full cognizance of all local food resources. From earliest training in the dooryard garden and in the river in front of the house, children of both sexes learn the rudiments of food preparation and household maintenance, which prepares them for later participation in food production. Sites for practicing these skills are the cultivated field, where children

practice using the bushknife, childcare and cultigen identification, and the pastures and grasslands, where children practice horseback riding.

Cultivation tasks are taught almost entirely within the locale designated for a cultivated field with the exception of early harvesting and plant identification, which is taught in the dooryard garden. Except for learning to care for and feed animals in the village, all animal husbandry instruction takes place in pastures and grasslands. Children are trained to fish and hunt in sites frequented by target species. Early education takes place in the river and cultivated field, but as a boy grows and becomes more skillful, he is taught to fish and hunt in the more dangerous backswamps and grasslands.

(5) Duration

Although it is realized that learning to manipulate the complex deltaic ecosystem is a life-long undertaking, formal or structured training in subsistence pursuits lasts only for about eight years, when boys are between the ages of six and 14. During this period, specific times during the daily work routine are allocated for instruction (Table 3)[2]. The duration of these periods is a function of both the complexity of what is being taught, and of the frequency with which training is undertaken. Similarly, the duration of both intensive training and the number of repetitions per session depend on both the laboriousness of the tasks, and the age at which the learner is introduced to them.

(6) Reinforcement

Children are punished only for breaching household rules during early childhood; they are never punished for deficiency in skill. Children learning subsistence activities are chastised when they fail in a task by being made ashamed of their failure to fulfill obligations both to themselves and to the non-food-producing members of their families. Thus, the child's reciprocal responsibilities to its family are emphasized.

Rewards, however, are not entirely lacking: small children learning to cook may be given pieces of food for their assistance; boys are urged to learn cultivation tasks with a promise of their own small bush knife or of a small field of their own. Children of both sexes may be rewarded for animal care with the ownership of a hen or pig. Nonetheless, it is felt that the principal reward comes from proficient performance in itself, and a steady progression towards recognition as a person "who knows."

(7) Teaching Labour

The input of person-hours to instruction in all food-production activities combined comprises 14 percent of the total labour input required to operate the entire household subsistence system (Table 4)[2].

Training in cultivation and complementary activities, like training in household chores, is almost a family undertaking (Table 5)[2]. Men are the principal teachers of subsistence activities, and women are the principal teachers of household chores. Certain cultivation tasks, like harvesting in the dooryard garden and some planting tasks, are performed by females, who are also the teachers of these tasks. Beyond the provision of a basic knowledge of wild fauna, imparted to the learner by the entire family, and the aspects of learning fishing, hunting and animal husbandry that take place in the village, training in complementary activities is done by the father, sometimes assisted by a child's grandfather or older brother.

Transmission of Traditional Knowledge on Pukapuka: a Polynesian Contrast

A striking contrast with the traditional education system described above for Guara Island is found on Pukapuka, one of the Cook Islands of Polynesia, as analyzed by Borofsky (1987). Pukapuka appears to be typical of much of Polynesia, where much of the corpus of traditional knowledge is transmitted informally, as on Rotuma (Howard 1973). On Pukapuka, however, both formal and informal patterns occur.

In Polynesia, the transmission of traditional knowledge occurs within the all-pervasive context of status rivalry (Goldman 1970; Howard 1972; Marcus 1978; Ritchie and Ritchie 1979; Shore 1982; Borofsky 1987), which is competition over status issues. On Pukupuka, such status issues of relevance to the transmission of traditional knowledge are (1) social hierarchy, dependency, and deference to superiors, and (2) autonomy and peer equality (Borofsky 1987). Superior persons are deferred to by virtue of their social rank, not because they possess a superior knowledge. As an affirmation of their own status and worth, people challenge, qualify or elaborate on the knowledge of others (Borofsky 1987). Further, knowledge is not always acquired or used for practical everyday purposes, since an appearance of being knowledgeable and the manipulation of knowledge are used to enhance the status of an individual.

On Pukapuka, most knowledge is transmitted in the context of an activity which is situationally relevant to performing daily tasks. This is similar to the situation on the Polynesian island of Tikopia (Firth 1936), as elsewhere in Polynesia (Ritchie and Ritchie 1979). For example, place names on a reef and the names and characteristics of reef fishes are gradually acquired as boys accompany their fathers on fishing trips. Some knowledge, however, is taught and learned for enjoyment, such as the entertainment provided by the narration of legends that gradually socialize children into a group's traditions.

On Pukapuka, verbal instruction is rare. Both children and adults learn by observation followed later by imitation. Like Tubuai, another Polynesian island where learning is based on close observation, formal instruction is minimal, and questioning, especially by children, discouraged except where it pertains to concrete situations (Levin 1978). Observation is of paramount importance; "knowledge is something grasped visually (Borofsky 1987:81-82), and most Polynesians are visually-oriented toward knowledge. Listening to the conversations of others is a second important means of acquiring knowledge. Repetition of observation, listening and practice are the principal factors in the Pukapukan transmission of knowledge.

Learners attempt to maintain their own status with teachers by regulating when and where they will acquire knowledge. Status is also the reason why adults do not ask questions of others, since this would reveal one's own ignorance, and might cause the person questioned to either lose face or to be subject to ridicule if an incorrect or inadequate answer is given. However, casual, indirect conversation about a topic saves face.

Ridicule of others, a "pervasive element in Pukapukan education" (Borovsky 1987:92), is an important means of asserting one's own status and competence. And children are physically punished for doing things incorrectly. In contrast, praise and encouragement are uncommon. This seems to be widespread in Polynesia (Levy 1973; Levin 1978; Hooper 1990).

Challenge, indirect criticism, joking, and teasing among adults are also used as educational tools. The resultant pressure and competition is a stimulus to learning. Hence, for the young, learning is often a humiliating and painful experience, and many people prefer to learn on their own (Levy 1973; Borofsky 1987).

Conclusion

In any society, the transmission of traditional knowledge among generations is a complex and fundamental process embedded within the deep socio-cultural structure. It is this characteristic rather than the inherent complexity of any biological and physical environment that determines the intricacy and methods of the transmission process and the complexity of the curriculum. Thus the formal/informal distinction has little relevance since the concern must be with the holistic study of a society. The curriculum and process of knowledge transmission is culture itself, and it is by no means haphazard or unstructured regardless of the methods of knowledge acquisition used, whether these methods are silent and individual observation and imitation, or additive and sequential direct teaching-learning.

Table 1: Division of Task Complexes by Gender and Age of Learner

Task	Sex M	Sex F	Age in Years
EARLY CHILDHOOD			
Household Task Complexes:			
Messenger	X	X	2–5
Carry water and wood	X	X	5–8
Child care	X	X	5–8
Cooking	X	X	6–8
Laundering	X	X	6–8
Construction	X	X	6–8
Preparatory Task Complexes:			
Identification of cultigens and animals	X	X	2–6
Care of domestic animals	X	X	3–8
Horseback riding	X	X	5–8
Use of machete	X		6–10
Swimming	X	X	2–4
Use of *piragua*	X	X	3–7
Line fishing	X	X	4–6
CULTIVATION			
Plant Identification			
Plants in harvested state	X	X	2–4
Food plants growing in dooryard garden	X	X	4–5
Ornaments and medicinals	X	X	5–6
Conuco plants	X	X	4–8
Natural vegetation	X	X	5–13
Harvesting			
Plants for home consumption			
Dooryard garden	X	X	4–7
Conuco plants	X		6–9
Larger root and tree crops	X		8–11
Berry and fruit	X		8–12
Coconuts	X		8–9
Commercial crops			
Observation	X		8–10
Packing cobs	X		8½–10
Cutting and harvesting own crop	X		10–13
Seed Selection	X	X	4–11
Sowing, Planting, Care			
Observation	X	X	6½–8
Covering holes	X	X	7–9
Planting seeds	X	X	8–10
Use of digging stick	X		10–12
Transplanting tree crops	X		10–12
Interplanting	X		10–13
Weeding	X		4–7
Cutting and Burning			
Observation – cutting	X		6–7½
Cutting with machete	X		6½–10½
Cutting with axe	X		10½–13
Observation – burning	X		6–7½
Gathering and clearing	X		9–10
Actual burning	X		9½–13
Marketing	X		9½–13
Care and Construction of Tools	X		8½–13
ANIMAL HUSBANDRY			
Identification and Care of Small Animals	X	X	2–4
Feeding Larger Animals	X	X	5–8½
Herding Techniques	X		8–11
Training and Taming	X		11–13
Marking	X		8–13
Curing	X		8–13
FISHING			
Fish Identification	X	X	2–6
Line Fishing	X	X	5–8
Guarál	X		8–10
Casting Net	X		8–10
Harpoon	X		8½–10½
Bow and Arrow	X		11–13
Poisons	X		12–13
HUNTING			
Animal Identification	X	X	2–6
Lizard Hunting	X		6–8
Netting Birds	X		8–10
Trapping Animals	X		8–10
Shooting Gun	X		9–13
Bow and Arrow	X		9½–13

Table 2: Sequence of Learning Within an Activity

EARLY CHILDHOOD

Household Task Complexes:

- Messenger
  - Verbal and physical identification of objects
  - Holding
  - Carrying
- Carrying Water and Wood
  - Identification of water and wood sources
  - Carrying small loads
  - Carrying water and wood for daily needs
- Child Care
  - Cleaning and swaddling
  - Assisting to walk
  - Carrying small loads
  - Watching
- Cooking
  - Fetching foodstuffs
  - Preparing utensils
  - Cooking foodstuffs
  - Combining of foodstuffs
- Laundering
  - Laundering of one piece
  - Gradual increase of quantity
- Construction
  - Retrieving
  - Hammering and mixing
  - Cutting and shaping

Preparatory Task Complexes:

- Identification of Cultigens and Animals
  - Visual exposure to those used in cooking
  - Repetition of names
  - Verbalization of characteristics
  - Retrieval of catch or harvest
- Care of Domestic Animals
    - Throwing food to chickens and ducks
    - Naming of personal pet
    - Bundling of fodder for larger animals
    - Carrying of bundles
- Horseback Riding
  - Sitting on horse
  - Clinging to walking horse
  - Using reins to guide and stop
  - Cantering and galloping
- Use of Machete
  - Clearing brush with grapnel
  - Slicing with machete
- Swimming
  - Floating on piece of wood
  - Paddling with arms and legs
  - Dog paddling without wood
  - Swimming with crawl stroke
- Use of *Piragua*
  - Playing in boat
  - Pretending to paddle
  - Untying boat
  - Pushing off
  - Entering boat
- Fishing with Line
  - Catching bait
  - Baiting hook
  - Tying hook to line
  - Pulling in fish

CULTIVATION

- **Vegetation Identification**
  - Verbal identification of plants consumed from dooryard garden
  - Identification of medicinals and decoratives
  - Identification of tree crops
  - Universally-cultivated conuco crops
  - Specialty crops
  - Rastrojo
  - Grassland
  - Swamps
- **Harvesting**
  - For home consumption
    - Carrying harvested plants
    - Pulling and picking
    - Removal of small root crops with machete
    - Cutting of larger root crops
    - Picking berry crops
  - Commercial crops
    - Cutting maize
    - Chopping smaller tubers
    - Cutting large root crops
    - Picking trees and berries
- **Seed Selection**
  - Seed plants used at table
  - Grain plants
  - Seedlings from tree crops
  - Plants propagated by cuttings
- **Sowing and Planting**
  - Sowing of annuals
    - Maize
    - Covering holes
    - Placing maize seeds
    - Use of digging stick
    - Individual differences among annuals
  - Planting of root crops
    - Cleaning and preparation of clones
    - Laying out of clones
    - Placing and covering of clones
    - Use of shovel
    - Transplanting of tree crops
    - Interplanting in small conuco
- **Care**
  - Weeding
  - Use of grapnel
  - Use of machete
  - Weeding of maize
  - Weeding of polycultural conuco
  - Protecting conuco from birds
- **Cutting**
  - Collecting cut material
  - Slashing underbrush with machete
  - Cutting saplings with axe
  - Cutting trees with axe
  - Construction of scaffolds
  - Identification of rastrojo
- **Burning**
  - Piling cut material
  - Clearing of firebreak
  - Firing against wind in conuquito
  - Identifying degree of dryness of cut vegetation
- **Marketing**
  - Pricing
  - Guarding dugout
  - Selling from dugout
  - Selling in market
- **Care and Construction of Tools**
  - Sharpening machete
  - Locating wood for handles
  - Shaping handles
  - Tying on blades

Table 2: Sequence of Learning Within an Activity *(continued)*

ANIMAL HUSBANDRY

Identification and Care of Small Animals
- Verbal identification of caserío animals
- Feeding of small animals
- Care and feeding of animals within caserío

Herding, Taming and Marking
- Rounding-up piglets
- Carrying piglets
- Training of young pigs
- Marking of piglets
- Naming of cattle
- Feeding cattle and horses
- Roping cattle
- Herding cattle in *chiqueros*
- Marking calves

Curing and Butchering
- Curing cattle
- Butchering pigs
- Butchering cattle
- Herding cattle to Uracoa

HUNTING

Identification of Animals Brought to Village

Lizard Hunting
- Beating of brush
- Bludgeoning of lizard

Netting
- Clearing undergrowth
- Scattering grain
- Constructing blind
- Pulling net
- Hunting with small net
- Selling surplus
- Repair and construction
  - Knot
  - Sew

Trapping
- Retrieving catch
- Searching for materials
- Placing and tying trigger
- Use of miniature traps
- Use of rope trap

Shooting Gun
- Care and handling
- Loading
- Shooting at large inanimate objects
- Shooting at birds
- Shooting at mammals
- Hunting in backswamps

Bow and Arrow
- Shooting at inanimate objects
- Shooting small birds
- Holding torch
- Shooting large animals

FISHING

Identification of Fish Brought to Village

Fishing with Hook and Line

Use of *Guarál*
- Baiting hook
- Pulling in fish
- Casting *guarál*
- Playing fish

Casting Net
- Pulling in net
- Throwing small net
- Fishing with companion
- Use of adult gear
- Repair and construction
  - Knot net
  - Sew net
  - Location of wood
  - Shaping of wood

Harpoon
- Fetching fruit
- Pull in catch in caño
- Throwing length of wood
- Throwing at inanimate objects
- Throwing at small fish
- Throwing at large fish
- Fishing with harpoon in backswamps

Bow and Arrow
- Shooting small bow at large inanimate objects
- Shooting birds and animals
- Shooting fish

Construction and repair
- Location of wood
- Shaping of wood
- Tying of points

Poisons
- Searching for plants
- Blocking stream
- Throwing poison
- Removing fish
- Cutting trees

Marketing
- Carrying surplus to friends or relatives
- Selling surplus in village with father
- Guarding boat in Tucupita market

Table 3: Division of Task Complexes by Length, Frequency and Duration of Training

Task	Age	Length of training session	Frequency of session	Repetitions per session	Duration of intensive training
EARLY CHILDHOOD					
Household Task Complexes:					
Messenger	2 – 3	5 mins	3 times/wk	2 – 3	2 – 3 mos
Carry water and wood	5 – 8	10 mins	daily	1 or 2	2 – 3 mos
Child care	5 – 8		2 – 3 times/wk	1	1 – 2 yrs
Cooking	6 – 8	10 – 15 mins	daily	1	1 yr
Laundering	6 – 8	10 – 15 mins	twice/wk	1	1 – 2 yrs
Construction	4 – 12				
Preparatory Task Complexes:					
Identification of cultigens and animals	2 – 6	2 – 3 mins	daily	2 – 3	5 yrs
Care of domestic animals	3 – 7	5 – 10 mins	daily	20 – 30	4 yrs
Horseback riding	3 – 8	15 – 30 mins	daily	1 – 2	5 yrs
Use of machete	6 – 8	2 – 3 hrs	1 time/wk	10 – 12	2 yrs
Swimming	2 – 5	30 mins	2 – 3 times/wk	many	2 yrs
Use of *piragua*	1 – 8	15 – 30 mins	2 – 3 times/wk	many	3 yrs
Line fishing	6 – 8	30 mins	2 – 3 times/wk	many	2 yrs
CULTIVATION					
Plant Identification					
Plants in dooryard garden	2 – 6	5 mins	daily	many	4 yrs
Conuco plants	4 – 6	5 mins	daily	many	2 yrs
Natural vegetation	5 – 15	5 mins	daily	many	10 yrs
Harvesting					
Plants for home consumption					
Plants in dooryard garden	2 – 6	30 mins	daily	many	2 yrs
Conuco plants	6 – 8	15 – 30 mins	daily*	many	3 – 6 mos
Larger root and tree crops	8 – 10	30 mins	daily*	many	3 mos
Berry and fruit crops	8 – 12	30 mins	daily*	many	3 – 6 mos
Commercial crops	8 – 12	1 hr	daily*	many	2 yrs
Seed Selection	4 – 10	10 – 15 mins	daily*	many	4 yrs
Sowing, Planting, Care					
Covering holes	8 – 9	30 mins	one day	5 – 6	1 season
Placing of seeds	8 – 9	½ – 1 hr	daily*	5 – 10	2 seasons
Laying out cormels	9 – 10	½ – 1 hr	daily*	5 – 10	1 season
Use of digging stick (shovel)	10 – 12	½ – 1 hr	daily*	many	2 seasons
Transplanting	10 – 11	½ – 1 hr	daily*	5 – 6	1 season
Interplanting	10 – 13	½ – 1 hr	daily*	many	3 yrs
Protecting plants from birds	8 – 10	10 mins	one	1 – 2	1 day
Weeding	6 – 8	1 hr	one day	10 – 20	2 yrs**
Cutting	10 – 14	1 hr	daily*	many	4 yrs
Burning	10 – 14	1 hr	daily*	many	4 yrs
Marketing	10 – 11	30 mins	1 – 2/wk	many	1 yr
Care and Construction of Tools	9 – 14	1 hr	when needed	5 – 6	4 – 5 yrs
ANIMAL HUSBANDRY					
Identification and Care of Small Animals	3 – 8	5 – 10 mins	daily	20 – 30	4 yrs
Feeding of Larger Animals in Potreros	8 – 10	30 mins	daily	4 – 5	1 yr
Herding Techniques	8 – 14	1 hr	daily*	30 – 40	1 yr
Training and Taming	8 – 12	1 hr	daily*	many	1 yr
Marking	8 – 12	1 hr	daily*	4 – 5	1 yr
Curing	8 – 14	1 hr	when needed	4 – 5	1 yr
FISHING					
Fish Identification	2 – 6	2 – 3 mins	3 – 5 times/day	many	4 yrs
Line Fishing	6 – 8	30 mins	2 – 3 times/mo	many	2 yrs
Guarál	8 – 10	15 – 30 mins	1 – 2 times/wk	many	1 yr
Casting Net	8 – 10	15 – 30 mins	1-2 times/wk	many	1 yr
Harpoon	10 – 12	15 – 30 mins	daily	many	4 – 6 yrs
Bow and Arrow	10 – 14	1 – 2 hrs	2 – 3 times/wk	many	4 – 6 yrs
Poisons	8 – 12	1 hr	3 – 4 times/yr	2 – 3	1 yr
HUNTING					
Animal Identification	2 – 6	2 – 3 mins	3 – 5 times/day	many	4 yrs
Lizard Hunting	6 – 8	5 – 10 mins	1/mo	1 – 2	1 yr
Netting Birds	8 – 9	½ – 1 hr	2/mo	many	2 yrs
Trapping Animals	8 – 9	½ – 1 hr	1/mo	many	2 yrs
Shooting Gun	10 – 12	15 – 30 mins	2 – 3 times/wk	many	2 yrs
Bow and Arrow	11 – 14	1 – 2 hrs	2 – 3 times/wk	many	4 – 6 yrs

* In season

** Includes time spent in learning the use of the *machete*

Table 4: Estimated Labor Inputs Per Annum

Activities and task complexes	Total input of man-hours	Man-hours spent teaching	Percentage/Input of man-hours spent teaching
CULTIVATION (per ha)			
Maizal Site Preparation	220	47	21
Cleaning for Re-Use as Conuco [a]	124	17	14
Sowing and Planting Conuco [b]	355[c]	47	20[d]
Weeding [e]	240	25	10
Harvesting [f]	170	26	15
Marketing [g]	200	13	6
Subtotal	1309[h]	175	15[h]
ANIMAL HUSBANDRY			
Daily Maintenance [i]	400	48	12
Supplemental Feeding, Marking and Curing	140	32	23
Training and Taming	40	10	25
Marketing	140	16	11
Miscellaneous Tasks	50	6	12
Transhumance	64	[j]	[j]
Subtotal	834	112	13
FISHING WITH:			
Line [k]	200	27	14
Guaral	74	15	20
Casting Nets	58	12	21
Harpoon [l]	36	3	8
Bow and Arrow [l]	24	3	13
Suffocants	16	2	13
Subtotal	408	62	15
HUNTING			
Lizard Hunting [k]	24	2	8
Netting Birds	96	12	13
Trapping Mammals	24	3	13
Shotgun (Use of) [l]	250	25	10
Bow and Arrow (Use of) [k]	60	7	12
Subtotal	454	49	11
TOTAL	3015[m]	398	14[m]

[a] Refers to *maisal* only

[b] Calculated for conuco only using data for maise, beans, manioc, sweet potatoes, cush-cush, and yams.

[c] Labor supplied by head-of-household, his wife, and pre-adult son(s).

[d] Percentage calculated using 66.6 percent of total input of man-hours.

[e] Calculated on basis of 5 weedings per year in conuco.

[f] Total refers to conuco and includes maize (35 hrs.), manioc, sweet potatoes, cush-cush and yams (70 hrs., Musaceae [44 hrs] and tree crops [22 hrs.]). Time includes allowance for sacking, transporting, storing and marketing produce in caserío.

[g] Not calculated per ha.

[h] Subtotal reduced by 119 hours in calculating percentage to allow for 33.3 percent reduction of input in sowing and planting corresponding learner's labor input.

[i] Task complex performed mostly by women and children.

[j] Task complex taught in other situations.

[k] Task complex performed mostly by boys.

[l] Not including practice time.

[m] Percentage calculated from a total reduced by the 119 hours which correspond to learner's labor input per year per ha. in sowing and planting.

Table 5: Division of Task Complexes by Teacher

	Relationship to Learner							
	Father	Mother	Older sibling		Grandparent		Compadre	Other
			Brother	Sister	Grandfather	Grandmother		
PRE-ACTIVITY PERIOD								
EARLY CHILDHOOD								
Household Task Complexes								
Messenger	—	Mo	—	Mi	—	S	—	—
Carry water and wood	—	Mo	—	Mi	—	S	—	—
Childcare	—	Mo	—	Mi	—	S	—	—
Cooking	—	Mo	—	Mi	—	S	—	—
Laundering	—	Mo	—	S	—	S	—	—
Construction	Mo	—	Mi	—	S	—	—	—
Preparatory Task Complexes								
Identification of cultigens and animals	Mo	S	S	S	S	S	S	—
Care of domestic animals	—	Mo	—	S	—	S	—	—
Horseback riding	Mo	—	Mi	—	S	—	—	—
Use of machete	Mo	—	S	—	S	—	—	—
Swimming	—	S	Mo	Mo	—	—	—	—
Use of *piragua*	—	S	Mo	Mo	—	—	—	—
Line fishing	S	—	Mo	—	—	—	—	—
ACTIVITIES								
1. CULTIVATION								
Plant Identification								
Plants in dooryard garden	—	Mo	—	Mi	—	S	—	—
Conuco plants	Mo	—	S	—	S	—	—	—
Natural vegetation	Mo	—	Mi	—	S	—	—	—
Harvesting								
Plants for home consumption								
Dooryard garden	—	Mo	—	Mi	—	Mi	—	—
Conuco plants	Mo-A	—	Mi	—	Mi	—	—	—
Larger root and tree crops	Mo-A	—	Mi	—	Mi	—	—	—
Berry and fruit crops	Mo-A	—	Mi	—	Mi	—	—	—
Commercial crops	Mo-A	—	Mi	—	Mi	—	—	—
Seed Selection	Mo	S-A	—	Mi	—	Mi	—	—
Sowing, Planting, Care								
Covering holes	S	Mo	—	Mi	—	Mi	—	—
Placing of seeds	Mi	Mo	—	Mi	—	Mi	—	—
Laying out cormels	Mi	Mo	—	Mi	—	Mi	—	—
Use of digging stick	Mo	—	—	—	Mi	—	—	—
Transplanting	Mo	—	—	—	Mi	—	—	—
Interplanting	Mo	—	—	—	Mi	—	—	—
Protecting young plants from birds	S	—	Mo	—	—	—	—	Mo
Weeding	Mo	—	S	—	S	—	—	—
Cutting	Mo	—	—	—	S	—	—	—
Burning	Mo-A	—	—	—	S	—	S	—
Marketing	Mo-A	—	Mi	—	Mi	—	—	—
Care and Construction of Tools	Mo	—	—	—	S	—	—	—
2. ANIMAL HUSBANDRY								
Identification and Care of Small Animals	—	Mo	—	S	—	S	—	—
Feeding Larger Animals	S	Mo	S	S	S	S	—	—
Herding Techniques	Mo	—	Mi	—	Mi	—	—	—
Training and Taming	Mo	—	Mi	—	Mi	—	—	—
Marking	Mo	—	Mi	—	Mi	—	—	—
Curing	Mo	—	Mi	—	Mi	—	—	—
3. FISHING								
Fish Identification	Mo	S	S	S	S	S	S	S
Line Fishing	S	—	Mo	—	—	—	—	—
Guarál	Mo	—	Mi	—	S	—	—	—
Casting Net	Mo-A	—	—	—	S	—	—	—
Harpoon	Mo-A	—	—	—	S	—	—	—
Bow and Arrow	S	—	—	—	S	—	S	S
Poisons	Mo	—	—	—	S	—	S	—
4. HUNTING								
Animal Identification	Mo	Mi	S	S	S	S	—	—
Lizard Hunting	—	—	Mo	—	—	—	—	Mo
Netting Birds	Mo	—	Mi	—	Mi	—	Mi	—
Trapping Animals	Mo	—	Mi	—	Mi	—	Mi	—
Shooting Gun	Mo-A	—	—	—	Mi	—	—	—
Bow and Arrow	Mo-A	—	—	—	Mi	—	—	Mi

A: All — Task taught exclusively by person. **S**: Some — Person undertakes some share of training

Mi: Minimal — Only occasionally teaches task. **Mo**: Most — Task principally taught by person.

—: In normal circumstances task never taught by person.

Endnotes

(1) I make no apologies for drawing closely on Berger and Luckmann (1984) in this section, since elements of their important work provide a sorely needed conceptual framework for understanding the fundamental socio-cultural importance of traditional ecological knowledge.

(2) Tables after Ruddle and Chesterfield 1977.

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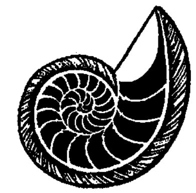
4. Integrating Traditional Ecological Knowledge and Management with Environmental Impact Assessment

R.E. Johannes



Indigenous peoples' traditional ecological knowledge and management systems (TEKMS) are the subject of increasing attention in the developed world. Recently, in fact, the study and preservation of traditional indigenous knowledge progressed in one dizzying leap from being the focus of a small, albeit fast-growing fraternity of social and biological researchers to a media-certified public issue, courtesy of a cover story in Time Magazine (September 23, 1991).

Four Perspectives

Awareness is spreading that TEKMS can be used to improve development planning in regions inhabited or exploited by indigenous peoples. TEKMS is especially pertinent to environmental impact assessment, but as Niamir (1990:98) states:

> Paying lip service to the need to incorporate (TEKMS) into development design can be just as bad as paying lip service to popular participation. Too many projects have tacked on a "research on TEKMS" phase as an after thought, resulting in volumes of interesting but too exhaustive and inappropriate research reports, which are then filed and not used by project designers and implementors. TEKMS needs to be incorporated effectively into the development process.

So how does one systematically obtain and organize information to ensure that it is useful for environmental impact assessment and that it can be tightly integrated with information obtained from other sources? Some investigators have gathered information on TEKMS indiscriminately in an attempt to record everything available for a culture, irrespective of its immediate practical value. Others have recorded this information on an ad hoc basis in the course of studying other aspects of indigenous cultures. Both approaches are valuable, but neither are appropriate for environmental impact assessment. I would like to suggest that, for this purpose, research on TEKMS should focus on four essential perspectives or frames of reference:

- taxonomic
- spatial
- temporal
- social

Taxonomic Frame of Reference

The first frame of reference for gathering and organizing traditional environmental knowledge is taxonomic. More has been written about indigenous plant and animal naming systems than any other aspect of traditional ecological knowledge. Many indigenous peoples know only the local language names for most local plants and animals even when they speak the outside investigator's language well. Thus, to study traditional knowledge about these species, one must first become familiar with these names.

The local significance of each indigenous plant and animal as well as soil/rock taxon should be determined. Otherwise, researchers are likely to overlook the importance of some as sources of food, medicine, structural material, tools, soil-improvers, totems or other sacred entities.

Spatial Frame of Reference

Fundamental to environmental impact assessment is recording the spatial distribution of living and non-living resources and amenities by mapping. Knowledge possessed by local users can be invaluable in this context, especially in regions where recorded knowledge of local environments is poor. For example, Conklin (1957), Dolva et al. (1988) and others have shown that indigenous knowledge of the distribution and characteristics of different soil types and the plants and animals associated with each can provide effective shortcuts for researchers investigating the local resource base. Local knowledge may make it possible to survey and map in a few days what would otherwise take months (for example, Howes 1980).

A good example of this approach is provided by the geographical information systems (GIS) for portions of northern Manitoba currently being created by First Nation peoples of the region (Wavey, this volume). By integrating information from sources as disparate as satellite imagery and TEKMS, traditional knowledge is being put into a format that is exceptionally valuable for environmental impact assessment.

Locations of rare or endangered species are more likely to be identified by local resource users involved in such mapping exercises than by outside researchers doing site inventories. Animal migration pathways and aggregation sites known to local people will not always coincide with areas judged to be important based on common criteria for identifying sensitive areas such as aesthetic qualities or species diversity. However, in these areas the value of the resources which are known to local people is sometimes very great.

Such aggregation sites often provide unparalleled opportunities to monitor and manage stocks because exceptionally large harvests may be made from them. Indeed, indigenous peoples often monitor year-to-year changes in the sizes of some of these aggregations and may reduce their exploitation pressure in periods when stocks are seen to be low (Johannes 1978).

Although not necessarily related, archaeological sites including burial grounds are often conveniently mapped at the same time as natural resources.

Temporal Frame of Reference

The third suggested framework for gathering and organizing traditional ecological knowledge is temporal. Indigenous resource users usually know the location and timing of a host of significant biological events. Areas that appear as unremarkable to an environmental impact assessment researcher during a site inventory in one period may serve as aggregation sites or migration routes for important animals in another. A relatively barren beach in September may be thronged with nesting turtles in May. Habitats that hold few birds during the day may fill with roosting birds at night after the resource inventory-takers have gone home.

While interviewing and working with Palauan fishermen in the mid 1970s, I was told of the months and lunar periods as well as the precise locations of spawning aggregations of some fifty-five species of food fish in this tiny archipelago (Johannes 1981). This amounted to more than twice as many species of fish exhibiting lunar spawning periodicity as had been described in the scientific literature for the entire world. Such information provides important spatio-temporal focuses for fisheries monitoring and management (Johannes 1980, 1991).

In northern Australia, white people name only two seasons —"the wet" and "the dry" — whereas Aborigines name six that are precisely defined by predictable changes in weather, tides, plant blooming and fruiting cycles, insect abundance, and the breeding cycles and migrations of fishes, mammals and birds (Davis 1988). The value of such information for environmental impact assessment (EIA) is obvious, but it would take years for an EIA team to assemble it using conventional means.

Social Frame of Reference

The social frame of reference includes the way indigenous peoples perceive, use, allocate, transfer, and manage their natural resources. This perspective is the hardest to bring into sharp focus, but it is no less important than the preceding three frames of reference. Traditional ecological knowledge cannot be used properly in isolation from the social and political structure in which it is imbedded. There is a burgeoning literature on this subject.

For environmental impact assessment, one important issue is often overlooked by people studying the sociology of traditional ecological knowledge: that is, the differing awareness among cultures of the impact that people can have on their natural environment. Some cultures clearly possess a traditional conservation ethic, by which I mean an awareness that people can deplete or otherwise damage their natural resources, coupled with a commitment to reduce or eliminate the problem (Johannes 1978). Other cultures apparently perceive little or no relationship between their activities and the state of their natural resources. (Carrier 1982; Johannes and MacFarlane 1991). Still others appear to have had a traditional conservation ethic, but one which has been eroded by external influences (Johannes 1978).

Environmental impact assessment should cover not only the direct impacts of a project on the environment, but also the impacts of altered human access to natural resources. The latter will depend in part on the nature — or absence — of a traditional conservation ethic among local people. For example, a road built through a remote area to allow access to a new mine gives access not only to miners but also to local peoples. How will the latter respond to these new opportunities? Will they exploit the newly accessible wildlife, timber and fish rapaciously or in moderation? The answer will depend in part on the extent to which they understand the consequences of uncontrolled harvesting. Where a traditional conservation ethic is weak or absent, those responsible for environmental impact assessments need to help to provide guidelines, especially through education, for reducing the environmental impacts of the local people.

On Methods

Some researchers attempt to gather and record traditional knowledge on environmental subjects about which they are not well informed. This is unsatisfactory for several reasons. Indigenous experts in traditional ecological knowledge are usually proud of this knowledge and are not likely to be enthusiastic about imparting it to investigators who obviously do not appreciate the finer points. Diamond (1989) recounts an amusing but apt story illustrating this point.

Moreover, biologically unsophisticated researchers are not well equipped to determine what portions of the information they obtain are new, important, already well-known or implausible. They cannot ask the appropriate questions to pursue promising biological leads opened up by the local expert. Some older anthropological writings are loaded with tantalizing bits of information on traditional ecological knowledge which were not explored further. This is because the researcher was untrained in the appropriate environmental subjects, and therefore unaware of the potential significance of such information. Opportunities to record large quantities of valuable traditional ecological knowledge have been lost irretrievably for this reason.

I do not mean to imply that the study of traditional ecological knowledge is the exclusive domain of biologists. Such knowledge should be recorded and evaluated by people who possess an appropriate background in biology, ecology and resource management, and in the social sciences, which provide the appropriate skills for translating information from one culture and language to another and for addressing the social frame of reference. When it comes to methods for studying traditional ecological knowledge, I have learned far more from social scientists than from biologists. But neither natural scientists nor social scientists can do the job well without the expertise of the other.

A flagrant deficiency in much of the literature describing traditional ecological knowledge is the absence of any effort to determine its validity. An informant who is an acknowledged local expert on environmental matters is just as concerned with getting the facts right as the researcher. However, there is always a temptation to embroider the facts to influence the outcome of any development initiative so as to favor the TEK expert's people — for example, to exaggerate the environmental significance of an area being considered for development so as to extract greater concessions from the developer. Furthermore, in some cultures, some individuals who are not TEK experts may pretend to be.

Obviously, it is desirable to test informants' assertions in the field at the appropriate times and places. But under the time constraints of EIA preparation this will often be impractical. So how does one gauge the reliability of one's informants? I ask a series of relevant questions to which I already know the answers. I also ask a series of questions that sound plausible but to which the informant could not possibly know the answers. An unequivocal "I don't know" in response to the latter provides some assurance that the information given by the informant will be reliable.

Because even the best experts are sometimes wrong, it is useful to differentiate between observation and interpretation. While observations of natural phenomena may be acute, the conclusions drawn from them may not be accurate. Being alert to this helps prevent accepting incorrect information. But by dismissing false interpretations of natural phenomena too quickly, the investigator risks overlooking the possible value of the underlying empirical knowledge (Johannes 1981:137).

Attitudes of Researchers to TEKMS

Many biologists still have an "attitude problem" when it comes to TEKMS. They dismiss the knowledge gained by indigenous peoples during centuries of practical experience as anecdotal and unsubstantiated. However, their own specialized knowledge is based typically on studies carried out over much shorter periods of time under conditions where being wrong does not entail the risk of going hungry.

But romantic and uncritical claims for traditional environmental knowledge and management practices represent an extreme which is almost as unfortunate. A taboo on the hunting of a species, assumed with little reflection by some social scientists to be an obvious conservation measure (McDonald 1977), may put increased pressure on some other, more easily depleted species. Locally prescribed methods for improving fishing or hunting which focus on propitiating spirits or counteracting the effects of sorcery may divert attention from the real and sometimes correctable causes.

Under the circumstances, it is exasperating to read assertions that superstitions and myths can be taken for granted to conceal functional ecological concerns. Some almost certainly do. But the assertion that all do implies that the *only* preoccupation of indigenous peoples is with their natural environment.

Some claims about the environmental wisdom of traditional cultures have been so overblown that they have provoked a backlash. To counteract these excesses, some writers now dwell single-mindedly on examples of bad natural resource management among indigenous peoples, even advancing the opposing notion that traditional environmental practices were basically unsound (for example, Diamond 1987).

The truth lies somewhere in between. Wise and unwise environmental practices and valid and invalid environmental beliefs coexist in many cultures. To assume differently is to assume that with respect to natural resource management indigenous peoples are either inherently superior or inherently inferior to the cultures of the developed world. Both of these extreme images — noble or ignoble savage — connote prejudice and do not serve the needs of development planners.

Proprietary TEK

Many cultures are not proprietary about their TEK. Some have even asked their governments to bring in researchers to record it for them. This is especially important where TEK is being lost. And percentage-wise, cultures are disappearing today much faster than species, while TEK is disappearing even faster.

But local people who reveal their traditional ecological knowledge are relinquishing a degree of status and power. They may be reluctant to reveal their knowledge if they can see no benefits from its disclosure, or if they fear that competitors might profit at their expense, or that development aided by their knowledge might damage their resources or restrict their use of them (Wavey, this volume).

Simeon Jiminez Turon, a member of the Ye'cuna tribe of Venezuela has said:

> Understand learned one that there can be no intermediary who understands our region better than we do, or who knows us better than we know ourselves. Those who want to learn from us may do so, but you must also teach us the laws and the useful means to pursue our goals and petitions before the official authorities. In so far as you help us, we will help you.
>
> (Brownrigg, 1982)

To pave the way for research on traditional ecological knowledge, development planners should have some incentives in mind, including lease payments, greater legal recognition of local authority over local resources, better protection from uncontrolled outside encroachment, enhanced income from tourism, assistance in dealings with the outside world, and employment in local natural resource management. Social scientists are comfortable with research that involves such tradeoffs; biologists who study TEK must learn to follow suit.

For some cultures, some portions of their TEK are strictly proprietary for good reasons. Robert Wavey, Chief of the Fox Lake First Nation of Manitoba states, for example, that, for his people, "maintaining complete indigenous control of the raw traditional land use information must be a cornerstone of linking TEK and science." This "allows communities to optimize the acknowledged value of this information through skills development, contracted projects and employment and other means." He also points out that, "it could be an impact in itself to make certain specific details of land use maps public by publishing maps of prime hunting and fishing sites, gravesites and former community locations" (Wavey, this volume).

Conclusion

For those to whom the importance of integrating TEKMS with environmental impact assessment has been obvious, widespread recognition has been a very long time in coming. We can now expect accelerating growth in activities in this area; I hope that the observations presented here will seem mundane within a very few years. More importantly, we hope that indigenous peoples will have much greater voices in planning development that affects the environments we all depend on.

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