Indigenous Experiences in the U.S. with Climate Change and Environmental Stewardship in the Anthropocene

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Abstract: *The recognition of climate change issues facing tribal communities and indigenous peoples in the United States is growing, and understanding its impacts is rooted in indigenous ethical perspectives and systems of ecological knowledge. This foundation presents a context and guide for contemporary indigenous approaches to address climate change impacts that are comprehensive and holistic. Tribal communities and indigenous peoples across the United States are re-envisioning the role of science in the Anthropocene; working to strengthen government-to-government relationships in climate change initiatives; and leading climate change research, mitigation and adaptation plans through indigenous ingenuity. Unique adaptive capacities of tribal communities stem from their ethics and knowledge, and help frame and guide successful adaptation. As documented in the Special Issue of the Climatic Change Journal on the impacts of climate change to U.S. indigenous communities (Maldonado and others 2013), these issues include the loss of traditional knowledge; impacts to forests, ecosystems, traditional foods, and water; thawing of Arctic sea ice and permafrost; and relocation of communities. This collaboration, by more than 50 authors from tribal communities, academia, government agencies, and NGOs, demonstrates the increasing awareness, interest, and need to understand the unique ways in which climate change will affect tribal cultures, lands, and traditional ways of life. Climate change is expected to affect animal and plant species that indigenous people depend on for their livelihoods, health and cultural practices. The impacts of climate change on forests and other ecosystems that are home to many of these species require tribal engagement in climate change research, assessments, and adaptation efforts. This paper synthesizes key issues and case studies related to climate change impacts on tribally valued forest resources and tribal adaptive responses to climate change.*

INTRODUCTION

The Anthropocene epoch is often defined as a time when the collective actions of humans have an unprecedented influence on natural systems. In the case of climate change, the Anthropocene is predicted to be a period characterized by environmental changes that are more

rapid and patterned differently than what human societies have experienced in the past (Kolbert 2010). In response to this prediction, it is important to try to anticipate how diverse societies in North America will uniquely experience the Anthropocene. Particular social, political, cultural, and economic circumstances define the unique vulnerabilities of different communities. Foresight of vulnerabilities can help communities develop local capacities for successful adaptation to climate change. A complete understanding of vulnerabilities and capacities can help land management and other agencies modify existing policies and create new policies more relevant to particular communities. In this paper, we focus on the vulnerabilities and capacities of tribal communities and indigenous peoples in the United States (and refer to tribes and indigenous peoples synonymously throughout the paper). Below we describe the context in which indigenous communities find themselves in a climate change era, provide an overview of the role of traditional knowledges in climate change initiatives, and expand on some of the ways indigenous vulnerabilities and strengths are being manifested in policy development and research. Later, we examine specific ways in which indigenous communities may be uniquely vulnerable to climate change impacts affecting the reciprocal relationship these communities have with the spiritual and living ecosystems of their region (in this case, forests). We follow this by assessing some of the unique sources of climate change resilience within tribes, particularly political and cultural capacities that may serve as catalysts for successful tribal climate change adaptation. In particular, we explore two examples of tribal adaptive capacity: the application of tribal practices and traditional knowledges into land management (Wabanaki), and the development of innovative collaborative relationships with state, federal and scientific entities (Pyramid Lake Paiute Tribe). We also assess the value of federal-tribal partnerships. We conclude by providing broad insights for federal land management agencies and other conservation professionals seeking to engage tribes in the development and implementation of resource management policies that are relevant to tribes in the Anthropocene.

CONTEXT

The Intergovernmental Panel on Climate Change (IPCC), as well as the 3rd National Climate Assessment (forthcoming), recognizes present socio-political environment, high rates of unemployment and poverty, and disease and risks to public health are factors that make indigenous peoples of North America disproportionately vulnerable to climate change (Field and others 2007). For example, damage caused by extreme weather events forced communities in Alaska, including Shishmaref and Newtok, to consider relocation because the cost of road and building repairs overwhelmed the limited resources of tribal governments (Bronen 2011; Larsen and others 2008; Maldonado and others 2013; Shearer 2011). Perhaps equally significant is that indigenous peoples are spiritually and culturally invested in the Earth's freshwater, and terrestrial and marine resources and systems. As such, many tribal identities, values, and cultural traditions are embedded in the land, water, and air (Daigle and Putnam 2009; Lynn and others 2013; Voggesser and others 2013; Wildcat 2013). The cultural and subsistence relationships that indigenous peoples maintain with the Earth's resources and systems are defined by the traditions and beliefs practiced by indigenous peoples. For example, an indigenous community may use spiritual ceremonies, educational traditions, and coming of age rituals to ingrain practical knowledge and ethical principles about how to hunt in ways that do not exhaust species populations and ensure adequate food for individual community members (Reo and Whyte 2012).

Houser and others (2001) estimates 1.2 million (60 percent) U.S. tribal members live on or near reservations, and many pursue lifestyles with a mix of traditional subsistence activities and wage labor and have strong connections with freshwater, terrestrial, and marine resources and systems. Wild foods such as fiddleheads, berries, mushrooms, rice, deer, moose, elk, fish, and seafood provide not only subsistence, but also cultural connections through storytelling, harvesting, processing, and sharing of food resources. It is this strong and multifaceted dependence on natural resources and systems that makes indigenous populations particularly vulnerable to climate change (Daigle and Putnam 2009). Changes in the range and distribution of culturally significant plant and animal species will severely affect tribal cultures, economies, and resources for governance (Lynn and others 2013; Voggesser and others 2013).

In the United States and around the world, indigenous peoples are affected by more than just impacts to physical infrastructure and natural resources; at risk are cultural and traditional ways of life (Abate and Kronk 2013; Maldonado and others 2013). Climate change and the very idea of the Anthropocene epoch brings to mind large-scale human impacts on the Earth, specifically, increased greenhouse gas emissions to the atmosphere through industrialization and deforestation. These impacts result from activities that benefit those who view freshwater, terrestrial, and marine resources and systems as commodities for extraction and exhaustion to support energy-intensive middle and upper class lifestyles. In contrast, indigenous perspectives are often founded on a relationship of reciprocity—the relationship of mutual responsibilities shared between indigenous peoples and the living and spiritual inhabitants and systems of the Earth (Williams and Hardison 2013; Whyte 2013). Indigenous worldviews are predicated on being attentive to happenings over time in unique natural environments and acknowledging that humankind does not stand above or outside of Earth's life system (Wildcat 2009). That is, many cultures who see responsibilities that bind all living and spiritual beings also recognize a tremendous imperative to learn as much as possible about how one can exercise responsibilities toward these beings. Indigenous ethics of reciprocity entail systems of creating and maintaining useful knowledge of how humans can be good stewards of the Earth. Indigenous knowledge of stewardship interconnects ceremonies that express respect for species and promote conservation practices that ensure species' health and sustainability (Reo and Whyte 2012; Trosper 2009; Kimmerer 2000; McGregor 2012).

The IPCC Fourth Assessment Report (AR4) noted that indigenous knowledge is "an invaluable basis for developing adaptation and natural resource management strategies in response to environmental and other forms of change." This was reaffirmed at the 32nd Session of the IPCC in 2010: "indigenous or traditional knowledge may prove useful for understanding the potential of certain adaptation strategies that are cost-effective, participatory and sustainable" (IPCC 2010). Additionally, in the last year, there has been an increasing realization that observations and assessments of indigenous peoples and marginalized populations provide valuable regional information, offer regional verification of global scientific models and satellite data sets, and provide the basis for successful adaptation and mitigation strategies (McLean and others 2011).

Traditional Knowledges

Traditional knowledges play an important role for many tribes in understanding how climate change impacts and adaptive strategies are affecting culturally important species.

"Climate impacts on tribal cultural resources will affect the formation and use of Traditional Ecological Knowledge (TEK). TEK, the indigenous way of understanding relationships among species, ecosystems, and ecological processes, can play a vital role in climate change assessment and adaptation efforts that bridge human and environmental systems" (Whyte 2013; Williams and Hardison 2013 in Voggesser and others 2013).

The role of and protections needed for traditional knowledges in climate change and environmental arenas are currently being explored at national and international levels. In this document, we refer to traditional knowledges (TKs), recognizing that other concepts, such as traditional ecological knowledge, native science, indigenous knowledge, and indigenous knowledge of the environment are commonly used in a diverse range of literatures and settings. Traditional knowledges offer a pathway for indigenous peoples to identify and interpret the potential impacts of climate change, as well as develop culturally relevant adaptation strategies. Riedlinger and Berkes (2001) describe five convergent areas that bring together TKs and western science, including local-scale expertise, climate history, research hypotheses, community adaptation, and community-based monitoring. Additionally, in the policy document *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation* (Nakashima and others 2012), Nakashima and others write that such "community-based and local knowledge may offer valuable insights into environmental change due to climate change, and complement broader-scale scientific research with local precision and nuance" (p. 6). While these TKs may offer understanding of impacts and solutions beyond indigenous communities, protections are needed to ensure that TKs are not misappropriated. International resolutions such as the United Nations Declaration of Rights of Indigenous Peoples and the Convention on Biological Diversity recognize the need for indigenous peoples and knowledge holders to give their Free, Prior and Informed Consent when sharing traditional knowledges in any manner (Williams and Hardison 2013).

Indigenous knowledge systems and ethical perspectives present a context and guide for contemporary indigenous approaches to address climate change (Williams and Hardison 2013). In this way, traditional knowledges represent opportunities to understand vulnerabilities indigenous peoples may face in the context of climate change, as well as adaptive strategies for addressing climate impacts. These indigenous approaches are making way for a comprehensive and holistic understanding of climate change impacts to indigenous peoples (Williams and Hardison 2013). Traditional knowledges and systems of reciprocity offer more than historical perspectives; they offer guidance on integrated and holistic approaches for use today and into the future. Based on this guidance, indigenous peoples across the United States are re-envisioning the role of science in the Anthropocene by strengthening their engagement in indigenous and non-indigenous climate change initiatives and playing leading roles in research, mitigation and adaptation plans through indigenous ingenuity (Wildcat 2013). Indigenous peoples, then, should be seen as having unique capacities, stemming from their ethics and knowledges that frame and guide their potential for successful adaptation in the Anthropocene.

Policy and Research

The vulnerabilities and adaptive capacities described above are playing a key role in policy development and policy-related literatures arising from native and non-native scientists, scholars, and environmental professionals (Maldonado and others 2013). In 2014, for the first time, the National

Climate Assessment report included a dedicated chapter on climate change impacts on tribal lands and resources, and documents many of the issues currently experienced by indigenous communities in the United States because of climate change (NCA, forthcoming). This report is required by Congress every four years as part of the Global Change Research Act of 1990 and serves to identify and communicate climate change science and impacts in the United States. Climate change impacts addressed in the tribal chapter include: loss of traditional knowledges; impacts to forests, ecosystems, water, and traditional foods; thawing of Arctic sea ice and permafrost; and relocation of indigenous villages and tribal communities (NCA, forthcoming). In light of understanding these diverse and numerous challenges, the tribal chapter of the National Climate Assessment (forthcoming) called for a more in-depth examination of indigenous climate change observations, experiences, and adaptive strategies around the United States. In response, nearly 50 authors representing indigenous and tribal communities, academia, government agencies, and NGOs in the United States wrote a Special Issue edition for the journal *Climatic Change,* "Climate Change and Indigenous Peoples in the United States: Impacts, Experiences and Actions" (Maldonado and others 2013). One particular article in this special issue edition of Climatic Change focuses on the impacts of climate change on tribally-valued forest resources (Voggesser and others 2013). This article will expand upon impacts to tribally-valued forests and will focus on the importance of understanding indigenous cultural values related to forests, and the potential for climate change to pose significant threats to those resources and values.

CLIMATE IMPACTS ON TRIBAL FOREST RESOURCES

According to the 2013 Indian Forest Management Assessment (IFMAT), more than 18 million acres of tribal forests are held in trust by the United States (IFMAT 2013). Tribal access to forest resources are threatened by climate change impacts including increased frequency and intensity of wildfires, higher temperatures, extreme changes in ecosystem processes and forest conversion, and habitat degradation (NCA forthcoming, Voggesser and others 2013). Climate change impacts on tribally-valued forests will affect the composition and distribution of plant, animal, and fungi species that many tribes rely on for culture, economy, traditional foods, nutrition and health (Lynn and others 2013; Voggesser and others 2013). The shift in the range and extent of species, or changes to the timing of availability of cultural resources could result in reduced access to culturally-important species, and the subsequent loss of traditional knowledges (Swinomish 2010; Turner and Clifton 2007).

Climate change will continue to alter most U.S. fire regimes (Cohen and Miller 2001; Trosper and others 2012). Specifically, longer fire seasons and the damage caused by wildfires will affect not only particular species, but also the cultural uses and tribal traditions dependent on those species (Voggesser and others 2013). An example of climate impacts on specific species is in the West, where wildfires and drought changed and reduced forage for elk and deer, consequently impacting wild game that is critical for tribal livelihoods (DeVos Jr. and McKinney 2007). Traditional practices and TKs form the basis for tribal adaptation strategies to changing fire regimes. Traditionally, tribes used fire to increase the predictability of resources and ecosystem resilience, for crop management, basketry, range-browse improvement, communication/signaling, warfare, rituals, fireproofing valued resources, clearing travel routes, driving game/prey, clearing riparian areas, and increasing water yield (Stewart 2002; Voggesser and others 2013; Williams 2002). Cultural fire regimes based on TKs and traditional use of fire can serve

as a model for achieving ecosystem resilience and cultivating cultural resources (Voggesser and others 2013). Today, tribes use silvicultural treatments and fire to reduce potential losses from projected increases in climate-related wildfires (Rose 2010; Wotkyns 2013). And in some cases, tribes and federal agencies are working together to address a range of issues related to potential climate impacts to forests, including invasive species, wildfire, and other related threats (Voggesser and others 2013).

Case study: Climate-related impacts from invasive species and pests

The relationship between invasive species and climate change is more and more important to understand as environmental changes create more suitable conditions for invasive species and will accelerate landscape-level change. Tribes may be forced to alter subsistence or ceremonial practices in response to the compounded stressors of climate change and invasive species (Voggesser and others 2013). Specific impacts involve the loss of traditional resources and changes in the geographical range of species. Invasive insects, pathogens and fungal diseases can kill trees valued for food or materials, and restructure the composition, structure and function of forests (Dukes and others 2009; Sturrock and others 2011).

Compounding climate change impacts to tribes are the multi-scale effects of invasive species as animal and plant pests, pathogens, and diseases directly affect subsistence and ceremonial practices, health and safety (Voggesser and others 2013). Sudden Oak Death, or SOD (*Phytophthora ramorum*), first detected in coastal northern California in the mid-1990s, is now threatening oak-dominated forest ecosystems (McPherson and others 2010; Valachovic and others 2011). As SOD spreads, it will diminish tribal opportunities for utilizing forest resources (Voggesser and others 2013). Many of the pathogen's hosts are trees or shrubs utilized by tribes for foods, materials, and medicines (Ortiz 2008). In the Midwest and eastern United States, the invasive emerald ash borer (EAB), which is a green beetle native to Asia and Eastern Russia, is creating landscape-level change and impacting cultural practices of indigenous peoples who use the black ash (*Fraxinus nigra*), a medium-sized deciduous tree. Figure 1 illustrates the Cooperative EAB Project and the initial county detections of EAB in North America as of February 2014. Despite aggressive eradication efforts, EAB, first discovered in Michigan in 2002, has spread to 20 states and two Canadian provinces, with a recent detection being last year (2013) in New Hampshire (USDA APHIS 2014).

For the Wabanaki nations of Maine (the Penobscot Indian Nation, Passamaquoddy Tribe-Pleasant Point, Passamaquoddy Tribe-Indian Township, Aroostook Band of Micmacs, and the Houlton Band of Maliseet Indians), black ash serves critical roles in the social, cultural and economic spheres of contemporary life. The cultural importance of black ash is reflected in Wabanaki origin stories, wherein Gluskabe, the Wabanaki trickster hero, shot an arrow into the basket tree (the black ash), giving rise to the people who came into the world singing and dancing. Given this context, there is no substitute for the *Fraxinus* or ash in Wabanaki culture. Moreover, baskets made of black ash are the oldest art form in New England and represent an original "green," value-added, sustainable forest product. The loss of ash and the associated basketry tradition would have deep economic, cultural, and spiritual effects on tribes. Sales of ash basketry exceed $150,000 each year and many tribal household incomes are partially dependent upon this resource (Daigle and Putnam 2009). More than 95 percent of tribal basketmakers in Maine live on or near reservations—many at or below the poverty level.

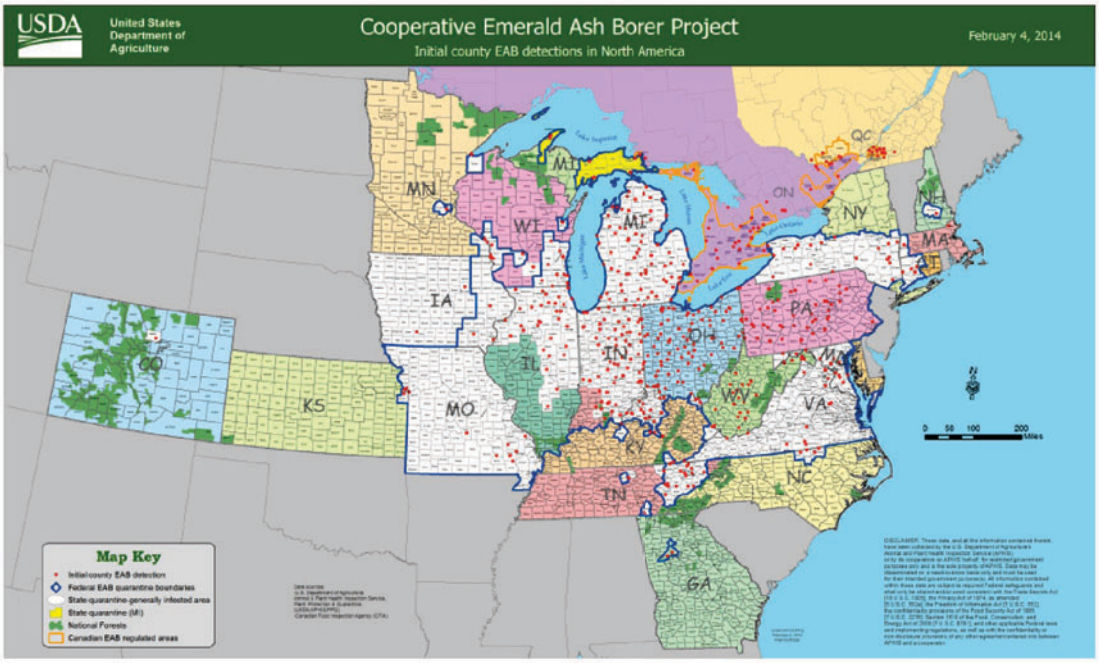

Figure 1. Cooperative Emerald Ash Borer Project

TRIBAL ADAPTIVE STRATEGIES

Tribal Adaptation to Forest Changes and Wildfire Threats

When indigenous peoples shape climate policies, foster strong economies, engage in sustainable development, and are part of natural resource management decisions, indigenous communities and livelihoods become more resilient (Daigle and Putnam 2009; Field and others 2007; Wildcat 2009). There have been increasing calls for tribes to be "at the table" as decisions are made about natural resource management, research design and implementation, and future policies (Galanda 2011; Grijalva 2011; Tsosie 1996). Indigenous peoples' participation and involvement in research is extremely important when planning for invasive forest pests such as the Emerald Ash Borer (EAB) in Maine (Ranco and others 2012). Indigenous peoples are also focusing their efforts on bringing to light the climate change experiences of indigenous communities region-wide in North America and the Pacific Islands (First Stewards 2012). Collaboration between tribal and government entities with trust responsibilities, as well as collaborations between tribes and non-governmental entities, emerge as important themes. Strengthening mutual respect between traditional knowledge holders and western scientists, and developing a better understanding of the relationship between the two approaches can strengthen future natural resource management collaborations.

Recently, tribal initiatives and activities have increased to address climate impacts and large-scale environmental changes on forests through research collaborations, public awareness, information campaigns, and restoration projects, including forest management treatments, hazardous fuels reduction and prescribed burns (Mason and others 2012; Ranco and others 2012). For example, indigenous basketmakers and black ash harvesters in Maine are working collaboratively with university researchers, state and federal foresters, landowners, and others, to prevent, detect, and respond to the invasive EAB (Ranco and others 2012). This collaboration combines extensive

indigenous history, traditional knowledges that identifies quality grade "basket trees", and geographic information systems (GIS), to initiate state-wide planning for protection and management of black ash resources.

Tribal governance and communication networks with tribal councils are being integrated in emergency response planning efforts in the event of an outbreak of EAB. Tribal natural resource agencies are initiating efforts to collect and preserve ash seeds, as well as record voice and field methods to identify high quality grade "basket-trees" to help retain traditional knowledges for future generations. These proactive initiatives are supplemented with coordinated information and education campaigns, such as national public television programming. These programs bring awareness of contemporary cultural traditions and highlight the importance of ash resources to Wabanaki tribes. These programs also raise awareness of other actions, including a law that prohibits the transportation of firewood into the state; firewood is a major contributor to the spread of EAB throughout the Midwest and Northeast United States.

Federal-Tribal Partnerships

Many of the efforts described above are accomplished through federal-tribal partnerships that provide tribes with an opportunity to engage in identifying resource management strategies to manage for and conserve culturally important species on and off-reservation. A strong government-to-government relationship must be in effect to ensure that consultation is occurring between the highest level of agency and tribal leadership so that tribal concerns and priorities are reflected in agency management plans (Harris 2011). Some policy and administrative mechanisms are in place to help achieve meaningful government-to-government relations, such as Executive Order 13175, November 6, 2000 (Consultation and Coordination With Indian Tribal Governments) and the Tribal Forest Protection Act, which, authorizes the Secretaries of Agriculture and Interior to give consideration to contracts or projects proposed by tribes on Forest Service or Bureau of Land Management (BLM) lands that border or are adjacent to Indian Trust Land (PL 108-278, 2004).

The importance of the federal-tribal relationship in addressing tribal access to forest resources is evident in the 15-year report evaluating the effectiveness of federal-tribal relationships under the Northwest Forest Plan, which adopts a coordinated management strategy to produce timber products while protecting and managing impacted species on lands administered by the BLM and Forest Service within the range of the Northern Spotted Owl (Harris 2011). The 15-year report suggests that Memorandums of Understanding (MOU) contribute to strengthening government-to-government relationships by defining federal trust responsibilities and establishing frameworks for how consultation (and collaboration) should occur (Harris 2011). A key finding from this report demonstrates that beyond just protocols for federal-tribal consultation, MOUs can be key components in effectuating strategies for communication, coordination, information sharing, and collaboration intended to meet the goals of protecting and restoring natural and cultural resources (Harris 2011).

The 2013 Indian Forest Management Assessment (IFMAT) also emphasizes the role of federal funding to support tribal climate change planning, assessment, and adaptation. The IFMAT report discusses climate change threats to tribal forests including wildfire, insects and diseases, among other issues. IFMAT policy recommends requiring "the allocation of federal agency funds for

climate change response and develop processes and criteria to assure a more equitable distribution of funding to tribes" (IFMAT 2013).

Case study: Pyramid Lake Paiute Tribe

The case of the Pyramid Lake Paiute Tribe (PLPT), the largest tribe in Nevada, exemplifies tribal vulnerabilities as a result of climate change. Located in the Truckee River Basin, PLPT's tensions regarding water rights are high, and climate change may upset the delicate balance between growing water demands of off-reservation users while simultaneously maintaining the health of a tribally-valued ecosystem of Pyramid Lake. PLPT is culturally and economically dependent on Pyramid Lake, which is located at the terminus of the Truckee River (Figure 2). The river begins at Lake Tahoe with headwaters in California's Sierra Nevada Mountain Range and flows through the semi-arid Reno-Sparks metropolitan region before terminating at Pyramid Lake. Pyramid Lake is extremely important for biodiversity, sociocultural traditions, recreation-based revenue sources, the federally-listed endangered fish cui-ui (*Chasmistes cujus*) and the threatened fish Lahontan cutthroat trout (LCT; *Salmo clarkii henshawi*).

The Pyramid Lake Paiute Tribe's name in Paiute is *Kooyooee Tukadu,* or cui-ui eaters, named after the Pyramid Lake sucker fish, which was one of their main food sources before its drastic decline in the early 1900's due to upstream diversions at Derby Dam for irrigation, upstream water use, and drought. Culturally, the Paiute origin story is based on Pyramid Lake and its tufa-rock formation, called the Stone Mother that represents a woman with a basket whose tears created the lake (Wheeler 1987). Today, fishing and recreational activities are central to PLPT economy. Like many Native American tribes, PLPT is especially vulnerable (Smith and others 2001) to both climatic and non-climatic stressors because of their reliance on natural resources for spiritual and socio-cultural practices (Jostad and others 1996); dependence on local natural resources (Adger 2003; Thomas and Twyman 2005); and poor socio-economic conditions (Sarche and Spicer 2008). Besides technical western approaches, understanding PLPT's vulnerability to climate change requires thoughtful consideration of values, history, and other local socio-economic and political contexts. Byg and Salick (2009) underline the importance of the local perception of climate change, impact assessment, and adaptation planning.

Socio-economic vulnerability factors of PLPT to climate change consider internal and external factors. Internal factors, like the local response capacity at the local scale include human capital (e.g., education and employment, climate change perceptions, institutional capacity, and technology), physical capital, economic resources and financial capital, social capital, and natural capital. External factors at the larger scale are linked to outside social, economic, legal, and environmental processes such as federal support and entitlement, power relations and legal stressors, and job opportunity and migration. The education and economic wellbeing of PLPT members is slightly better than the national average for Native Americans (from the U.S. Census 2010, 34 percent of PLPT members surveyed attained a 2 or 4 year college degree versus 23 percent of Native Americans), and PLPT's degree attainment rate is close to the mainstream U.S. rate (38 percent). From a survey of 687 households on the PLPT reservation with a 16 percent response rate, about 80 percent of PLPT members were aware of climate change and observed changes in their environment (Gautam and others 2013). Uncommon among tribes, in 2007, PLPT received "Treatment in the Same Manner as a State" (TAS) status by the Environmental Protection Agency (EPA) to implement Water Quality Standards (WQS) and as a result, PLPT gained a seat at the decision-making

Figure 2. Truckee River Basin Showing Pyramid Lake Indian Reservation (Credit to Karl Musser)

table regarding impacts to the Truckee River and limiting pollutant discharge. PLPT is largely dependent on federal support, which is extremely limited and underfunded (e.g., Indian Health Service). For example, in 2010, only 0.007 percent of the funding that states received from U.S. Fish and Wildlife Service (FWS) was available competitively to 565 federally-recognized tribes. Federal projects are responsible for most of PLPT's basic infrastructure. However, PLPT has a strong network of fish hatcheries to maintain cui-ui and LCT populations. There is a strong sense of individual tribal members desire to safeguard tribal interest and entitlement (e.g., 72 percent of surveyed tribal members vote in tribal elections). In addition, several active religious and social organizations show potential for emergency mobilization under extreme events or disasters. In addition to protecting the ecosystem of the lake, the natural capital of PLPT include groundwater and surface water, rangeland, wetlands, and agriculture which face concerns of decreasing water supplies, invasive species, and droughts.

While not specifically prepared for climate change impacts, within the past several years, there has been a strong willingness and common desire among PLPT tribal managers to include climate change in their respective programs. The prospects of geothermal and other solar energy projects on the reservation and, more importantly, potential use of the Truckee River Operating Agreement

(TROA) settlement fund for PLPT's economic development show some prospect for a diversified economy and may enhance the adaptive capacity to cope with climate change. Another positive factor demonstrating PLPT's adaptive capacity was the ability of PLPT to partner with universities, government agencies, non-profits, and other tribal nations and tribal consortiums to address climate change impacts. Native American reservations are nested within states and thus share and compete for natural resources with other resource users. While entitlement and access to resources can greatly determine the ability to adapt, there may be legal or institutional barriers that impede tribal entitlement and access to resources. PLPT went through a relentless legal battle for water rights for fisheries and succeeded through the listing of cui-ui as an endangered species in 1967 and LCT as a threatened species in 1975. Despite pressure for municipal and industrial needs in the Reno-Sparks area, Stampede Reservoir was designated as an upstream storage reservoir for the conservation of cui-ui and LCT. Recently, through the Preliminary Settlement Agreement of 1989 and Public Law 101-618, after the minimum in-stream flow in the Truckee River is maintained and all Orr Ditch Decree Rights are satisfied, then water can be stored in the Stampede Reservoir. This legislation also designates funds for PLPT to buy additional water rights, thereby enhancing tribal adaptive capacity. Reduced water supplies as a consequence of climate change would result in a compounded reduction of inflows to Pyramid Lake, thus potentially impacting the spawning and sustenance of a cultural livelihood, the cui-ui fish. Meanwhile, limited economic opportunities and dwindling federal support constrain tribal adaptive capacity. Factors that contribute to tribal adaptive capacity include: sustainability-based values, technical capacity for natural resource management, proactive initiatives for the control of invasive-species, strong external scientific networks, and remarkable tribal awareness of climate change.

PLPT faces multiple challenges for the protection of the quality and quantity of water reaching Pyramid Lake that is important to tribal values and economic activities and motivates PLPT to reach out to federal programs and science communities to build adaptive capacity. Gautam and others (2013) suggest multiple ways in which PLPT created collaborative partnerships with western scientists with whom some tribes have historically had tense relationships. Gautam and others (2013) emphasizes the importance of networks and indigenous rights frameworks like TAS. But a key lesson here is that programs like TAS are only effective if they are truly implemented such that tribes have the same opportunities as states. It is not sufficient for tribes simply to have the possibility of being treated like a state. There have to be sufficient options for gaining that authority and receiving funding that is appropriately equal to what states receive for setting up similar programs. As a growing amount of literature shows, knowledge networks like those highlighted by Gautam and others (2013) are crucial for climate change adaptation (Bidwell and others 2013). Guided by their culture and values, indigenous peoples are initiating knowledge networks with groups they previously have not worked with. They are also identifying challenges with federal programs that prevent tribes from having the flexibility and capacity needed for adaptation.

CONCLUSION

The Anthropocene epoch is a historical period when large-scale human impacts, such as increased greenhouse gas emissions to the atmosphere through industrialization and deforestation, influence earth systems in major ways. Some scientific and policy circles anticipate climate change to rapidly change the environment in the next 100 years in ways to which human societies are unaccustomed. Many indigenous communities are already observing and adapting to such changes (Swinomish

2010; Wotkyns 2013). While these changes may present certain opportunities for some societies, indigenous peoples must prepare for how to absorb substantial economic costs, threats to cultural practices, and increased political pressures. From this perspective, we must explore what capacities need to be developed by indigenous peoples in order to best cope with a rapidly changing world.

The vulnerabilities and potential negative impacts of climate change on tribal forests, water, and other natural systems can be understood as both ecological and governance issues. They can be described as ecological issues in the sense that they involve environmental changes that have ramifications for the relationships between natural systems and human cultural systems. For example, invasive species in forests threaten the sustainability of intrinsically valuable relationships that tribal members have maintained with certain species since time immemorial.

At the same time, ecological issues are often deeply interwoven with governance issues, particularly when it comes to tribes. For example, the Pyramid Lake Paiute Tribe (PLPT) case emphasizes the importance of governance institutions such as rights to protect Pyramid Lake, treatment as state (TAS) status, and networks with nonindigenous partners. Institutions such as TAS status may be problematic if the structures are not equitable for tribes. Additionally, rights to protect the lake may not be enough to control the ecological conditions required for spawning of cui-ui under climate change impacts. In these cases, there are governance concerns regarding whether tribal political relations with federal, state, and local governments and agencies are adequate to give tribes the space to exercise their culturally-motivated adaptation strategies and to influence the strategies of their non-indigenous partners. When such relations are insufficient—whether due to inadequacies in funding, unclear policies, force of policy mandate, or inflexible implementation plans—the ecological issues compound and become substantial burdens on tribal communities. This highlights the need to strengthen governance institutions such as government-to-government relationships, tribal consultation, and networks with non-indigenous parties in order to improve tribal governance and maximize tribes' adaptive capacity.

In addition to strengthening governance institutions, we must also expand our understanding of indigenous governance to account for unique situations that may arise in the Anthropocene. Climate change will alter relationships between culturally significant species, natural systems, and practices, as well as the jurisdictions of tribal governance. For example, species moving off reservation or outside a treaty area challenge these jurisdictions. As is illustrated in the PLPT case, tribes may find that an effective way to deal with these problems is to develop networks with partners from a broader geographic scope and with whom they may have never worked before. Expanding how we understand indigenous governance will be necessary to account for situations in which historic jurisdictions do not afford tribes the abilities to exercise their capacities as stewards of their cultural landscapes. The MOU and collaborative arrangements described by Daigle and Putnam (2009) and Harris (2011) represent a strong step forward in this direction, as do the networks discussed in the PLPT case. While not compromising on the longstanding meaning of the government-to-government relationship, MOUs, collaborative arrangements and networks add the sensitivity and flexibility that are needed for tribes to address climate change more successfully. It is important to note, however, that there are also potential challenges in these new relationships and partnerships because the particular parties may have little experience working with indigenous peoples.

Another key insight in both of the presented cases is that tribal cultures, practices, and knowledges possess abundant adaptive capacity, an example of which is illustrated in indigenous uses of fire.

These are human systems that can generate adaptive strategies even in an Anthropocene epoch in which the environment differs significantly from that which supported the development of many indigenous cultures. In this article, we point to two different approaches by which tribes pursue adaptive strategies. In the first approach, tribal practices, such as burning practices derived from traditional knowledges, are appropriate practices in the Anthropocene and offer alternatives to non-tribal strategies developed in contexts that may be inapplicable to tribes and may not be trusted by tribal members. In the second approach, tribes, motivated by their culture and values, foster new and strong collaborative relationships with state, federal and scientific parties that aim to provide the capability and flexibility for adaptation. This second approach also involves tribes taking action to ensure that federal programs are accessible to tribes to meet the challenges of climate change, and draws from tribal experience with federal programs and working with federal agencies through a government-to-government relationship.

For land management agencies, these points should illustrate that in this Anthropocene epoch, it will be critical to tailor governance instruments, including policy, to facilitate and support rather than obstruct tribal capacities to pursue their own adaptive strategies in numerous ways. The above cases demonstrate that we must renew efforts to create robust governance structures suggested by tribes for many years now, such as the government-to-government relationship and treaties. These governance institutions must be re-envisioned, taking into account the challenges of the Anthropocene as seen from a tribal perspective.

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This paper received peer technical review. The content of the paper reflects the views of the authors, who are responsible for the facts and accuracy of the information herein.