Title
Biocultural Engineering Design: An Anishinaabe Analysis for Building Sustainable Nations

Journal
American Indian Culture and Research Journal , 38(4)

ISSN
0161-6463

Author
Droz, PennElys

Publication Date
2014-09-01

DOI
10.17953/aicr.38.4.w1g6521017726785

Biocultural Engineering Design: An Anishinaabe Analysis for Building Sustainable Nations

PennElys Droz

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.[1] 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."[2] In acknowledgment of the intertwined nature of society and ecology, the term "social-ecological system" has come into common use; indeed, use of that term alone is bringing scientists closer to the indigenous understanding of an interconnected, relational world.[3] Writings from the field of biocultural diversity, which researches the

PennElys Droz (Anishinaabe), a doctoral candidate at the University of Arizona, is the executive director of Sustainable Nations, an indigenous peoples' sustainable community development organization. In this capacity she has trained, taught, and implemented renewable energy systems, natural buildings, and ecological wastewater treatment systems in indigenous territories since 2004.

inseparability of culture and ecosystem, have 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.[4]

The attempted integration of indigenous understandings and scientific research is not a new phenomenon. The history of this intersection, both in research and practice, has demonstrated the profound challenges in regard to 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, as well as the inequality of influence and power among researchers, policy makers, and indigenous peoples.[5] 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.[6]

Simpson clearly calls out the acquisitive and extractive approach to knowledge that has been 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 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 rather than a "body of knowledge," IK is the culturally and spiritually based way in which indigenous people relate to their ecosystems, a lived relationship.[7] 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.[8]

In their long-term research on traditional agroforestry and hydrology engineering practices in a Mayan community in Chiapas, Mexico, engineers Jay Martin and colleagues expressed this sense of interconnected relationship as being at the foundation of Mayan engineering. They write, "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."[9] Ethno-ecologist Fikret Berkes well described IK as a "knowledge-practice-belief complex", understanding that the living relationships that embody IK are guided by accumulated understandings and beliefs that are passed on through cultural practices. Speaking to the necessity of grounding technological design for sustainability in indigenous understandings, Berkes also noted that cosmologies that frame human/environment relationships and guide knowledge-making processes can ultimately determine the long-term sustainability of technological design.[10]

Scientists who research 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.[11] Some of these scientists have begun to look 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.[12] This development is intensely bittersweet. Indigenous communities have a history and a present shaped in large part by the views, decisions, and economies of nation-states and nearby non-indigenous communities, struggling with the legacy of a colonial society that intentionally disrupted and tried to destroy indigenous governance, unity, social fabric, teachings, and cultural practices: the very elements of indigenous societies to which scientists are now looking because of 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. Every day, many indigenous nations across the world are meeting the struggle to protect, relearn, and revitalize these critical elements of life in order to heal the people and the land.

Ultimately, indigenous nations need to provide housing, clean water, energy, infrastructure, and a balanced economic life for themselves in a manner that supports, cultivates, and restores their cultural values, relationships, and community resilience in the face of change. There has been an upwelling of interest in ecologically engineered systems as potential options to address these needs, including green and natural building, ecological wastewater treatment, renewable energy development, and integrated agricultural systems. Those seeking these options, however, have been inundated with externally derived, top-down approaches and mechanistically emerged "green" engineering techniques. Although better than the alternatives, these approaches 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.[13]

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 resilient sustainable design that is genuinely based in culture. In this article, these intersections are explored in the context of the Anishinaabe people, providing 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, and politically distinct communities in the Great Lakes region of North America that span the borders of the United States and Canada. They have a long history of colonial interaction, engaging in the fur trade in the early-eighteenth century. They were exposed to devastating disease, increasingly commercialized trade, the coming of several other nation-states and subsequent war, and the drawing of nation-state boundaries through the center of their territories, as well as missionaries who worked towards conversion during a time of social disruption.[14] They have remained remarkably intact culturally in spite of 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 subsequent water contamination.[15] Most Anishinaabe communities continue to participate to some degree in the traditional subsistence 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.[16]

Because of this history, the contemporary Anishinaabek are very diverse. Some communities located in and next to urban centers have urban-adapted lifestyles, some communities live in "the bush" and maintain a lifestyle much like that present at the time of the first settlers, and some have lifestyles that are everything in-between. In this diversity, the language, songs, ceremonies, stories, and the values that are contained and expressed through them, continue to be a thread of connection between Anishinaabe communities.[17] An understanding of who the Anishinaabe people are—particularly in light of identifying epistemology aligned 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 Anishinaabe worldview is grounded in the story of Creation. The following is a paraphrased excerpt of the creation story I was told as a young woman, which has also been corroborated 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 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.[18] Scholar Niigaanwewidam James Sinclair expresses this cosmology in his description of the clan system, which 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)."[19] Kitche Manitou is seen as continuously present, having care for Creation.[20] 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, and 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.'"[21]

Therefore Anishinaabe life is guided by the need to maintain good relations with an interconnected, peopled cosmos. Antagonistic relations create disorder, and 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 perceiving 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. Understood as a grandmother, the drum represents the feminine principle necessary for 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.[22]

In the Anishinaabe perspective, the purpose of the life path is to find one's place of balance within the rest of Creation. 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, and stories tell of the folly of trying to control elements of Creation, usually resulting in serious consequences.[23] 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.[24]

In keeping with this, 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.[25] As all of Creation is the unfolding dream-song, the implication is that humans also have the power to 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 to 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.[26] These stories are guides to finding the path of life that one should pursue to maintain harmony. 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.[27]

There is a saying that a person should work to have his or her actions mirror Creation in process, action, and principle as a means to creating balance within the web of relations. An underlying principle in society, this is heard in many contexts, including large-scale land management and ceremony, and how one should parent children, engage in society, and pursue everyday actions. For example, I was taught that when beading, I should not separate the beads into different colors for the reason 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 as being created through respect, reciprocity, generosity, and humility; these strongly emphasized values are conveyed by traditional stories and ceremony and reinforced by daily interactions.[28]

Anishinaabe Ways of Learning

The root of Anishinaabe philosophy is that, at its core, life is a process of learning. Life is understood through coming to know the patterns and relationships within Creation. Knowledge and meaning are derived from observing relationships present, rather than the objective evaluation of discrete parts of a system or attempts to make predictions. Because knowledge is ultimately relational, dependent upon learners' relationships and life purposes, the sense of seeking an absolute truth is not present.[29] 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. Distinctions are made between those perceptions that are useful as personal knowledge, and knowledge as wisdom with societal scope that can serve as the foundation for decision-making and action in community.[30]

Because the Anishinaabe traditional knowledge process involves the active living of closely observed relationships from the basis of understanding the dynamic nature of life, learning processes are structured to connect the learner to the living social-ecological and cultural landscape.[31] 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. Ecologist Iain Davidson-Hunt, in his work on adaptive learning in Anishinaabe communities, writes, "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."[32] Strong value is also placed on the cumulative knowledge gained from our ancestors and elders.[33] This social memory is contained in stories, both sacred stories and stories told casually, and also encoded not only in the names of places in the landscape, but also the relationship-based language that people use. The person who has demonstrated his or her ability to observe and respond in a good way to changes in the social-ecological environment is considered a valid source of new knowledge.

This encouragement of new knowledge that is gained from intimate experience with the land, combined with the guidance of elders and culture, is what fosters the adaptive capacity for resilience of which scientists speak. As

Davidson-Hunt states, "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."[34] In his work with the Pikangikum and Shoal Lake Anishinaabek of northern Ontario, Davidson-Hunt describes the inherent social-ecological resilience fostered by Anishinaabe epistemology, which allows knowledge to adapt without losing the linkages among the past, present, and future. Within the Anishinaabe community, to distinguish between cyclical change and change that presents a need to adapt is understood as a necessary ability, and both kinds of knowledge are encoded in ceremony, songs, and narratives, among other forms.[35] This land-based way of learning, the "institution" of elders, and society-wide respect for traditional stories as a source of knowledge continue in many Anishinaabe communities. These learning relationships, values, and stories 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.[36] Addressing our needs for safe buildings, transportation, energy systems, water systems, and food production, this practice includes structural, electrical, civil, chemical engineering, and more. Design itself is understood as the intentional shaping of matter, energy, and process to meet a perceived need or desire and inherently partakes of both culture and nature through exchanges of materials, flows of energy, and land-use choices.[37] The manner in which a society designs systems to fulfill needs is fundamentally an expression of their sociocultural values. As Sim Van der Ryn, a notable scholar and author in the field of ecological design, states, "Design manifests culture, and culture rests firmly on the foundation of what we believe to be true about the world."[38]

Various 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 rests firmly on the worldview of nature as a passive set of materials to be utilized, while also assuming easy access to resources obtained at long distances.[39] These approaches, together with a societal drive towards standardization, have resulted in closed system engineering design, which assumes a surrounding stable state and emphasizes the ability to predict or control design outcomes.[40] 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.[41]

Today, engineering fields are responding to the need for sustainable and equitable solutions. Civil and structural engineering literature address a new focus on social-ecological equity and sustainability; chemical engineering has an emerging "green chemistry" based on the principles of biomimicry, humility, and a "do no harm" ethic; and architectural design has been embracing the principles of environment-integrated building design, biomimicry, and the concept of zero-waste.[42] 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 basis of engineered design.[43] This emphasis is found particularly within the field of ecological engineering.[44]

The Foundation: Complexity, Self-Organization, and Resilience

The principles of ecological engineering and design rely upon contemporary scientific study of complex systems and ecology. 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 that are unpredictable, yet self-organizing: that is, interactions produce coordination and synergy, with emergent systemic properties that cannot be reduced to evaluation of the agents themselves.[45] For example, we might consider molecular structures to be such a system, with the agents being the atoms that comprise them, or, in the case of the solar system, the agents would be the planets, stars, meteorites, and dust. This complex systems model can also be applied to social systems such as governance systems or a family group, with the agents being the people involved.

Systems theorist and cyberneticist Francis Heylighen identified that within a complex system, the agents 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. When the agents are identical, increased scale of self-organization occurs more rapidly and results in a more uniform organization, as in the case of molecules of the same type forming a crystal. In cases where the agents are diverse, however, the resulting structure is much more complex. Most systems in Creation are diverse. In systems with diverse agents, self-organization occurs around a multitude of "attractors," or stable basins.[46]

The self-organization of a complex systems can be encouraged by increasing the variations the system is exposed to, making the system explore its 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.[47] To describe this in the context of a social system, the more diverse experiences one gains, the more experience one has with which to lead a strong and well-balanced life. Also, struggles or perturbation, if they are not excessive, increase a person's 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."[48] 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 Schrödinger, who described these systems as self-organizing, arising spontaneously, and evolving toward greater complexity, featuring an inherent requirement for energy capture.[49] Evaluation of biological complex systems has led to a revised view of evolution emphasizing the self-organizing properties of living matter itself, with natural selection playing a supporting role.[50] The dream song is guided by itself as it grows, changes, develops, and returns to the Source.

Because the requirement for energy capture and use drives the development of adaptive complex systems, the theoretical basis for understanding them lies in understanding energy flows.[51] The key ecosystem attributes that allow for self-organization and maximized energy efficiency are complexity and diversity.[52] Ecosystems are patchy and do not function around a single stable equilibrium or attractor. For example, destabilizing forces that are far from equilibria, multiple equilibria, as well as absence of equilibria all define functionally different states, and it is this movement between states that maintains structure and diversity.[53] In other words, the large functional space that ecosystems occupy produces their structure and diversity and allows them to remain healthy and persist.[54]

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; it refers to the capacity of a system both to withstand disturbances and rebuild itself afterwards.[55] The development of 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.[56]

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."[57]

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 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.[58] Ecologists Brian Walker and David Salt discuss resilient social-ecological systems as having the shared characteristics of:

- 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;
- Generating and sustaining both options and novelty, providing a shifting balance between vulnerability and persistence;
- Being capable of self-organization;
- Exhibiting high adaptive capacity and learning;
- Displaying a high level of transformability, related to adaptive capacity.[59]

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 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.[60]

The study of resilience has led to development of a framework for supporting resilience in social-ecological communities. As described by Carl Folke and colleagues, this framework 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) develop governance structures; (4) acknowledge and pay close attention to slow variables; (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.[61]

Utilizing the principles uncovered by complex systems and resilience studies within standard ecology, biology, and engineering, ecological engineering aims to design systems that benefit both human need as well as the environment from which we are inseparable.[62]

Applying Resilience: Ecological Engineering in Practice

Ecological engineering explicitly points to the need to mirror ecological relationships and principles at all levels, including an emphasis on ecological self-organization, humans as part of the ecological whole, and the need to design from an intimate knowledge of place. W. J. Mitsch, author of one of the first ecological engineering textbooks, grounded his values in the concept of respect: the respect needed to learn from natural systems, for energy and natural resources, for people and place, 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.[63]

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 patchy, mosaic, or networked structures; incorporating energy recycling and efficiency; and allowing intermittent perturbation. Given this dynamism, it is also important to keep designs simple, utilizing a precautionary approach to technological application.[64]

Scott Bergen, Susan Bolton, and James Fridley also describe the value of recognizing limits and boundaries, and using caution in design, noting that many engineering systems developed with "hubris" have failed.[65] Ecological economist Robert Costanza warned that the worst form of ignorance is misplaced certainty, bringing to mind similar thoughts on incomplete knowledge from cultural critic and environmental activist 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.[66]

In order to design ecologically appropriate systems we need to work within limits both of the ecosystem and of 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.

Given ecological engineering's emphasis on reflecting social-ecological relationships, its epistemology relies on the observer/designer to cultivate an intimate level of place-awareness, including an ability to note subtleties in the surroundings across temporal and spatial scales: to engage ecology in a learning relationship. This place-awareness also includes understanding the cultural landscape, such as the stories and histories of people that are present within the land.[67] That the designers and users maintain this active, creative, learning relationship with the social-ecological system is also important, since this relationship and the creation of avenues to incorporate new information into design is vital to developing adaptive capacity.[68] 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.[69] These ecological principles, design approaches, and epistemology complement the cultural cosmology of the Anishinaabe people remarkably. Specifically, both Anishinaabe cosmology and ecological engineering share:

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

Importantly, these alignments can provide the base for analysis of community design options, development choices, governance, and technology in order to foster resilient, culturally grounded, and sustainable indigenous nations.

Biocultural Engineering Design Methodology

The method of biocultural engineering design integrates the biocultural relationships, values, and decision-making processes at the core of indigenous ways of life with science-based design principles regarding resilience that guide ecological engineering. The intent of this method is to facilitate designed systems that can regenerate the ecological, social, and cultural health of the users. The term "Indigenous Regenerative Design" has been used to convey the meaning of this method to diverse audiences. Within this design methodology, the process is critical to a successful design outcome, with 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) envision the whole and create inventory; (5) identify design goals, create and evaluate options; (6) create design and implement; and (7) evaluate and learn 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 creating 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 with "design charrettes," intensive planning sessions that 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 and ensuring accessibility and inclusivity are critical. In these charrettes, the team should work in as much detail as possible, have participants working concurrently, and create short feedback loops between brainstorming and design sessions.[70] 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 an inherent part of the design and implementation process.

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 be physically present on the site of design implementation and to engage in walking/experiencing design sessions, noted to be useful to elicit deeper relations among human beings as well as nonhumans.[71] As well, the team articulates 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. To renew, re-empower, and pass on cultural knowledge and practices critical to engaging in this learning relationship, this phase of the design process may engage traditional knowledge-holders with others involved. This renewal of engagement can also be reinforced by the simple practice of having each design team member observe the land and its relations daily, in solitude, over a particular period of time, as well as joining 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 to reach 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, which is achieved by documenting information about the design site obtained through traditional knowledge and learned observations through time, as well as standard scientific survey. The inventory process would benefit greatly from the participation of people who can act as 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, to their community, and to 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 intermittently evaluated to assess possible adjustments and adaptations, learn from issues, and include new knowledge. Many of these steps reflect 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 history, together with urbanization and widespread technological data availability, has reduced the ability of many to engage in an intimate, interactive learning relationship with ecosystems.[72] Within many Anishinaabe communities social-ecological disruption—a legacy of colonialism—has affected the cultural practices that guide learning.[73]

As a result, developing or redeveloping these learning relationships that are 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, in 2008 the indigenous organization Sustainable Nations partnered with the Otomi community of San Pedro, Seccion 6, Mexico, to design, train, and construct a straw bale/adobe midwifery clinic. 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. Among the challenges were that, prior to the training phase, the community's midwife expressed concern that no one seemed interested in carrying on the healing traditions. Additionally, the Mexican government's 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. I was present as the director of the Sustainable Nations team. When the adobe plaster pit was constructed, within which the adobe was to be mixed by foot, elders who had been watching the training from their windows emerged. They informed us that 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 revaluing of their traditions as the basis for contemporary design, the younger builders within the community have continued to relearn these techniques from their elders. Additionally, the midwife received several local apprentices after the training concluded, something she attributes to the revaluing of indigenous ways sparked by the intercultural exchange.[74] 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 indigenous knowledge, while 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 facilitators share the cultural values of the design users. Where this is not possible, it is necessary for the facilitators to cultivate the ability to be a conduit for community values, an achievement that relies largely on the facilitators' personal qualities and institutional restrictions or pressures. If design facilitators do not manage to conduct community values, 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 scientists and engineers to support biocultural design. Furthermore, land tenure is complex within indigenous territories, and the related land-use planning policies, codes, and restrictions are 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 achieve project approval, although there are strong advances in policy along these lines.[75]

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.[76] Anishinaabe health and resilience scholar Patricia MacGuire concludes that indigenous resilience is an emergent property of the interconnected relationships within a place. She describes how this place-based resilience requires understanding the traditions, knowledge, and sustained relationships embedded in the land as 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.[77] It is land-based knowledge—inextricable from community relationship-building—that fosters the resilience of the Anishinaabek. In the context of climate change, old understandings of certain ecological regions passed down through the generations may be affected, which makes reengaging Anishinaabe land-based ways of originating knowledge even more critical. We must cultivate the ability of next generation to engage in traditional processes of knowledge creation. Through this, and by 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.

Acknowledgments

This article was made possible in part by financial assistance from the Ruth Landes Memorial Research Fund, a program of The Reed Foundation.

Notes

1. Luisa Maffi and Ellen Woodley, *Biocultural Diversity Conservation: A Global Sourcebook* (Washington, DC: Earthscan, 2010).

2. Fikret Berkes, *Sacred Ecology* (New York: Routledge Press, 2008).

3. Cameron Muir, Deborah D. Rose, and Phillip Sullivan, "From the Other Side of the Knowledge Frontier: Indigenous Knowledge, Social-Ecological Relationships, and New Perspectives," *The Rangeland Journal* 32, no. 3 (2010): 259–65.

4. Stewart A.W. Diemont and Jay F. Martin, "Lacandon Maya Ecosystem Management: Sustainable Design for Subsistence and Environmental Restoration," *Ecological Applications* 19, no. 1 (2009): 254–66.

5. Erin L. Bohensky and Yiheyis Maru, "Indigenous Knowledge, Science, and Resilience: What Have We Learned from a Decade of International Literature on 'Integration'"? *Ecology and Society* 16, no. 4 (2011): 6, http://dx.doi.org/10.5751/ES-04342-160406.

6. Naomi Klein, "Dancing the World into Being: A Conversation with Idle No More's Leanne Simpson," *YES! Magazine*, March 5, 2013, http://www.yesmagazine.org/peace-justice/dancing-the-world-into-being-a-conversation-with-idle-no-more-leanne-simpson.

7. Winona LaDuke, *The Winona LaDuke Reader: A Collection of Essential Writings* (Stillwater, MN: Voyageur Press, 2002).

8. Deborah McGregor, "Coming Full Circle: Indigenous Knowledge, Environment, and Our Future," *American Indian Quarterly* 28, nos. 3 and 4 (2004): 385-410.

9. Jay Martin, Eric Roy, Stewart Diemont, and Bruce Ferguson, "Traditional Ecological Knowledge: Ideas, Inspiration, and Designs for Ecological Engineering," *Ecological Engineering* 36, no. 7 (2010): 839–49.

10. Fikret Berkes and Mina Kislalioglu, "Ecological Complexity, Fuzzy Logic, and Holism in Indigenous Knowledge," *Futures* 41, no. 1 (2009): 6–12.

11. Brian Walker and David Salt, *Resilience Thinking: Sustaining Ecosystems and People in a Changing World* (Washington, DC: Island Press, 2006).

12. Fikret Berkes, Johann Colding, and Carl Folke, "Rediscovery of Traditional Ecological Knowledge as Adaptive Management," *Ecological Applications* 10, no. 5 (2000): 1251-62.

13. Kirsty Galloway McLean, "Advance Guard: Climate Change Impacts, Adaptation, Mitigation, and Indigenous Peoples—A Compendium of Case Studies" (Darwin, AU: United Nations University Institute of Advanced Studies Traditional Knowledge Initiative, 2010), http://www.unutki.org/downloads/File/Publications/UNU_Advance_Guard_Compendium_2010_final_web.pdf.

14. Darrell Bossineau, "The Traditional Role of Governance in Aboriginal Communities: 'Minobimaddisiwin Nationhood,'" Aboriginal Financial Officers Association of Canada National Conference, Vancouver, BC, February 2007, http://www.afoa.ca/conference/2007/Presentations/Boissoneau.pdf.

15. Great Lakes Indian Fish and Wildlife Commission website, www.glifwc.org.

16. Rachel Walker, "Wild Rice: The Dynamics of Its Population Cycles and the Debate over Its Control at the Minnesota Legislature," PhD diss., University of Minnesota, 2008.

17. Anton Treur, *Living Our Languages: Ojibwe Tales and Oral Histories* (St. Paul: Minnesota Historical Society, 2001).

18. Basil Johnston, *Ojibway Heritage* (1976; repr., Lincoln: University of Nebraska Press, 1990).

19. Niigaanwewidam James Sinclair, "Nindoodemag Bagijiganan: A History of Anishinaabeg Narrative," PhD diss., University of British Columbia, 2013.

20. Lee Foushee and Renee Gurneau, *Sacred Water: Water for Life* (Lake Elmo, MN: North American Water Office, 2010).

21. Kenneth M. Morrison, "The Cosmos as Intersubjective: Native American Other-than-Human Persons," *Indigenous Religions: A Companion*, ed. Graham Harvey (New York: Cassell, 2000), 23–26.

22. *Centering Anishinaabeg Studies: Understanding the World through Stories*, ed. Jill Doerfler, Nigaanwewidam Sinclair, and Heidi Stark (Lansing: Michigan State University Press, 2013).

23. Amy McCoy, "Minobimaadiziwin: Perceiving the Good Life through Anishinaabe Language," PhD diss., Michigan State University, 2007; Basil Johnston, *Honor Earth Mother* (Lincoln, NB: Bison Books, 2003); Norval Morriseau, *Legends of My People: The Great Ojibway* (Toronto: The Ryerson Press, 1965).

24. Thomas Vennum, *Wild Rice and the Ojibway People* (St. Paul: Minnesota Historical Society Press, 1988).

25. Johnston, *Ojibway Heritage*.

26. Thomas Peacock and Marlene Wisuri, *Ojibwe Waasaa-Inaabidaa* (Afton, MN: Afton Historical Society Press, 2001).

27. 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 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. Eddie Benton-Banai, *The Mishomis Book* (Minneapolis: University of Minnesota Press, 1988).

28. Pikangikum First Nation, *Keeping the Land; A Land Use Strategy for the Whitefeather Forest and Adjacent Areas* (2006), http://www.whitefeatherforest.com/wp-content/uploads/2008/08/land-use-strategy.pdf.

29. D'Arcy Rheault, *Anishinaabe Minobimatisiwin: The Way of a Good Life* (Peterborough, ON: Debwewin Press, 1999).

30. Iain J. Davidson-Hunt, "Journeys, Plants and Dreams: Adaptive Learning and Social-Ecological Resilience," PhD diss., University of Manitoba, 2003.

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

32. Davidson-Hunt, "Journeys, Plants and Dreams."

33. Andrew Chapeskie, "Indigenous Law, State Law, Renewable Resources and Formal Indigenous Self-Government in Northern Regions," *Law & Anthropology*, ed. René Kuppe and Richard Potz (Cambridge, MA: Martinus Nijhoff Publishers, 1996), 25–65.

34. Davidson-Hunt, "Journeys, Plants and Dreams."

35. Iain Davidson–Hunt, "Indigenous Lands Management, Cultural Landscapes, and Anishinaabe People of Shoal Lake, Northwestern Ontario, Canada," *Environments* 31, no. 1 (2003): 21-42.

36. Timothy F. H. Allen, Mario Giampeitro, and Amanda M. Little, "Distinguishing Ecological Engineering from Environmental Engineering," *Ecological Engineering* 20, no. 5. (2003): 389–407.

37. Sim Van der Ryn and Stuart Cowan, *Ecological Design* (Washington, DC: Island Press, 2006).

38. Ibid.

39. Scott Bergen, Susan Bolton, and James Fridley, "Design Principles for Ecological Engineering," *Ecological Engineering* 18, no. 2 (2001): 201–10.

40. Peter Schulze, *Engineering within Ecological Constraints* (Washington, DC: National Academy of Engineering, 1996).

41. Patrick Kangas, *Ecological Engineering* (Boca Raton: CRC Press, 2004).

42. Ben Haggard, Bill Reed, and Pamela Mang, "Regenerative Development," Revitalization March/April, 2006.

43. Shu-Yang Fan, Bill Freedman, and Raymond Cote, "Principles and Practice of Ecological Design," *Environmental Reviews* 12, no. 2 (2004): 97–112.

44. Robert Herman, "A Perspective on the Relationship between Engineering and Ecology," *Engineering within Ecological Constraints*, ed. Paul C. Schulze (Washington, DC: National Academy Press, 2006), 66–80.

45. Stuart Kauffman, *At Home in the Universe: The Search for Laws of Self-Organization and Complexity* (Oxford University Press, 1995).

46. Francis Heylighen, *Complexity and Self-Organization* (New York: Taylor and Francis, 2008).

47. Simon Levin, "Self-Organization and the Emergence of Complexity in Ecological Systems," *Bioscience* 55, no. 12 (2005): 1075–79.

48. Peter Corning, "Synergy and Self-Organization in the Evolution of Complex Systems," *Systems Research* 12, no. 2 (1995): 89–121.

49. Garry Peterson, "Scaling Ecological Dynamics: Self-Organization, Hierarchical Structure, and Ecological Resilience," *Climatic Change* 44, no. 3 (2000): 291–309.

50. Ian Stewart, Self-Organization in Evolution: A Mathematical Perspective (2003) *Philosophical Transactions of The Royal Society of London* 361, no. 1807: 1101–23.

51. Howard T. Odum and Bill Odum, "Concepts and Methods of Ecological Engineering," *Ecological Engineering* 20, no. 5 (2003): 339–61.

52. Lance Gunderson, Craig Allen, and Crawford S. Holling, *Foundations of Ecological Resilience* (Washington, DC: Island Press, 2010).

53. Crawford S. Holling, "Understanding the Complexity of Economic, Social and Ecological Systems," *Ecosystems* 4, no. 5 (2001): 390–405.

54. Carl Folke, Johann Colding, and Fikret Berkes, "Building Resilience for Adaptive Capacity in Social-Ecological Systems," *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*, ed. Fikret Berkes, Johann Colding, and Carl Folke (Cambridge University Press, 2003), 352–87.

55. Walker and Salt, *Resilience Thinking*.

56. *Navigating Social-Ecological Systems*, ed. Berkes, et al.

57. Gunderson, et al., *Foundations of Ecological Resilience*, 21.

58. Ibid.

59. Folke, Carl, Stephen R. Carpenter, Brian Walker, Marten Scheffer, Terry Chapin, and Johan Rockström. 2010. Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* 15(4): 20. [online] URL: http://www.ecologyandsociety.org/vol15/iss4/art20/

60. Gunderson, et al., *Foundations of Ecological Resilience*.

61. Carl Folke, Stephen R. Carpenter, Brian Walker, Marten Scheffer, Terry Chapin, and Johan Rockström, "Resilience Thinking: Integrating Resilience, Adaptability and Transformability," *Ecology and Society* 15, no. 4 (2010): 20, http://www.ecologyandsociety.org/vol15/iss4/art20/.

62. 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 systems. W. J. Mitsch created the term's standard definition: "ecological engineering is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both."

Odum and Odum, "Concepts and Methods of Ecological Engineering," *Ecological Engineering* 20, 339–61; William J. Mitsch and Stephen E. Jørgensen, *Ecological Engineering and Ecosystem Restoration* (Hoboken: John Wiley & Sons, Inc., 2004).

63. Mitsch and Jørgensen, *Ecological Engineering and Ecosystem Restoration*, 28.

64. Marty Matlock and Robert Morgan, *Ecological Engineering Design: Restoring and Conserving Ecosystem Services* (Hoboken: John Wiley & Sons, 2011).

65. Bergen, et al., "Design Principles for Ecological Engineering," 205.

66. Robert Costanza, "Designing Sustainable Ecological Economic Systems," *Engineering within Ecological Constraints*, ed. Paul C. Schulze (Washington, DC: National Academy Press, 1996), 82–99; Wendell Berry, *Life is a Miracle: An Essay against Modern Superstition* (Berkeley, CA: Counterpoint, 2001).

67. Buthayna Eilouti, "Environmental Knowledge in Engineering Design Processes," paper presented at the 5th International Conference on Knowledge Generation, Communication and Management, Orlando, FL, 2011, http://www.iiisci.org/journal/CV$/sci/pdfs/HGB633UI.pdf.

68. Erik Hollnagel, David Woods, and Nancy Leveson, *Resilience Engineering: Concepts and Precepts* (Burlington, VT: Ashgate Publishing, 2006).

69. Matlock and Morgan, *Ecological Engineering Design*.

70. Charles Kibert, *Sustainable Construction: Green Building Design and Delivery* (Hoboken, NJ: John Wiley & Sons, 2013).

71. David Edmunds, personal conversation with author, January 15, 2013.

72. Rafael Sagarin and Anibal Pauchard, *Observation and Ecology: Broadening the Scope of Science to Understand a Complex World* (Washington, DC: Island Press, 2012).

73. Lawrence Deane and Eladia Smoke, "Designing Affordable Housing with Cree, Anishinabe, and Metis People," *Canadian Journal of Urban Research* 19, no. 1 (2010): 51–70.

74. Diana Ramirez, personal conversation with author, August 22, 2009.

75. See, for example, Environmental Protection Agency, The Tribal Green Building Codes Workgroup website, http://www.epa.gov/region9/greenbuilding/tribal-workgroup.html.

76. Leann Simpson, Judy DaSilva, Betty Riffel, and Patricia Sellers, "The Responsibilities of Women: Confronting Environmental Contamination in the Traditional Territories of Asubpeechoseewagong Netum Anishinaabek First Nation," *Journal of Aboriginal Health* 4, no. 2 (December 2009): 6–8.

77. Patricia MacGuire, "Exploring Resilience and Indigenous Ways of Knowing," *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health* 8, no. 2 (2010): 117–29.