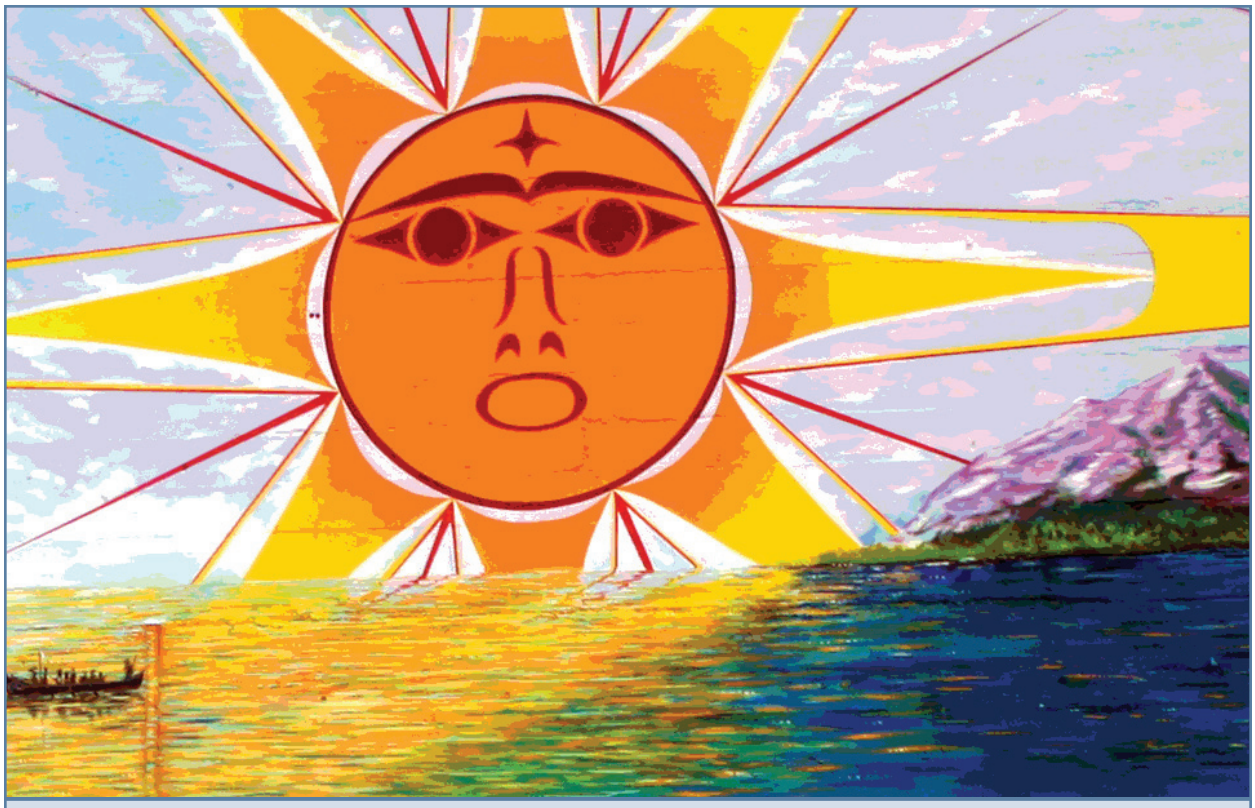

Weaving Indigenous and Sustainability Sciences: Diversifying our Methods (WIS²DOM) Workshop

February 13-16, 2013

Report prepared by

Jay T. Johnson, University of Kansas
Renee Pualani Louis, University of Kansas
Andrew Kliskey, University of Alaska-Anchorage

National Science Foundation 2014

Arctic Social Sciences Program, Directorate for Geosciences

Our cover art depicts a portion of the Paddle to Squaxin 2012 Canoe Journey mural in Olympia, Washington. The artist and Squaxin Island tribal member, Joseph Seymour Jr., welcomed our group to his territory at the mural on February 13, 2013.

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Workshop Participants

Fikret Berkes, University of Manitoba
Paulette Blanchard, University of Oklahoma
Joseph Brewer, Haskell Indian Nations University
Brian Buma, University of Colorado
Gregory Cajete, University of New Mexico
Ed Galindo, University of Idaho
Christian Giardina, Institute of Pacific Islands Forestry, U.S. Forest Service
Zoltan Grossman, The Evergreen State College
Lene Kielsen Holm, Greenland Institute of Natural Resources
Richard Howitt, Macquarie University
Jay T. Johnson, University of Kansas
Kekuhi Kealiʻikanakaʻoleohaililani, Hawaiʻi Community College
Andrew D. Kliskey, University of Alaska Anchorage
Renee Pualani Louis, University of Kansas
Deb McGregor, University of Toronto
Debra McNutt, The Evergreen State College
Liz Medicine Crow, First Alaskans Institute
Mark Palmer, University of Missouri
Marcela Palomino-Schalscha, Victoria University of Wellington
Lin Pei-Shan, National Taiwan University
Karina Walters, University of Washington
Jon Waterhouse, Yukon River Inter-tribal Watershed Council
Kyle Wark, First Alaskans Institute
Daniel Wildcat, Haskell Indian Nations University
Laura Zanotti, Purdue University
John Ziker, Boise State University

STUDENT ASSOCIATES

Katrina McClure, University of Kansas
Joshua Meisel, University of Kansas
Victoria Walsey, University of Kansas

Executive Summary

On February 13-16, 2013, a workshop, entitled Weaving Indigenous and Sustainability Sciences to Diversify our Methods (WIS²DOM), was held in Olympia, Washington at The Evergreen State University's Longhouse (*sgʷigʷial?txʷ*). The workshop was funded by an NSF grant from the Arctic Social Sciences Program to Drs. Jay T. Johnson and Renee Pualani Louis, University of Kansas; and Andrew Kliskey, University of Alaska-Anchorage. The purpose of the workshop was to challenge key thinkers in the areas of Indigenous and sustainability sciences to cultivate mutually conducive and appropriate principles, protocols, and practices that address our common concern to sustain resilient landscapes in the midst of rapid environmental change.

The WIS²DOM workshop brought together an internationally diverse set of Indigenous academics and community scholars with non-Indigenous academics interested in advancing this discussion. Workshop participants were asked to address the following four questions in their short papers and workshop deliberations:

1. What are the strengths of these two paradigms of science in sustaining resilient landscapes?
2. What are the limitations of these two paradigms of science in successfully sustaining resilient landscapes?
3. How can these two paradigms collaborate in their efforts toward sustaining resilient landscapes?
4. What protocols will aid in the collaboration of these two paradigms toward sustaining resilient landscapes?

The report is organized into five sections:

Part I outlines the ***strengths and limitations of sustainability science in sustaining resilient landscapes;*** provides a brief introduction to the development of sustainability science over the past two decades; addresses the strengths identified by participants (a transdisciplinary approach, systems framework, scientific method and measurement); as well as the weaknesses (politics of science, economics of sustainability management, scalar applications of sustainability science).

Part II identifies the ***strengths and limitations of Indigenous science in sustaining resilient landscapes;*** provides a brief introduction to the development of Indigenous science within the academy over the past two decades; address the strengths identified by participants (deep-spatial knowledge, long-term observations, an ethos of reciprocal appropriation); as well as the weaknesses (issues related to translation, finding common ground).

Part III explores ***successful collaborations between Indigenous and sustainability sciences in sustaining resilient landscapes;*** relevant theoretical work on Indigenous science and traditional ecological knowledge are referenced alongside participants' contributions.

Part IV discusses ***protocols necessary for successful collaborations between Indigenous and sustainability sciences in sustaining resilient landscapes;*** participant discussions regarding research protocols, principles and practices are described.

Part V contains recommendations to Indigenous and sustainability scientists as well as to funding agencies, including NSF, for fostering collaboration between Indigenous communities and scholars and sustainability scientists, encouraging Indigenous community research leadership with an emphasis on mentoring future Indigenous scholars, and further discussions and research into appropriate research principles, protocols, and practices in order to aid collaborations.

Recommendations for building bridges for collaboration:

- Increase collaborations between Indigenous and sustainability scientists to utilize the strengths and overcome any weaknesses inherent in both paradigms.
- Allow each paradigm to occupy their own separate intellectual space while building bridges between them for dialogue.
- Focus these collaborations on the shared concern of enhancing the native biodiversity, structure and function of natural environments.

Recommendations for encouraging Indigenous leadership in research:

- Encourage Indigenous scholars to take an increasingly active role in initiating and leading research initiatives within their own communities.
- Establish a funded research network to explore the research needs and capacities of Indigenous communities.
- Develop strategies for developing research capacity within Indigenous communities.

Recommendations for mentoring Indigenous scholarship:

- Facilitate the training of a new generation of Indigenous scholars skilled at building bridges between Western and Indigenous scientific traditions and knowledge systems.
- Secure on-going funding for a summer program aimed at preparing Indigenous undergraduate students for graduate study, particularly in STEM disciplines.
- Develop a national program to support and mentor Indigenous PhD students.
- Provide training on Indigenous community research needs for national research funders such as NSF, NIH, USDA, EPA, etc.

Recommendations for identifying and developing appropriate research methods:

- Fund research into how Indigenous communities and organizations are engaging research policies and review boards in research permitting and collaboration.

The report concludes with appendices that list workshop participants, the workshop agenda, and include the papers submitted by workshop participants. A complete copy of this report is available on the University of Kansas Indigenous Geographies Research Center website: http://ipsr.ku.edu/igrc/wis2dom/WorkshopReport2013.pdf

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Background

After holding a week-long NSF-funded workshop (Indigenous ecological knowledges and geographic information sciences (GIS) #1044906) bringing together an international interdisciplinary group of Indigenous scholars, cultural practitioners, students and non-Indigenous scholars working with or for Indigenous communities to discuss the development of spatial data infrastructure (SDI) capable of representing Indigenous perspectives of modeling environmental phenomena, we learned two important points:

1. Each Indigenous community as well as each academic discipline is at a different developmental stage of understanding the "who, what, when, where, and why" of SDI representation which means we needed to collectively identify the starting point and path for this kind of project.
2. One of the points of collective agreement was the necessity of relating to our environments through sustainable principles, protocols, and practices.[1]

As a result we proposed a 3-½ day workshop to address the area of our collective agreement – sustaining resilient landscapes by including Indigenous observations and perspectives. Indigenous peoples have systematically maintained localized place-based environmental knowledge for genera-tions.[2] This knowledge is critical for establishing or expanding an environmental baseline. The intellectual focus of this workshop was to explore the intersection of Indigenous and sustainability sciences.

The workshop challenged key thinkers in these areas to cultivate mutually conducive and appropriate principles, protocols, and practices that address our need to sustain resilient landscapes. The principal investigators (Johnson, Kliskey and Louis) acknowledged that while sustainability science has moved in directions that further articulate social-ecological systems it has increasingly been coupled with sustainable development and technocentric approaches to environmentalism that aim to sustain ecosystems and the services they provide by building a 'smarter planet'.[3] The technocentric and development-based approaches presupposes that the planet and human societies require improvement and depend upon Western science to advance their interaction with their ecological systems. Contrary to this approach, Indigenous societies are dependent on and built upon sustaining reciprocal relationships between culture and nature and therefore utilize scientific approaches that are rigorous and rely on long-term observations.

The WIS^{2}DOM workshop brought together an internationally diverse set of Indigenous academics and community scholars with non-Indigenous academics interested in advancing this discussion. In order to further our research efforts this workshop was geared around the following four questions:

1. What are the strengths of these two paradigms of science in sustaining resilient landscapes?
2. What are the limitations of these two paradigms of science in successfully sustaining resilient landscapes?
3. How can these two paradigms collaborate in their efforts toward sustaining resilient landscapes?
4. What protocols will aid in the collaboration of these two paradigms toward sustaining resilient landscapes?

Ultimately, we are interested in uncovering what kinds of new information and/or understandings can be gained by bringing together Indigenous and sustainability science. Aside from the opportunity to gather

[1] Hi'iaka Working Group. "Indigenous Knowledges Driving Technological Innovation." aapi nexus: Asian Americans & Pacific Islanders Policy, Practice and Community 9, no. 1-2 (2011): 241-48.
[2] Agrawal, Arun. "Dismantling the Divide between Indigenous and Scientific Knowledge." Development and Change 26 (1995): 413-39.
[3] Kauffman, Joanne. "Advancing Sustainability Science: Report on the International Conference on Sustainability Science (ICSS) 2009." Sustainability Science 4, no. 2 (2009): 233-42.

Indigenous and other interested scholars to begin addressing the main research questions, the outcomes of the workshop included an improved understanding of how Indigenous science can help expand the boundaries of sustainability science; and new insights on the relevance, feasibility, and challenges of cultivating new mutually conducive and appropriate principles, protocols, and practices that address our need to sustain resilient landscapes.

The workshop was organized to provide participants the opportunity to collaborate between Indigenous and non-Indigenous early career academics with senior scholars from several disciplines including Indigenous community scholars. It also allowed Indigenous peoples to communicate their ecological understandings to the wider scientific community. The workshop was held at The Evergreen State College's Longhouse with one day spent touring and learning about the Nisqually Tribe's use of various aspects of sustainability science alongside their Indigenous ecological knowledge over the river system that bears their name and how they are using both knowledge systems to support their efforts to restore and manage that watershed and associated natural resources of cultural significance.

What follows in this report is a summary of the discussions and recommendations that emerged from the workshop. The first four sections correspond to the questions posed to the participants prior to the workshop. Participants were asked to address the successes and limitations of Indigenous and sustainability sciences in sustaining resilient landscapes. We also asked that they identify successful collaborations between the two streams of thought and finally, to identify the protocols necessary to bring the two together into dialogue.

Part I summarizes the successes and limitations of **sustainability science** while Part II does the same for **Indigenous science**. Part III identifies the successful **collaborations between Indigenous and sustainability sciences** and their key components. Part IV summarizes our discussions of appropriate **principles, protocols and practices** necessary for successful collaborations. Part V contains **recommendations** for advancing Indigenous and sustainability sciences research collaborations, including recommendations for creating institutional efforts to facilitate Indigenous research, science and technological advancements.

Part I. Strengths and Limitations of Sustainability Science in Sustaining Resilient Landscapes

Human survival depends, directly and indirectly, on the natural environment from the air we breathe, the water we drink, and the food we eat to the fuels we use and fibers we felt. The health of our natural environment directly reflects on our ability to maintain a high quality of life. When we act responsibly, we flourish, when we do not, we suffer.[4] Rapid population growth and consumption of natural resources raised significant concerns internationally and sustainable development arose in the 1980's to "meet the needs of the present without compromising the ability of future generations to meet their own needs."[5] The United Nations (UN) recognized the need for a global response to achieve sustainable development and endorsed the 27 principles outlined in the *Rio Declaration on Environment and Development* in 1992.

Sustainability science emerged in the last two decades in response to humanity's concern about the ability of the earth to sustain human life. It is a transdisciplinary field concerned with the complex dynamics and interactions between humans and the environment.[6] These interactions occur at various temporal and spatial scales. Understanding scale is important because it sets the framework in which sustainability can be achieved. Sustainability science has been modeled conceptually as three interconnected "systems" – global, human, and social.[7]

Sustainability science is committed to developing solutions to those environmental issues that threaten human life at local and global scales such as climate change, resource depletion, ecological destruction, and other environmental crises. It incorporates social-ecological systems science, along with associated resilience and complexity theories, and attempts to advance human-natural dynamics. While sustainability science has moved in directions that further social-ecological systems, it has increasingly been coupled with sustainable development and techno-centric approaches to environ-mentalism that aim to sustain ecosystems and the services they provide by building a 'smarter planet'.[8]

Workshop participants identified three key strengths and three key limitations of sustainability science to achieve its goals in relation to the workshop theme. Both its strengths and limitations can be traced to its dominant Western worldview and the set of methodologies that emerge from that scientific tradition. The strengths identified include the transdisciplinary approach, systems theory framework, and scientific method and measurement. The limitations identified include the politics of science, economics of sustainability management, and scalar applications.

Strengths

Transdisciplinary Approach

One of the strengths of sustainability science is that it brings together a diverse set of methods from a wide range of disciplines allowing for pluralistic solutions that fit specific environmental and cultural conditions.

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[4] U.S. Environmental Protection Agency. "Sustainability and the U.S. EPA." Washington, DC, USA, 2011.
[5] Brundtland, Gro Harlem. "Our Common Future." In *Report of the World Commission on Environment and Development: Our Common Future*, edited by United Nations, 1987.
[6] See Clark, William C., and Nancy M. Dickson. "Sustainability Science: The Emerging Research Program." *Proceedings of the National Academy of Sciences* 100, no. 14 (8 July 2003): 8059-61. Kates, Robert W., William C. Clark, Robert Corell, and etal. "Sustainability Science." *Science* 292, no. 5517 (2001): 641-42 and Komiyama, Hiroshi, and Kazuhiko Takeuchi. "Sustainability Science: Building a New Discipline." *Sustainability Science* 1, no. 1 (2006): 1-6.
[7] Komiyama, Hiroshi, and Kazuhiko Takeuchi. "Sustainability Science: Building a New Discipline." *Sustainability Science* 1, no. 1 (2006): 1-6.
[8] Kauffman, Joanne. "Advancing Sustainability Science: Report on the International Conference on Sustainability Science (ICSS) 2009." *Sustainability Science* 4, no. 2 (2009): 233-42.

Closely related to this is how sustainability science brings together scholarship and practice, global and local perspectives from north and south.[9] Sustainability science requires the participation of diverse stakeholders in setting and implementing solutions to specific issues. This provides more vehicles to distribute knowledge gained in the process.[10] Jon Waterhouse (this volume) is hopeful the shared scholarship and practice will allow for greater acceptance of Native sciences.

Systems Framework

The environment that surrounds us is a complex of systems. This can be hard to understand. Sustainability science utilizes a systems theory framework providing a wide range of tools and technologies to investigate the principles in common to all complex entities and to examine the effects of change on an entire system. For example, remote sensing and geospatial modeling help decision makers examine the effect of climate change on an entire agricultural region as well as the effect on management policies on entire forest areas. Biogeochemical techniques and hydrological modeling provide necessary information on the water quality and water delivery from an entire mountain range.

Scientific Method and Measurement

Another important strength of sustainability science is its use of the scientific method when measuring quantitative information. Brian Buma (this volume) believes the mechanistic nature of the reductionist approach is an excellent means to determine cause and effect relationships. Repeatability that leads to reproducible results requires tight control over variables and may lead to a loss of generalization outside of individual study areas (or those tightly controlled conditions). However, the scientific method allows for new hypotheses to be easily undertaken with different controlled variable values leading to true progress of reductionist knowledge. Giardina (this volume) agrees that the hypothesis driven framework provides project managers reliable robust results derived from complex analyses that is often accessible in peer-reviewed publications adding another layer of reliability.

Lene Holm (this volume) adds that sustainability science provides necessary measurements, such as air temperatures, air humidity, winds etc. in time series, from the same sites/locations providing a knowledge metrics, to show e.g. change, or status quo. Giardina (this volume) agrees that the "methodologies and associated metrics that allow the impact (negative and positive) of actions (or inaction) to be quantified and monitored over time. For example, if a community defines clean rivers as a sustainability value, sustainability science can provide specific metrics for what constitutes clean water and the tools for quantifying and monitoring cleanliness of the water over time."

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[9] Clark, William C., and Nancy M. Dickson. "Sustainability Science: The Emerging Research Program." *Proceedings of the National Academy of Sciences* 100, no. 14 (8 July 2003): 8059-61.
[10] Kajikawa, Yuya. "Research Core and Framework of Sustainability Science." *Sustainability Science* 3, no. 2 (19 July 2008): 215-39.

Limitations

Politics of Science

The rapid emergence of sustainability science has been as concerned with securing its place in the discourses of science as it has been with addressing global issues of sustainability. This has led to sustainability science being framed as a discourse about science as much as a discourse about sustainability. In Richie Howitt's opening keynote, he noted that many of us working within science constantly face institutional circumstances in which this openness of science is threatened by an insistent expertocracy that is self-referential, censorious and powerful. Indeed, the expertocracy is often embedded within institutional structures that are endorsed and supported by states and corporations (military industrial complexes, colonial systems, territorial-production complexes to use other terminologies), which threaten sustainability and Indigenous rights (interalia) and are unequivocally part of the problem. As a result, much of scientific research including sustainability science research pursues only those questions it is funded to pursue (see Howitt this volume).

It is precisely this line of reasoning that led the workshop participants to pursue an Indigenous funded center for Indigenous research, science and technology where a dialogue between capital "S" science and Indigenous science can lead to locally or contextually tailored research solutions and can build frameworks of understanding that are pluralist, open and engaged across (linguistic, cultural, epistemological, spatial and temporal) difference.

Economics of Sustainability Management

To achieve and maintain sustainability, people in positions of authority such as policy makers and environmental managers require both timely and specific information. Time sensitive information indicates whether a system is generally becoming more or less sustainable. Specific information identifies which characteristics need the most improvement.[11] Giardina (this volume) notes that managers today are now being charged with simultaneously sustaining high value organisms, processes and/or outcomes but also managing for global change (climate change, atmosphere change, invasive species, introduced pests and disease, etc.) while accounting for mismanagement in the recent past, but "sustainable" traditional management in the distant past.

He further states that because applications of Sustainability Science must provide simple metrics that can be easily and quickly adopted and used by managers who often seek cost effective generalities across systems, the focus of these applications is most often on a small number of charismatic organisms, processes or outcomes that are of broad interest and perceived value. Sustainability of an entire system, including all of its components, typically cannot be examined because resources, tools, and even understanding are lacking.[12] Buma (this volume) agrees that oftentimes reductionist approaches with its emphasis on control and repeatability lead to an unrealistic amount of simplification of systems, limiting their applicability to various places and real situations.

Scalar Applications of Sustainability Science

Scale matters profoundly when dealing with sustainability science. Sustainability in your local community is very different from the sustainability of your nation. These different scales are not independent of one another as what happens at one scale can affect the other. The roles of geographical and temporal scale in relation to sustainability is complicated by those technologies that reshape the meaning of proximity and increase interconnections over what were once considered long distances, often speeding the diffusion of innovations.[13]

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[11] Mayer AL. (2007) Strenghts and Weaknesses of Common Sustainability Indices for Multidimensional Systems. *Environment International* 34: 277-281.
[12] Chase Alston. Playing God in Yellowstone: The Destruction of America's First National Park. Boston: Atlantic Monthly Press, 1986.
[13] Wilbanks TJ. (2007) Scale and Sustainability. *Climate Policy* 7: 278-287.

Giardina (this volume) recognizes that sustainability objectives can be at odds with observed rates of change that define most systems, rates that often are very dynamic even on short time scales (decades), while not addressing change that can occur on longer time scales such as centuries.

Howitt (this volume) emphasizes the workshop proposes framing our dialogue at the scale of 'resilient landscapes'. It is a scale that has not been widely discussed in the literature and presents its own challenges. At the scale of landscapes, particular relationships of connectivity, dependence and identification are comprehensible in the everyday practices of human activity. By framing our dialogue at the scale of 'resilient landscapes', then, we might find we contextualize our thinking in novel ways. Framed at the landscape scale, sustainability science and Indigenous science will see things quite differently. It should not surprise us to find each convinced of its (and our) own importance. Indigenous sciences will likely point to issues of connection, responsibility and meaning. Sustainability science will point to issues of management, governance, and adaptation. In between is the discursive space to be created by *WIS²DOM*– a space that challenges us and invites transformation in both approaches.

Part II. Strengths and Limitations of Indigenous Science in Sustaining Resilient Landscapes

Indigenous peoples have been employing systematic methods for learning and teaching about the natural world for thousands of years, sometimes utilizing techniques familiar to us today and sometimes not. The term science is itself only a few hundred years old, as is the process of systematic enquiry denoted by the name. The recognition of the contribution of Indigenous peoples to scientific enquiry and the development of the term, Indigenous science, began in the late 1960's with the work of pioneers such as Vine Deloria, Jr. Since that time, several organizations, including the American Association for the Advancement of Science and the National Science Foundation, have recognized the contributions made by Indigenous peoples to the various fields of science and technology. More recently, the work of authors such as Gregory Cajete, have encouraged the development and adoption of the term. As the term has developed, alongside competing terms such as 'traditional ecological knowledge', several definitions have emerged. We have synthesized the following definition and believe that it encompasses many perspectives currently held by those working in the field.

Indigenous science is spatially localized and place-based, temporally spans immediate short-term periods to extend on long-term observations, and includes integrative understanding of natural and human processes. Indigenous science represents the cumulative place-based observations of natural phenomena, and fully integrates and acknowledges humans as part of the natural world and its processes.[14] It also recognizes, develops, and applies appropriate technologies, while accepting their limits, to sustain resilient landscapes. Additionally, the application of Indigenous science to sustain resilient landscapes rests on the recognition of variability within ecosystems. We are aware of claims that Indigenous societies sometimes failed to manage their resources appropriately. We find that these claims, with a few notable exceptions such as the extinction of some New Zealand land-birds by Māori, have not been substantiated.[15]

Workshop participants identified three key strengths and two limitations of Indigenous science to achieving its goals, particularly in relation to sustainability science and the workshop theme. The strengths of Indigenous science rest predominately in its placed and experiential nature while its limitations primarily regard the challenges of establishing a dialogue between Indigenous and Western worldviews. The strengths identified include the deep-spatial knowledge acquired over long years of systematic observation and the connections and relationships drawn between the human and more-than-human. The limitations identified include issues of translation between worldviews and the challenges of finding common ground upon which to base dialogue between the two paradigms.

Strengths

Deep-spatial Knowledge

Indigenous science is constituted within the deep-spatial experience of Indigenous communities with their landscapes and non-human others, incorporating long-term and empirical observations to create understandings based upon a sustainable resilience. Indigenous science is as diverse as the groups around the world who engage local and traditional forms of ecological knowledge, such as the Inuit and Hawaiians; but they are also surprisingly similar in many regards. As Gregory Cajete (this volume) noted in his keynote presentation to the workshop, Indigenous science is based upon four foundations. "The first is traditional knowledge which is handed down and based on stories and experiences of a people through time. The second

[14] Cajete, Gregory. *Native Science : Natural Laws of Interdependence*. 1st ed. Santa Fe, N.M.: Clear Light Publishers, 2000.
[15] Barnosky, Anthony D, Paul L Koch, Robert S Feranec, Scott L Wing, and Alan B Shabel. "Assessing the Causes of Late Pleistocene Extinctions on the Continents." *Science* 306, no. 5693 (2004): 70-75, and Hunt, Terry L., and Carl P. Lipo. *The Statues That Walked: Unraveling the Mystery of Easter Island*. 1st Free Press hardcover ed. New York: Free Press, 2011.

is empirical knowledge that is gained through careful observation and practice over time. The third is revealed knowledge, which is gained through vision, ritual and ceremony. The final is contemporary knowledge that is gained through experience and problem solving."

Long-term Observations

One of the strengths of Indigenous science to sustain landscapes is its reliance upon long-term observations, frequently stored within stories, chants and dances and other forms of representation. These data provide a living representation of historic observations and understandings toward sustainable resource management. As Fikret Berkes (this volume) observed in his keynote address to the workshop, Indigenous ecosystem management based upon these long-term observations and understandings, are capable of maintaining some of the most biodiverse ecosystems globally. As Kyle Wark (this volume) notes, "our ecological interactions are not framed as exploitation, but are instead seen as mutually beneficial relationships. Humans are an integral component of the health of the land; we provide for it even as it provides for us."

Reciprocal Appropriation

This form of reciprocal appropriation and respect for human and non-human others, are all hallmarks of Indigenous science and its local ecological knowledge systems. This respect and the concept of interrelatedness between human and non-human communities is as Galindo (this volume) states, "a powerful idea in building and sustaining resilient landscapes." These local observations have been documenting profound changes to climate, sea level, animal migrations, and other direct indications of anthropogenic environmental change. Interdisciplinary and cross-cultural research programs have been working with Indigenous communities to document their observations of these changes alongside Western scientific observations.[16] These research collaborations are pointing to one form of successful collaboration but they are also documenting the adaptive capacity of human and non-human communities to respond to environmental change.

Limitations

Translation

While Indigenous science's greatest strength is that it is based within long-resident observations and represents a deep-spatial knowledge, frequently this knowledge is so place specific and culturally integrated that it can be difficult to translate this knowledge for broader audiences. While some knowledge and its associated practices should not be transferred from the communities and practitioners entrusted with that information, some of the knowledge gained over long-residence is of value and open for sharing with scientists. Creating protocols for such dialogues is discussed in detail in the next section of this report.

[16] Huntington, Henry, Terry Callaghan, Shari Fox, and Igor Krupnik. "Matching Traditional and Scientific Observations to Detect Environmental Change: A Discussion on Arctic Terrestrial Ecosystems." Issue Title: Special Report Number 13. The Royal Colloquium: Mountain Areas: A Global Resource: (2004): 18-23, and Huntington, Henry P. "Using Traditional Ecological Knowledge in Science: Methods and Applications." *Ecological Applications* 10, no. 5 (2000): 1270-74.

Finding Common Ground

The other common critique of Indigenous science is that it is saturated with, and integrated into, the spiritual belief systems of Indigenous communities. Modern Western scientific traditions, following the transformations of the Enlightenment, have excluded spiritual belief and practice from the academy and its epistemologies and methods. Finding a common ground upon which to bring Western and Indigenous sciences into dialogue requires first a reorientation or retelling of the narratives of Enlightenment thought.[17] Modern Western science must recognize its common, place-based foundations with other scientific traditions. As Louis challenges in her paper in this volume, Indigenous scientific practitioners need to make the metaphors embedded in their scientific records more accessible for those Western scientists seeking respectful collaborations.

[17] Johnson, Jay T., and Brian Murton. "Re/Placing Native Science: Indigenous Voices in Contemporary Constructions of Nature." *Geographical Research* 45, no. 2 (2007): 121-29.

Part III. Successful Collaborations between Indigenous and Sustainability Sciences in Sustaining Resilient Landscapes

"Science, in the general sense of systematic knowledge, was never uniquely Western, having exemplifications in a wide variety of cultures both ancient and modern, including Islam, India and China, the Americas, Africa and the Pacific."[18] Science is dynamic, definitive, and culturally relative. It consists of both a specific body of knowledge and the processes used to obtain and pass on that knowledge. We contend that there is not one universal perspective of science, but several lenses that are culturally defined ways of knowing.

Overlaps and Divides between Western and Indigenous Science

In general, Western and Indigenous science employ observation systems that share several features in that they operate by acquiring, organizing and storing data to determine patterns for the purpose of mounting appropriate responses.[19] By bringing Western and Indigenous sciences together we will finally be able to utilize the knowledge systems of those communities and individuals who have developed an exceptional understanding of the environments needed for their survival.[20] The collective memory of humans in such long-place residences holds information about past environmental variability that extends beyond the knowledge acquired by scientific observation in recent decades. This knowledge makes long established local residents, and especially Indigenous peoples, capable of observing and interpreting change with a level of precision that no other sensors can replicate.[21] Indigenous communities are engaged in restorative cultural programs including language revitalization, historical land use mapping and studies of place names. These programs are not only valuable culturally but are also "crucial in preserving the extensive data sets associated with Indigenous and placed knowledges."[22] Moreover, rapidly diminishing Indigenous populations, that is, those who have had extensive land-schooling (e.g., elders, hunters), often retain long memories of environmental variability and change and hold disappearing data that is essential to understanding the characteristics of change, thresholds, and sustainability under future conditions.[23]

Understanding how to develop appropriate adaptation strategies to change is crucial for communities around the world and is especially critical for Indigenous communities. Processes of environmental change are heterogeneous and this heterogeneity is more pronounced at finer scales.[24] Thus, successful responses to change are dependent on understanding how change is occurring at local scales from a baseline that makes sense to the communities who reside there. Key pre-requisites for adaptation include the need for understanding the trajectories and rates of change as well as the impediments that potentially limit response.[25] In response to a growing desire to understand adaptation, the need for reliable and meaningful baseline

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[18] Turnbull, David. Masons, Tricksters and Cartographers : Comparative Studies in the Sociology of Scientific and Indigenous Knowledge. Amsterdam, Abingdon: Harwood Academic; Marston, 2000; p. 6.
[19] Balasubramaniyan JS, Garcia-Fernandez JO, Isacoff D, et al. (1998) An architecture for intrusion detection using autonomous agents. *Computer Security Applications Conference, 1998. Proceedings. 14th Annual.* 13-24.
[20] Kliskey A, Alessa L and Barr B. 2009. Integrating local and traditional ecological knowledge for marine resilience. In: *Managing for resilience: new directions for marine ecosystem-based management.* McLeod L and Leslie H (eds.). Island Press Publishers,145–161.
[21] Louis RP. (2004) Indigenous Hawaiian cartographer: in search of common ground. *Cartographic Perspectives* 48: 7-23.
[22] Johnson JT. (2012) Place-based learning and knowing: critical pedagogies grounded in Indigeneity. *GeoJournal* 77: 829-836.
[23] Alessa L, Kliskey A and Brown G. (2008) Social-ecological hotspots mapping: A spatial approach for identifying coupled social-ecological space. *Landscape and Urban Planning* 85: 27-39.
[24] Jenssen BM. (2006) Endocrine-Disrupting Chemicals and Climate Change: A Worst-Case Combination for Arctic Marine Mammals and Seabirds? *Environmental Health Perspectives* 114: 76–80.
[25] Adger WN. (1999) Social vulnerability to climate change and extremes in coastal Vietnam. *World Development* 27: 249-269.

descriptions of the social-ecological system as a cultural landscape has become critical.[26] The full integration of the Indigenous Science perspective (i.e., highly integrated across disciplines and biophysical compartments) with powerful tools such as spatial approaches, models and other forms of technology is in its infancy.[27] We believe that the development of such techniques is critical in translating and successfully representing the deep spatial knowledge of Indigenous communities.

Toward Resilient Landscapes

In keeping with our central desire to utilize Indigenous science in sustaining resilient landscapes, we recognize the importance of the dwelling perspective in which "skills, sensitivities and orientations that have developed through long experience of conducting one's life in a particular environment" are acknowledged.[28] This not only describes the foundation of Indigenous ecological knowledge but also a sense of place that brings together Indigenous and phenomenological philosophies to create a bridge between Western and Indigenous scientific traditions.[29] It also integrates the field of sustainability science, which Kates et al. have defined as, "[seeking] to understand the fundamental character of interaction between nature and society…[and] differs to a considerable degree in structure, methods, and content from science as we know it."[30] In researching and representing Indigenous science concerning sustaining resilient landscapes we envision the development of protocols following Kates' challenge for sustainability science to "recognize the wide range of outlooks regarding what makes knowledge usable within science and society."[31] We also emphasize that sustainability science "requires place-based models because understanding the dynamic interaction between nature and society requires case studies situated in particular places."[32]

With our common shared interest in sustaining resilient landscapes we must explore the best practices of both the transdisciplinary approaches of sustainability science and the ontologically distinct traditions within Indigenous science toward reaching this common goal. Can these two paradigms work together? If so, what new insights might be gained through the incorporation of Indigenous science and its placed observations? What new or newly adapted methods will be required in order to meet the challenges that face humanity? As Kealiʻikanakaʻoleohaiʻilani states in this volume, any collaboration must be based upon "curiosity, compassion, and the willingness to flex and evolve our own practices. We do this by creating and fulfilling our personal relationships to being-human and to the more-than-human."

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[26] Davidson-Hunt, Ian and Fikret Berkes. "Learning as you journey: Anishinaabe perception of social-ecological environments and adaptive learning." Conservation Ecology 8, no. 1 (2003).
[27] Palmer, Mark H. "Engaging with< i> indigital</i> geographic information networks." Futures 41, no. 1 (2009): 33-40.
[28] Ingold T. (2000) *The perception of the environment: essays on livelihood, dwelling & skill,* London ; New York: Routledge, p.25.
[29] Johnson JT. (2012) Place-based learning and knowing: Critical pedagogies grounded in Indigeneity. *GeoJournal* 77: 829-836; and Johnson JT and Murton B. (2007) Re/placing native science: Indigenous voices in contemporary constructions of nature. *Geographical Research* 45: 121-129.
[30] Kates RW, Clark WC, Corell R, et al. (2001) Sustainability science. *Science* 292: 641-642.
[31] Ibid
[32] Berkes F. (2004) Rethinking Community-Based Conservation. *Conservation Biology* 18: 624.

Part IV. Protocols Necessary for Successful Collaborations between Indigenous and Sustainability Sciences in Sustaining Resilient Landscapes

Protocols define how a group proceeds or behaves in any given situation. Every society creates protocols as a part of establishing order and maintaining control. Indigenous science protocols are based on perceptions of natural law and guide how cultural practices are observed and performed. Similarly, sustainability science protocols are based on Western scientific understandings of the world and guide how scientific procedures are conducted and represented. In the final session of the workshop we asked attendees to help define those protocols that would lead to successful collaborations between Indigenous and sustainability sciences.

In order to establish a common ground, we began by asking, "what is sustainability?" Our discussion revolved around the definition of sustain as to support, hold up, or endure. Keali'ikanaka'oleohai'ilani said this is similar to the Hawaiian concept, *kāko'o* (kā - to create the impetus for; ko'o - to support). *Kāko'o* is considered both a noun and a transitive verb so someone or something must receive the action. The concept presupposes the idea of "being together in place" which means we all (including the elements and processes of nature) work together and share the responsibility of taking care of our places.[33]

With this in mind, attendees agreed that sustainability is simultaneously *the ability* and *the processes* necessary for the earth to support life – all life, not just human life. Thus, our protocols cannot just satisfy a purely intellectual argument of sustaining resiliency for prolonged human consumption; it must also uphold ethical principles with a biocentric perspective. This means that environmental decisions cannot be beholden to consumer and capitalist driven research agendas where return on investments rules the timeline of funding cycles (Louis, this volume).

Concepts such as respect, reciprocity, intentionality, humility, balance, renewal, reconnection, relationship, responsibility, virtuous practice, and paying attention were prominent in the discussion. The attendees reiterated that sustaining a resilient landscape needs human interaction, not human domination. "Humans are an integral component of the health of the land; we provide for it even as it provides for us" (Wark, this volume). Harvesting responsibly and culling animal populations of the weakest members maintains a balance and resiliency.

Unfortunately, there were far too many factors to consider for the workshop attendees to formulate distinct protocols. As a result, the attendees asked that further funding be sought to develop Indigenous research standards that reflect Indigenous knowledge production, honor Indigenous ingenuity ("indigenuity"), and resonate Indigenous perceptions of place.

[33] Howitt, R. (2011) Knowing/doing. In *A companion to Social Geography*, edited by V. del Casino et al. Malden, Mass.: Wiley-Blackwell, pp. 131-145.

Part V. Recommendations

The final session of the workshop was reserved for participants to provide their recommendations to the workshop organizers. This included a thorough and free-ranging discussion regarding future grant efforts, including a vision for expanding the work initiated by this workshop. These recommendations included fostering collaboration between Indigenous communities and scholars and sustainability scientists, encouraging Indigenous community research leadership with an emphasis on mentoring future Indigenous scholars, and further discussions and research into appropriate research principles, protocols, and practices in order to aid collaborations.

Building Bridges for Collaboration

The primary aim of the WIS^{2}DOM workshop was to engage a wide-range of scientists, community practitioners and Indigenous scholars in dialogue concerning the strengths and weaknesses of Indigenous and sustainability science approaches to sustaining resilient landscapes. As we have outlined in this report, these conversations aided in articulating how both of these broad paradigms are working toward aiding the health of our natural environment, as well as identifying the weaknesses we see with both approaches. Through this report and a proposed special edition of *Sustainability Science* journal, we intend to develop a literature that recognizes and identifies how the strengths of both paradigms can be utilized through research collaborations to aid in overcoming the weaknesses inherent in both. Collaborations between Indigenous and sustainability sciences must allow each to occupy their own separate intellectual spaces. Neither can be subsumed within the other. As Fikret Berkes (this volume) cautioned in his keynote address, our challenge is to find bridges between the two paradigms that allow for successful dialogue.

Taking Leadership in Research

For Indigenous scientific traditions to survive and thrive so that these dialogues can continue to take place, the participants noted that we must encourage Indigenous communities to take an increasing role in initiating and leading research initiatives within their own communities. It is hoped that through leading research initiatives Indigenous communities can maintain their own epistemological and methodological approaches to scientific enquiry. The participants also expressed a desire for the establishment of a network to explore the research needs and capacities of Indigenous communities. In an effort to further this investigation, several participants from the workshop have submitted a research coordination network (RCN) application to NSF in order to sustain an exploration of the research needs and capacities within Native American, Alaska Native, and Native Hawaiian communities. The FIRST (Facilitating Indigenous Research, Science, and Technology) network's goals, if funded, are to develop strategies for meeting the research needs of Indigenous communities and to encourage communities to take leadership in meeting those research needs.

Mentorship

One component of building the capacity of Indigenous communities in taking leadership in meeting their own research needs entails the training of a new generation of Indigenous scholars skilled at building bridges between Western and Indigenous scientific traditions. The workshop participants identified two areas of mentorship geared toward developing Indigenous research leadership. First, they identified the need for a summer program aimed at preparing Indigenous undergraduate students for graduate study, particularly in STEM disciplines. Second, they articulated the need for a national program to support and mentor Indigenous PhD students. Native American students are not succeeding at the same rate as other under-represented minorities in STEM disciplines therefore mentorship led by Indigenous academics may help to improve graduation rates. Several participants also discussed the need for increasing the comprehension of Indigenous communities research needs among the national research funders such as NSF, NIH, USDA, or EPA, etc.

Principles, Protocols, and Practices

Although the workshop organizers initiated a discussion concerning the appropriate methods to facilitate equitable collaborations between Indigenous and sustainability scientists, the general consensus of the participants was that this area required further study. Despite the establishment of national and international codes of research conduct aimed at ensuring ethical research practices, concerns remain particularly when Indigenous communities attempt to meet their own research needs. A few Indigenous organizations have attempted to address these concerns by producing their own policy statements.[34] Research into how Indigenous communities and organizations are engaging these policies or setting their own standards for research collaboration is still in its infancy. Participants from the University of Kansas and First Alaskans Institute are collaborating on an NSF proposal, CHIRP[3] (Collaboratively Harnessing Indigenous Research, Principles, Protocols, and Practices), to address this research gap.

[34] For example the National Congress of American Indians Policy Research Center's Tribal Research Regulation Toolkit (http://ncaiprc.org/research-regulation).

Appendix 1: Workshop Participants

Fikret Berkes, University of Manitoba
Paulette Blanchard, University of Oklahoma
Joseph Brewer, Haskell Indian Nations University
Brian Buma, University of Colorado
Gregory Cajete, University of New Mexico
Ed Galindo, University of Idaho
Christian Giardina, Institute of Pacific Islands Forestry, U.S. Forest Service
Zoltan Grossman, The Evergreen State College
Lene Kielsen Holm, Greenland Institute of Natural Resources
Richard Howitt, Macquarie University
Jay T. Johnson, University of Kansas
Kekuhi Kealiʻikanakaʻoleohaililani, Hawaiʻi Community College
Andrew D. Kliskey, University of Alaska Anchorage
Renee Pualani Louis, University of Kansas
Deb McGregor, University of Toronto
Debra McNutt, The Evergreen State College
Liz Medicine Crow, First Alaskans Institute
Mark Palmer, University of Missouri
Marcela Palomino-Schalscha, Victoria University of Wellington
Lin Pei-Shan, National Taiwan University
Karina Walters, University of Washington
Jon Waterhouse, Yukon River Inter-tribal Watershed Council
Kyle Wark, First Alaskans Institute
Daniel Wildcat, Haskell Indian Nations University
Laura Zanotti, Purdue University
John Ziker, Boise State University

Student Associates

Katrina McClure, University of Kansas
Joshua Meisel, University of Kansas
Victoria Walsey, University of Kansas

Appendix 2: Workshop Agenda

Weaving Indigenous and Sustainability Sciences: Diversifying our Methods (WIS²DOM) Workshop

Program Agenda

Day 1: Wednesday, February 13th – Travel Day and Welcome Dinner

Welcome to Squaxin Island tribal territory by Joe Seymour, meet in the hotel lobby at 4:30 pm. Welcoming Dinner at 5:30 pm in the Olympia Room, Phoenix Inn

Day 2: Thursday, February 14th – Nisqually Tour & Nisqually Casino

Nisqually Tribal Tour of the river and salmon restoration projects with tribal members and staff. Please be ready to depart from the Phoenix at 8:30 am. We will have catered box lunches and dinner at the Nisqually Casino at 6:00 pm.

Day 3: Friday, February 15th – The Evergreen State College Longhouse

Time	Sessions & Breaks	
9-10 am	**Sustainability Science Keynote**	**Dr. Richard Howitt Macquarie University**
10-10:30 am	Break	Coffee, tea, fruit, and muffins
10:30-12:30 am	**Sustainability Science Discussion Session**	**Dr. Andrew Kliskey**
12:30-1:30 pm	Lunch	
1:30-2:30 pm	**Indigenous Science Keynote**	**Dr. Gregory Cajete University of New Mexico**
2:30-3:00 pm	Break	Coffee, tea, soda and assorted desserts
3:00-5:00 pm	**Indigenous Science Discussion Session**	**Dr. Renee Pualani Louis**
5:00 pm	Dinner on your own	

Day 4: Saturday, February 16th – The Evergreen State College Longhouse

Time	Sessions & Breaks	
9-10 am	**Bridging Sustainability Keynote**	**Dr. Fikret Berkes University of Manitoba**
10-10:30 am	Break	Coffee, tea, fruit, and muffins
10:30-12:30 am	**Bridging Sustainability Discussion Session**	**Dr. Jay T. Johnson**
12:30-1:30 pm	Lunch	
1:30-4:00 pm	**Sustaining Resilient Landscapes**	**Dr. Jay T. Johnson Dr. Renee Pualani Louis Dr. Andrew Kliskey**
2:30-3:00 pm	Break	Coffee, tea, soda and assorted desserts
4:00-5:00 pm	**Future Directions & Publication Discussion**	
5:00 pm	Dinner at the Longhouse	

Day 5: Sunday, February 17th – Travel Day

Appendix 3: Workshop Papers

Fikret Berkes, University of Manitoba
Brian Buma, University of Colorado
Gregory Cajete, University of New Mexico
Ed Galindo, University of Idaho
Christian Giardina, Institute of Pacific Islands Forestry, US Forest Service
Zoltan Grossman, The Evergreen State College
Lene Kielsen Holm, Greenland Institute of Natural Resources
Richard Howitt, Macquarie University
Kekuhi Kealiʻikanakaʻoleohaililani, Hawaiʻi Community College
Renee Pualani Louis, University of Kansas
Deb McGregor, University of Toronto
Debra McNutt, The Evergreen State College
Mark Palmer, University of Missouri
Marcela Palomino-Schalscha, Victoria University of Wellington
Lin Pei-Shan, National Taiwan University
Kyle Wark, First Alaskans Institute
Jon Waterhouse, Yukon River Inter-tribal Watershed Council
Laura Zanotti, Purdue University
John Ziker, Boise State University

Bridging Sustainability and Indigenous Science

Fikret Berkes, University of Manitoba

Introduction

To bridge sustainability science and Indigenous science, I explore the various ways in which Western science and traditional ecological knowledge can be brought together. Sustainability science is concerned with the complex dynamics and interactions between humans and the environment (Kates et al. 2001; Clark and Dickson 2003). As such, it is open to complexity-oriented approaches such as resilience (Chapin et al. 2009). Sustainability science has sought to extend the range of knowledge available for sustainability planning, and to develop cases with community-based approaches and Indigenous and traditional knowledge (e.g., Tyler et al. 2007).

"A cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 2012, p. 7) is the working definition of traditional ecological knowledge that my colleagues and I have been using. Indigenous knowledge is considered the broader category which includes areas other than ecology. There are many other definitions of Indigenous knowledge and native science (e.g., Cajete 2000; Nakashima et al. 2012). Indigenous science is a science in the sense that it is the result of the general intellectual process of creating order out of disorder. However, it differs from Western science (including sustainability science) in some important ways. In particular, systems of Indigenous knowledge include a spiritual or a belief dimension, and Western science (by definition) does not. Traditional knowledge systems are diverse, with different kinds of traditional ecological knowledge and Indigenous knowledge around the world. For example, Inuit knowledge differs from Maori knowledge, but interestingly they have a great deal in common as well (Berkes 2012).

Rather than trying to respond to all of the WIS²DOM questions (the strengths and limitations of the two paradigms), I will focus on how these two kinds of knowledge (Indigenous science and Western science) can collaborate toward sustaining resilient landscapes, and what methods or models can be used to aid in this collaboration.

How the Two Paradigms can be Considered Together

In my experience, the two paradigms can best be considered together by combining knowledge in a collaborative way around a particular topic. For example, ethnobiology is a field that has developed specifically to use the two kinds of knowledge together. Ethnobotanists have developed methodologies to combine botany with Indigenous knowledge related to species identifications and classification (Hunn and Selam 1990; Nazarea 1999). Many of the attempts to combine the two kinds of science occur around species biology and ecology (e.g., Goldman 2007; Gagnon and Bertaux 2009), or around ecosystems such as forest ecosystems (Posey 1985; Parrotta and Trosper 2012). More to the point of the resilient landscape emphasis of this workshop, it can also occur around biocultural landscapes (Kimmerer and Lake 2001; Miller and Davidson-Hunt 2010; Davidson-Hunt and Berkes 2010; Johnson and Hunn 2010), biocultural landscape change (Robson and Berkes 2011); and landscape biodiversity conservation (Bhagwat et al. 2005; Verschuuren et al. 2010).

Combining the two kinds of knowledge is especially important in situations of insufficient information. Using the two paradigms together can improve problem solving. Such co-production of knowledge has been defined by Armitage *et al.* (2011: 996) as "the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and build an integrated or systemsoriented understanding of that problem." Knowledge co-production has been used productively in relation to questions about which neither

knowledge system by itself has sufficient information to deal with the issue. Climate change is one such problem, and the complementarity of Indigenous knowledge and Western science produces a better understanding of the issue than either would alone (Riedlinger and Berkes 2001; Tyler et al. 2007; Salick and Ross 2009; Peloquin and Berkes 2009; Nakashima et al. 2012).

These examples together indicate that respecting the integrity of each knowledge system produces healthy results. The operative word, therefore, should be "bridging" knowledge systems (Reid et al. 2006). Such an approach is preferable to "synthesizing" or "combining" or "integrating" knowledge systems. If and when integration occurs, such integration often works to the disadvantage of Indigenous people and Indigenous knowledge systems due to differences in power. As many examples show, power imbalances make local and Indigenous communities and their knowledge vulnerable to outside influences (Berkes 2012). Hence, bridging knowledge systems is preferable to integrating them. It certainly is preferable to "mining" Indigenous knowledge and using it, often out of context, as "data" for Western science!

How do we respect the integrity of each knowledge system, and consider the two on equal footing? An appropriate analogy for bridging is "the Two-Row Wampum which is a beaded belt describing a friendship treaty between the Dutch and the Iroquois. The rows of beads on the belt represent Dutch vessels and Iroquois canoes, traveling side by side down 'the river of life'. The paths of the two kinds of vessels remain separate, but the people on the two kinds of boats are meant to interact and to assist one another as need be. Such a relationship comes closest to respecting the integrity of both ways of knowing while maintaining the opportunities for the two kinds of knowledge to enrich one another" (as summarized in Berkes 2012, p. 263).

Methods of Collaboration to Bridge the Two Paradigms

A number of methods exist to bring together the two kinds of knowledge in ways that is respectable and generally acceptable to knowledge holders. Some of these methods, such as participatory rural appraisal, have a relatively long history of use. Others, such as community-based monitoring, are still being developed. The following list is by no means comprehensive. New approaches are being developed all the time. As well, the various approaches in the list are not equally applicable in a given situation for combining Indigenous science with Western science.

Participatory rural appraisal, originally developed for agricultural applications, is a toolkit that has been in use for some decades (Chambers 1983). It has been adapted for using local and Indigenous knowledge along with agricultural and other kinds of Western science (Warren et al. 1995).

Participatory action research also has a relatively long history and is closely related to participatory rural appraisal (Chambers 1983). However, it is not a toolkit but an approach that emphasizes collective inquiry and social change (Fals-Borda 1987). It seeks to understand the world by trying to change it collaboratively and reflectively.

Participatory education (critical pedagogy) comes out of a tradition of empowering learners. Freire's (1970) *Pedagogy of the Oppressed* proposes a new relationship between teacher, student and society, in which the learner is treated as the co-creator of knowledge. Some of these ideas have been applied to Native American education by Indigenous scholars (Kimmerer 2002).

Similar to the communities of practice concept in education that emphasizes learning-as-participation, place-based **learning communities** refers to groups of people with a shared interest, learning through partnerships through regular interactions based in practice (Davidson-Hunt and O'Flaherty 2007).

A number of processes use techniques to elicit and understand local and Indigenous views and knowledge. **Participatory mapping** (Chapin and Threlkeld 2001) is probably the best known of these techniques. Film, video and other visual arts can also be used in a similar way.

Participatory workshops and modeling have been used successfully with both Indigenous and nonindigenous rural knowledge holders such as ranchers (Knapp et al. 2011). They include a suite of techniques that can be adapted to different kinds of knowledge and different cultural backgrounds. Some sustainability science work, for example with the Saami, has used participatory workshops (Tyler et al. 2007).

Participatory scenario planning is a part of the toolkit of participatory workshops and modeling approaches. Scenarios in this context are plausible and challenging sets of stories about how the future might unfold. The approach was developed and used widely by the Scenarios Working Group of the Millennium Ecosystem Assessment (Bennett and Zurek 2006).

Community-based monitoring involves reading signs and signals of environmental change based on the ways of knowing of a given group (as opposed to monitoring based strictly on Western science). In using the two kinds of knowledge, there often are complementarities of scale (Cash and Moser 2000). Applications include Arctic Borderlands Ecological Knowledge Co-op (Kofinas et al. 2002; Eamer 2006).

Participatory conservation planning aims for the use of complementary knowledge from Western science and local/Indigenous communities. As in the case of monitoring, participatory conservation planning makes use of scale complementarities between the two kinds of knowledge (Roth 2004).

In a similar vein, **participatory environmental restoration** uses both local/Indigenous knowledge and Western science. In some cases, local knowledge can provide essential information not otherwise available to science (Robertson and McGee 2003).

Bridging and boundary organizations are designed to bring together the two sides of a divide, such as science and policy, or Indigenous knowledge and Western science (Cash and Moser 2000). They provide a forum for the interaction of different kinds of knowledge and the coordination of tasks that enable cooperation between them (Folke et al. 2005).

Co-management refers to the sharing of power and responsibility between the government and local resource users (Berkes 2009). Many co-management bodies tasked with the joint management of environment and resources employ bridging organizations to assist in the use of local and Indigenous knowledge in decision making.

Knowledge co-production, defined earlier as a collaborative process of bringing together different sources of knowledge to address a problem (Armitage et al. 2011), is a kind of bridging for a creative synthesis. It can be facilitated through co-management and learning communities in general.

In addition to these means or methods of collaboration between the two kinds of knowledge, there are two fields of western science that can help make sense of Indigenous knowledge and value its importance and potential contributions to sustainability science: fuzzy logic and adaptive management. **Fuzzy logic** is a form of probabilistic logic that deals with complex systems with a reasoning that is approximate rather than exact. It is a good fit for local and Indigenous knowledge which often uses rules of thumb (Gadgil et al. 1993), and the qualitative assessment of a large number of variables, rather than the quantitative assessment of a small number of variables, as done in science (Berkes and Berkes 2009). **Adaptive management** is a structured, iterative process of decision making in the face of uncertainty, with an aim of improving management over time by feedback learning from the outcome of previous decisions (Holling 1978). Adaptive management and its

broader form, adaptive governance (Folke et al. 2005), are based on learning-by-doing, which is an excellent way to describe Indigenous knowledge as well (Berkes et al. 2000).

Both fuzzy logic and adaptive management, along with resilience science (Chapin et al. 2009) help deal with complexity. Thus, Indigenous knowledge is generally consistent with complexity principles which posit (a) reality as dynamic, self-organizing and emergent; (b) generalizations limited by time and context; and (c) values inherently implicated in the inquiry process (Kuhn 2007). Hence, Indigenous science shares certain characteristics with complexity science that sets it apart from positivism.

Conclusions

Some of these ways of bridging knowledge systems are based on research methods and processes (participatory rural appraisal; workshops, modeling and scenario planning), and/or approaches that consider local and Indigenous people as equal partners (participatory action research; participatory education). Some rely on cooperating around a particular task at which local and Indigenous communities have specific expertise: environmental monitoring; conservation planning; and environmental restoration. Yet others are based on new institutions and governance arrangements: bridging/boundary organizations and co-management. Many are interactive: co-management; learning communities; and knowledge co-production. Some of the ways of bridging take advantage of the similarities between Indigenous knowledge and some areas of Western science: fuzzy logic and adaptive management are among them.

In conclusion, the two paradigms of Indigenous science (Indigenous knowledge and traditional knowledge) and Western science can work together. I have identified a number ways by which the two paradigms can be bridged. This does not necessarily mean that there are well established, sure-fire ways to bring together the two paradigms respectfully. In some cases (e.g., spiritual practices) it may not be appropriate to attempt any bridging at all. In other cases (e.g., knowledge co-production for conservation), it may be appropriate to go beyond bridging to synthesize the two kinds of knowledge creatively. General protocols for bridging are difficult to formulate. Each bridging effort will be unique and will no doubt take much hard work from all the partners involved. The payoff, however, is substantial: finding a better, more reliable, more respectful and people-sensitive knowledge basis for sustainability science.

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Workshop Questions

Brian Buma, University of Colorado

1. **What are the strengths of these two paradigms of science (Indigenous and sustainability) in sustaining resilient landscapes?**

2. **What are the limitations of these two paradigms of science in successfully sustaining resilient landscapes?**

3. **How can these two paradigms collaborate in their efforts toward sustaining resilient landscapes?**

4. **What protocols (methods) will aid in the collaboration of these two paradigms toward sustaining resilient landscapes**

What are the strengths of these two paradigms of science (Indigenous and sustainability) in sustaining resilient landscapes?

Any approach to knowing the world, honestly applied, will have strengths. The virtues of "traditional" science, and sustainability oriented research, are well established and evidenced by the strong track record of the natural sciences in producing knowledge and effecting change. The reductionist approach is extremely mechanistic, and is an excellent means to determine cause and effect relationships. Repeatability, as the gold standard in traditional science, means results are (ideally) reproducible, and that usually means tight control over covariates and a loss of generalization outside of individual study areas (or those tightly controlled conditions). But if things are not reproducible, the ease at which incorrect hypotheses are rejected and new studies begun is a real virtue and a necessity for true progress in mechanistic knowledge (again, in the ideal case). Indigenous approaches to knowledge and research, as I understand them, are more holistic and synoptic, with a larger perspective on setting, the people in the setting, and the interconnected nature of both the natural world and our knowledge of that world. Place based research is extremely important, especially as problems become too complex or emergent phenomena begin to overwhelm our traditional scientific approaches. Indigenous approaches, being more place-based, are therefore more flexible in a larger sense, as multiple locations can try different approaches, change them, and adapt as knowledge and conditions warrant.

What are the limitations of these two paradigms of science in successfully sustaining resilient landscapes?

The limitations of traditional ways of knowing spring from its strengths. Reductionist approaches sometimes give a distorted view of reality, and are limited to the factors being considered at any one time. The tight construction of repeatable experiments and generalizable laws narrows the view to what one can conceive of at the time, and also makes extrapolation difficult, as reductionist methods are, by nature, interpolative. This means we are ill equipped, in many ways, to deal with no-analog situations such as climate change. There are simply no similar situations to study, and models are only a substitute (although they are all we have). The emphasis on control and repeatability mean an often unrealistic amount of simplification of systems, limiting their applicability to various places and real situations. Indigenous means of knowing (again, as I understand them) have difficulty in generalizing beyond specific locations, communities, and settings. Lessons learned in one community may not work in another community due to inherent differences in people, systems, and desires.

How can these two paradigms collaborate in their efforts toward sustaining resilient landscapes?

Sustaining resilient landscapes, to me, means a recognition of the inevitability of change and working towards facilitating adaptation to new conditions. The reality of climate change means sustainability, if defined as maintaining what we already have in a long-term fashion, is likely doomed. Although the timing is still debated, rising sea levels will cause innumerable problems. Increased fires in many parts of North America will cause drastic changes. Flooding events will likely become more common. Adapting and creating resilient, sustainable landscapes will require flexibility, creativity, and an intimate knowledge of community. Indigenous science can bring creativity and the intimate knowledge necessary to build those new communities in the no-analog climate. A holistic approach is exactly what is needed when attempting to design landscapes in these new realities. But traditional science is still needed, for several reasons. First, the science of climate change, and their projections and timelines, are needed to determine where and when action is needed, and where it will be needed in the future. It can also be used to set bounds for realistic expectations – for example, how fast various species can be expected to migrate, or statistical analysis of future fire probabilities. Second, monitoring of adaptation efforts is required – after all, these are new situations for everybody. Third, resilience is typically defined as the ability to be disturbed (in some sense) and recover – rather than actually disturbing every ecosystem, science can inform us via modeling exercises and experiments if things appear to be going as planned.

What protocols (methods) will aid in the collaboration of these two paradigms toward sustaining resilient landscapes?

The first step is a delineation of specific problems, future realities, and timelines. This would take the form of an initial determination of what is important to maintain despite a changing climate, what ecosystem services are to be retained, and what future conditions will be like. This is basically a priority setting stage. Communities will need to determine where to put those priorities and how to set those goals – I would imagine this being more at the community level rather than a scientific activity.

Overall, I think the two paradigms would be integrated in an iterative fashion for designing and sustaining resilient landscapes. To cast them in entirely separate roles is somewhat of a false dichotomy, of course, but the following potential methods do that for illustrative purposes anyway.

Indigenous approaches, with their more holistic perspectives, would probably be the ones to outline potential methodologies for the actual design and implementation of the sustainable landscapes. These responses need to be place-based, as the challenges posed by climate change are specific to a given locale. Reductionist science, with its emphasis on generality, is not as well equipped (in many ways) for this challenge. Flexibility and adaptive approaches which have multiple opportunities to reflect and change tactic should be emphasized, but overall a spirit of system design would reign. Traditional science could set the bounds via climate modeling, sea level change projections, species migration modeling, etc. This would set the outside limits of potential actions, while allowing for a more holistic and hopefully experimental (in the sense of risk taking) approach to designing resilient landscapes for future conditions. During the implementation phase, traditional scientific methods would be useful for monitoring various aspects of the adaptation plans. For example, resilience theory expects, in many cases, changes in variance and spatial heterogeneity when systems are getting close to tipping points and thresholds of dramatic change. This could be looked for in the new, hopefully-resilient systems as they are designed and implemented according to the indigenous planning.

Resilience theory also emphasizes non-optimization as a means to maintain resilience. This essentially means that highly optimized systems tend to be fairly inflexible and overly specialized, susceptible to changes in outside factors, and somewhat brittle. For example, if the singular goal is to maintain a specific ecosystem service, say timber production, the optimal solution at any given time is to plant the fastest growing tree with

suitable wood and harvest on a set interval which maximizes yield (that's an exaggerated example, but it gets the point). This is not the most resilient nor sustainable approach, however, because slight changes in growing conditions, a pest from outside, or other factor may have drastic effects on the entire system. To that end, the methodologies from the indigenous science approaches would hopefully be quite varied, with different locations trying different things, with a multitude of goals. While those goals would likely not be entirely realized (e.g. non-optimal timber production), the system would be more sustainable and resilient as a result. And it would certainly need to be placed based, not generalized (again capitalizing on local knowledge); the monitoring, assessment, and other technical things could be done via "traditional" science, however.

All in all, I'm looking forward to learning more about this integration and participating in this workshop. I'm sure good things will come from it.

Re-Building Sustainable Indigenous Communities: Applying Native Science

Gregory A. Cajete, Ph.D., Santa Clara Pueblo, New Mexico

Indigenous Peoples and Climate Change

Indigenous peoples are like the miner's canary. When their cultures and languages disappear it is a reflection of profound sickness in a physical ecology (Paul Havemann and Helen Whall). In North America, climate change has already drastically affected Indigenous Peoples' hunting and fishing, economic infrastructure, water and housing availability, forest and agriculture resources and even their health and well-being.

Meeting formally and informally for the past twenty years, Indigenous peoples have been discussing and documenting changes. Using their traditional ecological knowledge and experience, they have been describing the same drastic shifts scientists now recognize are occurring. The scale of change will present severe challenges to all tribal cultures, resources and well-being.

Climate change is happening now. The Far North is affected by melting sea ice, glacier and permafrost; increase in fires, insects, flooding and drought patterns. The Southwest is affected by increased drought and insect infestation, unpredictable seasons and the spread of diseases such as Hanta Virus. The Great Plains is seeing more extreme weather including flooding, blizzards, tornados, and drought. The East has seen ice storms, flooding, rapid ice flows.

The Stake for Indigenous People

Climate Change significantly affects the cultural ways of life and place based rights of Indigenous people. Species and treaty boundaries are directly affected because they are based on place. A loss of traditional knowledge occurs because of loss of key plants, animals, and context. Coastal tribes are impacted by sea rise.

Ensuring freshwater supplies, secure food supplies, mediating impact on key plant and animal species, requires our attention to practiced forms of community which requires our reforming of traditional eco-knowledge, and requires us to exercise our "deep" sovereignty. It requires that we plan locally, but advocate globally, cooperate with other tribes, educational organizations, NGO's, governmental agencies and even corporations.

We must re-create community in a serious way. This requires an education process, gathering and sharing of information and formal research. Treaties and agreements must be applied to protect key habitats. Renewable energy and food sources must be developed. Finally, we must engage youth and participate at a global level. In their book *Coming Home*, Cheryl Charles and Bob Samples state healthy communities are cultural and natural systems where life and learning are nourished by the actions of members which enable peaceful and sustainable futures. Individuals begin with one core community but become members of many other kinds of communities through our life time.

Foundations of Indigenous Knowledge

There are four foundations of Indigenous knowledge. The first is traditional knowledge which is handed down and based on stories and experiences of a people through time. The second is empirical knowledge that is gained through careful observation and practice over time. The third is revealed knowledge which is gained through vision, ritual and ceremony. The final is contemporary knowledge that is gained through experience and problem solving.

Metaphors for Life

Biological metaphors are alive
Mechanical metaphors are dead.
Metaphors influence how we think,
and the ways in which we affect others.

Compelling Need

People today are searching for meaning. We lack a sense of the communal good and often struggle since we do not recognize that we need communal virtue and ethical action. A healthy society can only come from healthy communities comprised of self-determining individuals acting and taking responsibility for their actions for all. "The essence of community, it very heart and soul, is the non-monetary exchange of value; things we do and share because we care for others, and for the good of the place…It arises from a deep, intuitive, often subconscious understanding that self-interest is inseparably connected with community interest" (Hock 2000).

A community requires a perception of belonging and supports a sense of identity, it places our identity in context, requires participation and commitment, requires the support of individuals and in turn supports individuals, synergy through which it attains coherence. Communities reflect a sense of purpose, agreement on core values, participation, communication, commitment, collaboration and trust, conscious choice, shared responsibility, acceptance, accountability, respect, reciprocity, ethical behavior, efficacy.

Re-Creating Indigenous Education

Indigenous education needs to be re-created. Teaching and learning which is transformative and anticipates change and innovation is needed. Indigenous education can integrate and apply principles of sustainability along with appropriate traditional environmental knowledge and forms a foundation for community renewal and revitalization.

As concerned people we have to take a long, hard and honest look at the current educational, economic, governmental and community development policies, planning and processes which many times make us complicit with the status quo. We must create curricula that are transformative, anticipate change and innovation that anticipates change. Indigenous Science Curricula can integrate principles of sustainability along with appropriate traditional environmental knowledge. Indigenous Science forms a foundation for community renewal and revitalization. The new curricular models should use metaphors or models that have meaning within Indigenous contexts, for example, the "medicine wheel" or "the corn stalk" or the "tree of life" are American Indigenous symbols which have deep metaphoric meaning that frame essential goals and visions.

Building Sustainable Native Nations

Building sustainable native nations requires renewing and revitalizing Indigenous Communities and economies which are sustainable in the "lived" reality of community. This will entail engaging the enterprise of education at every level around the project of sustaining Indigenous communities and cultures. The conceptual framework of "sustainable development" forms a hospitable context for the introduction of principles of "Indigenous Science" into planning, policy and development. Traditional Environmental Knowledge can provide the models and creative insights necessary to renew and revitalize Native communities and economies. As Native people we have to take a long, hard and honest look at the current economic and community development policy, planning and process which many times make us complicit with our own continued exploitation.

A New Generation of Native Studies

A new kind of Native Studies predicated on enhancing wellbeing and educating Native students toward a vision of healthy, renewed and revitalized, sustainable and economically viable Indigenous families and communities. Students have three resources. The first is ecological integrity in which students start from the premise that what you do has integrity and honors life giving relationships. The second is sustainable orientation in which students build in a process which sustains community, culture and place. Finally, vision and purpose students see what you do in the light of revitalization of community.

Spiritual Purpose

- Cultural Integration (Actions originate through spiritual agency that stems from connections to a cultural way of being).
- Respect for All (Actions stem from respect for and celebration of community).
- Engaging Participation of Community (The community is both the medium and the beneficiary of activities).

Relationship

- Building upon and extending relationships are an essential process of development.
- Restoring and extending the health of the community is a key goal.
- The initiative should generate dynamic and creative process.

Commitment

- Commitment to developing the necessary skills.
- Commitment to community renewal and re-vitalization.
- Commitment to mutual reciprocal action and transformative change.
- Commitment to promoting well-being.

Characteristics of Indigenous Sustainability Education

- Educate for the re-creation of cultural economies around an Indigenous paradigm.
- Begin by learning the history and principles of (your) Indigenous Way of Sustainability and explore ways to "translate" into the present.
- Research the practical ways to apply these Indigenous Principles/Knowledge Bases.

Basic Shared Indigenous Principles

- Community and Place Based Traditional Environmental Knowledge.
- Resourcefulness and Industriousness.
- Collaboration and Cooperation.
- Integrating difference in political organization.
- Alliances and Confederation Building.
- Traditional Trade and Exchange

Challenges to Indigenous Sustainability

- Establishing Political Self-determination.
- Decolonization, Relearning and Education.
- Economic Exploitation, Diverse/Competing Ideologies, Political Restructuring.
- Individual Diversity, Identity Redefinition, Creating Formal/Informal Institutions.
- Cultural, Social, Political and Spiritual Fragmentation.
- Creation of Formal and Informal Institutions which advance Indigenous Sustainability.
- Flowing with Heterogeneity, Complexity and Differentiation.
- Political Restructuring (when necessary).

Configurations for Sustainability

Sustainability can be configured in multiple contexts, including the extended family, clan and tribe, the community, place or region, political, social, professional or trade organizations and co-ops, federations and societies. Even a corporation can be sustainable, if founded on principles of communal sustainability, practiced ecological ethics and Indigenous wisdom.

A Celebration of Life!

Indigenous Food Traditions
Indigenous Family
Indigenous Community
Indigenous Relationship
Indigenous Health
Indigenous Education

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Indigenous Families Sustainability

Ed Galindo, University of Idaho

The story of sustainability of Mother Earth and all who live on the earth is as old as the Earth itself. The world that we two legged share with all the other life forms on the planet is indeed a great gift from the creator and it is an honor for us to live here.

Many Indigenous scholars have known for a long time that for our planet to "live" the planet must be in harmony or balance and for human to live with our planet, we must know when things are out of balance or out of harmony and then strive to make things back in balance and in harmony once again. One of the great teachers of the concept I am talking about is an Indigenous scholar that goes by the name of Hanee (Shoshone), Castor Canadensis (Latin) or the Beaver (common name).

There are many stories about the Hanee family that many tribes share. Generally, this special animal is considered one the major players that was asked by the creator long ago to help create the world as we humans know it. I will not go into the specific stories or details that some of the tribes have about this animal at this time, for now know that this is a "special teacher" that Indigenous and non- Indigenous scholar can still learn from.

Strengths of Two Paradigms of Science (Indigenous and Sustainability) in Sustaining Resilient Landscapes

Using the Hanee family as a learning tool the strength (and weakness) of the Indigenous and Western science paradigms is one of respect. Shawn Wilson (Opaskwayak Cree) talks about Indigenous respect and the relationship of the land (Research is Ceremony, 2008). Shawn refers to Indigenous people's relationship to the land and the spiritual connection that links many Indigenous people to the landscape. This is an important point when we talk about sustainability.

From the lens of Indigenous scholars, respect is much more than saying thank you to someone that says nice things about you. Respect comes from the heart, the soul, and knowing that all things are to be respected because all things are related. I mean all things, every rock, tree, grassy meadow or tall mountain, all is related and it takes respect and time to understand this idea in its entirety. This is a powerful idea in building and sustaining resilient landscapes.

Many Western scholars were educated with the idea that man is against nature and that nature must somehow "be controlled" for the good of mankind. Many Indigenous scholars are educated in the belief that relationship to the land and the deep understanding of what the land needs and does is what mankind should do. The land controls itself no matter what man thinks. A good example of this idea of education is the research work I am currently involved with the many Hanee families I see and learn from.

Hanee and their family members are Indigenous folks of Mother Earth. They do not speak English (they are round and brown like me!). They do not hold engineering degrees from an accredited university. They do not ask for special permits to build their homes. They do not claim to own that water, plants or land that they use. They do not put up fences to keep others out. When a beaver family moves into a stream and start to build their lodges, they build dams to protect their home and their family members. During this "dam" process, they transform the landscape not only for themselves, but for many others that share the landscape. The relationship to the land and resilient landscape is dependent on their families' survival.

Hanee teaches us that once their lodges and dams are built, the riparian zones start to grow more. The grass on the banks of a stream which now has more water will start to green up and provide more shade for the

stream thus cooling the water. Trees and shrubs start to grow more robustly and birds can now build nests for their families in the tress. Since the grass is rich and green deer and elk and their families come to eat and have a cool drink of water. The water families (all that live in the water) start to thrive in their new environment as well. For example, salmon and steelhead families start to have their young in the slow cool, clear, deep moving water and the ponds that are made by the beaver dams act as rearing beds for the salmon and steelhead. All benefit from the work of the beaver family with one exception…man.

My research has shown me that some people will call the state Fish and Game department to complain that the beaver's dams have flooded their road or the beavers are killing their favorite tree. They have called to have the beaver family killed. Other men take the beaver lives so they can sell their skin and some just want to kill the beaver because they do not think they belong on their land. Others say that the beavers spread disease and must be killed. This is an example of not sustaining a resilient landscape and man being out of balance with the land.

One paradigm (Indigenous and some non-Indigenous students of biology) explains that the beaver is good for Mother Earth and that many other families benefit from the work of the family of beavers. Another paradigm (Western) believes that the beaver family must be destroyed and death is the only answer. I have another idea of living in balance with Hanee that does not involve killing this family. This is what my research is about and this is another story.

Relationship and sustainability of the land must begin and end with respect. Respect for all things that inhabit our Mother Earth is a critical idea. The beaver family can teach (and still does) many lesson about sustainability and the keeping a mindful eye on water and the environment. The research I conduct with Hanee, my students, and landowners teaches me that death and destruction of Hanee and his family is not the only answer to solving a "problem."

Limitations of these to Paradigms of Science in Successfully Sustaining Resilient Landscapes

The limitations of these two paradigms are about two main ideas. 1) How people are educated about the environment, and 2) The spirituality of the people.

Gregory Cajete (Tewa) states in his book (A People's Ecology, 1999) that Indian people talk about a sense of place that included the "spiritual place of being and understanding."

Our Hanee family in this story has a sense of place. From my research observations, the beaver knows where they are, who they are, and they know what they are doing. Many Indigenous students (and non-Indigenous) I work with are not so sure of who they are and what they are really supposed to be doing. This is why we have teachers and NSF workshops on resilient landscapes (ha).

The Hanee family has a gift from the creator on what they need to do. Mankind also has a gift of what we need to do as a family. Understanding and acting on that specific gift takes courage, education and many times a very deep spiritual understanding of respect and prayer.

Many Indigenous scholars have been trained about prayer and the respect of the environment and how the two concepts work in tangent together. The limitation of many non-native scholars is that many have not been trained in seeing or asking for help from a power higher other than themselves or text books. The division of science and spirituality is very clear in the academic Western world.

Collaboration in Paradigms their Efforts toward Sustaining Resilient Landscapes

For true collaboration to take place their must be respect toward both paradigms (Indigenous and Western Science). Only when this is done can we begin to understand each other and seek the true road to live in harmony. We need all ideas or efforts to make a difference in sustainability landscapes on this planet. All is related.

Once respect is truly established then relationships can be established. Both Wilson and Cajete talk at length about this idea of relationship building and how important it is to Indigenous people and I believe humanity as a whole.

Relationships with people begin with understanding and listening to who they are and what they are about as people.

Relationship building is not only important with people, but with animals, plants and Mother Earth. Once again, a good example of this point is with one of my teachers, the Hanee families.

Hanee shows us that the relationship of water and the plants they need to eat and build their lodges with are very important. They become part of the resilient landscape. When the beavers have used most the plants they like for food or the environment has changed, it is time for them to leave and they do. When they leave their dams are not maintained and the ponds that the dams created slowly drain. Once most of the water is gone what is left is rich moist mud composed of good sediments. This is a perfect bed for grass and flower seeds to grow. After a few years, a beautiful meadow appears to form a new landscape. This is once again owed in a large part to the family of beavers that once lived in the area. In a few more years, many more trees and other plants start to grow which serves as food for another Hanee family. A family returns to make a dam and lodge and the great life circle begins again and thus a resilient landscape is maintained once again.

The question becomes this: Can humans learn and follow this example of collaboration of life that my teachers, the Hanee family and others have showed us? Perhaps so, but it begins with respect and prayer.

Protocols (Methods) that will Aid in the Collaboration of the Two Paradigms (Indigenous and Western Science) toward Sustaining Resilient Landscapes

Relationship and relationship building is an important method that will aid in the collaboration of both Indigenous and Western science methods. What does this mean?

To build a relationship with a person one needs to understand that person. To build a relationship with a planet with the idea of understanding sustaining resilient landscapes one needs to understand the planet and this again can only be done with respect.

Cajete talks about American Indians people and a "theology of place." What Greg is talking about is the Indigenous people's relationship and participation with the landscapes but not only with the land but how to live in harmony or balance with the land itself. Greg states that "through generations of living in America, Indian people have formed and been formed by the land and the land has become an extension of Indian thought and being."

Greg ends this thought with the statement that "the land and everything with the land becomes a sacred orientation and not only the physical part of the land, the "spiritual landscape" as well."

Wilson speaks about "relations with the cosmos." Shawn states that spirituality with Indigenous people is just as important as mental, emotional and physical health. Shawn goes on to state that "people in the dominant society, research and academia are devoid of this aspect of humanity."

Teaching the protocols of respect and spirituality to ANY scholar is a challenge for teachers.
However, this can be done with yet some other variables, and that is with patience and compassion.

One day, a respected Elder of the Tribe asked me a question; "Ed, of all the science and math you teach, of all the research you show our young people, of all the ideas you share and do, are you teaching compassion? At that time I had to sadly say I was not (but now I do!). This is why we ALL have and need teachers.

Our teachers on this planet, the water, the air, the rocks, the finned one's, the rooted one's, the winged and four legged one's, and the ones I have failed to mentioned can all teach us two legged lessons about life and about sustaining resilient landscapes. Some questions to ask are: Do we have the respect, patience and compassion to learn from our first teachers? Can we respect each other enough to help each other learn and then practice what we are taught? Can we share this knowledge with our young ones so they can continue the great circle of life with compassion, harmony, balance and beauty to help Mother Earth keep building a sustaining resilient landscape? We will see…all my relations.

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Integrating Indigenous and Sustainability Science

Christian Giardina, Institute of Pacific Islands Forestry, U.S. Forest Service

Overview

Human values influence how Western-based Sustainability science is expressed on landscapes by affecting which organisms, processes or outcomes are identified for study or prioritized for action. In the implementation of Sustainability science, human values also determine how actions are conceived, developed and implemented. And so Sustainability science is at its core sensitive to and dependent on human values, and it is in assigning human value to an organism, process or outcome that allows Sustainability science to develop, test, validate and apply approaches and metrics for achieving the sustainability of that organism, process or outcome. In this regard, and in contrast to other sciences that seek to understand and describe the natural world, Sustainability science has little meaning in the absence of humans. Central emphases of Sustainability science can be divided into at least two broad categories: (*i*) understanding and quantifying the impact of human actions on the environment; and (*ii*) returning systems to a low/no impact, natural condition. A key goal of the first category is maintaining 'quality of life' while reducing impacts – achieved by substituting high impact technologies for low impact technologies or by enhancing efficiencies. A key goal of the second category is to sustain ecosystem services while maintaining 'integrity' or 'natural condition' of ecological systems. The academic literature as well as popular press addressing Sustainability science includes journals such as *Energy, Food and Society* that deal with the concepts, tools and approaches needed for reducing the human foot print on commodities and resources (energy, water, agriculture, minerals), as well as journals such as *Sustainability science* that also deal with enhancing sustainability by returning disturbed systems to a 'more natural' condition. Other journals such as *Environment, Development and Sustainability* are full of examples, from policy to on-the-ground-management, of how individuals, communities, cities, regions, countries and even planet Earth are moving (or not moving) to a more sustainable condition.

My working knowledge of Indigenous Science is that it emphasizes place and relationship – as with Sustainability science, which focuses on our relationship with the environment. In contrast to Sustainability science, which places humans at the center of a web of ecosystem goods and services (humans as beneficiaries, with the goal of reducing our impact on that web), Indigenous Science appears to emphasize humans as components of a complex system that make up with other organisms an ecological web. Emphasis is not on adapting or enhancing the system to maintain quality of life, but rather adjusting quality of life to meet the needs of the system. Further, while Sustainability science seeks general knowledge applied across systems, aggregated upwards, and gained through broadly established methods and protocols that lead to the accumulation of data, Indigenous Science appears to seek local knowledge particularly relevant to a place, often scaled down and attained through long-term and local relationships that lead to the accumulation of observations and experience. And so while a Sustainability science study need not include people from the place being studied as experts (approaches are agnostic, so to speak), Indigenous Science cannot proceed without individuals who are from the location being studied because expertise/knowledge resides with local individuals.

Western Notions of Sustainability

The foundations for Western-based Sustainability science can be traced to Eratosthenes (c. 276 BC – c. 195 BC), who was born in what is present day Libya. Eratosthenes built his complex career in Alexandria, Egypt, during which he birthed the field of "geography", accurately estimated the size and shape of the Earth, devised the modern day system of latitude and longitude, and invented scientific chronology. With these advances, Western (at the time Greek) science was enabled to understand two fundamental attributes of sustainability: the Earth as a precisely defined place with respect to shape and dimensions; and the Earth as a place that undergoes change that can be observed and documented. It is critical to understand that without

these early advances in our understanding of space and time at scales relevant to humans, and subsequent modern elaborations on this understanding, sustainability would have no meaning. This can be viewed as the first fundamental contribution of Western science to the sustainability discussion. Here is a short summary of the most widely cited or regarded efforts.

From Merriam Webster:

Sustainability: of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.

From Wikipedia:

The word sustainability is derived from the Latin sustinere (tenere, to hold; sus, up). More broadly ***sustainability*** *is the capacity to endure. In ecology the word describes how biological systems remain diverse and productive over time. Long-lived and healthy wetlands and forests are examples of sustainable biological systems. For humans, sustainability is the potential for long-term maintenance of well-being, which has environmental, economic, and social dimensions. Healthy ecosystems and environments provide vital goods and services to humans and other organisms. There are two major ways of reducing negative human impact and enhancing ecosystem services and the first of these is environmental management. This approach is based largely on information gained from earth science, environmental science and conservation biology. The second approach is management of human consumption of resources, which is based largely on information gained from economics. Since the 1980s sustainability has been used more in the sense of human sustainability on planet Earth and this has resulted in the most widely quoted definition of sustainability as a part of the concept sustainable development, that of the Brundtland Commission of the United Nations on March 20, 1987: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

From the Millennium Ecosystem Assessment:

The assessment focuses on the linkages between ecosystems and human well-being and, in particular, on "ecosystem services." An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit. The MA deals with the full range of ecosystems—from those relatively undisturbed, such as natural forests, to landscapes with mixed patterns of human use, to ecosystems intensively managed and modified by humans, such as agricultural land and urban areas. Ecosystem services are the benefits people obtain from ecosystems. These include ***provisioning services*** *such as food, water, timber, and fiber;* ***regulating services*** *that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and* ***supporting services*** *such as soil formation, photosynthesis, and nutrient cycling. (See Figure A.) The human species, while buffered against environmental changes by culture and technology, is fundamentally dependent on the flow of ecosystem services.*

The conceptual framework for the MA posits that people are integral parts of ecosystems and that a dynamic interaction exists between them and other parts of ecosystems, with the changing human condition driving, both directly and indirectly, changes in ecosystems and thereby causing changes in human well-being. (See Figure B.) At the same time, social, economic, and cultural factors unrelated to ecosystems alter the human condition, and many natural forces influence ecosystems. Although the MA emphasizes the linkages between ecosystems and human well-being, it recognizes that the actions people take that influence ecosystems result not just from concern about human well-being but also from considerations of the intrinsic value of species and ecosystems. Intrinsic value is the value of something in and for itself, irrespective of its utility for someone else.

Four Main Findings of the Millennium Ecosystem Assessment:

- *Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely* ***irreversible loss*** *in the diversity of life on Earth.*

- *The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the* ***degradation of many ecosystem services****, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people. These problems, unless addressed, will substantially diminish* ***the benefits that future generations obtain from ecosystems****.*
- ***The degradation of ecosystem services*** *could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals.*
- *The challenge of reversing the degradation of ecosystems* ***while meeting increasing demands for their services*** *can be partially met under some scenarios that the MA has considered, but these involve significant changes in policies, institutions, and practices that are not currently under way. Many options exist* ***to conserve or enhance specific ecosystem services*** *in ways that reduce negative trade-offs or that* ***provide positive synergies with other ecosystem services****.*

In response to meeting the sustainability crisis, there has been an explosion of Sustainability science literature (popular and academic), outreach materials, academic teaching and research positions, plans, visions and commercial statements (Komiyama and Takeuchi 2006). These are providing detailed insights via case studies and broader analyses into the meaning and mechanics of sustainability, from individual to planet (see Figure 1).

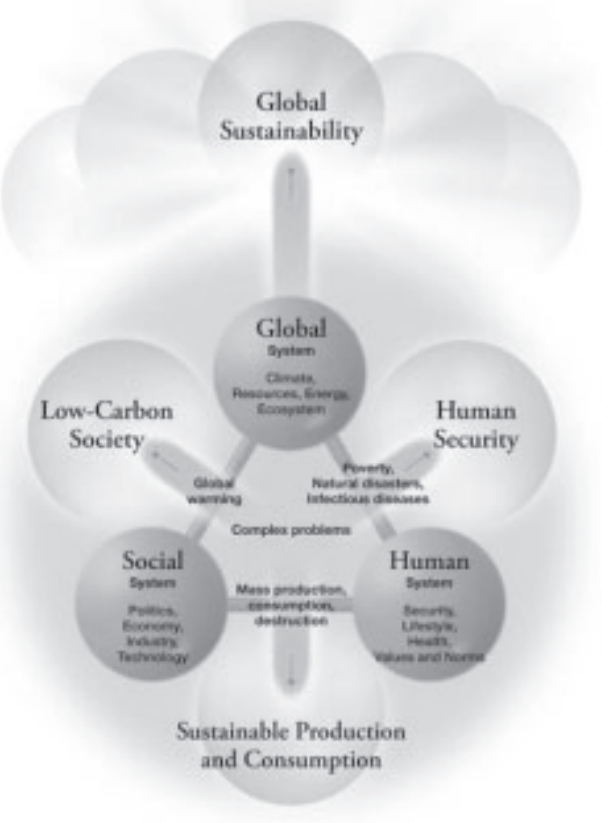
The Spatial and Temporal Scales Relevant to Sustainability science

There are several important attributes of this new field that should be recognized given the above concepts of sustainability. Ecological systems are not static – that is in the absence of humans they are not "sustained" over time. To assign a system the sustained label requires that an expiration date be placed on one's expectations. In general, understanding scale is important to Sustainability science because it begins the process of identifying the scale at which sustainability actually becomes relevant to humans and the spatial or temporal framework in which sustainability can be achieved. In the broader quest to understand our place in space and time, Western science has bounded the relevance of Sustainability science to a very small slice of the temporal and spatial continuum. The sum total of human history amounts to a tiny, tiny fraction of Earth's history, and Western scientists would assert that human actions exert very little influence on the Earth at larger spatial and longer temporal scales – for example those at which cosmic, geological, or even biogeochemical processes operate. At the upper bounds of space and time, the size of the observable Universe is estimated to be 93 billion light years. By comparison, light travels 10 trillion km in one year, 26 billion km in one day, while the Earth's diameter is approximately 13,000 km. Similarly impressive, the Universe formed some 13 billion years ago. By comparison, our Solar System and the Earth came into being 4.5 billion years ago, the first life on Earth formed at 3.5 billion years, and the human genus (Homo) evolved just a few million years ago. In the cycle of stellar birth, maturity and death, planetary systems that can support life are wed to the fate of the hosting star and so on large spatial and long temporal scales life is subject to periodic planetary-scale extinctions (see Figure 2).

At shorter geological time steps, on the order of thousands to millions of years, glacial, volcanic and meteor driven processes destroy components of the Earth's biosphere, with remaining components left to become the new plant and animal communities that shape ecosystems and associated processes. At this scale, the meaning of sustainability is unclear. While climate is dynamic and strongly influences the biosphere at the scale of hundreds to thousands of years (Figure 3), sustainability begins to have meaning at this shorter ecological time step. In the past century, but extending back several millennia, humans simultaneously begin to exert global-scale influence on the environment, as well as to gain awareness of change as captured in myths, chants, and language and via Western science methods of dendrochronology, palynology and stable isotope chemistry. Spatially, sustainability concepts now have relevance at global scales, but this is a very recent phenomena. Sustainability science literature and resulting understanding appear to focus on landscape scales (<1,000,000 ha), though modeling expands this range.

Within the Sustainability science framework, a major challenge under Category 1 goals is whether the impact of local sustainability efforts can scale to a positive impact at the planetary scale – critical as the nature of commerce and ecological degradation are global in nature. A major challenge under Category 2 relates to understanding the target baseline for sustainable management, which in many cases involves restoration. Based on the facts that natural forces of change have always and will continue to affect systems, often continuously, that human induced global change is accelerating (elevated CO2, nutrient deposition and O3 are now global issues), and that most if not all ecosystems have been subject to millennia of human activities, it may well be impossible to establish this target "natural" baseline. Hence, baselines tend to be arbitrary – a compromise function integrating societal pressures, ownership needs and scientific best guesses at for example what something might have looked like had Europeans not settled in an area and native cultures had continued managing land through the present as they had in the pre-European era, all the while keeping in mind that global change is altering the conditions that allow ecosystems to exist in one area but not another, etc., (see Figure 3).

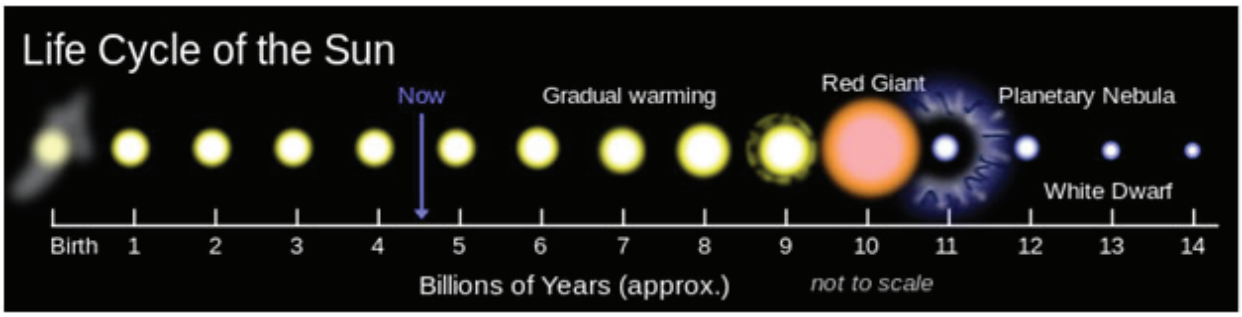
Figure 1. In this perspective of Sustainability science, global sustainability is a function of three systems operating at the individual, societal and global scales, as well as their linkages and sustainability solutions (Komiyama and Takeuchi 2006).



Strengths and Weaknesses of Sustainability science

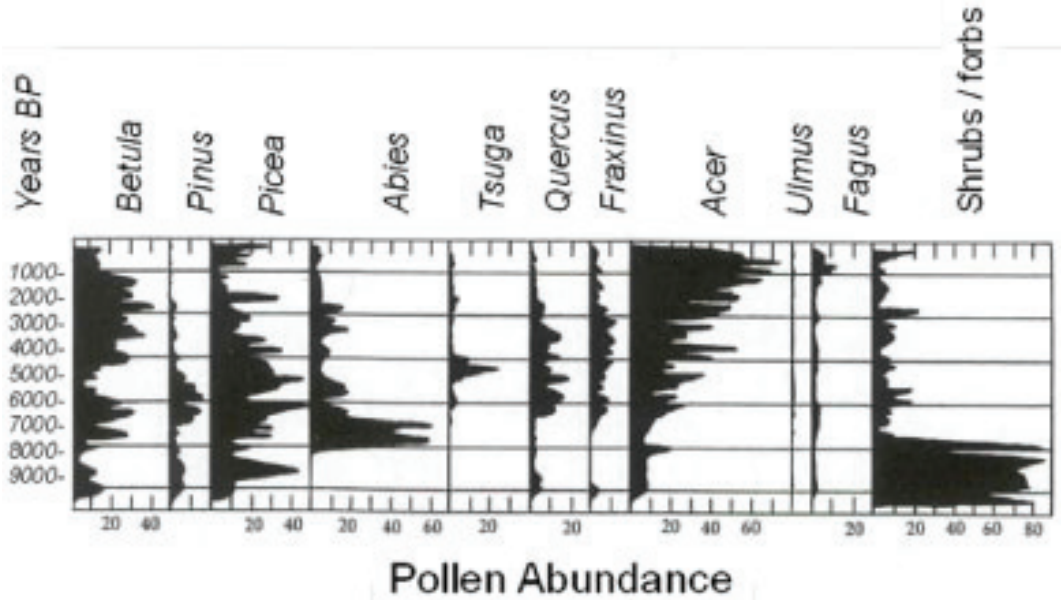
In the application of Sustainability science concepts to managing problems of the natural world at multiple scales, retrospective analyses reveal both strengths and weaknesses. Strengths include methodologies and associated metrics that allow the impact (negative and positive) of actions (or inaction) to be quantified and monitored over time. For example, if a community defines clean rivers as a sustainability value, Sustainability science can provide specific metrics for what constitutes clean water and the tools for quantifying and monitoring cleanliness of the water over time. More generally, the assigning of value to an organism, process or outcome allows Sustainability science to then develop, test, apply and validate metrics for the sustainability of that organism, process or outcome. An additional strength is the hypothesis driven framework in which Sustainability science operates so that managers can rely on robust results derived from complex analyses, often published in peer-reviewed publications (e.g., Hessburg et al. 2013). Given the reliance on strong metrics, managers know what component of an ecosystem is being examined and so to some extent what is being ignored. A final strength is the systems nature of the science. That is, Sustainability science has tools (hydrological and biogeochemical techniques, economic analyses, remote sensing, modeling, etc.) to examine the effects of change on an entire system – for example policy effects on fossil fuel consumption of an entire country, climate effects on water delivery from an entire mountain range, or management effects on global warming potential of an entire agricultural region.

Figure 2. Life cycle for a typical sun in the Universe (Wikipedia Commons).



Weaknesses include: a poorly defined framework for balancing actions that meet the needs of competing human values (Ostrom 2009); difficulty encountered by managers in achieving ecological sustainability when the context is dynamic and degraded (Chase 1986); and inability of consumers of sustainability knowledge to understand the limits of Sustainability science. There are some philosophical issues as well. Fundamentally, sustainability objectives can be at odds with observed rates of change that define most systems, rates that often are very dynamic even on short time scales (decades), while not addressing change that can occur on longer time scales (centuries). For example, managers today are now being charged with simultaneously sustaining high value organisms, processes and/or outcomes but also managing for global change (climate change, atmosphere change, invasive species, introduced pests and disease, etc.) while accounting for mis-management in the recent past, but "sustainable" traditional management in the distant past. Further, because applications of Sustainability science must provide simple metrics that can be easily and quickly adopted and used by managers who often seek cost-effective generalities across systems, the focus of these applications is most often on a small number of charismatic organisms, processes or outcomes that are of broad interest and perceived

Figure 3. Pollen abundance changes with time since before presence showing how dynamic plant communities are surrounding this Nova Scotia bog (Adapted from Livingston 1968).



value. Sustainability of an entire system, including all of its components, typically cannot be examined because resources, tools, and even understanding are lacking (Chase 1986). In the application of Sustainability science, other weaknesses have emerged. Because of various pressures on management to succeed, managing for sustainability has at times drifted to "command and control" solutions to sustainability problems (Chase 1986; Holling and Meffe 1996). Complicating what already are often intractable ecological problems, applications of Sustainability science can encounter conflicting public sentiments about management, distrust of agency leadership especially when controversial management decisions seek to be implemented, and short-sighted political pressures to achieve outcomes that may not lead to real solutions (Chase 1986; Komiyama and Takeuchi 2006).

To close, while "natural" systems may be affected by global change, they typically persist even while certain organisms, processes and outcomes do not. Even at the fine scales we think sustainability operates on – biodiversity and ecosystem function for example – ecosystem processes often continue even while the components of the system have changed. The classic rivet hypothesis describing the effects of biodiversity loss on ecosystem function may not be an accurate description of how biodiversity loss actually impacts ecosystem processes or services (as evidenced in Hawaii). Even with major losses of 'Native' species, ecosystem processes continue, life continues, because the systems are buffered by the expansion of remaining species or increasingly through invasion by exotic replacements. It is a different assemblage of life, but life and its associated processes continue (Marris 2011).

Indigenous Science

If correctly interpreted that the starting point for indigenous science is embracing relationship to each other and to place – that is among humans and between human and non-human in a specific location, then the following passage would appear to capture elements of this science.

> *Ecologically considered, it is not primarily our verbal statements that are true or false, but rather the kind of relations that we sustain with the rest of nature. A human community that lives in a mutually beneficial relation with the surrounding earth is a community, we might say, that lives in truth. The ways of speaking common to that community – the claims and beliefs that enable such reciprocity to perpetuate itself – are, in this important sense, true. They are in accord with a right relation between these people and their world. Statements and beliefs, meanwhile, that foster violence towards the land, ways of speaking that enable the impairment or ruination of the surrounding field of beings, can be described as false ways of speaking – ways that encourage an unsustainable relations with the encompassing earth. A civilization that relentlessly destroys the living land it inhabits is not well acquainted with truth, regardless of how many supposed facts it has amassed regarding the calculable properties of its world* (Abram, 1996).

Beyond this brief quote, my knowledge is limited and I am here to learn. I am trying to bring home that Sustainability science really needs to be solidly placed in the human sphere, and human values need to be embraced in any discussion of sustainability – let alone any efforts to achieve it. We cannot continue to assume that our Sustainability science applications are somehow critical for the functioning of native systems. Rather, we need to be able to use the tools of Sustainability science to rebuild relationships among members of a community and their surrounding environment by addressing local ecological, social and spiritual needs.

Thoughts on a Way Forward

Many systems have been fundamentally altered by the extirpation, functional extinction or real extinction of countless species, by the effects of large scale fragmentation on communities and processes, by the conversion of natural ecosystems to commercial land-uses, by the loss of pollinators or even the collapse of pollination webs, by invasive species introductions that have reconfigured food webs and displaced and replaced native

species, and most recently by atmosphere and climate change. Simultaneously, Western culture has led to the weakening, in many cases severing, of intimate relationships among humans and between humans and the natural world. While many of us know and lament the changes that are happening, too many individuals will not miss or even notice them – and worse will not support their return. And so the task ahead of us seems to be how to identify the needs of our landscapes and ourselves, redefine what it means to be in sustainable relationship with each other and our landscapes, and embrace the humanness of sustainability objectives – all the while knowing that further extinctions are inevitable, further degradation of ecosystem services impossible at least in the short-term to avoid, and spiritual and social alienation increasingly the norm.

So I believe that useful outcomes of this workshop's integration and collaboration could include: 1) Sustainability science positions itself to embrace sustainability as something inseparable from human value systems– a balanced manifestation of a communities collective values; 2) integrated perspectives on sustainability lead to educated, inspired, and motivated individuals who cultivate more meaningful relationships; 3) societies are more intentional about how value systems are constructed, evaluated, maintained and modified; and 4) pilot sustainability efforts are established that lead to the development of processes, methods, curricula, and documented demonstrations for integrating multiple knowledge systems in the management of landscapes.

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Nature exchange on novel ecosystems – bring into the discussion. *Biophilia* and expanded discussion on relationsip. Competing values – developing a sustainability plan is about establishing an informal selection process to identify the value system that will define the sustainability process. Ecosystem services focused with humans as recipients; relationship model with humans as members of a relationship web.

Science does not equal observation and learning. Scientific methods cannot be applied to all knowledge situations—not the only way to know, or even the most important for the important things in life. For example, knowing your spouse, your children, your friends – in short your relatives (at what point does life stop being a relative? Relative and Relationship and Relate). This knowing happens through a very different process of establishing intimacy with an individual. In a similar way, there is intimacy with the environment – with individual species or a place.

Culture and Science of Sustainability – unhitching the tools from the western culture wagon.

The Barcelona Declaration – the foundation for an Olympia Declaration?

Today's engineers must be able to:

- *Understand how their work interacts with society and the environment, locally and globally, in order to identify potential challenges, risks and impacts.*

- *Understand the contribution of their work in different cultural, social and political contexts and take those differences into account.*
- *Work in multidisciplinary teams, in order to adapt current technology to the demands imposed by sustainable lifestyles, resource efficiency, pollution prevention and waste management.*
- *Apply a holistic and systemic approach to solving problems and the ability to move beyond the tradition of breaking reality down into disconnected parts.*
- *Participate actively in the discussion and definition of economic, social and technological policies, to help redirect society towards more sustainable development.*
- *Apply professional knowledge according to deontological principles and universal values and ethics.*
- *Listen closely to the demands of citizens and other stakeholders and let them have a say in the development of new technologies and infrastructures.*

Engineering education, with the support of the university community as well as the wider engineering and science community, must:

- *Have an integrated approach to knowledge, attitudes, skills and values in teaching.*
- *Incorporate disciplines of the social sciences and humanities.*
- *Promote multidisciplinary teamwork.*
- *Stimulate creativity and critical thinking.*
- *Foster reflection and self-learning.*
- *Strengthen systemic thinking and a holistic approach.*
- *Train people who are motivated to participate and who are able to take responsible decisions.*
- *Raise awareness for the challenges posed by globalization.*

Decolonizing Landscapes: Unlikely Alliances Grow Resilience at the Grassroots

Zoltán Grossman, The Evergreen State College

Standing in the Nisqually River Delta on a misty February afternoon, one can observe a landscape that is healing. After decades of being diked to create pasture, tidal flows are again allowed to bring salt water and aquatic species into old restored channels. After decades of being grazed by cattle, riparian vegetation is being brought back to prevent erosion, and springs are protected. After decades of being straightened to drain the wetlands, upstream tributaries of the Nisqually River are being remeandered, and log jams are being installed to create pools for salmon to rest on their long journey back home from the ocean. After decades of declining runs, the salmon are returning to the Nisqually watershed, because their habitat is finally being restored, and a hatchery is restocking the river. The landscape is slowly being healed, and made more resilient.

At first glance, the restoration of the Nisqually Delta landscape can be attributed to enlightened Western scientific practices based on sustainability principles. Yet it is the role of the Nisqually Tribe, using a creative mixture of Indigenous and Western knowledge systems that has led this process of salmon habitat restoration. When the federal courts recognized Washington tribes' treaty rights in the 1974 Boldt Decision, the tribes acquired an important legal tool to protect and restore fish habitat. The result was state-tribal co-management, giving the tribes a seat at the table on natural resource questions outside the reservations. Washington state organized Water Resource Inventory Areas based on natural watersheds rather than jurisdictional boundaries. In its watershed, the Nisqually Tribe is recognized as the lead entity in creating watershed management plans for private farmland owners, state and federal agencies, together placing three-quarters of the Nisqually River mainstem in protected ownership (Nisqually River Council 2009).

The Nisqually watershed is being slowly decolonized at the same time as it is being slowly healed. In fact, the watershed is healing because the Tribe is beginning to decolonize its territory. Only because the Indigenous people of the watershed are asserting their self-determination, and strengthening the value of their lifeways rooted in this place, are they able to decolonize the landscape.

Colonizing the Landscape

To witness the decolonization of the Nisqually landscape is to witness a small reversal in the process of European colonization that began centuries ago, not in North America, but within Europe itself. In her classic study *The Death of Nature: Women, Ecology, and the Scientific Revolution*, Carolyn Merchant documents how Western European elites imposed a mechanistic worldview—that studies and manages the natural world by fragmenting it into small pieces—to replace an organic worldview that studies and manages holistic interrelationships within the natural world. The suppression of European "Indigenous" knowledge was an important element of colonizing European landscapes.

Although the process began centuries before, Merchant focused on its intensification in the 17th-century Scientific Revolution, examining the connections between the mass execution of women healers (who used pre-Christian local herbal knowledge), the draining of fens (wetlands), the restriction of villagers' hunting, fishing, and gathering rights in lands they had held in common, the allotment and fencing of the Commons into individual plots, and the exclusion of peasants from the estates of landed gentry—all resulting in widespread peasant rebellions.

E.P. Thompson documents how this "Enclosure of the Commons" stimulated Robin Hood-style rebel movements in British forestlands, and drove many peasants and artisans who lost their lands into urban areas (Thompson, 472-575). In the meantime, England extended its settler colonization from Wales and Scotland into Ireland, attacking clan-based kinship structures, collective land tenure, and local spiritual beliefs. If this

sounds like the colonization of North America, English leaders clearly saw Celtic lands as a testing ground for methods of control later used on Native American peoples.

In his book *Changes in the Land: Indians, Colonists, and the Ecology of New England*, William Cronon docments the importation of mechanistic landscape management as a central aspect of English colonization. He observed that shift from Indian to European dominance in involved "fundamental reorganizations" in the region's plant and animal communities, including grazing by cattle, sheep and hogs, and the massive felling of timber for wood and charcoal, all serving to increase erosion (Cronon, 147). The history becomes all too familiar to Native peoples across North America, who were subjected to land theft, the enclosure and privatization of their Commons, engineering of the landscape for settler/corporate profit, and degrading of their knowledge systems.

The resilience of time-tested Indigenous knowledge systems in the 19th and 20th centuries, through military defeats, epidemics, allotment, boarding schools, industrialization, pollution, and urbanization, parallels the resilience of landscapes and species (such as salmon) after centuries of abuse. From the beginning, the relationship between Indigenous knowledges and Western science has not been a respectful dialogue between two different worldviews, but has been dominated by the unequal relationship between the colonized and the colonizer.

Scientists cannot simply take Western structures of knowledge, and "Add Indigenous and Stir," and expect a perfectly Native-flavored synthesis of the two ways of knowing. Any protocols on collaboration between holders of these bodies of knowledge must acknowledge the need to equalize relationships of power. The political power regained by the federal recognition of treaty rights—and (to a lesser extent) the economic power of casino gaming rights—enabled Nisqually to take the lead on salmon habitat restoration. Whether it uses Western or Indigenous science, the tribe is beginning to define "sustainability" on its own terms (Nisqually Watershed Podcasts 2009).

By decolonizing their landscapes, Indigenous nations are benefiting not only themselves, but local settler communities that themselves may hold local knowledge of the landscape, perhaps not as "time-tested" as ancient Indigenous knowledge, but nevertheless valued by rural non-Native residents. Local-scale relationships that respect and combine Indigenous Knowledge and Local Knowledge, can be embedded and expressed in social movements involving both Native and non-Native communities, expressed as grassroots "protocols from below." European Americans are more separated in time from their Indigenous origins, and so in effect need exposure to Native peoples to find a clear path to sustainability, and what it means to be a human being living on the Earth. As Red Cliff Ojibwe environmental leader Walt Bresette once said to a group of Wisconsin non-Natives fighting a proposed mine, "You can all love this land as much as we do."

Unlikely Alliances

I began my current path by working with Lakota and Ojibwe communities in the Upper Midwest, who joined with their rural white neighbors (farmers, ranchers, or fishers) to protect their common lands and waters from large mining corporations. In South Dakota in the late 1970s, Lakota communities and white ranchers were often at odds over water rights and the tribal claim to the sacred Black Hills. Yet despite the contentious Indian-white relations in the state, the two groups began to unite in opposition to coal and uranium mining, which both viewed as endangering the groundwater. The Lakotas and white ranchers formed the Black Hills Alliance to stop the mining plans, and later formed the (aptly named) Cowboy and Indian Alliance, which has since worked to protect the region from other environmental threats.

Another treaty confrontation erupted in northern Wisconsin in the late 1980s, when crowds of white sportsmen gathered to protest Ojibwe exercising their treaty rights to spear fish outside their reservations. Like before in Washington, Wisconsin Ojibwe lived in constant fear of anti-Indian harassment and violence. Even as the intense racial conflict over fishing rights raged, tribes presented their treaty rights as legal obstacles to

mining plans. Instead of continuing to argue over the fish, white fishermen began to cooperate with tribes to protect the fish, recognizing tribal sovereignty as in their own interests. In the areas where the fishing conflicts had been the most intense is where the later environmental alliances won victories against the world's largest mining companies. As Mole Lake Ojibwe elder Frances Van Zile said, "This is my home; when it's your home you try to take as good care of it as how can, including all the people in it."

In each of these "unlikely alliances," Native Americans and their rural white neighbors—archetypal enemies in historic land rights conflicts—found common cause to defend their mutual place, in areas of the country where no one would have predicted or even imagined them. Farmers, ranchers, commercial fishers or sport-fishers had been in intense conflicts with Native nations over the control of land and resources. Yet in an evolution that continues today, members of the communities unexpectedly came together to protect the environment from a perceived outside threat. The neighbors felt that if they continued to contest the place, to fight over resources such as fish or water, there may not be any left to fight over.

These alliances have confronted mines, dams, logging, power lines, nuclear waste, military projects, and other perceived environmental threats in states such as Washington, Oregon, Nevada, Montana, South Dakota, and Wisconsin. Natives and non-Natives in each area took different paths from conflict to cooperation, and experienced varied levels of success in improving relations between their communities. My 2002 University of Wisconsin Geography dissertation *Unlikely Alliances: Treaty Conflicts and Environmental Cooperation Between Rural Native and White Communities* studied these unique convergences (Grossman 2005).

In some instances, a significant number of rural whites came to see Native American sovereignty as a legal tool to protect their common space, and redefined their common community of interest as including the Native community. In other instances, Native and rural white residents identified a common enemy in a resource corporation or government agency, and made parallels between their experiences of resource dispossession. In a few instances, a "sense of place" based on protecting the common environment built bonds between the two contending communities, and these bonds served as a starting point for cooperation—even extending beyond the immediate environmental issue. In the words of one Wolf River sportfisher in Wisconsin, "The river has built a community."

It would make logical sense that the highest levels of cooperation would develop in the areas with the least prior conflict. Yet a recurring irony is that the highest levels of cooperation instead often developed in the areas that had experienced the most intense Native/non-Native conflict, where tribes had asserted their rights the strongest, and the ensuing white "backlash" had also been pronounced. The conflict had educated rural whites about tribal cultures and legal powers, and educated both Native and white neighbors about the importance of the resources.

The alliances redrew community boundaries to define neighboring "outsiders" as "insiders" who are dependent on common resources in a natural area. The alliances challenge the idea that "particularism" (such as Indigenous identity) is always in contradiction to "universalism" (such as environmental protection). The particularist assertion of Native identity and political strength had not been in contradiction to a universalist project to bring together Natives and non-Natives in defense of common ground. In fact, unity strategies based solely on universalist commonalties tended to fail without a concurrent process of equalization that respected particularist differences.

In the 2010s, new "unlikely alliances" are opposing fossil fuel projects such as oil pipelines and fracking, and are learning from earlier alliances. In Washington, tribes are taking the lead against plans for coal and oil export terminals, partly on the argument that burning fossil fuels threatens salmon. Local tribal/non-tribal cooperation to protect salmon habitat provides a template for collaboration to respond to climate change. The Tulalip Tribes, for example are cooperating with local dairy farmers to keep cattle waste out of the Snohomish River watershed by converting it into biogas energy, and are exploring plans to store glacial and snowpack

runoff to lessen spring floods and summer droughts that have been exacerbated by warming temperatures (Ghoghaie). In this way, again, local non-Indian communities benefit greatly from the sustainable practices of their tribal neighbors. The 2012 anthology we edited at The Evergreen State College, *Asserting Native Resilience: Pacific Rim Indigenous Nations Face the Climate Crisis,* carries many of these stories of local collaboration for lasting resilience (Grossman and Parker, 175-188).

The Idle No More movement in Canada in similarly connects First Nations sovereignty to the protection of the environment for all people—Native and non-Native alike. A central debate within the Idle No More movement asks to what extent is the movement an "Indian thing," and to what extent can it resonate with the larger public (Ross; Klein). While the "Occupy" movement questions the unequal distribution of wealth in Western society, Idle No More questions the very underpinning of the society—the control of land and resources that is the basis of that wealth. Both upsurges have common historical roots in the desire of peoples on different continents to control their own wealth and resources, draw from their own knowledge systems (be they Indigenous or Local), and not be controlled by elites who look down on them. Idle No More co-founder Sylvia McAdam states, "Indigenous sovereignty is all about protecting the land, the water, the animals, and all the environment we share."

A respectful relationship between Western and Indigenous Science will be grown only with protocols establishing equal relationships between Western societies and sovereign Native nations. Any other protocol will lock Native ways of knowing into a subordinate status, or extract Native knowledge to assimilate it within Western Science, and thereby rob Native and non-Native people alike of important tools that can protect landscapes and make them more resilient. The words of Nisqually treaty rights leader Billy Frank, Jr. echo in this context: "The natural resources we all depend upon must be protected for future generations…to bring us to a place where there is a quality of life, and where Indians and non-Indians are to understand one another and work together."

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Lene Kielsen Holm

Silap Pissusianik Ilisimatusarfik - Greenland Climate Research Centre

My name is Lene Kielsen Holm. I am a researcher in a new project under development called, "Inuit Pinngortitarlu"/People and the Environment", working together with Professor Mark Nuttall in the 'Climate and Society' programme at Silap Pissusianik Ilisimatusarfik/Greenland Climate Research Center and Ilisimatusarfik/University of Greenland, as well as member of the communications team for the new Arctic Science Partnership that Pinngortitaleriffik, through the Silap Pissusianik Ilisimatusarfik/Greenland Climate Research Centre, is involved in as a key partner.

I am honored to share my thoughts on what I consider to be some of the major consequences of environmental and/or social changes induced by climate shifts, whether directly or indirectly, for Greenlandic nature and society.

Greenland has always gone through climatic shifts and transitions. Our ancestors moved to and around our country in several different waves, largely according to how the climate was and how it allowed movement and migration. Our "non-ancestors", the Norse, stayed in Greenland for several centuries and took advantage of what the climate offered, but they were also deeply affected by climatic changes.

Today, (again) we are experiencing a shift that is already affecting the people of this country and one that will have far-reaching consequences in the not-too-distant future.

To my mind, the climatic shifts that we are experiencing today bring both new opportunities and challenges.

- New opportunities are apparent in the prospects of using "new" and non-renewable resources, that the rest of the world is casting its eyes upon; and
- climate shifts mean "new" opportunities of making use of renewable resources that we have, and that we want to share with the rest of the world; (as an example of this, Greenland has an abundance of fresh water, which is becoming scarce in many places and for many people in the rest of the world.)

These new opportunities are of a multiple kind and how they will affect society is multifaceted and complex. I do not think that we are able to provide simple answers to questions about the nature of these potential developments. Not enough research has been done and not enough information has been provided to foresee the effects of these kinds of developments.

Although I say that not enough research has been done, I am not quite right when it comes to our understanding of renewable- and living resources. On this, our knowledge is very rich. It is very rich when you speak of science, but perhaps even more when you speak of knowledge that has been handed down from generation to generation among people who live with and use these resources. We have to make use of such knowledge, both scientific and local, in the further use and development of living resources at a time of rapid climate change.

This brings me to question 1.

What are the strengths of these two paradigms of science (Indigenous and sustainability) in sustaining resilient landscapes?

For me Indigenous Knowledge and Sustainability Science are two sides of the same thing. While Indigenous Knowledge is more holistic in its nature, sustainability science is more focused on parts of the whole thing. For example, when studying the climate and weather, sustainability science would have to have measurements of, for instance, air temperatures, air humidity, winds etc. in time series, from the same sites/locations in order to

have a knowledge base, to show e.g. change, or status quo. For Indigenous Knowledge, these same things are not necessarily measured with instruments, but are understood through generations of people living in, and making their livelihoods in, these areas. Both paradigms are compatible to each other, and when used together they strengthen a shared knowledge base that occurs.

The environment that surrounds us is a complex of systems, which can be hard to understand. In my experience, by bringing different but complementary ways of knowing together, we can achieve a higher understanding of these complex systems, and strive for more sustainable resilient landscapes.

The other question which has been put forward is 2.

What are the limitations of these two paradigms of science in successfully sustaining resilient landscapes?

The changing of our surrounding environments, especially in the Arctic, is happening now, and is happening faster than in other places.

In my own experience, we can only foresee what is happening by working together. The science which needs measurements over a long period of time would not be sufficient by itself, just as Indigenous Knowledge would not be sufficient by itself. Rather, they are complimentary to each other, they strengthen each other, in the striving for sustaining resilient landscapes.

When not enough research has been done and when not enough information has been given it demands some effort to address this, and this brings me to question 3.

How can these two paradigms collaborate in their efforts toward sustaining resilient landscapes?

As an example of how to achieve some good responses to these clusters and complexes of problems, we at the Silap Pissusianik Ilisimatusarfik/Greenland Climate Research Center, together with the new programme on Climate and Society, are striving to get both input from wider society and to get research done on pressing issues that are of importance to, and further develop, society. It is part of our vision to involve members of society by inviting people with different interests to engage in dialogue with us, so that we can get guidance and input from various organizations, institutions, and individuals as to where the gaps and missing links are and to guide us as we develop our research themes.

My personal thought on this is that this is the best way of directing the development of society, according to its own means and understanding of new opportunities, that the environmental changes gives. This is also linked to the next question that we have been asked to comment on, which is 4.

What protocols (methods) will aid in the collaboration of these two paradigms toward sustaining resilient landscapes?

To that, I provide some examples of how I see some efforts that are needed, both from society and researchers. All parts of society, from children in kindergarten to the elders, should be involved in the widely discussed changes happening in Greenland and the rest of the Arctic. This can be done simply by:

- developing multidisciplinary ways of exchange
- developing ways of communicating scientific research findings to society
- developing ways for the elders and other knowledgeable individuals to share their knowledge and provide input to research projects already being done

With regards to developing multidisciplinary ways of exchange in climate research, the Silap Pissusianik Ilisimatusarfik/Greenland Climate Research Centre is already working steadily in that direction. In the spring of 2012, researchers from different fields and from multiple research institutions carried out fieldwork in East Greenland, and as far as we have heard those involved are very positive about this approach.

I myself have been heavily involved in several multidisciplinary ways of exchange, for example a project called Siku-Inuit-Hila, where we have been bringing hunters from Alaska, Canada and Greenland together with researchers with multidisciplinary and multicultural backgrounds to work together, to better understand the changes happening in these areas. Another example is one in which we interviewed polar bear hunters in order to understand how the changes are affecting the hunt for these animals in the northwestern part of Greenland.

With regards to developing ways of communicating the findings of climate change researchers, I think that we have to make use of tools and technology such as radio and television to approach the non-researching part of society. Another way would be to do public presentations about the findings, which can be a good way of getting responses from the wider public to the research done, but also their thoughts on what still needs to be done.

Together with educators at all levels, we have to develop ways of communicating the research findings and the future scenarios that science suggests the world will look like. This would be achieved by training educators in climate change issues and research, and by cooperating with them (the educators) in the development of curricula for all different levels of education. In this it is important to involve elders and other knowledgeable individuals, since they have lifelong experience in the changing environment, and because they are knowledge holders that we can learn much from.

These are some of my ideas to the questions put forward to us and for what I think needs to be done to further climate research, and the responses to it from society.

Qujanaq!

The Challenges of Developing a Dialogue between Science and Indigenous Sciences

Richard Howitt, Department of Environment & Geography, Macquarie University

Introduction

In 1992 I began teaching an undergraduate resource management course that grappled with ideas of sustainability and the shared spaces of social and environmental justice in a program based in a science faculty (Howitt, 2000; Howitt, 2001a). In developing the course (published as Howitt, 2001b), I drew on a set of key texts, whose approaches resonate with the issues one confronts in considering the ways in which sustainability science might respond to Indigenous knowledges. Ekins (1992) provided a framework for conceptualising resource management as embedded in a global problematic. Leftwich (1983) acknowledged that politics and governance were fundamental to managing natural resources in human societies – and fundamental to the relationships between human societies and biophysical systems. And Knudtson and Suzuki (1992) advocated attention to elders from both Indigenous societies and the scientific community – many of whom they understood as advocating holistic, inclusive and sustainable approaches to the task of understanding humanity's place in complex, dynamic and shared environmental settings.

As both applied geographer and geographical educator, I have worked with scientists, engineers and others whose take on complexity and uncertainty struggles to encompass the dynamics of social, cultural and ontological difference that Knudtson and Suzuki framed in *Wisdom of the Elders*. The initial offering of the course involved coincided not only with the 1992 Rio Conference on Environment and Development (Roddick, 1997), but also the Australian High Court's historic Native title decision in the *Mabo* case in June 1992 (Stephenson and Ratnapala, 1993). It also came just a couple of years after the Oka Crisis in Montreal (York and Pindera, 1991). For me, this inescapably wove together the discourses of environmental science, sustainability and Indigenous rights. Demonstrating the value of this holistic and integrative discourse to my students, colleagues and wider audiences, however, has been neither inevitable nor easy. For sustainability science, however, there is broad agreement that holistic approaches to integrated (or at least coupled) natural and human systems are foundational to understanding and responding to the challenges of sustainability.

Ostrom (2007; see also Liu *et al.*, 2007) notes that in coupled human-natural systems there are no easy answers; no panaceas – and no simple way of representing, understanding or responding to the complexity within and between scales. The emergence of sustainability science at the turn of the 21st Century has offered an important way of approaching our understanding of coupled human-natural systems and landscapes that are simultaneously biophysical and cultural (Wilcock *et al.*, [accepted]). Sustainability science explores the wisdom that emerges from scholarly consideration of human-nature interaction. Yet human-nature interactions always entwine questions of social and environmental justice. Questions of human rights and Indigenous rights are inextricably bound to contemporary questions of justice and sustainability. Yet to date sustainability science has been largely disengaged from questions of Indigenous science, Indigenous knowledges and Indigenous rights. Social science has been central in developing sustainability science, but Indigenous science has been largely marginalised. The difficulty of developing a sustained and nurturing dialogue with Indigenous science is surprising and warrants serious reflection.

This paper explores grounds for such dialogue and invites wider engagement with the topic. It considers the possibility of such dialogue as simultaneously an invitation and a challenge; as simultaneously recognising commonality and difference; as simultaneously considering both tension and possible engagement. It also frames sustainability science's interaction with Indigenous experience in three ways, politically, epistemologically and methodologically. In doing so, the paper advocates framing and reframing as central to the task of developing a more humble, welcoming and receptive engagement between sustainability science

and Indigenous science in the future. As a colleague and I reflected when reviewing our teaching in resource management, it is:

> … *the act of reframing (and of reviewing any particular set of circumstances against multiple frames), rather than the application of a specific framework, that is the most important tool in building intercultural capacities in NRM systems* (Suchet-Pearson and Howitt, 2006: 118).

Adopting a position of "radical contextualism" as the basis for thinking about our particular place in the "awkward sticky messes that characterize the experiences and practices of coexistence – of being-together-in-place" (Howitt, 2011: 132) the paper considers the importance of context in dialogue between sustainability science and Indigenous science at the conclusion of the paper.

The Emergence and Limits of Sustainability Science

It is, of course, beyond the scope of this paper to provide a detailed reading of the development of sustainability science in the last 15 years (although for such readings see eg. Kates, 2012; Kates *et al.*, 2001; O'Riordan, 2004; Clark, 2007; Kajikawa, 2008; Komiyama and Takeuchi, 2006); or to encompass the diversity and complexity of Indigenous sciences as they are developed and practiced in multiple places. Rather, the discussion here explores foundations within sustainability science for developing dialogue with Indigenous science, and frames some important issues for further consideration and debate.

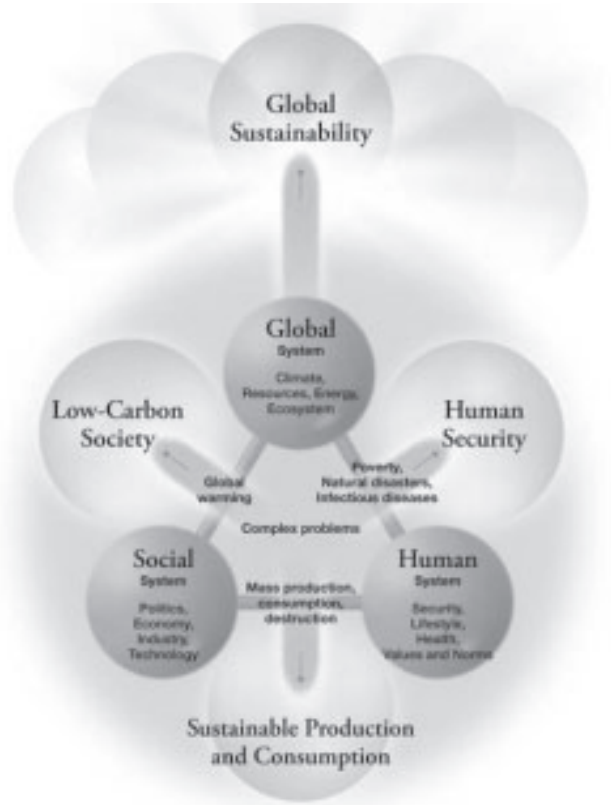
In its rapid emergence as a named field, sustainability science has been concerned to secure its place in the discourses of science – its place in academic discourse and its publication and institutional forms. There have been debates on whether it is best considered "applied science" (Kajikawa, 2008), "problem-driven" science (Perrings, 2007: 15179), a "new paradigm" (Martens, 2006), a "meta-discipline" (Mihelcic *et al.*, 2003),"an enterprise centered on … 'use-inspired basic research' "(Clark, 2007: 1737; Kates, 2012), or in some transition between multi-disciplinary, inter-disciplinary or trans-disciplinary (Kajikawa, 2008). Martens suggests it is too early to consider sustainability science as a discipline, but sees it as "a vital area in which science, practice, and visions of North and South meet one another" (2006: 38). The significant role of social science in developing an effective sustainability science is widely emphasized (Redclift, 2012), as is the nexus with policy (Wuelser *et al.*, 2012; O'Riordan, 2004), governance (Shiroyama *et al.*, 2012; Ostrom, 2007) and sustainable livelihoods (Adeel and Safriel, 2008). And it is widely acknowledged that integration of insights from multiple disciplines, across spatial and temporal scales and into arenas of practice, governance and behaviour are necessary alongside scientific research.

Introducing the first issue of *Sustainability Science* in 2006, Komeyama and Takeuchi (see Figure 1) suggested that sustainability science was

> *usually defined as a discipline that points the way toward a sustainable society. In addition to addressing such problems as that of inter-generational equity, as emphasized in the concept of sustainable development, we approach the problem of sustainability at three levels of "system"—global, social, and human— … All three systems are crucial to the coexistence of human beings and the environment, and it is our view that the current crisis of sustainability can be analyzed in terms of the breakdown of these systems and the linkages among them.*
>
> *The global system comprises the entire planetary base for human survival: the geosphere, atmosphere, hydrosphere, and biosphere. The earth sustains human life by providing us with natural resources, energy, and a supportive ecosystem. The global system is capable of great fluctuations in the earth's climate and crust—the subject of the earth sciences—that profoundly affect human activity and survival. Conversely, the rapid expansion of human activity has become a significant factor in fluctuations in the global system. Global warming and the destruction of the ozone layer are two salient examples of this human-induced change* (Komiyama and Takeuchi, 2006: 2).

Kajikawa (2008) recognises multi-, inter- and trans-disciplinary approaches (see Figure 2) in terms of its relationship with a range of scientific fields. Similarly, Komiyama and Takeuchi frame the focus of sustainability science on three interlocking systems (global, social and human) as the foundation for 'global sustainability' (Komiyama and Takeuchi, 2006). In both these figures, sustainability science is framed as central, with agency framed by its relationship with (and implied successful transformation of) the practice of science, and the operation of a range of systems. Such views of sustainability science present barriers to the sort of dialogue proposed for *Wis²dom*.

Figure 1. Sustainability science as as foundation for 'global sustainability' (from Komiyama and Takeuchi, 2006: 3).

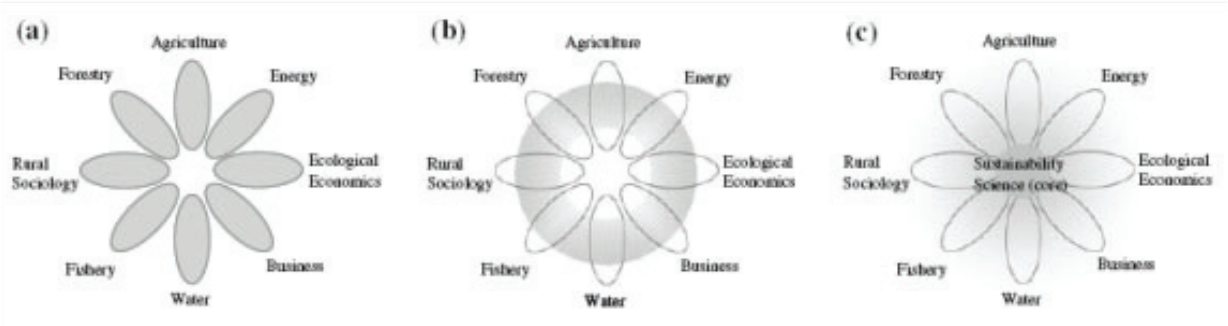


While contributors to sustainability science publications are drawn from across the globe and well-beyond the Anglo-American axis that dominates much science and social science discourse (Kates, 2011; Bettencourt and Kaur, 2011)[1], self-referential framing of sustainability science leaves little space for anything but science. For example, Snively and Corsiglia (2001: 6) see the traditional ecological knowledge of Indigenous peoples as "increasingly accessible through a burgeoning science-based TEK literature that documents numerous examples of time-proven, ecologically relevant, and cost effective indigenous science."

In contrast to its rhetorical openness to diversity, there is a risk that the self-consciously new paradigm of sustainability science is pressed by the political circumstances to reemphasises the importance of scientific practice in pursing questions of sustainability without problematising the history, methods and ethics of science. A sustainability science that proceeds without critiquing or contextualising the history of the practice of science risks reinventing the proselytising excitement of Enlightenment science and the technological revolutions of industrialisation and globalisation. Uncritical application of science's claim to a method that produces universal and objective knowledge (critiqued by, *inter alia*, Christie, 1990; Christie, 1992; Curtin, 1999: 10) risks sustainability science being framed as a discourse about science rather than as a discourse about sustainability. In the literature, there is much about the importance of science, but relatively little about the contexts in which it is practiced.

[1] Kates notes that "Sustainability science, as represented by the authors' addresses and institutions, is widely distributed and includes many authors beyond the normal concentration in such centers of traditional science as Japan, the United States, and Western Europe. These include almost all the emerging BRICS (Brazil, Russia, India, China, South Africa) economies but also such developing countries as Kenya and Nigeria. Home cities and institutions for papers also differ from traditional centers, with many originating in political centers (e.g., Beijing, Canberra, London, Tokyo, Washington) and in much more varied institutions, including corporate laboratories, government, and nongovernmental organizations, as well as universities large and small …. Sustainability science, as reflected in the disciplinary classification of the journals in which the papers were published, is also extraordinarily multidisciplinary, spanning the natural, social, and technological sciences, with a third of the papers appearing in social science journals, a quarter in biological journals, and a fifth in engineering journals" (2011: 19449).

Figure 2. Kajikawa's representation of multi-, inter- and trans-disciplinary approaches to sustainability science (from Kajikawa, 2008: 216).



There are, of course, dissident voices within the discourse of sustainability science. Allenby, for example, insists that existing ethical frameworks in science are necessarily inadequate because "the scale of sustainability science is not just that of the individual or of social levels of technology or ethics" (Allenby, 2006: 9). The challenge for sustainability, which he suggests is best characterised by the combination of complexity and multiculturalism,

> *requires the development of an ability to sympathetically perceive, and integrate, mutually exclusive but at least conditionally valid ontologies … It requires an ability to understand one's own belief structures as contingent and limited, and accept and respect other worldviews that may be not just different, but contrary, to one's own* (Allenby, 2006: 8).

Similarly, Curtin (1999) criticises the earlier efforts to develop a universal environmental ethics by Callicott (1990; 1979) for its treatment of Native American culture, experience and philosophy. For Callicott, Curtin argues, "Native American ethics comes 'ready-made' to serve [the needs] of Western philosophy" (1999: 110). This dissenting discourse seeks to circumscribe the powerful self-authorisation of science; to build a more humble and engaging ethical framework, rather than reinforce an insistent chorus of 'capital-S Science' as the only authoritative source of knowledge.

In contrast to a wider ethical debate about the social responsibility of science, and for all the soul-searching reflection in sustainability science, there are surprisingly few pointers to a mature and thoughtful engagement with Indigenous science in the sustainability science literature. Turner draws on powerful examples of Indigenous experience in his discussion, but quickly moves from such examples to "modern analogues" (Turner, 2012: 424). In doing so, like so many other well-intentioned commentators, he implies that Indigenous knowledges are somehow constructed in the human past, and are, at best, interesting analogues for the future. Such dismissal is hardly the foundation for constructive dialogue. In contrast, Rose, drawing on her long engagement with Indigenous people in the Victoria River District in north Australia (2004) suggests that fragmentation is a key characteristic of the ethical frameworks of colonisation, and that an inclusive ethics that encompasses both human and ecological rights – that engages ethically with both human and non-human domains – is demanded by the circumstances of the Anthropocene.

Similarly, Cornell *et al*. (in press) point to the importance of knowledge systems that engage with "a plurality of perspectives" (p1) in "bridging the knowledge/action gap [to transform] … the interfacing mechanisms between 'science' and 'policy' and indeed between 'science' and society as a whole" (p3), and the barriers created by science practice, which they see as:

> *still organized in what we characterize as a closed knowledge system: self-regulated; organized in disciplines; setting the research agenda autonomously; and substantially detached from society, politics and the media. Science in this mode has specific, restricted ways of engaging with societal demands for knowledge and in societal discourses, but generally on its own terms* (Cornell *et al*., in press: 7).

While they appeal for institutional transformation, Cornell *et al*. offer no opening to Indigenous science. In the same issue of the journal *Environmental Science and Policy*, O'Brien *et al*. make a tangential reference (in their Table 1) to "Knowledge that embraces indigenous perspectives and other sources of expertise and know-how" as one of the "types of knowledge considered necessary to address global challenges" (O'Brien *et al*., in press: 5), but do not expand on their discussion to engage with Indigenous science.

Huntington *et al*. point to a range of political and legal challenges faced in working with Indigenous knowledges, and conclude that the uncertainties generated by such complexity

> *may lead to reluctance on the part of some researchers to engage in studies of indigenous knowledge, but at present there are many good examples of collaborative projects that have benefited both the communities involved and those conducting the research (Huntington et al., 2005: 65).*

In particular, they point to the challenges of intellectual property rights, cultural and spiritual traditions governing knowledge, the significance of contextualised applications of knowledge and ethical issues as creating uncertainties for science-trained participants in dialogue with Indigenous knowledge-holders. Huntington *et al*. also point to the different scale frames used to evaluate scientific and Indigenous knowledges. On the one hand, scientific models of climate and environmental change

> *provide information on regional scales. Indigenous observations, by contrast, are more localized. A major challenge is to refine model outputs to finer scales, which requires the connection of large- and small-scale processes and information. A corresponding challenge is to combine indigenous observations from various areas to create a regional picture of environmental change. Using these different sources of information across different scales may help to identify the local components of regional processes as well as the regional processes that account for locally observed change* (Huntington et al., 2005: 72).

In terms of the dialogue proposed here, the lesson of the Arctic Climate Impact Assessment Scientific Report is salient. It points not only to the utility of Indigenous sciences for scientific discourses, but also the understanding that emerges from engagement with Indigenous sciences and the contexts in which Indigenous science is generated, applied and valued. While referring specific to climate change and adaptation, there is a wider lesson to be taken from the conclusion that:

> *The climate and environmental changes observed by arctic indigenous peoples produce impacts through their interactions with one another, and through the ways in which they play out in social, political, and cultural contexts. Indigenous perceptions of climate change do not arise in isolation, but are shaped by these contexts as well as the context of the overall climate change debate* (Huntington et al., 2005: 94-95).

There are also invitations to dialogue beyond the specific discourses of sustainability science that we should consider? Coinciding with the emergence of sustainability science at the turn of the 21st Century, there have been other calls for significant ethical reorientation of science (Rotblat, 1999; Ellis and Haff, 2009) and engagement with the ethical and political implications of the Anthropocene (Brauch *et al*., 2011; Crutzen, 2002; Steffen *et al*., 2011; Biermann *et al*., 2010). The 1999 *Budapest Declaration* of UNESCO's World Conference on Science (UNESCO, 1999) also emphasised the importance of science in society and insisted that circumstances at the turn of the century required development of a new ethical framework of science more generally. In a keynote speech at that conference, Nakoshima noted that Indigenous and other local knowledge systems:

> *have guided, and continue to guide, human societies around the globe in their innumerable interactions with the natural world … They represent the dynamic products of an extended history of fine-grained interplay between distinct cultures and specific local environments* (2000: 432).

Nakoshima continued:

> *[many] science-centred approaches pose other, more fundamental threats to indigenous knowledge. Indigenous systems possess a cultural logic of their own. When screened on the sole basis of value to science, knowledge judged useful is selected and the remains are discarded as 'superstition and belief'. Such a process dismembers, debases and destabilizes knowledge systems, jeopardizing their continued existence. By 'mining' these systems for short-term intellectual gain, we [scientists] undermine their very social and cultural foundations and menace the traditional societies that harbour them* (2000: 432).

In his summary of the relevant sessions at the World Science Conference, Nakoshima reported that the conference:

> *acknowledged that science and local knowledge remain on an equal footing when confronted with complex processes such as ecological systems and, in these domains, bridges should be built between the two. Despite these differing views on the status of traditional knowledge with respect to science, there was general agreement that traditional knowledge remains an invaluable resource for scientists and traditional societies, and that it deserves broader recognition and active protection* (2000: 443).

I was once impressed by a geomorphologist's epiphany on the implications of the context in which science is practiced. We were grappling with questions of river management, field access to research sites (requiring negotiations with and explanations to private landowners), the scales at which explanations might be generated, understood and implemented, and the challenges of rendering such scientific work accessible and meaningful to students, land managers, water users and scientific colleagues. We were discussing issues that colleagues who we geologists we having in accessing field sites on Aboriginal land were access required permits. Our mineral-focused colleagues saw no reasonable basis for the legal insistence that they had to have research permits to do their objective and universalist science. I'd had many similar discussions with corporate exploration geologists, field biologists and tourism operators – all of whom constituted their specific and vested interest as somehow universal, unproblematic and self-evidently justified as in a self-defined common (public) interest. My geomorphologist colleague was grappling with negotiating access to a privately owned stretch of river and the obvious need to respond to the questions, concerns and interests of the farmer-landowner who had his own questions about the particular reach of the river my colleague was seeking to access. The research program was modified to respond to the landowner's questions, the research process was tailored to the circumstances. "So what I can see", my colleague exclaimed, "is that we do our science differently in different circumstances!" Yes! Science itself is not objective, universal and unitary. It is contextual, circumstantial, responsive. That – not naive and exclusive proclamations of its universalism – is its strength.

Yet those of us working within the domains of science constantly face institutional circumstances in which this openness of science, which is another of its great strengths, is threatened by an insistent, self-centred and self-referential expertocracy that is censorious and powerful. Indeed, the expertocracy is often embedded within institutional structures that are endorsed and supported by states and corporations (military-industrial complexes, colonial systems, territorial-production complexes to use other terminologies) which threaten sustainability and Indigenous rights (*inter alia*) and are unequivocally part of the problem of the Anthropocene. As scientists, we have not succeeded in transformation of these institutions to secure ethical, sustainable and transformative practices in their everyday operations. It remains easier for a private mining company, bio prospecting company or tourism developer to walk into a university and secure research time, resources and expertise using its financial power than it is for representative community organisations, disadvantaged community groups, threatened populations or environmental defenders to secure standing to even ask for

research support. Science increasingly asks only those questions it is funded to pursue, yet it is so easily constructed as in practice value-free, objective and universal.

Simply accumulating documentation of knowledge (amassing data, recording findings, building libraries) is not a good surrogate for knowing. Building understanding as a basis for action – arguably the consensus goal of sustainability science – must be an educational endeavour. And as Freire (Freire, 1972a; Freire, 1972b; Freire, 1976) observed more than a generation ago, education is always a cultural *and* political practice. Understanding is never simply a process of accumulating facts (banking unproblematic knowledge into the interest-bearing bonds of blank slate individuals). Yet in the practice of science education we continue to find that universalist, objectivist, exclusive claims of the colonising expertocracy puts dialogue at risk. Content, not context, becomes the main driver of science education. Patronising experts tell 'others' what they need, what they must learn, what is valuable in what they already know, how to make what they know fit into to 'reality' in the form of markets, peer-reviewed research and development.

Where does this practice fit with ideas of co-production of knowledge? How does this practice sit with notions of transdisciplinary endeavour and the challenge of understanding changing circumstances posed as central to the work of sustainability science? The challenge of developing effective dialogue between sustainability science and Indigenous science is both great and urgent. For all the soul-searching reflection in sustainability science, there are few pointers to a mature and thoughtful engagement with Indigenous science, which is hardly the foundation for constructive dialogue.

The Persistence of Indigenous Science

Framing Indigenous knowledges (and peoples) as out of place and out of time (in so many senses!) is common amongst dominant (colonising) culture commentators. But in the case of sustainability science, it risks reducing Indigenous peoples as anachronistic sources of insights, information and knowledge that can be used by science to produce authoritative, authentic and useful universal knowledge in the present for the future. For example, Callicott's rejection of post-contact Native American thinking and experience (1990; see also Curtin, 1999) as irrelevant to the development of a contemporary environmental ethics is an extreme case, but consistent with much of the science-focused discourse of sustainability science. In the Australian setting, Turnbull reported that Indigenous collaborators in the late-1990s felt that "information [they] shared with non-Indigenous researchers is often still regarded as if the communities have no real moral or legal claims to dictate how it will be represented or used within the wider world." He adds tellingly that Wik Elder Gladys Tybingoompa felt that science collaborators she worked with treated her knowledge and understanding as:

> *'Uni tucker' – ie. raw information about natural phenomena that is free to be digested by western science with little or no consciousness of its being Indigenous intellectual property, and no guarantees that its owners will benefit from its use in the commercial development of processes and products* (Turnbull, 2000: 17).

Contrary to such utilitarian or instrumentalist valuing of Indigenous 'environmental knowledge', there is an increasing acknowledgement that locally-specific, contingent and conditional sciences, have persisted in many places. In changing circumstances, the use value of these sciences is often problematic. Confronted with changing environmental conditions, changing political, economic and social relationships, Indigenous science is not limited to 'traditional' knowledge.

Drawing on the work of Aboriginal philosopher Mary Graham (1999), Deborah Rose identifies two key precepts in the Indigenous science she has engaged with in Australia, which raise "profoundly unsettling questions about ourselves and nature" (2004: 187):

- *The Land is the Law.*
- *You are not alone in the world (Graham, 1999: 105).*

The first precept is based on a very inclusive concept of land. Within the word 'land' there is water, plants, animals, indeed the whole of what we generally call the natural world. Graham expands on this precept with this explanation:

> *The two most important kinds of relationships in life are, firstly, those between land and people and, secondly, those amongst people themselves, the second being contingent upon the first. The land, and how we treat it, is what determines our humanness. Because land is sacred and must be looked after, the relations between people and land becomes the template for society and social relations. All meaning comes from the land (Graham, 1999: 106).*

This precept offers huge challenges to all of the West's great thought systems: philosophy, religion, and science. But it also puts forward a very pragmatic challenge: to give the land priority in all our practice.

The second precept is given substance in Aboriginal worldview and practice through the fact that kinship includes the natural world, including land and water, plants and animals, and other phenomena, as I have discussed in other chapters. This precept is non-dualistic; as Mathews and others show, it challenges fundamental premises of modernity. Looked at from this perspective, modernity would claim that we are alone – as a species, and as individuals also (Mathews 1991). Graham counters modernity with this explanation:

> *Aboriginal people have a kinship system which extends into land . . . Every clan group has its own Dreaming or explanation of existence. We believe that a person finds their individuality within the group. To behave as if you are a discrete entity or a conscious isolate is to limit yourself to being an observer in an observed world* (Graham 1999: 106).

This approach which contextualises humans' place(s) in the cosmos through observation, connection, narrative and ethics is profoundly familiar to Indigenous philosophers in many societies. It is, I understand, a reasonable representation of a persistent core in what in the conversation we are hoping to enable in this National Science Foundation workshop. In opening this conversation, I will explore a number of key issues.

Indigenous and Sustainability Science: Challenge and Invitation to Respectful Dialogue

Political and institutional dimensions of invitation and challenge

Universities and academic disciplines of science and social science have unequivocally been part of the structure and infrastructure of European colonial power and its specific impacts on particular Indigenous peoples and their places and institutions. Entry of Indigenous voices into both the academy and political institutions has been – and typically remains – contingent and conditional. Compliance with scientific notions of rigour and method remain implicit requirements in most circumstances and Indigenous participants in debates are expected to respond on behalf of all Indigenous interests in ways that would never be asked of other scientists. Consistently framed in negative terms by the dominant colonising cultures, Indigenous cultures and the knowledges they produce have been seen and treated as out of place in academic discourses and institutions:

> *The emergence of the indigenous voice in academia in the last several decades has been recognized as a huge breakthrough for the right to speak for oneself and one's people. It is as fundamental as food and decent housing. It is a common acknowledgement that men and women do not live by bread alone; they live by the creative arts, by storytelling, and the intellect, all of which give vibrancy to culture and politics. Thus, the increasing presence of the native voice in the Americas provided much outstanding scholarship rising out of the analysis of oral histories and textual authority of native peoples. Suddenly, and to the surprise of those who scrutinized and supported new epistemologies in recent decades, adversarial scholarship seems now to be gaining in momentum. This adversarial scholarship, ever at the fringes of Native American studies, is able to place ignorance, stereotypes, reformist movement interests, the will to suppress, and, most significantly, conservative politics at the service of what may be called anti-intellectual debate. At the close of the century, the efforts that indigenous peoples have made to speak for themselves and their peoples, either through their own works or through the interpretative works of translators, are being subjected to abuse and scholarly/political attack that goes far beyond the normal critical analysis of academic work* (Cook-Lynn, 2000: 80).

In opening a dialogue between sustainability science and Indigenous science, then, it is necessary to recognise that power underpins the place of science in contemporary global society. Even as scientists decry the marginalisation of science in politicised decision systems, we need to insist that the marginalisation of Indigenous issues in institutional and disciplines needs to be addressed.

Framing epistemological differences

Perhaps the key challenge for sustainability science in the uncertain environmental and socio-political circumstances of intercultural and cross-scale governance and decision-making is to provide information to support and motivate appropriate behavioural changes and interventions; information that is fit for the purpose of improving outcomes across differences. But that begs the question of how judgement might be made about what is better. In shaping a dialogue with Indigenous science, one of the barriers to be faced is the explicit universalism of science and the need for not just locally or contextually tailored solutions to problems that are defined, investigated and solved by science, but also for work to build frameworks for understanding that are themselves pluralist, open and engaged across (linguistic, cultural, epistemological, spatial and temporal) difference.

If we treat the scientific endeavour as simply acquisitive and cumulative – as simply amassing facts and explanation, then the mad scramble to multiply publications, to amass research grants and the data they facilitate makes sense. If we recognise that the particular challenge of sustainability science is transformation, however, we are inevitably drawn into processes of education, politics, negotiation and practice. As many commentators note, this certainly makes the social domain (and therefore the social sciences) central to sustainability science. Yet it is insufficient to simply advocate inclusion of the social sciences as sufficient to secure the sorts of transformative outcomes that sustainability science discourses tell us we need. It is the social domain – indeed the environmental domain that encompasses coupled human-natural systems and itself constitutes the 'social' domain – that needs to be drawn into and catalyse transformation of sustainability science.

Nakata *et al*. (2012) discuss the challenges of shifting university students away from colonised thinking in a way that parallels the challenge of shifting scientists' thinking away from the colonising privileging of the dominance science as knowledge. Rushing towards a politically defined end-point such as "instating regenerated Indigenous 'ways' or 'traditions' as the counter-solution to overcoming colonial legacies" is pursued in many contexts too quickly. The rush for short-cuts to the imagined end-point – surely recognized as a dangerous tactic in a sustainability science that grapples with dynamic uncertainty in both earth and human systems – risks skipping "the more complex theoretical dilemmas students need to engage with to understand the conceptual limits of their own thinking" (Nakata *et al*., 2012: 121). In the context of our discussion, this is a timely warning. In engaging in this dialogue, scientists cannot skip to the end-point imaginary of a dialogue of equals. We have to learn to listen and to hear: remember Louis' provocative words—"Can you hear us now? … Have I got your attention yet? I hope so because it's really not my intention to preach about the ills and woes of Indigenous peoples in relation to research" (Louis, 2007: 130-131). We have to learn to see anew – to see our own privilege, our own context, our own deep colonizing. We have to learn to think anew – to think in ways that take seriously and actually respond to information, understanding and knowledges as if difference confronts us with the possibility of thinking differently. Benessia *et al*., for example, propose a:

> *new pragmatic defining space, articulated through a plurality of epistemologies, languages, styles of research, experiences, and actions, all coming from a global civil society and defining a variety of epistemic and normative stances and methods* (2012: 75).

They insist that there are "founding contradictory pillars of this dominant discourse about sustainability" (p75) (ie sustainability science), and that hybridizing multiple approaches to knowing offers a way out of the "contradictory, perverse and paradoxical framing" (p87) of sustainability science as a human-only (indeed science-only) endeavour. In its place, they propose exactly the sort of dialogue we are seeking in this workshop:

> *Novel pathways towards a fruitful hybridization between sustainability science and traditional knowledge and practice ... transcultural, hybridized, and "undisciplined" participatory research and action [in which, by] … coproducing knowledge and policies, public scientists and indigenous tribes are continuously remolding their identity, uncovering, recovering, and discussing all the ambiguities of their respective mythologies, populated with evidence based and other knowledge systems (Benessia et al., 2012: 87).*

Implications of Methodological issues

There is an important, extensive and extensive literature and emergent practice around questions of Indigenous methodologies that has implications for a dialogue between sustainability science and Indigenous science. Coincidentally, publication one of the key markers of this discourse, Linda Tuhiwa-Smith's *Decolonising Methodologies* (1999), coincided with the ferment of the late-1990s which spawned discussion sustainability science and the Anthropocene in the science literature. For the science community, which values methodologically sound research as the foundation for authoritative knowledge, Smith's opening statement heralds a huge challenge:

> *The word itself 'research' is probably one of the dirtiest words in the indigenous world's vocabulary. When mentioned in many indigenous contexts, it stirs up silence, it conjures up bad memories, it raises a smile that is knowing and distrustful* (Smith, 1999: 1)

More recently, Gaudry (2011) has advocated 'insurgent' approaches to research, arguing that traditional research methods often produce :

> *… an extractive process. In the contemporary academic environment, research and publishing expectations drive researchers to take deeply meaningful information, often from a marginal or "underresearched" community, and present it to a third party. This third party is usually a highly educated academic audience or government bureaucracy, both of whom have little staked on the preservation of the integrity of that extracted knowledge. Rarely are the people who participate in the research process as participants or "informants" considered to be the primary audience when it comes time to disseminate the research* (Gaudry, 2011: 113).

Gaudry's characterization of extraction research echoes precisely the approach of many scientists to Indigenous knowledge – where information is disarticulated from its historical, social and cultural context to become disembodied facts to be drawn into debates and understandings that are prioritised by science-based discourses.

Many Indigenous commentators challenge their science collaborators to shift focus; to reconsider how they construct and use knowledge. In my own discipline of geography, for example, Renee Louis challenges the traditional practice of science as the acquisition of knowledge by means of power:

> *We have been pathologised by Western research methods that have found us deficient either as genetically inferior or culturally deviant for generations ... We have been dismembered, objectified and problematised via Western scientific rationality and reason ... We have been politically, socially, and economically dominated by colonial forces and marginalized through armed struggle, biased legislation, and educational initiatives and policies that promote Western knowledge systems at the expense of our own ... We know better now …*
>
> *[if research does not benefit the community by extending the quality of life for those in the community, it should not be done* (Louis, 2007: 131)

While there may be a tendency to characterize differences between 'Western science' and Indigenous knowledge systems in terms of oversimplified binaries, there is increasing recognition in the Indigenous methodologies discourse of the strengths of participatory, narrative and ethical engagement with context as foundational to methodologies that are 'fit for purpose'. Absolon and Willett, for example, emphasise the importance of research as "solution focused":

> *Traditionally, research has been conducted to seek, counsel and consult; to learn about medicines, plants and animals; to scout and scan the land; to educate and pass on knowledge; and to inquire into cosmology. The seeking of*

> *knowledge is usually solution-focused and has an underlying purpose of survival* (Absolon and Willett, 2004: 7).

It is beyond the scope of this introductory discussion to explore the wider discourses of Indigenous research methodologies for knowing, understanding and acting, but in opening both an invitation and challenge to sustainability science, I see the importance of challenging the assumption that scientific method alone is able to produce authoritative knowledge and of pointing to innovative and thoughtful collaborations that problematise methodologies and the relationship between the producers, users and beneficiaries of knowledge in the overlapping contexts of local cultural survival and global ecological survival. Learning to listen to each other's methodological concerns and proposals with respect and openness to change is an important element of the process of dialogue between sustainability science and Indigenous science. For Indigenous participants, decolonisation of one's understanding of science, escaping the dominant privileging of science to allow valuing of local knowledge, weak theory and contextualised ethics often demands a transcendence of long histories of colonisation, colonial education and deep colonising patterns of thought (Tuck and Yang, 2012). For scientists, recognising that the social, political and historical context of scientific method hides the specificity (non-universalism) of scientific method and the knowledge it produces similarly demands decolonisation in a Freirean mode.

Reframing Sustainability Science

Benessia *et al*. point to a "fatal framing error" in sustainability science discourse:

> *Defining sustainability in terms of human progress and civilization employs the same assumptions and perceptions that caused the present social and ecological crisis. Our tools of Western civilization fail grotesquely because they do not match reality. The past half-millennium qualifies the West and its adherents for a unique place in human history as the engineer of the Sixth Great Extinction: an unprecedented sequence of genocides that have afflicted human and nonhuman species throughout the planet. The political and economic agendas that caused these genocides and undermined positive socio-moral parenting in tribal human … and animal … societies are also responsible for today's socio-moral crisis in modern communities (Benessia et al., 2012: 86).*

While not stretching as far towards Indigenous and non-human others as Benessia *et al.*, others point to important markers guiding sustainability science towards openness, diversity and transformation. Self-consciously writing outside his specific expertise in disciplinary geology, Reitan identifies religious traditions and deep ecology as pointers to "what is needed beyond science" (Reitan, 2005). Writing early in the development of sustainability science, Kates *et al* suggested that:

> *Combining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information … sustainability science needs to move forward along three pathways. First, there should be wide discussion within the scientific community—North and South—regarding key questions, appropriate methodologies, and institutional needs. Second, science must be connected to the political agenda for sustainable development …. Third (and most important), research itself must be focused on the character of nature-society interactions, on our ability to guide those interactions along sustainable trajectories, and on ways of promoting the social learning that will be necessary to navigate the transition to sustainability* (Kates *et al.*, 2001: no page numbers).

And emphasising the importance of collaboration across diversity, Bettencourt and Kaur suggest:

> *A science of sustainability necessarily requires collaboration between perspectives in developed and developing human societies, among theoretical and applied scientific disciplines, and must bridge the gap between theory, practice, and policy. There is arguably no example in the history of science of a field that from its beginnings could span such distinct dimensions and achieve at once ambitious and urgent goals of transdisciplinary scientific rigor and tangible socioeconomic impact* (Bettencourt and Kaur, 2011: 19540).

In all these comments, the need to frame and re-frame sustainability, science and humanity in relation to the context of rapid and significant change in the couple human-natural systems that bind us together is clear. Yet there is also a clear sense in which scientific discourse continues to insist on its own authority. The paradoxical need for science to abandon the basis of its authority at a time when that authority is the basis for pursuing urgently needed behavioural change presents a huge challenge to scientists. Having pursued the rigorous education and training to think like scientists, we now need to transcend the limitations and consequences of that experience. Ironically, those on the other side of the proposed dialogue with Indigenous science face parallel challenges. Having articulated a powerful critique of colonising science, we need to avoid losing access to important insights and understanding that has been produced by science; having adapted to diverse experiences of colonisation and marginalisation, we need to avoid expecting immediate solutions to yet-to-be-framed problems to emerge from Indigenous science.

The organizers of *Wis²dom* proposed framing our dialogue at the scale of 'resilient landscapes'. The notion of resilient landscapes has not been widely discussed in the literature. While resilience at the scale of ecosystems (Cumming *et al.*, 2006; Folke, 2006; Folke *et al.*, 2002; Olsson *et al.*, 2004), institutions (Berkes, 2010; Kofinas, 2009; Veland *et al.*, 2010; Young, 2010), communities (Berkes and Ross, 2013; Gooch and Rigano, 2010; Gooch and Warburton, 2009; Olwig, 2012; Robards and Greenberg, 2007; Wilson, 2012) and planetary systems (Walker and Salt, 2012) is widely debated, the landscape scale presents its own challenges.

At the scale of landscapes, particular relationships of connectivity, dependence and identification are comprehensible in the everyday practices of human activity. In Australian Aboriginal English this is the scale of 'Country', the scale at which cosmological relationships and processes intersect with human presences and responsibilities (Howitt, 2002). This is an important scale of connection because it is a scale of human responsibility in an everyday sense. In political terms, however, landscape is a slippery scale to work with. While some catchment-based institutions might govern at this scale, others vastly exceed the scale implied in Indigenous notions of 'Country', while others become captured at smaller scales of interest communities and political power (Brierley *et al.*, 2006; Falkenmark *et al.*, 2004; Winter *et al.*, 2011; Weir, 2009; Weir, 2008; Weir, 2011). Wu points to the importance of the landscape scale for sustainability science:

> *As landscapes are spatial units in which society and nature interact and co-evolve, it is more useful and practical to define landscape sustainability based on resilience rather than stability. Furthermore, the development of landscape sustainability measures can be facilitated by integrating landscape pattern metrics and sustainable development indicators* (2012: 59).

By framing our dialogue at the scale of 'resilient landscapes', we might find that we are pushed to contextualise our thinking in novel ways. 'Radical contextualism' offers a way to be "responsive to and aware of the context(s) in which knowledge is formed, debated and applied" (Howitt, 2011: 132). For Howitt, this reflects:

> *my own epistemological, political, philosophical and aesthetic orientation to the importance of the material, transactional and relational connections of history, geography and society (of time, place and social process) as influential on how things unfold, and how we come to understand and respond to the events, places and people around us – the sticky materialism of experience and being-together-in-place. It points also to the priority of ethical connection as a basis for understanding sociality and responding to the world of social relationships, social process and of being-together-in-place (see also Levinas, 1999; Levinas, 1998; Eskin, 1999; Visker, 2003). Radical contextualism is in tension with not only the grand theoretical claims of structuralist thinking but also the superficiality of postmodernist collage and the naïve specificity of parochial and exclusive localisms (Howitt, 2011: 133).*

So, reframing sustainability science in terms of this radical contextualism, one is drawn to the urgent significance of a dialogue with Indigenous science that is humble, respectful and hopeful; which listens to Country and all its peoples; which recognizes not only the need to acquire knowledge, but also the need to transform and respond to different knowledges, understandings, meanings and opportunity.

Conclusion

There can be no doubt that the challenge of sustainability is both complex and multifaceted. It is, of course, captive to the contexts in which ideas of sustainability, science and contemporary governance have been framed. As Benessia *et al*. remind us,

> *the very notion of sustainability is embedded in an essentially modern framework, entailing a number of contradictions and paradoxes, which can be interpreted as epistemic and normative diversions and obstacles, preventing the needed transformation* (2012: 75).

Framed at the landscape scale, sustainability science and Indigenous science will see things quite differently. It should not surprise us to find each convinced of its own importance. Indigenous sciences, we might find, will point to issues of connection, responsibility and meaning. Sustainability science, for its part, will likely point to issues of management, governance and adaptation to increasing knowledge as needing priority. In between is a discursive space that invites transformation in both approaches; which challenges both approaches to stretch towards understanding of the other, and in the process to deepen our understanding of the context of the simultaneous pursuit of justice and sustainability. This is, I feel, a space that we should enter with hope and excitement. But, be warned. There can be no simple solutions; no panaceas; no short cuts – indeed, there can actually be no obvious target end-point against which to measure progress in any simple sense. In entering this space, we journey together on the paths of dialogue to share understandings, learning and possibilities. I look forward to the challenges involved.

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Kekuhi Kealiʻikanakaʻoleohaililani – Hawaiʻi Community College

1. What are the strengths of these two paradigms of science in sustaining resilient landscapes?

Because Hawaii Environmental kinship is not born out of the same cosmology (that means environmental space, psyche, and related natural cycles) as sustainability science, I like to give them their own space by not calling Hawaii things "science" and by not forcing science to be more indigenous. It seems to me that Hawaii EK and Sustainability Science might appreciate it. Our challenge is not to force fit the two ways of knowing, thereby widening the gap between the two. Our challenge is to build the connection between the two. Ok then, here we go. Strengths...

Hawaii Environmental Kinship
- timeless
- regionally situated
- includes social-psychic-ecological relationships
- born from spatially oriented, multiple cosmologies
- kanaka born/reflection of nature
- interdisciplinary
- includes spirit

Sustainability Science
- born for this time
- globally concerned
- includes a bio-social frameworks
- born from a global scientific network
- human responsible for nature
- multidisciplinary
- intends to build spirit

2. What are the limitations of these two paradigms of science in succeeding in sustaining resilient landscapes?

No limits.

3. How can these two paradigms collaborate in their efforts toward sustaining resilient landscapes?

I dare say practitioners of these paradigms can collaborate on an individual/personal/spirit level. When that is stable or trusting, then we include our "disciplines" in the discussion. All that is needed is willingness. Given my limited knowledge of sustainability science, I predict that the intersections that allow the greatest latitude to collaborate may be found in the obscurity of sustainability science.

4. What protocols will aid in the collaboration of these two paradigms toward sustaining resilient landscapes?

The only protocols that aid any collaboration are curiosity, compassion, and the willingness to flex and evolve our own practices. We do this by creating and fulfilling our personal relationships to being-human and to the more-than-human. When we are moved to say hello and good morning to Jay and in the next breath say hello and good morning to rain on our skin, or the cold of the air, THEN we are ready for protocol because we have easily and effortlessly created and practiced the most basic level of protocol in a very accessible way.

5. Other Thoughts-From the Hawaii Landscape which may change if the space is different:

I figure we can change paradigms as much as we like, but the answer to whether or not indigenous-native environmental kinship and sustainability science can work together, I think is a matter of spirit. The Hawaii paradigm, the sustainability science paradigm. I have renamed SusSci, with respect, and in honor of my attempt to enter the notion of it (SusSci) into my consciousness. Ready for it? I call SusSci— haʻa honua. Haʻa means humble, humility, or to behave in such a way. Haʻa is a form of ritual dance, the first word used for the popular word for hula, or Hawaiʻi's form of dance. Haʻa is what nature does in her movement; it is movement

before the thought of movement became dance. Honua means earth, this earth, floating earths, the earth above us and below us. Honua is the image of a canoe so emended that it seems like the earth moving on the vast ocean. Honua is a reference to our own body. It is a fractal. It is land and land masses. It is the core of the earth, earth's womb, the very energy that creates honua above the oceans floor.

And so, Ha'a Honua is the action of dancing all of our earths. It is the attitude of approaching creation with humility and embodiment. That attitude IS the protocol, the manner in which one approaches each and every element in our spaces. Ha'a Honua is a dream, a myth, a timeless interpretation of the dance of atoms and their subatomic partners dancing in the bloom of creation and recreation over and over again.

In any juxtaposition of concepts (Ha'a Honua-SusSci & Hawaii Kinship), first we honor their origins, build or imagine what connects them, bridges them, and we focus on those connections by them, hanging tools of each trade onto the question of study. If we start at the landscape-mythic-spirit level, we will always know how two or more concepts can work together.

Renee Pualani Louis, University of Kansas

E Ala E
By Pualani Kanahele
(once started this is chanted continuously until the sun rises)

E ala e	**Arise**
Ka la i ka Hikina	**The sun in the east**
I ka moana	**From the ocean**
Ka moana hohonu	**The deep ocean**
Piʻi ka lewa	**Climbing (to) the heaven**
Ka lewa nuʻu	**The highest heaven**
I ka Hikina	**In the east**
Aia ka la.	**There is the sun**
E ala e!	**Awaken!**

Streaks of yellow-orange rays of sunlight color the eastern horizon. Resonant voices of rhythmic chanting fills your senses with a single purpose, greeting Kānehoalani, the sun. Pualani Kanakaʻole Kanahele, kumu hula (Hawaiian dance teacher/master) and scholar, composed this chant for a ceremony on Kanaloa (aka Kahoʻolawe). This seemingly simple chant prepares a group of people to focus on the specific tasks of the day by bonding not just with one another, but with nature itself. In the most metaphoric of understandings it invites nature to help us climb to the upper echelons of being and awaken our higher selves from a deep slumber. It is from this space that I address the workshop questions.

A decade ago Clark and Dickson summarized sustainability science as a movement that began a decade before when science and technology focused on long term needs of human consumption as it related to the environment. At that time the goal of sustainability science was to develop practices that were more in line with the planet's environmental limits to sustain the production of food, fuel, etc. It was the first time science seriously engaged in funding research that investigated the dynamic interactions between nature and society. This new direction led scientists to recognize that knowledge needed to be "coproduced through close collaboration between scholars and practitioners" (Clark and Dickson 2003).

Indigenous practitioners have been actively observing and recording their interactions with the natural environment far longer than any other scientist. This that makes them Indigenous scientists in my opinion because they use a systematic approach to acquire knowledge about the natural environment, form theories about that knowledge, test those theories, record the results of those tested theories, and ultimately increased their knowledge about the natural environment. As such, these Indigenous scientists possess baseline knowledge of their environments.

Bringing Indigenous and sustainability scientists together should be an obvious course of action. The reasons it has not been discussed in great detail is because of the differences in what is considered knowledge and how it is obtained, recorded and acted upon. It seems to me that we each need to get out of our own way to make a successful collaboration work. Indigenous science is saturated with the sacred and focuses on long-term relationship building. Sustainability science is firmly anchored in a Western paradigm of objectively based knowledge acquisition and appears to be largely funded by consumer and capitalist needs where return on investments rule the time lines of funding cycles. The question on how to make this work, really work, can only be answered if each is willing to compromise.

Since Indigenous science is much more metaphoric in nature, Indigenous scientists need to tease out from their environmental knowledge those bits that more easily relate to the Western perspectives of nature. For example,

on Hawai‘i Island we have two major mountain ranges, Maunaloa (the female) and Maunakea (the male). Maunakea is the tallest mountain on earth from sea level and is constantly sought out for building the newest telescope observatory. Hawaiians continually fight these developments citing Maunakea as a sacred place. As one can imagine, this line of reasoning frequently falls onto deaf ears as arguments of a religious/spiritual nature do not have a place in the U.S. Environmental Assessment process. However, as Indigenous scientists, we need to change our line of reasoning to better represent an argument that will make sense to the developers and government officials.

We need to concentrate on the reason Maunakea is a sacred place and given godlike status – its ability to attract and store vast quantities of freshwater. Building observatories on Maunakea changes its function in the natural world. If people start seeing and referring to Maunakea as the foremost location for astronomy, it will become that foregoing its important function of attracting and storing freshwater. Man can live without one of these things and any scientist that tells me there is enough room on the mountain to do both probably believes multitasking makes a person more efficient. This cannot be further from the truth.

When sustainable development shifted focus a decade ago, it was a step in the right direction. It promoted cross-disciplinary coordination and global cooperation to understand the dynamics of human-nature systems (UNESCO 2013). However, I do not believe sustainability science can continue to make progress in understanding the dynamics of human-nature systems from an anthropocentric worldview. It is time to take another step in the right direction. Sustainability science needs to focus on a more biocentric driven research agenda.

Let me give you an example of what I mean. I attended a Bioneers conference a few years back and heard someone from the farmer-owned company Organic Valley speak about their philosophy, much of which you can find online at their website, www.organicvalley.coop. This is a company that puts the environment first and farms in harmony with nature. They are not driven by dollar signs but by an insane degree of integrity to the land. In fact, they include CO_2 emissions for transporting their product all across the nation as part of their cost analysis. However, the story that caught my attention was their desire to create a better yogurt, which meant they needed sugar.

They went all around the country looking for a farmer that would abide by their strict organic agriculture methods. They could not find one farmer with enough land that was willing to work with them. Each one they encountered cited high startup costs and no short turnaround for their return on investment. The company had to go to a farming coop in a country south of the border (I cannot recall exactly where) to work with farmers willing to grow sugar cane and NOT burn the stalks when it was time to harvest. Instead, Organic Valley wanted the farmers to use the leaves and leftover plant material as composted mulch to enrich the soil before planting another crop. By the third planting, the sugar cane grew noticeably thicker and juicier and they are now getting more return out of that initial investment than the farmers who chose not to work with them.

I believe sustainability science needs to shift their concern away from making the planet more capable of sustaining human life and toward using science and technology to nourish the earth. Human survival is hinged on a healthy planet. Changing the reason for doing the research will change how the research can be conducted. Inevitably this leads to the uncomfortable discussion President Carter had decades ago about reducing human consumption. Less really is more in that if we each consume less, there will be more for others and for another day. Ah, but now I am not sure I am still talking about science.

Let me end as I began with a parting greeting to an important natural element, Kānehoalani. As we descend from the upper echelons of consciousness, so too does Kānehoalani descend casting an orange-red glow along the western horizon on his journey into the depths of the ocean. In the book, *Ka Honua Ola: ‘Eli‘eli Kau Mai (The Living Earth: Descend, Deepen the Revelation)*, Kanahele ends each chapter with the phrase, ‘eli‘eli kau mai. According to her, the phrase “is intended to move the reader’s mind away from the text and into one of the

many possibilities of emblematic imagery to deepen the revelation and allow the analytic mind to trigger yet another question" (Kanahele 2011). It is exactly this intent that I leave you with using her phrase, *'Eli'eli Kau Mai.*

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Theoretical Considerations for Indigenous Scientific Traditions

Deborah McGregor, University of Toronto

"We take wisdom where we can find it. No system has all the answers" (Borrows 2005, 5).

Introduction

As discussed by Howitt (this volume), 'sustainability science' is a relatively new scientific conception that draws upon other disciplines to form its core goals. Indigenous peoples, however, hold ancient and highly developed ideas of environmental or sustainability science which have significant applicability in understanding current environmental challenges faced in our communities (Kimmerer 2012, Turner 2005).

This paper briefly explores key concepts relating to Indigenous scientific traditions from the perspectives of various scholars who have devoted their lives to exploring the questions posed at the *Wisdom: Weaving Indigenous and Sustainability Sciences: Diversifying our Methods* workshop. In so doing, the paper draws upon the words and insights shared by a number of Elders, traditional knowledge holders and Indigenous scholars. The paper also offers suggestions as to how western and Indigenous scientists can potentially collaborate to respectfully bring their divergent intellectual traditions to bear on the sustainability challenges we all face.

Indigenous Scientific Traditions

Indigenous scientific traditions have ancient roots and hold much relevance for contemporary society. Such traditions speak to the present and future needs of humanity; in other words, such traditions have relevance for all people, not just Indigenous societies. Such sentiments have been expressed by Indigenous peoples at various international forums as part of the global sustainable development movement. Ensuring sustainable landscapes is a priority for Indigenous peoples internationally as evident in various environmental declarations (UNESCO 2006). The international community has long since acknowledged that Indigenous scientific traditions continue to exist (although these traditions are often referred to as "traditional knowledge", or "traditional ecological knowledge", or similar terms), and recognized that such knowledge can assist with addressing sustainability challenges all people face (WCED 1987). Indigenous and non-Indigenous scholars have spent decades exploring the potential contributions of TEK to questions of sustainability, biodiversity and sustainable development (see Berkes, this volume).

These Indigenous scientific traditions have been functioning since time immemorial, and are embedded in broader knowledge systems that provide the context for how Indigenous science is conducted and applied. These intellectual traditions are as diverse as Indigenous peoples themselves, as diverse as their nations and cultures, as diverse as the lands and resources upon which they emerged, transformed and flourished. They are reflected in relationships to the land. Many Indigenous nations describe their knowledge systems as emerging directly from the land itself, although there are other sources that frame and constitute such systems (Borrows 2010).

Indigenous scientific traditions are therefore fundamentally about relationships to the land, to the waters, the animals, the ancestors, the spirit world and even those yet to be born (HETF 1999). These relationships are governed by codes of conduct that guide our behaviour with each other, with other beings and with all the elements found in Creation. These ethical and moral codes of conduct are framed in terms of *obligations and responsibilities* which form central principles in relating appropriately with other orders of the world. As illustrated in the quote above, these types of relationships and responsibilities are evident in various Indigenous environmental declarations from around the world. In 1992, the United Nations Conference on Environment and Development (UNCED, also referred to as the 'Earth Summit') was held in Rio de Janeiro. Indigenous

peoples met at the Summit and prepared their own submission to the conference proceedings in the form of the *Kari-Oca Declaration*. The *Kari-Oca Declaration* contains 109 articles relating to human rights, lands and territories, biodiversity and conservation, development, culture, science and intellectual property. It also emphasizes the relationships between Indigenous peoples and the land: "We maintain our inalienable rights to our lands and territories, to all our resources—above and below—and to our waters. We assert our *ongoing responsibility* to pass these on to the future generations" (*Kari-Oca Declaration 1992)*. These traditions are about *relationships* with the land, Indigenous scientific traditions are inherently dynamic, and can be thought of as living systems. Indigenous peoples engaged in research and practice are thus continually advancing the body of knowledge available.

Central to Indigenous philosophical thought is that beings other than humans also create, possess, and share knowledge. The practice of Indigenous science is therefore not merely the domain of humanity. Such a premise has significant implications for Indigenous scientific research and methods. That all beings possess knowledge and can determine how, whether, and under what circumstances, to share knowledge, means relationships with these beings becomes an important (if not the most important) aspect of Indigenous scientific research. An important principle that emerges from the Indigenous science literature is that, "the Earth is a living entity" (Borrows 2010, 242). Such an epistemological underpinning has significant ethical implications in the practice of Indigenous science. Such a premise compels Indigenous scientists to act responsibly and respect life. Indigenous scientific methods have been developed to achieve this end. This kind of scientific inquiry has also required Indigenous scientists to establish appropriate relationships with beings and the universe (or Creation).

The late and eminent Indigenous scholar, Vine Deloria, Jr., asserted throughout his lengthy career the value of Indigenous scientific traditions based on principles such as those noted above. He writes that the principle "we are all relatives is very important as a practical methodological tool for investigating the natural world and drawing conclusions about it can serve as guides for understanding nature" and "that people experience the world as alive and not dead or inert "(1999, 34). Scientific research required Indigenous scientists to find "… the proper moral and ethical road upon which humans being should walk", Deloria continued, "All knowledge, if it is to be useful, was directed toward that goal" (Deloria 1999, 43). In Indigenous scientific research we seek certain kinds of relationships that ensure harmony and balance in Creation. Indigenous scientists sought to form relationships with the phenomena observed or experienced and were thus able to obtain information from other beings (trees, mountains, animals, etc.) that is often inaccessible to Eurocentric scientists.

In various Indigenous traditions, these kinds of relationships are founded and expressed in different ways. For example, for the Anishinabe people, these may be expressed through the clan system, where a person throughout his/her lifetime learns about what it means to be a clan member (clans are named for various animals) and the types of relationships one is encouraged to nurture as a result. The practice of Indigenous science may also be gendered. For example, in the Anishinabe tradition, women hold the responsibility to speak for water (Mandamin 2012). Anishinaabe Elder Josephine Mandamin, in her undertaking of Indigenous scientific practice, walked around each of the Great Lakes and was able to share her findings with Western scientists at the State of the Lakes Ecosystem Conference (SOLEC) in 2008.

Oneida scholar Pamela Colorado, in her seminal work, "Bridging Native and Western Science", (1988) explores theories and research methods that form "Native Science." She asserts that Indigenous science is about the process of "relating" and "engagement" based on principles of balance, harmony and respect. Colorado argues that *engagement* with the environment is required for understanding and conducting Indigenous scientific research. She points out that one must be "ready" to engage in this type of work. There is preparation and training involved, and guidance is necessary. She states that Indigenous scientists are held to high moral and ethical standards and must clearly understand the spiritual, emotional, intellectual and physical aspects of their lives in order to meaningfully engage in this work. Indigenous scientific research is thus not just an intellectual

exercise or experience. For many Indigenous peoples, preparation and guidance was often achieved through ceremony and practices under the guidance of a teacher (Archibald 2008, Wilson 2008).

Along with others such as Gregory Cajete (this volume), Deloria argued that Indigenous scientific theories and meanings are often contained in stories, teachings, values, beliefs, ceremonies, songs, dances and other practices. "In fact, tribal peoples are as systematic and philosophical as western scientists in their efforts to understand the world around them. They simply used other kinds of data and have goals other than determining the mechanical functioning of things."(Deloria 1999, p. 41). These types of research methods and the training involved are increasingly finding their place in Indigenous research scholarship (Kovach 2009).

Indigenous scientific traditions have unique strengths, including fairly pragmatic roots. They also have a significant spiritual component which trained practitioners can call upon when needed. Whether you are Anishinaabe, or Haida, or Onkwehonweh, you are obligated to care for your relatives (RCAP 1996). Our relatives, as observed in the preceding section, are comprised of Creation and its beings. As an Indigenous scientist, you are expected to come to know, and to care for, Creation and its processes, just as one comes to know and care for one's human relatives. The Indigenous scientist's preoccupation is thus learning to engage appropriately in a series of relationships with beings in Creation as a way of gaining understanding and knowledge.

Collaborations

The past few decades have seen various initiatives that attempt to integrate different scientific traditions with some success (Berkes this volume). The focus, in my view, is to *bring people together,* in a "good way" and with a "good mind", so as to advance our collective knowledge. Indigenous science is deliberative, in the sense that a large amount of dialogue and discussion occurs as part of the process. These types of deliberations can most certainly occur with other types of scientists, although they may have been trained differently. Colorado (1988) calls for Indigenous and non-Indigenous scientists to come together in co-existence to bridge and enhance knowledge in order to benefit all of humanity.

Indigenous peoples already have theories, approaches and practices that are based on respect, reciprocity, cooperation and co-existence that can form the basis of these types of collaborations (Ransom and Ettenger, 2001). Indigenous peoples functioned as nations for thousands of years prior to contact and already had existing models for "international" relations, including protocols for sharing knowledge. These models, in principle, draw upon the strengths of diverse knowledge systems. These traditions can contribute to the burgeoning dialogue on how we as Indigenous and non-Indigenous peoples can draw on our respective strengths to generate innovative understandings of science, or the grand story of the Earth.

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Bridging Indigenous and Local Knowledges through Tribal-Local Government Collaboration

Debra McNutt, The Evergreen State College

The WIS²DOM workshop highlighted the need for Western science to rethink its relationship to Indigenous Knowledge, away from an attempt to absorb or extract lessons from Indigenous peoples, and toward protocols of mutual respect. Instead of merging Western science with timeless and place-based knowledges, they can be kept both distinct and complementary. Protocols can provide bridges of communication and collaboration between Western and Native Sciences, based on decolonizing the ways of thinking of Western governments and academia.

A possible bridge between the two worldviews may be the Local Knowledge of non-Native rural residents. Although their ties to the place are much looser than Native peoples, and their experience of the landscape only stretches back a miniscule of the time of their Indigenous neighbors, they still view it as "home," and can value its abundance and sense of place. The Local Knowledge learned in a few generations is thinner than the thick Indigenous Knowledge accumulated over many centuries, and can reinforce an extractive attitude toward the land, but it in other cases can join with Native directions in sustainability.

Not only do many Western scientists ignore the knowledge of Native peoples about their landscapes; they often also ignore the knowledges of rural non-Native settlers, whose community-based observations and monitoring of the land are dismissed as the folklore of uneducated country people. If Western science cannot even have a respectful relationship with non-Native holders of Local Knowledge, it will have a difficult time establishing protocols with holders of Indigenous Knowledge. As Gregory Cajete points out, Native peoples have become advanced at developing protocols to criss-cross the perspectives of different peoples, because they have been doing it much longer than non-Native peoples.

The interests of Native and non-Native neighbors have the best potential to converge around the most basic necessity of life: water. For Indigenous peoples around the world and in our region, water is not simply a natural resource for economic development. Traditional people consider water to be sacred, as a source of all life. In Western society, on the other hand, "it is rare to think of water in ethical terms, when it has historically been viewed as a commodity, as an instrument, as a convenience" (Bates *et al*, pp. 178-179).

Nisqually Tribal Chair Cynthia Iyall observes, "For centuries, Indian people across this great country have respected and cared for water, one of our planet's most precious natural resources. This long-standing tradition has evolved sophisticated systems of sustainable resource management focused on maintaining a very sensitive ecological balance" (Iyall 2008).

Native and local non-Native communities can use complementary knowledge in different ways. Participatory Conservation has the potential to join in making the landscape and its waterways more resilient, if it comes from grassroots cooperation. That cooperation can sometimes be found in the collaboration of tribal and local governments, from the bottom up of their respective communities.

As a non-Native researcher with a background in building alliances between tribes and their rural neighbors, I have taken a special interest in tribal-local government partnerships, particularly concerning climate change adaptation and the security of freshwater supply. I grew up in a rural Wisconsin family that was centrally involved in local governments. Through the course of working on treaty rights and Native environmental justice issues in Wisconsin, I also attended meetings of (and was accountable to) several tribal governments.

In Wisconsin, I was active in the Midwest Treaty Network defending Ojibwe fishing rights, and later building an alliance between the tribes and sportfishing groups that defeated two proposed mining projects. I also

worked in my home county in an alliance among farmers, sportfishers and the Ho-Chunk Nation that defeated a proposed Perrier water bottling plant that threatened a sacred spring. In all these cases, relations between tribal and township/municipal/county governments were pivotal in building the local environmental alliances, which began to overcome decades of mistrust and jurisdictional conflicts.

In Wisconsin, relationships between tribal and local/county governments were not simply official intergovernmental relationships between elected officials or professional scientific staff. In many rural areas, they were deeply rooted social relationships between neighbors whose families have lived close to each other for many decades, and may have a history of animosity or intense conflict dating back to settlement times. They have known each other in schools, churches, workplaces, social services and sports events. Often the white community is still unaware of the history and cultures of their Native neighbors, and resentful or suspicious of Native sovereignty. Yet I have seen that when tribal and non-tribal communities face a common threat to their environment or economies, they can also pull together to defend their ways of life, I have seen this cooperation be successful in Wisconsin alliances against mining and water extraction, and in Washington State salmon habitat restoration projects.

As a graduate student in the Master of Public Administration-Tribal Governance Concentration program, I studied the overlapping issues of tribal/local intergovernmental cooperation, water rights, and climate change adaptation, focusing on Tribes around the Salish Sea (Puget Sound, Hood Canal, Straits of Georgia and Juan de Fuca). My 2012 Capstone project "Tribal and Local Government Collaboration for Secure Water Sources in the Salish Sea Basin" asserted that closer tribal-local government partnerships are essential to resilience in our era of climate change, especially in ensuring continued access to freshwater supplies.

Government-to-government relationships with state and federal governments are an important priority for most tribes. But local partnerships with neighbors can sometimes last longer than cooperation with state or federal officials who may not last in their positions. When Indian and non-Indian neighbors reach common ground on protecting their local environment and economy for future generations, they can together become a powerful force.

From below, Native and non-Native neighbors can develop deeply rooted solutions that can trickle up through levels of government, instead of having cooperation imposed from above. As Frank Pommersheim observes in his book *Braid of Feathers*, improvement in local relations "will not be easy … Yet it is necessary if there is to be any unity on the issues central to the existence and reinvigoration of Indian and non-Indian rural communities, which often share common attributes of being underdeveloped, isolated, and easily ignored by the powers that be" (Pommersheim 1997, p. 30).

Tribes and local/county governments in Washington are building partnerships around their common environmental concerns, such as salmon habitat restoration and water quality. Some of the early partnerships are covered by the Northwest Renewable Resources Center in its resource guide on "Building Bridges" for tribal/county intergovernmental cooperation (Reynolds 1997). Rather than always disputing jurisdictional positions, tribe and counties can agree on a joint planning program for their mutual watershed. Litigation is often too costly for both parties, so both sides may see that a formal government-to-government relationship needs to be formed.

The Nisqually Tribe has been one of the leading tribes in the country in developing environmental collaboration with local, state and federal governments, to restore salmon in the Nisqually Watershed. The Nisqually River flows 78 miles from Mount Rainier National Park to the Nisqually National Wildlife refuge at its delta. After the 1974 Boldt Decision gave the tribe a seat at the resource management table, it cooperated with the State in developing the Nisqually River Management Plan (Nisqually River Task Force 1987). It helped to form the Nisqually River Council, which jointly developed the Nisqually Watershed Stewardship Plan, which

the Tribe is taking the lead in implementing. Director David Troutt of the Nisqually Tribe Natural Resources Department, observes,

> "When we began our habitat protection efforts in 1990, less than 5 percent of the Nisqually River stream banks within the anadromous fish area in the watershed were in some form of permanent stewardship. In fact, increasing pressures from growing urban areas in and around the basin were resulting in threats to quality salmon habitat. Since then, due to the efforts of the Nisqually Indian Tribe, the Nisqually Land Trust, City of Tacoma, City of Centralia, U.S. Army at Fort Lewis, and many other partners we have over 73 percent of these areas in protective stewardship. This is amazing to think that nearly three quarters of the river is protected and will only get better over time and we are well on our way of achieving our goal of 90 percent" (Troutt 2009).

The Nisqually watershed success story also involves local governments. After many years of court fights, Centralia and Tacoma changed water level procedures at their hydroelectric dams, which had been harming fish in the river. The City of Roy is working with both the Nisqually Tribe and Joint Base Lewis-McChord to restore chum in Muck Creek, and hosts an annual Salmon Homecoming to welcome the fish that have returned to the stream.

The Nisqually Tribe and the City of Olympia agreed in 2008 on a "regional water source partnership… believed to be the first of its kind between a municipality and a Indian tribe." Olympia had been drawing water from McAllister Spring, at the headwaters of McAllister Creek (historically known as Medicine Creek, the site of the 1854 treaty signing). Tribal Chair Cynthia Iyall and Mayor Doug Mah and City agreed to move the water source to a more sustainable McAllister Wellfield, located on higher ground away from saltwater contamination (City of Olympia and Nisqually Tribe 2008).

Nisqually Chair Iyall noted that the "partnership with the City strengthens our commitment to protecting the Nisqually Watershed, the lifeline to our Tribe. Our restoration efforts – including investments in our salmon recovery and enhancement program, our shellfish program and our environmental management program as well as our Tribal members' volunteer service – have helped make the Nisqually River one of the cleanest and wildest rivers in the country" (Iyall 2008).

In the current climate crisis, these relationships based on water and watersheds become exponentially more critical. Local relationships are growing in importance, as tribes and local governments have to plan for major storms and disruptions that may cut them off from outside help. Adapting to the inevitable effects of climate change can be used to improve local-tribal relationships, and to create healthier ecosystems and sustainable economies. Native and non-Native governments that plan ahead for a future of limited or disrupted freshwater supplies will be much better prepared than those governments that do not prepare.

The Swinomish Tribe, located in the Skagit River Delta, has made great strides in overcoming decades of mistrust with neighboring local governments, and leads Indian Country in planning for climate change adaptation, but still faces water rights disputes that threaten to derail its progress. The Swinomish Tribe launched a Swinomish Climate Change Initiative, to assess the projected impacts of climate change (such as sea-level rise) on its reservation at the mouth of the Skagit River, and plans for adaptation to these predicted changes. The Initiative was given priority in the Tribe because of a series of damaging floods and storm surges that had threatened the tribal community and non-Native communities (on and off the reservation). The Swinomish Climate Change Initiative has released an Impact Assessment Technical Report, and a Climate Adaptation Action Plan, which are considered the most advanced tribal studies of climate change in the Pacific Northwest—if not in the country (SCCI 2009; SCCI 2010).

One of the most innovative aspects of the Initiative is its collaboration with non-Native local and county governments, which have often been at odds with the Tribe over jurisdictional and environmental issues. The

Skagit River Delta has very rich agricultural land, and some residents fear their economic prosperity would be threatened by a tribal role in local decision-making. But because tribal and non-tribal lands alike are within a flood plain, they have become more vulnerable in an era of climate change. By working together to respond to the new challenges of climate change, they are beginning to build a closer relationship as neighbors, rather than competitors, and looking to the long-term security of future generations rather than short-term gains. The Swinomish Climate Change Initiative is the cutting edge of applied research on climate change in Indian Country and has provided a new opportunity and model for non-Indian communities, but disputes over jurisdiction and water rights threaten to stand in the way of this collaboration for local resilience.

A key method of getting both Native and non-Native communities involved in responding to climate change is to make the technical issues understandable to people not trained in the sciences, and show how so-called "global warming" is actually a *local* crisis, that affects all communities here and now. For the Northwest Indian Applied Research Institute in 2010, I edited a community organizing booklet on climate change for Native communities. The 16-page booklet, entitled *Northwest Tribes: Meeting the Challenge of Climate Change*, has become a tool for members of tribal nations in the Pacific Northwest, to educate each other about the challenge that climate change poses to tribal cultures, economies and treaty rights, and the tribal responses to that challenge. To make the scientific information accessible, it is rewritten in English that any high school student could understand (McNutt 2010). The booklet was also published in the 2012 Oregon State University Press anthology *Asserting Native Resilience: Pacific Rim Indigenous Nations Face the Climate Crisis*.

Local governments that partner with tribes in protecting the security of their common freshwater supply are better equipped to face the challenge of climate change than local governments that continue to battle tribes over jurisdiction and natural resources. Local governments should understand and respect tribal water rights as potentially helping to ensure the long-term supply of freshwater for all residents of a river basin, Indian and non-Indian alike. In working together to protect their common land and waters, tribal and local governments can draw from both their Indigenous Knowledge and Local Knowledge, and in the process help bridge the gap between Native and non-Native worldviews.

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On Bridging Indigenous and Sustainability Sciences

Mark H. Palmer, Ph.D., University of Missouri-Columbia
palmermh@missouri.edu

The purpose of this essay is to begin deconstructing and mediating the dichotomy between Indigenous and Sustainability sciences. To do this, I suggest using technology as sites for connecting the sciences. Geospatial technologies, like maps and geographic information systems (GIS) can mediate between Indigenous and Sustainability sciences and other socially constructed binary or dualist relationships. One approach for conducting mediation work is through poststructuralist frameworks. Poststructuralist philosophies include a broad and complex spectrum of theoretical positions/counter-positions, and emphasize the geographies and sciences of colonized peoples and their knowledge systems. Engaging with poststructuralist philosophies and methods can help open up spaces where both Indigenous and Sustainability science may have an open dialogue. Much of this essay focuses on the deconstruction of oppositional dualisms and the opening of third spaces so that mediation work can take place.

Indigenous people use geospatial technologies to redress past injustices and address present threats to local resources. The mapping of territory, by or for indigenous people, is partially influenced by the UN Declaration on the Rights of Indigenous Peoples (Laituri 2011). This is a strength that can be attributed to the resilience of Indigenous science and communities that demand to be heard. Local, regional, and global policies impact the use of maps and GIS because they are always embedded within historical power relations that entangle people and institutions, for example, in Canada (Sparke 1998), Indonesia (Peluso 1995), and through antiquated internal colonial processes within one United States federal government agency (Palmer and Rundstrom 2013). Engaging with government agencies is both a strength and limitation. Counter-mapping is meant to balance such relations. Indigenous counter-mapping is considered tactical for decolonizing methodologies (Smith 1999; Louis 2007), geographies (Coombes et. al 2011; Shaw et. al 2006), and for protecting Indigenous peoples' self-determination options and sovereignty, while representing their own physical, social, cultural, and economic landscapes (Pearce and Louis 2008).

Recently, a workshop on cartography, GIS, and Indigenous knowledge wrestled with questions like: 1) how do geospatial technologies represent local geographies? and 2) What are the implications of digital representations (Johnson 2011)? The Hi'iaka Working Group outlined a research agenda that focused on new ways of combining Western technologies with Indigenous knowledge systems. The Group made the recommendation for increasing case study research and providing more empirical evidence to support existing theories. Advocates supporting collaborations between Indigenous and Sustainability science should consult the Working Group's findings. But in the meantime, how might we address the oppositional dichotomies that are constructed as boundaries between Indigenous and Western knowledge systems?

Oppositional dualistic thinking is one of the primary lenses through which academia views the world. There is nothing fundamentally wrong with viewing the world as a series of dichotomous relationships. The problems arise when the boundaries become impermeable, closing opportunities for one side of the equation and opening up unlimited space for the other side. Socially constructed boundaries exist between Indigenous and Western ontologies and their systems of operation within academia. Debates revolving around ontologies are prevalent in the disciplines of geography, philosophy, anthropology and international development (Agrawal 1995). Scholars and advocates of Indigenous people seem to be caught within a paradox that on the one hand sees Indigenous knowledge as something of value, something to preserve, and protect. On the other hand, methods of preservation can lead us to the trap of taking knowledge out of its cultural and historical contexts (no matter how complex or blended) and instead adopting only technical methods of recording, documenting, archiving, and storing in a modern, scientific fashion. A major obstacle to a bridging and mixing approach is getting past the opposition dualism separating Indigenous and Western knowledge systems.

How are colonial oppositional dualisms framed? Indigenous knowledge is perceived as a primitive, traditional, innocent, static, and closed-system existing in some mythical pristine physical environment. Western geographic knowledge and science are perceived as dynamic, progressive open-systems that thrive on changes and adaptations (Agrawal 1995). This view creates a dichotomy between Indigenous knowledge on the one hand and science on the other. In reality, both systems are open and susceptible to transformations. There is nothing advantageous about this oppositional dichotomy, and its application can have adverse impacts upon the emerging relationships between Indigenous and Sustainability sciences. However, there are ways to get around this stalemate.

The concept of *third space* offers an alternative to oppositional dualistic thinking. Some scholars create a third space where geography, linguistics, human rights, animal rights, political activism, and stories all intermingle, and as an "attempt to live theory in the immediate" (Routledge 1996, 401). Third space is not for the faint of heart; there are many benefits, there are setbacks, jubilation, questioning, and ambivalence (Routledge 1996, 406). With this in mind, I propose the development of a more accessible theory of a hybrid, third space. One approach would be to mediate through geospatial technologies like maps and geographic information systems (GIS).

Understanding how knowledge systems come together is extremely important. Currently, Kiowa language narratives are integrated into a vector-based GIS (passive process) and another approach imagines Kiowa story geographies assimilating geospatial technologies (active approach). Some scholars are just beginning to experiment with what might be broadly referred to as Indigenous geographic knowledge systems (Palmer 2012). There are strengths to third space approaches. There are also limitations. The greatest limitation is the fact that not all scholars are familiar with the ideas of living within and between two worlds: Indigenous and non-Indigenous. Rather, the Earth is more generalizable when viewed as purely scientific or Indigenous. The concept of purity is difficult to overcome, on both sides of the equation.

The purity of knowledge systems, whether Indigenous or Western, is a myth. There are few impenetrable boundaries between cultures, but rather an abundance of grey areas and "This presents a profound challenge to [Indigenous and Sustainability sciences because] modern Western thought is structured around a series a binaries which suggest that a person [or system] is one thing or the other (indigenous/non-indigenous; Cowboy/Indian; black/white; Occidental/Oriental) (Sharp 2008, 121). Homi Bhabha's complex theory on hybridity and third space examines the grey areas associated with places and spaces. For Bhabha, "all forms of culture are continually in a process of hybridity...[giving] rise to something different, something new and unrecognizable, a new area of negotiation of meaning and representation" (Bhabha 1994). Bhabha's ideas are relevant on a global-scale. Good examples of hybrid geographies are American Indian allotment land areas in the United States. Allotment areas are but fragments of nineteenth century reservations, a land geography representing a checkerboard. In oppositional dualistic fashion, land was set up as Indian/non-Indian land. However, allotment land areas are places of encounters and exchanges or an amalgamation of people, ideas, and materials. Allotment geographies are denoted as grids, spaces of authority, and assimilation. However, the connotation of allotments is much different. Family relations, stories, memories, and experiences shape the meaning of the land. In other words, the geography of allotment areas is complex. However, many scholars are moving beyond the traditional/progressive oppositional binary relationships in their research approaches. Hybridity as a postcolonial theory represents a strong desire "to undo the authority of assimilation" and encourages an examination of hybridity in "overtly hybrid postcolonial locations" (Bhabha 1990). Richard Howitt argues that it is at the landscape scale that collaborations between Indigenous and Sustainability science might occur.

A third way (preferred in this thesis over 'the only-way' and the 'old-way') perpetuates itself and gains momentum through knowledge systems and cultures. Arun Agrawal informs us, "Instead of trying to conflate all non-Western knowledge into a category termed indigenous, and all Western knowledge into another category,

it may be more sensible to accept differences within these categories and perhaps find similarities across them" (Agrawal 1995, 22). In theory, the combination of knowledge or coming up with a strategy that promotes intellectual reciprocity is more difficult when dealing directly with knowledge. For example, a meteorologist does not recognize the spiritual embodiment of tornadoes, their creation story, and the knowledge of Man-ka-yi or the wind spirit that connects the Earth with our galaxy. However, language systems, maps, images, stories, and storytellers connect at a human level. Once a connection between systems occurs participants can debate the animate or inanimate characteristics of tornadoes. And this scenario has already been put into practice at the undergraduate level of higher education (Palmer, et. al 2009).

Many scholars are advocates for social justice, marginalized human populations, and the Earth itself. But weaving academia and advocacy is a tricky process. Some scholars create a third space where geography, linguistics, human rights, animal rights, political activism, and stories all intermingle, and as an "attempt to live theory in the immediate" (Routledge 1996, 401). Here, third space processes are very flexible and fluid. Routledge goes further by pointing out that academic+advocacy thirding is a processes of interwoven "personal and collective experiences" (Routledge 1996, 410). We must take this theoretical position very seriously, because, "[o]ne of the purposes of critical engagement is to open up legitimate spaces for practical actions creating networks of ideas, strategies, communications and alliance" that benefit community action, social justice, and academic processes (Routledge 1996, 406).

In summary, poststructuralism presents multiple positions in which Indigenous and Sustainability science can talk with one another. My contributions, here, are limited to ideas surrounding geospatial technologies and ways of deconstructing oppositional dichotomies. This is both a difficult task and one that can be rather simple, too. We are often conflicted. Why? Because there has been hundreds of years of encounters and exchanges between Indigenous people and Euroamericans. These relationships continue to shape the landscapes of interactions between Indigenous and non-Indigenous peoples, their ideas, materials, technologies, and knowledge. Even with this understanding, dualistic methodologies in the social sciences divide Indigenous and Western knowledge into two distinct categories. Within a dualistic framework, Indigenous knowledge is characterized as primitive, local, particular, and closed to changes, while Western knowledge is progress, global, universal, open, dynamic, and thrives on changes. Though these are strong and affective political positions, the reality of encounters and exchanges makes it virtually impossible for a pure and separate form of either Indigenous or Sustainability science to exist.

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Weaving Indigenous and Sustainability Sciences: Reflections on Decolonisation, Politics and Reflexivity

Dr. Marcela Palomino-Schalscha, Victoria University of Wellington, Aotearoa New Zealand

Some weeks ago I was giving a lecture about the perspectives of an Indigenous community on a particular environmental conflict. At some point a student asked "But why is that significant? Why is their view so special in relation to the other stakeholders?" This comment led to an engaging debate among the class around questions such as why is it important to consider Indigenous sciences, why can it be relevant to bring them into conversation within "Western scientific" debates, who calls for or needs this conversation, and who could benefit from and/or become marginalised in this dialogue. Acknowledging the fact that often it is non-Indigenous people those more in need to learn from the "other", it is crucial to think why we engage in these conversations, how they are performed, and who is involved or not and their/our roles. Be it a non-Indigenous person motivated by simple curiosity, an Indigenous people asserting their rights, a policy maker wanting to find more appropriate alternatives, an activist or scholar aiming to decolonise and pluralise scientific knowledges, and/or a community organisation looking for innovative solutions to the challenges they face, the ways in which these different "sciences" and their underpinning ontologies are negotiated are never easy. If we are serious about creating an open and equal conversation, bringing these sciences together will be hardly only a matter of "add-and-stir" different knowledges, to use the well-known feminist phrase. In this article I do not pretend to give definitive answers to these questions. Instead, I will explore a few issues that in my opinion need special attention in this on-going conversation.

Some Reasons to Talk

Although challenging, there is certainly much to be gained in trying to bridge Indigenous and Sustainability (Western) sciences. In fact, with the increased prominence of relational approaches within the Western sciences (such as actor-network theory, hybrid geographies, and non-representational theory among others), Western scientific paradigms might now have conceptual tools that enable them to re-think relations with non-humans in more nuanced and diverse ways. Indigenous and Western scientific paradigms (multiple and mixed) have many albeit different strengths, and through such dialogue, they can complicate, complement, and expand each other. In turn, this can help us enlarge the spaces to imagine and enact more creative, respectful and decolonised alternatives.

But as Mapuche authors have acknowledged, to face current environmental, economic, and social challenges what is needed is not only more technical or "expert" knowledge. Rather, they propose an intentional, non-subordinated conversation across knowledges and ontologies where multiple worlds can co-exist (Caniullán, 2003; Caniuqueo, 2003). Thus, it involves a decolonising exercise.

The Urgency for Decolonisation

Engaging in a dialogue across Indigenous and Sustainability sciences involves addressing colonial legacies that have discarded and subordinated what Santos (2003) calls a range of experiences, knowledges and actors "wasted" by the "indolent reason" of Western modernity. Western modern scientific paradigms, behind their pretentions of neutrality and universalism, have (not innocently) constructed hierarchies of superior and inferior knowledges and peoples. Therefore, the exercise of decolonisation requires a critical dialogue between diverse "epistemic/ethical/political projects towards a pluriversal as opposed to a universal world" (Grosfoguel, 2007 p. 212). So without rejecting modernity, decolonisation entails acknowledging different approaches to territory, politics, culture, spirituality and economy in equal terms, both at institutional and everyday levels (Currín & Valdés, 2000).

Johnson and Murton (2007 p. 127) have suggested that actually by including and recognising Indigenous ontologies "we have the opportunity to re/write the colonial/neocolonial displacement of the indigenous voice", decolonising constructions of nature that determine and marginalise Indigenous people, in a process that could benefit not only Indigenous peoples but all of us who are constrained by this divide. Indeed, enacting forms of "ontological pluralism" that allow non-universalist and more equitable and sustainable relations of co-existence (Howitt & Suchet-Pearson, 2006), can also help addressign the complex intersections of what is commonly seen as separated environmental, political, cultural and economic issues (Panelli, 2010).

No Dialogue without Politics

The role of politics in this dialogue must not be downplayed. De la Cadena (2009) argues that in Latin America "ontological disputes" are at the root of environmental conflicts, "pulling out of the shadows" particular relations between humans and non-humans. They are challenging the exclusion from politics of Indigenous knowledges that relegated them to the religious, ritual or superstitious realms by separating nature (or science) from politics and culture. Therefore, Indigenous peoples involved in these struggles are "pluralising" politics not only by enhancing Indigenous peoples' participation, but also because they are emphasising the need to negotiate different ways of being and the role and rights of non-humans.

The connection between ontology and politics is clear, for instance, in the case of the Mapuche people in contemporary Chile and Argentina. An ontology in which the dead are still present, places maintain connections, rituals involve more-than-human dialogues, and dreams transport strength, creates a framework that delineates the relations with multiple others, and is inextricably linked to politics (Ramos, 2009). Therefore, "politics cannot be understood outside Mapuche relationality and its links between humans, non-humans, past and present" (p. 72), which challenges modern understandings of the relations and limits between nature, culture and politics. This is evident in the centrality that Mapuche activists and scholars give to Mapuche values, knowledges and ways of being in their constructions of self-determination, development, and relations with non-humans (J. Marimán, 2005). Debates conducted within conventional political spaces, then, are linked to the inclusion of Mapuche *Kimün* (knowledge) and concepts such as *ixofil mongen* (non-anthropocentric relations with nature), *küme felen* (cosmic balance), *küme mongen* (good life), *kejuwün* (solidarity) and *kizungünewal* (self-government, autonomy) (Chihuailaf, 1999; P. Marimán, 2002).

Other Points for Attention

Despite their important symbolic and material implications, dialogues across Indigenous and Sustainability sciences require careful, reflexive attention. Their diversity, differences and sometimes incompatibility need consideration, and in particular, the tensions and silences within these conversations. But conflict, instead of a limitation, can actually open opportunities to maximise polivocality and plurality. As Currín and Valdés (2000) suggest in their interpellation to non-Mapuche, non-Indigenous people, there is no need to always reach agreement, and in relations of equal dignity the best option might be at times to disagree. Also, Rupailaf (2006) warns against "cosmovisionist reductions", or in Mapuche terms "kultrunist reductions", when trying to build non-hierarchical relationships. He asserts that they do not help as they tend to "reduce" dialogues (and tensions) to the encounter of essentialised "pure" cultures. To move beyond this divide, he calls to create sciences (in the plural sense) that include a range of people and knowledges in non-dichotomous and excluding ways, based on equity and respect.

Another issue that needs to be addressed is the inherent personal aspect of processes of decolonisation. Attention to the workings of power, language, assumptions, and relationships are not only important in the formal or institutional space, but also at the personal level. They require on-going reflexivity and a constant effort to challenge and "decolonise" ourselves. This can lead us to face uncomfortable, unpleasant or destabilising aspects of ourselves. As a non-Indigenous woman, for me this means maintaining awareness of the hegemony

of Western epistemologies in explicit and subtle ways. Indeed, Jones and Jenkins (2008) have suggested that cross-cultural work can be processes of mutual learning "from" the other rather than "about" the other. The emphasis then is not so much on the impossible task of fully understanding the other, but in examining the complexity of the Indigenous-dominant group relations. Learning "from" the other, thus, means to experience difference and "allows the indigene-coloniser relationship to be interrogated in uneasy ways that insists on examining power and common sense, as well as the place of histories in the present" (Jones & Jenkins, 2008 p. 483).

Finally, a dialogue based on equity, respect and dignity while acknowledging that all knowledge is always partial and situated (including "scientific" knowledge), should lead us to cultivate a humble stance that embraces uncertainty and diversity. Or in the words of Gibson-Graham (2008 p. 619), a position that favours "weak theory" over "strong theory." Weak theory for them "welcomes surprise, tolerates coexistence, and cares for the new, providing a welcoming environment for the objects of our thought…rather than masterful knowing or moralistic detachment." Choosing weak theory, then, "is a political/ethical decision that influences what kind of worlds we can imagine and create, ones in which we enact and construct rather than resist (or succumb to)."

Thinking Protocols

Protocols that support fair and equal dialogues between Indigenous and Sustainability sciences can be useful and necessary. However, they need to be context and culturally specific and appropriate, avoiding to become prescriptive in ways that preclude discussion and negotiation by those involved. For me protocols more that one-off checklists, are tools that help address on-going issues such as how processes are developed, by whom, who is benefiting and who might be in disadvantage, and facilitate spaces for reflexivity and adjustments. They must help find ways to avoid over-emphasising commonality and agreement, while also overcoming the re-production of binaries that set Indigenous and Sustainability sciences as two opposed, clearly defined and static entities. Therefore, they need to help find appropriate ways to ensure that differences are acknowledged and respected, and to create grounds for collaboration and contestation, based on understandings that embrace the enormous fluidity and potential of Indigenous and Sustainability sciences and their encounters.

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Bridging Indigenous and Sustainability Sciences Together for Sustaining Resilient Landscapes and Livelihood in Rapidly Changing Social-Ecological Systems

Pei-Shan (Sonia) LIN, Department of Geography, National Taiwan University
E-mail: f97228001@ntu.edu.tw

Bridging Indigenous and Sustainability Sciences Together: Why, and How?

Sustainability science and Indigenous science are two research paradigms with a common goal: sustaining landscapes for a resilient human future. Although these paradigms have been studied in different academic fields according to their respective ontologies in recent decades, their streams of thought are actually closely linked through the common goal of sustaining the landscapes known as social-ecological systems (SESs). Both sustainability and Indigenous sciences recognize the dynamic, intertwined character of an SES and humanity as parts of nature crucial to sustaining our rapidly changing landscapes. Indigenous science not only focuses on maintaining "local scientific" viewpoints and methods but also searches for practical applications in modern society. On the other hand, sustainable science, with its transdisciplinary knowledge, has deepened insights into the complexity of the human-system–environmental interrelationship. Thus, sustainable science is eager to enrich its research concerns by collaborating with local peoples in creating sustainable landscapes for the well-being of humanity.

Unfortunately, even though Indigenous and sustainability sciences have the same goal and similar perspectives, their practitioners have not been engaged in productive dialogue either academically or practically. Although their different academic ontologies—in "hard" science and "soft" human/social sciences—may present some collaborative challenges, they need to form an allied relationship using their complementary bodies of knowledge for sustaining resilient landscapes. Before successfully joining Indigenous and sustainability sciences to uncover new insights and applications, we must clearly understand their strengths and limitations. Among all the steps and protocols, it is crucial to take an open-minded approach to understand each other's world view and ways of thinking, and then to put into practice with respect for local people, Indigenous knowledge, and scientific thinking. Then, we may be able to merge their strengths while mitigating the gaps between them in order to create resilient landscapes.

Sustainability Science: Structuring the Framework

Sustainability science originates from natural science. With its disciplinary research tradition and concerns, it has the strengths of systematic perspectives, logical frameworks, and analytical tools for investigating complicated issues. Therefore, sustainability science can analyze intricate relationships and mechanisms among factors in SESs.

On the basis of holistic concerns for socio-cultural, economic, and environmental conditions, sustainability science uses SES as an analytical framework for addressing complex sustainability issues. It generally begins by defining specific boundaries, simplifying factors, and then defining the relationships that form a system. Combining quantitative techniques with a new conceptual framework enables sustainability science to analyze dynamic SES systematically. Furthermore, a system-based perspective enables the research applications of logical thinking and methods, such as model and scenario simulations (Moran, 2010). With these strengths plus its recent progress in research methods, sustainability science not only recognizes the dynamic character of an SES but also expands the discipline by focusing rather narrowly on human effects on the environment). However, sustainability science has some limitations in explaining the details of less systematic concepts such as culture and analyzing SESs within the local context and its environmental setting. Sustainability science

tends to underestimate, or even neglect, the fine socio-cultural fabric that comprises resilience. Therefore, its results can be disconnected from local needs, and such a situation might cause local rejection of a project, even though the planning and scenario simulations seemed workable. Therefore, we must be fully aware of socio-cultural contexts while analyzing an SES; these intangible factors mitigate vulnerability and increase resilient dynamics. Engaging "local knowledge," formed within place-based culture, in initiatives for the environment challenges sustainability science. "Ecocultures," which was proposed as a supplementary concept in a sustainability-science-based SES, aims at reconnecting people with the environment for resilience improvement (Pretty, 2011), but the concept still needs more illustrative applications.

Thus, for investigating complicated issues, sustainability science shows merit in systematic perspectives, logical frameworks, and analytical methods but has limitations in explaining the details of less systematic concepts and analyzing intangible ideas.

Indigenous Science: Practicing Down-to-earth Initiatives

In contrast, Indigenous science is more socio-culturally embedded and locally oriented than sustainability science. Indigenous science originates from anthropology with human/social science as its literature background. It traditionally emphasizes Indigenous peoples' subsistence on their land and territories. Because Indigenous people, especially those who depend significantly on natural resources for their livelihood, maintain a close connection with nature, their living knowledge integrates human society and natural dynamic processes (Gadgil *et al.*, 2003). With the recognition of Indigenous people's intense interactions with nature and their unique environmental perceptions, Indigenous science has expanded its research concerns to sustaining the SES in daily practices.

Compared with other hard sciences, Indigenous science, which evolves from Indigenous knowledge, demonstrates the strengths of adapting to dynamic local contexts and embracing continually changing uncertainties. Furthermore, Indigenous science follows traditional thinking, which perceives humans and the environment as a holistic body of knowledge (Cajete, 1999). With an open-minded attitude, Indigenous science applies traditions of learning from nature and adapting to changes to develop resilient landscapes and styles of living. Because Indigenous science emanates from Indigenous people's daily knowledge about obtaining their livelihoods, they view it as everyday life and are thus comfortable with variations, uncertainties, and changes. In addition, Indigenous science activates traditional ecological knowledge derived from daily interactions with nature that nourish and further cultivate resilience to disturbances. With these strengths, Indigenous science not only prevents the loss of biodiversity by enhancing local resilience but also emphasizes the process of forming knowledge rather than the content itself, which are both important factors for sustaining resilient landscapes (Berkes, 2009). However, Indigenous science also has inherent limitations in analyzing complex interactions of SESs. For example, local context-based features are generally characterized by a lack of organized methods and logical standards. Although Indigenous knowledge might not be easy to pass down through documents or word of mouth, it exists in daily practices in a rich, multi-layered body of knowledge. Thus, it is difficult to organize Indigenous science into categories or to be practiced through linear development. Furthermore, the dynamic concepts of Indigenous science might cause difficulties in evaluating the "value" of a system. People who are used to thinking in a certain way may encounter difficulty in merging unconstructed Indigenous knowledge with highly structured science discourses for applications in the real world. Perceiving humans and the environment as a holistic system, Indigenous science is intensely condensed knowledge based on deep accumulated experiences, thus enabling it to adapt to the dynamic environment.

In conclusion, Indigenous science demonstrates the strengths of adapting to dynamic local contexts and embracing continually changing uncertainties. Also, it uses a holistic body of knowledge to view humans and the environment through traditional thinking. On the other hand, it poses limitations in systematically analyzing the complex interactions of SESs.

Niching Indigenous and Sustainability Sciences in Nexus: Open-mindedness, Understand, and Practice

Although both research paradigms have the same goal, they exhibit distinct strengths and limitations, but they also demonstrate great potential for integrating their strengths and minimizing their limitations. The strengths of sustainability science—systematic perspectives, logical frameworks, and analytical methods for investigating complicated issues—may minimize Indigenous science's limitations in systematically analyzing the complex interactions of SESs. Conversely, the strengths of Indigenous science—adapting to dynamic local contexts and embracing continually changing uncertainties—may minimize its limitations in explaining the details of less systematic concepts and analyzing intangible ideas.

A good example might be a local river conservation project in the Tongmen Village in Taiwan, composed of Truku people, and its promotion of the Meqmegi natural and cultural eco-landscape area. More specifically, two village communities aggregate into three settlements consisting of eight clans. The Meqmegi family is the largest clan in the village. In 1990, Typhoon Ofelia struck Taiwan and caused serious landslides in the village, killing 36 villagers. Afterward, some villagers began thinking about how to save the village from this sorrowful situation. They found that their beautiful rivers and fish might be a good starting point. After many discussions, in 2003, they asked the government for legislation to prohibit use of rivers for two years to allow the river to restock. At that time, residents divided the river into twelve sections on the basis of their traditional territories and voluntarily took turns patrolling their respective sections for protecting the fish. Besides using this "zoning concept" emerging from local knowledge, they transformed their traditional hunting groups into local "rangers" to protect their forest from deforestation and construct trails using traditional techniques. Thus, the richness of fish species rose, and environmental quality was significantly improved (Lin and Chang, 2011). At that time, they did successfully merge their traditional knowledge and modern conservation ideas together to restoring the rivers and fish for sustaining their landscapes and livelihood.

With preliminary success, the local association planned natural eco-corridors along the river and asked the government to authorize them. By the end of 2010, the local government passed a specific regulation establishing a natural and cultural eco-landscape area for the Tongmen Village and named it after the Meqmegi community. They aimed to make it the exemplary first case in Taiwan. However, some residents opposed the protected-area regulation, mainly because the planning process, including zoning, naming, and managing, was completed by a research team and a few residents of the Meqmegi community. Furthermore, most of the methods were drawn from recreational science, such as biomass simulation, tourist projection, and zoning rules for protected areas. However, the most important criticism is that the naming of the Meqmegi nature and culture eco-landscape area empowered the Meqmegi community, but disempowered other smaller communities and also led to the diminishment of their traditional territory. Thus, the other families believe that the protected area has stolen their roots. This case study perfectly shows that the bridging of Indigenous and sustainability sciences clearly sustained resilient landscapes in the early phase, but the disconnection between sustainability and Indigenous sciences led to negative effects. In addition, the experiences in the first phase suggest that convergence of the two streams of thought can sustain resilient landscapes. This case also echoes to the discussions during the workshop and the fieldtrip in Nisqually watershed that with understanding and respect during the governance process, Indigenous science and sustainability science do have great possibility to work hand in hand to taking care of both the natural environment and human well-being.

In recent decades, the global environmental change has threatened some species, ecosystems, and even human society. The sustainability and Indigenous research paradigms may not only bridge local SES issues but may also be integrated to address global SES issues by merging analysis techniques from sustainability science with local contexts derived from the perspective of Indigenous science (Chapin *et al.*, 2009). More specifically, Indigenous science can serve as the base for providing the contexts of changing landscapes, while sustainability science provides analytical approaches for mapping resilience patterns. To accomplish these goals, the

geographer's specialty in combining different research paradigms turns out to be crucial. Geographers, trained in both hard science and human/social science, can facilitate the transdisciplinary tasks necessary for the collaboration between sustainability and Indigenous sciences. Protocols such as workshops where people share various concerns and engage in collaborative brainstorming might help unify the two paradigms and contribute to a sustainable, resilient future. Education plays an important role to equip people for understanding various knowledge bodies and be able to respect other's thoughts. Then, exchanging thoughts and ideas during the projects' planning stages and agreeing on strategies that not only create resilience but also fit the local context can lead to long-term sustainability.

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WIS²DOM–Weaving Indigenous and Sustainability Sciences: Diversifying our Methods Workshop

Kyle Wark, Indigenous Research & Policy Analyst, First Alaskans Institute

Like others attending this workshop, I am an Indigenous community member trained in Western academia. My perspective on neither paradigm is dispassionate, but neither is dispassion necessarily warranted. Scientists are also human beings, and to some degree, all humans are scientists. We all relate our behavior and thought to observable phenomena (i.e., we systematize cause-and-effect relationships), which is the hallmark of science: yet none of us do that without bias, that is, without allowing our experience and cultural background to influence our observations and interpretations. Western science has developed a language and diverse collection of practices to reduce this bias, but cannot eliminate it altogether. While I recognize my own bias with regard to Indigenous and Western science, and may make attempts to minimize it; nevertheless, to divorce myself from my heritage would deny a vital part of my experience, perspective, and voice, and would tacitly privilege the Western academic paradigm over the Indigenous one. The scientific establishment tends to value the ideal of disembodied, abstract "objectivity" above all, while most Indigenous cultures primarily treasure relationships and human connections. (One could even argue that science simply replaces one type of bias with another, that the typical scientific definition of "objectivity" is itself culturally determined.)

From the perspective of the Indigenous paradigm, our traditions comprise refined strategies for the sustainable utilization of the local environment. Each local cultural suite constitutes an Indigenous thesis proposing various methods for the sustainable use of the land. For my culture, this suite encompasses 'stewardship' (i.e., being the land's 'caretaker' rather than its 'owner'), hospitality and sharing, clan relationships and historical knowledge, practices intimately tied to specific territories, and a deep emotional and spiritual connection to the land that produces informed observations of animals and plants and other ecological factors guiding the flow of seasons in a given region. Enduring local traditions like those of my Tribe reflect the consensus view of Indigenous peoples as to how to meet the needs of the traditional society for this and all foreseeable generations. (One particular point to highlight here is the emphasis on the "local" in local tradition: there was no "one size fits all" model for ecological preservation and utilization among Indigenous peoples.)

It's important to note that there are many branches of Indigenous knowledge just as there are within Western science (for example, as relates to navigation, medicine, construction, food preservation, etc.), but one example we could discuss in more depth is Traditional Ecological Knowledge, or TEK, as it is often called in the literature. TEK represents the collective knowledge of often hundreds of generations spanning thousands of years. As some of the presenters at this workshop noted, TEK also represents the collective effort of hundreds or thousands of people in each generation whose very livelihood depends on their ability to observe and correctly interpret dozens, hundreds, or thousands of ecological indicators so they can accurately predict, for example, when the next salmon run will begin, or where to catch the halibut that dwell hundreds of feet below the sea, or how high they can plant a potato plot. (In contrast, Western science typically looks at one or a handful of indicators, albeit quantitatively, and very closely.) In this sense, it is perhaps better to call TEK "Practical Ecological Knowledge" because it is based in practice; but that title unfortunately misses the theoretical component of Indigenous knowledge.

We don't just observe how things happen, we also have ideas concerning why they happen, that is, a theoretical model for cause-and-effect. Unlike with Western science, these theoretical models are often grounded in relational beliefs: for my Tribe, these beliefs include the sentience of animal and plant life, the reincarnation of spirits, etc. A key principle that falls out of these beliefs is that people must respect all other beings: without respect, the land withers and dies, the salmon don't return. It is not simply that people take animals because they have the power to do so; on the contrary, my Tribe recognizes that the animals are smarter, faster, stronger, and

have better senses than we do. If they did not want to give themselves to us, we could not catch them. Hence, for us, our ecological interactions are not framed as exploitation, but are instead seen as mutually beneficial relationships. Humans are an integral component of the health of the land; we provide for it even as it provides for us. My grandfather told me when our Tribe could harvest seals and seagull eggs from the neighboring National Park (which was the traditional homeland of my Tribe), there were more seals, more seagulls; now that our traditional subsistence practice has been banned, their populations have declined. In Yellowstone, some workshop attendees told me, similar patterns occurred: stopping the harvest of elk led to population increase, which led to overgrazing, which resulted in starvation, disease, and ultimately population decline. Embedded within this paradigm of mutual respect is a deep concern for the quality of the human experience. In my Tribe, that mutual respect and interdependency manifests itself in communal identity, rather than the focus on individualization that is common in Western societies.

The Western paradigm has a different set of strengths. Because it relies on measurable quantifiable data, Western science offers a method to assess the outcomes of different policy strategies, and consequently a way to monitor the progress of any one strategy through time. It also has a global perspective that is able to systematically integrate the impacts of ecological policy in many parts of the world across many different times – it isn't tied to local conditions (which is both a strength and a weakness).

Moreover, the shared ideology of the diverse fields of Western science (i.e., that the world is understandable through a systematic analysis of empirical observations) helps ensure the cross-discipline communication of theory, and results in a mutually intelligible format, such that the work of one field can often be utilized in another allied field. One stellar example of that collaboration is this workshop itself, which brings together biologists, geographers, ecologists, anthropologists, educators, and members of other Western academic disciplines. Much of this interdisciplinary communication is made possible through the shared reliance (and hence tacit understanding) of quantitative data, as well as a shared language of scientific and mathematical jargon (e.g., statistical terminology). To put it in different terms, there is a fundamental shared "culture of science" common across the academic disciplines, which can allow them to work together despite their superficial differences (just as there is within the Indigenous community).

As with the example from above (albeit for slightly different reasons), the deep roots that usually tie Indigenous cultures to their homelands are both a strength and a weakness: they can be a limiting factor that narrows the scope of experience, such that Indigenous peoples – drawing only from their own culture – might not be in the best position to suggest how others can manage lands outside their traditional territory. There are exceptions to this general rule, and oftentimes Indigenous peoples may feel that the attitudes and practices that they employ constitute a set of behaviors whose guiding principles are applicable elsewhere: they're just "common sense" and "human values" they might say. For example, the general principles of not taking more than you need and "leaving some behind" (e.g., when members of my Tribe harvest seagull eggs, they always leave 1-2 behind) – are principles that mesh well with Western ideas of "harvest caps" and avoiding "wanton waste."

However, the specific mechanisms to implement that principle – the policy that reflects those values – might be difficult for an Indigenous person to craft. I might suggest there is a hesitancy for Indigenous people to tell others what to do: even in our traditional pedagogy, which revolves around telling stories whose message the listener must work out for themselves, there is a strong tendency to allow people to make up their own minds and do as their conscience dictates; recognizing communal interdependence does not necessarily preclude emphasizing self-reliance. To put it another way, Indigenous peoples do not typically build a life ruled by fiat, as is the case in the "rule of law" Western states (where "word" is indeed "law"). Hence, adapting their thinking to the "rule of law" mentality can be challenging. Moreover, there may be difficulties when attempting to apply Indigenous strategies to people outside the Indigenous culture. For example, other authors have discussed how the worldview that fish and game are sentient creatures who give themselves to the people often looks askance

at catch-and-release "sport fishing" (as it rejects the fish's offer of its body), but simply telling a sport fisher not to catch-and-release fish because that is a violation of Indigenous spiritual values is not necessarily a productive policy. A more refined compromise must be crafted in those cases.

Similar conflicts can arise out of the other paradigm. Despite the best efforts of traditional Western academics, the scientific method was not developed – and generally struggles – to assess the emotional, psychological, and social impacts of policy, especially in multi-cultural settings. This deficit is most pronounced in the methods of "laboratory science," because human lives do not subject themselves easily to the demands of controlled experimentation. (It is unethical to do large-scale cultural experimentation on human beings, yet alternative social science methodologies such as surveys or ethnographic field visits are often criticized as non-rigorous by the "hard science" community.)

Consequently, there is a disconnect between the scientific community's (understandable) reliance on quantitative data and the lived reality of the general public. Emotions, psychology, and society –which together constitute the typical frame of reference of the "everyman" – are defined primarily by their qualitative, not quantitative, aspects. Human experience is difficult to relate to quantitative material: it is hard to become passionate about a number, and takes a strong effort of will to do so. Given the investment of emotions, time and energy into the methods and products of their research, scientists have already become passionate about "the numbers" (i.e., quantitative data). While in itself a strength, this situation can also make cross-cultural communication from inside the scientific community to non-scientists outside it especially problematic, insofar as those issues which define the matter for the scientists (i.e., "the numbers") do not have the same emotional resonance to non-scientists – and often, vice versa.

In particular, the scientific method offers no reliable guide to handling the real, important, but intangible concerns of Indigenous people, such as spiritual fulfillment, or the emotional commitment to honoring the lifestyle of our ancestors. There is no mathematical formula for human happiness and wellbeing, at least not in the same manner that there is for calculating salmon escapement recommendations. Not all Western academics ignore these issues – many are authentically passionate about their work and the quality of human experience, but they typically have to step outside the scientific paradigm to work towards those goals.

To reiterate, the strengths of the Indigenous science paradigm are local knowledge, deep time perspective, multi-factor analysis, and viewing the human being as a whole person connected with the whole world (rather than an abstract, discrete entity within a larger system). The strengths of the Western science paradigm are the ability of quantitative data to serve as a monitoring device for assessing different policies, or assessing a given policy through time; a global perspective that can compare local conditions to the wider region and worldwide systems; and the ability to collaborate across disciplines. Working together, Indigenous and Western scientists can create a deep picture of local conditions, compare those conditions with other parts of the globe, and craft policies that meet the diverse needs of people (as emotional, social beings) and that adapt the time-tested strategies of Indigenous people to large-scale multi-cultural populations. The primary effective means for collaboration between Indigenous and Western scientists is simply communication: sharing the study design, analysis and presentation of data with Indigenous people. Furthermore, both sides need to recognize the value of the other paradigm.

WIS²DOM–Weaving Indigenous and Sustainability Science: Diversifying our Methods

Jon Waterhouse, Yukon River Inter-tribal Watershed Council

Let me begin by asking that we don't go down the path of the Indigenous/Indians being reduced and held to the romanticized version so prevalent in popular culture, all Native People are not the crying Indian of 70's fame. Not losing sight of the fact that the Traditional culture lived within nature, but not always in harmony. At times we have reshaped our world and changed natural patterns to suit our needs just as any people would. There were successes and failures as with any culture. In the contemporary Native culture some, but not all, have lost their way and have been seduced by modernity, greed and plagued with apathy, leaving behind the Traditional values and respect. This is not to say that I think we should all live in the past as museum pieces. Native People throughout history have been quick to adopt new technology and techniques. But, as time passes, it is wise to not forget who you are and your place in the world as a real human.

Now, having said that, I must admit that I was unfamiliar with the term "sustainability science" or at least thought I was. Like anyone these days I turned to the Internet to find a definition and of course Wikipedia provided some insight. While reading the definition below it struck me that modern science seems to have finally matured to the point where they are beginning to understand the deeper meaning and relationship between people and science. For science, without people, is what exactly?

Sustainability Science definition from Wikipedia;

> "The cultivation, integration, and application of knowledge about Earth systems gained especially from the holistic and historical sciences (such as geology, ecology, climatology, oceanography) coordinated with knowledge about human interrelationships gained from the social sciences and humanities, in order to evaluate, mitigate, and minimize the consequences, regionally and worldwide, of human impacts on planetary systems and on societies across the globe and into the future – that is, in order that humans can be knowledgeable Earth stewards."

Admitting a limited understanding of Sustainability Science, I am beginning to see the importance of developing a relationship between the two tracks of thoughts as similar as connecting the neurons of the brain due to the parallels and their complimentary nature, no different than the relationship of fish to water, birds to the air or bears to land.

They are equal, but in need of each other.

The combination of these two sciences can complement each other to assist in making decisions for the future of resilient landscapes and the benefit these landscapes bring to the human race cannot be ignored, and if so, at the peril of humankind.

Some of the strengths within Sustainability Science, by its nature, being bred in the halls of academia, would be in the form of critical analysis and analytical problem solving. Not to say this doesn't exist in the world I come from, it does, just in a different manner.

It might also help break through the reluctance of some in the scientific world to allow for acceptance of Native Science.

Collaboration between Native/Indigenous Science and Sustainability Science, as the world moves into the future is critical to our success as humans. These are two powerful ways that have much to learn from one another and combined, will solve the challenges we face. I believe we will have to begin with an "understanding" approach (with open minds, leaving behind preconceived notions) that will develop the trust and respect needed for the collaboration to be successful. Spending time with one another and learning the "language" of the others discipline would be very helpful. I've seen times when modern scientists have come to the communities to give a presentation of results as a pay back to the community. One of the things they either forgot, didn't know, or disregarded was time. They didn't spend any time in the community, fly in- fly out, is not a good way to build a relationship. Spending a few days (at least) is a good way to build the trust and quite possibly learn things they missed in their study. Ideally this time spent together building collaboration would be a two way street. Meaning that Native People spending time exposed and immersed in the world of scientific understanding outside of their home communities and territories could prove valuable to the exchange of knowledge. Facilitating these times together could seem, on the face of it, difficult. I think though that over time they would prove to be most valuable. Another thing that was overlooked was "knowing the audience". A suggestion would be to tone down the Ph.D. level discussion points and bring the presentation to a level understood by the participants in the room. Otherwise, the fate that awaits is something akin to when, at one of these presentations, the Yup'ik Elders just started reading their newspapers and ignoring the presenter. Later that evening, after the scientist had departed, they asked a local biologist to explain what was said. Engage the community, visit with Chief, visit with the Elders (have a lot of time for tea or coffee).

My experience, with regards to this collaboration, is that the Native/Indigenous People are eager to learn from modern science. Of, course there are a few that don't trust scientists, but, in the last ten years even those folks have begun to come around. And, just for the record, they might not accept all that they are told and will discard or ignore the bits that they don't.

The younger generations seem to be the key in strengthening the bond between Native Science and Sustainability Science. Their path into the future almost demands this bond if they want to maintain their roots while being part of contemporary culture and technology. They are also not held back by the prejudices of their Elders. The same goes for the new, younger generation of non-native scientist that I have had pleasure and honor to meet and work with.

I believe the strength Native science brings to the conversation is a view that humanizes the science. Our connection to the natural world, the world we all truly live in, is manifest. The direct connection to the world around us is what created the science. This connection to the land, and lack of, has been described by Richard Louv in his book "Last Child in the Woods" as a critical need of the human condition. Native science is intertwined with the awe and respect of, and for, all things. The spiritual side of this vision of the world "that all things are connected within the circle" is something that sets the Native view apart. Apart from the .0001 of modern western science, giving a deeper human meaning to the observations and outcomes. This is an applied science that was developed through trial and error with the ultimate goal being the survival of the practitioners. Further, Native science has the strength and wisdom of age. Depending on who you listen too, the age is 15,000 years to time immemorial. By this measure, Native science brings to the table a vast storehouse of, as of yet, untapped knowledge.

As for limitations, so much has been lost through forced assimilation and destruction of the culture. As with many aboriginal groups, the conquered were subjugated, their beliefs outlawed and destroyed, replaced by new values and world views. Many of the new ways of viewing the world are in direct conflict with Traditional Native beliefs. The losses range from stories with scientific meaning to the marine architecture of Native vessels to natural medicines and so on. The oral history tradition of Native people limits the handing down of knowledge and science with the passing of the Elders and the loss of native language. The loss of language has possibly the most detrimental effect. Many words and expressions have no equivalent in the other languages limiting the conveyance of thoughts, ideas and knowledge. That lack, in some cases, of not having a true written language contributes to the difficulty in preserving knowledge through the generations. Along with this, the combined effect of language loss, lack of accurate translation and written language add to the obstacles of understanding for non- native scientist and others with an interest. Some of the effects on sustaining resilient landscapes are felt with the aforementioned modernity and greed.

In some cases Native People have moved far from the "Native" and closer to the modern or development (modern – lack of interest in traditional ways, language and heritage, greed, religion, politics, vices, etc., development – mining, clear cut logging, oil and gas, fracking, casinos, tobacco and alcohol industry, over harvest of fish, ocean, plant and animal resources, etc), leaving behind the Native science/TEK and a circular value system that has guided their cultures through the eons. Another limitation that must not be overlooked is the lack of quality education opportunity in the Native community and access to higher education. The devastating effects this has on the Native youth, barring their participation and success in the scientific fields and life in general, cannot be disregarded or ignored. A thought on remedying this would be to include in all Native/Indigenous - Sustainability Science Projects a budget line item, a percentage of the overall research grant/funding, for educational assistance and scholarships to Native youth.

Looking to protocols to assist in collaboration, I think it best that we discuss the ideas face to face once we've spent some time together at the WIS^{2}DOM Gathering. I think getting to know each other, even on a limited basis will help to begin creating protocols that will make sense. Expanding on that, I would offer that we find a way to spend some of our time meeting outdoors, maybe with a campfire, away from the four square walls that tend to confine exuberant thought.

WIS²DOM—Weaving Indigenous and Sustainability Sciences: Diversifying our Methods

Sustainability, Resilience and Well-being

Laura Zanotti, Purdue University, Email: lzanotti@purdue.edu

In the first few pages of Asserting Native Resilience, Grossman and Parker (2012) offer up two definitions of resilience, one which reads: "'Ability to recover readily from illness, depression, and adversity, or the like' buoyancy." My participation in this workshop is based on my long-term interest in buoyancy or building sustainable and resilient communities for present and future generations through valuing culturally diverse worldviews. As an environmental anthropologist, I have had the privilege for over ten years to work with local natural resource users, scientists, and invested stakeholders about ways in which to effectively address concerns about and obstacles to resilient landscapes and socio-ecological well-being.

Through partnering with the Kayapó, an Amazonian indigenous group, I have come to understand landscapes as comprised of multiple interconnected communities (people, animals, plants, fish, birds, ancestors, and spirits) that are made resilient through: 1) defending cultural, linguistic, and biological diversity; 2) nurturing multi-generational and multi-stakeholder exchanges; 3) forging creative alliances and partnerships on a variety of temporal and spatial scales; 4) valuing diverse perspectives of sustainability but at the same time recognizing power-laden fields of exchange and knowledge legitimation; 5) understanding that moral and ethical codes in relation to "nature" and the "environment" vary depending on epistemological, ontological, and methodological commitments; 6) creating interactive formal and informal spaces for learning in community, corporate, institutional, religious, and governmental contexts; 7) building robust economies while adhering to locally defined notions of prosperity and wealth; and 8) healing through socio-environmental justice. Attendant to research germane to sustainability science, this list is a composite of approaches from multiple disciplinary frameworks and local-level perspectives (Berkes and Folke 1998; Orr 2002; Berkes and Sexias 2005; Berkes 2007).

Over the past several decades, sustainability science has stressed understanding complex socio-ecological systems (SES) in order to address some of "wicked" problems of the twenty-first century (Rittell and Webber 1973; Clark 2007; Brown et al. 2010). An SES approach has emerged for several, interconnected reasons. In the 1980s and 1990s, a stark realization began to take hold that international development strategies, managerial regimes, and conservation programs over the previous decades had failed and, in some cases, resulted in increased vulnerability (Western and Wright 1994; Berkes 2004; O'Riordan 2012). These outcomes, coupled with flourishing social movements centered on widespread inequities and rights-based infractions, resulted in a jagged and not unproblematic transition from top-down, command-and-control solutions to participatory, community-based ones (Brechin et al. 2003; Brosius et al. 2005). Environmental agendas thus changed and according to new sustainable development paradigms began to address social, economic and ecological issues, such as with multiple-use forestry systems. Inherent in this shift was recognition that local knowledges or sometimes controversially referred to as Traditional Environmental Knowledge (TEK) are key to more sustainable futures (Silletoe 1998; Berkes et al. 2000; Dove 2006; Johannes et al. 2000; Johnson et al. 2007; Lauer and Aswani 2009). Meaningfully working with communities with worldviews often distinct from Western ways of being presents several possibilities for better grappling with the limitations of Western philosophies of science (Harding 2011:155). This understanding also brought with it implications for the co-production of knowledge across disciplinary divides and alongside Indigenous peoples, practitioners, scholars, and local users (Clark and Dickson 2003).

Yet, many obstacles are present when thinking about weaving together Indigenous and Sustainability Science. Despite decades of demonstrating the value of Indigenous science, non-Western knowledge systems are

unevenly and often insensitively integrated into research, policy, and action (Nadasdy 2003; Harding 2011; Kates 2011). Scholars also highlight the methodological, ontological, and substantive differences between Western science versus other types of science (Haraway 1988; Escobar 1998; Cajete 2000; Harding 2008; Harding 2011). For example, Gregory Cajete (2000) eloquently explains some of the differences between Native Science and Western paradigms. Cajete (2000:x) notes, "The Native American paradigm is comprised of and includes ideas of constant motion and flux, existence consisting of energy waves, interrelationships, all things being animate, space/place, renewal, and all things being imbued with the spirit" whereas Western science is more compartmentalized and object-driven. In a similar manner, Science and Technology Studies (STS) scholars marshal the criticism that Western science is Eurocentric and patriarchal and, as such, its colonial underpinnings are inevitably translated into an emphasis on scientific rationality, technical expertise, and the commodification of nature in conservation as development programs (Sullivan 2009; Harding 2011; Arsel and Bruscher 2012). Only through understanding science as a process that is embedded in social relations, dominant discourses, politico-economic worlds, and cultural values can we transform the practice into one that embraces feminist, postcolonial, and/or non-Western perspectives.

Where central arguments of STS research seem to point to an impasse in thinking about Indigenous and Western Sciences, other work has emphasized a more compatible vision of working with diverse knowledge systems. Agrawal (1995) dismisses what he sees as a fictitious "divide" between Western and Indigenous knowledge as fixed, stable and separate entities (also see Ellen et al. 2000). Instead, Agrawal (1995: 433) suggests, "It makes much more sense...to talk about multiple domains and types of knowledges, with differing logics and epistemologies." Acknowledging the heterogeneity of knowledge moves toward a politics of engagement and communities of practice—the key to equitable futures. Similar research has stressed that a more complex picture is emerging: Indigenous scientists as consumers and producers of scientific knowledge, non-indigenous scientists integrating Indigenous science into their research programs, the emergence of hybrid knowledges, and other types of unexpected exchanges taking place (Gupta 1998; Thomas and Twyman 2004; Noongwook et al. 2007; Lauer and Aswani 2009).

Moreover, work such as Grossman and Parker's (2012) highlight the unique position of Indigenous individuals, scientists, scholars, and citizens as contributors to local/global research about climate change and other pressing socio-environmental concerns. Grossman and Parker (2012) suggest that Indigenous groups bring distinctive traditional knowledge systems, the power of sovereignty, a sense of community built on care and support, and the acknowledgement of necessary and immediate action to global conversations concerning pressing issues. Without dismissing the historical and contemporary landscapes of inequity and silence, these programs outline pathways for a possible future that translate the discourse of empowerment to practice. Indeed, the emphasis on resilience and sustainability should be soldered to engaged scholarship where the research process is also one of sharing and decolonization (West 2005; Denzin et al. 2008; Kovach 2009; Tuhiwai Smith 2012).

I find the strength of considering an approach to Indigenous and Sustainability Science is that it has the potential to powerfully addresses global challenges while tailoring solutions to locally situated sacred landscapes. Here, I find kinship with standpoint theory, also built from STS work that, "recognizes the positive scientific and political value of local knowledge without falling into claims either of its absolute, universal validity and applicability or of its legitimacy by only local standards" (Harding 2011:21). Continuing to envision different possible pathways of linking Indigenous and Sustainable Science seems to be vital for future decades. Moreover, avoiding a top-down or one-size-fits all perspective will be imperative as we forge ahead. Building spaces for sharing and learning, outlining practices for collaboration, and highlighting areas of mutual interest and the associated mix methods that accompany them will be critical (Mertens 2007).

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Developing a Relational Approach to Resilience

John Ziker, Boise State University

Introduction

In this century of epic climate change there is an urgent need to bridge the gap between sustainability sciences as housed in urban centers and the sustainable strategies held by indigenous communities. There is a growing consensus that humanity needs to act promptly in order to ensure that our planet remains resilient for the future. But how we conceive of the problem and solutions to it differ tremendously. Do we engineer and manage our way out of the situation, or do we return to our roots? Do we push forward with technology without questioning how technology is used?

An underlying issue that makes bridging the gap difficult is that sustainability sciences, following the Western intellectual tradition formalized by Descartes, typically assume a separation between human systems and natural systems (Ingold 2000: 3). Fields such as ecology, engineering, resource management and most social science fields struggle to conceptually integrate human and natural systems in their research.

On the other hand, indigenous approaches to sustainability assume that individuals are embedded in fields or spheres of relationships (Ingold 2000: 209-219). These relationships include people and non-human personages alike. There is virtually no conceptual separation of the human and the natural. The question is: do such conceptions ensure sustainability? There is a strong sense that indigenous communities hold knowledge about how to dwell in the world in ways that are more compatible with long-term resilient landscapes. These knowledge and practices are referred to in the literature as traditional ecological knowledge (TEK). However, there is significant debate in both the academic and popular literature about whether or not traditional ecological knowledge always or necessarily leads to sustainable outcomes with the evidence of indigenous societal collapse (Diamond 2005, Hames 1996, Krech 2005, Smith and Wishnie 2000).

It is my contention that the reason why there is confusion about traditional ecological knowledge—and its role in creating resilient landscapes—is that it is viewed with much the same dualism that is pervasive in the sciences. Further, it is not a stretch to suggest that many resource managers and policy makers conceive of traditional ecological knowledge in terms of its *functionality* in relation to (changing) natural systems. There is apprehension that with changing environments, traditional ecological knowledge will no longer serve indigenous peoples, particularly in regions with rapidly changing climate, such as the Arctic. Such knowledge, and the people who maintain it, are viewed as little more than museum pieces. There is an urgent need to de-museify such knowledge and to translate it to wider human society (Ziker and Stammler 2011). For many indigenous communities, drawing lines between natural and social systems is an alien concept; to the contrary, their relationship to the environment is experientially and cosmologically embedded. How then to build a shared understanding?

The Approach

This question requires us to develop a new integrated approach to sustainability, moving beyond conceptual and cultural divisions. By focusing on relationships and the development of relationships in a context of traditional ecological knowledge we can better understand the processes and contexts in which ecologically respectful, "whole" people are reproduced. This perspective prioritizes indigenous philosophies and the growing engagement of indigenous scholars in the academy, while utilizing the tools developed by scientific communities. Techniques to understand the structures and characteristics of social network data and skill development in social network contexts are tools that have great promise in understanding relational behavior (Armitage et al. 2011).

Policy researchers have recognized the importance of social networks for multilateral action, extending beyond interpersonal cooperation to link in with various orders of governance (Evans 2011). Of particular interest to developing a relational approach to resilient landscapes is the way that traditional knowledge (e.g., virtuous practices and sacred ecologies) ameliorates collective action problems. A necessary element in this research is the need to understand the roles of the communicative processes that bring traditional social networks into existence (i.e., the social networks that foster traditional ecological knowledge and ecological wisdom).

A story from my own fieldwork in Siberia illustrates how traditional ecological knowledge helps to support prosocial norms (vs. egoistic behavior). I respectfully repeat this story about a man and the Lower World in memory of Oksye Bezrukikh (b. 1907), great aunt of one of my best friends in the Taimyr Region. This is a story of an ordinary man with two sons. Only this man did not like to communicate with other people, so he and his family lived alone. He did not even allow his sons to visit with neighbors. And so, they lived alone with no neighbors – just their family.

> Once, the man went to gather his reindeer. Having rounded them up, he turned the herd in the direction of his *chum* [conical tent]. He started to look at his surroundings and back from where he had walked. He saw that the earth was ripped. A deep cavity appeared where he had just walked on solid ground. He began to walk by the edge of the canyon and he asked himself, 'How is it that I did not notice this? I almost killed all my reindeer.'
>
> At that point the man himself fell into the void. He fell. He fell a long time in the nothingness. He fell until he perceived the ground, solid under his legs. It turned out to be solid earth.
>
> The man saw three *chumy* [plural of *chum*] in the semi-darkness. Farther off in the dusk he saw a big herd of reindeer. The *chumy* were big – gigantic, in fact. Near the central *chum* he saw two people blacksmithing. The man walked up to the camp, approached the blacksmiths, and said, 'How do you do?'
>
> One of the blacksmiths asked the other, 'What happened?' Their fire crackled. The other blacksmith said, 'Why is our fire trying to tell us something? *Ot* ähätär.' [The fire is our grandfather.]
>
> The man from the Middle World said to them in surprise, 'Ah, hey! What happened to you?' And again he said, 'Hello.' The two blacksmiths did not see the newcomer. One said, 'Something is going to happen. We need to stop working.' They paid no attention to the man from the Middle World. 'Let's go home,' they said. And the blacksmiths went into their chum. The man from the Middle World followed right behind.

The story continues with the man from the Middle World trying to communicate with the Lower World people. When he talks, they hear the fire crackle. The Lower World people make sacrifices to the fire, but these do not help, and the fire continues to crackle when the man from the Middle World talks. He sits in their *chum*, hungry, while a Lower World woman makes soup out of bones. When the Middle World man touches one of their reindeer, it falls down and dies. When he sits next to the daughter, she falls ill. The Lower World family observes these ill omens and calls for a shaman. The shaman arrives and performs a shamanic ritual [*kamlanie*], but to no avail. The Lower World people search out and find another, more powerful shaman, who upon arrival to the camp can see the man and understands their problem. The second shaman asks the Lower World family to complete several sacrifices, and during a *kamlanie* he calls the powerful spirit Ayyi from the Upper World to take the man back to his world, both riding on a great white reindeer. Before he leaves, the shaman tells the man from the Middle World that he must live near other people and let his sons visit. Upon his return, the man rejoins his community and retells the story of what happened to him.

This narrative, and others like this one, reinforces social norms of cooperation through the vicarious experience that behaviors have consequences. When listeners respectfully listen to such narratives, they reflect on their own behavior and are encouraged develop intentions to behave in a virtuous, cooperative manner. Such

communication and acceptance can be observed and analyzed to better understand how resilient social norms develop and serve to reduce self-aggrandizing behavior (Ziker 2013).

Since much of human behavior is socially acquired, individuals must learn skills from other individuals in their communities and in educational settings. It is these social relations of learning that are critical for both calibrating human needs and expectations and acquiring the skills needed to attain these goals. Ultimately, through better understanding the sources of variation in how human needs are defined and met through traditional ecological knowledge and skills, we can better understand this key human variable in sustainable and resilient landscapes.

Discussion

Developing a relational approach to resilience entails theoretical and methodological collaboration between indigenous communities and the advocates of sustainability science. The strengths of sustainability science, including objectivity, methodological rigor, and validity, are its greatest weaknesses. The indigenous approach to sustainability is holistic and relational—characteristics that pose challenges to scientific inquiry. Through training in the social network analysis and skill development research, techniques developed by social scientists can be transferred to indigenous communities so that they can be empowered to do the research on how their traditional ecological knowledge adds to resilience. At the same time, empirical data generated with relational, indigenous perspectives as the starting point can help to move sustainability science forward without ontological dualism.

Current approaches to systems resilience typically assume a separation between human and natural systems that are subsequently integrated in ecological models. In the Brundtland Commission's definition of sustainability— "one in which human needs are met equitably without harm to the environment…"— humans and the environment come across as separate and distinct systems. It is ironic that this common definition of sustainability reflects the Cartesian dualism that some have argued is an ultimate cause of our current global warming crisis.

A relational approach to resilience that is centered on indigenous perspectives that emphasize interconnectedness with the environment will move sustainability science forward in a more holistic way. Humans have the predisposition to behave for the collective good as well as for ego. It is in the developmental process (and very importantly the social environment of development) where we see social norms forming, specifically: the definition of "us," various frameworks for decision-making (i.e., profit motive vs. subsistence), thresholds for needs, as well as expectations, consequences, and definitions of virtuous behavior.

Building resilience into the substance of academic inquiry rather than making it solely the object of inquiry is an ethical principle and a methodological approach that makes science a two-way process rather than a one-way means of dissemination of scientific information. It also enables the relational approach to resilience to become a self-sustaining method that enables the translation of resiliency from one social context to others. Local and self-organizing efforts to improve resilient landscapes are already occurring in urban and industrial contexts. For example, community supported agriculture, downtown farmer's markets, bike friendly planning, permitting chickens in the city, and the local sourcing movement are contributing to positive change. How to best nurture these efforts without turning to market models or state control would benefit from greater study and wisdom from traditional indigenous societies.

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