BIOCULTURAL ENGINEERING DESIGN FOR INDIGENOUS COMMUNITY RESILIENCE

by

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TABLE OF CONTENTS

LIST OF FIGURES 7

ABSTRACT 8

CHAPTER 1. THEORY AND METHODOLOGY 9

INTRODUCTION 9
THEORY 10
RESEARCH QUESTION AND METHODOLOGY 19

CHAPTER 2. ARTICLE 1. BIOCULTURAL ENGINEERING DESIGN: AN ANISHINAABE ANALYSIS FOR BUILDING SUSTAINABLE NATIONS 23

ABSTRACT 23
RESILIENCE, RELATIONSHIP AND VISIONS FOR THE FUTURE 23
THE ANISHINAABEK 28
ECOLOGICAL ENGINEERING DESIGN 36
THE BIOCULTURAL ENGINEERING DESIGN METHODOLOGY 47
CONCLUSION 54
ARTICLE 1. REFERENCES 56

CHAPTER 3: ARTICLE 2. A SOCIAL ANALYSIS OF INDIGENOUS ECOLOGICAL DESIGN METHODS IN INDIGENOUS COMMUNITIES 61

ABSTRACT 61
INTRODUCTION 61
INDIGENOUS ECOLOGICAL DESIGN 62
SOCIAL ANALYSIS OF INDIGENOUS ECOLOGICAL DESIGN IN PRACTICE 65
MOVING FORWARD 69
CONCLUSION 72
ARTICLE 2. REFERENCES 76

CHAPTER 4: ARTICLE 3. INDIGENOUS ECOLOGICAL ENGINEERING: A DESIGN APPROACH FOR BUILDING RESILIENT NATIVE NATIONS 78

INDIGENOUS RESILIENCE, CHALLENGES, AND AN AVENUE FOR INNOVATION 78
INDIGENOUS ENGINEERING DESIGN METHODOLOGY 83
INDIGENOUS ECOLOGICAL ENGINEERING IN PRACTICE 85
CONCLUSION 100

ARTICLE 3. REFERENCES 103

CHAPTER 5. CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH .. 106

CONTRIBUTIONS TO LITERATURE 106
LIMITATIONS AND FUTURE RESEARCH 108

REFERENCES 110

APPENDIX I 122

LIST OF FIGURES

FIGURE 1. 13

FIGURE 2. 14

ABSTRACT

Indigenous peoples worldwide are engaged in the process of rebuilding and re-empowering their communities. They are faced with challenges emerging from a history of physical, spiritual, emotional, and economic colonization, challenges including a degraded resource base, lack of infrastructure, and consistent pressure on their land tenure and ways of life. These communities, however, continue demonstrating profound resilience in the midst of these challenges; working to re-empower and provide for the contemporary needs of their people in a manner grounded in supporting bio-cultural integrity; the interconnected relationship of people and homeland. At the same time, in response to contemporary environmental degradation, the fields of resilience science, adaptive management, and ecological engineering have emerged, the recommendations of which bear remarkable similarity to Indigenous ontologies, epistemologies, and governance structures.

The relationship between these fields and Indigenous epistemology, underscored by experience in the field, has led to the conceptualization of bio-cultural engineering design; design that emerges from the inter-relationship of people and ecology. The biocultural engineering design methodology identifies the unique cosmological relationships and cultural underpinnings of contemporary Indigenous communities, and applies this specific cultural lens to engineered design and architecture. The development of resilience principles within the fields of architecture and engineering have created avenues for biocultural design to be translatable into engineering and architectural design documents, allowing access to large scale financial support for community development. This method is explored herein through literature and analysis of practical application in several different Indigenous communities and nations. This method lends itself to future research on biocultural design processes as a source of technological and design innovation as Indigenous communities practice placing their values and cosmologies at the center of development decisions, as well as comprehensive start-to-finish documentation of the methodology applied to diverse engineered applications, including water systems, energy systems, and building construction.

CHAPTER 1. BACKGROUND, THEORY AND METHODOLOGY

INTRODUCTION

The purpose of this work is to develop the concept and process of biocultural engineering design, evaluating its potential role in contributing to Indigenous community resilience. Bio-cultural engineering design emerges from the inter-relationship of people and ecology, with a focus on Indigenous and land-based cultures. I have come to explore the formalizing of this approach as a response to my work within Indigenous environmental justice movements and the organization Sustainable Nations, offering ecological engineering and design training, construction, and program development within Indigenous nations and communities.

The creation of the organization Sustainable Nations was a response to the Indigenous environmental justice and human rights movements, which organize to prevent exploitive industries from contaminating and commandeering Indigenous lands while simultaneously building social, cultural and political power to move Indigenous communities from positions of oppression to positions of authority. Due to the destruction or degradation of Indigenous traditional economies and the complex impacts of colonization, this oftentimes includes working with our own people to convince them not to accept or seek out contracts that would be destructive of their own lands. In discussing the hopelessness and struggles of our community members, I came to the belief that our suicide, substance abuse, and social struggles are contributed to by the perceived inability to maintain traditional spiritual and cultural values and live in the modern era. These discussions also led to the understanding that in order to resist negative forms of economic or infrastructure development, we bear the responsibility to create alternatives that regenerate the ecological, cultural, and social health of our peoples. I personally

have had the privileged opportunity to access engineering and design training in sustainable building, energy generation, and water management techniques and realized that, at the time, this training was inaccessible to most of our people, not only due to cost and proximity, but also the cultural context in which this type of education was offered. We created Sustainable Nations in order to offer culturally based technology and design training and development services with the specific intent of strengthening and re-Indigenizing our nations, allowing our communities to maintain our unique cosmologies while practicing our values in our modern lives. Through this work, I have witnessed the power of cultural relationships with land and community still present in diverse Indigenous communities. I have learned that all it takes is the creation of avenues of possibility for these relationships, cosmologies, and values to be expressed in design, development decisions, and infrastructure for the creative visions and designs of the communities themselves come to fruition. It is time to share these stories, possibilities, and our design methodology, formalizing them through analyzed cases the written word to allow not only grassroots families and organizations to use these methodologies, but also our Indigenous governments as they navigate the necessary administrative processes to rebuild culturally and ecologically resilient nations.

THEORY

The interdisciplinary social and scientific nature of this research requires the use of an integrated theory. My work is founded on critical Indigenous theory, and the theoretical and scientific approaches of resilience and ecological engineering to analyze the biocultural engineering design methodology.

CRITICAL INDIGENOUS THEORY

I utilize a critical Indigenous theoretical foundation as described by Denzin et. al., McCoy, and Kovach. The critical Indigenous theoretical approach acknowledges that all research has both political and moral implications and underpinnings. This approach seeks to uplift local Indigenous knowledge, with a focus on healing, re-Indigenizing, and serving a performative function (Denzin et al, 2008; Kovach, 2009; McCoy, 2007). Some important tools of critical theory are stories and narratives from the people themselves, and the subsequent deconstruction of doctrines and structures that maintain external hegemony. Indigenous critical theory focuses on the intersection of 'race,' indigeneity, and the process of colonization as the lens through which to explain the circumstances Indigenous peoples find themselves in. It has a stated purpose to advance empowerment of the people, a commitment to dialogue, community voice, self-determination, and cultural autonomy. It also resists efforts to confine inquiry to a single paradigm or interpretive strategy, acknowledging the need to continuously adapt. In a divergence from traditional critical race theory, it has an emphasis on the collective local empowerment, rather than an emphasis on the empowerment of specific individuals. Inherent within this approach is an emphasis on identifying both the meaning, importance of, and process of decolonization (Brayboy, 2005). As Dr. Michael Yellowbird describes, since the truths about the colonization of the Americas have been denied or otherwise explained away, Indigenous truth-telling, becomes an important strategy for decolonization (Yellowbird & Wilson, 2005).

My particular use of critical Indigenous theory has been shaped by conversations with Jose Malvido of the Peace and Dignity Journeys. While supporting the concept and processes understood as "decolonization," he identified that this approach still relies on colonization for its

identity. Decolonization is a reaction to oppression, which, while necessary, is not the final step in our journey. Malvido utilized the term "re-Indigenizing," describing both philosophy and praxis that relies on the identification of our core values and cosmologies. It is these that give one the responsibilities and relationships with land and community that make one Indigenous. Actions generating from these, rather than actions generated from response to colonial oppression, may give us a stronger foundation for regenerating our nations (Malvido, 2014).

As an Anishinaabe person approaching Indigenous research from an Anishinaabe ontology, I acknowledge that underlying my research approach includes awareness of the interconnectedness of all things, the spiritual realm that is infused in all aspects of life, the impact of motives and intention, emphasis on lived experience as the foundation for research, the sacredness and responsibility of maintaining personal and community integrity and the recognition of cultures as living processes (McCoy, 2007; Watts, 2006).

RESILIENCE THEORY

The theory of resilience is based on understanding the world as made up of diverse social-ecological systems, linking the human and ecological realms. Social-ecological systems are complex, adaptive, and dynamic, lending themselves to analysis utilizing complex systems theory. These systems are modeled as a collection of interacting synergistic agents, evolving via feedback loops. Complex systems are interconnected and unpredictable; changes in any part of the system may have effects throughout the entire system. They are also self-organizing, in the sense that interactions produce coordination and synergy, with emergent properties that cannot be reduced to evaluation of the agents themselves (Heylighen, 2008; Stewart, 2003; Corning, 1995; Levin, 2005; Kauffman, 1995).

Out of the study of the self-organizing nature of complex systems has emerged a special focus on the resilience of these systems. Resilience is the term used for the capacity of a system to continually change and adapt, yet remain within critical thresholds, referring to the capacity of a system to both withstand disturbances and to rebuild itself afterwards (Walker et al, 2006). The resilience of a given system is strongly related to the adaptive capacity and the potential transformability of the system (Gunderson, 2000; Folke, 2006). Resilience is an emergent property of social-ecological systems, supported by elements and processes acting across spatial and temporal scales (Thompson et al, Gunderson, 2000).

Resilience theory deals with the dynamics and development of complex systems, advancing the concept that social-ecological systems can exist in more than one type of stable state (Folke et al, 2010). If a system changes too much, it crosses a threshold and begins behaving in a different way, with different feedbacks, termed a 'regime shift' (Gunderson et al, 2010). A visual representation of these different stable basins and threshold points are represented in Figure 1.

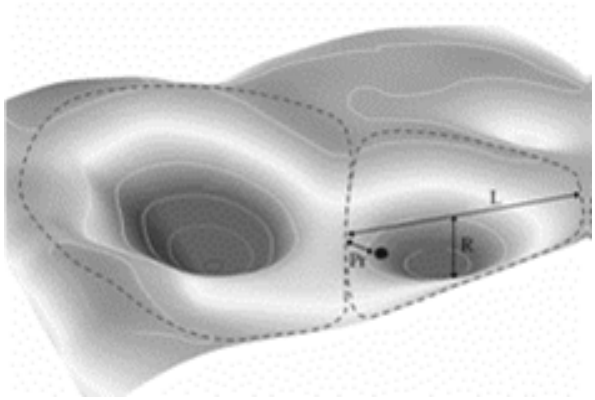

Figure 1. Diagram of Thresholds[1]

[1] Walker, B., Holling, C. S., Carpenter, S. R., Kinzig, A. (2004). "Resilience, adaptability and

The term 'adaptive cycles' describe how these systems change over time, emerging from system dynamics. Adaptive cycles are seen to go through four phases; rapid growth (r phase), conservation (K phase), release (omega phase), and reorganization (alpha phase). The release phase is initiated by a disturbance that exceeds the systems' resilience and breaks the web of reinforcing interactions, resulting in an energy release from the system. Examples include fire, drought, and disease. Within this chaotic release, new options are open for reorganization and renewal. The nested sets of adaptive cycles within social-ecological systems have been termed 'panarchy,' visually represented in Figure 2 (Gunderson et al, 2002).

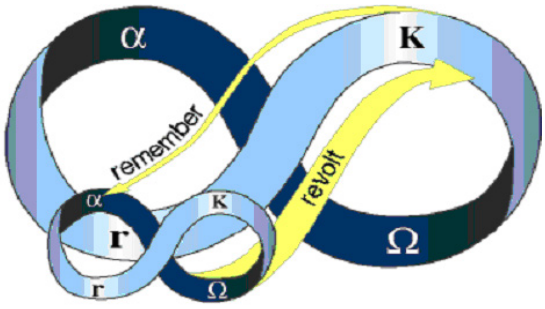

Figure 2. Visual Model of Panarchy[2]

In this model the adaptive cycle, represented by the figure eight, does not simply exist on its own but as part of a set of interlinked and nested adaptive cycles. These cycles exist across scales of space and time, from the quantum to the universal. The smaller scale, faster levels are those of inventing, experimenting, and testing. The larger, slower levels stabilize and conserve the accumulated memory. The connections between levels are seen as essential for the sustainability of the system, as they allow for the new, creative principle to inform the older, established system, and vice versa (Gunderson et al., 2002).

[2] Online url: www.resalliance.org/panarchy

All of the elements within a social-ecological system can be described as variables, and while any of these variables can have affect the system, there are usually only a small number of 'controlling' variables that can tip the system over a threshold. These variables typically operate in the slower levels of the adaptive cycle (Walker & Salt, 2006). A system is understood to be resilient if it exhibits 1., productivity (obtaining resources and also accumulating resources for the potential they offer in the future); 2., features a shifting balance between stabilizing and destabilizing forces reflecting the degree and intensity of internal controls and the degree of influence of external variability; 3., has the ability to generate and sustain both options and novelty, providing a shifting balance between vulnerability and persistence; 4., is capable of self-organization, and 5., has a high adaptive capacity and ability to learn (Walker et al, 2002).

Adaptive capacity in ecological systems relies on diversity, the principle of functional redundancy (in which many beings are capable of performing a similar ecological role), and the mosaic, 'patchy' patterning of the landscape, and periodic perturbations. In social systems, adaptive capacity is dependent upon the existence of institutions and networks that are capable of openness to new information, as well as the ability to incorporate that information into social memory. The ability to create flexibility in problem solving and balance power among interest groups is also a crucial component of a resilient social system (Berkes et al; 2003; Berkes et al, 2000; Davidson-Hunt, 2003; Davidson-Hunt & Berkes, 2003; Folke, 2004; Ostrom, 2007; Costanza Walker et al, 2006). Adaptive learning and memory are encoded in the system by the motion of the system through the networked cycles of the panarchy. This is demonstrated through the process of human learning and memory (social memory), but also the adaptive learning and memory stored in the rest of the ecosystem (ecological memory) (Berkes, 1999).

Resilience in Engineering

Engineering is the study and practice of meeting human needs with systems design (Kangas, 2004; Allen et al, 2003). These systems can include structural engineering in buildings, electrical engineering, civil engineering, chemical engineering and more, addressing our needs for safe buildings, transportation, energy systems, water systems, and food production. The standard fields of engineering developed highly technological design responses to serving human needs, focused primarily on the service needed to be performed, with a limited scope of variables to consider (Allen et al, 2003; Bergen et al, 2001). This system of analysis rests firmly on the principle that 'Nature' is a passive resource – or set of 'materials' – to be utilized to perform services; the perceived separation of humans from the 'environment,' and relatively easy access to resources obtained from long distances (Van der Ryn, 1996; Martin et al, 2010).

Engineered systems, reflecting these principles, resource access, and societal drive towards standardization, have been designed out of their surrounding context as closed systems, designed to operate close to a single chosen equilibrium point. Emphasis has been on the ability to predict or control design outcomes, and the assumption of a surrounding stable state underpinned this form of engineering design (Schulze, 1996). Treating error as a thing that can be counted and addressed with interventions to reduce that count. The concept of resilience in the field of engineering, then, has been associated with the ability of a system to remain in a stable state, or return to that stable state rapidly (Walker et al, 2006; Gunderson et al, 2010; Holling et al, 1973). This definition of engineering resilience, however, is changing. These forms of engineering design have led to infrastructure that is poorly designed to function in a dynamic

world, and have contributed to ecological disruption, climate change, and social inequity worldwide (Schulze, 1996).

The varying engineering fields are responding to the need to engineer sustainable and equitable solutions. Civil and structural engineering literature addresses a new focus on social-ecological equity and sustainability, chemical engineering has emerged 'green chemistry,' based on the principles of biomimicry, humility, and a 'do no harm' ethic, and the list can go on (Wahl, 2012; Schulze, 1996; Haggard et al, 2006; Reap et al, 2005). These new directions in engineering are moving towards an understanding that design occurs in the dynamic and complex realm of social-ecological systems, and design principles that mirror ecology and contribute to ecological resilience are actively encouraged to be the new foundation for engineered design, particularly within the field of ecological engineering (Bergen et al, 2001; Allen et al, 2003; Fan et al, 2004; Herman, 1996; Kangas, 2004; Mitsch et al, 2004; Odum & Odum, 2003; Reap et al, 2005; Todd et al, 1996; Wahl, 2005). The standard definition of ecological engineering was created in 1996 by Mitsch, who stated that "ecological engineering is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" (Mitsch, 2004; Bergen et al, 2001). Ecological engineering incorporates the natural complexity, adaptive dynamic nature, and self-organizing principles of ecosystems into the analysis as the basis from which design should occur (Allen et al, 2003; Bergen et al, 2001; Van derRyn, 1996; Fan et al, 2004; Reap et al, 2005; Mitsch et al, 2004; Howard, 2004). Ecological engineering has to be a flexible iterative process of design in which the designer must continually update goals, essences, typologies, and processes of realization (Odum & Odum, 2003; Todd et al, 1996). Hollnagel et al. emphasized that in the case of 'hard' engineered

structures, particularly, the human role as part of the system is critical to maintaining the resilience of engineered systems: humans are capable of providing the role of the primary adaptive element in the face of complexity emerging from change (Hollnagel et al, 2006).

The concept of resilience has undergone shifts in the light of external drivers such as climate change. External drivers are seen as drivers that exist at higher levels of the nested sets of adaptive cycles -sometimes referred to as 'outside' the system (Folke et al, 2010; Thompson, 2009; Walker et al, 2012). External drivers can affect the slow variables within the system, and when these slow variables approach threshold levels, fast variables can fluctuate more dramatically in response to perturbations or surprises, pushing the entire system over the threshold into a new stability regime (Walker et al, 2012). It is encouraged, therefore, to focus research on understanding the relationships of these slow variables to external drivers – seen in contemporary analyses of the slow variables of soil fertility, dissolved carbon dioxide in the ocean, and biodiversity in response to the external driver of climate change (Walker et al, 2012).

Folke et al. (2010) described three aspects of social-ecological resilience: persistence, adaptability, and transformability. Persistence, relying on the social-ecological systems' adaptive capacity, describes the ability of the system to remain within the stable basin it currently occupies. However, within resilience thinking social-ecological systems can occupy more than one stable basin. Transformability refers to the ability of a social-ecological system to self-organize into a new stable basin, or equilibrium, rather than experience a forced transformation that could be chaotic. Self-organized transformability is seen to utilize crises as windows of opportunity, encourage options and novelty, and incorporate social learning. It is understood that transformability within smaller scale nested sets within a panarchy can contribute to the

persistent resilience of the larger scales. In light of profound external drivers of change, such as climate change, the emphasis in much of the resilience literature seems to be shifting towards building the adaptive capacity and transformability of the social side of the social-ecological system, addressing social change, governance, and adaptive, community based management for renewal, reorganization, and development (Folke et al, 2002; Lemos et al, 2007; Ostrom, 2007; Costanza et al, 2001; Norberg et al, 2008)

RESEARCH QUESTION AND METHODOLOGY

This work, designed to address the practice and process of biocultural engineering, asks 'Can Indigenous practices, epistemologies, and relationships with ecology and cultural community provide the foundation for contemporary ecologically engineered design?' This larger question was addressed through dividing the research into the following subquestions: 1.How does ecological engineering and resilience thinking align with Indigenous cosmology?, 2. How can this alignment be used to formalize a process of biocultural engineered design?, 3., What are the social and cultural considerations of this design process?, and 4. Can biocultural design cultivate resilience in Indigenous communities? This research was carried out using an Indigenous participatory action research methodology, with it's clearly stated commitment to both serve and be accountable to the communities one is working with, also drawing on the practices of observational ecology, ecological engineering, and resilience science. Indigenous participatory action research seeks to produce research outcomes and action simultaneously. The site of action is the development of designed systems that draw on an Indigenous way of relating to the local social ecology, that also incorporate contemporary design elements of ecological engineering as fit the needs and desires of the community. According to Allen (2001), the four

basic themes of the participatory action approach include 1., collaboration through participation, 2., acquisition of knowledge, 3., social change, and 4., the empowerment of participants. The standard participatory action research involves planning, acting, observing, and reflecting, requiring a reflective researcher who is accountable, self evaluative, and participative (Allen, 2001). In utilizing an Indigenous methodology, it is important to locate oneself in relation to the research. I came to this research topic through both my background in ecology and engineering, in combination with my responsibility as an Anishinaabekwe (an Anishinaabe woman). I was captivated at a young age by the alignments of contemporary science, the stories I heard growing up, and the way of being I was encouraged to develop. Originally it was the fields of physics and the mathematics of complexity that captured my attention, now unfolding into environmental sciences, ecology, and engineering. I am a mixed heritage woman, of European, Anishinaabe, and Wyandot descent, raised in the Yurok community of northern California, in which I have family ties as well. I have a strong foundation in Anishinaabe understandings, and a sense of responsibility in relation to Anishinaabe culture, given to me by both my upbringing and through my experience re-connecting as an adult. I also have worked in the international, interlinked Indigenous community for many years. However, as I was not brought up within the Anishinaabe community, part of this research includes reflecting in detail on my own upbringing and family stories with other Anishinaabe people. Within the communities I will be working with, I have had both an insider and outsider perspective.

In order to receive detailed and critical feedback of my analysis of biocultural engineering to a specific Indigenous cultural context, I chose to analyze the method within the Anishinaabe context. I chose to do this because my personal heritage and connections to

Anishinaabe people would allow a deeper level of communication and feedback than I would be able to access with an entirely foreign culture. I gathered a cultural review committee of Anishinaabe people who are acknowledged traditional knowledge holders; those who would be able to speak in an educated manner regarding Anishinaabe ways of being. The cultural review committee members as well as the people I work with on design implementation will be given research consent documents to sign. I used intensive literature review unstructured open-ended individual and group interviews to identify Anishinaabe epistemological principles and values that may inform design. The written findings were disseminated to the review committee, and amendments, adaptations, and reflections adjusted the article produced. This article, "Biocultural Engineering Design: An Anishinaabe Analysis for Building Sustainable Nations," was accepted and will be published in the upcoming American Indian Culture and Research Journal. This analysis provided the cultural foundation for the development of the bio-cultural design process. My second article, "A Social Analysis of Indigenous Ecological Design Methods for Cultural Revitalization and Nation-building in Indigenous Communities," will be submitted to cultural and social science journals. This article substitutes the term 'biocultural' with 'Indigenous,' because it was pointed out by my cultural committee as well as interview participants that the term 'biocultural' is unknown, sounds foreign, and creates an intellectual obstruction to good communication. This article explores the social and cultural process of applying this design methodology based on field experience and understandings gained from the first stage of my research. The third article, "Indigenous Ecological Engineering: A Design Approach for Building Resilient Native Nations," will be submitted to engineering design journals, and has received invitations for submission from the Journal of Ecological Design and

the American Indian Culture and Research Journal. This article explores through case studies the practical application of the various stages of the biocultural, or Indigenous, design methodology, evaluating the ability of the method to contribute to resilience within Indigenous communities and nations. My original research plan included a highly documented start-to-finish design and implementation process using this method within an Anishinaabe community. This design and implementation process is still underway, but is not completed to the extent needed for proper academic evaluation. I have simultaneously been applying this method over the course of the last year in diverse Indigenous communities, pursuing projects that are in varying stages of development. Three of these cases have been chosen as the examples I utilize in the third article to provide analysis of the biocultural engineering design method. In order to establish a strong research backing for the method, I will be continuing to document the process within the Anishinaabe community I am working with, and will be documenting and analyzing the process as it continues to be implemented within the other communities as well. We are currently applying the method to a contemporary educational facility building design, a master planned community, and the construction of three traditional architectural homes. Detailing the method as applied specifically to energy systems, water filtration, and wastewater treatment as it pertains to enhancing resilience would contribute strongly to this body of research.

CHAPTER 2. ARTICLE 1. BIOCULTURAL ENGINEERING DESIGN: AN ANISHINAABE ANALYSIS FOR BUILDING SUSTAINABLE NATIONS

ABSTRACT

There are strong epistemological relationships and common principles shared by the field of ecological engineering, resilience research, and Anishinaabe culture. These alignments can be found in worldview, ways of learning, traditional Indigenous ecosystem engineering methods, and governance; alignments that enable Anishinaabe cultural knowledge and ways of being to inform and provide the foundation for contemporary engineered design. This article explores these alignments, proposing the use of a biocultural engineering design method that integrates the design principles of ecological engineering with Indigenous knowledge, cultural relationships, values, and decision-making processes to support contemporary sustainable nation building.

RESILIENCE, RELATIONSHIP AND VISIONS FOR THE FUTURE

The impacts of our present resource use and exploitation have become apparent in the form of climate change, contaminated air and water, diminishing fresh water supplies, and deepening social and economic inequity. In response, researchers across scientific disciplines have been pursuing pathways to 'sustainability.' The discoveries of these scientists have resulted in conclusions that bring them remarkably closer to Indigenous understandings of the world; initiating the new fields of resilience and sustainability science, ecological engineering, green

chemistry, and biocultural diversity, among others.[3] As Fikret Berkes stated, "Researchers are discovering a universe that is dynamically alive: a whole system, fluid and interconnected . . . the world that has been part of the natural mind for most of human history."[4] In acknowledgement of the intertwined nature of society and ecology the term 'social-ecological system,' has come into common use, that term alone bringing scientists closer to the Indigenous understanding of an interconnected, relational world[5]. Writings from the field of biocultural diversity, which researches the inseparability of culture and ecosystem, has also been very helpful in communicating Indigenous concepts to non-Indigenous scientists and researchers. The literatures of these fields have increasingly noted the role Indigenous knowledge (IK) may serve in informing contemporary engineering techniques and understanding what creates adaptive resilience in social-ecological systems.[6]

The attempted integration of Indigenous understandings and scientific research is not a new phenomenon. The history of this intersection in research and practice has demonstrated the profound challenges regarding knowledge sharing, intercultural collaborations, and the role of IK, particularly in light of the very real political, land tenure, and human rights needs present within Indigenous communities, and the inequality of influence and power between researchers,

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[3] Maffi, Luisa and E. Woodley. *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan, 2010.

[4] Berkes, Fikret. *Sacred Ecology.* Routledge Press, 2008.

[5] Muir, Cameron, D. Rose, Deborah, and P. Sullivan. From the other side of the knowledge frontier: Indigenous knowledge, social-ecological relationships, and new perspectives. *The Rangeland Journal*. (2010) 32:259-265.

[6] Diemont, S. A.W., and J. F. Martin. Lacandon Maya ecosystem management: sustainable design for subsistence and environmental restoration. *Ecological Applications*. 19 (2009): 254–266.

policy makers, and Indigenous peoples.[7] As Anishinaabe scholar Leann Simpson stated,

> "Extraction and assimilation go together. Colonialism and capitalism are based on extracting and assimilating. My land is seen as a resource. My relatives in the plant and animal worlds are seen as resources. My culture and knowledge is a resource. My body is a resource and my children are a resource because they are the potential to grow, maintain, and uphold the extraction-assimilation system. The act of extraction removes all of the relationships that give whatever is being extracted meaning…. That's always been a part of colonialism and conquest. Colonialism has always extracted the indigenous—extraction of indigenous knowledge, indigenous women, indigenous peoples."[8]

Simpson clearly calls out the acquisitive and extractive approach to knowledge that has been as a critical source of disjunction between Indigenous and non-Indigenous societies. In order to move beyond the extractive paradigm, it is critical to establish the meaning of Indigenous knowledge (IK). IK is not a 'thing' that can be captured in the documentation of a traditional story, or otherwise packaged and removed from its context. It has been articulated that Indigenous knowledge is the culturally and spiritually based *way* in which Indigenous people relate to their ecosystems, a lived relationship rather than a 'body of knowledge.'[9] This lived relationship encompasses the entirety of the social-ecological system, including the relationships of humans with each other across cultures, political spheres, and economies.[10]

Engineers Martin et al, in their long-term research on traditional agroforestry and hydrology engineering practices in a Mayan community of Chiapas, Mexico, expressed this

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[7] Bohensky, E. L., and Y. Maru. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? *Ecology and Society* (2011)**16**: 6. http://dx.doi.org/10.5751/ES-04342-160406

[8] Simpson, Leanne. Interview, YES Magazine. Accessed online: http://www.yesmagazine.org/peace-justice/dancing-the-world-into-being-a-conversation-with-idle-no-more-leanne-simpson

[9] LaDuke, Winona. The Winona LaDuke Reader: a collection of essential writings. Voyageur Press, 2002.

[10] McGregor, Deborah. 2004. Coming Full Circle: Indigenous Knowledge, Environment, and Our Future. *American Indian Quarterly*. (2004) 28 Vol.4.

sense of interconnected relationship at the foundation of Mayan engineering, writing, "The weaving together of nature and culture is like the exchange between living cells and their surroundings: the vital breathing in and out, the flux of water and nutrients, the co-minglings of outer world and inner flesh."[11] Ethno-ecologist Fikret Berkes described IK well as a knowledge-practice-belief complex, understanding that the living relationships that embody IK are guided by the accumulated understandings and beliefs passed on through cultural practices. He also noted that cosmologies that frame human/environment relationships and guide knowledge making processes can ultimately determine the long-term sustainability of technological design, speaking to the necessity of grounding technological design for sustainability in Indigenous understandings.[12]

Scientists researching what creates resilience and balance in social-ecological systems have been producing recommendations that share remarkable similarity to traditional Indigenous governance structures, social relations, land management practices, learning processes, and cosmological principles.[13] Some of these scientists have begun looking to Indigenous communities not to extract their 'knowledge,' but to understand the dynamics and meanings of their relationships to Creation, and how that guides their political, social, and ecological life.[14] This is intensely bittersweet. Indigenous communities have a history and a present that is shaped in large part by the views, decisions, and economies of nation-states and nearby non-Indigenous

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[11] Martin, Jay; E. Roy, S. Diemont, and B. Ferguson. Traditional Ecological Knowledge: Ideas, inspiration, and designs for ecological engineering. *Ecological Engineering*, (2010) 36:839-849.

[12] Berkes, Fikret and M. Kislalioglu. Ecological complexity, fuzzy logic, and holism in Indigenous knowledge. *Futures.* (2009) 41(1):6-12.
[13] Walker, Brian and D. Salt. *Resilience Thinking*. Island Press, 2006.
[14] Berkes, Fikret., J. Colding, and C. Folke. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*. (2000)10:(5)

communities, struggling with the legacy of a colonial society who intentionally disrupted and tried to destroy Indigenous governance, unity, social fabric, teachings and cultural practices of the people: the very elements of Indigenous societies being looked to by scientists for their inherent resilience. When a people have been inundated with the perspective that their beliefs and practices are primitive, the generations begin to internalize that belief, losing faith in the ability of their cultural values and principles to guide contemporary choices. Many Indigenous nations across the world are meeting the struggle every day to protect, re-learn, and revitalize these critical elements of life in order to heal the people and land.

Ultimately, Indigenous nations have a need to provide housing, clean water, energy, infrastructure, and a balanced economic life for themselves in a manner that supports, cultivates and re-emerges their cultural values, relationships, and community resilience in the face of change. There has been an upwelling of interest in ecologically engineered systems, including green and natural building, ecological wastewater treatment, renewable energy development, and integrated agricultural systems as potential options to address these needs. Those seeking these options, however, have been inundated with externally derived, top-down approaches and mechanistically emerged 'green' engineering techniques which, although better than the alternative, still do not support or empower traditional knowledge and spiritual relationships and responsibilities with land and community. It is possible to use 'sustainable' techniques and technologies in just as spiritually destructive and extractive a manner as the development of an oil field, something that is beginning to occur across Indigenous territories worldwide.[15]

[15] McLean, Kirsty Galloway. 2010. *Advance Guard: Climate change impacts, adaptation, mitigation, and Indigenous peoples.* United Nations University.

The uncovering of deep intersections between resilience science, ecological engineering, and Indigenous epistemology, cosmology, and practice may provide an intellectual avenue for empowerment, rebuilding of spiritual relationships with land and each other, effective intercultural communication, and genuinely culturally based, resilient sustainable design. These intersections are explored herein in the context of the Anishinaabe people, becoming the basis for the development of a biocultural engineering design methodology.

THE ANISHINAABEK

The Anishinaabek Indigenous people, numbering in the hundreds of thousands, live in multiple dispersed, politically distinct communities in the Great Lakes region of North America, across the boundaries of the United States and Canada. They have a long history of colonial interaction, originally engaging in the fur trade in the early 18th century. Through contact, they were exposed to devastating disease, increasingly commercialized trade, the coming of several other nation-states and subsequent war, the drawing of nation-state boundaries through the center of their territories, as well as the presence of missionaries working towards conversion during a time of social disruption[16]. They have remained remarkably culturally intact through extermination and assimilation policies, residential schools and reservations, restriction of life and mobility, and a profound level of traditional resource exploitation, including overhunting and fishing, clear-cutting, dam building, mining, and the subsequent water contamination.[17] Most Anishinaabe communities continue to participate to some degree in the traditional subsistence

[16] Bossineau, Darrell. The Traditional Role of Governance in Aboriginal Communities: 'Minobimaddisiwin Nationhood.' *Aboriginal Financial Officers Association of Canada National Conference.* 2007. Accessed online, January, 2011. http://www.afoa.ca/conference/2007/Presentations/Boissoneau.pdf.

[17] Great Lakes Indian Fish and Wildlife Commission. Accessed online March, 2013. www.glifwc.org

economy based on the seasonal cycles of harvesting wild rice (manomin), berry and plant gathering, fishing, large game and waterfowl hunting, rabbit snaring, maple sugaring, and the planting of seasonal gardens.[18]

Because of this history, the contemporary Anishinaabek are very diverse. There are communities located in and next to urban centers who have urban-adapted lifestyles, communities who live in 'the bush,' maintaining a lifestyle much like what was present at the time of the first settlers, and everything in between. In this diversity, it is the language, songs, ceremonies, stories, and the values that are contained and expressed through these, that continue to be a thread of connection between Anishinaabe communities.[19] An understanding of who the Anishinaabe people are, particularly in light of identifying aligned epistemology with science and engineering, requires understanding of several of these foundational stories and cosmological principles that create the Anishinaabek world.

Anishinaabe Creation and Cosmology

The foundation of Anishinaabe worldview lies in the story of Creation. The following is a paraphrased excerpt of the creation story I was told as a young woman, reflected with other writings: Before time existed, Kitche Manitou, the Source, the mysterious spirit that pervades Creation, had a vision of experience. In this vision all of Creation, the beauty and ugliness, joy and sorrow, all the galaxies and stars, mountains and forests, were all seen. It was understood that this dream had to come into being and, after reflection, the first Creation was sent out with a

[18] Walker, Rachel. *Wild Rice: the Dynamics of Its Population Cycles and the Debate Over Its Control at the Minnesota Legislature.* Dissertation. University of Minnesota, 2008.

[19] Treur, Anton. *Living Our Languages: Ojibwe Tales and Oral Histories.* Minnesota Historical Society, 2001.

song. There was nothing to reflect the song back, and since no learning can happen without reflection, Kitche Manitou gathered the dream-song back. The stars and galaxies are the trails of this original sending. Then the song was sent again, unfolding to create the worlds we know today, beginning with the elements of rock, water, fire, and wind, and eventually becoming the world with plants, animals, and humans. All of Creation is the dynamic unfolding of the dream-song of Kitche Manitou. As a song, it is vibration in motion. What differentiates the beings and creates the world we know is the relationships and patterns of the song interacting with itself. It is thus understood that we exist in relational becoming with the rest of Creation.[20] Scholar Niigaanwewidam James Sinclair expresses this cosmology in his description of the clan system, stating that it is, "formed through two concepts, *enawendiwin* (strands connecting all parts of creation) and *waawiyeyaag* (interwoven systems of circularity). These come together to construct *nindinawemaganidog* (all of my relations)."[21]

Kitche Manitou is seen as continuously present, having care for Creation.[22] As the dream-song, all Creation is potentially sentient, has agency, and is related to on a kinship level. As anthropologist Irving Hallowell noted, the Anishinaabe world is an interconnected reality made up of 'other-than-human persons.' Other-than-human persons are known to have intelligence, knowledge, wisdom, ability to discern right from wrong, as well as the ability to influence. Hallowell stated that the "Ojibwa do not ask 'what causes,' they ask 'who causes.'"[23]

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[20] Johnston, Basil. *Ojibway Heritage.* University of Nebraska Press, 1976.
[21] Sinclair, Niigaanwewidam James. *Nindoodemag bagijiganan: A History of Anishinaabeg Narrative.* Dissertation. University of British Columbia, 2013.
[22] Foushee, Lee and R. Gurneau. *Sacred Water: Water for Life.* North American Water Office, 2010.
[23] Morrison, K.M. The cosmos as intersubjective: Native American other-than-human persons, in *Indigenous Religions: a Companion.* Ed G. Harvey. London: Cassell, 23-26. 2000.

Therefore Anishinaabe life is guided by the need to maintain good relations with an interconnected, peopled cosmos. Antagonistic relations create disorder, and that this imbalance is the cause of illness, hunger, and other harm. The smallest shifts can affect the entire world, a principle I was taught through the drum as a microcosm of creation. The drum embodies the directional principles that guide the dream-song, the original duality that enabled creation to come into being, and the elements of life. The song emerging from the drum mirrors the dream-song of the Creator. The drum, understood as a grandmother, represents the feminine principle foundational to life. When the song is being brought out of the drum, the vibration resounds throughout her body. Just as each drummer sends an individual vibration throughout the drum that is felt in the entire circle, the actions, thoughts, and words of each being are understood to resound through creation, causing effect. This principle also comes through in traditional stories that discuss the dramatic consequences of small events, including a person's thoughts and intent.[24]

In the Anishinaabe perspective, the purpose of the life path is to find one's place of balance within the rest of Creation.[25] It is also understood that all of the beings in the web of relations – animals, plants, rivers, winds – also hold their own purposes that need to be carried out. To interfere excessively is to behave in a disharmonious and disrespectful way.[26] There are stories that tell of the folly of trying to control elements of Creation, usually resulting in serious

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[24] Doerfler, Jill, N. Sinclair, and H. Stark, eds. *Centering Anishinaabeg Studies: Understanding the World through Stories*. Michigan State University Press, 2013.
[25] McCoy, Amy. *Minobimaadiziwin: Perceiving the good life through Anishinaabe language*. Dissertation. Michigan State University, 2007
[26] Johnston, Basil. *Honor Earth Mother.* Bison Books, 2003.

consequences.[27] Even as one is required to take life and alter the landscape to survive, it needs to be done in a manner that respects the rights of other families to exist. Another aspect of Anishinaabe worldview is the understanding that each culture of people was created to exist in reciprocal relationship with a particular homeland.[28]

In keeping with this, the concept of acknowledging human boundaries, humility, and limits are strongly present in Anishinaabe culture. Oral history describes how the first Anishinaabe people were born from Sky Woman, sustained only through the assistance and generosity of the animals. When Kitche Manitou created the different beings, each was given his or her own special gifts and strengths. The humans, weak in body and the most dependent of all the creatures, were given the power to dream.[29] As all of Creation is the unfolding dream-song, the implication is that humans have the power to also create. With this power comes responsibility. Of all the animals, only we can become dangerously out of balance, due to our dreaming power. We had to be taught by many beings throughout our history, and had learn from all around us in order to maintain harmony. There are old stories that tell of a time when things became imbalanced due to our actions and the world had to be renewed.[30] These stories are guides to finding the path of life that one should pursue to maintain harmony. An example is the story of how at one time humans and animals all spoke the same language, having good relations with one another. Humans gradually became greedy, taking too much and not

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[27] Morriseau, Norval. *Legends of My People: The Great Ojibway*. The Ryerson Press, 1965.
[28] Vennum, Thomas. *Wild Rice and the Ojibway People*. Minnesota Historical Society Press, 1988.
[29] Johnston, Basil. *Ojibway Heritage, 1976.*
[30] Peacock, Thomas, and M. Wisuri. Ojibwe Waasaa-Inaabidaa. Afton Historical Society Press, 2001.

respecting the lives or the gifts of the animal people. So, the animal people gathered together and decided to take themselves away from the Anishinaabek, who subsequently suffered very much. When the Anishinaabek were ultimately forgiven, they never could speak the same language again. This story, told to young people, teaches one not to be presumptuous and abuse the gifts of life. The Anishinaabek have a spiritual relationship with the beings that give life, and have the responsibility of caring for their survival just as they care for the people's survival.[31]

There is a saying that a person should work to have their actions mirror Creation in process, action, and principle as a means to creating balance within in the web of relations. An underlying principle in society, this is heard in many contexts, including large-scale land management and ceremony to how one should parent children, engage in society, and pursue everyday actions. For example I was taught that, when beading, I should not separate out the beads into different colors. The reason I was given was that "life isn't like that;" rather it's a mixed experience out of which we should select the beauty we want to create. Good relations are understood to be created through a strong emphasis upon respect, reciprocity, generosity, and humility; values conveyed through traditional stories and ceremony, and reinforced through daily interactions.[32]

Anishinaabe Ways of Learning

Fundamental to Anishinaabe philosophy is that life is, at its core, a process of learning. Life is understood through coming to know the patterns and relationships within Creation.

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[31]Benton-Banai, Eddie. *The Mishomis Book*. University of Minnesota Press, 1988.
[32] Pikangikum First Nation. *Keeping the Land; A Land Use Strategy for the Whitefeather Forest and Adjacent Areas*. Pikangikum First Nation, 2006. Accessed online March, 2012. http://www.whitefeatherforest.com/wp-content/uploads/2008/08/land-use-strategy.pdf

Knowledge and meaning is derived from observing relationships present, rather than the objective evaluation of 'parts' of the system or attempts to make predictions. Because knowledge is ultimately relational, dependent upon the learners' relationships and life purposes, there is not the sense of seeking an absolute truth.[33] Truth exists within the land, relationships between all life, and the patterns of creation. One's ability to perceive the truth, and hold truth that can be passed on to others, is dependent on the clear vision of the individual. There are also distinctions made between which perceptions are intended for personal knowledge, and which knowledge is wisdom that has societal scope and can serve as the foundation for decision-making and action in community.[34] The Anishinaabe traditional knowledge process involves the active living of closely observed relationships, from the basis of understanding the dynamic nature of life, thus learning processes are structured to connect the learner to the living social-ecological and cultural landscape.[35] These processes include participation in daily life processes that link one to the land, stories, and spiritual practices such as ceremonies, dreams, and fasting, in which a young man or woman is expected to cultivate his or her relationships with the whole. Iain Davidson-Hunt, in his work on adaptive learning in Anishinaabe communities stated;

> "Elders pass on their wisdom by setting up teaching moments that create a learning environment for the novice… a person builds wisdom, or what is often called 'power,' as she is able to distinguish or recognize critical features of the environment."[36]

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[33] Rheault, D'Arcy. *Anishinaabe Minobimatisiwin: The Way of A Good Life.* Debwewin Press, 1999.

[34] Davidson-Hunt, I.J. Journeys, plants and dreams: Adaptive learning and social-ecological resilience. Unpublished Ph.D. Thesis, University of Manitoba, Winnipeg, 2003.

[35] Ballard, Myrle. *Flooding Sustainable Livelihoods of the Lake St. Martin First Nations: The Need to Enhance the Role of Gender and Language in Anishinaabe Knowledge Systems*. Dissertation. University of Manitoba, 2012.

[36] Davidson-Hunt, I.J. *Journeys, plants and dreams.* 2003.

Strong value is also placed on the cumulative knowledge gained from our ancestors and elders.[37] This social memory is contained in stories, both sacred stories and stories told casually, encoded in the names of places in the landscape, as well as in the relationship-based language that people use. The person who has demonstrated their ability to observe and respond in a good way to changes in the social-ecological environment is considered a valid source of new knowledge. It is this encouragement of new knowledge gained from intimate experience with the land combined with the guidance of elders and culture that foster the adaptive capacity for resilience that is spoken of by scientists. As ecologist Davidson-Hunt stated, "Elders sanction the creativity of youth, the creativity of elders is sanctioned by their dreams and experience, and, ultimately, knowledge is situated in the land."[38] Davidson-Hunt, in his work with the Pikangikum and Shoal Lake Anishinaabek of northern Ontario, described the inherent social-ecological resilience fostered by Anishinaabe epistemology, which allows knowledge to adapt without losing the linkages between the past, present, and future. Within the Anishinaabe community, the ability to distinguish between cyclical change and change that represents a need to adapt is understood as necessary, and that both kinds of knowledge are encoded in ceremony, songs, and narratives, among other forms.[39] This land-based way of learning, the 'institution' of elders, and society-wide respect for traditional stories as a source of knowledge continue to be

[37] Chapeskie, Andrew. 1996. Indigenous Law, State Law, Renewable Resources and Formal Indigenous Self-Government in Northern Regions. In Kuppe, R. & Potz, R. eds. Law and Anthropology. Martinus Nijhoff Pubishers.
[38] Davidson-Hunt, I.J. *Journeys, plants and dreams.* 2003.
[39] Davidson-Hunt, Iain. Indigenous Lands Management, Cultural Landscapes, and Anishinaabe People of Shoal Lake, Northwestern Ontario, Canada. *Environments.* Volume 31(1) 2003.

present within many Anishinaabe communities. It is these learning relationships, values and stories that can provide the foundation for resilient ecologically engineered design.

ECOLOGICAL ENGINEERING DESIGN

Engineering is the study and practice of meeting human needs with systems design.[40] This practice includes structural, electrical, civil, chemical engineering and more, addressing our needs for safe buildings, transportation, energy systems, water systems, and food production. Design itself is understood as the intentional shaping of matter, energy, and process to meet a perceived need or desire, inherently culture and nature through exchanges of materials, flows of energy, and land use choices.[41] The manner in which a society designs systems to fulfill needs is fundamentally an expression of their social-cultural values. As Sim Van derRyn, notable scholar and author in the field of ecological design stated, "Design manifests culture, and culture rests firmly on the foundation of what we believe to be true about the world."[42]

The varying fields of engineering have developed highly technological design responses to human needs focused on the service needed to be performed, with a limited scope of variables to consider; analysis resting firmly on the worldview of nature as a passive set of materials to be utilized to perform services, and upon the assumption of easy access to resources obtained from long distances.[43] This, along with a societal drive towards standardization, has resulted in engineered systems designed as closed systems, with the assumption of a surrounding stable

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[40] Allen, T. F. H., M. Giampeitro, and Little, A. M. 2003. Distinguishing ecological engineering from environmental engineering. *Ecological Engineering*, 20:389-407

[41] Van der Ryn, Sim, and S. Cowan. 1996. *Ecological Design.* Island Press.

[42] Ibid.

[43] Bergen, Scott, Bolton, Susan, and Fridley, James. Design principles for ecological engineering. *Ecological Engineering*. (2001)18: 201-210.

state, and an emphasis on the ability to predict or control design outcomes.[44] These goals, principles, and assumptions have led to infrastructure poorly designed to function in a dynamic world. These systems have also contributed to ecological disruption, climate change, and social inequity worldwide.[45]

Today the engineering fields are responding to the need to engineer sustainable and equitable solutions. Civil and structural engineering literature addresses a new focus on social-ecological equity and sustainability, chemical engineering has emerged 'green chemistry,' based on the principles of biomimicry, humility, and a 'do no harm' ethic, and the architectural design field has been embracing the principles of environment-integrated building design, biomimicry, and the concept of zero-waste.[46] These new directions in engineering acknowledge that design occurs in the dynamic and complex realm of social-ecological systems. As such, design principles that mirror ecology and contribute to ecological resilience need to become the new foundation for engineered design.[47] This emphasis is found particularly within the field of ecological engineering.[48]

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[44] Schulze, Peter. *Engineering within Ecological Constraints.* National Academy of Engineering, 1996.
[45] Kangas, Patrick. *Ecological Engineering.* CRC Press, 2004.
[46] Haggard, Ben, B. Reed, and P. Mang. Regenerative Development. *Civil Engineering News.* March, 2006.

[47] Fan, Shu-Yang, B. Freedman, and R. Cote. *Principles and Practice of Ecological Design.* NRC Research Press, 2004.
[48] Herman, R. A perspective on the relationship between engineering and ecology. In Schulze, P.C. (Ed.), *Engineering within Ecological Constraints*. National Academy Press, Washington, D.C. (2006) 66-80

The Foundation: Complexity, Self-organization, and Resilience

The contemporary study of complex systems and ecology provide the scientific foundation for the principles of ecological engineering and design. Complex systems understandings can be applied to all levels of existence, from dynamic behavior of stars and planets, to social-ecological systems and quantum level interactions. These systems are modeled as a collection of interacting synergistic agents, unpredictable but self-organizing, in the sense that interactions produce coordination and synergy, with emergent properties that cannot be reduced to evaluation of the agents themselves.[49] For example, a system could be molecular structures, with the agents being the atoms that comprise them. The system could also be the solar system, the agents being the planets, stars, meteorites, and dust. This also applies to social systems, such as governance systems or a family group, the 'agents' being the people involved.

Systems theorist and cyberneticist Francis Heylighen identified that the agents within a complex system act to reduce tension between each other, typically with the result that not all agents can achieve their ideal preferences. Instead, they coordinate their actions to minimize friction and maximize synergy. Increased scale of self-organization occurs more rapidly when the agents are identical (as in the case of molecules of the same type that form a crystal), resulting in a more uniform organization. In cases where the agents are diverse, however, the resulting structure is much more complex. Most systems in Creation are diverse. There exists in these systems a multitude of 'attractors' or stable basins around which the self-organization

[49] Kauffman, Stuart. *At Home in the Universe: the search for laws of self-organization and complexity*. Oxford University Press, 1995.

occurs.[50] The self-organization of a complex systems can be encouraged by increasing the variations the system is exposed to, making the system explore it's state space. The more different states it experiences, the sooner it will reach a state that holds a strong attractor – the more steady state. The simplest way to do this is to subject the system to random perturbation.[51] To describe this in the context of a social system, the more diverse experiences one gains, the more experience they have with which to lead a strong and well-balanced life. Also, struggles (perturbation), if they are not excessive, increase a persons' spiritual, mental, emotional, and physical strength. Ecosystems experience this same response. Physicist Ilya Prigogine was the first researcher to publish on this phenomenon from the frame of reference of nonequilibrium thermodynamics, which he described as 'order through fluctuation.'[52] This manner of system development leads to the intrinsic stability and adaptive nature of the self-organized whole. The structure of these systems is a network.

Prigogine also elaborated on earlier insights presented by physicist Erwin Schrodinger, described these systems as self-organizing; arising spontaneously, and evolving toward greater complexity, featuring an inherent requirement for energy capture.[53] Evaluation of biological complex systems has led to the view of evolution based on the self-organizing properties of

[50] Heylighen, Francis. Complexity and Self-organization. Taylor and Francis, 2008.
[51] Levin, Simon. Self-organization and the emergence of complexity in ecological systems. Bioscience. Vol 55, No. 12. December, 2005
[52] Corning, Peter. Synergy and Self-organization in the evolution of complex systems. Systems Research (1995)12 (2): 89-121
[53] Peterson, Garry. Scaling Ecological Dynamics: Self-Organization, Hierarchical Structure, and Ecological Resilience. *Climatic Change*. (2000)44, (3):291-309.

living matter itself, with natural selection playing a supporting role.[54] The dream song is guided by itself as it grows, changes, develops, and returns to the Source.

Because requirement for energy capture and use drives the development of adaptive complex systems, the theoretical basis for understanding them is grounded in the understanding of energy flows.[55] The key ecosystem attributes that allow for self-organization and maximized energy efficiency are complexity and diversity.[56] Ecosystems are patchy, and do not function around a single stable equilibrium, or attractor. Destabilizing forces far from equilibria, multiple equilibria, and absence of equilibria define functionally different states, and it is this movement between states that maintains structure and diversity.[57] The structure and diversity produced by the large functional space occupied by ecosystems is what allows them to remain healthy and persist.[58]

Out of the study of the self-organizing nature of complex systems has emerged a special focus on the resilience of these systems. Resilience is the term used for the capacity of a system to continually change and adapt, yet remain within critical thresholds, referring to the capacity of a system to both withstand disturbances and to rebuild itself afterwards.[59] The development of

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[54] Stewart, Ian. *Self-organization in evolution: a mathematical perspective*. Philosophical Transactions of The Royal Society of London. 2003

[55] Odum, Howard, and B. Odum. Concepts and methods of ecological engineering. *Ecological Engineering*. (2003)20:339-361.

[56] Gunderson, L, Allen, C., & Holling, C.S. *Foundations of Ecological Resilience*. Island Press, 2010.

[57] Holling, C.S. Understanding the complexity of economic, social and ecological systems. *Ecosystems* (2001)4: 390-405.

[58] Folke C., J. Colding, and F. Berkes. Building resilience for adaptive capacity in social-ecological systems. In: Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, 2003.

[59] Walker, Brian and D. Salt. *Resilience Thinking*. Island Press, 2006.

theory around the resilience of complex, self-organizing systems (including human-scale social-ecological systems) is based in the following fundamental concepts:

- Complex systems evolve based on feedback loops.
- They have a characteristic of self-organization and emergent behavior that is not understandable by evaluation of the parts.
- Changes in a small element of the system (a variable) can transform the entire system, which occupies many different scales of time and space.[60]

Resilience theory advances the concept that social-ecological systems can exist in more than one type of stable state. If a system changes too much, it crosses a threshold and begins behaving in a different way, with different feedbacks, termed a 'regime shift'. [61] A visual representation of these different stable basins and threshold points are represented in Figure 1.

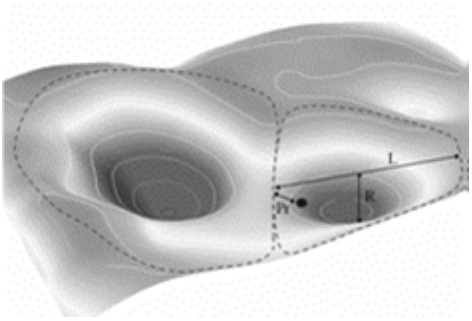

Figure 1. Diagram of Thresholds[62]

Resilience can be represented in two different ways. A system is seen to be resilient if it is persistent, remaining within the same stable basin throughout disturbance events. A system is

[60] Berkes F., J. Colding, and C. Folke (eds). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, 2003.
[61] Gunderson, et al, 2010.
[62] Walker, B., Holling, C. S., Carpenter, S. R., Kinzig, A. "Resilience, adaptability and transformability in social–ecological systems". *Ecology and Society* (2004)9. Accessed online January, 2013. http://www.ecologyandsociety.org/vol9/iss2/art5/

also said to be resilient if it exhibits high transformability. Transformability is the ability to self-organize into a new stable basin, or equilibrium, rather than experience chaotic forced transformation.[63] Walker et al (2004) discussed the shared characteristics of resilient social-ecological systems as:

- Productivity, acquiring resources and accumulating them, not for the present, but for the potential they offer in the future;
- A shifting balance between stabilizing and destabilizing forces reflecting the degree and intensity of internal controls and the degree of influence of external variability,
- The system generates and sustains both options and novelty, providing a shifting balance between vulnerability and persistence.
- Capable of self-organization.
- Exhibiting high adaptive capacity and learning
- Displaying a high level of transformability, related to adaptive capacity.

Strongly resilient social-ecological systems demonstrate high adaptive capacity and ability to learn. Adaptive capacity in ecological systems relies on diversity, the principle of functional redundancy, in which many beings are capable of performing a similar ecological role, the mosaic, 'patchy' patterning of the landscape, and periodic perturbations. In social systems, adaptive capacity is dependent upon the existence of institutions and networks that are capable of openness to new information, as well as the ability to incorporate that information into social

[63] Ibid.

memory. The ability to create flexibility in problem solving and balance power among interest groups is also a crucial component of a resilient social system.[64]

The study of resilience has led to the emergence of a framework for supporting resilience in social-ecological communities. This framework, as described by ecologists Walker and Salt, would 1., Embrace change and create space for new options through encouraging diversity at all levels, 2. Work with ecological variability instead of attempting to maintain a perpetual stable state of an ecology, 3., Consist of modular components (such as discrete diverse eco-regions and local governance structures), 4., Acknowledge and pay close attention to slow variables, and 5., Enable tight feedback loops to more effectively incorporate new knowledge gained from the responsive relationships of people and land, and 6., Develop strong social networks and trusted leadership, that encourages creativity, experimentation, and the creation of new knowledge, enabling this new knowledge to be incorporated into public action effectively.[65]

The study of complex, self-organizing systems, emerging with the development of a body of study around the resilience of these systems, informs the development and application of ecological engineering. Ecological engineering utilizes the principles uncovered by these fields, reflected within standard ecology, biology and engineering, to design systems that benefit both human need and the environment we are inseparable from.

Applying Resilience: Ecological Engineering in Practice

The term 'ecological engineering' was coined by Odum and Odum in 1957 to describe the conscious use of the 'self-designing' element of ecological systems in human engineered

[64] Ibid.
[65] Walker, Brian and D. Salt. *Resilience Thinking*. Island Press, 2006.

systems.[66] The standard definition was created by engineer M. Mitsch, who stated; "ecological engineering is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both."[67] Ecological engineering explicitly points to the need to mirror ecological relationships and principles at all levels, including emphasis on ecological self-organization, acknowledge humans as part of the ecological whole, and the need to design from intimate knowledge of place. Mitsch, author of one of the first ecological engineering textbooks, grounded his values in the concept of respect. He stated that ecological engineering needs to stem from the respect needed to learn from natural systems, respect for energy and natural resources, respect for people and place, respect for the future, and the use of systems thinking. Ecological engineering also maintains an intentional ethic of humility and equitability, featuring an iterative process of design in which the designer continually updates goals and processes, taking into account the need to design adaptive resilience into the system.[68]

Ecological engineers work to embed the designed system into the surrounding ecosystem, mirror ecological systems and principles, recognize and utilize the function of form, foster the ecological health of the surrounding ecosystem through design, and ensure that the self-organization of natural energy and material flows is allowed to express itself through the designed system. Design responses to the unpredictability and dynamism of social-ecological systems include fostering high diversity at all scales, creating and encouraging interconnections across scale and time, designing for multiple equilibria and functional redundancy, utilizing

[66] Odum, Howard, and B. Odum. *Concepts and methods of e. engineering.* 2003.
[67] Mitsch, W.J., and S. E. Jørgensen. 2004. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc.

[68] Mitsch, W.J., and S. E. Jørgensen. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc, 2004.

patchy, mosaic, or networked structures, incorporating energy recycling and efficiency, and intermittent perturbation. Given this dynamism, it is also important to keep designs simple, utilizing a precautionary approach to technological application.[69] Bergen et al also describe the value of recognizing limits, boundaries, and caution in design, noting that many engineering systems developed with 'hubris' have failed.[70] Ecological economist R. Costanza warned that the worst form of ignorance is misplaced certainty,[71] bringing to mind a quote from Wendell Berry;

> *"What we have come to know so far is demonstrably incomplete, since we keep on learning more . . .the mystery surrounding our life probably is not significantly reducible, and so the question of how to act in ignorance is paramount. Our history enables us to suppose that it may be all right to act on the basis of incomplete knowledge if our culture has an effective way of telling us that our knowledge is incomplete, and also of telling us how to act in our state of ignorance."*[72]

In order to design ecologically appropriate systems we need to work within the limits of both the ecosystem, and human capacity, knowledge, and understanding. The precautionary approach advocated by the ecological engineering design method is one way of guiding our decision-making in the face of incomplete knowledge.

Ecological engineering epistemology, given the fields' emphasis on reflecting social-ecological relationships, relies on the observer/designer to cultivate an intimate level of place-awareness and ability to note subtleties in the surroundings across temporal and spatial scales,

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[69] Matlock, Marty, and R. Morgan. *Ecological Engineering Design: Restoring and conserving ecosystem services.* Wiley and Sons, 2011.
[70] Bergen, Scott, Bolton, Susan, and Fridley, James. Design principles for ecological engineering. *Ecological Engineering*. (2001)18: 201-210.
[71] Costanza, R. *Designing sustainable ecological economic systems.* In: Schulze, P.C. (Edd.), Engineering within Ecological Constraints. National Academy Press, Washington, D.C. (1996) 82-99.
[72] Berry, Wendell. *Life is a Miracle: An essay against modern superstition*. Counterpoint, 2001.

engaging 'ecology' in a learning relationship. This place awareness includes understanding the cultural landscape; the stories and histories of people that are present within the land.[73] It is also important for the designers and users to maintain this active, creative learning relationship with the social-ecological system. It is this human learning relationship and the creation of avenues to incorporate new information into design that is vital to developing adaptive capacity.[74] Common examples of ecologically engineered systems include the design of constructed wetlands to purify water, reclaim nutrients, and provide habitat; agricultural systems that integrate and mimic natural ecosystems, and industrial systems in which the wastes from one process are designed to be useful inputs to the next. While ecological engineering began with a focus on ecosystem restoration, water and sanitation, and agricultural applications, it has expanded to the built environment, energy production, and community planning.[75] These ecological principles, design approaches, and epistemology complement the cultural cosmology of the Anishinaabe people remarkably. Both Anishinaabe cosmology and ecological engineering share the following:

- A worldview of interconnected, dynamic, self-organizing social-ecological systems
- Emphasis on adaptation and continual change
- Recognizing the creative value of disruption or perturbation

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[73] Eilouti, Buthayna. Environmental Knowledge in Engineering Design Processes. *The 5th International Conference on Knowledge Generation, Communication and Management.* Orlando, Florida, U.S.A. 2011.

[74] Hollnagel, E., D.Woods, and N. Leveson. *Resilience Engineering: Concepts and Precepts.* Ashgate Publishing, 2006.

[75] Matlock & Morgan, Ecological Engineering. 2011.

- Recognizing the presence of social-ecological thresholds or boundaries.
- Emphasis on long-term decision making and productivity
- Cultivation of diversity and functional redundancy
- Intentional mirroring of 'ecology,' or 'creation'
- Learning from other beings
- Recognition of and planning for unpredictability
- Focus on creation of strong social networks
- Encouragement of new knowledge
- Land-based, relational epistemology
- Reliance on traditional knowledge
- Sense of responsibility for the health of social-ecological communities.

These alignments can become the base for analysis of community design options, development choices, governance, and technology to foster resilient, culturally grounded and sustainable Indigenous nations.

THE BIOCULTURAL ENGINEERING DESIGN METHODOLOGY

The biocultural engineering design method integrates the biocultural relationships, values, and decision-making processes that are at the core of Indigenous ways of life with the science-based design principles of ecological engineering for resilience to emerge designed systems. The intent of this method is to facilitate designed systems that are regenerative to the ecological, social, and cultural health of the users. The term 'Indigenous Regenerative Design' has also been used to convey the meaning of this design method to diverse audiences. Within this design methodology, the process itself is critical to a successful design outcome, the process itself

grounded in place-based relational learning. Design phases include 1., Identify the Design Team; 2, Create the Foundation, 3., Engage Social-ecological and Traditional Learning, 4., Visioning the Whole and Inventory Creation, 5., Identify Design Goals, Create and Evaluate Options, 6. Design Creation and Implementation, and 7., Evaluation and Learning for Adaptation.

1. Identify the Design Team

The people who have a stake in the design outcome should be the ultimate source of knowledge and vision for design. Empowering them to embrace that role is necessary, as well as the creation of a forum in which free visioning and effective communication across social networks is made possible. This is particularly critical for Indigenous communities in light of the dependency framework and social disempowerment when engaging with outsiders that was well established by colonial history. This community-empowered design can be achieved utilizing 'design charrette' strategies, which bring family or community members together in a culturally grounded manner to create a common vision. In the case of community design or larger-scale public systems, effective community outreach, ensuring accessibility and inclusivity is critical. In these charrettes, the team should work in as much detail as possible, and have participants working concurrently, creating short feedback loops between brainstorming and design sessions.[76] Equally important is the development of skills and capacity within the community to serve their own needs. This can be accomplished through training and intensive skill development services that are inherently part of the design and implementation process.

[76] Kibert, Charles. *Sustainable Construction: Green Building Design and Delivery.* John Wiley & Sons, 2013.

2. Create the Foundation

Identifying founding values, individual and team roles and responsibilities, and common vision establishes trust and respect within the design team. In this phase, the team 'locates' itself, articulating the founding cosmology, spiritual and community responsibilities, and future dreams and visions, physically displaying these in an accessible location. The place and relationship-based nature of biocultural design makes it important for the design team to physically be present on the site of design implementation, engaging in walking/experiencing design sessions, noted as useful to elicit deeper human-human and human-nonhuman relations.[77] Social, political, and economic values and differences of perception are articulated. In community-scale projects, the history, politics, and social phenomena within the community may be discussed, addressing the manner in which the design team may affect or respond to these impacts through the design process.

3. Engage Social-Ecological and Traditional Learning

The basis for biocultural design is the learning relationship and responsibilities between people and homeland, guided by cultural practices, stories, and cosmologies. Good design is grounded in the peoples' ability to maintain these relations, and where this engagement has diminished, it should be renewed as the first step in the design process. In this phase the design process may engage traditional knowledge holders with others involved in the design process to renew, re-empower, and pass on cultural knowledge and practices that are critical to engaging in this learning relationship. This can also be reinforced by the simple practice of each design team member observing the land and relations present in solitude, daily, over a particular period of

[77] Edmunds, David. Personal conversation with author, 2013.

time, as well as engaging in group experiences on the land. Articulation and documentation of the important values, understandings, stories, relationships, and life in the land should emerge from this phase.

4. Visioning the Whole and Inventory Creation

Ecological engineering and Anishinaabe cosmology both share a necessary whole-systems perspective; it is critical to ground design and decision-making on an understanding and clear vision of the whole system. The design team is responsible for the creation of a visual map illustrating what is considered the 'whole system.' In this design phase, inventory of the whole social-ecological system is taken, achieved through documenting information about the design site obtained through traditional knowledge, learned observations through time, as well as standard scientific survey. The inventory process would benefit greatly from the participation of people who can be intercultural knowledge bridges.

5. Identify Design Goals, Create and Evaluate Options

Once inventory is taken, documented, and approved by the design participants, specific design goals are outlined. The impacts of different design decisions on the whole system are considered, as well as different alternatives for meeting the design goals. Considerations of mirroring Creation, enhancing networked relationships, respecting the life in the land, energy recycling, and using simplicity and functional redundancy to address unpredictability are included. The base design is then established, requiring multiple co-design sessions during which the design is taken through several iterations until it represents the cumulative understanding and experience of the team, as well as precautions put in place for future design adaptations.

6. Design Creation and Implementation

At this point, the engineer, designer, or other primary people responsible for the drafting process produce the final drafted design document. Upon approval, this document is used to implement the final project, be it a house, community plan, water treatment facility, or farming system. Where possible, the design participants can also be part of the installation, construction, or implementation team, further cultivating their responsibility and connection to the system or building, their community, and each other.

7. Evaluation and Learning for Adaptation

In keeping with the understanding of the dynamism of social-ecological systems, or Creation, the design also should be evaluated intermittently to assess possible adjustments and adaptations, learning from issues and including new knowledge. Many of these steps are reflective of standard design methodology. The uniqueness of the biocultural design process is its founding cosmology, integrated manner of originating design knowledge, cultural, socio-political, and ecological regenerative purpose, inherent adaptability, community-based design process, and mandate to develop the skills and capacity of the participants in the process.

Challenges

There are a number of challenges facing widespread implementation of biocultural engineering design methods. Social-ecological learning relationships have been highly compromised in society as a whole, including within Anishinaabe communities. Science itself, ultimately grounded in systematic observation, is recovering from a time period of strictly reductionist approaches unable to account for the dynamism and interconnectedness of ecological and social systems. This, along with urbanization and widespread technological data

availability has reduced the ability of many to engage in an intimate, interactive learning relationship with ecosystems.[78] Within many Anishinaabe communities social-ecological disruption, a legacy of colonialism, has affected the cultural practices that guide learning.[79]

Because of this history, the development or re-development of these learning relationships, based on cultural values, understandings, and practices is an initial challenge. The design process can, however, become a site for cultural knowledge transmission and revitalization as well as practical system design. For example, the Indigenous organization Sustainable Nations co-hosted a strawbale/adobe midwifery clinic design, training, and construction with the Otomi community of San Pedro Seccion 6, Mexico in 2008. Organized as an Indigenous knowledge exchange, the building was co-designed by the women who would use it, and constructed with both straw bales and traditional adobe plaster and bricks. Prior to the training the midwife of the community expressed concern that no one seemed interested in carrying on the healing traditions. Additionally, the Mexican governments' encouragement of cement block construction had led to almost exclusive use of block as the most 'progressive' building technique.

Indigenous peoples from across the Americas attended, working alongside local community members. When the adobe plaster pit was constructed, within which to mix the adobe by foot, the elders who had been watching the training from their windows emerged. They informed us that this method was their traditional mixing method, enthusiastically taking

[78] Sagarin, R. and A. Pauchard. *Observation and Ecology: Broadening the Scope of Science to Understand a Complex World*. Island Press, 2012.
[79] Deane, Lawrence and E. Smoke. Designing affordable housing with Cree, Anishinabe, and Metis People. Canadian Journal of Urban Research. (2010)19(1).

over the work, teaching us their techniques, and leading the remainder of the plastering work. Through this design process and subsequent re-valuing of their traditions as the basis for contemporary design, the younger builders within the community have continued to re-learn these techniques from their elders. Additionally, the midwife received several local apprentices after the training concluded, something she attributes to the re-valuing of Indigenous ways sparked by the intercultural exchange.[80] This is one of many examples of the facilitation of Indigenous cultural regeneration resulting from biocultural design practices.

Another challenge exists in the realm of power dynamics. Successful biocultural design relies on working with both ecological engineering and IK. The holders of these knowledge bases may emerge from very different core cosmologies and social histories. Design will be simpler to achieve when the design facilitator/s share the cultural values of the design users. Where this is not possible, it is necessary for the facilitator/s to cultivate the ability to be a conduit for community values, something that relies largely on the facilitators' personal qualities and institutional restrictions or pressures. If this does not occur, the entire process risks co-optation by the default dominance of a strictly materialist approach. Developing a detailed understanding of Indigenous epistemologies may contribute to the ability of foreign scientists and engineers to support biocultural design. Land tenure is also complex within Indigenous territories; the related land use planning policies, codes, and restrictions equally complex. In many cases, what is implemented within Indigenous lands must go through external administrations. Designers may find it necessary to adapt what is documented on paper to

[80] Ramirez, Diana. 2009. Personal conversation with author.

achieve project approval, although there are strong advances in policy along these lines.[81]

CONCLUSION

Faced with ecological degradation, social disruption, and climate change, people from diverse fields of research and walks of life are working to develop sustainable, resilient communities and nations. Anishinaabe communities have also been actively seeking ways to address their needs for survival while remaining culturally and spiritually intact.[82] Anishinaabe health and resilience scholar Patricia MacGuire concluded that Indigenous resilience is an emergent property of the interconnected relationships within a place. She described how this place-based resilience requires understanding the traditions, knowledge and sustained relationships embedded in the land as the spiritual relationships that bind reality together. Knowledge of places is linked to knowledge of self and community, and the health of places is inextricable from the health of people and community.[83] It is land-based knowledge, inextricable from community relationship building, that fosters the resilience of the Anishinaabek. In the context of climate change, it is even more critical to re-engage Anishinaabe land-based ways of originating knowledge. The old understandings of certain ecological regions passed down through the generations, may be affected by climate change. It is critical we cultivate the ability of next generation to engage in traditional processes of knowledge creation. Through this, and

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[81] Environmental Protection Agency. Accessed online January, 2013. http://www.epa.gov/region9/greenbuilding/tribal-workgroup.html.

[82] Simpson, Leann, J. DaSilva, B. Riffel, and P. Sellers. The Responsibilities of Women: Confronting Environmental Contamination in the Traditional Territories of Asubpeechoseewagong Netum Anishinaabek First Nation. *Journal of Aboriginal Health.* December, 2009.

[83] MacGuire, Patricia. Exploring resilience and Indigenous ways of knowing. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health.* (2010)8(2).

maintaining the reciprocity and humility passed to us through culture and elders, the next generation may offer sound direction for future adaptation.

The biocultural design method can regenerate these ways of learning, cultivate community networks, and strengthen the social memory passed on by elders, while employing the new tools and understandings of ecological engineering to create resilient designed systems. Biocultural design concepts may also create avenues of communication between Indigenous peoples, scientists, engineers, and planners, a critical step towards building allied strategies for bioregional resilience and sustainability. Though resulting from extensive field experience, this methodology has yet to be fully researched and documented. Future research is ongoing to refine the methodology, and offer long-term case studies documenting the social-ecological, political, and economic results of its use.

ARTICLE 1. REFERENCES

Allen, T. F. H., M. Giampeitro, and Little, A. M. 2003. Distinguishing ecological engineering from environmental engineering. *Ecological Engineering*, 20:389-407

Benton-Banai, Eddie. 1988. *The Mishomis Book*. University of Minnesota Press.

Bergen, Scott, Bolton, Susan, and Fridley, James. 2001. Design principles for ecological engineering. *Ecological Engineering*. 18: 201-210.

Berkes, Fikret., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*. 10: (5).

Berkes, Fikret. 2012. *Sacred Ecology*. Taylor and Francis.

Berkes, Fikret and M. Kislalioglu. 2009. Ecological complexity, fuzzy logic, and holism in Indigenous knowledge. *Futures*. 41(1):6-12.

Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, 2003.

Ballard, Myrle. 2012. *Flooding Sustainable Livelihoods of the Lake St. Martin First Nations: The Need to Enhance the Role of Gender and Language in Anishinaabe Knowledge Systems*. Dissertation. University of Manitoba.

Blaser, Mario, H. Feit, and G. McRae. 2004. *In the Way of Development: Indigenous Peoples,Life Projects, and Globalization.* Zed Books.

Bossineau, Darrell. 2007. The Traditional Role of Governance in Aboriginal Communities: 'Minobimaddisiwin Nationhood.' *Aboriginal Financial Officers Association of Canada National Conference.* [online] URL: http://www.afoa.ca/conferencE/2007/Presentations/Boissoneau.pdf

Bohensky, E. L., and Y. Maru. 2011. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? *Ecology and Society* **16**(4): 6. http://dx.doi.org/10.5751/ES-04342-160406

Cajete, Gregory. In: Waters, Anne. American Indian Thought: Philosophical Essays. Blackwell Publishing, 2004.

Chapeskie, Andrew. 1996. Indigenous Law, State Law, Renewable Resources and Formal Indigenous Self-Government in Northern Regions. In Kuppe, R. & Potz, R. eds. Law and Anthropology. Martinus Nijhoff Pubishers.

Costanza, R. 1996. *Designing sustainable ecological economic systems.* In: Schulze, P.C. (Edd.), Engineering within Ecological Constraints. National Academy Press, Washington, DC pp. 82-99.

Corning, Peter. 1995. Synergy and Self-organization in the evolution of complex systems. *Systems Research*. 12 (2):89 – 121.

Davidson-Hunt, I.J. 2003. Journeys, plants and dreams: Adaptive learning and social-ecological resilience. Unpublished Ph.D. Thesis, University of Manitoba, Winnipeg.

Davidson-Hunt, Iain. Indigenous Lands Management, Cultural Landscapes, and Anishinaabe People of Shoal Lake, Northwestern Ontario, Canada. Environments. Volume 31(1) 2003.

Davidson-Hunt, I. J. (2006). Adaptive learning networks: Developing resource management knowledge through social learning forums. *Human Ecology, 34*(4), 593-614.

Davidson-Hunt, Iain, K. Turner, A. Mead, J. Cabrera-Lopez, R. Bolton, C. Idrobo, I. Miretski, A Morrison, and J. Robson. 2012. Biocultural Design: A new conceptual framework for sustainable development in rural Indigenous and local communities. *S. A. P. I. EN. S.* 5 (2).

Davidson-Hunt, I.J. and F. Berkes. 2003. Nature and society through the lens of resilience: toward a human-in-ecosystem perspective. In F. Berkes, J. Colding and C. Folke (eds.) Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge: 53-82.

Deane, Lawrence and E. Smoke. 2010. Designing affordable housing with Cree, Anishinabe, and Metis People. Canadian Journal of Urban Research. 19(1).

Delgado, Louis. 2013. Native Voices Rising: A Case for Funding Native-led Change. Common Counsel Foundation.

Deutsch, Nathan. 2008. Anishinaabe governance and the commons: The Whitefeather Forest Initiative for community economic renewal. International Association for the Study of the Commons conference, Cheltenham, England.

Diemont, S. A.W., and J. F. Martin. 2009. Lacandon Maya ecosystem management: sustainable design for subsistence and environmental restoration. *Ecological Applications*. 19(1):254–266.

Dietz, T., Ostrom, E., Stern, P., 2003. The struggle to govern the commons. Science 302, 1907–1912.

Doerfler, Jill, N. Sinclair, and H. Stark, eds. 2013. *Centering Anishinaabeg Studies: Understanding the World through Stories*. Michigan State University Press.

Environmental Protection Agency. 2013. [online] URL: http://www.epa.gov/region9/greenbuilding/tribal-workgroup.html

Edmunds, David. 2013. Personal conversation with author.

Eilouti, Buthayna. 2011. Environmental Knowledge in Engineering Design Processes. *The 5th International Conference on Knowledge Generation, Communication and Management.* Orlando, Florida, U.S.A.

Fan, Shu-Yang, B. Freedman, and R. Cote. 2004. *Principles and Practice of Ecological Design.* NRC Research Press.

Folke, C.; Carpenter, S.; Walker, B., Scheffer, M., Chapin, T.; & Rockstrom, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability, and Transformability. *Ecology and Society* **15**(4): 20.

Folke, C. Traditional knowledge in social–ecological systems. Ecology and Society, Vol 9 (4). 2004.

Folke C., J. Colding, and F. Berkes, 2003. Building resilience for adaptive capacity in social-ecological systems. In: Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, 2003.

Ford, J., and D. Martinez. 2000. Traditional ecological knowledge, ecosystem science, and environmental management. *Ecological Applications*. 10:1249-1250.

Foushee, Lee and R. Gurneau. 2010. *Sacred Water: Water for Life.* North American Water Office.

Geniuz, Wendy Makoons. 2009. *Our Knowledge is Not Primitive; Decolonizing Anishinaabe Botanical Teachings.* Syracuse University Press.
Great Lakes Indian Fish and Wildlife Commission. [online] URL: www.glifwc.org
Grim, John. 2001. *Indigenous Traditions and Ecology; the interbeing of cosmology and community.* Harvard University Press.
Gunderson, L, Allen, C., & Holling, C.S. *Foundations of Ecological Resilience*. Island Press, 2010.
Haggard, Ben, B. Reed, and P. Mang. 2006. Regenerative Development. *Civil Engineering News.* March.
Herman, R. 1996. A perspective on the relationship between engineering and ecology. In Schulze, P.C. (Ed.), *Engineering within Ecological Constraints*. National Academy Press, Washington, DC, pp 66-80.
Heylighen, Francis. Complexity and Self-organization. Taylor and Francis, 2008.
Hill, Lilian. Personal Conversation with PennElys Droz, 2013.
Holling, C.S. Understanding the complexity of economic, social and ecological systems. Ecosystems 4: 390-405. 2001.
Hollnagel, E., D.Woods, and N. Leveson. 2006. *Resilience Engineering: Concepts and Precepts.* Ashgate Publishing.
Howard, Jeff. 2004. Toward participatory ecological design of technological systems. *Design Issues.* 20 (3):40-53
Johnston, Basil. 1976. *Ojibway Heritage.* University of Nebraska Press.
Johnston, Basil. 2003. *Honor Earth Mother.* Bison Books.
Jorgensen, Miriam, ed. 2008. Rebuilding Native Nations: Strategies for Governance and Development. University of Arizona Press.
Kauffman, Stuart. At Home in the Universe: the search for laws of self-organization and complexity. Oxford University Press, 1995.
Kibert, Charles. 2013. *Sustainable Construction: Green Building Design and Delivery.* John Wiley & Sons.
Kohl, Johann Georg. 1860. *Kitchi-Gami: Life among the Lake Superior Ojibway.* Chapman and Hall, London.
LaDuke, Winona. 2002. The Winona LaDuke Reader: a collection of essential writings. Voyageur Press.
LaDuke, Winona. Recovering the Sacred: The Power of Naming and Claiming. South End Press, 2005.
Landes, Ruth. 1968. *Ojibwa Religion and the Midewewin*. University of Wisconsin Press.
Levin, Simon. Self-organization and the emergence of complexity in ecological systems. Bioscience. Vol 55, No. 12. December, 2005
MacGuire, Patricia. 2010. Exploring resilience and Indigenous ways of knowing. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health.* 8(2).
Maffi, Luisa and E. Woodley. 2010. *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan.
Mander, J & Tauli Corpuz, V. Paradigm Wars. International Forum on Globalization publication with Sierra Club Press, 2006.
Marker, M. 2004. Theories and disciplines as sites of struggle: The reproduction

of colonial dominance through the controlling of knowledge in the academy. Canadian Journal of Native Education, 28 (1/2), 102–111.
Martin, Jay; E. Roy, S. Diemont, and B. Ferguson. 2010. Traditional Ecological Knowledge: Ideas, inspiration, and designs for ecological engineering. *Ecological Engineering*, 36:839-849.
Matlock, Marty, and R. Morgan. 2011. *Ecological Engineering Design: Restoring and conserving ecosystem services.* Wiley and Sons.
McCoy, Amy. 2007. *Minobimaadiziwin: Perceiving the good life through Anishinaabe language*. Dissertation. Michigan State University.
McGregor, Deborah. 2004. Coming Full Circle: Indigenous Knowledge, Environment, and Our Future. *American Indian Quarterly*. 28 (4).
McGregor, Deborah. Traditional Ecological Knowledge and Sustainable Development: Towards Coexistence. International Development Research Center. 2004.
McLean, Kirsty Galloway. 2010. *Advance Guard: Climate change impacts, adaptation, mitigation, and Indigenous peoples.* United Nations University.
Menzies, Charles. 2006. *Traditional Ecological Knowledge and Natural Resource Management*. University of Nebraska Press.
Mitsch, W.J., and S. E. Jørgensen. 2004. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc.
Morrison, K.M. 2000. The cosmos as intersubjective: Native American other-than-human persons, in *Indigenous Religions: a Companion.* Ed G. Harvey. London: Cassell, 23-26.
Morriseau, Norval. 1965. *Legends of My People: The Great Ojibway*. The Ryerson Press.
Muir, Cameron, D. Rose, Deborah, and P. Sullivan. 2010. From the other side of the knowledge frontier: Indigenous knowledge, social-ecological relationshiops, and new perspectives. *The Rangeland Journal*. 32:259-265.
Nelson, Melissa. 2008. Original Instructions: Indigenous Teachings for a Sustainable Future. Collective Heritage Institute. Bear & Company.
Odum, Howard, and B. Odum. 2003. Concepts and methods of ecological engineering. *Ecological Engineering*. 20:339-361
Peacock, Thomas, and M. Wisuri. 2001. Ojibwe Waasaa-Inaabidaa. Afton Historical Society Press.
Peterson, Garry. 2000. Scaling Ecological Dynamics: Self-Organization, Hierarchical Structure, and Ecological Resilience. *Climatic Change*. Vol. 44, No. 3. 291-309.
Pierson, Brian. 2013. Housing Development Handbook. 2013 National American Indian Housing Council (NAIHC).
Prigogine, I., Stengers, I. 1984. Order Out of Chaos: Man's New Dialogue with Nature. Heinemann, London, UK.
Pikangikum First Nation. 2006. *Keeping the Land; A Land Use Strategy for the Whitefeather Forest and Adjacent Areas.* Pikangikum First Nation. [online] URL: http://www.whitefeatherforest.com/wp-content/uploads/2008/08/land-use-strategy.pdf
Reap, John, D. Baumeister, and B. Bras. 2005. Holism, Biomimicry, and Sustainable Engineering. *ASME International Mechanical Engineering Conference and Exposition.* Orlando, Florida, U. S. A.

Rheault, D'Arcy. 1999. *Anishinaabe Minobimatisiwin: The Way of A Good Life.* Debwewin Press.
Riddle, Lori. Personal Conversation with PennElys Droz. January, 2014.
Sagarin, R. and A. Pauchard. 2012. *Observation and Ecology: Broadening the Scope of Science to Understand a Complex World*. Island Press.
Schulze, Peter. 1996. *Engineering within Ecological Constraints.* National Academy of Engineering.
Simpson, Leann, J. DaSilva, B. Riffel, and P. Sellers. 2009. The Responsibilities of Women: Confronting Environmental Contamination in the Traditional Territories of Asubpeechoseewagong Netum Anishinaabek First Nation. *Journal of Aboriginal Health.* December.
Sinclair, Niigaanwewidam James. 2013. *Nindoodemag bagijiganan: A History of Anishinaabeg Narrative.* Dissertation. University of British Columbia.
Stewart, Ian. 2003. Self-organization in evolution: a mathematical perspective. Philosophical Transactions of The Royal Society of London.
Todd, John and B. Josephson. 1996. The design of living technologies for waste treatment. *Ecological Engineering.* 6:109-136.\
Treur, Anton. 2001. *Living Our Languages: Ojibwe Tales and Oral Histories.* Minnesota Historical Society.
Trosper, Ronald. 2010. Resilience, Reciprocity, and Ecological Economics: Northwest Coast Sustainability.
Van der Ryn, Sim, and S. Cowan. 1996. *Ecological Design.* Island Press.
Vennum, Thomas. 1988. *Wild Rice and the Ojibway People*. Minnesota Historical Society Press.
Walker, Brian and D. Salt. 2006. *Resilience Thinking*. Island Press.
Walker, B., Holling, C. S., Carpenter, S. R., Kinzig, A. (2004). "Resilience, adaptability and transformability in social–ecological systems". *Ecology and Society* **9** (2): 5.
Walker, B. H., S. R. Carpenter, J. Rockstrom, A.-S. Crépin, and G. D. Peterson. (2012) Drivers, "slow" variables, "fast" variables, shocks, and resilience. *Ecology and Society* **17**(3): 30.
Walker, Rachel. (2008) *Wild Rice: the Dynamics of Its Population Cycles and the Debate Over Its Control at the Minnesota Legislature.* Dissertation. University of Minnesota, July

CHAPTER 3: ARTICLE 2. A SOCIAL ANALYSIS OF INDIGENOUS ECOLOGICAL DESIGN METHODS FOR RE-INDIGENIZATION IN INDIGENOUS COMMUNITIES

ABSTRACT

Contemporary Native nations are actively working to identify innovative and creative solutions to their development needs while revitalizing cultural and spiritual relationships with community, families, and homeland. Indigenous ecological design can be a meaningful tool to achieve both of these critical needs, although the application of this design method must take different forms within different social ecological contexts due to the internal diversity of Indigenous communities. When this method is approached using the lens of re-Indigenization, responsive to the impacts of colonization yet focused on identifying the values and visions of the people as the guiding force of action, the process itself can be transformative and a catalyst for contemporary culturally based nation-building.

INTRODUCTION

Indigenous peoples are faced with the challenge of maintaining and strengthening land tenure, health, and nationhood while providing creative and innovative development opportunities for their people. This work is being done in spite of the legacy of physical, socio-cultural and economic colonization: testimony to the resilience of Native peoples (Delgado, 2013; LaDuke, 2005; McLean, 2010, Nelson, 2008). Native scholar Patricia MacGuire, in her research identifying sources of resilience within Native communities, states that Indigenous resilience requires understanding the traditions, knowledge and sustained relationships embedded in the land; the spiritual relationships that bind reality together. She concluded that land-based knowledge, inextricable from community relationship building, fosters Indigenous resilience

(MacGuire, 2010). In the context of climate change, it is even more critical to re-engage land-based ways of originating new knowledge in response to changing ecological circumstances. Thus, while addressing the contemporary needs of our nations, it is critical to place the teachings, ways of life, and spiritual values that create this innate resilience at the center of development decisions, and re-emerge them where they have been diminished.

Many grassroots organizations and community groups throughout Native communities have been working to create innovative pathways forward that cultivate the resilience of our nations, including Sustainable Nations and Blue Star Studios, who together utilize a community directed, culturally based Indigenous ecological design approach to address this need. This design methodology is grounded in Indigenous culture and the relationship of people to their homeland and each other, as well as standard ecological design techniques and tools. This approach can be applied to infrastructure, architecture, landscape design and whole-systems community design. In their work applying this process, Blue Star Studios/Sustainable Nations have learned to apply the Indigenous ecological design method in a manner that allows the creation of avenues of possibility to achieve truly culturally based contemporary design, while also being responsive to the legacies of colonization and subsequent complex social circumstances and diversity present within Indigenous nations.

INDIGENOUS ECOLOGICAL DESIGN

The foundation of the basic ecological design approach is intimate observation and relationship building with the local ecology, including the human social and cultural relationships that are part of that ecology. Understandings based on this observation and experience then provide the framework and foundation for all subsequent design decisions

(Mitsch & Jorgensen, 2004). Examples of ecological design include working with native wetland ecology to purify wastewater while cultivating wildlife habitat, creating community layouts that integrate and enhance the ecological and social health of the beings that inhabit the region, and designing homes and buildings that are responsive to the local climate to enable efficient heating, cooling, and lighting, while utilizing locally sourced, nontoxic, and natural building materials. Indigenous ecological design adds to this by using culturally founded observation and learning practices, and the unique cultural values and cosmology of the people as the foundation of design, in combination with scientific data. This method has a specific guiding intention of supporting the culture and socio-political vitality of the people.

Our identification of Indigenous epistemologies is based on the understanding that Indigenous knowledge is the culturally and spiritually based *way* in which Indigenous people relate to their ecosystems, a lived relationship rather than a 'body of knowledge' (Berkes, 2012; LaDuke, 2005; McGregor, 2004). This lived relationship encompasses the entirety of the social-ecological system, including the relationships of humans with each other across cultures, political spheres, and economies (Edmunds, 2013). Thus many traditional knowledge processes involve the active living of closely observed relationships, connecting the learner to the living social-ecological and cultural landscape (Davidson-Hunt, 2003; Rheault, 1999; McGregor, 2004; Gegeo, 2001). This includes everything from the modeling of daily life processes to social and personal ceremony. Strong value is also placed on the cumulative knowledge gained from ancestors and elders, this social memory contained in oral histories, casually told stories, and encoded in place names as well as in the relationship-based language that people use (Foushee & Gurneau, 2010; Johnston, 2004). It is this encouragement of new knowledge gained from

intimate experience with the land combined with cultural social memory and guidance of elders that foster the adaptive capacity for resilience that is spoken of by scientists. As Davidson-Hunt stated,

> *"Elders sanction the creativity of youth, the creativity of elders is sanctioned by their dreams and experience, and, ultimately, knowledge is situated in the land"* (Davidson-Hunt, 2003).

This land-based way of learning, the 'institution' of elders, and society-wide respect for traditional stories as a source of knowledge continue to be present within many Native communities. It is these learning relationships, values and stories that can easily provide the foundation for resilient Indigenous ecological design.

This methodology is composed of seven phases: 1. Identify the Design Team, 2., Create the Foundation, 3., Engage Social-ecological and Traditional Learning/Knowledge, 4. Visioning the Whole and Inventory Creation, 5., Identify Design Goals and Create Design Options, 6., Design Creation and Implementation, and 7., Evaluation and Learning for Adaptation (Droz, 2014). In Phase 1, Identify the Design Team, the stakeholders are identified and actively engaged as design originators. In Indigenous ecological design, the design users are always the most important members of the design team. In small projects, this may be limited to members of an individual family. In larger, community scale design, it can be the entire community or Tribe. In these cases, education, publicity, outreach, and ensuring ease of participation through providing transportation, food, and childcare is critical. Within Phase 2, Create the Foundation, the design team identifies common founding values, roles and responsibilities, and articulates vital cultural principles that should guide the design. Phase 3, Engaging Social-ecological and Traditional Learning/Knowledge, includes active outreach for and incorporation of traditional knowledge that should inform design. The design team also participates in activities on the site

of design implementation designed to engage them in learning relationships with the land. This can include group walking sessions through the site, as well as the simple practice of design team members observing the land in solitude, daily, over a period of time (Edmunds, 2013). Discoveries, stories, and important understandings coming from this experience are documented to guide the rest of the design process. Within Phase 4., Visioning the Whole and Inventory Creation, the team meets to map the whole system, including the energy, water, biological, spiritual, geological and social processes that exist on site, from both Indigenous knowledge, the teams' experiences on the land, and scientific data. In Phase 5, the previous data, experiences, and knowledge are used by the design team members primarily responsible for creating detailed designs to develop several different options for evaluation by the entire team and/or community. The design is physically implemented in Phase 6. This implementation ideally includes education, training, and participation by the design users. Once the designed system has been implemented for several months, be it a water system, home, energy system, or whole community layout, the team engages in Phase 7., Evaluation and Learning for Adaptation, evaluating how the design serves the people and the values and visions stated in the beginning of the process (Droz, 2014).

SOCIAL ANALYSIS OF INDIGENOUS ECOLOGICAL DESIGN IN PRACTICE

Social-ecological learning relationships have been highly compromised, in both the larger society and within Native communities. Science, the foundation of design fields, is recovering from a time period of strictly reductionist approaches unable to address the dynamism and interconnectedness of ecological and social systems. This, along with urbanization and widespread technological data availability has reduced the ability of many to engage in an

intimate, interactive learning relationship with ecosystems (Sagarin & Pauchard, 2012). While urbanization has a smaller generalized impact within Native communities, these factors combine with the intensive social-ecological disruption of colonialism and assimilation programs to affect the cultural practices that guide ecological relationships and learning, as well as impact the way these practices show up in applied situations (Deane & Smoke, 2010).

The phases of Indigenous ecological design, when undertaken by a design team made of stakeholders and culturally appropriate specialists who are accountable to the community, have been found to be easily understood by those who have intentionally and consciously maintained traditional cosmology, practices, and cultural relationships. These people, groups, and families tend to maintain knowledge of the motion and life in the land, practices that teach one to cultivate these relationships, and often pass on stories and understandings about what lives where and how these things should be cared for. Within these groups, there also may be specialized knowledge held by a particular gender, age group, clan, or other form of distinguishing experience and/or skill level, which is vital to be aware of and include (Gurneau, 2013; Day, 2013). This knowledge can guide how a particular land base is cared for, the patterns of community planning, how homes and buildings may be constructed, infrastructure created, how food systems are integrated, and what energy systems are utilized.

Indigenous nations are socially diverse, however, and to pursue strong, unified, nation-building development pathways it is critical to engage with and be guided by all sectors of society, whether they are part of families that actively maintain traditional practices or not. This makes the identifying of unifying cosmology, values, and visions, and the engagement of social-cultural and traditional learning a complex process requiring openness and willingness to do the

hard, time-consuming work of building trust, communication, and participation.

The history of attempted cultural annihilation through missionaries, boarding schools, and other programs undertaken within Indigenous nations has a powerful legacy today. The violent oppression received from the carrying on of cultural teachings, cultivation of self-hatred, and the forced dependency created through the destruction or diminishment of the traditional economy and resources has left a mark within Indigenous societies that needs to be actively worked with to emerge knowledge and visions for resilient Indigenous design (Doerfler et al, 2013; Sinclair, 2013). This legacy of colonization can be seen in the fear, hesitancy, and skepticism that is a common response from Indigenous peoples when they are asked to create visions for the future based on cultural principles. It is challenging for people who have been told for generations that their knowledge and practices are lesser and primitive to be asked to look to this knowledge and practices for contemporary development. The irony that scientists and engineers themselves are looking to Indigenous peoples for social understandings, ecological techniques, and design inspiration does not go unnoticed (Barreiro & Johnson, 2001). Additionally, many simply do not believe that they will be listened to respectfully or their visions taken seriously, due to a history of being ignored or treated patronizingly by those who are responsible for development decisions. Within the United States, for example, the form of development and infrastructure within Indigenous territories has been largely externally imposed through negotiations with the Bureau of Indian Affairs, Housing and Urban Development, corporations, and private contractors. Indigenous peoples themselves are only just beginning to have enough access to capital, political power, and Western-educated citizens to push back and advance their own interests (Jorgensen, 2007). Another source of discomfort engaging in

visioning processes designed to uplift Indigenous knowledge is the historical abuse of this knowledge, often by well-intentioned non-Native people (McGregor, 2004). In order to transcend this discomfort, these visioning sessions should be designed and led by local people with known integrity, and be guided by spiritual leaders. If direct consistent involvement by well-respected spiritual leaders is not a possibility, avenues should be created to ensure their input and involvement at key decision-making points.

The legacy of colonization has also made the creation of foundational unifying values, visions, and cosmology complex. Today there are widely diverse relationships with traditional knowledge, epistemologies, and ways of life within Native communities. There remains fear around the sharing and carrying on of teachings, particularly among elders who experienced more powerful oppression. Some Indigenous peoples have the sense of not feeling "Indian enough," due to attacks on culture and blood quantum policies used to determine who is recognized as an 'Indian' by the percentage of Indian blood a person has. This can limit confidence in sharing and receiving knowledge (Barriero, J & Johnson, T., 2001). There are people who may not consider themselves keepers of traditional knowledge, but who in fact maintain strong understandings, practices, and stories, and others who may hold understandings but do not want to be labeled as cultural knowledge keepers. Being identified specifically as a knowledge holder creates mixed feelings associated with being 'pointed out in the world.' These feelings result from numerous things including 1., knowing that there are many things one doesn't know yet, 2., feeling resistance to potentially being seen as self-important, and 3. putting oneself out for criticism and ridicule. Speaking about the land and ways of caring for life as "culture" within the context of community life can also be uncomfortable. When one has been

brought up with these relations forming the foundation of daily life, many valuable insights or guiding principles will not be seen as 'cultural,' rather it is simply how things are done, or 'common sense.' There are also people in both rural and urban Indigenous community contexts who have not been brought up with any taught connection to their lands at all, and may hold either indifference, painful insecurity, or passionate drive to re-learn their teachings. These people and their families, as citizens of nations and Indigenous descendants who inherently hold memories of the land, can and should also participate in any visioning and planning session related to the creation of sustainable Indigenous nations. Oftentimes this work has been described as supporting decolonization, or the effort to heal the negative impacts of the history of colonization through the identification of and removal of those elements of our societies, hearts, and minds that come from colonial attempts at oppression. While supporting and appreciating the meaning of decolonization, the Indigenous engineering methodology can be seen instead as a process of re-Indigenizing. Decolonization is a reaction to oppression, relying on its relationship with colonialism for its identity. While this is necessary, we emphasize an Indigenizing approach, describing both a philosophy and praxis that relies on the identification of our core values and cosmologies. It is these that give one the responsibilities and relationships with land and community that make one Indigenous. Actions generating from these, rather than actions generated from response to colonial oppression, may give us a stronger foundation for regenerating our nations (Malvido, 2014).

MOVING FORWARD

While the results of colonial history have left challenges for the use of Indigenous ecological design, its application in practice has demonstrated how the process itself can support

healing and become a site for cultural knowledge transmission and revitalization in addition to practical resilient system design.

Engaging the Design Team

In order to engage a strong local design team, the elements of fear and skepticism discussed above can be addressed through action initiated by local change agents. It only takes a few local people who are determined to see visions realized to open up the possibility for others to engage. These change makers tend to have in common 1., the support of their spiritual elders, 2., a life commitment to work on overcoming colonized behavior and dependency, and 3., a fierce tenacity and willingness to accept the social challenges they will be faced with by standing up for change (Common Counsel, 2013; Droz, 2013). These change agents and the necessary professionals they bring in, have the responsibility of initially gathering community members to engage in the process, through ensuring accessibility, providing necessary education and an open forum, as well as possibly creating a small demonstration of the techniques or project proposed. As noted by Lori Riddle, a Gila River woman intent on advancing culturally appropriate housing for her Tribe, most people are not going to want to sit around and talk about philosophy. They want to see something accomplished, and see that their voices will, in fact, be heard. Once a small success has been achieved, then people will engage, participate, and be catalyzed by this action (Riddle, 2013). After the design team has been formed, typically of these change agents, necessary professionals, and catalyzed community, it is time to create the foundation for design and engage in learning processes together.

Create the Foundation/Engage Social-Ecological Learning

In order to emerge a common vision, cosmology and values from the social, religious, and cultural diversity found within Indigenous communities today, we have found that hosting open facilitated meetings, organized with wide outreach, can be an effective practice. These meetings can be opened with prayer to create the openness and clarify the re-Indigenizing intent of the process. These meetings involve multiple round table discussions with diverse community members and the design team to answer key questions. The key questions identified by Blue Star Studios, Inc. include: 1. What values inform your (Native Nations') identity? 2. What are visions for the (Future, Project, Development) based on these values? and 3., What are ways this (Project, Program, Development) can support and put into action this vision and values? These questions and format can effectively open dialogue to find this unifying foundation. Coming into the process of asking these questions expecting more reticence, it has been profound to note how naturally common core values are identified by community members of diverse backgrounds and ages. I have been consistently struck by the depth and beauty of these values, even as spoken to by individuals who do not identify themselves as traditional people. Moving from the identification of values to future visions and project designs based on those values can be initially challenging, but again, once a few examples of how this can happen are explored, or a local change-maker speaks out, we have seen the unfolding of visions and projects that are remarkable, unique, and innovative expressions of the contemporary Indigenous culture. Out of these initial meetings, strategies of how to learn together from the land and community emerge and are engaged with and design inventory is taken. Participating in the phases of the Indigenous ecological design method can also provide seeds of renewal where culturally based

learning relationships with the land have been compromised. During a workshop for the Mississippi Choctaw designed to connect young people to these relationships, a visiting elder remembered the traditional building method of wattle-and-daub, which is coming into popularity with contemporary natural builders. He spoke to how the training exercises that cultivated a persons' ability to observe in a relational way with the land reminded him to see the world in the "old way" (Droz, 2011). During this same workshop, a young woman also remembered a plant medicine recipe her grandmother taught her.

Design/Implement/Evaluate

Creating the foundation and learning from the land and each other result ultimately in the creation of designs to be implemented. These designs and the construction process can be utilized to continue the engagement of people with each other and the land, through community education, training, and inclusion in the actual construction, and can result in the continued re-vitalization of culture and the use of Indigenous design. For example, Sustainable Nations co-hosted a design process, training, and construction of a strawbale/adobe midwifery clinic with the Otomi community of San Pedro Seccion 6, Mexico in 2008. Organized as an Indigenous knowledge exchange, the building was designed by the women who would use it, and constructed with both straw bales and traditional adobe plaster and bricks. Most of the community homes were built with cement block, a result of the Mexican governments' encouragement of cement block construction as the most 'progressive' building technique. The local organizer (the change agent) had been engaging community members around the creation of other possibilities that would support their sense of strength in their culture and ways of life as Otomi people, and had received support from her elders, including the local midwife and

traditional doctor. She outreached to Sustainable Nations to assist in the development of this project, and it was determined to achieve the build through an international Indigenous knowledge exchange and training to share techniques, visions, and inspiration in a specifically Indigenous cultural setting.

Indigenous peoples from across the Americas attended, working alongside local community members. When the adobe plaster pit was constructed within which to mix the adobe by foot, the elders who had been watching the training from their windows emerged. They informed us that this method was their traditional mixing method, enthusiastically taking over the work, teaching us their techniques, and leading the remainder of the plastering work. Through this design process and subsequent re-valuing of their traditions as the basis for contemporary design, the younger builders within the community have continued to re-learn these techniques from their elders. Prior to the training, the midwife expressed concern that she could not find apprentices to learn and carry on the healing traditions. Soon after the ending of the training, the midwife received several local apprentices she continues to work with today, something she attributes to the re-valuing of Indigenous ways sparked by the intercultural exchange (Droz, 2008).

CONCLUSION

Indigenous peoples worldwide are finding ways to recover from colonization and build a strong future, working to provide housing, water systems, food systems, and infrastructure in a way that supports the vitality of their cultures and homelands (McLean, 2010). Many techniques and approaches used by ecological designers and engineers can be excellent tools, but lacking a specific process and directive for emerging Indigenous values, social structure, and political

needs, these techniques can devolve into yet another externally derived intervention that does not build the health and sovereignty of the people. The Indigenous ecological design method begins with the learning relationship between people and the land, re-building this relationship from within where it has been compromised. It does this through facilitating slow processes of gathering community, asking specific open-ended questions related to this relationship and identifying the heart of what gives Indigenous people their core values and identity. Engaging people in active relationship building activities including traditional ceremonies as well as simply intimate observational time with the land allows knowledge and core values to re-emerge naturally. The results of community gatherings and knowledge building on the land then become the foundation for all design and engineering decisions.

Every Indigenous nation carries a different history, and colonial legacies remain present, causing challenges to those working to re-emerge traditional learning relationships, values, and cosmologies as the basis of today's development decisions. Today there are very diverse internal social relationships and ways of seeing the world in Indigenous communities, and so these processes are slow, requiring patience, communication, and fierce determination by the local organizers. However, after applying this methodology for many years, we have noted its contribution to the re-Indigenization of our nations, and a source of good decision-making for a healthy social ecology (Hill, 2013; Shimek, 2013; Ramirez, 2009). We have seen that often all it takes is the creation of avenues of possibility for the values of the people to again become the foundation of decision making for the unfolding of remarkable, unique, and innovative visions and designs to be implemented. It is only recently that organizations such as Blue Star Studios/Sustainable Nations have practiced applying the method at whole-community levels,

working through Tribal and federal administration funding sources. These larger scale cases are currently being documented in four different Indigenous communities in North America, and will be used for future analysis of the Indigenous ecological design method as a cultural revitalization and nation-building tool.

ARTICLE 2. REFERENCES

Barreiro, Jose & Johnson, Tim. 2001. Ed. American Indian Millenium: Renewing our Way of Life For Future Generations. Proceedings. Ithaca, New York. November 29-December 2.

Berkes, Fikret. Sacred Ecology. Taylor & Francis, 2012.

Davidson-Hunt, Iain. 2003. Indigenous Lands Management, Cultural Landscapes, and Anishinaabe People of Shoal Lake, Northwestern Ontario, Canada. Environments. Volume 31(1)

Delgado, Louis. 2013. Native Voices Rising: A Case for Funding Native-led Change. Common Counsel Foundation.

Dahl, Michael. Personal Conversation with PennElys Droz. July, 2013.

Day, Sharon. Personal conversations with PennElys Droz. July, 2013

Deane, Lawrence and E. Smoke. 2010. Designing affordable housing with Cree, Anishinabe, and Metis People. Canadian Journal of Urban Research. 19(1).

Doerfler, Jill, N. Sinclair and H. Stark, eds. Centering Anishinaabeg Studies: Understanding the World Through Stories. Michigan State University Press, 2013.

Droz, PennElys. Biocultural Engineering Design: An Anishinaabe Analysis for Building Sustainable Nations. American Indian Culture and Research Journal. 2014.

Droz, PennElys. Keya Wakpala Community Meeting Dialogue Notes. Oct. 1 – Nov. 2013.

Droz, PennElys. Sustainable Nations Project Report, 2008

Droz, Pennelys. Sustainable Nations Project Report, 2011.

Foushee, Lee and R. Gurneau. 2010. Sacred Water: Water for Life. North American Water Office.

Gegeo, David W. & Watson-Gegeo, Karen Ann. "How We Know" : Kwara'ae Rural Villagers Doing Indigenous Epistemology. The Contemporary Pactific, Vol 13, No. 1, Spring 2001, 55-88 University of Hawaii Press.

Goldtooth, Tom. Personal Conversations with PennElys Droz, 2013.

Gurneau, Renee. Personal Conversations with PennElys Droz, 2013.

Hill, Lilian. Personal Conversation with PennElys Droz, 2013.

Johnston, Basil. Honor Earth Mother. Bison Books. 2003.

Jorgensen, Miriam, ed. Rebuilding Native Nations: Strategies for Governance and Development. University of Arizona Press, 2008.

LaDuke, Winona. The Winona LaDuke Reader: A Collection of Essential Writings. Voyageur Press, 2002.

LaDuke, Winona. Recovering the Sacred: The Power of Naming and Claiming. South End Press, 2005.

MacGuire, Patricia. Exploring resilience and Indigenous ways of knowing. Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health. 8(2). 2010.

Malvido, Jose. Conversation with PennElys Droz. 2014.

McGregor, Deborah. Coming Full Circle: Indigenous Knowledge, Environment, and Our Future. American Indian Quarterly. 28 (4). 2004.

McLean, Kirsty Galloway. Advance Guard: Climate change impacts, adaptation, mitigation, and Indigenous peoples. United Nations University. 2010

Mitsch, W.J., and S. E. Jørgensen. Ecological Engineering and Ecosystem Restoration. John Wiley and Sons, Inc. 2004.
Nelson, Melissa. Original Instructions: Indigenous Teachings for a Sustainable Future. Collective Heritage Institute. Bear & Company, 2008.
Rheault, D'Arcy. Anishinaabe Minobimatisiwin: The Way of A Good Life. Debwewin Press. 1999.
Sagarin, R. and A Pauchard. Observation and Ecology: Broadening the Scope of Science to Understand a Complex World. Island Press, 2012.
Shimek, Bob. Personal Conversation with PennElys Droz, July 2013.
Ramirez, Diana. Personal Conversation with PennElys Droz, 2009.
Riddle, Lori. Personal Conversation with PennElys Droz. January, 2014.

CHAPTER 4: ARTICLE 3. INDIGENOUS ECOLOGICAL ENGINEERING: A DESIGN APPROACH FOR BUILDING RESILIENT NATIVE NATIONS

ABSTRACT

The Indigenous Ecological Engineering Design methodology can be a tool for cultural revitalization as well as resilient system design to provide culturally and ecologically regenerative homes, water systems, and other infrastructure in Indigenous communities. Indigenous practices, epistemologies, and relationships with ecology and cultural community can provide the foundation for contemporary Indigenous ecologically engineered design. This is analyzed using qualitative ethnographic data collection in the Sicangu Lakota and Tohono O'odham Nations, and the Otomi community of San Pedro Seccion 6, Mexico.

INDIGNENOUS RESILIENCE, CHALLENGES, AND AN AVENUE FOR INNOVATION

Indigenous peoples are faced with the challenge of maintaining and strengthening land tenure, health, and nationhood while providing creative and innovative development opportunities for their people. This is being accomplished in spite of the legacy of physical, socio-cultural and economic colonization: testimony to the resilience of Indigenous peoples. There is strong impetus within Indigenous nations to provide housing, clean water, energy, infrastructure, and a balanced economic life in a manner that supports their cultural values, relationships, and community resilience in the face of change.

Historically in the United States, the form of infrastructure and development within Native lands has been externally imposed through negotiations between the Bureau of Indian

Affairs, Housing and Urban Development, corporations, and private contractors. These externally derived developments tend to exist in opposition to the traditional values and culture of the people themselves (Mander & Tauli-Corpuz, 2006; LaDuke, 2005). Examples from the last several decades include the signing away of mining rights to large companies at great ecological and health expense, and the construction of inefficient, substandard homes that have become the famous norm on Native reservations throughout the United States (Ballard, 2012; LaDuke, 2005; Pierson, 2013). Many decades of research and work in the field of sustainable development have resulted in the understanding that without a cultural base that reflects the real visions, values, and ways of life of the people, technological design fails (IUCN, 1997; WCED, 1987). It is necessary to identify a process to not only include culture, but place culture at the center of technological design decisions.

As Native peoples have obtained access to capital and more control over the management of their nations, they have been slowly seeking better options for providing for their people. The interest in ecologically engineered systems such as green and natural building, biologically based wastewater treatment, renewable energy development and integrated agricultural systems, among other techniques, as contemporary expressions of Native values is blossoming (EPA, 2013; McLean, 2010). The scope of what is occurring with regard to culturally based applications of these technologies remains limited, however, speaking to the lack of Native ecological and environmental engineers and designers and a continued reliance on externally derived solutions to address contemporary development issues. Due to cultural domination and assimilation programs designed to convince Native peoples that their beliefs and practices are primitive, many have lost faith in the ability of their cultural values and principles to guide contemporary

choices. Those seeking these solutions are often faced with continued challenge. There have been instances of Native development choices being ignored or dismissed by contractors who have won bids, pressure placed on Tribes to adapt their choices to fit contractors' ideas, as well as simply the use of top-down approaches and mechanistically emerged 'green' engineering solutions to provide for community needs which, although better, still do not support or empower traditional knowledge and spiritual relationships and responsibilities with land and community (Klein, 2013; Mander & Tauli-Corpuz, 2006).

The importance of maintaining and strengthening Indigenous knowledge and traditional responsibilities for land and community have been well documented by scholars, scientists, and engineers alike (Ballard, 2012; Berkes, 2012; Martin et al, 2010). Indigenous nations have demonstrated strong social and cultural resilience in the face of immense change. Resilience describes the capacity of a social-ecological system to continually change and adapt, yet remain within critical thresholds, referring to the capacity of a system to both withstand disturbances and to rebuild itself afterwards (Walker et al, 2006). Strongly resilient social-ecological systems demonstrate high adaptive capacity and ability to learn. Adaptive capacity in ecological systems relies on high complexity and diversity at all scales within the ecosystem, the principle of functional redundancy (in which many beings are capable of performing a similar ecological role), and the mosaic patterning of the landscape, and periodic perturbations. In social systems, adaptive capacity is dependent upon the existence of institutions and networks that are capable of openness to new information, as well as the ability to incorporate that information into social memory. The ability to create flexibility in problem solving and balance power among interest groups is also a crucial component of a resilient social system (Dietz, 2003; Davidson-Hunt et al,

2003; Folke, 2004; Walker et al., 2012). I also suggest that a resilient culture is one in which the ways of life of the social system encourage and enhance those specific characteristics of ecological resilience, fostering diversity, functional redundancy, the mosaic patterning, and regular, smaller scale perturbations.

Indigenous ways of life are based in maintaining an adaptive learning relationship with what is understood to be a dynamic, unpredictable and interconnected, living cosmos, guided by old histories while acknowledging perpetual change (Cajete, 2000; Folke et al, 2010; McGregor, 2004; Pierotti, 2012). The older governance processes that both distribute power and allow decision making to occur within local, directly ecologically and socially responsive contexts also contribute to the social-ecological resilience of Indigenous lands and lives (Dietz, 2003; Walker et al, 2012).

The lands still controlled by Indigenous peoples continue to maintain the greatest biodiversity present in the world, even as they are being worked with to provide for the people (Maffi, 2010). Ecological engineers have noted the model strategies employed by Indigenous people to care for the present and future resilience and productivity of their lands, including the practice of disturbance ecology (intense production followed by rest periods) selective harvesting, intentional cultivation of the diversity of the natural lands to support specific species and interspecies symbioses, periodic human disturbance to foster the influx of new species, agroforestry, organic sustainable agriculture utilizing integrated pest management, efficient use of rainwater and, importantly, effective communal property management systems (Diemont et al, 2009; Martin et al, 2010). It is vitally important to recognize that all of these sustainable techniques emerge directly from the cosmologies and ways of learning from the land that are

specific to those Indigenous cultures. Where those cosmologies and ways of learning have been diminished, the sustainable ecology of the region is also diminished. Reciprocally, the physical, social, and spiritual health of Indigenous peoples has been demonstrated to be strongest where this knowledge and traditions have either been maintained or are undergoing resurgence (Chandler & Lalonge, 1998; Klein, 2013; MacGuire, 2010).

Native health scholar Patricia MacGuire, in researching resilience in the Anishinaabe native community, concluded that Indigenous resilience is an emergent property of the interconnected relationships within a place. She described how this place-based resilience requires understanding the traditions, knowledge and sustained relationships embedded in the land, "the spiritual relationships that bind reality together" (MacGuire, 2010). Knowledge of places is linked to knowledge of self and community, and the health of places is inextricable from the health of people and community (MacGuire, 2010). She concluded that land-based knowledge, inextricable from community relationship building, fosters the resilience of Indigenous people. Thus, in order to re-build resilient and healthy Native peoples and homeland ecologies, it is important to pursue an approach to infrastructure development that emerges from the foundation of land-based knowledge, relationships, and cosmology.

Ecological engineering, with its emphasis on place based ecological and cultural knowledge as the foundation for design, can be a source of technical tools and approaches for resilient Indigenous nation building. Examples of ecological engineering design include working with native wetland ecology to purify wastewater while cultivating wildlife habitat, creating community layouts that integrate and enhance the ecological and social health of the beings that inhabit the region, and designing homes and buildings that are responsive to the local climate,

enabling efficient heating, cooling, and lighting while utilizing locally sources, nontoxic and natural building materials. These practices can easily be accomplished from a specifically Indigenous cosmological perspective due to alignments in perspective and epistemology, not only contributing to the maintenance of healthy ecology, but to the cultural health and resilience of the people (Droz, 2014).

Indigenous Cosmology/Resilience and Ecological Engineering Shared Principles and Practices

- *View of Interconnected, Dynamic, Self-Organizing Social-Ecological Systems*
- *Emphasis on Adaptation and Continual Change*
- *Recognizing the Creative Value of Disruption or Perturbation*
- *Recognizing the Presence of Social-Ecological Thresholds*
- *Emphasis on Long-term Decision making and Productivity*
- *Cultivation of Diversity and Functional Redundancy*
- *Intentional Mirroring of 'Ecology,' or 'Creation'*
- *Learning from other Beings*
- *Recognition of and Planning for Unpredictability*
- *Focus on Creation of strong Social Networks*
- *Encouragement of New Knowledge*
- *Land-based, Relational Epistemology*
- *Reliance on Traditional Knowledge*
- *Sense of Responsibility for the Health of Social-Ecological Communities*

INDIGENOUS ENGINEERING DESIGN METHODOLOGY

The Indigenous engineering design method integrates biocultural relationships, values, and decision-making processes with the science-based design principles of ecological engineering to emerge designed systems, evaluating design decisions utilizing resilience principles. The intent of this method is to facilitate designed systems that are regenerative to the ecological, social, and cultural health of the users. In the Indigenous design methodology, the process itself is critical to a successful design outcome, grounded in place-based relational learning. Design phases include **1., Identify the Design Team; 2, Create the Foundation, 3.,**

Engage Social-ecological and Traditional Learning, 4., Visioning the Whole and Inventory Creation, 5., Identify Design Goals, Create and Evaluate Options, 6. Design Creation and Implementation, and 7., Evaluation and Learning for Adaptation. In Phase 1, **Identify the Design Team**, the stakeholders are identified and actively engaged as design originators. In Indigenous ecological design, the design users are always the most important members of the design team. In small projects, this may be limited to members of an individual family. In larger, community scale design, it can be the entire community or Tribe. In these cases, education, publicity, outreach, and ensuring ease of participation through providing transportation, food, and childcare is critical. Within Phase 2, **Create the Foundation,** the design team identifies common founding values, roles and responsibilities, and articulates vital cultural principles that should guide the design. Phase 3, **Engaging Social-ecological and Traditional Learning/Knowledge,** includes active outreach for and incorporation of traditional knowledge that should inform design. The design team also participates in activities on the site of design implementation designed to engage them in learning relationships with the land. This can include group walking sessions through the site, as well as the simple practice of design team members observing the land in solitude, daily, over a period of time. Discoveries, stories, and important understandings coming from this experience are documented to guide the rest of the design process. Within Phase 4., **Visioning the Whole and Inventory Creation,** the team meets to map the whole system, including the energy, water, biological, spiritual, geological and social processes that exist on site, from both Indigenous knowledge, the teams' experiences on the land, and scientific data. In Phase 5, **Design**, the previous data, experiences, and knowledge are used by the design team members primarily responsible for creating detailed designs to develop

several different options for evaluation by the entire team and/or community. Phase 6., **Implementation,** includes the physical construction of the designed system, ideally also including education, training, and participation by the design users. Once the designed system has been implemented for several months, be it a water system, home, energy system, or whole community layout, the team engages in Phase 7., **Evaluation and Learning for Adaptation**, evaluating how the design serves the people and the values and visions stated in the beginning of the process (Droz, 2014).

INDIGENOUS ECOLOGICAL ENGINEERING IN PRACTICE

This method is explored through analysis of its application through its seven phases by the Native organizations Blue Star Studio and Sustainable Nations in our collaborative work with 1., the Otomi community of San Pedro Seccion 6, Mexico building a midwifery clinic, 2., the Sicangu Lakota Nation of South Dakota in the planning of a new sustainable community, 3., the Tohono O'odham Nation of Arizona on the beginning steps of designing a new college building.

Identify the Design Team

In all of these communities, we were invited in as outsiders specifically because of our Indigenous design methodology. Even with this invitation, the first steps of this method involve building community trust and understanding of the process so that the people themselves feel a full sense of ownership and engaged participation. Depending upon the community, this can involve simply being present while demonstrating an open heart, knowledge, and willingness to deeply listen. In other situations, this has involved participating in ceremony and prayer with our hosts as the conversation of working together begins. In the evaluated cases, the design team was/is composed of community members, local community organizers and decision makers, and

our architecture and engineering team. The design teams form after the initial meetings, in which we gather local people through publicity, word of mouth, direct invitation, and more to a meeting and visioning session. After opening the community meeting with a prayer and a presentation about our culturally based, community building, and sovereignty supporting process, In our introduction, we also emphasize the potential of the design/build process as a community building, training, and education tool.

Create the Foundation/Social-Ecological Learning

After our initial organizing, if the community has determined to work with us, the design team can host a meeting discussing the concept of resilience – the ability to adapt and change yet retain the unique values and ways of life that have maintained the integrity of the culture for generations –as our goal in design.

Blue Star Studio originated the approach of inviting the design team and local participants to think about what makes a resilient community, and gather in small groups to answer the following questions: 1. What values inform your (Native Nations') identity?, 2. What are visions for the (Future, Project, Development) based on these values? and 3., What are ways this (Project, Program, Development) can support and put into action this vision and values? These questions and format open dialogue effectively to find this unifying foundation, thus establishing a vibrant circle of trust where Indigenous planning and design can emerge. These particular questions posed tend to emerge responses aligned with the signifiers of resilient social-ecological systems. This meeting ideally includes a wide representation of the community, including children. We invite participants to physically map their visions in drawing form. This identifies the way the people see the land, their knowledge about what is important and present

within the land, and how they see themselves in relation to the site of design. Within these meetings, we also walk the physical site with community members, listening to their reflections.

Sicangu Lakota Traditional Knowledge and Values for Design

By the end of the series of meetings in the Sicangu Lakota Nation, discussing the creation of the sustainable Lakota community of Keya Wakpala Waíçageyapi, the values of Wolakota were articulated as the foundation of the people. Wolakota is the combined term that encompasses the following:

- Wowahwala / Unsiiciyapi - "To be modest, unpretentious." (humility)
- Wowacintanka - "To patiently persist and strive despite difficulties." (perseverance)
- Wawoohola - "To be considerate, to hold in high esteem." (respect)
- Wayuonihan - "To have integrity, to have an honest and upright character." (honor)
- Cantognake - "To place and hold in one's heart." (love)
- Icicupi - "To give of one's self, an offering." (sacrifice)
- Wowicake - "That which is real, the way the world is." (truth)
- Waunsila - "Walk with compassion for your relatives." (compassion)
- Woohitike - "To be guided by principles. Having or showing courage." (bravery)
- Cantewasake - "Strength of heart and mind." (fortitude)
- Wacante Oganake / Canteyuke - "To help, to give, to share, to have a heart." (generosity)
- Woksape - "To understand what is right and true." (wisdom)
- Womankanskan – "Everything is interconnected energy moving at all levels."
- Nake Nula Waun – "Preparation, readiness, planning ahead" (REDCO, 2014).

These values, expressed in the concept of Wolakota, were identified as important to the design success of the Keya Wakpala Waíçageyapi community. Family connections, co-parenting, and balanced relations with human and non-human relatives were clearly stated as an expression of Wolakota, as well as a clear focus on education, health, and artistic creative expression. These values, placed into action, align with resilience principles. They recognize that decisions must consider long-term adaptability and productivity, encourage the diversity of

and mirror ecology, rely on the stabilizing forces of the knowledge of elders while encouraging new and innovative knowledge of educated youth, maintain networks of shared knowledge, community support and resources, and continuously learn through ceremonial relations, stories, and educational institutions.

Sicangu Lakota Community Design

From this place we can begin to understand how to design community that supports this knowledge and values. The ways these values were discussed as expressing themselves in community design included buildings, homes, and community layout that cultivates family relationships, intergenerational connections, and mutuality that is central to Lakota ways. Intergenerational recreation, conflict resolution, safety, and educational programs are included in the preliminary community plan, within walking distance to groups of homes potentially arranged in a circular manner to facilitate mutuality and the extended family (tiyospaye) integration. Playgrounds and community gardens can be located in the center. Ceremonial spaces would be distant for privacy, but accessible. All signage would be in the Lakota language, and the community would feature local art, sculpture, and kiosks with critical values and history placed in public locations. A stated goal was that a child growing up in the community would learn their native language and know who they are, their responsibilities, and where they come from simply by living there. Interconnections to the surrounding communities, human and non-human, would be created through biking, walking, and horse trails, as well as the maintenance and enhancement of on-site natural habitats. The community also expressed their desire for solar and wind energy, organic and sustainable agriculture, and water systems that acknowledge the sacredness of water, ensuring that water used is respected and returned to the

Earth in pure condition. Within the community meetings, it was acknowledged that what we design and build embodies and reinforces central understandings about our place in the Universe. This includes meanings encoded into the shapes used, the placement of buildings on the land, artistic elements, and materials used. An example includes the following statement made within their preliminary design. They stated,

> "Prior to colonization, our ancestors lived in tipis, which were a continuous reminder of Lakota cosmology and relationships, as well as being highly resourceful and functional. The very act of putting up a tipi is a ceremony. Kapemni, the vortex at the top of the tipi where the poles come together, is the place at the top of the head that connects a person to the spirit world. The hole in middle of that vortex is the middle of the hole in the Pleiades, which was the origin place of the people. The center pole represents the woman's backbone, the back two are her shoulder blades, and inside is the circular world that holds her family and shows what the tiwahe had accomplished. The structure of and placement of the tipi also determined the social relationships of the families within them. The tipi is a sacred place defining a culture. For Keya Wakpala Waíçageyapi, buildings and homes will be designed to be continuous reminders of vital Lakota interrelationships. By re-integrating cultural meaning and environmentally responsive and regenerative design into our community, we are placing ourselves again in right relationship to culture and landscape. Living in this way is a continuous reminder to current and future generations of the sacred obligations we keep to each other and the lands of our ancestors" (REDCO, 2014).

The plan also incorporated the desire of local community members to have traditional Lakota ways brought to the forefront when defining the roles and responsibilities within the new community of Keya Wakpala Waíçageyapi. It was recommended that as the community grows, any codes or neighborhood associations that form draw heavily from Lakota culture and traditions while manifesting modern translations to keep local order and maintain respect for leadership. Greg Grey Cloud, a young Lakota organizer and community member, stated the following vision, exemplifying the tone of the community meetings,

> "This community is very organized and involved. We are hard working and respectful. We take care of each other and honor all things. We know we are safe in our environment

> because we have come the realization we as a people are relatives. So we protect and provide for one another. That is Keya Wakpala" (REDCO, 2014).

In conclusion, the Sicangu Lakota decided for themselves that building a resilient community will require acknowledging and encouraging beneficial interconnections, familial and ecological diversity, ceremony that continues to maintaining their adaptive learning relationship with land, traditional governance structures that localize responsive decision making, prioritizing the use of sustainable and local materials, knowledge, and labor, and incorporates the need to remain adaptive to potential climate changes in construction and flexibility in decision making, continuously evaluating how this new community is serving the values, visions, and health of the people. The first stage of the Indigenous design process seeded these conversations, decisions, and the plan to achieve them.

Tohono O'odham Traditional Knowledge and Values for Design

Another example of the resilient design application of Indigenous values and knowledge is the result of a community meeting held with a group of Tohono O'odham community members and college faculty at the Tohono O'odham Community college, discussing the design of a future science building. The values identified within the meeting included maintaining a focus on community, reciprocity, and family. This includes the value of generosity, and keeping good relationships with others, human and non-human. Acknowledgement of the sacredness and deep connection with the seasons, water, and natural beauty, the open spaciousness of the land, as well as the necessity of learning and living with the traditional teachings of the desert was noted as critical, maintaining traditional agricultural practices, wild harvesting, and hunting. High value was placed on continuing the life of ceremony, songs, and stories from history, as

well as acknowledgement of the living spirits present that those things express and carry forward, as well as ensuring that children are educated in these ways.

Tohono O'odham Building Design

When asked to create building designs that expressed these values, the participants came up with an octagonal adobe building featuring saguaro ribs, traditionally called an Olaski. The circular center of this building would be sunken into the Earth, which is both a traditional and contemporary technique to provide temperature regulation. The floors would be made of adobe, finished with contemporary finishes. A skylight at the top would be included to connect the inhabitants to the stars and sky, with a shade for the intense summer heat. The largest windows would face Baboquivari, a sacred mountain that is the home of the Creator I'itoi. Skylights would be used in the hallways for daylighting. These hallways would bisect the octagon in the four cardinal directions, with the primary doorway opening to the east, with a central fire pit located outside. The classrooms themselves would feature circular seating, with the instructor having an option to sit at level view with the students. The interior art would feature local land, culture, artistic expressions, and cooling color shades. There would be natural flow created between the indoor and outdoor spaces, with traditional shade structures, called watto, surrounding the building, with a traditional adobe oven and sitting areas. The landscaping would be a reflection of the natural desert, utilizing native mesquite trees for shade and food, cactus, basket making resources, and other important plants. An elder man contributed that it was critical to look at land before you build to think about where water goes, involving the local people because they have deep knowledge of how water moves through the land. He recommended the use of infiltration basins and swales to help the monsoon waters sink into the

land and reduce erosion. The participants also expressed desire for a metal roof for rainwater collection, draining to an underground cistern with a solar-powered pump, water re-use, and solar electricity. After discussing the Tohono O'odham understanding of the living presences and spiritual understandings of the desert, it was suggested to call it the 'Living Sciences' Building. Future design sessions would need to include elders, singers, more representatives of the local area to ensure that the design express respect and understanding of the site and the education of the Tohono O'odham that would occur within the building (Droz, 2014).

Both of these cases illustrate the manner in which traditional Indigenous values, knowledge, and relationships with the land and each other can be the foundation of contemporary engineered design that cultivates social-ecological resilience. Newer techniques, including the use of cisterns, solar electricity, contemporary adobe finishes, and the use of scientific climate, energy, and hydrologic data can be used as modern expressions of Indigenous understandings, responsibilities, and relationships with their homelands.

Otomi of San Pedro Design and Implementation

The final case explored, the construction of a midwifery clinic with the Otomi of San Pedro Seccion 6, outside of Temoaya, Mexico, illustrates the cultural revitalization that can be achieved through the full design/build process using the Indigenous ecological design method.

Sustainable Nations co-hosted a strawbale/adobe midwifery clinic design, training, and construction with the Otomi community of San Pedro Seccion 6, outside of Toluca Mexico in 2008, utilizing the Indigenous ecological design process. The process of design for the clinic took a full year. The project was initiated by an Otomi/Mazahua woman who sought out Sustainable Nations to assist her in bringing education on sustainable techniques to her village.

She had asked the women, specifically, what their greatest need was. They responded that they wanted a place where they could leave their homes to go birth their babies. The village was composed of mostly concrete block one, two, or three room homes occupied by large families. The women wished to have a peaceful place to go birth. Additionally, the midwife of the village was also the traditional doctor, who treated people from all over Mexico in a small side room of her home.

Identifying the Design Team and Creating Our Foundation

Many meetings were called throughout several months to discuss the possibility of building a clinic and midwifery center, often bringing together the entire village of several hundred people to air conflicts, misunderstandings, and determine the direction forward. In this case, traditional leadership and locally responsive and accountable governing processes were present and strong, and the bilingual woman who originally outreached to Sustainable Nations did remarkable organizing, visiting each family home and assisting conflict resolution: key to the success of the project. Once the community unanimously agreed to build the clinic, the land to build upon was assigned based on communal decision-making process in a large village meeting. The design team was formed, composed of four young Otomi adults without children who would work with Sustainable Nations, the village women, and the midwife to design the clinic and carry forward the organizing process, while also identifying the foundation of values, principles, and priorities we were going to move forward with.

This primary design team then began the process of cultural mapping, touring the lands of the village and joined occasionally by other community members. In the beginning of the mapping process, the primary organizer, local design team members, and the midwife expressed

strongly that it was important to underscore Indigenous culture and strength, noting how the community seemed to be losing their desire to maintain their Otomi identity and traditions. Strongly expressed public disdain for Indigenous peoples is common in Mexico, which has had impact upon the community's youth in particular. It is important to note that this is the particular community responsible for the caretaking of the main ceremonial center of the Otomi people, and therefore has a strong impetus to maintain the vital elements of Otomi culture. Otomi cultural values are based on the responsibility to maintain the balance of the zaki, a common spiritual life force that animates all beings, including plants, animals, spirits, and humans. This spiritual life force is the expression of the first and present Sacred Father and Sacred Mother, living also through the presences of Sun, Grandfather Fire, Earth, and the Waters (Dow, 2003; Sandstrom, 1981). Although the life force of humans is seen as weaker and more vulnerable, humans still have the responsibility to care for and maintain balance with the lives of animals, plants, and spirits, also maintaining the sanctity of the sacred places. In this community, the primary sacred places are the spring and the ceremonial center. There is also strong value on maintaining the vitality of the family and family relationships. Maintaining these responsibilities, as well as encouraging a sense of strength and pride in Otomi identity, was noted as critical to the development of this project.

It was pointed out by an elder couple that the concrete block homes that the Mexican government has been advocating as the most modern technique are cold and uncomfortable, whereas their adobe and stone home maintains a better temperature and retains more heat in the evening. The team shared curiosity about the potential impact of the build, because the community hadn't built a new adobe building in many years. The traditional healer and midwife

of the community also expressed concern that no one seemed interested in carrying on the healing traditions. Based on the previous experience of Sustainable Nations, it was decided that the building process would be organized as a week long international Indigenous knowledge exchange and training to celebrate and share the local culture and building techniques in an intercultural Indigenous forum.

Social-ecological Learning and Design Inventory

Mapping and design inventory was taken to the degree needed to accomplish the build and get a sense of the relationship of the community to their lands, resources and each other. As notes were taken, we discussed how the design and building process, as well as the clinic itself, could support and enhance the most important values of the people. Local spiritual leaders, elders with traditional building knowledge, and caretakers of the water were identified and brought into the mapping and design process to guide the team. Characteristics of the community that were identified as important to the resilience of the Otomi and their land were the overall environment, the social location of the community, food production, and water systems. The rural village of San Pedro Seccion 6 is located in the mountains at a very high altitude, resulting in cold winters. The single walled cement block homes that make up the majority of the housing do not provide enough insulation to maintain comfort in the winter. The idea of external straw bale walls was discussed as a good option for the clinic due to its ease and efficiency of construction, its technical similarity to brick-laying, which is the primary local building strategy, and its very high insulation value. The local farmers also make bales out of old cornstalks, and while this would not be able to provide the majority of the bales used in the walls, wheat straw bales were also easily obtainable a short distance away. After deliberation,

the design team and community representatives determined that the external walls would be constructed out of straw bales and the inner walls would be constructed with traditional adobe brick. This community, being the site of the ceremonial center and the home village of a well-known traditional doctor, hosts visitors from other Indigenous communities as well as mestizos who receive doctoring and attend local ceremonials. Because of this, the design team recognized the importance of locating the clinic in an easily accessible central area, the inclusion of a large open receiving room in the front of the clinic, as well as ensuring that the design reflect local aesthetics and tradition. Water, as the source of life and health, was another strongly expressed value of the mapping process. The village is located at the site of a spring, which serves as a water source as well as the location of the ceremonial center of all of the Otomi villages. The people of San Pedro Seccion 6 maintain the responsibility of caring for this spring, continuing its offerings and relationship with the life-giving forces present at this location. The design team noted that asbestos pipes were used to carry water from the pure spring to the village, which was discussed privately with the lead organizer as a concern to address in the future. Once water is used, it is dumped into the agricultural fields. Toilets are flushed by hand with buckets, which drain directly to the fields as well. This is not only an important source of water, but also an important source of fertilizer for the fields. Sustainable Nations discussed the possibility of composting toilets, or a wetland system to pre-treat this water prior to its release, and the design team decided to visit with the families of the village to discuss altering this practice. The milpas – family owned fields of maiz – are the center of community life. The community maintains the biodiversity of their maiz, growing at least twenty different definable strains. They also harvest and dry local mushrooms, raise several kinds of beans and potatoes and keep chickens for meat

and eggs. The local design team and primary hosting family discussed what kinds of food should be purchased for the visitors, initially suggesting the purchase of wheat bread, milk, and other items. Ultimately, it was determined that, given the agreed upon importance of celebrating local culture and sharing within a cultural exchange setting, that the visitors would be very happy eating the food of the community. The design team also traveled to visit other grassroots sustainability organizations operating in the nearby city of Toluca, to outreach for future partnerships and learn from their experience.

Design and Implementation

Based on the guidance from elders, and social-ecological learning gained from the mapping process, an original design was created. This design went through several iterations, first within the design team itself and then based on input gathered from a community meeting. When the design went through final approval, the design team and Sustainable Nations pursued the funds needed to host the gathering and purchase windows, lumber, and roofing. The cost of constructing a natural building in Mexico is minimal, requiring only $7,000 for the actual construction and another few thousand more to host the gathering and cover travel for the non-local design team member, which was easily raised from private donors. Several weeks prior to the build the community laid the foundation, purchased supplies from local builders, and prepared to host the non-local attendees.

Indigenous peoples arrived from across the Americas. The first night prior to the build, we gathered the visitors and local people to prepare for the next day's work with enthusiastic sharing of stories, visions for the future, and songs. Many of the visitors came from Native communities who no longer had a traditional doctor and midwife, and they expressed admiration

for the maintenance of these traditions. The beauty of the lands, village, and traditional food were honored and actively spoken to by the visiting people. In the morning the construction process began, with strong participation of the local children and young adults. We worked strongly together every day for just short of a week to finish the first stage of the building process. People from surrounding communities came to visit and help for periods of time. An important transition took place after the roof and straw bale walls were up and it was time to plaster the bales with an adobe plaster mix. There was no electricity on site to run a cement mixer, so a pit was constructed in which to mix the adobe by foot. The elders, who until this time had been primarily watching the training from their windows, came out and excitedly informed us that this method was their traditional mixing method. They enthusiastically took over the work, teaching the local young people and visitors their techniques, and ultimately leading the remainder of the plastering work. It took another several weeks after the knowledge exchange was over to finish the inner walls, floor, electrical connections, and finish coat of plaster. The clinic opened with a large celebration, attended by the local people, representatives of many other villages, students, and professors from the university in Toluca.

Evaluation and Adaptation

The evaluation and adaptation stage took place about a year later. The team reflected several things that could have been improved. Due to time and funding shortages, we were limited to focusing on the building only, and were not able to fully pursue work involving more systems, such as the electricity and water. The community wants solar electricity, and is interested in better water and sanitation systems. They also need another piping system that is does not involve asbestos pipes. The local people tried composting toilet systems, and decided

that they did not fit their preferences. The design team will implement constructed wetlands to allow the continuation of the locally desired practice of draining wastewater to the milpas. In order to maintain momentum, and assist the community in being able to realize their visions we determined that it would be useful to form a closer partnership with the university in nearby Toluca, which itself is focused on supporting Indigenous culture. Most of the community members are very busy with work and the raising of children, and while they know what they want for their future, only a very small number of people are free and confident enough to organize projects and build skill sets that enable them to carry out this work without external technical support. Plans were discussed for supporting the next generation of young adults to carry this work forward when the lead organizer may have other future responsibilities to care for.

There were very strong positive impacts on the community of San Pedro Seccion 6 as a result of this one building, however. The re-valuing of their adobe building traditions as the basis for contemporary design, and the demonstrated comfort and beauty of this traditional building method has led the younger builders within the community to re-learn these techniques from their elders, once again valuing them as a source of wisdom. Additionally, the midwife received several local apprentices after the training concluded, something she attributes to the re-valuing of Indigenous ways sparked by the intercultural exchange (Ramirez, 2009). The resilience of the community was supported by the Indigenous ecological design process through the re-valuation of local governance structures, highlighting the elders' knowledge of their beautiful, climate-appropriate and affordable building methods, and the seeding of long-term community organizing strategies that place their knowledge and relationship with their land and

each other at the center of community decision-making. The sharing of their ways of maintaining the ecological resilience of their territories, through nutrient recycling, diversity in food systems, crop rotation, prescribed burning of the fields, and honor for their water, as well as their culturally based conflict resolution and community governance reminded the visiting Indigenous peoples of strategies for re-building resilience back in our home communities.

CONCLUSION

Faced with ecological degradation, social disruption, and climate change, people from diverse fields of research and walks of life are working to develop resilient, healthy social-ecological systems. Social and ecological scientists, among others, have been increasingly looking to Indigenous communities for models of resilience. The inherent resilience of these communities has been demonstrated by the sole fact of their continued existence over hundreds or thousands of years as culturally intact peoples living within diverse and, for the most part, healthy ecosystems. This continuance is particularly notable given the attempts at genocide most Indigenous communities have survived, although many of these communities have been deeply compromised.

Research on the sources of resilience within Indigenous communities has identified the unique cultural cosmologies of these nations as a source of resilience. These cosmologies share a view of the world as interconnected, dynamic, self-organizing social-ecological living systems with sentience and agency. These cultures place emphasis on responsive adaptation to an ever dynamic and unpredictable world, recognizing the creative value of disruption, as can be seen in the practices of prescribed burning, diverse and rotated agricultural systems, and stories that tell of the benefits of the element of chaos (Droz, 2014). They focus on long-term decision-making

and productivity, and the maintenance of strong social networks, cultivating a strong sense of responsibility for the continued health of their social-ecological communities. And, critically, they share a land and relationship-based epistemology that is responsive to the living, dynamic social ecology they are a part of, allowing for the continuous incorporation of new knowledge emerging directly from the landscape and brought into understanding through reflection with older traditional knowledge and ways of life (Berkes, 2012; Droz, 2014; Davidson Hunt et al, 2003; Gegeo, 2001). Each of these elements of cosmology are directly referred to by the resilience literature as contributors to the resilience of social-ecological systems (Folke et al., 2010; Gunderson et al, 2010; Martin et al, 2010; Walker et al, 2012)

Folke et al. (2010) described three aspects of social-ecological resilience: persistence, adaptability, and transformability. Persistence, relying on the social-ecological systems' adaptive capacity, describes the ability of the system to remain within the stable basin it currently occupies. Transformability refers to the ability of a social-ecological system to self-organize into a new stable basin, or equilibrium, rather than experience a forced transformation that could be chaotic. Self-organized transformability is seen to utilize crises as windows of opportunity, encourage options and novelty, and incorporate social learning. Transformability in the context of resilience is based on Native knowledge and relationships with their homelands. It is fostered by creating community networks and social memory based on these relationships, passing on old knowledge while incorporating creativity and new knowledge in keeping with Indigenous cosmology and values that have guided the creation of resilient sustainable Indigenous nations for hundreds and hundreds of years. Indigenous ecological design methodologies re-build these relationships as the explicit foundation for contemporary design. It does this through cultivating

community networks for knowledge and strengthening the social memory passed on by elders, bringing in the new knowledge and tools of ecological engineering that fit the values and cosmology of Indigenous people.

As explored within the cases of the Sicangu Lakota, Tohono O'odham, and Otomi communities, these practices can support the resilience of Indigenous communities, through placing Indigenous cosmologies, including new knowledge from land-based epistemology and the social memory of elders and history at the center of design decision making, encouraging strong community networks, and locally responsive and adaptive governance and decision-making. Thus far, the Otomi community has been the sole case documented from initial design phase through completion and first-year evaluation. This case was also limited to the construction of one building. The cases discussed herein, and others to come, will continue to be followed and documented as they come into the further stages of design and development to allow for deeper analysis of the Indigenous ecological design methodology's contribution to the resilience of Indigenous nations and communities.

ARTICLE 3 REFERENCES

Berkes, Fikret. 2012. *Sacred Ecology.* Taylor and Francis.

Ballard, Myrle. 2012. *Flooding Sustainable Livelihoods of the Lake St. Martin First Nations: The Need to Enhance the Role of Gender and Language in Anishinaabe Knowledge Systems*. Dissertation. University of Manitoba.

Cajete, Gregory. In: Waters, Anne. American Indian Thought: Philosophical Essays. Blackwell Publishing, 2004.

Chandler MJ, Lalonde C. 1998. Cultural continuity as a hedge against suicide in Canada's First Nations. Transcultural Psychiatry. Vol. 35:191–219.

Davidson-Hunt, I.J. 2003. Journeys, plants and dreams: Adaptive learning and social-ecological resilience. Unpublished Ph.D. Thesis, University of Manitoba, Winnipeg.

Davidson-Hunt, Iain, K. Turner, A. Mead, J. Cabrera-Lopez, R. Bolton, C. Idrobo, I. Miretski, A Morrison, and J. Robson. 2012. Biocultural Design: A new conceptual framework for sustainable development in rural Indigenous and local communities. *S. A. P. I. EN. S.* 5 (2).

Davidson-Hunt, I.J. and F. Berkes. 2003. Nature and society through the lens of resilience:

Day, Sharon. Personal conversations with PennElys Droz. July, 2013

Deane, Lawrence and E. Smoke. 2010. Designing affordable housing with Cree, Anishinabe, and Metis People. Canadian Journal of Urban Research. 19(1).

Delgado, Louis. 2013. Native Voices Rising: A Case for Funding Native-led Change. Common Counsel Foundation.

Diemont, S. A.W., and J. F. Martin. 2009. Lacandon Maya ecosystem management: sustainable design for subsistence and environmental restoration. *Ecological Applications*. 19(1):254–266.

Dietz, T., Ostrom, E., Stern, P., 2003. The struggle to govern the commons. Science 302, 1907–1912.

Droz, PennElys. 2014. Biocultural Engineering Design: An Anishinaabe Analysis for Building Sustainable Nations. American Indian Culture and Research Journal.

Droz, PennElys. Tohono O'odham Community College (TOCC) Design Charrette Meeting Notes. March, 2014.

Droz, PennElys. Keya Wakpala Community Meeting Dialogue Notes. Oct. 1 – Nov. 2013.

Droz, PennElys. Sustainable Nations Project Report, 2008

Droz, PennElys. 2011. Project Report, Sustainable Nations.

Doerfler, Jill, N. Sinclair, and H. Stark, eds. 2013. *Centering Anishinaabeg Studies: Understanding the World through Stories*. Michigan State University Press.

Dow, JW. 2003. Sierra Otomi Religious Symbolism: Mankind responding to the natural world. In: Douglas, Sharon, ed. Mesas and Cosmologies in Middle America. San Diego Museum Papers 42.

Environmental Protection Agency. 2013. [online] URL: http://www.epa.gov/region9/greenbuilding/tribal-workgroup.html

Folke, C.; Carpenter, S.; Walker, B., Scheffer, M., Chapin, T.; & Rockstrom, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability, and Transformability. *Ecology and Society* **15**(4): 20.

Folke, C. Traditional knowledge in social–ecological systems. Ecology and Society, Vol 9 (4).
Gegeo, David W. & Watson-Gegeo, Karen Ann. (2001) "How We Know" : Kwara'ae Rural Villagers Doing Indigenous Epistemology. The Contemporary Pactific, Vol 13, No. 1, 55-88 University of Hawaii Press.
Goldtooth, Tom. Personal Conversations with PennElys Droz, 2013.
Gurneau, Renee. Personal Conversations with PennElys Droz, 2013.
Gunderson, L, Allen, C., & Holling, C.S. *Foundations of Ecological Resilience*. Island Press, 2010.
IUCN Intercommission Task Force on Indigenous Peoples. Indigenous Peoples and Sustainability. International Books, 1997.
Jorgensen, Miriam, ed. 2008. Rebuilding Native Nations: Strategies for Governance and Development. University of Arizona Press.
Klein, Naomi. 2013. Dancing the World into Being: A Conversation with Idle No More's Leanne Simpson. http://www.yesmagazine.org/peace-justice/dancing-the-world-into-being-a-conversation-with-idle-no-more-leanne-simpson. Accessed October.
LaDuke, Winona. Recovering the Sacred: The Power of Naming and Claiming. South End Press, 2005.
MacGuire, Patricia. 2010. Exploring resilience and Indigenous ways of knowing. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health.* 8(2).
Maffi, Luisa and E. Woodley. 2010. *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan.
Mander, J & Tauli Corpuz, V. Paradigm Wars. International Forum on Globalization publication with Sierra Club Press, 2006.
Martin, Jay; E. Roy, S. Diemont, and B. Ferguson. 2010. Traditional Ecological Knowledge: Ideas, inspiration, and designs for ecological engineering. *Ecological Engineering*, 36:839-849.
McLean, Kirsty Galloway. 2010. *Advance Guard: Climate change impacts, adaptation, mitigation, and Indigenous peoples.* United Nations University.
Mitsch, W.J., and S. E. Jørgensen. 2004. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc.
Muir, Cameron, D. Rose, Deborah, and P. Sullivan. 2010. From the other side of the knowledge frontier: Indigenous knowledge, social-ecological relationshiops, and new perspectives. *The Rangeland Journal*. 32:259-265.
Nelson, Melissa. 2008. Original Instructions: Indigenous Teachings for a Sustainable Future. Collective Heritage Institute. Bear & Company.
Pierotti, R. 2011. Indigenous Knowledge, Ecology, and Evolutionary Biology. Taylor & Francis.
Pierson, Brian. 2013. Housing Development Handbook. 2013 National American Indian Housing Council (NAIHC).
Rosebud Economic Development Corporation (REDCO). 2014. Keya Wakpala Waicageyapi/Turtle Creek Green Development.
Ramirez, Diana. 2009. Personal conversation with author.
Riddle, Lori. Personal Conversation with PennElys Droz. January, 2014.

Sagarin, R. and A. Pauchard. 2012. *Observation and Ecology: Broadening the Scope of Science to Understand a Complex World*. Island Press.
Sandstrom, Alan R. 1981. *Traditional Curing and Crop Fertility Rituals Among Otomi Indians of the Sierra de Puebla, Mexico: The Lopez Manuscripts*. Occasional Papers and Monographs, Number 3. Bloomington: Indiana University Museum.
Shimek, Bob. Personal Conversation with PennElys Droz, July 2013.
Simpson, Leann, J. DaSilva, B. Riffel, and P. Sellers. 2009. The Responsibilities of Women: Confronting Environmental Contamination in the Traditional Territories of Asubpeechoseewagong Netum Anishinaabek First Nation. *Journal of Aboriginal Health.* December.
Sinclair, Niigaanwewidam James. 2013. *Nindoodemag bagijiganan: A History of Anishinaabeg Narrative.* Dissertation. University of British Columbia.
Van der Ryn, Sim, and S. Cowan. 1996. *Ecological Design.* Island Press.
WCED World Commission on Environment and Development. Our Common Future. Oxford University Press, 1987.
Walker, Brian and D. Salt. 2006. *Resilience Thinking*. Island Press.
Walker, B. H., S. R. Carpenter, J. Rockstrom, A.-S. Crépin, and G. D. Peterson. (2012) Drivers, "slow" variables, "fast" variables, shocks, and resilience. *Ecology and Society* **17**(3): 30.

CHAPTER 5. CONTRIBUTIONS TO LITERATURE, LIMITATIONS, AND FUTURE RESEARCH

CONTRIBUTIONS TO LITERATURE

This body of research has demonstrated that there are strong epistemological relationships and common principles shared by the field of ecological engineering, research on social-ecological resilience, and Indigenous cosmologies and cultural values. These alignments include a view of the world as interconnected, dynamic, self-organizing social-ecological systems, an emphasis on adaptation and continual change, recognition of social-ecological thresholds, or necessary limits to behaviors, emphasis on long term decision making and productivity, and the intentional imitation of ecological forms, processes, and principles, such as diversity, functional redundancy, intentional small scale disruption of systems to encourage systemic health, and more. Other common elements include emphasis on the creation of strong social networks, the encouragement of new knowledge with avenues for that knowledge to be incorporated into social memory, a sense of responsibility for the health of social-ecological communities, and an epistemology based on an active, continuing responsive relationship with ecology. These alignments enable Indigenous cultural knowledge and ways of being to inform and provide the foundation for contemporary engineered design both at grassroots as well as national scales of development. This creates avenues for Indigenous knowledge for design to be translatable into engineering and architectural design documents, which in turn allows access to large-scale financial support for community development. In addition to contributing to engineering and design literatures, this finding contributes to the analysis of the role of cultural cosmology in the creation of resilience within social-ecological systems. There are very specific

cultural teachings that speak directly to the recommendations of the resilience literature, implying that processes of re-Indigenization – the centering of Indigenous values, cosmologies, and visions as the base for decision making and action within community – may contribute strongly to the creation of resilience within Indigenous nations.

The second primary contribution to literature has been the articulation of a biocultural, or Indigenous, engineering design approach based on these alignments. Biocultural engineering is founded on Indigenous cosmologies, knowledge, cultural relationships and decision-making processes, while integrating appropriate design tools and techniques of ecological engineering and architecture with the intent of contributing to the social-ecological resilience of Indigenous communities. This seven-phase methodology has been developed and is being applied at various scales in many different Indigenous nations, and thus far has successfully been used to create a master plan for a community, several homes, a water system, and a clinic. This methodology is reproducible, intended for use by engineers, architects, planners, and community organizers.

Another contribution to the literature is the identification of the creative and transformative responses that can be generated when colonized and culturally repressed communities are given the space and opportunity to create action for the future based on their unique cosmologies. The Indigenous engineering design method in practice must be adaptive to cultural contexts and ecologies, responsive to the unique histories of people with their land, each other, and the varying impacts of colonization. Bringing Indigenous values and cosmologies into contemporary design and visioning for the future can elicit powerful emotional responses from community members that have experienced oppression related to the maintenance of their belief systems and ways of life, or whose communities have survived programs designed to assimilate

them into the hegemonic society. This needs to be taken into consideration by all practitioners of this design method, as participating in the process can have very real social, emotional, and political impacts. The organizations Blue Star Studios, Inc, and Sustainable Nations have learned to address this through working with respected change makers within their communities, following their lead regarding the nature of community organizing. We have identified strategies to emerge the contemporary values of the people, witnessing the remarkably intact cultural relationships with land and community still present in diverse Indigenous communities. We have seen how these relationships and values can easily become the basis of engineered design and architecture. We note that there is no lack of determination, creativity, and cultural strength limiting the applicability of biocultural design: we have seen that simply the creation of an avenue of possibility, asking the right questions within a context of trust, respect, and humility, allows the visions and values of the people to become designs, and then implemented systems.

Finally, this work contributes to understanding the role of re-Indigenization of our communities in a practically applied context. Re-Indigenization refers to the identification of the core values, relationships, and responsibilities that give one Indigenous identity, and the practice of, once again, placing these values at the core of action and decision-making. Indigenous peoples all have experienced some form of disconnection with our core values and the actualization of those in practice. The biocultural engineering design methodology has demonstrated that a re-Indigenizing process can contribute to the transformability aspect of building resilience, allowing Indigenous peoples to adapt and transform from a strong foundation

of core values and generations of social memory into a new era of time and transformed social-ecological systems we live within today.

LIMITATIONS AND FUTURE RESEARCH

Originally intended to be a very focused single case study with an Anishinaabe community, my research was limited by the time constraints and planning activities of this community. I continue to be in this research process, and will be constructing a contemporary wigwam with energy and water systems using an Anishinaabe biocultural engineering method, documenting the process to contribute to this body of research. I am also continuing my work with the Sicangu Lakota and Tohono O'odham, as well as the Pueblo of Jemez of New Mexico and the Gila River Indian Community of Arizona, whose finalized projects and educational/training programs will be well documented as contributing case studies as well. This body of research lends itself to the study of biocultural design processes as a source of technological and design innovation as Indigenous communities practice placing their values and cosmologies at the center of development decisions. Further, comprehensive start-to-finish documentation of the methodology applied to diverse engineered applications, including water systems, energy systems, and building construction is needed, as well as evaluations of how the method has or has not contributed to long term social-ecological resilience within the participating Indigenous communities according to the indicators of resilience.

REFERENCES

Allen, T. F. H., M. Giampeitro, and Little, A. M. 2003. Distinguishing ecological engineering from environmental engineering. *Ecological Engineering*, 20:389-407

Barreiro, Jose & Johnson, Tim. Ed. 2001. American Indian Millenium: Renewing our Way of Life for Future Generations. Proceedings. Ithaca, New York. Novermber 29-December.

Benton-Banai, Eddie. 1988. *The Mishomis Book*. University of Minnesota Press.

Bergen, Scott, Bolton, Susan, and Fridley, James. 2001. Design principles for ecological engineering. *Ecological Engineering*. 18: 201-210.

Berkes, Fikret., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*. 10: (5).

Berkes, Fikret. 2012. *Sacred Ecology*. Taylor and Francis.

Berkes, Fikret and M. Kislalioglu. 2009. Ecological complexity, fuzzy logic, and holism in Indigenous knowledge. *Futures*. 41(1):6-12.

Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, 2003.

Ballard, Myrle. 2012. *Flooding Sustainable Livelihoods of the Lake St. Martin First Nations: The Need to Enhance the Role of Gender and Language in Anishinaabe Knowledge Systems*. Dissertation. University of Manitoba.

Blaser, Mario, H. Feit, and G. McRae. 2004. *In the Way of Development: Indigenous Peoples,Life Projects, and Globalization.* Zed Books.

Bossineau, Darrell. 2007. The Traditional Role of Governance in Aboriginal Communities: 'Minobimaddisiwin Nationhood.' *Aboriginal Financial Officers Association of Canada National Conference.* [online] URL: http://www.afoa.ca/conferencE/2007/Presentations/Boissoneau.pdf

Bohensky, E. L., and Y. Maru. 2011. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? *Ecology and Society* **16**(4): 6. http://dx.doi.org/10.5751/ES-04342-160406

Cajete, Gregory. In: Waters, Anne. American Indian Thought: Philosophical Essays. Blackwell Publishing, 2004.

Chandler MJ, Lalonde C. 1998. Cultural continuity as a hedge against suicide in Canada's First Nations. Transcultural Psychiatry. Vol. 35:191–219.

Chapeskie, Andrew. 1996. Indigenous Law, State Law, Renewable Resources and Formal Indigenous Self-Government in Northern Regions. In Kuppe, R. & Potz, R. eds. Law and Anthropology. Martinus Nijhoff Pubishers.

Costanza, R. 1996. *Designing sustainable ecological economic systems.* In: Schulze, P.C. (Edd.), Engineering within Ecological Constraints. National Academy Press, Washington, DC pp. 82-99.

Corning, Peter. 1995. Synergy and Self-organization in the evolution of complex systems. *Systems Research*. 12 (2):89 – 121.

Dahl, Michael. Personal Conversation with PennElys Droz. July, 2013.

Davidson-Hunt, I.J. 2003. Journeys, plants and dreams: Adaptive learning and social-ecological resilience. Unpublished Ph.D. Thesis, University of Manitoba, Winnipeg.

Davidson-Hunt, Iain. Indigenous Lands Management, Cultural Landscapes, and Anishinaabe People of Shoal Lake, Northwestern Ontario, Canada. Environments. Volume 31(1) 2003.

Davidson-Hunt, I. J. (2006). Adaptive learning networks: Developing resource management knowledge through social learning forums. *Human Ecology, 34*(4), 593-614.

Davidson-Hunt, Iain, K. Turner, A. Mead, J. Cabrera-Lopez, R. Bolton, C. Idrobo, I. Miretski, A Morrison, and J. Robson. 2012. Biocultural Design: A new conceptual framework for sustainable development in rural Indigenous and local communities. *S. A. P. I. EN. S.* 5 (2).

Davidson-Hunt, I.J. and F. Berkes. 2003. Nature and society through the lens of resilience: toward a human-in-ecosystem perspective. In F. Berkes, J. Colding and C. Folke (eds.) Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge: 53-82.

Day, Sharon. Personal conversations with PennElys Droz. July, 2013

Deane, Lawrence and E. Smoke. 2010. Designing affordable housing with Cree, Anishinabe, and Metis People. Canadian Journal of Urban Research. 19(1).

Delgado, Louis. 2013. Native Voices Rising: A Case for Funding Native-led Change. Common Counsel Foundation.

Deutsch, Nathan. 2008. Anishinaabe governance and the commons: The Whitefeather Forest Initiative for community economic renewal. International Association for the Study of the Commons conference, Cheltenham, England.

Diemont, S. A.W., and J. F. Martin. 2009. Lacandon Maya ecosystem management: sustainable design for subsistence and environmental restoration. *Ecological Applications*. 19(1):254–266.

Dietz, T., Ostrom, E., Stern, P., 2003. The struggle to govern the commons. Science 302, 1907–1912.

Droz, PennElys. 2014. Biocultural Engineering Design: An Anishinaabe Analysis for Building Sustainable Nations. American Indian Culture and Research Journal.

Droz, PennElys. Tohono O'odham Community College (TOCC) Design Charrette Meeting Notes. March, 2014.

Droz, PennElys. Keya Wakpala Community Meeting Dialogue Notes. Oct. 1 – Nov. 2013.

Droz, PennElys. Sustainable Nations Project Report, 2008

Droz, PennElys. 2011. Project Report, Sustainable Nations.

Doerfler, Jill, N. Sinclair, and H. Stark, eds. 2013. *Centering Anishinaabeg Studies: Understanding the World through Stories*. Michigan State University Press.

Dow, JW. 2003. Sierra Otomi Religious Symbolism: Mankind responding to the natural world. In: Douglas, Sharon, ed. Mesas and Cosmologies in Middle America. San Diego Museum Papers 42.

Environmental Protection Agency. 2013. [online] URL: http://www.epa.gov/region9/greenbuilding/tribal-workgroup.html

Edmunds, David. 2013. Personal conversation with author.

Eilouti, Buthayna. 2011. Environmental Knowledge in Engineering Design Processes. *The 5th International Conference on Knowledge Generation, Communication and Management.* Orlando, Florida, U.S.A.

Fan, Shu-Yang, B. Freedman, and R. Cote. 2004. *Principles and Practice of Ecological Design.* NRC Research Press.
Folke, C.; Carpenter, S.; Walker, B., Scheffer, M., Chapin, T.; & Rockstrom, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability, and Transformability. *Ecology and Society* **15**(4): 20.
Folke, C. Traditional knowledge in social–ecological systems. Ecology and Society, Vol 9 (4). 2004.
Folke C., J. Colding, and F. Berkes, 2003. Building resilience for adaptive capacity in social-ecological systems. In: Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, 2003.
Ford, J., and D. Martinez. 2000. Traditional ecological knowledge, ecosystem science, and environmental management. *Ecological Applications*. 10:1249-1250.
Foushee, Lee and R. Gurneau. 2010. *Sacred Water: Water for Life.* North American Water Office.
Gegeo, David W. & Watson-Gegeo, Karen Ann. (2001) "How We Know" : Kwara'ae Rural Villagers Doing Indigenous Epistemology. The Contemporary Pactific, Vol 13, No. 1, 55-88 University of Hawaii Press.
Geniuz, Wendy Makoons. 2009. *Our Knowledge is Not Primitive; Decolonizing Anishinaabe Botanical Teachings.* Syracuse University Press.
Goldtooth, Tom. Personal Conversations with PennElys Droz, 2013.
Gurneau, Renee. Personal Conversations with PennElys Droz, 2013.
Great Lakes Indian Fish and Wildlife Commission. [online] URL: www.glifwc.org
Grim, John. 2001. *Indigenous Traditions and Ecology; the interbeing of cosmology and community.* Harvard University Press.
Gunderson, L, Allen, C., & Holling, C.S. *Foundations of Ecological Resilience*. Island Press, 2010.
Haggard, Ben, B. Reed, and P. Mang. 2006. Regenerative Development. *Civil Engineering News.* March.
Herman, R. 1996. A perspective on the relationship between engineering and ecology. In Schulze, P.C. (Ed.), *Engineering within Ecological Constraints*. National Academy Press, Washington, DC, pp 66-80.
Heylighen, Francis. Complexity and Self-organization. Taylor and Francis, 2008.
Hill, Lilian. Personal Conversation with PennElys Droz, 2013.
Holling, C.S. Understanding the complexity of economic, social and ecological systems. Ecosystems 4: 390-405. 2001.
Hollnagel, E., D.Woods, and N. Leveson. 2006. *Resilience Engineering: Concepts and Precepts.* Ashgate Publishing.
Howard, Jeff. 2004. Toward participatory ecological design of technological systems. *Design Issues.* 20 (3):40-53
IUCN Intercommission Task Force on Indigenous Peoples. Indigenous Peoples and Sustainability. International Books, 1997.
Johnston, Basil. 1976. *Ojibway Heritage.* University of Nebraska Press.
Johnston, Basil. 2003. *Honor Earth Mother.* Bison Books.

Jorgensen, Miriam, ed. 2008. Rebuilding Native Nations: Strategies for Governance and Development. University of Arizona Press.
Kauffman, Stuart. At Home in the Universe: the search for laws of self-organization and complexity. Oxford University Press, 1995.
Kibert, Charles. 2013. *Sustainable Construction: Green Building Design and Delivery.* John Wiley & Sons.
Klein, Naomi. 2013. Dancing the World into Being: A Conversation with Idle No More's Leanne Simpson. http://www.yesmagazine.org/peace-justice/dancing-the-world-into-being-a-conversation-with-idle-no-more-leanne-simpson. Accessed October.
Kohl, Johann Georg. 1860. *Kitchi-Gami: Life among the Lake Superior Ojibway.* Chapman and Hall, London.
LaDuke, Winona. 2002. The Winona LaDuke Reader: a collection of essential writings. Voyageur Press.
LaDuke, Winona. Recovering the Sacred: The Power of Naming and Claiming. South End Press, 2005.
LaDuke, Winona. 2006. In Mander, J and V. Tauli Corpuz, eds. *Paradigm Wars.* International Forum on Globalization publication with Sierra Club Press.
Landes, Ruth. 1968. *Ojibwa Religion and the Midewewin*. University of Wisconsin Press.
Levin, Simon. Self-organization and the emergence of complexity in ecological systems. Bioscience. Vol 55, No. 12. December, 2005
MacGuire, Patricia. 2010. Exploring resilience and Indigenous ways of knowing. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health.* 8(2).
Maffi, Luisa and E. Woodley. 2010. *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan.
Mander, J & Tauli Corpuz, V. Paradigm Wars. International Forum on Globalization publication with Sierra Club Press, 2006.
Marker, M. 2004. Theories and disciplines as sites of struggle: The reproduction of colonial dominance through the controlling of knowledge in the academy. Canadian Journal of Native Education, 28 (1/2), 102–111.
Martin, Jay; E. Roy, S. Diemont, and B. Ferguson. 2010. Traditional Ecological Knowledge: Ideas, inspiration, and designs for ecological engineering. *Ecological Engineering*, 36:839-849.
Matlock, Marty, and R. Morgan. 2011. *Ecological Engineering Design: Restoring and conserving ecosystem services.* Wiley and Sons.
McCoy, Amy. 2007. *Minobimaadiziwin: Perceiving the good life through Anishinaabe language*. Dissertation. Michigan State University.
McGregor, Deborah. 2004. Coming Full Circle: Indigenous Knowledge, Environment, and Our Future. *American Indian Quarterly*. 28 (4).
McGregor, Deborah. Traditional Ecological Knowledge and Sustainable Development: Towards Coexistence. International Development Research Center. 2004.
McLean, Kirsty Galloway. 2010. *Advance Guard: Climate change impacts, adaptation, mitigation, and Indigenous peoples.* United Nations University.
Menzies, Charles. 2006. *Traditional Ecological Knowledge and Natural Resource Management*. University of Nebraska Press.

Mitsch, W.J., and S. E. Jørgensen. 2004. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc.
Morrison, K.M. 2000. The cosmos as intersubjective: Native American other-than-human persons, in *Indigenous Religions: a Companion.* Ed G. Harvey. London: Cassell, 23-26.
Morriseau, Norval. 1965. *Legends of My People: The Great Ojibway*. The Ryerson Press.
Muir, Cameron, D. Rose, Deborah, and P. Sullivan. 2010. From the other side of the knowledge frontier: Indigenous knowledge, social-ecological relationshiops, and new perspectives. *The Rangeland Journal*. 32:259-265.
Nelson, Melissa. 2008. Original Instructions: Indigenous Teachings for a Sustainable Future. Collective Heritage Institute. Bear & Company.
Odum, Howard, and B. Odum. 2003. Concepts and methods of ecological engineering. *Ecological Engineering*. 20:339-361
Peacock, Thomas, and M. Wisuri. 2001. Ojibwe Waasaa-Inaabidaa. Afton Historical Society Press.
Peterson, Garry. 2000. Scaling Ecological Dynamics: Self-Organization, Hierarchical Structure, and Ecological Resilience. *Climatic Change*. Vol. 44, No. 3. 291-309.
Pierson, Brian. 2013. Housing Development Handbook. 2013 National American Indian Housing Council (NAIHC).
Pierotti, R. 2011. Indigenous Knowledge, Ecology, and Evolutionary Biology. Taylor & Francis.
Prigogine, I., Stengers, I. 1984. Order Out of Chaos: Man's New Dialogue with Nature. Heinemann, London, UK.
Pikangikum First Nation. 2006. *Keeping the Land; A Land Use Strategy for the Whitefeather Forest and Adjacent Areas.* Pikangikum First Nation. [online] URL: http://www.whitefeatherforest.com/wp-content/uploads/2008/08/land-use-strategy.pdf
Ramirez, Diana. 2009. Personal conversation with author.
Reap, John, D. Baumeister, and B. Bras. 2005. Holism, Biomimicry, and Sustainable Engineering. *ASME International Mechanical Engineering Conference and Exposition.* Orlando, Florida, U. S. A.
Rheault, D'Arcy. 1999. *Anishinaabe Minobimatisiwin: The Way of A Good Life.* Debwewin Press.
Riddle, Lori. Personal Conversation with PennElys Droz. January, 2014.
Sagarin, R. and A. Pauchard. 2012. *Observation and Ecology: Broadening the Scope of Science to Understand a Complex World*. Island Press.
Sandstrom, Alan R. 1981. *Traditional Curing and Crop Fertility Rituals Among Otomi Indians of the Sierra de Puebla, Mexico: The Lopez Manuscripts*. Occasional Papers and Monographs, Number 3. Bloomington: Indiana University Museum.
Schulze, Peter. 1996. *Engineering within Ecological Constraints.* National Academy of Engineering.
Shimek, Bob. Personal Conversation with PennElys Droz, July 2013.
Simpson, Leann, J. DaSilva, B. Riffel, and P. Sellers. 2009. The Responsibilities of Women: Confronting Environmental Contamination in the Traditional Territories of

Asubpeechoseewagong Netum Anishinaabek First Nation. *Journal of Aboriginal Health.* December.
Sinclair, Niigaanwewidam James. 2013. *Nindoodemag bagijiganan: A History of Anishinaabeg Narrative.* Dissertation. University of British Columbia.
Stewart, Ian. 2003. Self-organization in evolution: a mathematical perspective. Philosophical Transactions of The Royal Society of London.
Todd, John and B. Josephson. 1996. The design of living technologies for waste treatment. *Ecological Engineering.* 6:109-136.\
Treur, Anton. 2001. *Living Our Languages: Ojibwe Tales and Oral Histories.* Minnesota Historical Society.
Trosper, Ronald. 2010. Resilience, Reciprocity, and Ecological Economics: Northwest Coast Sustainability.
Van der Ryn, Sim, and S. Cowan. 1996. *Ecological Design.* Island Press.
Vennum, Thomas. 1988. *Wild Rice and the Ojibway People*. Minnesota Historical Society Press.
WCED World Commission on Environment and Development. Our Common Future. Oxford University Press, 1987.
Walker, Brian and D. Salt. 2006. *Resilience Thinking*. Island Press.
Walker, B., Holling, C. S., Carpenter, S. R., Kinzig, A. (2004). "Resilience, adaptability and transformability in social–ecological systems". *Ecology and Society* **9** (2): 5.
Walker, B. H., S. R. Carpenter, J. Rockstrom, A.-S. Crépin, and G. D. Peterson. (2012) Drivers, "slow" variables, "fast" variables, shocks, and resilience. *Ecology and Society* **17**(3): 30.
Walker, Rachel. (2008) *Wild Rice: the Dynamics of Its Population Cycles and the Debate Over Its Control at the Minnesota Legislature.* Dissertation. University of Minnesota, July

REFERENCES

Allen, T. F. H., M. Giampeitro, and Little, A. M. 2003. Distinguishing ecological engineering from environmental engineering. *Ecological Engineering*, 20:389-407
Barreiro, Jose & Johnson, Tim. Ed. 2001. American Indian Millenium: Renewing our Way of Life for Future Generations. Proceedings. Ithaca, New York. Novermber 29-December.
Benton-Banai, Eddie. 1988. *The Mishomis Book*. University of Minnesota Press.
Bergen, Scott, Bolton, Susan, and Fridley, James. 2001. Design principles for ecological engineering. *Ecological Engineering*. 18: 201-210.
Berkes, Fikret., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*. 10: (5).
Berkes, Fikret. 2012. *Sacred Ecology*. Taylor and Francis.
Berkes, Fikret and M. Kislalioglu. 2009. Ecological complexity, fuzzy logic, and holism in Indigenous knowledge. *Futures*. 41(1):6-12.
Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, 2003.
Ballard, Myrle. 2012. *Flooding Sustainable Livelihoods of the Lake St. Martin First Nations: The Need to Enhance the Role of Gender and Language in Anishinaabe Knowledge Systems*. Dissertation. University of Manitoba.

Blaser, Mario, H. Feit, and G. McRae. 2004. *In the Way of Development: Indigenous Peoples,Life Projects, and Globalization.* Zed Books.
Bossineau, Darrell. 2007. The Traditional Role of Governance in Aboriginal Communities: 'Minobimaddisiwin Nationhood.' *Aboriginal Financial Officers Association of Canada National Conference.* [online] URL: http://www.afoa.ca/conferencE/2007/Presentations/Boissoneau.pdf
Bohensky, E. L., and Y. Maru. 2011. Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? *Ecology and Society* **16**(4): 6. http://dx.doi.org/10.5751/ES-04342-160406
Cajete, Gregory. In: Waters, Anne. American Indian Thought: Philosophical Essays. Blackwell Publishing, 2004.
Chandler MJ, Lalonde C. 1998. Cultural continuity as a hedge against suicide in Canada's First Nations. Transcultural Psychiatry. Vol. 35:191–219.
Chapeskie, Andrew. 1996. Indigenous Law, State Law, Renewable Resources and Formal Indigenous Self-Government in Northern Regions. In Kuppe, R. & Potz, R. eds. Law and Anthropology. Martinus Nijhoff Pubishers.
Costanza, R. 1996. *Designing sustainable ecological economic systems.* In: Schulze, P.C. (Edd.), Engineering within Ecological Constraints. National Academy Press, Washington, DC pp. 82-99.
Corning, Peter. 1995. Synergy and Self-organization in the evolution of complex systems. *Systems Research*. 12 (2):89 – 121.
Dahl, Michael. Personal Conversation with PennElys Droz. July, 2013.
Davidson-Hunt, I.J. 2003. Journeys, plants and dreams: Adaptive learning and social-ecological resilience. Unpublished Ph.D. Thesis, University of Manitoba, Winnipeg.
Davidson-Hunt, Iain. Indigenous Lands Management, Cultural Landscapes, and Anishinaabe People of Shoal Lake, Northwestern Ontario, Canada. Environments. Volume 31(1) 2003.
Davidson-Hunt, I. J. (2006). Adaptive learning networks: Developing resource management knowledge through social learning forums. *Human Ecology, 34*(4), 593-614.
Davidson-Hunt, Iain, K. Turner, A. Mead, J. Cabrera-Lopez, R. Bolton, C. Idrobo, I. Miretski, A Morrison, and J. Robson. 2012. Biocultural Design: A new conceptual framework for sustainable development in rural Indigenous and local communities. *S. A. P. I. EN. S.* 5 (2).
Davidson-Hunt, I.J. and F. Berkes. 2003. Nature and society through the lens of resilience: toward a human-in-ecosystem perspective. In F. Berkes, J. Colding and C. Folke (eds.) Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge: 53-82.
Day, Sharon. Personal conversations with PennElys Droz. July, 2013
Deane, Lawrence and E. Smoke. 2010. Designing affordable housing with Cree, Anishinabe, and Metis People. Canadian Journal of Urban Research. 19(1).
Delgado, Louis. 2013. Native Voices Rising: A Case for Funding Native-led Change. Common Counsel Foundation.

Deutsch, Nathan. 2008. Anishinaabe governance and the commons: The Whitefeather Forest Initiative for community economic renewal. International Association for the Study of the Commons conference, Cheltenham, England.

Diemont, S. A.W., and J. F. Martin. 2009. Lacandon Maya ecosystem management: sustainable design for subsistence and environmental restoration. *Ecological Applications*. 19(1):254–266.

Dietz, T., Ostrom, E., Stern, P., 2003. The struggle to govern the commons. Science 302, 1907–1912.

Droz, PennElys. 2014. Biocultural Engineering Design: An Anishinaabe Analysis for Building Sustainable Nations. American Indian Culture and Research Journal.

Droz, PennElys. Tohono O'odham Community College (TOCC) Design Charrette Meeting Notes. March, 2014.

Droz, PennElys. Keya Wakpala Community Meeting Dialogue Notes. Oct. 1 – Nov. 2013.

Droz, PennElys. Sustainable Nations Project Report, 2008

Droz, PennElys. 2011. Project Report, Sustainable Nations.

Doerfler, Jill, N. Sinclair, and H. Stark, eds. 2013. *Centering Anishinaabeg Studies: Understanding the World through Stories*. Michigan State University Press.

Environmental Protection Agency. 2013. [online] URL: http://www.epa.gov/region9/greenbuilding/tribal-workgroup.html

Edmunds, David. 2013. Personal conversation with author.

Eilouti, Buthayna. 2011. Environmental Knowledge in Engineering Design Processes. *The 5th International Conference on Knowledge Generation, Communication and Management.* Orlando, Florida, U.S.A.

Fan, Shu-Yang, B. Freedman, and R. Cote. 2004. *Principles and Practice of Ecological Design.* NRC Research Press.

Folke, C.; Carpenter, S.; Walker, B., Scheffer, M., Chapin, T.; & Rockstrom, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability, and Transformability. *Ecology and Society* **15**(4): 20.

Folke, C. Traditional knowledge in social–ecological systems. Ecology and Society, Vol 9 (4). 2004.

Folke C., J. Colding, and F. Berkes, 2003. Building resilience for adaptive capacity in social-ecological systems. In: Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, 2003.

Ford, J., and D. Martinez. 2000. Traditional ecological knowledge, ecosystem science, and environmental management. *Ecological Applications*. 10:1249-1250.

Foushee, Lee and R. Gurneau. 2010. *Sacred Water: Water for Life.* North American Water Office.

Gegeo, David W. & Watson-Gegeo, Karen Ann. (2001) "How We Know" : Kwara'ae Rural Villagers Doing Indigenous Epistemology. The Contemporary Pactific, Vol 13, No. 1, 55-88 University of Hawaii Press.

Geniuz, Wendy Makoons. 2009. *Our Knowledge is Not Primitive; Decolonizing Anishinaabe Botanical Teachings.* Syracuse University Press.

Goldtooth, Tom. Personal Conversations with PennElys Droz, 2013.

Gurneau, Renee. Personal Conversations with PennElys Droz, 2013.
Great Lakes Indian Fish and Wildlife Commission. [online] URL: www.glifwc.org
Grim, John. 2001. *Indigenous Traditions and Ecology; the interbeing of cosmology and community.* Harvard University Press.
Gunderson, L, Allen, C., & Holling, C.S. *Foundations of Ecological Resilience*. Island Press, 2010.
Haggard, Ben, B. Reed, and P. Mang. 2006. Regenerative Development. *Civil Engineering News.* March.
Herman, R. 1996. A perspective on the relationship between engineering and ecology. In Schulze, P.C. (Ed.), *Engineering within Ecological Constraints*. National Academy Press, Washington, DC, pp 66-80.
Heylighen, Francis. Complexity and Self-organization. Taylor and Francis, 2008.
Hill, Lilian. Personal Conversation with PennElys Droz, 2013.
Holling, C.S. Understanding the complexity of economic, social and ecological systems. Ecosystems 4: 390-405. 2001.
Hollnagel, E., D.Woods, and N. Leveson. 2006. *Resilience Engineering: Concepts and Precepts.* Ashgate Publishing.
Howard, Jeff. 2004. Toward participatory ecological design of technological systems. *Design Issues.* 20 (3):40-53
IUCN Intercommission Task Force on Indigenous Peoples. Indigenous Peoples and Sustainability. International Books, 1997.
Johnston, Basil. 1976. *Ojibway Heritage.* University of Nebraska Press.
Johnston, Basil. 2003. *Honor Earth Mother.* Bison Books.
Jorgensen, Miriam, ed. 2008. Rebuilding Native Nations: Strategies for Governance and Development. University of Arizona Press.
Kauffman, Stuart. At Home in the Universe: the search for laws of self-organization and complexity. Oxford University Press, 1995.
Kibert, Charles. 2013. *Sustainable Construction: Green Building Design and Delivery.* John Wiley & Sons.
Klein, Naomi. 2013. Dancing the World into Being: A Conversation with Idle No More's Leanne Simpson. http://www.yesmagazine.org/peace-justice/dancing-the-world-into-being-a-conversation-with-idle-no-more-leanne-simpson. Accessed October.
Kohl, Johann Georg. 1860. *Kitchi-Gami: Life among the Lake Superior Ojibway.* Chapman and Hall, London.
LaDuke, Winona. 2002. The Winona LaDuke Reader: a collection of essential writings. Voyageur Press.
LaDuke, Winona. Recovering the Sacred: The Power of Naming and Claiming. South End Press, 2005.
LaDuke, Winona. 2006. In Mander, J and V. Tauli Corpuz, eds. *Paradigm Wars.* International Forum on Globalization publication with Sierra Club Press.
Landes, Ruth. 1968. *Ojibwa Religion and the Midewewin*. University of Wisconsin Press.
Levin, Simon. Self-organization and the emergence of complexity in ecological systems. Bioscience. Vol 55, No. 12. December, 2005

MacGuire, Patricia. 2010. Exploring resilience and Indigenous ways of knowing. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health.* 8(2).
Maffi, Luisa and E. Woodley. 2010. *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan.
Mander, J & Tauli Corpuz, V. Paradigm Wars. International Forum on Globalization publication with Sierra Club Press, 2006.
Marker, M. 2004. Theories and disciplines as sites of struggle: The reproduction of colonial dominance through the controlling of knowledge in the academy. Canadian Journal of Native Education, 28 (1/2), 102–111.
Martin, Jay; E. Roy, S. Diemont, and B. Ferguson. 2010. Traditional Ecological Knowledge: Ideas, inspiration, and designs for ecological engineering. *Ecological Engineering*, 36:839-849.
Matlock, Marty, and R. Morgan. 2011. *Ecological Engineering Design: Restoring and conserving ecosystem services.* Wiley and Sons.
McCoy, Amy. 2007. *Minobimaadiziwin: Perceiving the good life through Anishinaabe language*. Dissertation. Michigan State University.
McGregor, Deborah. 2004. Coming Full Circle: Indigenous Knowledge, Environment, and Our Future. *American Indian Quarterly*. 28 (4).
McGregor, Deborah. Traditional Ecological Knowledge and Sustainable Development: Towards Coexistence. International Development Research Center. 2004.
McLean, Kirsty Galloway. 2010. *Advance Guard: Climate change impacts, adaptation, mitigation, and Indigenous peoples.* United Nations University.
Menzies, Charles. 2006. *Traditional Ecological Knowledge and Natural Resource Management*. University of Nebraska Press.
Mitsch, W.J., and S. E. Jørgensen. 2004. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc.
Morrison, K.M. 2000. The cosmos as intersubjective: Native American other-than-human persons, in *Indigenous Religions: a Companion.* Ed G. Harvey. London: Cassell, 23-26.
Morriseau, Norval. 1965. *Legends of My People: The Great Ojibway*. The Ryerson Press.
Muir, Cameron, D. Rose, Deborah, and P. Sullivan. 2010. From the other side of the knowledge frontier: Indigenous knowledge, social-ecological relationshiops, and new perspectives. *The Rangeland Journal*. 32:259-265.
Nelson, Melissa. 2008. Original Instructions: Indigenous Teachings for a Sustainable Future. Collective Heritage Institute. Bear & Company.
Odum, Howard, and B. Odum. 2003. Concepts and methods of ecological engineering. *Ecological Engineering*. 20:339-361
Peacock, Thomas, and M. Wisuri. 2001. Ojibwe Waasaa-Inaabidaa. Afton Historical Society Press.
Peterson, Garry. 2000. Scaling Ecological Dynamics: Self-Organization, Hierarchical Structure, and Ecological Resilience. *Climatic Change*. Vol. 44, No. 3. 291-309.
Pierson, Brian. 2013. Housing Development Handbook. 2013 National American Indian Housing Council (NAIHC).

Pierotti, R. 2011. Indigenous Knowledge, Ecology, and Evolutionary Biology. Taylor & Francis.
Prigogine, I., Stengers, I. 1984. Order Out of Chaos: Man's New Dialogue with Nature. Heinemann, London, UK.
Pikangikum First Nation. 2006. *Keeping the Land; A Land Use Strategy for the Whitefeather Forest and Adjacent Areas.* Pikangikum First Nation. [online] URL: http://www.whitefeatherforest.com/wp-content/uploads/2008/08/land-use-strategy.pdf
Ramirez, Diana. 2009. Personal conversation with author.
Reap, John, D. Baumeister, and B. Bras. 2005. Holism, Biomimicry, and Sustainable Engineering. *ASME International Mechanical Engineering Conference and Exposition.* Orlando, Florida, U. S. A.
Rheault, D'Arcy. 1999. *Anishinaabe Minobimatisiwin: The Way of A Good Life.* Debwewin Press.
Riddle, Lori. Personal Conversation with PennElys Droz. January, 2014.
Sagarin, R. and A. Pauchard. 2012. *Observation and Ecology: Broadening the Scope of Science to Understand a Complex World*. Island Press.
Schulze, Peter. 1996. *Engineering within Ecological Constraints.* National Academy of Engineering.
Shimek, Bob. Personal Conversation with PennElys Droz, July 2013.
Simpson, Leann, J. DaSilva, B. Riffel, and P. Sellers. 2009. The Responsibilities of Women: Confronting Environmental Contamination in the Traditional Territories of Asubpeechoseewagong Netum Anishinaabek First Nation. *Journal of Aboriginal Health.* December.
Sinclair, Niigaanwewidam James. 2013. *Nindoodemag bagijiganan: A History of Anishinaabeg Narrative.* Dissertation. University of British Columbia.
Stewart, Ian. 2003. Self-organization in evolution: a mathematical perspective. Philosophical Transactions of The Royal Society of London.
Todd, John and B. Josephson. 1996. The design of living technologies for waste treatment. *Ecological Engineering.* 6:109-136.\
Treur, Anton. 2001. *Living Our Languages: Ojibwe Tales and Oral Histories.* Minnesota Historical Society.
Trosper, Ronald. 2010. Resilience, Reciprocity, and Ecological Economics: Northwest Coast Sustainability.
Van der Ryn, Sim, and S. Cowan. 1996. *Ecological Design.* Island Press.
Vennum, Thomas. 1988. *Wild Rice and the Ojibway People*. Minnesota Historical Society Press.
WCED World Commission on Environment and Development. Our Common Future. Oxford University Press, 1987.
Walker, Brian and D. Salt. 2006. *Resilience Thinking*. Island Press.
Walker, B., Holling, C. S., Carpenter, S. R., Kinzig, A. (2004). "Resilience, adaptability and transformability in social–ecological systems". *Ecology and Society* **9** (2): 5.
Walker, B. H., S. R. Carpenter, J. Rockstrom, A.-S. Crépin, and G. D. Peterson. (2012) Drivers, "slow" variables, "fast" variables, shocks, and resilience. *Ecology and Society* **17**(3): 30.

Walker, Rachel. (2008) *Wild Rice: the Dynamics of Its Population Cycles and the Debate Over Its Control at the Minnesota Legislature.* Dissertation. University of Minnesota, July

APPENDIX I

Example Design Inventory Data Collection Tool and Questionnaire

Indigenous Knowledge	**Ecological Engineering**
Identify the Whole System: Cultural Mapping	Identify the Whole-System: Ecosystem/Bioregional Mapping
What is present within the land? What is the Earth like in different areas?	Geology What are the landforms present? What types of soil are on site? Elevations? Notable features?
Water flows: Where does the water come from? Where does it go? What is the pattern of water through the seasons? How much? Any shifts noticeable in the water?	Water Flows: Where does the water come from? Where does it go? Obtain hydrological data from various sources.
What is present within the land that provides life? How are these cared for? What are the responsibilities of the people?	Land Fertility: Soil fertility considerations. Soil testing. Presence of Humus. Ecological diversity. Plant life. Native plant and animal diversity. Restoration considerations?
Wildlife, domestic animals, migrations: What kinds of animals are here? What do they need to live? What are their relationships with each other? Do they move through or stay year round? What is the timing of their motions? Are there domestic animals here? Are they wanted? What do the domestic animals need, and how are they suited for the land.	Wildlife, domestic animals, migrations: What are considerations on site?
When is the sun the strongest? How does the suns' light move through the land? Where is it the strongest? Where is it	Energy: Sun energy, energy flow through ecosystems. What are areas of potential energy production and conservation?

always shady? Where are the coldest and warmest places during the different times of the year? How does the wind move through the land here?	
What are the values of your family and community that are important to you? How would you like to see those values lived in your daily life? How can you imagine those values being expressed through the landscape, through your home design, through your community?	Social considerations: What values should be expressed through design?
Economy: What do people do now to provide for their families? How would they like to provide for their families, ideally?	Economy: What is the present economy of the region? How might it be impeded and/or supported by design?