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# Indigenous frameworks for observing and responding to climate change in Alaska

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**Abstract** Despite a keen awareness of climate change, northern Indigenous Peoples have had limited participation in climate-change science due to limited access, power imbalances, and differences in worldview. A western science emphasis on *facts* and an indigenous emphasis on *relationships* to spiritual and biophysical components indicate important but distinct contributions that each knowledge system can make. Indigenous communities are experiencing widespread thawing of permafrost and coastal erosion exacerbated by loss of protective sea ice. These climate-induced changes threaten village infrastructure, water

Caleb Pungowiyi is deceased; Inuit leader/hunter.

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supplies, health, and safety. Climate-induced habitat changes associated with loss of sea ice and with landscape drying and extensive wildfires interact with northern development to bring both economic opportunities and environmental impacts. A multi-pronged approach to broadening indigenous participation in climate-change research should: 1) engage communities in designing climate-change solutions; 2) create an environment of mutual respect for multiple ways of knowing; 3) directly assist communities in achieving their adaptation goals; 4) promote partnerships that foster effective climate solutions from both western and indigenous perspectives; and 5) foster regional and international networking to share climate solutions.

## 1 Introduction

> "Not that long ago the water was far from our village and could not be easily seen from our homes. Today the weather is changing and is slowly taking away our village. Our boardwalks are warped, some of our buildings tilt, the land is sinking and falling away, and the water is close to our homes. The infrastructure that supports our village is compromised and affecting the health and well-being of our community members, especially our children" (Village of Newtok) (ADCCED 2012)

Air temperatures in Alaska are increasing twice as fast as the global average. This has led to a shrinkage of summer sea ice, a shortening of the snow-covered season, warming and thawing of permafrost, which together have altered the structure and functioning of northern ecosystems, including their human and non-human residents. These facts are well documented (ACIA 2005; IPCC 2007), but what are the consequences for the people who live there?

Although most Alaskans live in cities, the majority of the land area is sparsely populated by a largely indigenous population living in small communities with no road access and no connection to the electrical grid. Excluding the oil-rich North Slope, rural Alaska is the most extensive area of poverty in the United States, in terms of household income, yet has the highest costs of fuel and other commercial goods because of the physical isolation of these communities (e.g., $7–12 per gallon for fuel). In addition, few jobs are available to provide a cash income. Given these stark economic realities, indigenous people in rural Alaska depend directly on the local environment for food, transportation, and survival and have a strong need to understand and manage the consequences of climate change.

However, this is nothing new. Indigenous Alaskans have lived off the land and sea for thousands of years with minimal connection to the global economy. Over the millennia indigenous people have developed a traditional knowledge that allowed survival, and often thriving, in the landscapes and seascapes of the North (Langdon 1986; Huntington and Watson 2012). Moreover, the weather, environment, and plant and animal populations are so variable, both seasonally and among years, that indigenous people have developed skills to cope with a wide range of conditions. Given the close connections between indigenous people and environment and the rapid environmental changes occurring in Alaska, Alaska Natives are well poised to observe climate change, understand its ecological and societal consequences (Krupnik and Jolly 2002), and develop potential response strategies (Voggesser et al. 2013).

Despite a keen awareness of climate change, northern indigenous peoples have not played a central role in national and international assessments of climate change. To the extent that indigenous issues are considered, assessments have been largely *about* indigenous people, not *by* them. This reflects, in part, a rejection by western science of indigenous

worldviews that integrate spiritual, biophysical, and cultural dimensions of reality. In this paper we briefly (1) summarize some elements of indigenous worldviews that are important in understanding their potential to contribute to climate-change solutions, (2) present examples of the impacts of climate change on indigenous communities, and (3) suggest a path forward that will enhance the capacity of indigenous peoples to contribute to and benefit from climate-change research.

## 2 Traditional knowledge as a lens for observing climate change

Although indigenous understandings of climate change are as diverse as the many environments and cultures in which they are situated, there are some common features and differences compared to western science. Respect for elders and the natural environment, for example, are commonly held community values, and traditional stories of biophysical and spiritual ties between people and nature reflect these values across most of Alaska's indigenous cultures, despite important cultural and environmental differences in the specific ways in which people interact with their environment (ANSC 2003–04; ANKN 2012). Many elements of indigenous worldviews are embedded in a holistic framework that connects the land to the air and water, the earth to the sky, the plants to the animals, the people to the spirit (Deloria and Wildcat 2001; Wildcat 2009). This perspective recognizes Earth as a coupled social-biophysical system in which all things are connected (Levin 1999), so it is not surprising to many arctic residents that arctic changes exert important feedbacks to the Earth System (ACIA 2005; IPCC 2007). Following from this holistic framework, Alaskan indigenous perspectives often emphasize relationships between people and other living and non-living entities ("how to"), whereas western science tends to emphasize facts ("what is"). Traditional ways of knowing therefore provide an ethical framework that can guide adaptation to current and emerging conditions (Huntington and Watson 2012). Given these important differences between western and indigenous worldviews, it important not to attempt to merge them into a single framework but to recognize respectfully what each has to offer in solving the challenges faced by modern society (Huntington 2000a; Huntington et al. 2005; Huntington and Watson 2012).

Native cultures and sense of identity are directly tied to the places where people have lived for generations through observations, riddles, stories, dances, art, language, music, and traditions (Wildcat 2001; Huntington and Watson 2012). Since each cultural element evolved in a climatic and ecological context, it is vulnerable when climate alters that context and as elder knowledge-keepers pass away. In addition, plants and animals in these places are viewed as relatives that share the world—not as resources to be exploited (Morrow and Hensel 1992; Wildcat 2009). This strong sense of place and sense of connection to the organisms that inhabit this place makes climate change a much deeper and more personal impact than in communities that view the environment primarily as a place to live, work, and extract resources (Huntington et al. 2006).

## 3 Climate-change impacts on Alaskan indigenous communities

Hunters from indigenous communities frequently speak of the thinning sea and river ice that makes harvest of wild foods more dangerous (Ford and Furgal 2009; Loring and Gerlach 2010; McNeeley and Shulski 2011; Moerlein and Carothers 2012), changes to permafrost that alter spring run-off patterns, changes in seasonality of vegetation and animal movements

(McNeeley and Shulski 2011), a northward shift in seal and fish species, and rising sea levels with more extreme tidal fluctuations (Krupnik and Jolly 2002; Downing and Cuerrier 2011; Davis 2012; McNeeley 2012; University of Alaska Fairbanks 2012). These and other indigenous observations indicate a widespread awareness that climate is changing in ways that were not anticipated based on traditional knowledge. Although western and indigenous observers often make similar observations, the context for interpreting their significance frequently differs. In the words of the late Caleb Pungowiyi, an Indigenous Elder from Savoonga, Alaska (quoted in Eamer et al. 2007):

> "As we think about the future and where these trends may lead us, we wonder what alternatives are available to Native villages in Alaska and elsewhere in the Arctic. If marine mammal populations are no longer available or accessible to our communities, what can replace them? In the Great Famine, there were no alternatives to the food provided by hunting and fishing. Today, there are stores with food and other resources that can be harvested. A gradual change might give us time to adjust, but a sudden shift might catch us unprepared and cause great hardship. We need to think about the overall effects on marine mammals and other resources. Some may adjust, but others will not. Our ancestors taught us that the Arctic environment is not constant, and that some years are harder than others. But they taught us that hard years are followed by times of greater abundance and celebration. As we have found with other aspects of our culture's ancestral wisdom, modern changes, not of our doing, make us wonder when the good years will return."

In the remainder of this section we emphasize climate changes that have greatest impacts on indigenous communities. Problems intrinsic to many rural Alaskan communities, such as the failure or lack of adequate drinking water systems, sanitary sewage disposal, and usable landfills, are magnified by climate change (Alessa et al. 2008; Brubaker et al. 2011b; Doyle et al. submitted for this issue). Thawing of permafrost beneath lakes and ponds that provide drinking water, for example, cause water-security challenges (Alessa et al. 2008), and deteriorating water and sewage systems increase the risk of skin and respiratory infections (Gessner 2008; Hennessy et al. 2008). Warming may bring new diseases to the Arctic through diseases in harvested foods (McLaughlin et al. 2005; Virginia and Yalowitz 2011) or through northward-moving insect and vertebrate vectors (Parkinson and Evengård 2009), such as the northward movement of giardiasis in beaver that follow the climate-induced expansion of shrubs in western Alaska.

Ice cellars traditionally used for storing food are thawing, causing food contamination illnesses and loss of traditional foods (Alessa et al. 2008; Brubaker et al. 2011a). In some communities residents are seeking new methods to store food or are shifting from a traditional to a western diet (Brubaker et al. 2009; Moerlein and Carothers 2012), which increases dependence on non-traditional, expensive, and often less-healthy store-bought foods (Ford 2009; Loring and Gerlach 2010). Climate-induced impacts on arctic peoples interact with contaminants, such as POPs (persistent organic pollutants) and heavy metals, many of which are concentrated at high latitudes (AMAP 2009). Local concerns about contaminants sometimes contribute to the shift in diet away from traditional foods. This is associated with increases in "modern diseases" such as obesity, diabetes, cardiovascular disease, and cancer (Ford 2009; Parkinson 2010) and contributes to negative social, cultural, economic, and nutritional effects (Weller 2005; Redsteer et al. this issue).

Climate change has significantly altered both terrestrial and marine habitats and therefore the opportunities for hunting and fishing, which are important both nutritionally and culturally (Huntington et al. 2005). Reductions in winter sea ice reduce habitat for walrus

and seals, which are a critical component of people's diet in northwest Alaska. In addition, the thinner, less stable sea and river ice is a significant safety hazard for hunters (Laidler et al. 2009) and can disrupt the timing and dependability of subsistence economies (Ford and Furgal 2009; Gearheard et al. 2010). On the other hand, a shorter ice-season expands the time available to hunt from boats. The net effect of climate change on subsistence probably depends on context.

Most (86 %) Alaskan indigenous villages are affected to some extent by flooding and erosion: "While the problems are long-standing, various studies indicate that coastal villages are becoming more susceptible to flooding and erosion due in part to rising temperatures" (GAO 2003). Newtok, a Yupik Eskimo village in western Alaska, and other coastal communities experiencing accelerated rates of erosion caused by the combination of thawing permafrost, decreased arctic sea ice, and autumn storms that now occur during the ice-free season. As a result of these geophysical changes, the community has lost critical basic infrastructure, and storms are a continuing threat to life and property. Although the community has sought for a generation (17 years) to relocate, the stipulations of current federal and state statutes and regulations, such as the post-disaster recovery legislation, have impeded their efforts (Bronen 2011; Maldonado et al. 2013).

On land, the major impacts of climate change have been changes in temperatures, snow, ice, weather, seasonality, permafrost thaw, and wildfire. Increased evapotranspiration and declining river discharge reduce opportunities for barge delivery of fuel and increase the cost of living in remote villages (Kofinas et al. 2010). The ecological and hydrological changes related to permafrost degradation are changing the habitats, migration patterns, and distribution of species that are important for fishing and hunting ; (Kofinas et al. 2010; Loring and Gerlach 2010; Voggesser et al. 2013).

The frequency and severity of wildfire in the Interior are expected to continue increasing with climate warming and will likely result in increased fire suppression near communities, which may provide economic opportunities through the deployment of local fire fighting crews (Trainor et al. 2009). However, increased severity and annual extent of area burned will increase risk to life and property, alter hunting opportunities, and likely increase both physical and mental health effects from wildfire smoke. Lichens, which are a key winter food for caribou, require 70 years to recover after wildfire, whereas moose increase in abundance within a few years (Chapin et al. 2008; Nelson et al. 2008).

## 4 Interactions of climate change and development

Development activities in the Arctic (e.g., oil and gas, minerals, tourism, and shipping) are of interest to indigenous communities, because of both perceived threats and anticipated benefits (Kruse 1991; Huntington et al. 2007; Maynard et al. 2011). The retreat of summer sea ice removes a major barrier to access to much of the Arctic, as can be seen in the transit of the Northern Sea Route by cargo ships and the Northwest Passage by cruise ships (AMSA 2009). Greater levels of industrial activity across the Arctic are expected to alter the distribution of species, disrupt subsistence activities, increase the risk of oil spills, and create various social impacts (Baffrey and Huntington 2010; Maynard et al. 2011). Oil and gas development as well as mining activities have already impacted some major populations of Eurasian reindeer herds and the associated indigenous herder communities in Northern Russia and Norway (Maynard et al. 2011). At the same time, development provides economic opportunities, if it can be harnessed appropriately (Kruse 1991; Kruse et al. 2004; Baffrey and Huntington 2010). For indigenous peoples in Alaska, a major question

is how such activities will be managed and by whom, and how such management will take account of the impacts of climate change (Huntington et al. 2012). There are often strong differences of opinion within and among communities about how to balance development with traditional lifeways. To the extent that development can help pay for climate impact prevention and mitigation, there are potential benefits, albeit at the cost of accepting more industrial development. Here as elsewhere, community futures will depend in large part on the degree to which communities are empowered to make or influence the decisions that will affect them.

## 5 Preparing for the future

In this paper, we have shown that indigenous Alaskans have extensively documented patterns and processes of climate change and its impacts on ecosystems and human communities. How can indigenous peoples contribute more effectively to understanding and adapting to climate change? We suggest a multi-pronged approach:

1. *Engage communities in designing climate-change solutions*. Regional Advisory Councils, comprised largely of indigenous hunters from rural Alaska, can provide advice to the Alaska Board of Game about adjustments in hunting seasons needed to account for climate change-induced changes in seasonality (McNeeley 2012). A recent shift in decision-making authority from the politically appointed Board of Game to the Subsistence Division of the Alaska Department of Fish and Game should make these decisions about hunting regulations more responsive to local observations and needs. In other cases, adaptation solutions are constrained more by economics and competing ways to earn a living (e.g., summer construction vs. subsistence harvest) than by regulations. For example, declines in sea ice and stronger winds often produce earlier and larger open-water leads during the spring whaling season, requiring larger boats for safe navigation and whaling (Krupnik 2002). At the same time, later fall freeze-up has allowed hunters on St. Lawrence Island to pursue bowhead whales in November and December, providing a new opportunity for hunting that can help offset some of the difficulties in spring (Noongwook et al. 2007), an innovation made possible by a lack of seasonal restrictions on whaling activity. The Alaska Native Science Commission, the University of Alaska Fairbanks and four Alaskan indigenous communities (Igiugig, Koyukuk, Newtok, and Nikolai) recently initiated a Community Partnership for Self-Reliance and Sustainability. The goal of the partnership is to develop a collaboration that implements each community's own vision for self-reliance and sustainability, based on potential solutions chosen by communities and implemented with assistance from the university and agencies. Each community had at least one issue that differed from issues faced by the other three communities, was critical to community self-reliance, and was not addressed by any government program. This included funding for village relocation in Newtok, acceptance of Koyukuk's strategy of adapting to flooding by protecting infrastructure in place, secure rights to pure water in Igiugig, and rights to fish for salmon in Nikolai. In addition, there were some problems such as the high cost of energy that were faced by all communities. Each community found *different* ways to address this problem.
2. *Create an environment of mutual respect for multiple ways of knowing*. Scientists should be encouraged to engage respectfully in indigenous venues such as talking circles at regional tribal meetings (ANSC 2003–04; Huntington 2007), knowledge-

sharing networks (ANKN 2012), and tribal newsletters (Huntington and Huntington 2005). In response to a letter from Caleb Pungowiyi to the Marine Mammal Commission in 1998 pointing out that few scientists were taking seriously the observations of Native hunters and elders about climate change, a workshop was organized on changes in arctic sea ice and environment that had equal participation and engagement by scientists and Native experts (Huntington 2000b). This workshop led to a 1-year pilot project on *Watching Ice and Weather Our Way* that was conceptualized, designed, and implemented by Yupik experts (Krupnik 2002). There are still substantial barriers to communicating ideas between knowledge systems with respect to both the language that is used and the confidence in the ideas that are shared (Cajete 2000; Kovach 2009). Peer review is important in both oral traditions and western science, but the process is quite different. Over the longer term, educational reforms are necessary that acknowledge both knowledge systems and recognize the value of hands-on outdoor learning in an indigenous context, as in culture camps and involvement of youth in subsistence harvest.

3. *Directly assist communities in achieving their adaptation goals*. The Newtok Planning Group is a collaboration of 25 government agencies, tribal groups, and non-governmental organizations, led by the Newtok Traditional Council, that assists Newtok in designing and implementing a plan to relocate from its current site which is vulnerable to climate change-induced flooding and erosion to a site selected by the community (Bronen 2011). Other efforts seek to address climate change at larger scales. For example, the Inuit Circumpolar Council (ICC) claimed in 2005 in their Petition to the Inter-American Commission on Human Rights that rapid high-latitude warming and its unprecedented impacts on ecosystems and indigenous communities violate their human rights (http://www.inuitcircumpolar.com/, Trainor et al. 2007). In their petition, the ICC asked that the United States be required to reduce its carbon emissions in order to protect the human rights of northern indigenous peoples.
4. *Promote partnerships that foster effective climate solutions from both western and indigenous perspectives*. This requires moving beyond simply collecting or citing traditional knowledge to applying traditional knowledge in problem-solving. Working in true partnership involves recognizing, respecting, and, where appropriate, resolving epistemological differences in devising place-based solutions (Trainor in press; Voggesser et al. 2013; Whyte 2013). Scientists across the Arctic are increasingly working with indigenous communities to co-design the science (Krupnik and Jolly 2002), as in the Bering Ecosystem Study (http://www.arcus.org/bering/projects.html) and the U.S.-Canada Arctic Borderlands Project (Kofinas et al. 2002). Sometimes, however, co-management efforts fall short of addressing the needs for both cultural and ecological integrity (Robards and Lovecraft 2010). When successful, such collaborative efforts can also lead to the identification of local and tribal measures in response to the challenges that have been jointly identified (e.g., Salomon et al. 2011).
5. *Foster regional and international networking to share climate solutions*. As indigenous communities strive for sustainable adaptation in response to climate impacts, communities can learn from each other how to document observations, devise and implement adaptation solutions, and overcome barriers in funding, information exchange, and institutional hurdles. In many cases, the most appropriate venues will be conferences of indigenous peoples, such as the Indigenous Peoples' Global Summit on Climate Change held in Anchorage in 2009 (www.un.org/ga/president/63/letters/globalsummitoncc.pdf) or websites maintained by tribal organizations (e.g., the Alaska Native Science Commission, Inuit Circumpolar Council). There is scope for substantial innovation to link more

effectively the communication networks of tribes, scientists, and managers who share a common goal in fostering effective adaptations to climate change. The Exchange for Local Observations and Knowledge in the Arctic (ELOKA; www.eloka-arctic.org) fosters the "collection, preservation, exchange, and use of local observations and knowledge of the Arctic," partnering with indigenous communities, researchers, and others who share this goal to devise new approaches to building networks and establishing connections between people with common interests and goals (Pulsifer et al. 2012).

Much work has been done to date on each of the five prongs, but more is needed, especially in the transition from strong individual projects to larger efforts to connect and draw from individual successes. Greater recognition of the larger body of practice and improved ability to draw upon the lessons of others will remove the sense of isolation that can constrain resilience and foster collaborative problem-solving. This in turn will help Alaska Native communities better characterize the challenges they face and better design solutions that will work in their communities on their terms.

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## References

ACIA (2005) Arctic climate impact assessment. Cambridge University Press, Cambridge

ADCCED (2012) Strategic management plan: Newtok to Mertarvik. Alaska Department of Commerce and Community and Economic Development (ADCCED), Anchorage

Alessa LN, Kliskey AA, Busey R, Hinzman L, White D (2008) Freshwater vulnerabilities and resilience on the Seward Peninsula: integrating multiple dimensions of landscape change. Global Environ Chang 18:256–270

AMAP (2009) AMAP assessment 2009: human health in the arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo

AMSA (2009) Arctic marine shipping assessment 2009 report. Arctic Council, Stockholm

ANKN (2012) Alaska Native Knowledge Network (ANKN), www.ankn.uaf.edu/, Fairbanks, AK

ANSC (2003–04) Regional meeting reports. Alaska Native Science Commission (ANSC), http://www.nativescience.org/pubs/reports.htm

Baffrey M, Huntington HP (2010) Social and economic effects of oil and gas activities in the Arctic: assessment 2007—oil and gas activities in the Arctic-effects and potential effects. Arctic Monitoring and Assessment Program, Oslo, pp 3.1–3.71

Bronen R (2011) Climate-induced community relocations: creating an adaptive governance framework based in human rights doctrine. N Y Univ Rev Law Soc Chang 35:356–406

Brubaker M, Bell J, Rolin A (2009) Climate change effects on traditional Inupiaq food cellars: http://www.anthc.org/chs/ces/climate/upload/CCH-Bulletin-No-01-Permafrost-and-Underground-Food-Cellars-Revised-Final.pdf Alaska Native Tribal Health Consortium, Anchorage, AK

Brubaker M, Berner J, Chaven R, Warren J (2011a) Climate change and health effects in Northwest Alaska. Glob Heal Action 4:8445

Brubaker MY, Bell JN, Berner JE, Warren JA (2011b) Climate change health assessment: a novel approach for Alaska Native communities. Int J Circumpolar Health 70:266–273

Cajete G (2000) Native science, natural laws of interdependence. Clear Light Publishers, Santa Fe

Chapin FS III, Trainor SF, Huntington O, Lovecraft AL, Zavaleta E, Natcher DC, McGuire AD, Nelson JL, Ray L, Calef M, Fresco NL, Huntington H, Rupp TS, DeWilde L, Naylor RL (2008) Increasing wildfire in Alaska's boreal forest: pathways to potential solutions of a wicked problem. BioScience 58:531–540

Davis M (2012) Climate change: our voices, sharing ways forward. Alaska Forum on the Environment, Anchorage

Deloria V, Wildcat D (eds) (2001) Power and place: Indian Education in America. Fulcrum Resources, Golden

Downing A, Cuerrier A (2011) A synthesis of the impacts of climate change on the First Nations and Inuit of Canada. Indian J Tradit Knowl 10:57–70

Eamer J, Lambrechts C, Prestrud P, Young O (2007) Policy and perspectives. In UNEP (ed) Global outlook on snow and ice. United Nations Environment Program, Arendal, Norway, www.unep.org/publications/polarbooks/books/1006.aspx

Ford JD (2009) Vulnerability of Inuit food systems to food insecurity as a consequence of climate change: a case study from Igloolik, Nunavut. Reg Environ Chang 9:83–100

Ford JD, Furgal C (2009) Climate change impacts, adaptation and vulnerability in the Arctic. Polar Res 28:1–9

GAO (2003) Alaska native villages: most are affected by flooding and erosion, but few qualify for federal assistance. Government Accountability Office, Washington

Gearheard S, Pocernich M, Stewart R, Sanguya J, Huntington HP (2010) Linking Inuit knowledge and meteorological station observations to understand changing wind patterns at Clyde River, Nunavut. Clim Chang 100:267–294

Gessner B (2008) Lack of piped water and sewage services is associated with pediatric lower respiratory tract infection in Alaska. J Pediatr 152:666–670

Hennessy T, Ritter T, Holman R, Bruden D, Yorita K, Bulkow L, Cheek J, Singleton R, Smith J (2008) The relationship between in-home water service and the risk of respiratory tract, skin, and gastrointestinal tract infections among rural Alaska Natives. Am J Public Health 98:2072–2078

Huntington HP (2000a) Using traditional ecological knowledge in science: methods and applications. Ecol Appl 10:1270–1274

Huntington, HP (ed) (2000b) Impacts of changes in sea ice and other environmental parameters in the Arctic. Report of the Marine Mammal Commission Workshop, 15–17 February 2000, Girdwood, Alaska. Marine Mammal Commission, Bethesda, Maryland

Huntington OH (2007) It's a changing thing. Polar-Paloosa, podcast, http://passporttoknowledge.com/polar-palooza/pp06/php

Huntington OH, Huntington HP (2005) "We hate fire": understanding statements on context. Naalaktuaqtuni Ilitchiruni-Lu/ Listening and learning. Alask Native Sci Comm Newsl 5:1–2

Huntington OH, Watson A (2012) Interdisciplinarity, native resilience, and how the riddles can teach wildlife law in an era of rapid climate change. Wicazo Sa Review 27:49–73

Huntington HP, Fox S, Berkes F, Krupnik I (2005) The changing Arctic: indigenous perspectives. In: ACIA (ed) Arctic climate impact assessment. Cambridge University Press, Cambridge, pp 61–98

Huntington HP, Trainor SF, Natcher DC, Huntington O, DeWilde L, Chapin FS III (2006) The significance of context in community-based research: understanding discussions about wildfire in Huslia, Alaska. Ecol Soc 11: http://www.ecologyandsociety.org/vol11/iss11/art40/

Huntington HP, Boyle M, Flowers GE, Weatherly JW, Hamilton LC, Hinzman L, Gerlach C, Zulueta R, Nicolson C, Overpeck J (2007) The influence of human activity in the Arctic on climate and climate impacts. Clim Chang 82:77–92

Huntington HP, Goodstein E, Euskirchen E (2012) Towards a tipping point in responding to change: rising costs, fewer options for arctic and global societies. Ambio 41:66–74

IPCC (2007) Impacts, adaptation and vulnerability: contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge

Kofinas GP, Communities of Aklavik, Arctic Village, Old Crow, and Fort McPherson (2002) Community contributions to ecological monitoring: knowledge co-production in the U.S.-Canada arctic borderlands. In: Krupnik I, Jolly D (eds) The earth is faster now: indigenous observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks, pp 54–91

Kofinas GP, Chapin FS III, BurnSilver S, Schmidt JI, Fresco NL, Kielland K, Martin S, Springsteen A, Rupp TS (2010) Resilience of Athabascan subsistence systems to interior Alaska's changing climate. Can J For Res 40:1347–1359

Kovach M (2009) Indigenous methodologies. University of Toronto Press, Toronto

Krupnik I (2002) Watching ice and weather our way: some lessons from Yupik observations of sea ice and weather on St. Lawrence Island, Alaska. In: Krupnik I, Jolly D (eds) The earth is faster now: indigenous observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks, pp 156–197

Krupnik I, Jolly D (eds) (2002) The earth is faster now: indigenous observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks

Kruse JA (1991) Alaska Inupiat subsistence and wage employment patterns: understanding individual choice. Hum Organ 50:3117–3126

Kruse JA, White RG, Epstein HE, Archie B, Berman M, Braund SR, Chapin FS III, Charlie J Sr, Daniel CJ, Eamer J, Flanders N, Griffith B, Haley S, Huskey L, Joseph B, Klein DR, Kofinas GP, Martin SM, Murphy SM, Nebesky W, Nicolson C, Peter K, Russell DE, Tetlichi J, Tussing A, Walker MD, Young OR

(2004) Modeling sustainability of arctic communities: an interdisciplinary collaboration of researchers and local knowledge holders. Ecosystems 7:815–828
Laidler GJ, Ford JD, Gough WA, Ikummaq T, Gagnon AS, Kowal S, Qrunnut K, Irngaut C (2009) Travelling and hunting in a changing Arctic: assessing Inuit vulnerability to sea ice change in Igloolik, Nunavut. Clim Chang 94:363–397
Langdon SJ (ed) (1986) Contemporary Alaskan native economies. University Press of America, Lanham
Levin SA (1999) Fragile dominion: complexity and the commons. Perseus Books, Reading
Loring PA, Gerlach SC (2010) Food security and conservation of Yukon River salmon: are we asking too much of the Yukon River? Sustainability 2:2965–2987
Maldonado JK, Shearer C, Bronen R, Peterson K, Lazrus H (2013) The impact of climate change on tribal communities in the US: displacement, relocation, and human rights. Clim Chang. doi:10.1007/s10584-013-0746-z
Maynard NG, Oskal A, Turi JM, Mathiesen SD, Eira IMG, Yurchak B, Etylin V, Gebelein J (2011) Impacts of arctic climate and land-use changes on reindeer pastoralism: indigenous knowledge and remote sensing. In: Gutman G, Reissell A (eds) Eurasian Arctic land cover and land use in a changing climate. Springer, Dordrecht, pp 177–205
McLaughlin JB, DePaola A, Bopp CA, Martinek KA, Napolilli NP, Allison CG, Murry SL, Thompson EC, Bird MM, Middaugh JP (2005) Outbreak of *Vibrio parahaemolyticus* gastroenteritis associated with Alaskan oysters. N Engl J Med 353:1463–1470
McNeeley SM (2012) Examining barriers and opportunities for sustainable adaptation to climate change in Interior Alaska. Clim Chang 111:835–857
McNeeley SM, Shulski MD (2011) Anatomy of a closing window: vulnerability to changing seasonality in Interior Alaska. Global Environ Chang 21:464–473
Moerlein KJ, Carothers C (2012) Total environment of change: impacts of climate change and social transitions on subsistence fisheries in northwest Alaska. Ecol Soc 17. doi:10.5751/ES-04543-170110
Morrow P, Hensel C (1992) Hidden dissension: minority-majority relationships and the use of contested terminology. Arct Anthropol 29:38–53
Nelson JL, Zavaleta E, Chapin FS III (2008) Boreal fire effects on subsistence resources in Alaska and adjacent Canada. Ecosystems 11:156–171
Noongwook G, the Native Village of Savoonga, the Native Village of Gambell, Huntington HP, George JC (2007) Traditional knowledge of the bowhead whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. Arctic 60(1):47–54
Parkinson A (2010) Sustainable development, climate change and human health in the Arctic. Int J Circumpol Heal 69:100
Parkinson A, Evengård B (2009) Climate change, its impact on human health in the Arctic and the public health response to threats of emerging infectious diseases. Glob Heal Action 2. doi:10.3402/gha.v3402i3400.2075.
Pulsifer P, Gearheard S, Huntington HP, Parsons MA, McNeave C, McCann HS (2012) The role of data management in engaging communities in Arctic research: overview of the Exchange for Local Observations and Knowledge of the Arctic (ELOKA). Polar Geogr 35(3–4):271–290
Robards MD, Lovecraft AL (2010) Evaluating comanagement for social-ecological fit: indigenous priorities and agency mandates for Pacific walrus. Policy Stud J 38:257–279
Salomon A, Huntington HP, Tanape N Sr (2011) Imam cimucia: our changing sea. Alaska Sea Grant, Fairbanks
Trainor SF (in press) Deeper sense of place for indigenous and western science partners in climate change assessment and adaptation in Alaska. In: Johnson J, Larsen S (eds) A deeper sense of place: stories and journeys of indigenous-academic collaboration. Oregon State University Press, Corvallis
Trainor SF, Chapin FS III, Huntington HP, Natcher DC, Kofinas G (2007) Arctic climate impacts: environmental injustice in Canada and the United States. Local Environ Int J Justice Sustain 12:627–643
Trainor SF, Calef M, Natcher D, Chapin FS III, McGuire AD, Huntington O, Duffy P, Rupp TS, DeWilde L, Kwart M, Fresco N, Lovecraft A (2009) Vulnerability and adaptation to climate-related fire impacts in rural and urban interior Alaska. Polar Res 28:100–118
University of Alaska Fairbanks (2012) Climate change project jukebox home page: website, accessed May 31, 2012 at http://jukebox.uaf.edu/ClimateChange/home.html
Virginia RA, Yalowitz KS (2011) A new paradigm for Arctic health—challenges and responses to rapid climate, environmental, and social change—report of an international workshop, May 23–25, 2011. The Dickey Center for International Understanding, Dartmouth College, and University of the Arctic, Dartmouth College, Hanvover, NH
Voggesser G., Lynn K, Daigle J, Lake FK, Ranco D (2013) Cultural impacts to tribes from climate change influences on forests. Clim Chang. doi:10.1007/s10584-013-0733-4

Weller G (2005) Summary and synthesis of the ACIA. Arctic Climate Impact Assessment (ACIA). Cambridge University Press, Cambridge, UK, accessed December 27, 2011, at http://www.acia.uaf.edu

Whyte KP (2013) Justice forward: tribes, climate adaptation and responsibility in Indian country. Clim Chang. doi:10.1007/s10584-013-0743-2

Wildcat D (2001) Technological homelessness. In: Deloria V, Wildcat D (eds) Power and place: Indian Education in America. Fulcrum Resources, Golden, pp 67–77

Wildcat D (2009) Red alert! Saving the planet with indigenous knowledge. Fulcrum Publishing, Golden