

Native American Perspectives on Health and Traditional Ecological Knowledge

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BACKGROUND: Traditional ecological knowledge (TEK) is a conceptual framework that highlights Indigenous knowledge (IK) systems. Although scientific literature has noted the relevance of TEK for environmental research since the 1980s, little attention has been given to how Native American (NA) scholars engage with it to shape tribal-based research on health, nor how non-Native scholars can coordinate their approaches with TEK. This coordination is of particular importance for environmental health sciences (EHS) research exploring interdisciplinary approaches and the integration of environmental and human health.

OBJECTIVE: Our perspective on TEK arose from a series of Health and Culture Research Group (HCRG) workshops that identified gaps in existing EHS methodologies that are based on a reliance on Euro-American concepts for assessing environmental exposures in tribal communities. These prior methods neither take into account cultural behavior nor community responses to these. Our objective is to consider NA perspectives on TEK when analyzing relationships between health and the environment and to look at how these may be applied to address this gap.

DISCUSSION: The authors—the majority of whom are NA scholars—highlight two research areas that consider health from a TEK perspective: food systems and knowledge of medicinal plants. This research has yielded data, methods, and knowledge that have helped Indigenous communities better define and reduce health risks and protect local natural food resources, and this TEK approach may prove of value to EHS research.

CONCLUSION: NA perspectives on TEK resulting from the HCRG workshops provide an opportunity for developing more accurate Indigenous health indicators (IHI) reflecting the conceptualizations of health maintained in these communities. This approach has the potential to bridge the scientific study of exposure with methods addressing a tribal perspective on the sociocultural determinants of health, identifying potential new areas of inquiry in EHS that afford nuanced evaluations of exposures and outcomes in tribal communities. <https://doi.org/10.1289/EHP1944>

Introduction: The Context of Health and Traditional Ecological Knowledge

The term traditional ecological knowledge (TEK) was first introduced in the 1980s as a means to raise awareness of the existence and value of Indigenous knowledge (IK) in conservation efforts and to ensure equity to its treatment, especially in the context of scientific theories and methods. The application of TEK within the environmental sciences, however, has been subject to an ongoing debate centered around the acceptance of fields of knowledge and expertise that are identified as either Indigenous or scientific. As this debate is well documented (Finn et al. 2017), we do not seek to revisit it, but rather build off that perspective to examine an understudied area—how TEK is conceptualized when applied by Native American (NA) scholars and communities to address environmental health disparities. We provide a brief précis to the origins of TEK, employing this as a way to outline the contemporary research landscape in which concurrent concepts operate, such as traditional

and Indigenous knowledge, as well as ideas about well-being. In addition, we consider the exposome, which is the course of environmental exposures over a life span.

We also consider the interdisciplinary, cultural, scientific and environmental research realm in which these authors conduct research. This overview reveals particular intersections between different areas of cultural and discipline-based expertise and highlights where concepts about the environment, mental and physical health and well-being cross over and relate to each other. We subsequently address the potential of TEK as an interdisciplinary conceptual framework and systems-based approach that has the ability to advance insight into complex environmental health problems, especially when employed to bridge disciplinary and culturally diverse knowledge systems.

These specific perspectives on TEK communicated here have their origins in a series of workshops organized by what has become known as the Health and Culture Research Group (HCRG). This group was started in 2014 at the Smithsonian Institution and later expanded to hold workshops at Western Carolina University in April of 2015 and the National Institutes of Health in December of 2015. These workshops explored NA concepts of health and TEK in order to address how these could be used as mechanisms for improving Native health outcomes. Our aim for this working group was also to convene a cross-cultural and interdisciplinary research group whose combined expertise could potentially bridge the medical, earth, and social sciences with IK systems. The workshops revealed NA concepts of health were often not acknowledged or included in the research conducted in NA communities (Donatuto et al. 2016), despite the involvement of tribal-affiliated research partners. The group subsequently outlined the need and desire by a wide range of stakeholders for broader communication of Native perspectives on the relationship between culture and well-being across a wide range of disciplines such as psychology, biology, medicine, and environmental and public health, as well as the necessity of building bridges between federal and scientific agencies/institutions and Native

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communities. These discussions led to the impetus to disseminate NA views on health and TEK to the NIH, as well as to a larger field of researchers in the environmental health sciences (EHS) through webinars and interdisciplinary publications (Finn et al. 2017).

Based on our specific lines of research in NA environmental health and social contexts, we explore this distinct perspective on TEK based on its use by Native scholars and its adoption in community-based programming, focusing on the dynamics between distinct knowledge systems. We concentrate on the value of TEK as a conceptual framework that enables analysis of compound knowledge dynamics, firstly in the cross-cultural intersections between scientific community-based researchers and NA communities, and secondly in interdisciplinary contexts, such as the EHS. Environment is understood not only to be socially constructed but, for many Indigenous peoples, historically initiated and must include an understanding of the consequence of colonization (Czyzewski 2011). The NA perspectives presented here also frame the discussions around examples of Indigenous efforts to reclaim or utilize cultural resources to address some of these consequences. As a result, the use of TEK as a conceptual framework enabled us to identify where and why cultural capital (Eames 2006) and resources are used to address both the cultural and environmental determinants of health. This cross-cultural and interdisciplinary framework is exemplified by case studies of the successful application of TEK by Native scholars working in the EHS, biology, medicine, and anthropology. Its significance to these scholars is in part due to its ability to mediate and synthesize the diversity of knowledge systems used by Indigenous peoples, as well as the complex relationships between NA and non-Native knowledge systems.

Background: Cultural Plurality and Environmental Health

The fundamental premise for understanding conceptual frameworks like TEK is that cultural diversity around the world has resulted in a plurality of knowledge systems, each with their own distinct environmental and cultural contexts, as well as specific social mechanisms for the production and transmission of this knowledge. While the idea of different knowledge systems largely emerged out of the discipline of anthropology (Barnhardt 2005; Barth 2002; Geertz 1983; Hansen 1982; Hardesty 1977; Isaac 2005, 2007; Morphy 1991; Sillitoe 1998; Yarrow 2008) and cognitive science (Abelson 1979), it has found traction and proliferation in interdisciplinary environmental studies (Maldonado et al. 2015). In particular, the term TEK has its origins in conservation research of the mid- to late twentieth century, which sought to consider on an equal basis knowledge gained from scientific and IK systems (Berkes 1993; Freeman and Carbyn 1988). This type of conservation research emphasized not only ecosystem management and biological diversity but also cultural diversity and how IK was an instrumental factor in environmental stewardship and sustainability.

The term TEK was first introduced in 1989 by the International Conservation Union and a working group by that name (Johannes 1989). Subsequently, Berkes et al. (2000) have defined it as “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes handed down through the generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment” (Berkes et al. 2000). The inclusion of TEK in research methodology has triggered discussions about the differences between IK and science, resulting in research appearing in anthropology, development studies, and conservation biology that highlighted the distinctions between cultural knowledge systems, as well as those approaches which sought commonalities. For example, in outlining the difference between the two, Nakashima and Roué (2002) argued that

Western science separated its objects of study from their contexts by putting them in controllable experimental environments. In contrast, IK was seen to depend on and gain value to its users from its relation to local conditions and cultural systems. This article, however, is not written to reiterate the contrasting elements of these knowledge systems but to understand how these approaches can be used in a complementary manner to broaden our understanding of the spectrum of health and disease as experienced in tribal communities.

The acquisition of TEK is seen to come from three sources: traditional knowledge (TK) (from generation to generation), empirical knowledge (gained from observation), and revealed knowledge (acquired through spiritual origins and recognized as a gift) (Castellano 2000). NA scholars have also emphasized that TEK represents the integration of person, place, product, and process (McGregor 2004), and that Indigenous languages are important because these transmit and interpret culturally specific worldviews, values, conceptualizations, and knowledge (Simpson 2004). While TEK research at the global level is beyond the scope of this paper, examples of how TEK has been applied in North America fall largely into the category of research in environmental conservation and species management (Giles et al. 2016; McGregor 2012; Menzies and Butler 2007; Troster 2007; Wolfley 1998), as well as climate change (Ford and Smit 2004; Ignatowski and Rosales 2013; Leduc 2010; Pearce et al. 2015). More recently, TEK has also been applied to research in the EHS (Jack et al. 2010; McOliver et al. 2015).

Parallel to TEK but more broadly defined are the concepts of TK and IK, which have wide-ranging contexts for application, including anthropology (Bode 2006; Huntingdon et al. 2004; McMullin 2010; Noble 2007; Olsen 2013), ethnobiology (Flint et al. 2011; Uprety et al. 2012), and public health research (Simonds and Christopher 2013), as well as environmental history and law (Cruikshank 2005; Smithers 2015; Williams and Hardison 2013). TK and IK have also played an increasingly significant role in either collaborative or NA-directed research (Milburn 2004; Bassett et al. 2012; Gonzales et al. 2012). Notable also are projects where TK and IK have been used by NAs as concepts to develop and describe community-based programming for health care and substance abuse (Gone 2009, 2011; Moghaddam et al. 2015; Nadeau et al. 2012). (Note: In November 2018, the Indigenous Caucus at the Convention of Biological Diversity recommended using the term IK over the term TK when referring to knowledge from Indigenous Peoples, as the term TK is seen by this caucus to have originated from now out-of-date developmental agency frameworks. We include this information to note that the terminology around these knowledge systems continues to evolve.)

A third conceptual framework that is proving useful for scientists seeking to understand TEK and IK is the link between TEK and the recently emerged environmental health framework, the exposome. Environmental health research has long focused on environmental inequities and the extreme health disparities of specific populations. These studies acknowledge that NA and Alaskan Native communities are among those most at risk from the combined effects of environmental exposures and social and psychological stressors such as poverty and historical trauma. To address the combined factors associated with environmental health disparities, environmental health scientists have begun to use the theoretical framework of the exposome.

The concept of the exposome, first articulated by Wild in 2005, “encompasses life-course environmental exposures (including lifestyle factors), from the prenatal period onwards” and is being used in the EHS to denote the totality of human environmental exposures that, together with genomics, could provide a fuller picture of factors that influence health (Wild 2005; Pleil 2012; Wild 2012) (Figures 1 and 2). This scientific understanding of

Environmental Exposures and Social Stressors Affecting Tribal Communities

Research Addressing Tribal Health Disparities at Regional, Community, and Household Levels

The Exposome considers the totality of environmental exposures and psychosocial stressors across the lifespan

An approach consistent with the perspective of **Traditional Ecological Knowledge** that considers the interactions and interconnectedness of human and environmental health

Research is increasingly embracing a more holistic approach to promoting health and understanding the combined factors that lead to disease

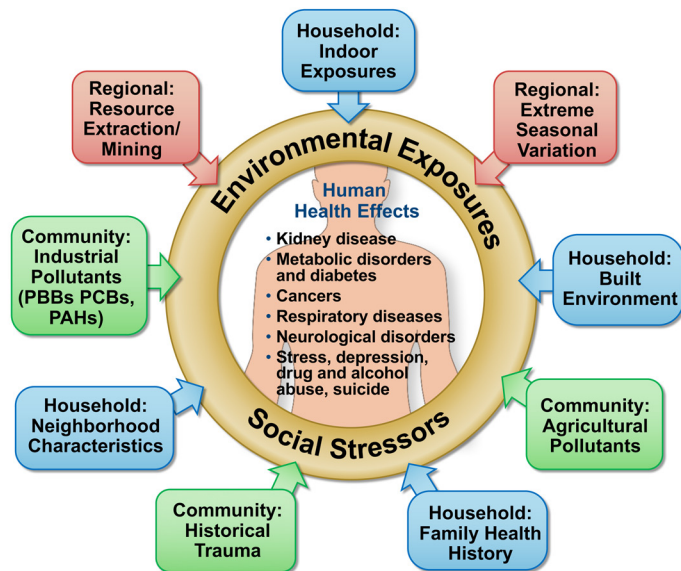


Figure 1. The exposome and its relation to traditional ecological knowledge (TEK) approaches. Diagram showing the interconnectedness of environmental and social stressors affecting tribal communities over time. Note: PAH, polycyclic aromatic hydrocarbon; PBB, polybrominated biphenyl; PCB, polychlorinated biphenyl; TEK, traditional ecological knowledge.

the interconnectedness of environmental factors, social stressors, and human health has striking similarities to the concept embodied in TEK, although it does not incorporate cultural and spiritual values as a factor in these relationships. Despite these differences, referencing the similarity between TEK and the exposome may help environmental health scientists better integrate Indigenous perspectives of exposures within their collaborative research.

These conceptual frameworks have played out across a variety of disciplines, particularly when research is conducted in partnership with members of tribal communities. In such cases, researchers in public and environmental health fields are finding the concepts underlying both TEK and IK essential for increasing awareness about different cultural approaches to knowledge production and transmission and their role in evaluating and maintaining environmental health (Finn et al. 2017).

In particular, we have found that there is a growing need for interdisciplinary research designed to solve complex health issues through the synthesis of environmental, cultural, and allopathic data. We support this effort through our conceptualization of TEK as a means to unite diverse approaches and help researchers understand the extent to which humans, culture, and the environment are codeterminants in shaping overall health.

The case studies we draw on in the discussion section include examples that illustrate this conceptualization of TEK, including analyzing food not only as a source for nutrition but as an indicator of human/cultural/environmental interactions. As described by Hoover (2017a), this TEK approach also analyzes how food sources are part of larger cultural, political, and biological systems, where environment and culture overlap. As TEK incorporates cultural behavior, such as hunting and plant use, over time, collaborative TEK-based research by tribes and scientists on the absorption of pollutants into a wide variety of environmental subjects such as water, plants, and animals advances locally based problem-solving centered on that community's cultural viewpoint. As increasing numbers of scientific disciplines seek out

interdisciplinary approaches to analyze the intersection between humans and their environment, TEK appropriately incorporates cultural values—an approach we believe will help identify and recognize locally informed solutions for improving health outcomes for NA communities.

There has also been growing interest in understanding health in terms of the concepts of wellness and well-being, especially in regard to defining and evaluating the social determinants of health in Indigenous communities. The term well-being has been used to look at relationships between cultural values, mental health, and the importance of land and place (Goodkind et al. 2015), while the term wellness encompasses a culture's overall conceptualization of health (Hopkirk and Wilson 2014; Loppie et al. 2016; Martin Hill 2009). At the HCRG meetings in 2015, participating NA scholars argued that these terms constructively identified broader operational healing modes used in their communities, rather than narrow clinical techniques that decontextualize and rarify health conditions, such as diabetes, substance abuse, and suicide, which have been the focus of clinical research. According to Durie (2004), "an increasing recognition of the goal of wellbeing as distinct from the absence of illness has led to the development of a range of measures that go beyond the presence or absence of symptoms". As we have learned from discussions with members from NA communities, these concepts communicate the more holistic concept of health that Indigenous, aboriginal, and NA communities have argued should acknowledge both spiritual and environmental practices and factors.

A core function of the HCRG was to explore and understand these emerging areas of NA-conceived health programs and examine how they intersected with environmental health science and related disciplines as a means for understanding the effectiveness of current research methodologies. Consequently, the area where TEK, IK, wellness, and medical, environmental, and social sciences converge is our foci and where NA scholars who participated in the HCRG have positioned their interdisciplinary research programs. Our meetings and related research have uncovered a wide range of projects developed by NA researchers and community

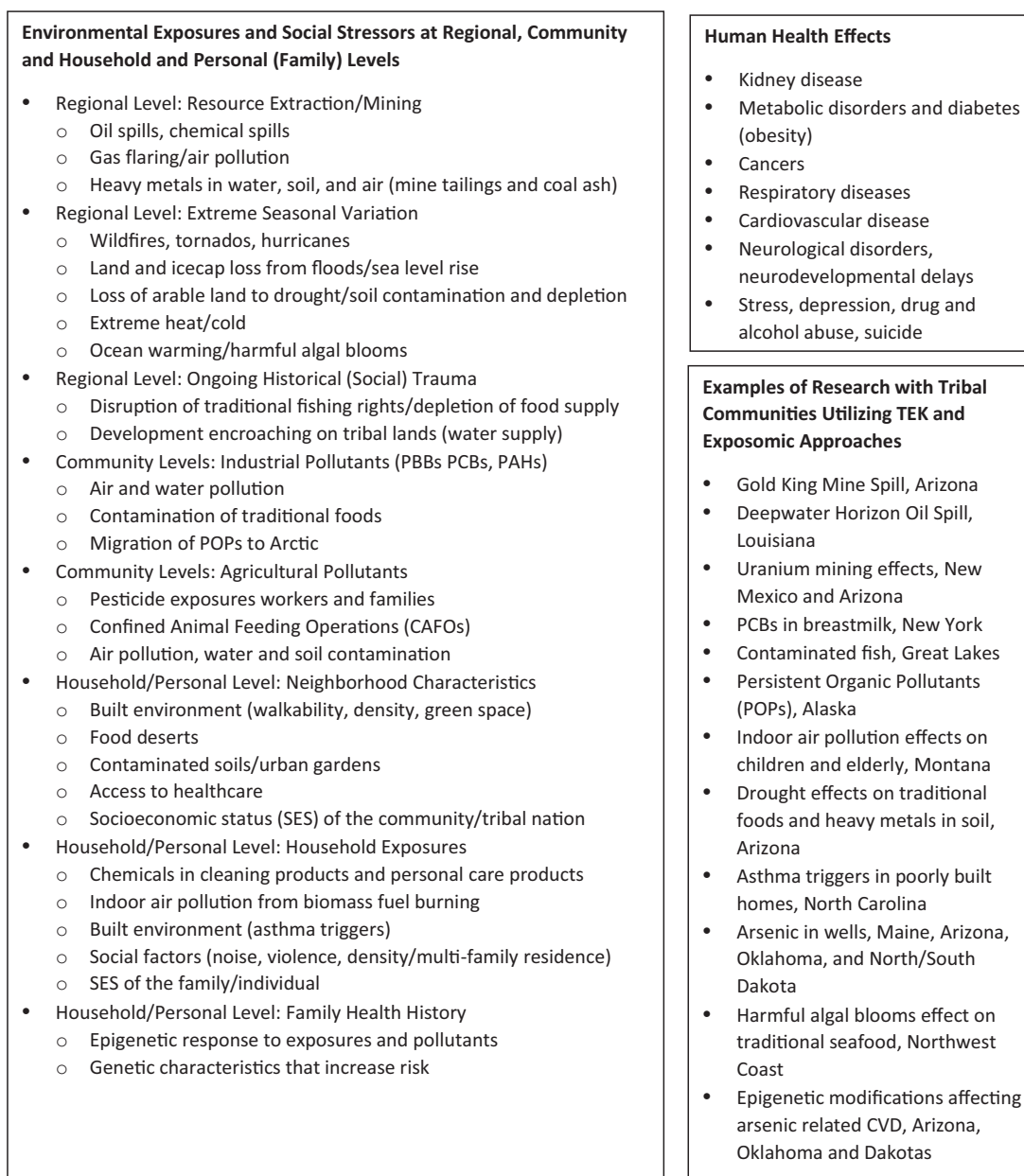


Figure 2. Examples of environmental exposures and social stressors over time affecting tribal communities, human health effects and research using TEK and exposome approaches. Note: PCB, polychlorinated biphenyl; TEK, traditional ecological knowledge.

members that are using local cultural protocols and values to restructure how health is perceived and managed in their communities. In these projects, mental and physical health, environmental issues, and food security work together to form a total system that correlates social, environmental, and physical well-being. Akin to Mauss (1990)'s concept of "total prestations," this TEK approach defines a system of total well-being.

Many of these NA community-based projects are immersive educational programs that encourage intergenerational exchanges centered on teaching the value of specific social roles and responsibilities towards others in the community and the larger environment. For example, in the Akwesasne Haudenosaunee community, a program has been established known as *Ohero:kon*—a Mohawk term meaning "under the husk" (in reference to young corn still under its protective covering). The *Ohero:kon* provides a 4 year immersive culturally based intervention that brings together elders

and youth to ensure the cultural knowledge needs of Mohawk youth are met during their transition from adolescence to adulthood. A 20-wk curriculum includes cultural instruction, farming, traditional arts, and ceremonies, and seems promising for counter-ing issues facing Haudenosaunee youth, such as suicide, addiction, and teen pregnancies (see the film *Ohero:kon – Under the Husk* made by Melissa Katsitsionni Fox). In Alaska, Yup'ik/Cup'ik community members have collaborated with psychiatric researchers, Stacey Rasmus and Jim Allen, to design the Qungasvik project that uses intergenerational cultural activities and the *qasgiq* (communal house) model to prevent suicide and alcohol abuse among Yupik youth (Rasmus et al. 2014). In our opinion, the potential success of these programs lies in how they aim to prevent mental disease and addiction according to NA values and knowledge systems, rather than treat these conditions in isolation from the social contexts in which they arise.

Objectives

Our overall aim is to situate case studies of NA-led TEK research within a framework that elucidates how different cultural approaches to knowledge intersect, conflict, or enable effective collaboration across cultures and disciplines. A critical aspect of this work is to examine approaches that will facilitate this group to move beyond anecdotal interpretations of community-based health programming and to develop methods and assessment that can advance both NA and collaborative scholarship in this area. This is especially critical for the HCRG, which already inhabits the confluence of research on human and environmental health. Acknowledging the relevant gaps in scholarship in this area highlights how biological and clinical environmental health research has largely used models and methodology that do not accurately reflect the cultural contexts of rural NA communities, especially the particular cultural factors that affect exposure evaluation and treatment options (Donatuto et al. 2016; Walls et al. 2017). Part of this work includes recognizing specific inequities that NAs have faced in regard to the externally operated oversight of their lands and health-care system, many of which remain under federal management by the Bureau of Indian Affairs or the Indian Health Services.

While self-governance movements led by U.S. tribes have resulted in some gaining management of these resources, the correlation between colonial regimes, government removal policies, the blocking of access to resources, and Indigenous health problems has become a growing topic in health-related research (Boksa et al. 2015; Hodge et al. 2009; Kelm 1998; Simonds and Christopher 2013). These factors are especially notable with NA and First Nation mental health issues (Gone and Trimble 2012; Kirmayer et al. 2009; Kral 2009). For this reason, the HCRG consideration of TEK acknowledges the accrual, erosion, and temporal dimensions of cultural knowledge systems as a reflection of colonialism, but also acknowledges the history and development of medical and environmental science in relation to IK rather than separate from it. Consequently, we position TEK as a nonhierarchical historical and socially engaged conceptual framework. As this particular group of NA scholars concurred, no analysis should reduce data or knowledge systems to a battleground entrenched in the Native knowledge vs. science divide. Rather, the principles of TEK can be used to provide a constructive and much needed systems-based approach to intersecting knowledge systems that is relational and adaptive and enables researchers to distinguish culturally specific health indicators.

The following section provides two examples of health and TEK-related studies and programming from the perspective of Native scholars who participated in the HCRG workshops. This includes Elizabeth Hoover (Haudenosaunee) and her synopsis of how food and health are being viewed by Native communities and the TEK-related programming that has developed to combat community-based health concerns. The second example is Jennie R. Joe's (Navajo) examination of the history of NA medicinal plant use and knowledge and the importance that TEK provides in recognizing Native contributions to pharmacology and scientific research on the medicinal use of plants.

Discussion: Native American Perspectives on Traditional Ecological Knowledge for Community Health

Traditional Ecological Knowledge, Food Systems, and Health. Elizabeth Hoover

Indigenous food systems refer to “specific collective capacities of particular Indigenous peoples to cultivate and tend, produce, distribute, and consume their own foods, recirculate, refuse and acquire trusted foods and ingredients from other populations”

(Whyte 2015). Successful food systems require a deep familiarity with the local landscape—a robust body of TEK that is deeply entwined with not only the nutritional but also the sociocultural needs of Indigenous communities. On a nutritional level, traditional foods have health-promoting benefits. For example, biomedical research has confirmed that many berries contain natural phytochemicals that alleviate symptoms of hyperglycemia, inhibit fatty tissue accumulation, and address other problems related to metabolic syndrome (Basu et al. 2010; Flint et al. 2011; Lynn et al. 2013; Seeram 2008).

But foods also contribute to health beyond nutritional value—gathering foods maintains cultural connections through storytelling, ceremonies, harvesting, and processing and sharing resources; provides outdoor activity; and helps to build and maintain interpersonal relationships and community traditions (Flint et al. 2011; Lynn et al. 2013; Parlee et al. 2006). Food systems are part of the relational responsibilities felt in many Indigenous communities in which people have responsibilities to each other as family members and as members of a community, but also culturally based responsibilities to other plant and animal species. The maintenance of and control over traditional food systems and subsistence economies are required for a community's collective continuance, or the “capacity to be adaptive in ways for the livelihoods of its members to flourish in the future” (Whyte 2013).

A series of factors has worked to disrupt Indigenous food systems. Scorched earth battle tactics utilized against Native people in the 18th century (Mt Pleasant 2011) and the 19th century (Diné of the Eastern Region of the Navajo Reservation 1991) sought to destroy food stores and make Native people reliant on the American government. Indigenous communities have been pushed to marginalized territories (Reo and Parker 2013), and in many cases, the treaty-making system alienated tribes from their land. Land bases were further diminished through the allotment system that allocated communal land to individuals and families. During the late 19th and 20th centuries, on many reservations, despite tribes' successful histories of fishing and gathering, federal policies encouraged Native people to farm on marginal lands. The fact that the best farmland was often usurped by non-Indians and the lack of farming knowledge or interest on the part of many Indigenous peoples in regions like the Great Basin and the plains led to the failure of many of these farming projects (Hoover 2017b; Rudolph and McLachlan 2013).

During this era, many Native youth were also sent to boarding schools, where they were encouraged to forget their tribal connections and where the staples of the standard institutional diet embodied Anglo ideals of foodways and nutrition, centering around starches and dairy for students who were previously used to diets centered around fresh and dried meats, fruits, and vegetables (Bess 2013). Urban relocation programs in the 1950s brought Native people from rural reservations to urban centers for employment opportunities, but this move often left families food insecure (Companion 2013; Jernigan 2012) and was another means by which Native people were dislocated from their traditional diets.

Environmental change—both through intentionally reshaping the landscape and through climate change—has also impacted access to traditional foods. For example, the damming of the Missouri River in the 1940s and 1950s resulted in Native people losing most of their arable land on the Standing Rock, Cheyenne River, Crow Creek, and Fort Berthold reservations in the Dakotas (White and Cronon 1988). Similar dams built across the Northeast (Hauptman 2013; Hoover 2013) and the Northwest (Norgaard et al. 2011) have disrupted fisheries and flooded Indigenous homelands.

In addition, industrial contamination has impacted fishing in places like the Akwesasne Mohawk community on the New York/Canadian border (Hoover 2013) and for the Coast Salish Swinomish community in Washington state (Donatuto et al. 2011). In the polar

regions, persistent organic pollutants have made consuming the usual amounts of traditional foods hazardous to community health (Carpenter et al. 2005; Miller et al. 2013). Climate change has led to declining sea ice and forced community relocations in the Arctic, shifts in plant and animal populations around North America, changes in river flow impacting water availability for crops, and a broadening of the range of disease organisms (Lynn et al. 2013; Weinhold 2010). All of these changes have impacted Indigenous food systems over the past century.

To stave off starvation and malnutrition that would have resulted from disrupted food systems, during the 19th century, food rations were distributed on many Indian reservations, as agreed upon in many treaties to make up for the loss of hunting, fishing, and agricultural lands. These rations consisted of foods that would have been foreign to Indian people: beef, bacon, flour, coffee, salt, and sugar (Wiedman 2012). While the U.S. Department of Agriculture has been working to improve the quality of foods available to communities through this program (USDA, Food and Nutrition Service 2012, 2015), including making more fresh foods available, these programs do little to reinforce the relational, cultural, and nutritional aspects that traditional food systems relied on.

The disruption of traditional food systems has led to a number of health and social problems in Indigenous communities. American Indians have higher levels of food insecurity when compared to the U.S. average (Gurney et al. 2015). In 2008, nearly one in four NA households were food insecure (vs. 15% of all U.S. households). NA children have approximately twice the levels of food insecurity, obesity, and type 2 diabetes relative to the average for all U.S. children of similar ages (USDA, Food and Nutrition Service 2012). Diabetes was first documented among NAs around the mid-20th century (Wiedman 2012); currently, NA adults (16.1%) are more likely than black adults (12.6%), Hispanic adults (11.8%), Asian adults (8.4%), or white adults (7.1%) to have ever been told they had diabetes.

In addition to physical health problems that resulted from the disruption of traditional food systems, as the availability of foods declined, so have stories, language, cultural practices, and interpersonal relationships and outdoor activities around those food systems (Hoover 2017b). A tribal community's capacity for "collective continuance" and "comprehensive aims at robust living" (Whyte 2018) are hindered when the relationships that are part of traditional food cultures and economies are disrupted.

Lynn et al. (2013) point out that despite the challenges of culture loss, many traditional practices are still being employed in Indigenous communities. These practices need to be supported and upheld through community-based programming and ensuring that the environmentally healthy habitat needed for Native plant and animal species is available. International development research has also established that TEK and agroecology are viable approaches to improving nutrition and access to food for Indigenous communities (Suárez-Torres et al. 2017). There are research and conservation projects that are working to uphold traditional environmental food knowledge, create a framework to support the habitat needed for traditional foods, and develop standards by which to better measure the impact on tribal communities when safe access to traditional foods is lost. In these projects, several key conditions need to be met in order to effectively address NA environmental health disparities: *a*) cultural relevance, *b*) mutual respect and trust, *c*) adequate and sustained resources, and *d*) sustainable partnerships (McOliver et al. 2015).

In one project that demonstrates partnership between TEK- and science-based approaches, research teams in the social and biological sciences from the University of Illinois and Rutgers University joined with naturopathic medicine professionals at the Alaska Native Tribal Health Consortium and elders and youth from three Alaska Native communities (Seldovia, Akutan, and Point Hope) to

study Native berries traditionally utilized by these communities. Youth and elders came together to gather berries, and field deployable bioassays were used to assess bioactive mechanisms and properties in the berries. The quantitative results corroborated the wisdom of local TEK, as they demonstrated that plants that were cited as useful remedies for high blood sugar were proven to regulate α -glucosidase or α -amylase activity (Grace et al. 2014; Kellogg et al. 2010). Perhaps more importantly, the project inspired local youth to take more of an interest in the topics of science and local foods (Flint et al. 2011).

A second example of tribal community-based research involves measuring the health impacts from the loss of traditional foods as a result of environmental contamination and climate change so the community can work to mitigate these losses. The Swinomish Indian Tribal Community in Washington state wanted tribal-specific definitions of health to be developed and properly weighed when decisions regarding their community's environment and health were being made. The project team conducted interviews with tribal members and experts, created literature reviews, and combed through ethnographic records to create six Indigenous health indicators (IHI) that reflect key health considerations essential to the Coast Salish way of life. These indicators included community connection, natural resources security, education, cultural use and practices, self-determination, and emotional stability—each with specific attributes and measures (Donatuto et al. 2014, Swinomish Indian Tribal Community; McOliver et al. 2015). Several potential uses of the IHIs have been identified for improving human health risk assessments, health impact assessments, natural resource damage assessments, measuring baseline community environmental health, and ecosystem services evaluations (McOliver et al. 2015).

We determined that these projects have yielded data, tools, products, methods, and knowledge that have helped Indigenous communities better define and reduce health risks, protect natural food resources essential to cultural and spiritual practices, and encourage the transmission of TEK. Creating inclusive research- and community-based projects entails not just sharing stores of knowledge around traditional food resources but also sharing understanding of the responsibilities that should play an integral role in environmental steward, as well as health promotion practices.

Traditional Ecological Knowledge and the Medicinal Uses of Plants. Jennie R. Joe

Traditional medicine is still employed to promote health in many NA communities. According to the World Health Organization, approximately 88% of Indigenous peoples residing in developing countries rely chiefly on traditional medicine—mostly plant extracts—for their primary health care needs (Anyinam 1995). We have observed that the utilization of these TEK-based treatments also continues among Indigenous populations living in developed countries like the United States. In particular, in many NA communities, the use of traditional tribal healing resources continues alongside those that are allopathic. Medicinal plants remain an important part of healing ceremonies conducted for patients or to celebrate important events, such as weddings, naming ceremonies, etc. The value and the need to maintain tribal healing ceremonies are rarely questioned by NA communities. In fact, many tribal-operated healthcare facilities have incorporated these traditional resources into a wide range of community-based programming.

Scientists and/or pharmaceutical corporations continue their quest for potential cures in medicinal herbs (phytotherapy)—plants used in treating ailments. Unfortunately, the process of obtaining this IK often ends in exploitation rather than in shared partnerships with Indigenous and NA communities (Battiste and Henderson 2000; Gupta et al. 2005; Masango 2010; Otmar 2003; Pan et al. 2014). To what extent this exploitation translates into financial profits for the

pharmaceutical corporations is not readily known, but Principe (1989) notes that in 1985, the annual market value of pharmaceutical products derived from medicinal plants discovered and utilized by Indigenous peoples exceeded \$43 billion. Similarly, Posey (1990) states that less than 0.001% of the 1985 profits in this market were received by the Indigenous people who guided researchers to the plants. Ongoing advances in biotechnology are also contributing to the exploitation of these resources, especially as the race intensifies to find treatments posed by the increasing rates of degenerative or chronic diseases, such as cancer (Ryan 2014). Against this backdrop of growing global scientific endeavors in botanical research, many Indigenous and NA communities visited by botanical researchers have become increasingly cautious and ambivalent about sharing their knowledge.

TEK about plants and their application in treating different types of ill health has evolved from long-term interactions Indigenous people have with their local environments. As such, TEK represents a holistic and longitudinal approach to health—an approach that integrates ecological, social, empirical, and spiritual knowledge (Kidwell 1985). It is also understood that to be effective, the administration of many herbal medicines should be applied as a part of spiritual healing ceremonies. Plants are viewed as living helpers and require respect and acknowledgment of their healing abilities. Prayers and songs that accompany the treatment acknowledge the interdependency between the ecological and spiritual realms.

In documenting the use of plants in NA medicine, Porterfield and Keoke (2003) point out that Indigenous people throughout the Americas developed local plants for use as anesthetics such as cocoa (cocaine), peyote, and *Datura* (jimson weed). These medicinal agents were administered orally or prepared as poultice for painful wounds or infections. Porterfield and Keoke (2003) describe the use of the maguey sap from the plant agave by the Aztec healers to dress wounds. In laboratory studies, it was found that maguey serves as an antibiotic by extracting the fluid from the bacterial, leaving dehydrated tissue that starves the bacteria. Other NA communities have developed their antibiotics by using white sage and root (rhizome) of fern plants, blueberries, cranberries, etc. Similarly, biologists have found that arbutin found in blueberries and cranberries are especially effective as a diuretic as well as a source of antibiotic (Landon 1993).

The history of modern medicine and pharmacology reflects how this TEK has become critical to Western medicine. Chemical extraction or key ingredients from the herbal medicine made in laboratories have resulted in a number of active drugs (Weatherford 1988). Porterfield and Keoke (2003) report that following initial European contact in the Americas, explorers like Christopher Columbus acknowledged the superiority of the medicinal accomplishments of the Indigenous peoples they encountered. Vogel (1970) documented the influence that Indigenous medical knowledge has had on Western medicine and pharmacology. He recounts several medicinal agents developed and used by Indigenous peoples for anesthesia, astringents, and obstetrical practices, including a list of 220 herbal medicines and/or their derivatives that were included in the U.S. Pharmacopoeia and the National Formulary in the early and late 1800s. Vogel (1970) also documents the use of botanical treatments for cancers and tumors by NAs.

In considering temporally based insights that come from TEK, Hutchens notes the importance of seasonal harvesting. For example, the tincture of fresh poke root was harvested in winter for certain health problems, while summer harvest of the tincture of the ripe poke berries was used to treat different cancers (Hutchens 1992). According to Mitich (1994) pokeweed antiviral protein is shown in laboratory studies to have antitumor properties.

We believe that NA contributions to medicine would most likely have been more robust and significant had this knowledge

and use not been decimated by ravages of warfare, communicable diseases, displacement and relocation from familiar ecological resources, etc. Although there are no statistics available on mortality rates for various age groups during these periods of conquest, it is safe to suggest that many elders and children did not survive, and in particular, this would have resulted in a reduction of the number of elderly healers who were most knowledgeable about traditional healing. While some Native lands remain, it is also not uncommon to find the environment has become a health hazard due to development and/or contamination by toxic waste. We have also observed firsthand how many Indigenous peoples today have to seek permission to harvest some of their medicinal plants because their former land base is no longer theirs.

Conclusions

We have positioned TEK as an informative conceptual framework that has the potential to elucidate how different Indigenous cultures and knowledge communities classify and link ecological and health-related knowledge. Specific to the NA examples given here, we have presented certain subfields—food systems and medicinal uses of plants—and discussed the extent to which these are better understood through an expansive and integrative framework.

Specific to the HCRG, TEK has emerged as an interdisciplinary framework that allows for:

- a systems-based approach to local knowledge that includes physical, mental, and environmental health,
- synergistic points between tribally based and scientific research, and
- cross-cultural integration of diverse disciplinary approaches to environmental and health-based knowledge.

In particular, Hoover's study demonstrates how partnerships between tribes and researchers in the biological sciences provide manifold insights into Native foods by uniting chemical analysis and social values gained from collective farming practices and observations about environmental health. The history and contemporary value of Native plant knowledge from Joe demonstrates how scientific practices have integrated TEK into biomedical knowledge; however, this process has not included the incorporation of the Native values that maintain this knowledge and, therefore, does not address issues of environmental sustainability—an area ascertained as needing further work.

In examining the outcomes of the HCRG meetings and analyses, we have become further informed of the critical role that NA scholars play in bridging these different knowledge systems, especially in how environmental, social, and medical research currently intersects with NA knowledge systems. We found that NA professionals already working in these areas had the necessary integration skills with respect to these different concepts of health science and, therefore, are well positioned to study and teach about these critical research intersections.

Moreover, their work introduces key Native concepts into scientific fields, many of which will help to develop more precise research methodologies for the study of Native-related environmental health. As several of the preexisting environmental health criteria have not had success in mirroring or considering NA behavior and environmental interactions, we feel this endeavor contributes a framework and approach that can more accurately identify and evaluate culturally specific indicators.

The role of Indigenous scholars as “agents at the interface” of science and IK (Durie 2004) highlights the necessity for research from this specialized cohort who are contributing to “the evolution of Indigenous academics and research methodologies in both Western academic and Native community contexts” (Stewart 2009). We anticipate that the analytical observations of this TEK

framework once combined with culturally informed scientific expertise will encourage wider interdisciplinary and cross-cultural methodologies more suited to environmental health research with, by, and for NA communities.

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