ARCTIC
VOL. 66, NO. 3 (SEPTEMBER 2013) P. 338 – 350

A Methodological Model for Exchanging Local and Scientific Climate Change Knowledge in Northeastern Siberia

SUSAN A. CRATE[1] and ALEXANDER N. FEDOROV[2]

(*Received 18 February 2012; accepted in revised form 8 January 2013*)

ABSTRACT. This paper analyzes findings from "Knowledge Exchanges," which engaged communities of Viliui Sakha, native horse and cattle agropastoralists of northeastern Siberia, Russia, with regional scientific specialists, a cultural anthropologist, and a permafrost scientist. Our process of knowledge exchange involved first gathering ethnographic data from affected communities, through focus groups, interviews, and surveys, and analyzing how people perceived, understood, and responded to local change. Next we documented the community results and compared them with regional climate change data. Lastly, we discussed these results during community knowledge exchange events, facilitating an increased understanding across knowledge systems and stakeholder groups. The knowledge exchange method documented in this article provides an adaptable model for integrating local and scientific knowledge systems that allows participants to reach understanding more quickly at global and local levels of how climate change is affecting places and peoples.

Key words: climate change, knowledge exchange, methodological model, collaborative research, permafrost, Siberia, Sakha Republic, Russia

RÉSUMÉ. Cette communication vient analyser les constatations émanant de l'échange de connaissances auquel ont participé les collectivités de Viliui Sakha, des agropasteurs indigènes s'occupant de chevaux et de bétail dans le nord-est de la Sibérie, en Russie, des spécialistes scientifiques régionaux, un anthropologue des cultures et un scientifique spécialisé en pergélisol. Notre échange de connaissances a commencé par la collecte de données ethnographiques auprès des collectivités concernées, données qui ont été recueillies au moyen de groupes de discussion, d'entrevues et de sondages. Cette collecte de données a été suivie de l'analyse de la manière dont les gens percevaient les changements qui se produisent à l'échelle locale, de la manière dont ils comprenaient ces changements et de la manière dont ils y réagissaient. Ensuite, nous avons consigné les résultats obtenus au sein des collectivités et les avons comparés aux données sur le changement climatique régional. En dernier lieu, nous avons discuté de ces résultats à l'occasion de séances d'échanges de connaissances organisées dans les collectivités, puis nous avons favorisé une plus grande compréhension à l'échelle des systèmes de connaissances et au sein des groupes d'intervenants. La méthodologie de l'échange de connaissances dont il est question dans le présent article présente un modèle adaptable d'intégration des systèmes de connaissances locales et de connaissances scientifiques, modèle qui permet aux participants de comprendre plus rapidement, mondialement et localement, comment le changement climatique influe sur les lieux et les gens.

Mots clés : changement climatique, échange de connaissances, modèle méthodologique, recherche concertée, pergélisol, Sibérie, République de Sakha, Russie

Traduit pour la revue *Arctic* par Nicole Giguère.

INTRODUCTION

At one of our eight knowledge exchange events during the summer of 2010, a community member who had travelled 20 km on horseback to participate told us the following:

> I am a horse-herder and hunter, and I know that the land has changed. Where there was never a ravine, there now is one. [It appears that] all has caved in. Where there were flat hay lands, ravines have now formed. Mostly I am speaking about how the land's surface has changed: where there never was a hill, there now is. The erosion of our lands is occurring rapidly, in just the last few years, and horses have a very hard time in the warm winter. We thought that warm [temperatures] would be good for the horses, but now we understand it is bad for them. Overall, we have come to a time when we cannot predict the weather. Before, things came in the right times, and now [they do] not.

Later, a permafrost scientist showed that the regional hay lands, used both for grazing and for harvesting fodder to

[1] Corresponding author: Department of Environmental Science and Policy, George Mason University, Fairfax, Virginia, USA; scrate1@gmu.edu
[2] Melnikov Permafrost Institute, Siberian Branch of Russian Academy of Sciences, Yakutsk, Russia; fedorov@mpi.ysn.ru

over-winter herds, are characterized by the type of permafrost most susceptible to degradation. He illustrated with photos of permafrost landscapes that looked like those the horse-herder had described.

Thus we heard two stories of the same phenomenon—one based on local knowledge, the other on scientific knowledge. Such local testimony illustrates the intimate knowledge of place-based peoples (referring to those who have an immediate daily dependence and interaction with their local environment) (Nuttall, 1992; Davidson-Hunt and O'Flaherty, 2007). The testimony of local people in Siberia also echoes what people like them in other world areas are saying about how changes in weather and annual cycles are affecting their lands and livelihoods (Salick and Byg, 2007; Crate and Nuttall, 2009). Local knowledge contributes the detail necessary for scientific knowledge to accommodate how a global process, such as climate change, is resulting in very diverse changes on the ground. Likewise, scientific data provide an explanation of global phenomena to the local people, contributing new information on change not yet known in the local context. It follows that these two knowledge systems, if brought into dialogue, can complement each other and add new details to both local and scientific understandings.

To this end, the authors, one a cultural anthropologist and the other a permafrost scientist, organized knowledge exchanges in the summer of 2010. In this article we explain how participants exchanged information across the two knowledge systems and how they complemented and informed each other. In the process, we model a method that others can adapt to the Arctic and other world contexts where such knowledge exchange could be useful.

LOCAL AND SCIENTIFIC KNOWLEDGE

Researchers and policymakers recognize the need to understand the "human dimension" to address global climate change effectively (IPCC, 2007; IPF, 2007; IPY, 2008). One valuable source of information is the observations of climate changes by local inhabitants of affected areas (Krupnik and Jolly, 2002; Cruikshank, 2005; Crate, 2008; Milton et al., 2008; Roncoli et al., 2009a; Gearheard et al., 2010a). Place-based peoples are experts in their immediate environment. This expertise, based on daily observation and intergenerational (ancestral) understanding requires a highly situated knowledge, which we refer to in this paper as "local knowledge." Several maxims clarify what local knowledge is and what it is not. It is a situated knowledge found in all societies and not the exclusive possession of indigenous peoples (Antweiler, 2004**;** Nuttall, 2004). It is not the "opposite" or corollary to scientific knowledge, but rather a different and complementary way of knowing. While scientific knowledge is based on validity and predictability achieved through specific scientific methods, local knowledge is founded in the diverse and situated human experience (Antweiler, 2004). While scientific knowledge is generalizable and content-independent, local knowledge is culture-specific and place-dependent, and it is often understood within a culture as "common sense" (Geertz, 1983:78–79). The latter definition underscores the importance of demystifying local knowledge by focusing on what actors know in relation to specific events or issues or in ecological and cultural context (Vayda et al., 2004). Like scientific knowledge, local knowledge is an empirical knowledge system, based on time-tested methods and expertise. In short, local and scientific knowledge are highly complementary.

Research in the field of global change and the human dimension increasingly aims to account for all relevant understandings, integrating the social science or human dimension and multiple ways of knowing into interdisciplinary efforts (Freeman, 1992; Alcorn, 1993; Agrawal, 1995; Stevenson, 1996; Abele, 1997; Sillitoe, 1998; Berkes, 1999; Huntington et al., 2001, 2004; Crate, 2006a; Oakes and Riewe, 2006; Crate and Nuttall, 2009; Mahoney et al., 2009; Green and Raygorodetsky, 2010; Gearheard et al., 2010b; Weatherhead et al., 2010). Additionally, many researchers are making their projects culturally appropriate with participatory and ethnographic methods that involve "users," or local communities, incorporating societal values, priorities, and needs into long-lasting adaptive strategies that perpetuate negotiation and learning among users (Huntington, 2005; Roncoli et al., 2009b). Scientific data provide an explanation of global phenomena to the local people and can potentially bolster climate change adaptation and, more broadly, the reconfiguration of the roles of science, policy, and lay knowledge (Meinke et al., 2009).

Given that Nature is "always constructed by our meaning-giving and discursive processes, so that what we perceive as natural is also cultural and social" (Escobar, 1999:2) and that local perceptions "exist in dynamic tension" with the material and discursive reality in which people live their lives (Vedwan, 2006:8), it is crucial to understand perceptions within both the local sociocultural context and the broader dimensions of environmental change (Rosen, 2007:10). In this context, anthropology has a unique role. Anthropologists, "absorbed with the artisanal task of seeing beyond the parochial facts" (Geertz, 1983:167), gain unique access to local knowledge through methods of participant observation, interview, and ethnography, and so can contribute greatly to our understanding of local knowledge systems, perceptions, and responses (Freeman, 1992; Agrawal, 1995; Stevenson, 1996; Abele, 1997; Sillitoe, 1998; Berkes, 1999; Escobar, 1999; Bicker et al., 2004; Vedwan, 2006; Crate and Nuttall, 2009; Roncoli et al., 2009a).

Bicker et al. (2004:xi) stated that, "Local knowledge needs to interface with global scientific knowledge, each drawing on the other to effect sustainable adaptation to changing natural and socio-economic environments." For at least a decade before Bicker et al. (2004) published their work, applied anthropologists had already advocated dismantling the dichotomous relationship of scientific and

local knowledge in order to take advantage of how these knowledge systems can inform each other in at least two areas: development efforts (Agrawal, 1995) and articulation of the local effects of climate change (Hinkel et al., 2007; Salomon et al., 2007; Cuomo et al., 2008; Eisner et al., 2008, 2009; Jones et al., 2008; Eicken, 2010; Gearheard et al., 2010a; Green et al., 2010; Huntington et al., 2010; Kapsch et al., 2010; Nweeia, 2010; ELOKA, 2012).

That said, despite much recent research on how global change is affecting local environments and cultures, the reality of integrating local and scientific knowledge systems remains problematic because of both the colonial legacy of Western research activities in many world regions (Smith, 1999) and the lack of meaningful ways to integrate the knowledge systems so they convey meaning for local and scientific knowledge holders alike. Central to integrating local knowledge systems into research is the recognition that these systems are, on the one hand, founded in long-term experience in place and, on the other hand, also "rooted in individual personalities and experiences, actively evolving, and taking place at the interface between scientifically regulated knowledge formation processes and subjective personal experience" (Lawrence, 2009:174). Integration and knowledge exchanges are nothing new and have been done before (e.g., Krupnik and Jolly, 2002; Smit and Wandel, 2006; Hovelsrud and Smit, 2010). This article illustrates a method for such knowledge exchanges that can be replicated in other world contexts.

BACKGROUND AND METHODS

The knowledge exchange process described here was part of a four-village, three-year collaborative effort to decipher how rural Viliui Sakha, a Turkic-speaking native horse and cattle breeding people of northeastern Siberia, Russia (Fig. 1), understand and are affected by the local consequences of global climate change (Crate, 2008, 2011a, b). The project was based on both the results of a 2003 – 05 project in the same communities that showed their overwhelming concern about unprecedented changes in weather patterns, climate, and seasonal timing (Crate, 2006b), and a growing body of scientific data that clarifies how climate change was affecting the Viliui regions. During the past decade, Viliui Sakha have been finding it increasingly difficult to adapt to local changes, which have included the inundation of hayfields, gardens, and pastures, which prevents use of substantial land areas and harvesting of essential resources; changes in the quality and quantity of snow that prevent hunters and horse herds from accessing winter food; increased flooding that rots homes and other buildings and ruins transportation ways; and disrupted rain patterns in the temperate months that create droughts in spring and dampness in harvest times, affecting hay production.

During the first two summer field seasons (2008, 2009) the research team conducted focus groups, interviews, and surveys in four Viliui Sakha communities, to document and

FIG. 1. Map of the contemporary Sakha Republic, showing the locations of the capital city, Yakutsk, the Viliui River, and the base research villages, Elgeeii and Kutana.

verify what changes inhabitants were observing, how these changes were affecting them, their ideas on what was causing the changes, and what they thought the future would be like should the changes continue (for further details see Crate, 2011a, b). To elicit inhabitants' input about changes in the local weather and annual cycles, we deliberately planned not to use the term "global climate change," since it is often, if not always, absent from the vernacular (Marino and Schweitzer, 2009). Research has shown that to learn about the local effects of global climate change, the best approach is to talk to people about weather and weather changes, which are in the vernacular in all local contexts (Strauss and Orlove, 2003). In the project's second summer, we administered an eight-part survey designed to gauge the extent to which the broader population's observations and perceptions did or did not corroborate those of the focus groups and interviews (Table 1).

In summer 2010, in an effort to fill the gaps in local understanding of climate change, we developed a participatory knowledge exchange process to bring local people and scientists together for a dialogue. This process was also to serve the purpose of informing regional scientific data with the finer details of how global climate change was affecting landscapes and lives via local knowledge. To compare and contrast differences in change across regions and settlements, we planned to conduct the knowledge exchange not only in our four original research villages, but also in the four main regional centers of the Viliui regions, located downriver from Suntar (see Fig. 1).

Preparation for the knowledge exchange process began during the project's second year with both community buy-in and a major input of regional scientific data. To

TABLE 1. Illustrates and cross-references the methods, time frame, meeting types and numbers, participant characteristics, main findings and how each informed overall knowledge exchange process.

Year	Method	Location	Number of meetings	Participant qualifications	How solicited	Main findings generated	How informed process
2008	Focus groups	4 research villages	8 focus groups, 2 in each village (one male, one female)	Each group had 2 youth (18–25); 2 middle (26–55) and 2 elders (56+)	By our local village-level research assistant	Nine main changes; 4 main explanations/ causes; overall effects on livelihoods, perceptions of future	Provided initial data for survey
	Interviews	4 research villages	60 interviews, 15 in each village	In each village interviewed 5 youth, 5 middle and 5 elders fairly equally mixed genders	By our local village-level research assistant	Corroboration and greater details of 9 main changes; 4 main explanations/ causes; overall effects on livelihoods, perceptions of future	Provided initial data for survey
2009	Surveys	4 research villages	67 surveys	Within random sample	Through a random sample of 10% of all research village households (n = 67)	Corroboration and greater details of above focus group and interview findings, verification of gap in knowledge of climate change and understanding of its local effects	Demonstrated need to bring regional scientific findings into local vernacular and vice versa
2010	Knowledge exchanges	4 research villages and 4 regional centers	8 knowledge exchanges	Open to all interested in attending	Through communication by local contacts and organizations	Wealth of local knowledge, added two new observations and one new explanation across regions, clarified need for regional science in vernacular	Showed overall interest in getting this process and knowledge shared widely, initiated development of booklet
2011	Interviews	4 research villages	20 interviews	Attended 2010 knowledge exchange	By our local village-level research assistant	Overall enthusiasm about knowledge exchange and feedback on draft booklet	Provided critical input for final drafts of booklet

cover local logistics, we coordinated with the central and regional representatives of "Obshestvo Znaniye" (Community of Knowledge), who took responsibility for advertising the event, reserving a hall for the occasion, and coordinating housing for our traveling team. During the winter of 2009–10, we incorporated both the field research results to date (focus groups, interviews, and surveys) from the four Viliui Sakha communities and information on the effects of global climate change in the Republic and Viliui regions into a PowerPoint presentation to share our project findings with audiences.

We designed the knowledge exchange process to allow audience members to share their local knowledge. We would first ask the audience to share any observations of local change. This allowed inhabitants to be heard, brought their knowledge to the forefront, and set a precedent for open audience input throughout the exchange. We would next show our field research findings to date, with three opportunities to allow audience response. After detailing the main changes and the effects on people's lives, we invited audience input. We would then present the four main explanatory stories, of how inhabitants explained the changes as being the result of 1) the Viliui hydroelectric reservoirs; 2) the natural wet and dry cycles; 3) too much 'technika'; and 4) global climate change, after which we again opened the floor for audience comment. Lastly, we would observe that most inhabitants did not understand the link between the changes they were observing and the local effects of global climate change, largely because the general population does not have enough information about regional effects. We would again open the floor for comments.

Next, we would show the regional scientific knowledge on climate change, first discussing the global phenomenon, showing a world map, color-coded to show the increase in average temperatures. This map showed audiences that the high-latitude areas of the world are warming the most, and within the high latitude context, that the Sakha Republic is warming more than other areas. We then explained that global climate change is resulting in catastrophes the world over, specifically droughts, floods, hurricanes, and other extreme events, and that the main climate change catastrophe

FIG. 2. Permafrost degradation in the Churapcha region of Central Yakutia, showing how once flat landscapes have fallen into valleys (photo by A.N. Fedorov).

in the Sakha Republic is permafrost degradation. Showing a map of the republic, we would explain the different types of permafrost and point out that Sakha happen to inhabit the areas with permafrost characterized by ice wedges, the type most susceptible to degradation. Here we would talk directly about findings to date in the Sakha Republic's Central regions, where inhabitants are witnessing many of the same changes reported in the Viliui regions, involving the falling and rising of the land and also an increase of water on the land. We would illustrate with pictures, which communicate more effectively than verbal descriptions (Figs. 2–5). For example, the newly formed valleys and depressions in Central settlements show what permafrost degradation looks like on a village level (Fig. 2). Another good example is the deterioration of infrastructure, like the subsidence of roofs when permafrost degrades, a sight also commonly seen in Viliui Sakha villages (Fig. 3). The same figure included graphs of rising air and permafrost temperatures, which helped participants see how both are warming.

Another illustration showed how the increased water on the land is generating cascading effects, giving the example of how forests deteriorate as water invades the forest floor and trees suffocate (Fig. 4).

We would then explain how the phenomenon of increasing water on the land, the change that our project participants are most concerned about, is happening in most of the large ice-wedge permafrost areas. Further research data show that 45% of the water on the land originates from degrading permafrost.

The presentation would also include regional data that corroborated others of the nine main observations (listed in full in RESULTS), including data showing the increase of precipitation across the whole of northern Russia and the Viliui regions, with annual precipitation patterns skewed and the increase of 3.5ºC in annual air temperatures in the last 10 years, which is resulting in warmer winters and cooler summers.

We would also provide useful information about regionally developed technologies to help to slow permafrost degradation, showing several slides of new Sakha technologies, which included how to build a new house or retrofit an old one to preserve permafrost (Fig. 5). Following the presentation, we would open the floor for discussion.

In summer 2011, we conducted interviews with 20 inhabitants of our four research villages to gauge the impact

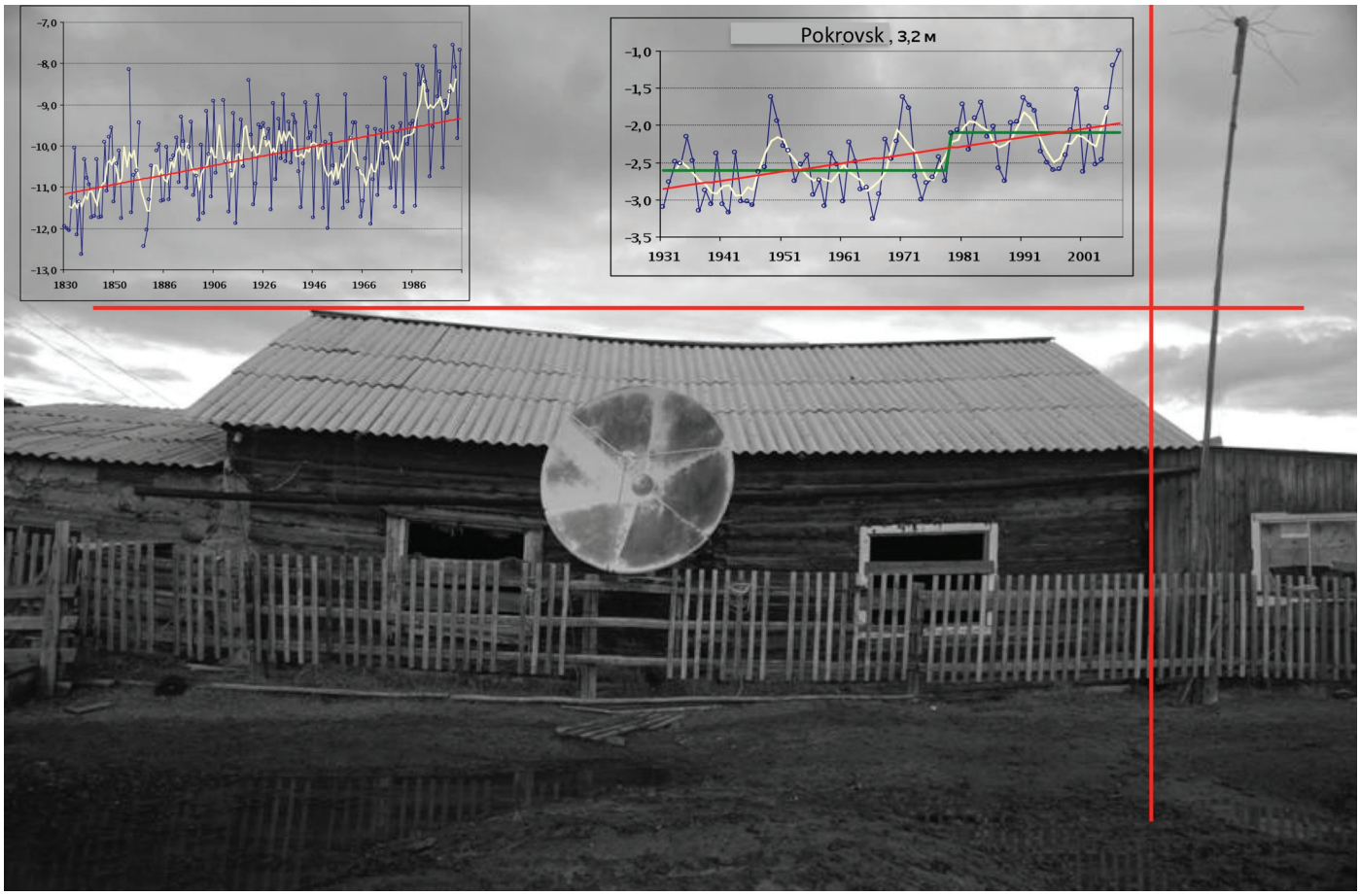

FIG. 3. Permafrost degradation in the Sylan settlement in the Churapcha region of Central Yakutia shows how houses are often affected. Graphs at top show increasing temperatures of permafrost and ambient air (photo by V.S. Makarov).

of the knowledge exchange and garner their critique of the first draft of our preliminary handbook.

RESULTS

Analysis of data from the 2008 focus group and interviews produced a list of nine universal changes: 1) winters are warm; 2) the land is flooded with water; 3) lots of rain; 4) summers are cold; 5) more floods; 6) seasons come late; 7) lots of snow; 8) temperatures change suddenly; and 9) fewer birds and animals. The main cause cited by participants was the presence of the Viliui hydroelectric reservoir. Other causes were the flux of "natural wet and dry cycles," or "too much technika," referring to the growth of technology in the last decades. Only a few participants mentioned global climate change.

Summer 2009 survey results showed that the majority of survey participants had observed all nine changes reported during our first summer of research and that a majority also explained the main causes of the local changes as the Viliui reservoir, "natural cycles" or "too much technika" (or both) (Crate, 2011a). As before, only a small percentage (limited to teachers, students who were back for the summer from the capital city, and elders who read newspapers a great deal) attributed any of the local change to global climate change. Additionally, in the final survey section where we asked specifically about global climate change, we learned that all survey participants had heard of it, had known about it for the past 5–10 years, and had learned about it via TV, radio, and the press, but considered it as something happening elsewhere in the world.

This local interpretation was incongruous with the science. In-country scientists monitoring these regions report an unprecedented increase in average annual air temperature (Fedorov and Svinoboev, 2000; Skachkov, 2005) and increased precipitation rates in the last decade. Although very few scientists directly attribute local change to global climate change, the literature engaging both the increased temperatures and precipitation considers both as direct results of global climate change (Roshydromet, 2008; Iijima et al., 2010). Regional scientists have documented increased permafrost degradation directly due to climate change (Fedorov and Konstantinov, 2008, 2009). Despite such overwhelming scientific proof, few Viliui region inhabitants identify global climate change as one of the causes of local change because of the paucity of locally relevant information (Crate, 2011a).

In response, between 1 and 12 July 2010, we facilitated eight knowledge exchanges in the Viliui regions. In the

FIG. 4. Increased water on the land at the Yukechi Site near the Maya settlement in Central Yakutia has caused cascading effects like forest deterioration (photos by A.N. Fedorov).

FIG. 5. Two methods of protecting permafrost: (left) by creating an insulating layer under new house construction and (right) by retrofitting existing buildings. Churapcha region, Central Yakutia (photos by A.N. Fedorov and P.P. Federov).

process of these events, detailed in the methods section, we were able to corroborate with audiences that they were also witnessing the nine main changes documented by our research communities and that they found scientific data on the local effects of global climate change lacking. Beyond that, by including the regional centers, which cover greater geographic and ecological areas in the Viliui regions, participants brought to light two new observations and one explanatory story, adding to our project's knowledge base about local perceptions of change. We include an example of each below to illustrate.

The first new observation was about changes in wind, with many participants speaking about the increase in damaging winds. A local hunter shared the testimony below based on his experience on the land.

> There are more *khara kholoruk* (destructive cyclones) and they completely ruin the forests. They take away the natural protection to the land, making it more susceptible to erosion.

Participants also talked about wind as being a new phenomenon in the formerly still months of deep winter. Before, from early December to late February, winters were a period of deep cold, characterized by windless stills. With winters warmer, snow falls throughout the winter and wind prevails. Among other things, the wind means more work for inhabitants clearing snow and attending to their animals' needs.

The second new observation concerned unknown species. Testimony by a resident, considered an expert gardener in her village and beyond, provides a detailed account:

> All the list of nine problems are here—animals and birds are less—there are lots of ducks that don't come now, and there are no *kweregei* (skylark)—they are gone and we don't hear them. As a gardener, I know that the animals and birds are decreasing—some are more and some are less. And [there are] some brand new birds—*drozdi* (thrush) and *grach* (rook)—and they make nests and live here. For the last 5 or 6 years, they are moving into here, from one village to the next, year by year. There were

> two nests outside my house, and this year 100 came, it seems. They eat the insects, and it turns out they also eat the tomatoes and they eat the very ripest tomatoes and suck the juice out. If you keep them in the greenhouse, they can't get them, but in the open ground they get them. Never before did those birds eat our vegetables!

Regional scientists are documenting and reporting that new species are arriving from the south and others are changing their ranges in response to climate change (Maksimov, 2008). Such rich local testimony adds a new level of detail to the existing scientific knowledge base.

The local testimonies also added to our understanding of explanatory stories for observed change. Several inhabitants explained the changes as being a result of celestial realignments, and this view was expressed fairly consistently across the eight knowledge exchanges. Here is one example:

> Before, the sun went along the low, and now it goes very high. The moon also has changed its path. I think because the earth's axis has changed, so they go differently, and also the climate has changed. When we went in the shadow, it was long, and now the shadow is small, so the sun is higher.

Research in other Arctic areas shows that the Sakha, like many of their Arctic counterparts, are keen observers of the sun, moon, and stars, and are making similar associations (Saladin d'Anglure, 1994; ACIA, 2005:655). For example, consider this description of Inuit elders' thoughts on climate change: "Even stranger is the fact that the sun now appears to set many kilometers off its usual point on the horizon, and the stars are no longer where they should be. Is the Earth shifting on its axis, causing the very look of the sun and stars to change?" (Dixon, 2010:1). The prevalence of testimonies and concerns about planetary realignments, changes in the paths of the sun and moon, and the like, highlights how important celestial observation is and the need to integrate these observations and findings into our further work in this project. Similarly, it underscores the need to corroborate these celestial observations with those of other Arctic communities.

In addition to the two new observations of wind and new species and the additional explanatory story, we also documented consistent local understanding among our audiences of "multiple stressors," understood as the combined effects of ongoing global changes (O'Brien et al., 2004). Regional research shows that the combination of diamond mining, deforestation, environmental degradation, population pressure, and nuclear contamination contributes to the complex of multiple stressors in the Viliui regions (Maksimov, 2008). Local inhabitants talked about how change is interacting with existing and new environmental issues. Here is one elder's testimony:

> I write down the daily temperatures. Some years are cold and some are hot. But if I look at all I have recorded and compare, it has gotten hotter. There are many effects from the cold and hot. In addition, there is more damage and breaking of our nature—it has sped up—they cut the forests and the forest cannot come back fast enough. The air is more and more polluted from transportation and industries dirtying the air.

Additionally, the elder quoted above came to the knowledge exchange with a briefcase of diaries in which he had recorded daily weather and climate observations. Many elders keep such records. This wealth of local record keeping already in place is of huge value to the communities' understanding of change over time. We are working with such elders and village schools to establish village-level citizen science initiatives, engaging the younger generations.

When we opened the floor for discussion after our main presentation, one common request across the events was to make the information we shared more broadly available. Considering that Internet access is still problematic for most village households (slow or no connection), we decided to create a handbook in the native Sakha language that would emulate the knowledge exchange process. We began working on the handbook immediately after the 2010 exchanges, brought the first draft to the field in 2011 for participant input, and finalized it over the next year. The handbook was published in late spring 2013, and our team distributed several hundred of the total 3000 copies to inhabitants of the four research villages and the Suntar regional center during fieldwork that same summer. The rest will be distributed to all schools, libraries, administrative offices, and ministries of ecology across the four Viliui regions of the knowledge exchanges.

There were also many knowledge interactions left undocumented: interactions of audience members among themselves during the exchange and the many communications about the events that occurred afterwards, on the street, in households, or elsewhere in the community.

Beyond the active exchange during the event, the process had other effects. In informal follow-up conversations, participants talked about how useful the regional scientific data were, especially the illustrations with data and photographs of landscape changes due to permafrost degradation, the satellite data showing the threefold increase in water on the land in the last 10 years, and the like, exactly because they brought the scientific data into the participants' own reality of local change. They also appreciated that the communicator and source of the regional data was himself Sakha and from a rural Sakha village in the Viliui regions. Research on the science of climate change communication emphasizes how important the "trusted messenger" is when it comes to effective transfer of information (Moser and Dilling, 2004).

The experience also affected the authors. Although Crate has always shared her research findings with the Viliui inhabitants as a matter of course, this was the first time to do it in a formal setting with such active community participation. It was Fedorov's first time to share findings with

local inhabitants (to date he had presented his research only at scientific meetings) and in his native Sakha language (to date he had only presented in his second language, Russian). The knowledge exchange process left him committed to corroborating local and scientific data more precisely for the benefit of both local communities and scientists and to seeking funding to expand his scientific research in the Viliui regions.

When we conducted follow-up interviews in summer 2011, the majority felt that the exchanges were important, that the regional scientific data gave them a more holistic understanding of change in their locale, and that the local testimonies, knowing that others also were observing unprecedented change and were unsettled by it, provided a sense of community support. All agreed that this type of participatory exchange event would be useful in other Viliui Sakha villages.

DISCUSSION

By gathering data from Viliui communities on perceptions and understandings of and responses to local change, documenting climate change data from regional scientists, and bringing these knowledge sources together in participatory knowledge exchanges, we created the "enabling environment" (Stammler and Wilson, 2006:14) for productive exchanges of local and scientific understandings. The process worked to build a certain level of community verification and consensus on local inhabitants' observations of change—a sort of village-level "environmental change support group." Considering inhabitants' fear about the future, expressed in focus groups and interviews, as increasing water on the land and the other environmental changes continue, this process is an important part of capacity building in the Sakha culture, where people tend to hold their emotions and concerns to themselves.

The exchanges were productive on many levels, but we also encountered hurdles to overcome. Local knowledge is based in place and also founded in historical and political context. This case study, set in the geopolitical and socioeconomic context of post-Soviet Russia, illustrates this fact. The Soviet legacy continues to discount and even discourage the use of ancestral knowledge, one of the foundations of local knowledge (Crate, 2006a, b). The Soviet period also instilled in its people a passivity and lack of civic engagement, which here works to undermine participatory events beyond what was recognized as acceptable, such as participating in a highly staged "traditional" festival (Miller, 1990; Slezkine, 1991). Additionally, contemporary research shows that importing Western models of information exchange to Russia usually does not work (Wilson, 2007a, b). In this case, these special considerations became important aspects of designing the knowledge exchange process, to value, encourage, and make ample opportunities for audience participation.

However, that process was not seamless. We had envisaged a group sharing process like what has been done in other Arctic localities, where such knowledge exchange is familiar to the communities (McDonald et al., 1997; Krupnik and Jolly, 2002). The differences in our field site can be understood as largely due to a cultural mismatch (Wilson, 2007a, b). Our intent was to first elicit audience testimonies of change, but the reality was very different. In most of the regional center venues, officials of the local Ministry of Nature Protection came prepared to deliver speeches about the Viliui ecological problems, a suite of watershed-wide environmental issues related to the Soviet-period discovery and extraction of diamonds (Crate, 2002). These speeches were an important point of departure for the exchanges, especially considering the extent to which, for example, the Viliui hydroelectric reservoir, part of that history, continues to frame inhabitants' perceptions of environmental change. We honored all participants' requests to speak albeit limiting each testimony to five minutes to give all a chance.

With these hurdles in mind, our knowledge exchange experience does suggest an adaptable framework for other local contexts. The knowledge exchange process employed here uses a grounded approach, one that can be adapted as needed by 1) collaborating with affected communities to document local knowledge, including observations of change, opinions about causes, ways they are having effects, and perspectives on what the future will bring if changes continue; 2) consulting with regional scientists who are generating the data about how global climate change is affecting local areas; 3) engaging local communities and scientists in the knowledge exchange process; and 4) initiating continued exchange of this knowledge via translatable materials and community-based citizen science projects.

Such knowledge exchange processes increase both local and scientific understandings and can potentially bolster climate change adaptation (van Alst et al., 2008; Tschakert and Dietrich, 2010) and the broader reconfiguration of the roles of science, policy, and lay knowledge (Meinke et al., 2009). Resiliency researchers advocate such collective action as an apropos response to address the multiscale process of adaptation to unprecedented change (Adger, 2001). If "global and national policies strongly influence adaptation options and actions" (Meinke et al., 2009:70) and the policy community stays out of touch with local cultural contexts, their policy tends to encourage the adoption of biophysically resilient livelihoods. In the local context, these policy initiatives are often subjectively experienced as the radical transformation of cultural systems (Crane, 2010). Policy needs to accommodate the risk of irreversible loss of places by recognizing the cultural significance of place and what place means to individual and community identity (Adger et al., 2011).

The need to integrate the knowledge systems for more holistic understanding across stakeholder groups is critical, considering future predictions of change. Locally relevant information gives individuals and households insight into the basis of change to better gauge what the future

may bring. Findings in anthropology, to date most prominently in medical anthropology (e.g., Briggs, 2003; Daley et al., 2006; Lowe, 2010), and in the field of risk communication (Mozumder et al., 2009), support the idea that a more holistic understanding of risk enhances adaptive response. Also, in the process of creating an "enabling environment," inhabitants have been witness to each other's testimonies and concerns about unprecedented change and shared their inward concerns, which works to bring people together and is an essential first step in strengthening social and community cohesion (Duhaime et al., 2004; Kingston and Marino, 2010). This integrated knowledge could aid in developing an advocacy base to inform the science and policymaking communities about how global climate change is affecting the locales and inhabitants under their policy purview and help to influence policy decisions. Bridging the research-to-policy abyss remains difficult, and this challenge is even greater within Russia (Crate, 2006b; Forbes and Stammler, 2009; Stammler-Gossman, 2010).

CONCLUSION

Even if local inhabitants have the integrated knowledge and understand actions, for example, ways to build houses to protect the permafrost, the issue, although clearly on people's minds, to date remains largely peripheral to their daily challenges of getting all the work done to prepare for the winter, getting money to pay for basic needs, keeping up with the fast pace of change as their young people grow more and more alienated to village life, and the like. For inhabitants, it is not a matter of lack of adaptive capacity. Climate change is not the first issue Viliui Sakha have coped or are coping with. Historically they are experts at adapting to the challenges they have faced —to an extreme subarctic climate, to Russian colonization, to sovietization, and to post-Soviet times (Crate, 2006b). But how they will adapt to these new changes, which threaten their ability to continue horse and cattle herding and to inhabit their ancestral lands, is yet to be seen. Our 2009 survey revealed that the vast majority of residents do not want to move away, even if it means they cannot continue keeping cows. Like most place-based peoples, they are tied to their ancestral homelands.

There are many local contexts where place-based peoples and the scientists who serve them, in climate-sensitive areas, both within Russia and without, could benefit from this knowledge exchange process. As stated in the introduction, many research efforts exist that emulate this goal both inside and outside the Arctic. But considering the accelerated pace of global climate change, the question is whether enough can be done fast enough. Perhaps academics can find a more expedient way than peer-reviewed articles and other modes of communicating our research to build upon our findings, bring about more robust understandings, and bolster adaptive capacities for those most affected. The knowledge exchange method documented in this article provides an adaptable model for integrating local and scientific knowledge systems to reach local to global understandings more expediently of how climate change is affecting places and peoples.

ACKNOWLEDGEMENTS

This article is based mainly on research from two grants through the Office of Polar Programs of the National Science Foundation (NSF), one from the Arctic Social Science Program, Grant 0710935, ''Assessing Knowledge, Resilience & Adaptation and Policy Needs in Northern Russian Villages Experiencing Unprecedented Climate Change,'' and the other from the Arctic Science Program, Grant 0902146, "Understanding Climate-Driven Phenological Change: Observations, Adaptations and Cultural Implications in Northeastern Siberia and Labrador/Nunatsiavut (PHENARC)." Any opinions, findings, conclusions, and recommendations expressed in this material are those of the senior author and do not necessarily reflect the views of the NSF. We gratefully acknowledge and thank the NSF for supporting our research.

REFERENCES

Abele, F. 1997. Traditional knowledge in practice. Arctic 50(4): iii–iv.

ACIA (Arctic Climate Impact Assessment). 2005. Arctic climate impact assessment: Scientific report. Cambridge: Cambridge University Press. 1042 p.

Adger, W.N. 2001. Scales of governance and environmental justice for adaptation and mitigation of climate change. Journal of International Development 13(7):921–931.

Adger, W.N., Barnett, J., Chapin, F.S., III, and Ellemor, H. 2011. This must be the place: Underrepresentation of identity and meaning in climate change decision-making. Global Environmental Politics 11(2):1–25.

Agrawal, A. 1995. Dismantling the divide between indigenous and scientific knowledge. Development and Change 26(3):413–439.

Alcorn, J.B. 1993. Indigenous peoples and conservation. Conservation Biology 7(2):424–426.

Antweiler, C. 2004. Local knowledge theory and methods: An urban model from Indonesia. In: Bicker, A., Sillitoe, P., and Pottier, J., eds. Investigating local knowledge: New directions, new approaches. Aldershot, United Kingdom: Ashgate. 1–34.

Berkes, F. 1999. Sacred ecology: Traditional ecological knowledge and resource management. Philadelphia: Taylor & Francis.

Bicker, A., Sillitoe, P., and Pottier, J., eds. 2004. Investigating local knowledge: New directions, new approaches. Aldershot, United Kingdom: Ashgate.

Briggs, C.L. 2003. Why nation-states and journalists can' teach people to be healthy: Power and pragmatic miscalculation in public discourses on health. Medical Anthropology Quarterly 17(3):287–321.

Crane, T.A. 2010. Of models and meanings: Cultural resilience in socio-ecological systems. Ecology and Society 15(4): 19, http://www.ecologyandsociety.org/vol15/iss4/art19/.

Crate, S.A. 2002. Co-option in Siberia: The case of diamonds and the Vilyuy Sakha. Polar Geography 26(4):289–307.

———. 2006a. Elder knowledge and sustainable livelihoods in post-Soviet Russia: Finding dialogue across the generations. Arctic Anthropology 43(1):40–51.

———. 2006b. Cows, kin, and globalization: An ethnography of sustainability. Lanham, Maryland: AltaMira Press.

———. 2008. Gone the bull of winter: Grappling with the cultural implications of and anthropology's role(s) in global climate change. Current Anthropology 49(4):569–595.

———. 2011a. A political ecology of "water in mind": Attributing perceptions in the era of global climate change. Weather, Climate, and Society 3(3):148–164.

———. 2011b. Integrating local and scientific knowledge about the regional effects of global climate change. Course Reader eBooks. Belmont, California: Wadsworth Cengage Learning.

Crate, S., and Nuttall, M., eds. 2009. Anthropology & climate change: From encounters to actions. Walnut Creek, California: Left Coast Press.

Cruikshank, J. 2005. Do glaciers listen?: Local knowledge, colonial encounters, and social imagination. Vancouver: UBC Press.

Cuomo, C., Eisner, W., and Hinkel, K. 2008. Environmental change, indigenous knowledge, and subsistence on Alaska's North Slope. The Scholar and Feminist Online, Issue 7.1. In: Bloom, L., Glasberg, E., and Kay, L., eds. Gender on ice. New York: Barnard Center for Research on Women. 9 p.

Daley, C.M., James, A.S., Barnoskie, R.S., Segraves, M., Schupbach, R., and Choi, W.S. 2006. "Tobacco has a purpose, not just a past": Feasibility of developing a culturally appropriate smoking cessation program for a pan-tribal native population. Medical Anthropology Quarterly 20(4):421–440.

Davidson-Hunt, I.J., and O'Flaherty, R.M. 2007. Researchers, indigenous peoples, and place-based learning communities. Society and Natural Resources 20(4):291–305.

Dixon, G. 2010. New documentary recounts bizarre climate changes seen by Inuit elders. *Globe and Mail*, October 19. http://www.theglobeandmail.com/news/arts/movies/new-documentary-recounts-bizarre-climate-changes-seen-by-inuit-elders/article1763952/.

Duhaime, G., Searles, E., Usher, P.J., Myers, H., and Fréchette, P. 2004. Social cohesion and living conditions in the Canadian Arctic: From theory to measurement. Social Indicators Research 66(3):295–317.

Eicken, H. 2010. Indigenous knowledge and sea ice science: What can we learn from indigenous ice users? In: Krupnik, I., Aporta, C., Gearheard, S., Laidler, G.J., and Kielsen Holm, L., eds. SIKU: Knowing our ice – Documenting Inuit sea ice knowledge and use. New York: Springer-Verlag. 357–376.

Eisner, W.R., Hinkel, K.M., Jones, B.M., and Cuomo, C.J. 2008. Using indigenous knowledge to assess environmental impacts of overland travel routes, Arctic Coastal Plain of Alaska. In: Kane, D.L., and Hinkel, K.M., eds. Proceedings of the 9th International Conference on Permafrost, June 29–3 July 2008, Fairbanks. Fairbanks: Institute of Northern Engineering, University of Alaska Fairbanks. 415–420.

Eisner, W.R., Cuomo, C.J., Hinkel, K.M., Jones, B.M., and Brower, R.H., Sr. 2009. Advancing landscape change research through the incorporation of Iñupiaq knowledge. Arctic 62(4): 429–442.

ELOKA (Exchange for Local Observations and Knowledge of the Arctic). 2012. Baffin Bay Region narwhal research. http://eloka-arctic.org/communities/narwhal/.

Escobar, A. 1999. After nature: Steps to an antiessentialist political ecology. Current Anthropology 40(1):1–30.

Fedorov, A.N., and Konstantinov, P.Y. 2008. Recent changes in ground temperature and the effect on permafrost landscapes in Central Yakutia. In: Kane, D.L., and Hinkel, K.M., eds. Proceedings of the 9th International Conference on Permafrost, June 29–3 July 2008, Fairbanks. Fairbanks: Institute of Northern Engineering, University of Alaska Fairbanks. 433–438.

———. 2009. Response of permafrost landscapes of Central Yakutia to current changes of climate, and anthropogenic impacts. Geography and Natural Resources 30(2):146–150.

Fedorov, A., and Svinoboev, A. 2000. Recent dynamics of cryogenic landscapes of Central Yakutia (in Russian). Science and Education 19(3):15–18.

Forbes, B., and Stammler, F. 2009. Arctic climate change discourse: The contrasting politics of research agendas in the West and Russia. Polar Research 28(1):28–42.

Freeman, M.M.R. 1992. The nature and utility of traditional ecological knowledge. Northern Perspectives 20(1):9–12.

Gearheard, S., Pocernich, M., Stewart, R., Sanguya, J., and Huntington, H.P. 2010a. Linking Inuit knowledge and meteorological station observations to understand changing wind patterns at Clyde River, Nunavut. Climatic Change 100(2):267–294.

Gearheard, S., Aipellee, G., and O'Keefe, K. 2010b. The Igliniit Project: Combining Inuit knowledge and geomatics engineering to develop a new observation tool for hunters. In: Krupnik, I., Aporta, C., Gearheard, S., Laidler, G.J., and Kielsen Holm, L., eds. SIKU: Knowing our ice – Documenting Inuit sea ice knowledge and use. New York: Springer-Verlag. 181–203.

Geertz, C. 1983. Local knowledge. New York: Basic Books.

Green, D., and Raygorodetsky, G. 2010. Indigenous knowledge of a changing climate. Climatic Change 100(2):239–242.

Green, D., Billy, J., and Tapim, A. 2010. Indigenous Australians' knowledge of weather and climate. Climatic Change 100(2):337–354.

Hinkel, K.M., Jones, B.M., Eisner, W.R., Cuomo, C.J., Beck, R.A., and Frohn, R. 2007. Methods to assess natural and anthropogenic thaw lake drainage on the western Arctic coastal plain of northern Alaska. Journal of Geophysical Research 112: F02S16, doi:10.1029/2006JF000584.

Hovelsrud, G.K., and Smit, B., eds. 2010. Community adaptation and vulnerability in Arctic regions. Vienna: Springer.

Huntington, H.P. 2005. "We dance around in a ring and suppose": Academic engagement with traditional knowledge. Arctic Anthropology 42(1):29–32.

Huntington, H.P., Brower, H., and Norton, D. 2001. The Barrow Symposium on Sea Ice, 2000: Evaluation of one means of

exchanging information between subsistence whalers and scientists. Arctic 54(2):201–204.

Huntington, H., Callaghan, T., Fox, S., and Krupnik, I. 2004. Matching traditional and scientific observations to detect environmental change: A discussion on Arctic terrestrial ecosystems. Ambio Special Report 13:18–23.

Huntington, H.P., Gearheard, S., and Kielsen Holm, L. 2010. The power of multiple perspectives: Behind the scenes of the Siku-Inuit-Hila Project. In: Krupnik, I., Aporta, C., Gearheard, S., Laidler, G.J., and Kielsen Holm, L., eds. SIKU: Knowing our ice – Documenting Inuit sea ice knowledge and use. New York: Springer-Verlag. 257–274.

Iijima, Y., Fedorov, A.N., Park, H., Suzuki, K., Yabuki, H., Maximov, T.C., and Ohata, T. 2010. Abrupt increases in soil temperatures following increased precipitation in a permafrost region, central Lena River basin, Russia. Permafrost and Periglacial Processes 21(1):30–41.

IPCC (Intergovernmental Panel on Climate Change). 2007. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC: Summary for policymakers. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf.

IPF (International Polar Foundation). 2007. Dr. Grete Hovelsrud of CICERO on social science in the IPY. http://www.sciencepoles.org/articles/article_detail/grete_hovelsrud_of_cicero_on_social_science_in_the_ipy/.

IPY (International Polar Year). 2008. IPY projects related to people. http://www.ipy.org/index.php?ipy/detail/ipy_projects_related_to_people/.

Jones, B.M., Hinkel, K.M., Arp, C.D., and Eisner, W.R. 2008. Modern erosion rates and loss of coastal features and sites, Beaufort Sea coastline, Alaska. Arctic 61(4):361–372.

Kapsch, M.-L., Eicken, H., and Robards, M. 2010. Sea ice distribution and ice use by indigenous walrus hunters on St. Lawrence Island, Alaska. In: Krupnik, I., Aporta, C., Gearheard, S., Laidler, G.J., and Kielsen Holm, L., eds. SIKU: Knowing our ice – Documenting Inuit sea ice knowledge and use. New York: Springer-Verlag. 115–144.

Kingston, D.M., and Marino, E. 2010. Twice removed: King Islanders' experience of "community" through two relocations. Human Organization 69(2):119–128.

Krupnik, I., and Jolly, D., eds. 2002. The earth is faster now: Indigenous observations of Arctic environmental change. Fairbanks, Alaska: Arctic Research Consortium of the United States.

Lawrence, A. 2009. The first cuckoo in winter: Phenology recording, credibility and meaning in Britain. Global Environmental Change 19(2):173–179.

Lowe, C. 2010. Viral clouds: Becoming H5N1 in Indonesia. Cultural Anthropology 25(4):625–649.

Mahoney, A., Gearheard, S., Oshima, T., and Qillaq, T. 2009. Sea ice thickness measurements from a community-based observing network. Bulletin of the American Meteorological Society 90(3):370–377.

Maksimov, T. 2008. Stop gassing! *Kiim, Yakutsk* June 18.

Marino, E., and Schweitzer, P. 2009. Talking and not talking about climate change in northwestern Alaska. In: Crate, S.A., and Nuttall, M., eds. Anthropology & climate change: From encounters to actions. Walnut Creek, California: Left Coast Press. 209–217.

McDonald, M., Arragutainaq, L., and Novalinga, Z. 1997. Voices from the bay: Traditional ecological knowledge of Inuit and Cree in the James Bay bioregion. Ottawa: Canadian Arctic Resources Committee and Environmental Committee of Municipality of Sanikiluaq.

Meinke, H., Howden, S.M., Struik, P.C., Nelson, R., Rodriguez, D., and Chapman, S.C. 2009. Adaptation science for agriculture and natural resource management— Urgency and theoretical basis. Current Opinion in Environmental Sustainability 1(1):69–76.

Miller, F.J. 1990. Folklore for Stalin: Russian folklore and pseudofolklore of the Stalin era. Armonk, New York: M.E. Sharpe.

Milton, K., ed. 2008. Soapbox forum: Anthropological perspectives on climate change. The Australian Journal of Anthropology 19(1):57–88.

Moser, S.C., and Dilling, L. 2004. Making climate hot: Communicating the urgency and challenge of global climate change. Environment 46(10):32–46.

Mozumder, P., Helton, R., and Berrens, R.P. 2009. Provision of a wildfire risk map: Informing residents in the wildland urban interface. Risk Analysis 29(11):1588–1600.

Nuttall, M. 1992. Arctic homeland: Kinship, community, and development in Northwest Greenland. Toronto: University of Toronto Press.

———. 2004. Epilogue: Cultivating Arctic landscapes. In: Anderson, D.G., and Nuttall, M., eds. Cultivating Arctic landscapes: Knowing and managing animals in the circumpolar North. New York: Berghahn Books. 200–209.

Nweeia, M.T. 2010. Narwhal tusk discoveries. http://www.narwhal.org/Martin.html.

Oakes, J., and Riewe, R., eds. 2006. Climate change: Linking traditional and scientific knowledge. Winnipeg: Aboriginal Issues Press.

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., et al. 2004. Mapping vulnerability to multiple stressors: Climate change and globalization in India. Global Environmental Change 14(4):303–313.

Roncoli, C., Crane, T., and Orlove, B. 2009a. Fielding climate change in cultural anthropology. In: Crate, S.A., and Nuttall, M., eds. Anthropology & climate change: From encounters to actions. Walnut Creek, California: Left Coast Press. 87–115.

Roncoli, C., Kirshen, P., Etkin, D., Sanon, M., Somé, L., Sanfo, B.J., Dembélé, Y., Zoungrana, J., and Hoogenboom, G. 2009b. From management to negotiation: Technical and institutional innovations for integrated water resource management in the Upper Comoé River basin, Burkina Faso. Environmental Management 44(4):695–711.

Rosen, A.M. 2007. Civilizing climate: Social responses to climate change in the ancient Near East. Lanham, Maryland: AltaMira Press.

Roshydromet (Federal Service for Hydrometeorology and Environmental Monitoring). 2008. Assessment report on

climate change and its consequences in Russian Federation. Moscow: Roshydromet.

Saladin d'Anglure, B. 1994. Brother moon (Taqqiq), sister sun (Siqiniq), and the direction of the world (Sila): From Arctic cosmography to Inuit cosmology. In Irimoto, T., and Yamada, T., eds. Circumpolar religion and ecology: An anthropology of the North. Tokyo: University of Toyko Press. 187–212.

Salick, J., and Byg, A., eds. 2007. Indigenous peoples and climate change. Oxford: Tyndall Centre for Climate Change Research. http://www.ecdgroup.com/docs/lib_004630823.pdf.

Salomon, A.K., Tanape, N.M., Sr., and Huntington, H.P. 2007. Serial depletion of marine invertebrates leads to the decline of a strongly interacting grazer. Ecological Applications 17(6):1752–1770.

Sillitoe, P. 1998. The development of indigenous knowledge: A new applied anthropology. Current Anthropology 39(2):223–252.

Skachkov, Y.B. 2005. Trends of recent air temperature changes in Sakha Yakutia Republic (in Russian). In: Studies of cryogenic region landscapes. Problems of Geography of Yakutia 9:27–31.

Slezkine, Y. 1991. The fall of Soviet ethnography, 1928–38. Current Anthropology 32(4):476–484.

Smit, B., and Wandel, J. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16(3):282–292.

Smith, L.T. 1999. Decolonizing methodologies: Research and indigenous peoples. London: Zed Books.

Stammler, F., and Wilson, E. 2006. Dialogue for development: An exploration of relations between oil and gas companies, communities, and the state. Sibirica 5(2):1–42.

Stammler-Gossman, A. 2010. 'Translating' vulnerability at the community level: Case study from the Russian North. In: Hovelsrud, G., and Smit, B., eds. Community adaptation and vulnerability in Arctic regions. New York: Springer. 131–162.

Stevenson, M.G. 1996. Indigenous knowledge in environmental assessment. Arctic 49(3):278–291.

Strauss, S., and Orlove, B.S., eds. 2003. Weather, climate, culture. Oxford: Berg Publishers.

Tschakert, P., and Dietrich, K.A. 2010. Anticipatory learning for climate change adaptation and resilience. Ecology and Society 15(2): 11, http://www.ecologyandsociety.org/vol15/iss2/art11/.

van Alst, M.K., Cannon, T., and Burton, I. 2008. Community level adaptation to climate change: The potential role of participatory community risk assessment. Global Environmental Change 18(1):165–179.

Vayda, A.P., Walters, B.B., and Setyawati, I. 2004. Doing and knowing: Questions about studies of local knowledge. In: Bicker, A., Sillitoe, P., and Pottier, J., eds. Investigating local knowledge: New directions, new approaches. Aldershot, United Kingdom: Ashgate. 35–58.

Vedwan, N. 2006. Culture, climate and the environment: Local knowledge and perception of climate change among apple growers in northwestern India. Journal of Ecological Anthropology 10:4–18.

Weatherhead, E., Gearheard, S., and Barry, R.G. 2010. Changes in weather persistence: Insights from Inuit knowledge. Global Environmental Change 20(3):523–528.

Wilson, E. 2007a. Indigenousness and the mobility of knowledge: Promoting Canadian governance practices in the Russian North. Sibirica 62(2):26–50.

———. 2007b. Time, idealisation and international development: Promoting Canadian co-management in northern Russia. Area 39(3):323–330.