TRADITIONAL ENVIRONMENTAL KNOWLEDGE AND WESTERN SCIENCE: IN SEARCH OF COMMON GROUND

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Abstract / Résumé

Controversy has surrounded the decision made by the federal government of Canada to give equal standing to Traditional Environmental Knowledge (TEK) with respect to western science, in the environmental impact assessment process. Part of the problem relates to the portrayal of TEK and science, in most of the literature, as being significantly different from each other in almost all aspects. It is difficult to make a rational judgement about another system of knowledge when differences are being emphasized. In this paper, similarities rather than differences have been stressed. We show with examples how some of the differences are not as definitive as expressed in the literature. Decisions about the utility of TEK as a complementary system of knowledge should at least be informed.

La décision du gouvernement canadien d'accorder au savoir écologique traditionnel (SET) un statut égal à celui de la science occidentale dans le processus d'évaluation des incidences sur l'environnement a soulevé la controverse. Le problème est lié en partie à la description du SET et de la science dans la plupart des études comme étant très différents l'un de l'autre sous la plupart de leurs aspects. Les auteurs utilisent des exemples pour démontrer que les différences ne sont pas aussi tranchées qu'on l'indique dans la documentation.

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Introduction

> Traditional environmental knowledge [TEK] is a body of knowledge and beliefs transmitted through oral tradition and first-hand observation. It includes a system of classification, a set of empirical observations about the local environment and a system of self-management that governs resource use. Ecological aspects are closely tied to social and spiritual aspects of the knowledge systems. The quantity and quality of TEK varies among community members, depending on gender, age, social status, intellectual capability and profession.... With its roots firmly in the past, TEK is both cumulative and dynamic, building upon the experience of earlier generations and adapting to the new technological and socioeconomic changes of the present (Dene Cultural Institute, as cited in Stevenson, 1996:281).

In Canada, great controversy has been generated by government decisions to utilize traditional environmental knowledge (TEK) in environmental impact assessments (EIAs) (Stevenson, 1996; Howard and Widdowson, 1996; Usher, 2000). In 1993, the Government of the Northwest Territories (GNT) adopted a policy that recognized TEK as a valid source of knowledge that should be incorporated into territorial government decisions where appropriate (GNT, 1993). Moreover, two recent Government of Canada EIA panels (i.e., BHP diamond mines in the NT; Voisey's Bay nickel mines in Labrador) were advised to give equal weighting to TEK as compared to western science (MacLachlan et al. 1996; Griffiths et al. 1999). In the case of the BHP diamond mines in the NT, TEK of the Dene people was incorporated into the EIA. The use of TEK in the EIA process allowed for the determination of the importance of the Lac de Gras area to the caribou herd, the range and variability of herd composition over time and at various locations, and the determination of the anticipated effects of anthropocentric emissions on the caribou. The identification of important migratory corridors, critical habitats, spatial and temporal grazing patterns, and the importance of specific plant species to the caribou was also possible through the incorporation of TEK in the EIA. Moreover, the enlistment of traditional Dene methods to divert herds from potentially threatening sites and situations was crucial because the use of TEK helped to mitigate the effects of the mine on the caribou populations. Nevertheless, people have been critical of the requirement to use TEK in the EIA process in Canada (Stevenson, 1996).

Howard and Widdowson (1996:34) have even stated that utilizing

TEK in EIAs results "in the imposition of religion on Canadian citizens." Their commentary was the catalyst for a series of "scholarly" articles in the journal Policy Options. Unfortunately, objectivity was generally not maintained in these articles. Statements such as "ignorance and racial intolerance" were used by Stevenson (1997:26-28), in reference to the Howard and Widdowson (1996) article. Similarly, "parasitic consultants" (in reference to Stevenson, who is a consultant) and "keeping aboriginal peoples ignorant and dependant" appeared in commentary by Howard and Widdowson (1997:48). Even the respected academic Berkes was involved, stating that Howard and Widdowson were guilty of "mischief" (Berkes and Henley, 1997:31). Although very different in their perspectives, a theme common to all these papers (Howard and Widdowson, 1996, 1997; Berkes and Henley, 1997; Stevenson, 1997) was the stressing of the differences between western science and TEK (cf. Agrawal, 1995).

We believe that more controversy will surround the utilization of TEK in "mainstream" society to complement western science, if perceived and real differences between the two knowledge systems continue to be stressed instead of similarities. Points of similarity have often been used by educators (e.g., Andersen, 1978) to interest people in topic areas usually outside a persons normal sphere of interest. It is often very difficult to accept a different system of knowledge when one is constantly being reminded about how different it is from one's own. This situation is true for both indigenous and non-indigenous people.

The approach we are suggesting was pioneered by Dr. Thom Alcoze, who has a Ph.D. in biology and is of Cherokee ancestry (Greer, 1992). He holds the belief that "scientific concepts exist in Native American traditions" (Greer, 1992:12). Further, he stresses that similarities between western science and TEK must be emphasized to dispel the myth that science is "a white man's thing. Indians don't do that. We don't analyze" (Alcoze quoted in Greer, 1992:13). Alcoze's contention that there are similarities between science and TEK is highlighted in his retelling of one of his experiences:

> My favorite story that demonstrates this unity of all things comes from an Ojibwa elder who was taking a course at Laurentian University a few years ago. He visited me at my home to talk about something he had read in the library that had started him thinking about the connection between the world of nature and himself as an Ojibwa person. He began by asking about a basic scientific fact: "Do all things in nature have atoms?" My immediate response was, "Yes, all of nature is composed of atoms." He questioned me further to clarify

> that clouds, rivers, mountains, plants, all kinds of animals, and the air itself is composed of atoms in many different forms. The answer seemed to make him very pleased. He then said, "So that's what the old people must have meant." He began to leave, but I asked him to stay and explain. [He began]... "The whole of creation, while very different in shape and form and function, all has one thing in common. All of creation and all the elements that make up the Earth have a spirit." He continued with the idea that the atom and the spirit were very much the same thing as expressed in... teachings. Spirit is associated with a fundamental life force that all things share (Alcoze, 1991:30-31) .

In this paper, similarities rather than differences between TEK and western science will be emphasized (cf. Lalonde, 1993; DeWalt, 1994; Stevenson, 1996; Berneshawi, 1997; Brascoupe and Mann, 2001). Moreover, we will show how some of the emphasized differences between TEK and western science have been overstated in the literature. Differences are often based on assumptions we will show to be, in some cases, incorrect. In stressing similarities not differences between TEK and western science, hopefully, people will see reasons to be more open-minded and objective in assessing the utility of TEK as an alternative system of knowledge. If TEK is accepted as an alternative form of knowledge then TEK and western science can be used as complementary tools to study and resolve environmental issues. Some examples on how TEK and western science can be utilized in a complementary way will be given in the last part of this article.

TEK and Western Science

This section examines the epistemic differences and similarities between TEK and science. This has been hotly debated within the literature, as it is difficult to even reach consensus on operational definitions of each. However, if common ground between TEK and science is to be found and if TEK and science are to be used as complementary knowledge systems, it is imperative that these knowledge systems be understood, to at least some degree, if not understood and defined fully.

Agrawal (1995) states that there are three main differences between science and TEK as found in the literature. These are: substantive (differences in the subject matter), epistemological (differences in methods of knowledge acquisition), and contextual (differences in how deeply each is rooted in its own context) (Agrawal, 1995). In this section, we are concerned with how TEK and science create knowledge. If there are differences, then it can be concluded that these two knowledge systems are distinct, and should be treated as such. If they are not, then it can be concluded that both knowledge systems are similar in methodology, and thus any differences between the two are due to either substantive or contextual factors.

Epistemology can be defined as "the branch of philosophy that concerns itself with human knowledge, or the theory of knowledge" (Williams, 2001:1). In particular, theories of knowledge are concerned with whether or not there is more than one way of acquiring knowledge, and if such methods for seeking knowledge can be improved upon (Williams, 2001). In fact there are many epistemologies, which includes science, TEK, and lay-knowledge. All epistemologies are based on some or all of four basic premises, which are logic, intuition, authority, and observation. Every knowledge system, including science, TEK, and lay-knowledge, utilizes some or all of these four basic premises. What defines each knowledge system is how they use these premises to distinguish truth from fiction.

Palys (1997) distinguishes science as an epistemology separate from lay-knowledge, stating that there are four characteristics that separate scientific knowledge from everyday or lay-knowledge. In general, scientific approaches have been described as being systematic, subject to peer and public review, part of a collective process, and self-reflexive (Palys 1997). This positivistic-reductionist (or positivistic-rationalist) approach includes a common method of observation, hypothetico-deductive reasoning, verification by experimentation or other forms of testing (e.g., computer simulation), and replication (Johnston, 1983). On the other hand, lay-knowledge is generally based on one or two observed phenomena, or on sparse and unsystematic data. Lay-knowledge also tends to be skewed to fit with a person's belief system (Palys, 1997).

As opposed to lay-knowledge, TEK can also be thought of as having the characteristics of scientific knowledge as defined by Palys (1997). There is a systematic element to the collection of TEK, as specific observations are gathered from certain activities during identified times of the year (e.g., caribou harvesting and distribution; Ferguson et al. 1998; Berkes, 1999). TEK is also subject to peer and public review. For example, predictions of where and when organisms will aggregate can be tested through observation by peers or by scientists (Johannes, 1978; Tsuji, 1996a; Berkes, 1999). Many studies have also indicated that TEK about any given phenomenon is not held by one person, but is understood and accepted by many people who have experience in that area (Shute & Knight 1995; Tsuji 1996a; Ferguson & Messier 1997). TEK is also part of a collective process as it depends on the observations and teachings of previous generations and other community members (see e.g., the Cree Elder's prediction of the return of the caribou in the eastern James Bay region of northern Quebec, Canada - Berkes, 1999). Finally, TEK is also self-reflexive as the knowledge holders are constantly incorporating new knowledge in the context of previously held knowledge (Tsuji et al. 1999).

From the brief examples given above, it appears that by the standards of the scientific approach, TEK more closely resembles science than lay-knowledge. However, some real differences exist between TEK and science in that non-testable phenomena such as intuition and beliefs, as well as inter-generational and personal observations, are components of knowledge in TEK. Thus, for the rest of this section, only the epistemic variation between science and TEK are discussed, as it is assumed that TEK is significantly different from lay-knowledge, although some authors might dispute this.

Many academics hold different views on how TEK and science create knowledge, and whether or not they are in fact, different in their methods of knowledge acquisition. Agrawal (1995) purports that there are no real differences between science and TEK, and rather that the accepted differences are due to political rather than to epistemic factors. Further, science is becoming more holistic and interdisciplinary (Agrawal, 1995), while TEK holders are becoming increasingly familiar with scientific methods and approaches through political, cultural, and educational influences (e.g., Duerden and Kuhn, 1998; Wenzel, 1999). Thus, attempts to define or differentiate between science and TEK have failed for two reasons (Agrawal, 1995). The first is that both knowledge systems are highly heterogeneous. The second is that both knowledge systems are highly dynamic, evolving over time.

With these caveats in mind, many academics have still attempted to define and differentiate science from TEK, realizing that while it is neither an easy nor a simple task, there are inherent differences between the two. However, the challenge lies in articulating these differences and for us, identifying the similarities between TEK and western science. In the following sections, we will address characteristics (or group of characteristics) that have been identified by academics as being significantly different for TEK compared to science (Table 1) and show how TEK and western science are not that dissimilar in some aspects.

Table 1

Some Major Differences Between Traditional Environmental Knowledge (TEK) and Western Science as Presented in the Literature

Characteristic	TEK	Western Science	Source
Position in western society	Subordinate	Dominant	1, 10
Dominant mode of thinking	Intuitive	Analytical (rational)	1, 2, 5, 8, 10, 11
	Holistic (cyclical)	Reductionist (linear)	1, 2, 5, 7, 9-11
Basic principles	Everything has a spirit	Only humans possess a spirit	1, 2
	Sharing, wealth distribution	Saving, wealth accumulation	3, 11
	Stewardship	Ownership	3, 11
Reason for data collection	Subsistence goals	Various reasons	5, 11
Type of data	Subjective	Objective	1, 2, 4, 10
	Qualitative	Quantitative	2, 4, 5, 8, 9
	Diachronic	Synchronic	2, 4, 7
Data collection	Slow and inclusive	Fast and selective	1, 2, 10
Data storage	Oral	Written	1, 2, 5, 6, 8-11
Learning	Storytelling	Didactic	1, 2, 5, 6, 9-11
	Hands-on, experimental	Reading, experimental	1, 2, 5, 6, 9-11
Management	Consensus-based, self-regulated	Top-down policies, heavily regulated and externally enforced	1, 3
	Long-term outlook	Short-term outlook	1, 3
	Sustainable with low population densities and primitive technology	Not sustainable	5, 8, 11
	TEK-based	Science-based	1, 3
	Resource users collect and utilize data (decentralized, grass roots)	Scientists collect data to be used by centralized bureaucracy	1, 3

Selected sources: 1. Berneshawi, 1997; 2. Berkes, 1993; 3. Berkes, 1994; 4. Cruickshank, 1981; 5. DeWalt, 1994; 6. Eythorsson, 1993; 7. Freeman, 1992; 8. Howard and Widdowson, 1997; 9. Johnson, 1992a; 10. Lalonde, 1993; 11. Stevenson, 1996.

Position In Western Society

Historically, TEK has occupied a subordinate position to science in western society because indigenous cultures have always been considered more primitive with TEK being considered anecdotal (Cruickshank, 1981). However, during the 1970s TEK gained credibility on the international stage, supplementing western science in the EIA that became known as the Berger Inquiry. The Berger Inquiry was commissioned to evaluate potential socioeconomic and environmental impacts associated with the construction and maintenance of a fossil fuel pipeline from arctic regions (Prudhoe Bay and the Mackenzie Delta) to more southerly locales in Canada and the United States. The use of TEK aided in the identification of sensitive areas that would be detrimentally affected by the construction and maintenance of a pipeline (e.g., reproductive habitats of animals and migratory routes; Gamble, 1978).

The utility (and credibility) of TEK, internationally, has been further strengthened by the Brundtland Report (World Commission on Environment and Development [WCED], 1987), Agenda 21 of the Rio de Janeiro conference (United Nations [UN], 1993), and the Convention on Biological Diversity (UN Environment Program [UNEP], 1992). The Brundtland Report recognized the role of TEK in sustainable development (WCED, 1987), the "Earth Summit" declared that indigenous people possessed "traditional scientific knowledge" (UN Conference on the Environment, 1992, Agenda 21, Chapter 26, Section 1 - UN, 1993), while the Convention on Biological Diversity, among other things, stated that signatory countries should "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge" (UNEP, 1992:Arcticle 8(j)). Further, several recent studies critically assessing the "validity" of TEK formally (e.g., Tsuji, 1996a; Ferguson and Messier, 1997; Ferguson et al. 1998) and informally (e.g., Huntington, 1998; Fienup-Riordan, 1999) have established that TEK can indeed be factual from a western perspective.

Although progress has been made concerning the acceptance of TEK as an alternate knowledge system, it still remains to be seen if equal status will actually be given to TEK, in comparison to western science; the move from theory to practice is often a difficult one. Politics has played and will play an important role in determining the future use of TEK in mainstream western society; the future is uncertain. As stated by Usher (2000:184), "Although the general policy requirement is in place, its wording is neither clear nor consistent, and there is virtually no guidance on how to implement it in the public arena where knowledge claims must be tested."

Dominant Mode of Thinking

To suggest that TEK is mostly intuitive with little rational thought, and that western science is purely rational without an intuitive component is incorrect, on both counts. Although intuition does come into play in TEK (e.g., ritual songs known complete after dreams/visions - Philips, 1972), like any other system of knowledge, TEK must be learned (e.g., Kuhn and Duerden, 1996). If TEK was dominantly intuitive as has been assumed, why has there been substantial loss of some components of TEK in many First Nation communities (e.g., Tsuji, 1996b; Ohmagari and Berkes, 1997)? Obviously, the acquisition of TEK requires a substantial learning component, as well as an intuitive component.

Intuition in science may not be the dominant mode of thought but intuition in science even has a name, gestalt (i.e., "the bright idea"). Gestaltism has been defined (Stedman, 1982:583) as the theory "that the objects of mind come as complete forms or configurations which cannot be split". For example, in mathematics a solution to a problem may be known even before the derivation ("proof") is known. In other words, the answer to the question is known, even though the process of deriving the answer is unknown. Work by Tsuji (1992) clearly illustrates this point, as will be briefly described.

In one-dimensional space (i.e., a straight line or time series), a departure from random expectation can be calculated. Under this format, a group of N points along a line of length D, and distance to nearest neighbour r; (for all i=l, N) , was used to generate the ratio

$$R = r_a/r_e \tag{1}$$

where

$$r_a = \frac{\sum_{i=1}^{N} r_i}{N} \tag{2}$$

and

$$r_e = \frac{N+2}{N+1} \cdot \frac{D}{2N} \tag{3}$$

The terms above are defined as follows: R is a ratio (when the distribution is random, R = 1; when maximum aggregation has occurred, R = 0; when points/events/individuals become more evenly spaced, R > 1 with an upper limit of 2.1491) ; r_a is the actual or observed mean distance of points (events or individuals) along one dimensional space for the group being studied; and r_e is the expected mean distance of a random population. Prior to the Tsuji (1992) article, r_e had to be generated through computer simulations, in the order of 10^5 realizations of a population, N. The method of directly calculating r_e with no restrictions on the size of N (i.e., equation 3) was known months before the derivation became apparent to the researcher. The mathematically calculated numbers using equation 3 were found to be in excellent agreement with those generated by computer simulations (e.g., D = 100, N = 2; r_e = 33.33, computer generated; r_e = 33.33, mathematically calculated), verifying the validity of the simple equation (Tsuji, 1992). This type of intuitive thinking is especially critical to the theoretical sciences where both linear and nonlinear thought are valued. Clearly, intuitive and rational (analytical) modes of thinking are important components of both TEK and western science.

It should also be stated that there is a spiritual or cultural component to TEK, which is missing from scientific approaches. Thus, TEK does tend to have a larger intuitive component to knowledge creation than science. Scott (1996) describes Cree TEK as being similar to scientific approaches, but different only in its roots in culture and spirituality. These two aspects guide the process of knowledge formation and interpretations from observations. The intuitive component can be explained partly by a spiritual attachment to place, or more holistically, the environment (Kimmerer, 2000).

Accounting for the fact that the holistic perspective dominates practitioners of TEK, it must be emphasized that not all community members possess the same quantity and quality of TEK. That is, community members often know a lot about everything, but some community members have specialized knowledge and training (Colorado, 1988; Dene Cultural Institute, as cited in Stevenson, 1996; Fergusson and Messier, 1997). For example, in a study by Fergusson and Messier (1997:24) documenting Inuit knowledge (in southern Baffin Island) with respect to historical changes in a caribou (*Rangifer tarandus*) population, it was reported that Inuit seal and caribou hunters differed in the extent and types of knowledge that they possess (P. Kilabuk, pers. comm. 1990). Further, when examining their data, Ferguson and Messier (1997) found that most harvesters born prior to 1930 were caribou hunters, while those born in the late 1930s and 1940s were mostly seal hunters. The researchers explained this observation by noting that caribou densities were relatively low during the 1940s. It appears that internal as well as external factors can affect the quantity and quality of TEK a person may possess.

Although scientists have often been maligned for being reductionist and specialized, this stereotyping is not always true. In disciplines, such as environmental sciences and/or studies, a holistic viewpoint is often required with these researchers often being "qualified" in several different fields of study. It should be added that the adoption of a more holistic viewpoint by some scientists is a reaction to the limitations of the linear, reductionist and compartmentalized approach of science to environmental issues. Reality has shown that many environmental problems and/or issues need holistic, nonlinear explanations in addition to the systematic analysis of science. However, taking a more holistic approach and viewpoint does not necessarily make science holistic, with science still being limited by its reductionist framework. Nevertheless, collaborative programs that integrate the social, physical, health, and natural sciences have been established at universities. For example, the University of Toronto and McMaster University have established interdisciplinary programs in the area of environment and health (University of Toronto, 1997; Eyles, 2002).

Basic Principles

One principle that has been presented as sharply contrasting TEK with western science is that TEK teaches that "Everything has a Spirit", while western beliefs teach that "Only humans possess a Spirit" (Berneshawi, 1997:124). As was presented in the Introduction section of this paper, Dr. T. Alcoze and an Elder (Alcoze, 1991:31) contend that "the atom and the spirit were very much the same thing as expressed in... teachings. Spirit is associated with a fundamental lifeforce that all things share." The atom is fundamental to science in that everything is made up of atoms and the spirit is fundamental to TEK because everything possesses a spirit; in other words, in science, the atom is the common thread that connects all things, while in TEK the universal connector is spirit. Thus, this principle rather than illustrating a major difference between TEK and science, this example actually illustrates the similarity in thought of the two types of knowledge.

The other basic principles presented in Table 1 will not be explored because these principles (sharing and stewardship versus saving and ownership) are not comparable from a TEK and western science viewpoint; culture is the underlying factor.

Reason for Data Collection

To state that TEK is based on empirical evidence taken from trial-and-error and that TEK is not systematic is perhaps the greatest point of conflict for many people (e.g., DeWalt, 1994; Stevenson, 1996; Howard and Widdowson, 1997). This line of thought implies that TEK is not obtained for the sake of understanding phenomena in general, but rather that TEK is only accumulated through lived experiences for the purpose of survival. In contrast, science is driven by curiosity and by a desire to understand for the sake of understanding. Such differences can create stereotypical views of TEK, implying that aboriginal knowledge is driven by base needs and survival, as opposed to higher faculty curiosity. Although it has often been assumed that practitioners of TEK collect data solely for the purpose of subsistence, another school of thought suggests that indigenous people do possess scientific curiosity, and that TEK also encompasses matters not of immediate practical interest (Berkes, 1993).

Two examples illustrating indigenous scientific curiosity will now be presented. First, Algonkian natives have been shown to possess a complete taxonomy (generic and specific) for snakes even though these creatures were of no economic use to them (Speck, 1923 cited in Cruickshank, 1981). Second, in a study by Tsuji (1996a), it was reported that one Elder possessed extensive knowledge of the sharp-tailed grouse even though he rarely harvested them. It appears that both indigenous people and western scientists collect data for a variety of reasons, one of them being “scientific curiosity”. In addition, to state that motives for scientific research are consistently driven by curiosity alone and not by the need to satisfy more immediate needs (e.g., cures for various diseases) is not always true.

Type of Data

It is incorrect to assume that TEK is subjective, while western science is objective. Both TEK and western science are based upon the collection of data, however, the difference between the two knowledge systems relates to the interpretation of the data. The interpretive component in both systems requires special training and introduces an element of subjectivity. For example, often in the scientific community, scientists using the same data arrive at very different conclusions, the two schools of thought scenario. A popular example often mentioned in the mass media asks: Did certain dinosaurs evolve into birds? Basically, “experts” from one camp say yes, while “experts” of the other camp say no, using the same fossil evidence (Ingram, 1997).

Another difference between TEK and western science that has been emphasized in the literature (e.g., Johnson, 1992a:3) is that western scientists stress the use of quantitative measures while practitioners of TEK accumulate qualitative data. Although the above scenario may be representative for many cases, it is not true for all cases. In a study by Tsuji (1996a), Cree Elders provided quantitative data concerning the biology of the sharp tailed grouse, such as: when (months) the birds "danced" (mating activity); the number of birds typically found on a dancing ground; and the number of eggs typically found in the nest. The Elders answers were compared to the scientific literature and were found to be in agreement. Further, annual dancing grounds could be located using detailed descriptions supplied by the Elders. Similarly, in a study by Johannes (1993) where he interviewed and worked with Palauan fisherman, quantitative data were collected concerning the months and lunar periods, along with the precise locations of spawning aggregations of 55 species of fish. Clearly, some TEK is quantitative in nature, but one must remember to separate observation from interpretation (Johannes, 1993; Tsuji, 1996a; Fienup-Riordan, 1999).

To suggest that only quantitative data are collected and used in western science is also misleading. Although a majority of data collected can be classified as quantitative, some data may be qualitative, such as "brightness" data. For example, see the voluminous amount of work published in the 1980s and 1990s with respect to the "Bright Bird Hypothesis" of Hamilton and Zuk (1982).

Diachronic data can be defined as "a long series of observations over many generations" in a relatively small area, while synchronic data are "snapshots over large areas" (Berkes, 1994:20). Although several researchers (e.g., Gadgil et al. 1993) have suggested that diachronic observations are the basis of TEK, while western science is based on synchronic observations, both assumptions are incorrect. The Dene, who inhabit a large area of the subarctic from Manitoba to Alaska, have through a social organization of kinship established a reconnaissance system for monitoring caribou herds over a large expanse of land. In this way, as described by Berkes (1999), the Dene are able to collect both synchronic as well as diachronic data. Similarly in science, both synchronic and diachronic data may be gathered. Disciplines such as palynology (the study of fossil pollen) and dendrology (the study of tree rings) produce diachronic data that helps in the reconstruction of past environments. Also, ice cores obtained from glaciers have provided diachronic data detailing the history of pollutants, such as lead in the environment (Lobinski et al. 1993). Apparently, both TEK and western science are capable of producing different types of data.

Data Collection

It is not surprising that the collection of TEK requires a relatively large amount of time because TEK data are based on observations and experiences. Unlike most laboratory experiments, where if something goes wrong, one can repeat the experiment the same day or soon afterwards, observations and experiences in the bush may be time limited and/or specific. That is, if observations and/or experiences do not occur during a specified time period, a person has to wait a whole year to have another opportunity to acquire that specific knowledge (Tafoya, 1995). Similarly, not all data collection is rapid in western science, especially in field biology. Similar to practitioners of TEK, if a window of opportunity is missed, a whole field season can be lost and data can only collected during subsequent years. Also, extended periods of time have been spent in the field by biologists observing their particular study organism. An example, field biologists observing the predatory behaviour of raptors with respect to grouse: 3 kills/5,145 mornings (Berger et al. 1963); 1 kill/20,000 bird hours (Oring, 1982); and 9 kills/17,115 days (Bradbury et al. 1989). It is clear that data collection may be relatively fast in some disciplines of science, but in others, data collection is relatively slow being similar to the collection of TEK data.

Another reason why TEK data collection is relatively slow with respect to some disciplines of western science is that data collected by TEK practitioners are inclusive. In other words, all observations and experiences are important to TEK collection; thus, the holistic nature of TEK data requires a long period of collection. In contrast, data collection in science is often fast and selective because only certain data are required to test specific hypothesis. However, although data collection is usually selective, data collection need not always be selective and data use may be different than that originally intended.

Serendipity is an important component of western science. Serendipity can be defined as accidental discovery, "finding one thing while looking for something else" (Stedman, 1982: 1276). A famous example is the discovery of the widely used antibiotic, penicillin (Stedman, 1982). If scientists were purely selective in data collection, some of the greatest scientific discoveries would not have occurred.

Lastly, Palys (1997) describes four stages of science, increasing in sophistication. The first stage is exploratory, in which science is unfamiliar with a phenomenon of interest, and initial research (i.e., data collection) is conducted to understand some of the basic principles or variables involved. The second stage is descriptive, in which science seeks to describe initial observations and explorations. The third is relational, in which science seeks to relate some variables to another, perhaps inferring causality with some degree of confidence. The final stage is explanatory, and is the end goal of all scientific endeavours, in which causality is inferred with certainty, and all variables are explicative of each other. In a scientific context, these explanatory goals are often in the form of laws or theories, and are held to be "truths" in the scientific community. However, TEK is also explanatory in nature, as it explains environmental phenomena through a complex web of mythical and cultural stories and relationships (Berkes 1999). Stories of creation and animal relationships explain environmental phenomena observed today, and all observed environmental phenomena are explained through these cultural and spiritual laws or "truths".

Data Storage

Allowing for the fact that in the past, TEK was "stored" in the oral traditions of indigenous people, and western science was collected and collated in the written medium, recent developments have altered these associations. Examples will be given to illustrate this point. In the *Delgamuukw v. British Columbia* land claim case, the "truth" of the oral testimony given by Elders of the Gitskan and Wet'suwet'en hereditary Chiefs was questioned (Cruickshank, 1992) because in western society, written documents are considered immutable compared to oral recollections. Nevertheless, one very important thing did result from this case, "our history being put on [written] record" (D. Wilson, 1992:204).

Other recent examples of TEK being preserved in the written medium include: the Cree sharp-tailed grouse study by Tsuji (1996a); the Inuit caribou studies by Ferguson and Messier (1997) and Ferguson et al. (1998); and most notably the *Voices from the Bay* compilation (McDonald et al. 1997) detailing for the first time both Inuit and Cree TEK from the Hudson and James Bay Bioregion. The reason for recording Inuit and Cree TEK in the written medium is best expressed by the Elder Louis Bird of Peawanuck First Nation (as recorded in McDonald et al. 1997:69):

> It is important to distribute these materials that we have put into writing. We should give them to the young people so they are informed of why our Elders sat here...we must educate our children to adjust more easily than we do, but still not to lose our Ancestral respect of our land and environment, both spiritually and materially....We should make sure [copies] exist in each community and for each group that is involved in the public, like politicians or even companies that are interested in our region. So they may

> understand what we are talking about. What we want them to know is how much we care for the place we live in, the land and everything.

With this perspective in mind, First Nation cultural data have even been collected and stored on compact discs (CDs) and a website (J. Wilson, 1992; Lentz and Filipetti, 1998). Although it has often been argued that one should not decontextualize TEK (e.g., Bielawski, 1996; Duerden and Kuhn, 1998; cf. Wenzel, 1999), aboriginal groups often have little choice with the number of Elders decreasing. Loss of TEK has been documented in some areas (Tsuji, 1996b; Ohmagari and Berkes, 1997; Tsuji and Nieboer, 1999) and there may not be any other way to preserve TEK.

Storage and retrieval of information on CDs has also changed peoples' reliance on the written medium in mainstream society. Young children (before they can even read) can easily navigate through most educational science CDs, using only icons. An ability to read is not a prerequisite to learning and operating a computer. The proliferation of specialty science-based television stations, science-based shows, and science videos preclude any ability to read and/or write. One can learn and be exposed to a large amount of scientific educational material through the multi-media world of today, by observing and listening. It appears that there is a convergence between TEK and science with respect to dissemination of knowledge.

Learning

To adequately compare the learning strategies of TEK and western science is beyond the scope of this paper. Nevertheless, we will stress one important point, western educators have recently become more receptive to experiential and hands-on educational approaches, as used in the teaching of TEK. This is readily apparent, as noted by Tsuji et al. (1998), by the proliferation of journals and magazines such as, *Hands On!*, *Journal of Experiential Education*, *Holistic Education Review*, and the *Green Teacher.* Experiential science education has even been taken to the extreme in the popular television/video, CD, and book series *The Magic School Bus* by Scholastic. Evidently, the gap between learning strategies for TEK and mainstream society is decreasing.

Management

Indigenous "management" systems have been shown to be community-based (decisions arrived at by consensus) and self-regulated, based upon "codes of conduct." This type of system sharply contrasts the western-based system, where decision-making power is centralized, and policies externally enforced over large areas (Berkes, 1994; Berneshawi, 1997). But recent factors, such as fiscal restraint have made regulation and future enforcement of some management policies, difficult (e.g., the use on nontoxic shot for the harvesting of migratory birds in Canada - Scheuhammer and Norris, 1995; Balogh, 1999). Thus, some top-down policies that are supposed to be externally enforced (theoretically), are in actual practice, self-regulated.

Changes in the harvesting practices of indigenous people have also been noted. Indeed, in a recent study by Tsuji and Nieboer (1999) it has been suggested that current First Nation harvesting practices in the western James Bay region of northern Canada, may not be sustainable into the near future, because of recent technological and cultural changes. Traditionally, First Nation harvesting activities occurred throughout the entire year with the harvesting seasons corresponding to species abundance and/or accessibility to game species. Switching of harvest species with the change of seasons ensured that over-harvesting of any one species did not occur. Further, only enough animals were harvested for subsistence with no wastage and/or stockpiling of wild game. The importance of strictly adhering to these and other codes of conduct as related to sustainable harvests cannot be overemphasized. At present, traditional harvesting practices based on sustainable codes of conduct are now falling into disuse. This statement is probably true for a lot of First Nation groups, because in the past, official Canadian educational policy was one of forced assimilation of First Nation people through cultural destruction (Wavey, 1993). The result has been that many First Nation people harvest only during specified seasons and do not utilize all parts of harvested wild game. In addition, technological changes (e.g., the use of modern firearms and ammunition, snow-machines, refrigeration units) have allowed for the rapid harvesting and stockpiling of large amounts of wild game. Thus, in some First Nation people, a short-term outlook has replaced the old TEK based, sustainable, long-term outlook.

Historically, many science-based renewable harvesting practices were formulated on a short-term outlook. The classic example is the collapse of the Canadian offshore fisheries. However, present management practices are beginning to change, looking towards the future. For example, recently a group of scientists, wildlife managers, and naturalists were brought together in a joint Canadian and American government initiative designated the Goose Habitat Working Group (Rockwell et al. 1996). The main goal of this organization was to drastically reduce the snow goose (*Chen caerulescens*) population breeding in the Hudson Bay Bioregion by "lengthening the hunting seasons, liberalizing hunting regulations, recruiting new hunters, and increasing egg collecting by northern native peoples" (Rockwell et al. 1996:21). Ankney (1996) even suggested legalization of the commercial sale of waterfowl in North America.

Drastic measures have been suggested because the large snow goose population is destabilizing (i.e., degrading) the fragile arctic ecosystem in the Hudson Bay Bioregion where they breed. If the overpopulation of snow geese and giant Canada geese (*Branta canadensis maxima*) is not managed, a population crash due to starvation and disease is inevitable (Ankney, 1996; Rockwell et al. 1996; Batt, 1998). Clearly, the Goose Habitat Working Group has approached this issue from a long-term holistic perspective. Hopefully, future renewable management plans can adopt a similar outlook aimed at sustainability.

In the past, it has been suggested by many researchers (e.g., Stevenson, 1997) that indigenous harvesting practices were often sustainable because specific codes of conduct were strictly adhered to by all community members. In contrast, Howard and Widdowson (1997:47) contend that

> any claim to environmental stewardship in the past is a moot point since the primitive technology and subsistence economy of aboriginal peoples made environmental destruction impossible.

The above claim by Howard and Widdowson (1997) is unsubstantiated. Indigenous people have been shown by several researchers (Johannes, 1978, 1993; Tsuji, 1996a) to possess precise knowledge (spatial and temporal) of where certain species of animals aggregate for reproductive purposes, which would have allowed easy harvesting of a species even without the use of modern technology. This scenario would especially be true for sub-arctic and arctic species of wild game that experience population cycles. For example, if sharp-tailed grouse were harvested from a large number of dancing grounds during a natural population crash, the species could be severely affected with the local population even becoming extinct. Moreover, Diamond (1986) gives many examples of pre-industrial societies being environmentally destructive. Diamond (1986) even suggests that recent archaeological discoveries have destroyed the "noble savage"/conservationist stereotype. However, environmentally destructive practices often coexists with conservation practices in any society; the existence of one should not diminish the significance of the other (Johannes, 1978).

One assumption that has been made in the literature by TEK researchers is the importance of science-based evidence for policy decisions. It has been suggested that state-level management is based on scientific data (e.g., Berkes et al. 1991; Eythorsson, 1993; Nakashima, 1993; Witty, 1994). The importance of science-based data to policy considerations has been overstated by TEK researchers as will be illustrated in this brief example.

As late as 1992, Wendt and Kennedy (1992) of the Canadian Wildlife Service maintained that lead poisoning had rarely been investigated or reported in Canada. In April 1995, Scheuhammer and Norris (1995) updated the lead shotshell (poisoning of wildlife) issue in Canada. In this report, several provinces and one territory were stated as being set to legislate province- and territory-wide bans prohibiting the use of lead shotshell for the harvesting of waterfowl (i.e., the formation of non-toxic zones). Other provinces and one territory had no plans to establish non-toxic zones, while other provinces (e.g., Ontario) were to have expanded and/or establish non-toxic zones. Incredibly, in July 1995, Sheila Copps (the then Canadian Environment Minister) announced a nation-wide ban on the use of lead shot for harvesting migratory game birds effective in the fall of 1997. No scientific evidence was presented for this quick change in policy (only three months had elapsed since the comprehensive report of the Canadian Wildlife Service), because no new scientific evidence was available to justify this abrupt change in policy (unless human health concerns were considered by the Minister, which they were not). Moreover, on August 19, 1997 (just weeks before the Canada-wide ban was to be implemented), the *Migratory Birds Regulations* were once again amended (Tsuji, 1998).

Clearly, in the case of the mandatory use of non-toxic shells for the harvesting of migratory game birds while in Canada issue, policy was not based on scientific data, other factors were more important. Taking into account that policy makers do not always base their decisions on scientific-based data as explained above, it is not surprising that TEK has not been adequately utilized in resource management (Usher, 1993).

The final point, with respect to the management category, deals with data collection; in other words, epistemic differences between science and TEK. TEK is collected and utilized by resource users; by contrast, scientists (often from different locales with little hands-on experience with the environment at hand) generate data for policy makers. Bielawski (1995) states that this is one of the more important differences between science and TEK in the north, as many scientific researchers are unable to understand the complexity of northern ecosystems through sporadic observation, as opposed to lived experience. Other authors support this distinction between TEK and science as this experience provides knowledge that is difficult to attain through conventional scientific methods (Hobson 1992; Berkes 1999a; Fienup-Riordan 1999).

Discussion

Although TEK and science appear to be different in how knowledge is acquired in that TEK has a spiritual or cultural component while science does not, and TEK is generated by resource users and not by unaffiliated researchers, similarities do exist between these knowledge systems. There is no evidence to support claims that TEK is not systematic or self-reflexive. Indeed, TEK is clearly part of a societal process and subject to peer critique through shared lives and experiences. In addition, both science and TEK seek to explain phenomena through universal assertions and laws. Both also employ observation, logic, and authority to create knowledge. Even though TEK and science are similar in many aspects, they are clearly different, variations of a "universal truth".

It is not to say, then, that TEK should be considered to be less predictive or explanatory than science, but rather that TEK is a different approach to understanding and acquiring knowledge than science. If applicable, it may be advantageous to utilize both systems. Since both science and TEK employ different methods to gain knowledge, it cannot be assumed that the contributions of each to general knowledge are equal. When there is more than one way of knowing, all ways should be used to contribute to a more complete understanding of knowledge in general.

In overview, it is not surprising that common ground was found between TEK and western science considering the heterogeneity *within* both systems of knowledge (Agrawal, 1995). In addition, it is clear (even from the limited examples given in this paper) that the differences between TEK and western science have been overstated in the literature. Hopefully, by presenting some common ground between the two systems of knowledge, this paper has stimulated people to the point of reexamining previously held views and beliefs about both TEK and western science. Perhaps, by having a better understanding of similarities (as well as real differences; e.g., interpretation) between the knowledge systems, one can gain a better understanding of one's own.

Allowing for the fact that there exists common ground between TEK and western science, integration of the two should not be a goal. TEK and western science should be viewed as two separate but complementary sources of information and wisdom (DeWalt, 1994; Stevenson, 1996; Riedlinger and Berkes, 2001), where practitioners of both would benefit from a reciprocal flow of knowledge (Johnson, 1992b; Nakashima, 1993).

The symbolism of the Haudenosaunee, 17th century treaty belt known as the Kaswentha (also known as the Two-Row Wampum), offers a framework from which collaborative TEK and scientific projects could be built, as described by Ransom and Ettinger (2001). The Kaswentha recorded the agreement between the Haudenosaunee Confederacy and Dutch settlers in eastern New York, and consists of alternating rows of purple and white shell beads running the length of the belt. The two purple rows symbolized the two vessels (a Dutch ship with its culture and a First Nation birch bark canoe with its culture) travelling side-by-side on the river of life. Mutual respect and reciprocity were the foundation of the treaty. It was expected that First Nation people and non-Natives would assist each other when problems arose, using their distinct knowledge systems as tools in this partnership. Thus, traditional knowledge may complement science as long as the knowledge systems remain distinct (Ransom and Ettinger, 2001).

How TEK might complement scientific approaches to environmental issues

Before briefly examining the plethora of literature regarding how TEK might complement environmental studies, the question of why TEK is needed in the first place must be addressed. Freeman (1992) states that the nature of ecosystems and their inherent complexity is a poor match for conventional deductive, reductionist science. Therefore, it has been hypothesized that TEK with its holistic approach might be able to offer insights into complex, nonlinear systems. There are four general ways in which TEK might complement or supplement conventional scientific approaches in addressing complex environmental issues. Utility may be related to taxonomic, spatial, temporal, and social/cultural frames of reference (Johannes 1993). These frames of reference (not mutually exclusive) may enhance or even be the sole source of baseline data, from which scientific approaches may base its research.

Using TEK as taxonomic frames of reference. Johnson (1992b) describes how, during the 1950s, scientists first became interested in TEK with respect to taxonomy (i.e., the classification of organisms), which was found to be, in some cases, more complex and utilitarian for local communities than scientific methods. In contrast to scientific methods of classification by genetic composition, TEK methods incorporate plant and animal relationships and uses. Thus, traditional herbal medicine could complement science by identifying species of plants and/or animals that may have "healing" properties. It has been estimated that of the approximately 25,000 species of plants that have been used in traditional medicine, only 1% is known to western science and used commercially (Aguilar, 2001). Studies have shown that TEK identified plant species often have pharmacological properties, explaining, why some plant extracts have been known to cure specific ailments. For example, Berlin et al. (1996) have shown in the laboratory that many plant species that have been used to treat gastrointestinal ailments by the highland Maya of Mexico have properties that either attack the causative organism (e.g., antimicrobial) or treat the symptoms (e.g., spasmolytic activity - relief from cramping of the stomach). Since, most medicinal plant species used by the highland Maya specifically target individual health conditions, this knowledge must have been developed based on experimentation (Berlin et al. 1996). Obviously, experimentation is not exclusive to western science.

Using TEK as spatial frames of reference. The Mid-Canada Radar Line was built during the “Cold War” as a component of a larger surveillance network in the north (Environmental Sciences Group, 1999). These radar line sites were abandoned by 1965 but never properly decommissioned (Environmental Sciences Group, 1998, 1999). As part of the site delineation and assessment process, TEK was incorporated to identify areas of concern that were not obvious for various reasons. In one example, J. Koostachin identified an area where a helicopter had dropped a 5,000-gallon fuel tank causing a fuel spill, approximately 12 years earlier. The area when investigated showed no surface staining and no surface contamination, however, deeper soil samples revealed contamination with petroleum hydrocarbons (Environmental Sciences Group, 1999). If TEK had not been used, the contaminated area would have never been identified. TEK identified the area of concern while science provided the toxicological verification. Similarly, J. Kataquapit used TEK to identify an additional 32 potential sites of concern (contamination and/or physical hazard) that were not noted in the original assessment of radar line site 050 (Tsuji et al. 2001). The physical-hazard sites have been remediated and the other potentially contaminated sites have been analyzed for chemical contamination. In these two examples, the two knowledge systems complemented each other by providing information unavailable to the other; TEK provided site location while science was used to assess the contamination state of the site.

Using TEK as temporal frames of reference. Several polar bears have recently been reported to have been killed by Cree, during the traditional spring waterfowl harvesting season, in the southern coastal area of the western James Bay region of northern Ontario, Canada (Anonymous, 2000; Porter, 2000). Polar bears have rarely been reported so far south on the coast and during the spring harvest (Jonkel et al., 1976; B. Katapatuk, 2000, pers. comm.). To investigate the increasing activity of polar bears in this region, Cornwell et al. (MS) studied the long-term trend in polar bear distribution (southern periphery of the James Bay and Belcher Islands population) as related to climate change. TEK and science were used in a complementary way. Cree TEK was utilized to establish the historical southern boundary of this polar bear population, while science was used to investigate climate change in the region. Time-series analyses revealed a significant increase in the length of the ice-free season in this region (1971-1999) with the majority of this increase being attributable to the earlier break-up of sea ice. In addition, spatial and temporal changes in the southern distribution of polar bears was apparent based on TEK collected during the study; polar bears (or signs; e.g., tracks) were rarely reported in the southern James Bay region by Elders over their lifetime. Thus, it appears that global warming may be affecting polar bears of the western James Bay region because the duration of sea ice and its distribution in this region influences body condition. Polar bears use sea ice as hunting platforms in their quest for their main prey species, the ringed seal, *Phoca hispida* (Jonkel et al., 1976; Stirling and Archibald, 1977; Stirling and Derocher, 1993). If polar bears are unable to achieve a minimum body mass to sustain themselves during the open water period when feeding is rare, then polar bears in poor body condition will increase their home range (C. Elliott, 1988 as cited in Stirling et al., 1999; Cornwell et al. MS). This hypothesis would help to explain the change in distribution of polar bears in the western James Bay region (Cornwell et al. MS).

Using TEK as cultural frames of reference. TEK can give insight into the social and cultural impacts of environmental management decisions. This is especially true in Canada and Alaska where an increasing number of development and resource management issues have been identified. In this section, a case study that has used TEK and science in a complementary manner with respect to a cultural frame of reference will be discussed.

Huntington (2000) documents the case of the Alaskan Bowhead Whale Census, which occurred in the early 1980s. In the late 1970s, the International Whaling Commission imposed a ban on all Bowhead whales. However, the Inuit of Alaska protested, citing the importance of the Bowhead whales to their culture, and formed the Alaskan Eskimo Whaling Commission. This eventually led to the creation of a quota for the harvest, however, the quota was based on a scientifically derived census of the whales, which found there to be between 2000 and 3000 Bowhead whales in the region. The Alaskan Eskimo Whaling Commission, however, felt that this number was not representative of the true whale population, and that in fact the estimate was too low. The scientific census was based on field observations from cliffs or pressure ridges along the whale migratory path. However, the Inuit felt that the scientific estimation of the migratory path was incorrect, and that a more representative census could be obtained by including aerial counts in areas away from the steep cliffs and pressure ridges, as well as audio counts from farther out from the cliffs, on the ice. Through a collaborative field study with the government-appointed scientists, the Inuit estimate was 6000 to 8000 whales, allowing for an increase in Inuit harvest quotas.

Cautionary Note. It should be stressed that if TEK and science do not remain distinct then problems may arise. For example, both traditional (ayurveda, siddha, and unani) and modern medicine have been supported by the Government of India, however, a great deal of controversy was generated by an Indian health ministry proposal to introduce courses in traditional medicine in modern medicine colleges. There was a fear that exposing medical students to two fundamentally different systems of medicine would promote not only ambiguity and confusion but even quackery (Mudur, 2001). Respect for another system of knowledge is much different than trying to be a practitioner of it.

Ethical Considerations

It should be noted that while TEK might complement science, there has been much controversy surrounding its use and appropriation by conventional scientists. Much of this debate has centred upon intellectual property rights (Brascoupe and Mann, 2001). This concern relates to the increased use of TEK in pharmaceutical research in which informants providing the TEK did not give consent for the use and marketing of such information (Ruppert 1996). Increasingly, indigenous peoples are seeking to gain more control of the collection and use of TEK (Ruppert 1996).

Concern has also been raised with researchers collecting TEK for scientific purposes inadequately including Native people in the research processes. Native peoples are often not informed of the purpose of the research, the findings of the research, nor the implications of the research (Fienup-Riordan 1999; Wenzel 1999).

It is important to consider not only the ethical guidelines for TEK research (e.g., Association of Canadian Studies for the Conduct of Research in the North, 2002), but also the implications of that research for the communities and peoples involved. These considerations should underpin all attempts to utilize TEK as a complementary form of knowledge with respect to science. Reciprocity is the keyword to success.

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