The Politics of Adaptation: Subsistence Livelihoods and Vulnerability to Climate Change in the Koyukon Athabascan Village of Ruby, Alaska

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ABSTRACT
The concepts of vulnerability and adaptation have contributed to understanding human responses to climate change. However, analysis of the implications of the broader political context on adaptation has largely been absent. Through a case study of the subsistence livelihoods of Koyukon Athabascan people of Ruby Village, this paper examines the implications of adaptation to the social changes precipitated by colonization for the articulation of present responses to climate change. Semi-structured interviews, seasonal rounds, and land-use mapping conducted with twenty community experts indicate that subsistence livelihoods are of continued importance to the people of Ruby in spite of the dramatic social change. While adaptive responses demonstrate resilience, adaptation to one form of change can increase vulnerability to other kinds of perturbations. Research findings illustrate that a historical approach to adaptation can clarify the influence of the present political context on indigenous peoples' responses to climatic impacts.

KEYWORDS
Adaptation, Climate change, Equity and justice, Indigenous peoples, Subsistence livelihoods, Vulnerability

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INTRODUCTION

Arctic and subarctic regions of the world are experiencing some of the most extreme impacts of climate change (Nuttall et al. 2005). Although local impacts vary widely (Nuttall et al. 2005), climate change poses substantial risks to indigenous peoples across the Arctic and Subarctic (ACIA 2005). Many of these risks are associated with subsistence livelihoods, which continue to have sociocultural and ecological significance for indigenous peoples (Kassam 2009; Wheeler and Thornton 2005). While little research on the human dimensions of climate change existed a decade ago, a large number of studies now document its impacts on indigenous peoples of the Arctic and Subarctic (ACIA 2004; Herman-Mercer et al. 2011; Kassam 2009; Krupnik and Jolly 2002; Nichols et al. 2004; Reidlinger and Berkes 2001). These studies primarily examine climatic impacts from the perspective of vulnerability and adaptation to climate change.

Vulnerability and Adaptation to Climate Change

While mitigation continues to be important in addressing the root causes of climate change, the slow pace of political negotiations to reduce greenhouse gas emissions and evidence suggesting that we are committed to a certain amount of warming has motivated a shift in focus toward adaptation (Ford and Smit 2004). Adaptation to climate change is broadly defined as an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007:869). Adaptation can be planned or spontaneous and, depending on its timing, can be either anticipatory or reactive (IPCC 2007; Smit and Wandel 2006). It occurs at multiple and interacting scales simultaneously (Adger et al. 2005) and in response to diverse stimuli (Smit et al. 2000).

Recent scholarship on climate change draws on the theory of vulnerability to explain why some populations are more able to adapt than others (Adger and Kelly 1999; Agrawal and Perrin 2009; Ribot 1995). *Vulnerability* is defined as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of *climate change*, including *climate variability* and extremes. Vulnerability is a function of the character, magnitude, and rate of change and variation to which a system is exposed, its *sensitivity*, and its adaptive capacity" (IPCC 2007:883). Other social and biophysical nonclimatic drivers of change also contribute to vulnerability (Adger 2006).

The study of vulnerability is rooted in three theoretical approaches (Eakin and Luers 2006). First, the risk-hazard approach to vulnerability comes from natural hazard literature (Burton et al. 1993; White 1973). The risk-hazard approach measures vulnerability as the difference between biophysical risk factors and potential loss (Eakin and Luers 2006). Second, a political-economy or political-ecology approach examines vulnerability resulting from social inequalities and conflict in societies, with more emphasis on power relations than traditional risk-hazard approaches (Eakin and Luers 2006). Such an approach emphasizes difference in vulnerability based on "exposure units," defined variously as class, ethnicity, etc., that are the basis for differential entitlements (Turner et al. 2003). Third, an ecological resilience approach defines vulnerability in the context of stresses acting on coupled social and ecological systems where humans are constantly interacting with the biophysical environment (Eakin and Luers 2006). C. S. Holling (1973) defines *resilience* as the ability of a system to absorb change and disturbance without modifying its structure or relations. Resilience is an important factor in determining the potential for societies to adapt to environmental

changes because "the adaptive capacity of all levels of society is constrained by the resilience of their institutions and the natural systems on which they depend. The greater their resilience, the greater is their ability to absorb shocks and perturbations and to adapt to change" (Berkes et al 2003:14). Resilience is understood as the converse of vulnerability and must be taken into account in order to avoid conceptualizing local communities as the passive victims of change (Kassam et al. 2011). Because the characteristics of particular systems differ, understanding resilience within those specific contexts is an important element of analysis of sociocultural and ecological systems (Turner et al. 2003). Since vulnerability is not only a function of environmental or biophysical variability but also of sociopolitical and institutional factors (Adger et al. 2006; Agrawal and Perrin 2009), the socio-ecological approach should be applied to climate change analysis (Adger et al. 2006; Turner et al. 2003). Consequently, the ecological resilience approach addresses the weaknesses of the first two approaches to vulnerability by acknowledging both social and biophysical factors within a complex system. Most studies of vulnerability represent a combination of the three approaches defined above (Eakin and Luers 2006).

The impacts of climate change on arctic and subarctic indigenous communities have primarily been studied from a vulnerability perspective (Chapin III et al. 2004; Ford 2007; Ford and Pearce 2010; Ford et al. 2006; Kassam et al. 2011; McNeeley 2011). However, the vulnerability approach can be strengthened with more explicit attention to the ethical dimensions of climate change adaptation (Adger et al. 2006). First, justice is central to adaptation due to the reality that indigenous peoples are among the world's populations who have contributed the least to the causes of climate change, yet they are

most affected by its impacts due to the close connection between their livelihoods and their local ecology (Crate and Nuttall 2009; Mearns and Norton 2010). Second, although the influence of politics on the adaptive cycles in socio-ecological systems has to some extent been examined in the resilience literature (Carpenter et al. 2001), the study of vulnerability and adaptation has been critiqued for its failure to sufficiently acknowledge the influence of the broader political context on a human community's capacity to respond to change (Cameron 2011). Colonialism has had dramatic impacts on indigenous peoples. Given indigenous peoples' documented ability to adapt to ecological change, it has been suggested that some of the largest barriers to climate change adaptation will be political rather than ecological (Wenzel 2009). Therefore, understanding the political context within which indigenous peoples are responding to the impacts of climate change adds further complexity to the analysis of justice in adaptation.

While there are many definitions of adaptation (Smit et al. 2000), any discussion of adaptation requires clarification of both the units of analysis (who or what is adapting?) and the specific stimuli that they are responding to (adaptation to what?) (Smit et al. 2000). For the purpose of this analysis, the author defines *adaptation* as "a community-led process, based on communities' priorities, needs, knowledge, and capacities, which should empower people to plan for and cope with the impacts of climate change" (Reid et al. 2009:13). Community-led approaches to adaptation suppose that there are many ways to respond to the impacts of climate change and that local communities are the most qualified to determine their path to adaptation (Smit and James Wandel 2006). While it must be acknowledged that there is considerable diversity within communities (Kassam 2009), this research does not analyze the influence of this diversity

on adaptation. The study introduced in this paper focuses on the political context for adaptation in Ruby Village, Alaska, by examining the influence of historical social changes on subsistence livelihoods and the bearing these changes have on the communities' present responses to climate change.

Context for Case Study of Ruby Village

Ruby Village is situated in the middle river region of the Yukon River, in the interior of Alaska (64° 44' 22.00" N, -155° 29' 13.00" W) (Figure 1). This region is characterized by plentiful bogs, streams, lakes and sloughs, open spruce forests, and shrubs and provides habitat for a rich variety of fish and wildlife including salmon, moose, diverse species of migratory waterfowl, bears, wolves, beavers, and other small game (Nelson 1986).

[Figure 1 Map depicts the location of Ruby Village, Alaska in the Yukon River Basin**]**

While the land and water surrounding Ruby Village has been part of the traditional territory of the Koyukon Athabascans for millennia, the settlement itself was founded as a supply point for gold prospectors during the mining booms of 1906 and 1910 (Larson 2006). After WWII, most miners had moved away and Ruby became primarily a native village. The current population of Ruby is 166 persons, living in 62 households. Approximately 87 percent of the residents of Ruby are Alaska Native (U.S. Census Bureau 2010).

The people of Ruby rely on their local ecology to maintain subsistence livelihoods. Populations living in rural areas of Alaska depend on wild foods to a greater extent than those in urban areas: wild foods provide approximately 57 percent of the total calories and 396 percent of required protein in rural Alaska, whereas wild foods provide 2 percent of the calories and 15 percent of the protein needs in urban areas such as

Fairbanks and Anchorage (McNeeley 2011; Wolfe 2000). The location of Ruby Village off the Alaska road system means that it is difficult and expensive to access other sources of food, which have to be flown in or shipped to the village via the Yukon River barge system. For the people of Ruby, subsistence is viewed as a means not only to meet their basic nutritional needs but also to maintain their traditional "way of life" (Wheeler and Thornton 2005).

The climate of the interior of Alaska is characterized by natural variability, including extremes in annual temperatures and changes associated with the Pacific Decadal Oscillation (PDO), which causes decadal shifts in climate averages (Salinger 2005). Furthermore, populations of subsistence species fluctuate dramatically (Nelson 1986). Local subsistence livelihoods are adapted to the natural variability of the climate and ecology of the interior of Alaska (Nelson 1986; VanStone 1974). Specifically, subsistence livelihoods are characterized by a high level of flexibility that allows for shifts in the timing, intensity, and location of harvesting depending on climatic and ecological factors that vary annually (Nelson 1986; VanStone 1974).

Climate change is projected to result in climatic extremes that have not previously been experienced (ACIA 2004; IPCC 2007). These changes are already being observed. For example, mean temperature increases indicate that arctic and subarctic regions are disproportionately experiencing the effects of climate change (ACIA 2005; Hansen et al. 2006). Climate data from the interior of Alaska indicate some of the most marked warming statewide over the last six decades (Salinger 2005). Despite populations' adaptation to climatic variability, unprecedented climate change has the potential to challenge the limits for adapting subsistence practices. This paper is primarily concerned

with the implications of past social changes for the people of Ruby's vulnerability to the present impacts of climate change on subsistence livelihoods.

METHODS

This study takes a participatory approach. Participatory Action Research (PAR) is an iterative approach to research used to generate knowledge through cycles of action and reflection (Greenwood and Levin 2008). Furthermore, PAR is a fundamentally ethical research philosophy that informs research methods and design in order that science can serve as the basis for social change (Greenwood and Levin 2008). The study can be characterized as participatory in the sense that it was designed and conducted in partnership with the Yukon River Inter-Tribal Watershed Council (YRITWC), whose goal is to meet the needs of the 70 indigenous governments they serve in the Yukon River Basin. Furthermore, the YRITWC facilitated a research partnership with the Ruby Tribal Council (RTC). The project was modified to fit the context of Ruby Village. All research outputs were shared with and validated the RTC and the YRITWC.

Research was carried out during two field seasons, in 2010 and 2011. Semistructured interviews were conducted with 20 community experts, including Elders, subsistence harvesters, and tribal administrators. Interviewees included eight women and twelve men whose ages ranged from 49 to 92. Community experts were recruited using a snowball method (Patton 2002). Contacts at the RTC were asked to make a list of community experts who could contribute to the research, and individuals were added to the initial list when referred by individuals who had already participated in the study. The community experts were selected because they were considered knowledgeable about subsistence practices and had lived in Ruby for an extended period of time.

A minimum of three meetings was held with each community expert. During an initial interview, participants were asked to describe their subsistence livelihoods and observations of social and ecological change. Specific follow-up questions were asked to clarify responses. Interviews were documented using written field notes rather than audio recordings. The author wrote an interview narrative or an essay based on interview field notes.

Seasonal rounds or annual calendars depicting the timing of fourteen subsistence livelihood activities were created based on interview data. Of the twenty community experts interviewed, fifteen participants opted to make seasonal rounds representing present subsistence practices. Three married couples created a seasonal round to show their combined harvesting. A total of twelve seasonal rounds resulted from this research. These calendars include both the twelve-month Gregorian calendar and selected months from the Koyukon traditional lunar calendar (Jetté and Jones 2000).

Land use mapping was also conducted during interviews. Community experts

were asked to place icons representing key species, livelihood activities, and drinking water sources on a 1:250,000 scale topographic map encompassing the traditional territory of the people of Ruby Village.[1] This map was then digitized using ArcGIS.

Typed versions of interview narratives, seasonal rounds, and the land use map were validated during a second interview. Interview narratives were read out loud to the community expert. At the time of validation, changes were made to either correct information or add other important information left out at the time of the initial interview. A printed version of the digitized land use map was also presented during follow-up interviews, at which point additional icons and place names were added and feedback regarding the layout was gathered. During a third visit, each individual received final printed versions of interview narratives and seasonal rounds for their records.

Interview narratives were coded for observations of change using Text Analysis Markup System (TAMS) Analyzer, a qualitative data analysis tool. The interpretation of this research was then shared with the community for validation during a public presentation in Ruby Village in July 2011. Community experts consented to having their names used in this research. Their names are used as a form of citation and to recognize the essential contribution their knowledge has made to this research.

RESULTS AND DISCUSSION

Adaptation is a pertinent topic for the people of Ruby, who are already experiencing the impacts of climate change. Research findings indicate that the study of adaptation should include not only seeking to understand the immediate impacts of climate change on subsistence livelihoods but also considering the ways that the political and historical context in which harvesting takes place influences a community's ability to respond to

these changes. The people of Ruby and their subsistence livelihoods have undergone dramatic social change since the 1950s that may have a continued effect on their capacity to adapt to the impacts of climate change.[2] In the analysis that follows, I briefly review the observed impacts of climate change on the subsistence livelihoods of the people of Ruby. I then explore how the people of Ruby responded to past social changes and examine the implications of these adaptations for their current responses to climate change.

Observed Impacts of Climatic Change on Subsistence Livelihoods

Community experts are observing a wide variety of climatic changes in the traditional territory of the Koyukon Athabascans of Ruby Village. These include changes in temperature, precipitation, permafrost thaw, erosion of river banks, river ice regimes, and fish and wildlife. These changes are in many cases consistent with those observed elsewhere in the Arctic and Subarctic (ACIA 2004). The impacts of observed changes can be divided into four categories: access, predictability, safety, and species availability (Berkes and Jolly 2001) (Table 1). While it is not the purpose of this paper to review these observations in detail, documenting the impacts of climate change is essential to the analysis of vulnerability and adaptation to change in Ruby Village. For this purpose, the specific impacts of the observed changes on moose populations are discussed in depth later in this paper. The following section describes subsistence livelihoods in Ruby prior to the 1950s and the people of Ruby's responses to the dramatic social changes that have occurred in recent decades in order to gain insight into their present vulnerability to climate change.

[Table 1]

Social Change and Subsistence Livelihoods

Subsistence livelihoods have changed for the people of Ruby in a number of ways since the 1950s. The current seasonal round for Ruby Village depicts the harvesting timing of the people of Ruby (Figure 2). Seasonal rounds depict the timing of 14 subsistence livelihood practices prior in the present (for a detailed description of these practices, see Appendix A). Land use mapping illustrates the current spatial distribution of subsistence practices (Figure 3).[3] Data documenting present subsistence practices are compared to narratives of interviews with several Elders including Lorraine Honea, Clara Honea, Billy McCarty, and Martha Wright, who were active subsistence harvesters prior to the 1950s.

Interview narratives indicate that before the 1950s, the people of Ruby followed a seasonal pattern of migration, moving three to four times a year. Elders from Ruby Village, including Martha Wright and Lorraine Honea, referred to this annual seasonal movement as the "cycle of life." They would spend the winter months in winter camp, hunting and trapping up the "Novi" River (Nowitna River) and the summer months on the Yukon River, in the Village of Kokrines or at fish camp. Although the social changes the people of Ruby have experienced since the 1950s are too numerous to name, three major ones have influenced subsistence livelihoods during this time: sedentization, intensified contact with the market economy, and the creation and enforcement of fish and wildlife regulations pertaining to subsistence harvesting.

[Figure 2 Combined seasonal round depicts the timing of present subsistence practices of all community experts. Grey areas, circled in red, indicate moose hunting seasons that are no longer permitted.**]**

[Figure 3 Land use map for the people Ruby Village illustrates the spatial distribution of present subsistence practices throughout the majority of the people of Ruby's traditional territory.**]**

In the 1950s, the people of Ruby stopped spending the winters up the "Novi" and began to settle permanently. Sedentization, or settlement in a central village location rather than seasonal movement on the land, occurred as the result of a number of influences including increased pressures to enroll children in schools. Once people were required to put their children in school they could no longer spend the whole winter in hunting and trapping camps as they used to. The effects of mandatory education on traditional seasonal migration have also been noted among other Alaska Native peoples (Dombrowski 2001; Kawagley 1999). Due to this pressure, people began to settle more permanently in the village of Kokrines, and the majority of these residents moved to Ruby when the Kokrines School was closed. Although sedentization did not take place as the consequence of the same overt government policies promoting settlement and relocation that have been seen in the Canadian Arctic and Subarctic (Tester and Kulchyski 1994), mandatory education laws can be understood as an indirect, but nevertheless coercive, means of encouraging people to settle.

Increased contact with the market economy was another major change that occurred for the population of Ruby after the 1950s. Assimilationist theories of cultural change led to predictions that indigenous cultures would be "'lost' through assimilation to expanding Euro-American cultures" (Erickson and Murphy 1998:74). Instead, cash and technologies such as snowmobiles have been actively integrated into subsistence practices, which continue to constitute an important way of life. The hybridization of

traditional and market economies, in which cash resources become an important input into subsistence activities, has been referred to elsewhere as the creation of a "mixed economy" (Wenzel et al. 2000).

The introduction of new technologies was facilitated by contact with the market economy and has had lasting impacts on subsistence. Snowmobiles were introduced in Ruby Village during the late 1950s or early 1960s. The integration of new technologies, such as snowmobiles, is seen as an adaptive response to sedentization by indigenous peoples (Wenzel 1991). While subsistence harvesters began to live in a central village location, snowmobiles allowed them to maintain a modified seasonal round in spite of the social disruptions that accompanied the increased distance from traditional hunting and trapping sites (Wenzel 1991). Although some Elders, such as Lorraine Honea and her late husband John Honea, used dogs as their main method of transportation throughout their lives, travel over land in the winter is now done almost exclusively by snowmobile.

The use of snowmobiles also had some negative consequences. These and other new technologies contributed to a dependency on cash and fossil fuels in order to maintain subsistence livelihoods. Emmitt and Edna Peters (2011) discussed their reliance on fossil fuels:

> Gas for hunting is also expensive. Some people say that it is almost too expensive to hunt. You have to have gas to hunt. The price of gas in Ruby is currently about $4.80 a gallon. In Galena, it is almost a dollar more than Ruby. So, subsistence becomes difficult, unless you are going up the river in a canoe.

Reliance on fossil fuels makes subsistence harvesters vulnerable to fluctuations in the market economy. The impending global fuel crisis highlights problems associated with dependency on fossil fuels that are likely to intensify.

Harvesting regulations have also had a major impact on subsistence livelihoods. Koyukon Althabascans have a well-developed system of knowledge, practice, and beliefs regarding conservation of moose and other fish and wildlife (Nelson 1986). Although the people of Ruby place importance on the continued use of Koyukon conservation practices, interview narratives reveal that the introduction of hunting and fishing regulations has substantially reduced local control over subsistence livelihoods, consequently diminishing the flexibility to choose the timing, location, and intensity of harvesting. Junior Gurtler (2011) stated, "before if you wanted a moose you would just hunt it." Karen and Junior Gurtler (2011) commented on the impacts that the enforcement of regulations have had on subsistence livelihoods:

> [The Alaska Department of] Fish and Game is giving out a lot of tickets. It didn't used to be like that. You used to be able to get what you needed and Fish and Game would only come every five years or so. Now they are coming all the time. Now you have to have a license.

Regulations have seriously impacted subsistence by limiting harvesting practices to the open season and to a designated bag limit or a permitted maximum, for example, for moose harvested. The failure to follow these regulations results in serious penalties.

Since the 1950s, subsistence regulations have changed significantly. Alaska Statehood, in 1959, led to major alterations in subsistence regulations. The Statehood Act (1958) did not acknowledge the rights of Alaska Natives to land or property held in trust for them and gave the state the right to select more than 103 million acres of lands they considered "vacant, unappropriated, and unreserved" (U.S. Public Law 85-508 1958). Although aboriginal title to these lands was never extinguished, the state treated the traditional territories of Alaska Natives as part of the public domain. Consequently, the

state's attempt to regulate subsistence began in 1958. Alaska Natives actively resisted these regulations by pushing for the recognition of native subsistence rights (Berger and the Alaska Native Review Commission 1985).

In 1971, a growing global interest in developing natural resource extraction, such as the oil discovered at Prudhoe Bay in 1968, motivated the passing of the Alaska Native Claims Settlement Act (ANCSA) to extinguish native rights to the land and its resources. ANCSA resulted in the creation of 13 regional corporations and the allocation of 44 million acres (ten percent of the total land) and $962.5 million in compensation for relinquished lands (about $3 per acre). At the same time, 197 million acres of land were reserved for the federal government (60 percent of the total land), and the State of Alaska was granted the remaining 124 million acres (30 percent of the state) (Berger and the Alaska Native Review Commission 1985).

ANSCA also included a vague promise that native subsistence rights would be protected. This protection was not realized until 1980 with the passage of the Alaska National Interest Lands Conservation Act (ANILCA). ANILCA applies exclusively to federal lands. Title VIII of ANILCA creates a rural subsistence priority. Subsistence rights to wild resources are promoted over all other uses, including recreational and commercial uses, in times of shortage. Only conservation takes priority over rural subsistence (U.S. Public Law 96-487 1980). The subsistence rights guaranteed by ANILCA are not exclusive to Alaska Natives, because they are granted on the basis of rural residency. However, ANILCA acknowledges the importance of subsistence rights for native cultural existence, allowing for hunting for "customary and traditional uses," such as hunting a moose for a community potlatch (Berger and the Alaska Native Review

Commission 1985; U.S. Congress 1980). In contrast, the State of Alaska guarantees subsistence priority for all Alaska residents (Alaska 1956). Many native peoples take issue with subsistence rights in Alaska, as defined by the state and federal governments, because competition for scarce resources poses a threat — not only to their food security but also to their way of life (Thornton 2001; Wheeler and Thornton 2005). Consequently, subsistence rights continue to be one of the most hotly debated issues in Alaska (Wheeler and Thornton 2005).

Subsistence is regulated by both state and federal agencies. Changes in subsistence regulations are determined by both the Federal Subsistence Board and State Board of Game (BOG) and implemented by the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game (ADF&G) respectively (Carey 2009). The Alaska Department of Fish and Game manages the hunt on all state and private lands including native allotments and lands held by native corporations. U.S. Fish and Wildlife regulates hunting on all federal lands including Nowitna National Wildlife Refuge (the "Novi"), part of the traditional territory of the people of Ruby. The people of Ruby hunt in the middle Yukon region, which consists of a patchwork of native corporation–selected land, native allotments, and state and federal lands (Unit 21).

Subsistence Livelihoods, Vulnerability, and Adaptation to Climate Change

Research findings indicate that social vulnerabilities created by having to adapt subsistence livelihoods to past social change have bearing on the current ability to respond to climate impacts (Table 2). The potential for social vulnerabilities to constrain adaptation to ecological change is illustrated by several examples. First, adaptation to the impacts of climate change will be influenced by a dependency on cash resources and

fossil fuels. The development of a mixed economy and the use of new technologies represent adaptive responses to the social changes. While these adaptations allowed the people of Ruby to maintain subsistence livelihoods in spite of dramatic social change, the resulting dependency on cash resources and fossil fuels makes them susceptible to fluctuations in the market economy. The above case study indicates that dependency on cash and fossil fuels has important implications for subsistence livelihoods. Climate change adds complexity to this scenario. Because their ability to respond to ecological changes is limited by the availability of resources, these dependencies will influence the people of Ruby's ability to respond to climatic changes requiring that they hunt for longer or travel further away to meet their subsistence needs. For example, reduced fall water levels in sloughs can be a barrier to accessing important hunting grounds. The inability to access certain sloughs by boat can mean that hunters must travel further to hunt for moose, therefore using more gas.

[Table 2]

Second, adaptation to climate change is constrained by the people of Ruby's loss of flexibility and control over subsistence harvesting due to the creation and enforcement of fish and wildlife regulations. The imposition of regulations removed local control over decision making about subsistence harvesting including choice regarding the timing,[4] intensity, and locations of the harvest. Climate change is impacting subsistence species and their habitat. For example, the people of Ruby are already observing and responding to the impacts of climate change on moose hunting.[5] Increasing temperatures are believed to be a factor in an observed a shift in the timing of the moose rut to later in the fall. George Albert noted that

> except for this year [2010], it has been too warm. It has been hard for the moose because they don't start moving around until really late. One odd thing I noticed about moose is that last year, they got a bull moose on the 16th of September and he was with two cows but wasn't in rut either. He didn't smell or anything. Somebody else got a moose that late also and it was not in rut.

Several other community experts made similar observations regarding a delay in the rutting season, which they believed to be triggered by increasing temperatures. Fall breeding dates are determined by photoperiod (length of daylight) (Schwartz 1998) and temperature, when cool temperatures cause bulls start to move around in search of cows (Bubenik 1997). The exact temperature that triggers bull movements is not known; however, other Koyukon hunters in the interior of Alaska have similarly observed that increasing temperature is contributing to a delayed bull movement (McNeeley and Shulski 2011).

The ability of the people of Ruby and other Alaska Native hunters to shift the timing of their harvest in response to the delayed rut is limited by state and federal subsistence hunting regulations.[6] Regulations are implemented in response to perceived declines in moose populations. Threats to moose populations identified by conservation biologists (Stout 2008) and the people of Ruby include predation by wolves, weather, and overhunting, largely by nonlocal hunters. The objective of these regulations is twofold: to maintain and enhance moose populations and their habitat, and to provide sustained opportunities for moose hunting for subsistence and sport hunters (Stout 2008). As described above, federal regulations give subsistence priority to rural residents while state regulations grant these rights to all Alaska residents.

The observed shift in timing of the moose rut has prompted negotiations over the timing of the regulated fall subsistence hunt. The people of Ruby and other Alaska Native

villages in the Koyukon region of Alaska have negotiated with both state and federal agencies in an attempt to lengthen the regulated time frame for subsistence hunting or shift it to later in the fall season (McNeeley 2011). In 2008 and 2009, Ruby experienced especially poor moose seasons. According to Tribal Fish and Wildlife staff, the Ruby Tribal Council bargained with state and federal agencies to change the hunting season in response to the need to harvest more moose. The impacts of temperature on the timing of rut were considered during the process. While U.S. Fish and Wildlife was responsive to the possibility that climate change may be a factor affecting moose harvest for the people of Ruby, the ADF&G took the position that climate does not affect the timing of the rut and hunting should not take place during the peak breeding dates, which, they assert, occur between September 25 and October 5 (Van Ballenberghe and Miquelle 1993). Notably, this position is based on studies of the median copulation dates of moose conducted between 1982 and 1987, making the data nearly three decades old (Van Ballenberghe and Miquelle 1993). Consequently, U.S. Fish and Wildlife extended the season on the Nowitna Wildlife Reserve by one week, September 25 to October 1. The ADF&G extended the hunt by an additional five days at the end of August.

The case of moose hunting shows that the people of Ruby have some influence over the decisions regarding subsistence harvesting through direct negotiation with these agencies; it also demonstrates the potential for fish and wildlife regulations to increase vulnerability by constraining the ability of those directly affected to respond to the impacts of climatic change on subsistence species and their habitat. Shannon McNeeley states, "Alaskan communities are impacted by a regulatory decision-making process that, to date, can't effectively respond to slow-onset climate change that impacts moose

behavior and moose harvest success thereby threatening food security and community well-being" (McNeeley 2011:2). While the objective of fish and wildlife regulations to conserve fish and wildlife populations is not in dispute, the role of indigenous communities, such as Ruby Village, in the decision-making process is problematic. This case study indicates that current institutional arrangements have the capacity to increase vulnerability to ecological change by reducing local control over harvesting decisions.

Implications for Climate Change Adaptation

Climate change adaptation is a pertinent issue for the people of Ruby and their subsistence livelihoods. The people of Ruby have experienced incredible social changes during the course of the last six decades including sedentization, increased contact with the market economy, and the creation and enforcement of subsistence harvesting regulations. These changes have largely been a consequence of European contact and colonization. Analysis of adaptation to historical change experienced since the 1950s can provide insight into the ways that social and political contexts shape vulnerability to climate impacts. For example, dependency on cash and fossil fuels and imposition of fish and wildlife regulations, resulting from past social changes, can increase vulnerability by constraining people's ability to respond to ecological change.

It was been noted that diversity is essential for adaptation within socio-ecological systems (Kassam 2010; 2009; 2008; Pretty et al. 2008; Valdivia et al. 2010). While this paper focused on the role of broader political factors on a community's ability to adapt to climate change, it must be acknowledged that Ruby Village and other communities are heterogeneous and characterized by variation in knowledge and practices related to subsistence harvesting, political perspectives, and other factors that result in the use of

diverse adaptation strategies. Understanding the role of diversity *within* communities in adaptation to change is a promising area of future inquiry that merits further investigation.

As issues of justice in climate change adaptation are increasingly brought to the forefront, acknowledging the influence of the political context for adaptation becomes a necessity. Human communities differ in their ability to respond to the impacts of climate change (Adger 2006), and adaptation to the biophysical impacts of climate change has the capacity to aggravate and reproduce existing vulnerabilities (Adger et al. 2006; Mearns and Norton 2010). Climate justice for indigenous peoples has at least three dimensions. First, indigenous peoples have contributed the least to the causes of climate change (Crate and Nuttall 2009). Second, they are among the first to be impacted due to their close connections to their local ecology through subsistence livelihoods (Kassam 2009). Third, as this study illustrates, the legacy of colonialism presents political barriers that can make indigenous communities more vulnerability to the impacts of climate change.

The impact of fish and wildlife regulations on the people of Ruby's ability to respond to ecological change has been raised in this case study as an example of a political barrier to adaptation. Although the regulation of subsistence livelihoods for Alaska Natives and the impacts of native self-determination has been hotly contested since Alaska Statehood, through ANCSA and ANILCA (Berger and the Alaska Native Review Commission 1985), climatic impacts on subsistence add further relevance to existing criticisms. Further research should be done to examine alternative institutional arrangements that might address the current lack of flexibility and local control in harvesting regulations and also ensure the conservation of subsistence species for present

and future generations. Koyukon Athabascan conservation practices (Nelson 1986) would be an effective starting place for developing alternative institutional arrangements. Given the long-term struggle on the part of Alaska Natives to gain control over subsistence harvesting, convincing both state and federal agencies to alter the current power-sharing arrangements is likely to be a significant hurdle to increasing local control over subsistence livelihoods, through the implementation of comanagement agreements or otherwise. This reality adds to the urgency for future research on this topic.

CONCLUSION

Climate change adaptation is an important issue for indigenous peoples and their subsistence livelihoods, which are closely connected to the local ecology. The people of Ruby have faced tremendous changes in the last half century. Interview narratives illustrate many of these changes in subsistence livelihoods. The people of Ruby's responses to historical changes, including sedentization, increased contact with the market economy, and the creation and enforcement of subsistence harvesting regulations, demonstrate their resilience and determination to maintain subsistence livelihoods. Research findings also indicate adaptations to these past social changes have bearing on the people of Ruby's present vulnerability to climate impacts. Furthermore, this analysis raises many ethical considerations regarding the constraints presented by the current political context, shaped by a colonial history, to indigenous peoples' ability to respond to the impacts of climate change in the manner of their choosing. As such, adaptation to climate change is not solely about responding to the directly observable impacts of climate change on subsistence livelihoods, it is also about understanding and addressing

the manner in which the broader political context can make communities more or less vulnerable to the impacts of climate change.

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REFERENCES

ACIA (Arctic Climate Impact Assessment)

2004 Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge, UK: Cambridge University Press.

2005 Arctic Climate Impact Assessment. Cambridge, UK: Cambridge University Press.

Adger, W. Neil

2006 Vulnerability. Global Environmental Change 16(3): 268–281.

Adger, W. Neil, Nigel W. Arnell, and Emma L. Tompkins

2005 Successful Adaptation to Climate Change Across Scales. Global Environmental Change Part A 15(2): 77–86.

Adger, W. Neil, and P. Mick Kelly

1999 Social Vulnerability to Climate Change and the Architecture of Entitlements. Mitigation and Adaptation Strategies for Global Change 4(3): 253–266.

Adger, W. Neil, Jouni Paavola, Saleemul Huq, and M. J. Mace, eds.

2006 Fairness in Adaptation to Climate Change. Cambridge Mass.: MIT Press.

Agrawal, Arun, and Nicolas Perrin

2009 Climate Adaptation, Local Institutions and Rural Livelihoods. # W08I-6. IFRI Working Paper. University of Michigan: International Forestry and Resources Institution.

Alaska

1956 The Constitution of the State of Alaska. Fairbanks: Alaska Constitutional Convention.

Alaska Fish and Wildlife Service

2010 Unit 21 / Hunting - Middle Yukon. Federal Subsistence Wildlife Regulations. http://alaska.fws.gov/asm/pdf/wildregs/unit21.pdf, accessed January 23, 2012.

Van Ballenberghe, Victor, and Dale G. Miquelle

1993 Mating in Moose: Timing, Behavior, and Male Access Patterns. Canadian Journal of Zoology 71(8): 1687–1690.

Berger, Thomas, and the Alaska Native Review Commission

1985 Village Journey: The Report of the Alaska Native Review Commission. 1st ed. New York: Hill and Wang.

Berkes, Fikret, Johan Colding, and Carl Folke

2003 Navigating Social-ecological Systems: Building Resilience for Complexity and Change. New York: Cambridge University Press.

Berkes, Fikret, and Dyanna Jolly
2001 Adapting to Climate Change: Social-ecological Resilience in a Canadian Western Arctic Community. Conservation Ecology 5(2): 18.

Brown, Caroline L., Robert j. Walker, and Susan B. Vanek
2004 The 2002-2003 Harvest of Moose, Caribou, and Bear in Middle Yukon and Koyukuk River Communities. Division of Subsistence, Alaska Dept. of Fish and Game. http://www.subsistence.adfg.state.ak.us/TechPap/tp280.pdf.

Bubenik, Anthony B.
1997 Behavior. *In* Ecology and Management of the North American Moose. Washington [D.C.]: Smithsonian Institution Press.

Burton, Ian, Robert W. Kates, and Gilbert F. White
1993 The Environment as Hazard. Guilford Publications.

Cameron, Emilie S.
2011 Securing Indigenous Politics: A Critique of the Vulnerability and Adaptation Approach to the Human Dimensions of Climate Change in the Canadian Arctic. Global Environ. Change.

Carey, Erin
2009 Building Resilience to Climate Change in Rural Alaska: Understanding Impacts, Adaptation and the Role of TEK. University of Michigan.

Carpenter, Steve, Brian Walker, J. Marty Anderies, and Nick Abel
2001 From Metaphor to Measurement: Resilience of What to What? Ecosystems 4(8): 765–781.

Chapin III, F. Stuart, Gary Peterson, Fikret Berkes, et al.
2004 Resilience and Vulnerability of Northern Regions to Social and Environmental Change. AMBIO: A Journal of the Human Environment 33(6): 344–349.

Crate, Susan A., and Mark Nuttall
2009 Anthropology and Climate Change: From Encounters to Actions. Walnut Creek, CA: Left Coast Press.

Dombrowski, Kirk
2001 Against Culture: Development, Politics, and Religion in Indian Alaska. University of Nebraska Press.

Eakin, Hallie, and Amy Lynd Luers

2006 Assessing the Vulnerability of Social-environmental Systems. Annual Review of Environment and Resources 31: 365–394.

Erickson, Paul A., and Liam D. Murphy
1998 A History of Anthropological Theory. illustrated edition. UTP Higher Education.

Ford, James D., and Tristan Pearce
2010 What We Know, Do Not Know, and Need to Know About Climate Change Vulnerability in the Western Canadian Arctic: a Systematic Literature Review. Environmental Research Letters 5(1): 014008.

Ford, James D., Tristan Pearce, Barry Smit, et al.
2007 Reducing Vulnerability to Climate Change in the Arctic: The Case of Nunavut, Canada. Arctic 60(2): 150–166.

Ford, James D., and Barry Smit
2004 A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated with Climate Change. Arctic: 389–400.

Ford, James D., Barry Smit, and James Wandel
2006 Vulnerability to Climate Change in the Arctic: A Case Study from Arctic Bay, Canada. Global Environmental Change 16(2): 145–160.

Greenwood, Davydd J., and Morten Levin
2008 Introduction to Action Research: Social Research for Social Change. 2nd ed. Thousand Oaks, California: Sage.

Hansen, James, Makiko Sato, Reto Ruedy, et al.
2006 Global Temperature Change. PNAS 103: 39.

Herman-Mercer, Nicole, Paul F. Schuster, and Karonhiakt'tie Bryan Maracle
2011 Indigenous Observations of Climate Change in the Lower Yukon River Basin, Alaska. Human Organization 70(3): 244–252.

Holling, C. S.
1973 Resilience and Stability of Ecological Systems. Annual Review of Ecology and Systematics 4(1): 1–23.

IPCC (International Protocol on Climate Change)
2007 Climate Change 2007: Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Fourth Assessment Report of the IPCC (Climate Change 2007). Cambridge UK: Cambridge University Press.

Jette´, Jules, and Eliza Jones

2000 Koyukon Athabaskan Dictionary. Fairbanks, AK: Alaska Native Language Center, University of Alaska Fairbanks.

Kassam, Karim-Aly S.
2008 Diversity as If Nature and Culture Matter: Bio-cultural Diversity and Indigenous Peoples. The International Journal of Diversity in Organizations, Communities and Nations 8(2): 87–95.
2009 Biocultural Diversity and Indigenous Ways of Knowing: Human Ecology in the Arctic. Calgary: University of Calgary Press/Arctic Institute of North America.
2010 Coupled Socio-cultural and Ecological Systems at the Margins: Arctic and Alpine Cases. Frontiers of Earth Science in China 4(1): 89–98.

Kassam, Karim-Aly S., Michelle Baumflek, Morgan Ruelle, and Nicole Wilson
2011 Human Ecology of Vulnerability, Resilience, and Adaptation: Case Studies of Climate Change from High Latitudes and Altitudes. *In* Climate Change – Socioeconomic Effects. Juan Blanco and Houshang Kheradmand, eds. Pp. 217–236. Intech. http://www.intechopen.com/articles/show/title/human-ecology-of-vulnerability-resilience-and-adaptation-case-studies-of-climate-change-from-high-la, accessed April 30, 2011.

Kassam, Karim-Aly S., and the Soaring Eagle Friendship Centre
2001 " So That Our Voices Are Heard": Forest Use and Changing Gender Roles of Dene Women in Hay River, Northwest Territories. CIDA-Shastri Partnership Project.

Kassam, Karim-Aly S., and the Wainwright Traditional Council
2001 Passing on the Knowledge: Mapping Human Ecology in Wainwright, Alaska. Arctic Institute of North America.

Kawagley, Angayuqaq Oscar
1999 Alaska Native Education: History and Adaptation in the New Millennium. Journal of American Indian Education 39(1): 31–51.

Krupnik, Igor I., and Dyanna Jolly
2002 The Earth Is Faster Now: Indigenous Observations of Arctic Environmental Change. Arctic Research Consortium of the United States.

Larson, Walter
2006 Ruby Alaska a Gold Rush Town on the Yukon River. http://rubyalaska.info/, accessed July 27, 2010.

McNeeley, Shannon M.
2011 Examining Barriers and Opportunities for Sustainable Adaptation to Climate Change in Interior Alaska. Climatic Change: 1–23.

McNeeley, Shannon M., and Martha D. Shulski

2011 Anatomy of a Closing Window: Vulnerability to Changing Seasonality in Interior Alaska. Global Environmental Change.

Mearns, Robin, and Andrew Norton, eds.
2010 Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World. Washington, DC: World Bank.

Nelson, Richard K.
1986 Make Prayers to the Raven: A Koyukon View of the Northern Forest. University Of Chicago Press.

Nichols, T., F. Berkes, D. Jolly, and N.B. Snow
2004 Climate Change and Sea Ice: Local Observations from the Canadian Western Arctic. Arctic: 68–79.

Nuttall, Mark, Fikret Berkes, Bruce Forbes, et al.
2005 Hunting, Herding, Fishing and Gathering: Indigenous Peoples and Renewable Resource Use in the Arctic. Arctic Climate Impact Assessment. Cambridge University Press, Cambridge: 649–690.

Patton, Micheal Q.
2002 Qualitative Research & Evaluation Methods. 3rd edition. Sage Publications, Inc.

Pretty, Jule, Bill Adams, Fikret Berkes, et al.
2008 How Do Biodiversity and Culture Intersect. *In* Plenary Paper Presented at the Conference for Sustaining Cultural and Biological Diversity in a Rapidly Changing World: Lessons for Global Policy Pp. 2–5.

Reid, Hannah, Mozaharul Alam, Rachel Berger, et al.
2009 Community-based Adaptation to Climate Change: An Overview. Participatory Learning and Action 60(1): 11–33.

Reidlinger, Dyanna, and Fikret Berkes
2001 Contributions of Traditional Knowledge to Understanding Climate Change in the Canadian Arctic. Polar Record(203): 315–328.

Ribot, Jesse C.
1995 The Causal Structure of Vulnerability: Its Application to Climate Impact Analysis. GeoJournal 35(2): 119–122.

Salinger, M. James
2005 Climate Variability and Change: Past, Present and Future – An Overview. Climatic Change 70(1-2): 9–29.

Schwartz, Chuck C.

1998 Reproduction, Natality and Growth. *In* Ecology and Management of the North American Moose. Pp. 141–171. Washington, DC: Smithsonian Institution Press.

Smit, Barry, Ian Burton, Richard J.T Klein, and James Wandel
2000 An Anatomy of Adaptation to Climate Change and Variability. Climate Change 45(223-251).

Smit, Barry, and James Wandel
2006 Adaptation, Adaptive Capacity and Vulnerability. Global Environmental Change 16(3): 282–292.

Stout, Glenn W.
2008 Unit 21B Moose. Wildlife Moose Management Report, Project 1.0. Moose Management Report of Survey and Inventory Activities 1 July 2005-30 June 2007. Juneau, Alaska, USA: Alaska Department of Fish and Game.

Tester, Frank J., and Peter K. Kulchyski
1994 Tammarniit (mistakes): Inuit Relocation in the Eastern Arctic, 1939-63. UBC Press.

Thornton, Thomas F.
2001 Subsistence in Northern Communities: Lessons from Alaska. The Northern Review 23: 82–102.

Turner, B. L., Pamela A. Matson, James J. McCarthy, et al.
2003 Illustrating the Coupled Human–environment System for Vulnerability Analysis: Three Case Studies. Proceedings of the National Academy of Sciences of the United States of America 100(14): 8080–8085.

U. S. Congress
1980 Alaska National Interest Lands Conservation Act (ANILCA). Public Law 96: 487.

U.S. Census (United States Census)
2010 Ruby City, Profile of General Population and Household Characteristics. Summary File (Public Law (P.L.) 94-171). http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1&prodType=table, accessed September 21, 2011.

U.S. Public Law 85-508
1958 Alaska Statehood Act. http://www.lbblawyers.com/statetoc.htm, accessed July 1, 2011.

U.S. Public Law 96-487
1980 ANILCA (Alaska National Interest Lands Conservation Act).

Valdivia, C., A. Seth, J.L. Gilles, et al.
2010 Adapting to Climate Change in Andean Ecosystems: Landscapes, Capitals, and Perceptions Shaping Rural Livelihood Strategies and Linking Knowledge Systems. Annals of the Association of American Geographers 100(4): 818.

VanStone, James W.
1974 Athapaskan Adaptations: Hunters and Fishermen of the Subarctic Forests. Aldine Publishing Co.

Wenzel, George W.
1991 Animal Rights, Human Rights: Ecology, Economy and Ideology in the Canadian Arctic. University of Toronto Press.
2009 Canadian Inuit Subsistence and Ecological Instability—if the Climate Changes, Must the Inuit? Polar Research 28(1): 89–99.

Wenzel, George W., Grete Hoevelsrud-Broda, Nobuhiro Kishigami, and Kokuritsu Minzokugaku Hakubutsukan.
2000 The Social Economy of Sharing: Resource Allocation and Modern Hunter-gatherers. Osaka: National Museum of Ethnology.

Wheeler, Polly, and Thomas F. Thornton
2005 Subsistence Research in Alaska: A Thirty Year Retrospective. Alaska Journal of Anthropology 3(1): 69–103.

White, Gilbert F.
1973 Natural Hazards Research. Directions in Geography: 193.

Wolfe, Robert J.
2000 Subsistence in Alaska: a Year 2000 Update. Division of Subsistence, Alaska Department of Fish and Game.

1 **APPENDIX –** Description of fourteen subsistence activities in Ruby Village, AK[7] [8]

2 **Appendix** – Description of fourteen subsistence activities in Ruby Village, AK

Livelihood Activity	Description	Species Names (Common, Scientific & Koyukon)
Moose Hunting	Moose hunting is one of the most important subsistence activities for the people of Ruby. It is culturally important, and moose meat comprises a large proportion of their diet (Brown et al., 2004).	Moose (*Alces alces*): *Deneega*
Fishing	Fishing is one of the most important subsistence activities. Salmon provide one of the most important subsistence sources of food. Salmon fishing occurs between the end of June and the end of September and many people still maintain a fish camp. Other fish are caught throughout the year. However, the spring camp where much of this fish was at one time caught is no longer practiced.	Alaska blackfish (*Dallia pectoralis*): *oonyeeyh* Burbot, loche, ling cod (*Lota lota*): *tl'eghes* Dolly Varden trout (*Salvelinus malma*, uncertain identification): *ggaal yeega', silyee lookk'a* Grayling (*Thymallus arcticus*): *tleghelbaaye* Longnose sucker (*Catostomus catostomus*): *bedleneege toonts'oode* Northern Pike *(Esox lucius): K'oolkkoye* Salmon (any kind): l*ookk'e* Chinook or King Salmon (*Oncorhynchus tshawytscha*): *ggaal* Summer-run Dog or Chum salmon (*Oncorhynchus ketaII*): *noolaaghe* Fall-run Dog or Chum salmon (*Oncorhynchus ketaII*): *noldlaaghe* Silver or Coho Salmon (*Oncorhynchus kisutch*): *leghaane* Sheefish, inconnu *(Stendous leucichthys nelma): ledlaaghe* Whitefish (any kind): *look'e*
Bear Hunting	Bears are hunted for their skins and meat. Bear hunting is traditionally only done by men and takes place at various times of the year. Bears are considered *Hutlanee* Animals (taboo)**,** which have very strong spirits.	American Black Bear (*Ursus americanus)*: *ses* Grizzly or Brown Bear (*Ursus arctos*): *tlaaghoze*
Fur Animal Hunting and	Trapping usually starts in November when the snow falls and ends in March or April at the end of the beaver season.	Marten (*Martes Americana*): *sooge* American Mink (*Neovison vison*): *taahgoodze* Literally: "under water"

Trapping	Marten, mink, fox, lynx, wolf, wolverine, beaver, and muskrat are all trapped for their furs and in some cases for meat. Furs are either used locally or sold to fur traders. Although currently fewer individuals actively participate in trapping, it continues to be an important activity.	Red Fox (*Vulpes fulva*): *naaggedle* Lynx (*Lynx canadensis*): *kaazene* Literally: "black tail" Wolverine (*Gulo luscus*): *neltseel*, *doyonh* Wolf (*Canis lupus*): *nek'eghun, tookkone* Muskrat (*Ondatra zibethicus*): *bekenaale* Beaver (*Castor canadensis*): *noye'e, ggaagge*
Snowshoe Hare Hunting and Trapping	Rabbit snaring begins in late November or early December when the snow has fallen and the rabbits have changed color. There is no closed season and no harvest limit. Rabbits are snared for their meat and fur. Their fur is used to make mittens and other articles of clothing.	Snowshoe Hare (*Lepus americanus):* *White in winter: gguh* *Brown summer coat: saanh zooge*
Waterfowl Hunting	People hunt waterfowl such as ducks, geese, and swans when they return in March until break up occurs on the Yukon River. They are hunted again after break up when people go out on the river in their boats. People make sure to stop hunting them in June when they are breeding. Specific trips to hunt these birds are not made often. They are hunted in the course of other subsistence activities such as moose hunting.	Common Loon (*Gavia immer*): *dodzene* Goose (general term): *dets'ene* Canada Goose (*Branta Canadensis): belaalzene* Snow Goose (*Chen hyperboreus*): *hugguh* Duck (general term): *nendaale* Sandhill Crane (*Grus Canadensis): deldoole* Swan (*Cygnus sp.*): *toyene*
Spruce Grouse Hunting	Spruce grouse or spruce hens can be hunted starting as early as mid-August up until mid-April. However, most people hunt them from September until it snows in November, because after a certain time their meat begins to taste like spruce.	Spruce Grouse (*Canachites canadensis): deyh*
Willow or Ruffed Grouse Hunting	Willow grouse (Ruffed grouse) can be hunted from August until about mid-April. Most people hunt them in the fall between September and November, when the snow falls. Some people begin hunting them again in January and February. Some	Willow Grouse *(Bonasa umbellus)*: *tsonggude*

	people said that they have the same season as Spruce grouse, while others stated that they hunt Willow Grouse later into the season.	
Ptarmigan hunting	Ptarmigan live in the tundra of the high Arctic in the summer months and migrate south to the forest for the winter months. It is possible to hunt these from late November or early December until the end of February.	Willow Ptarmigan (*Lagopus lagopus*): *daaggoo* Rock Ptarmigan (*Lagopus muta*): *daak'aa*
Berry Picking	The people of Ruby pick many kinds of berries during the summer and fall months. Berries are eaten fresh, made into fish ice cream, made into baked goods, or preserved as jam.	Bog cranberry (*Oxycoccuss microcarpus*): *daal nodoodle*' Highbush cranberry (*Viburnum edule*): *donaaldloye* Lowbush cranberry (*Vaccinium vitis*): *denaalekk'eze* Crowberry, blackberry *(Empetrum nigrum): deenaalt'aas* Red Currant (*Ribes triste*): *notsehtl'oone* Black Currant (*Ribes hudsonianum*): *dotson' geege'* Raspberries (*Rubus idaeus*): *dets'en tl'aakk* Rosebuds (*Rosa acicularis*): *kooyk* Salmonberry, cloudberry (*Rubus chamaemorus*): *kkotl* Wild rhubarb (*Polygonum alaskanum*): *ggool*
Wood Cutting	Wood is cut or collected for various uses including firewood and to build traditional snowshoes and sleds.	American Green Alder (*Alnus crispa*): *kk'es* Balsam poplar (often mistakenly called cottonwood poplar) *(Populus balsamifera): t'eghel* White spruce (*Picea glauca*): ts'ebaa Black spruce (*Picea mariana*): *ts'ebaa t'aal* Paper Birch (*Betula papyrifera*): *kk'eeyk* Quaking aspen (*Populus trichocarpa*): *t'eghel kk'ooge* Willow (general term): *kk'uyk*

Gardening	Gardens have been cultivated in Ruby since the early twentieth century. At the time this research was conducted, 11 out of 62 households had a small garden. There is also a community garden that being used primarily to teach children about gardening.	A variety of vegetables are cultivated including potatoes, turnips, carrots, strawberries, tomatoes, rutabaga, cabbage, and lettuce.
Wage Labour	The economy of Ruby can be characterized as a "mixed" economy, where cash is an important input into subsistence livelihoods (Wenzel et al. 2000).	A variety of seasonal and year-round jobs are held in industries including carpentry, construction, and firefighting.
Caribou Hunting	There are caribou from the Western Arctic Herd in the Kilbuck-Kuskokwim Mountains near Ruby. The people of Ruby used to hunt caribou, but this is not practiced anymore.	Caribou (*Rangifer tarandus granti): bedzeeyh*

FIGURES

Figure 1 Map depicts the location of Ruby Village, Alaska in the Yukon River Basin

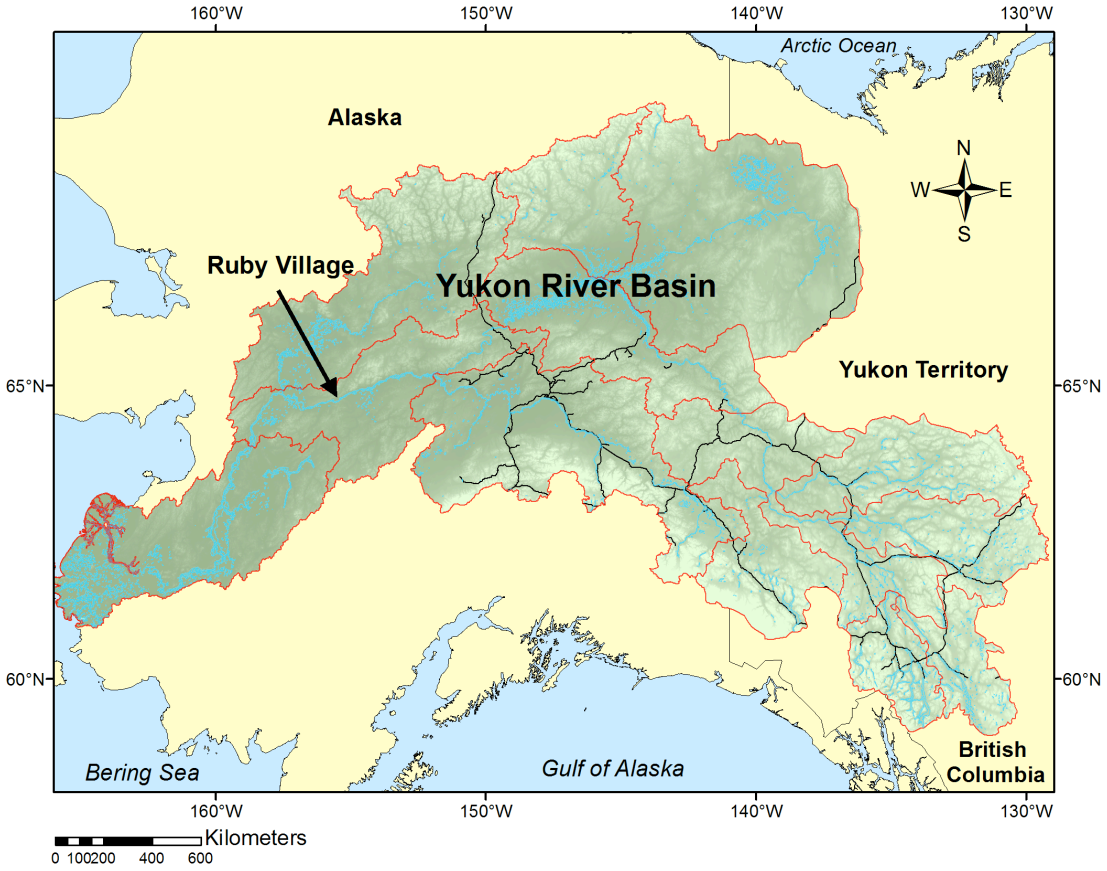
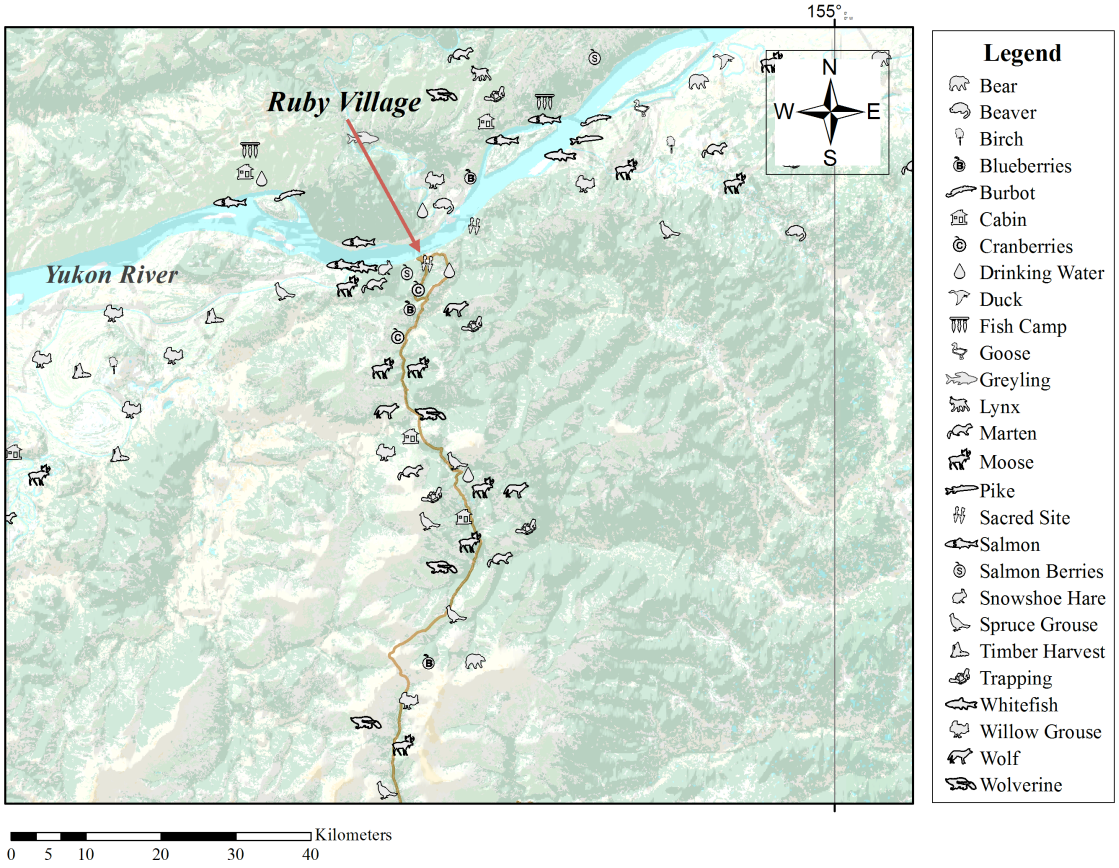


Figure 2 Combined seasonal round depicts the timing of present subsistence practices of all community experts. Grey areas, circled in red, indicate moose hunting seasons that are no longer permitted

Figure 3 Land use map for the people Ruby Village illustrates the spatial distribution of present subsistence practices throughout the majority of the people of Ruby's traditional territory



TABLES

Table. 3. Examples of observed environmental changes and their impacts on subsistence harvesting in Ruby Village, AK

Impacts	Definition	Observations
Predictability	Climate impacts that reduce the ability to predict weather including, rain, snowfall and temperature, to the detriment of a harvester's ability to plan and carry out subsistence livelihood activities.	The weather these days is strange and it is harder to predict. Increased variability of rain and snowfall. Reduced ability to predict when river ice will freeze or break up. Reduced predictability of streamflow on the Yukon River.
Access	Climate impacts reducing or preventing access to a particular area for subsistence harvesting. Access can be influenced by changes in ice, snow, or open water crucial for transportation.	Sandbars forming at the mouths of sloughs reduce access by boat. Reduced water levels in sloughs during the fall prevent entry by boat and therefore access to key hunting grounds. Changing freeze-up and break-up dates for river ice can temporarily alter time periods in which people have access to certain areas. Changes in streamflow and sediments may be altering context-specific conditions required to fish, e.g.,. changes in eddies important for fishing salmon.
Safety	Climate impacts reducing the safety of subsistence harvesters, largely in the course of travel on the Yukon River and its tributaries. Safety is closely linked to predictability.	Increased number of open leads, or unfrozen spots, on the river make travel over frozen rivers and sloughs dangerous. Water levels have been higher than normal on the Yukon River during the summer, making travel and fishing on the river more dangerous at times. Increased spoilage of meat due to higher fall temperatures.
Species Availability	Climate impacts reducing the availability of subsistence species either through the introduction of new species to the area or reduction in the temporal or spatial availability of other species through altered migration or other factors.	Observed delay in moose rut, likely caused by increased temperature. New birds have been observed. Observed changes in salmon populations could be influenced by climate since streamflow and temperature may affect salmon populations, as they are controlling factors in their life cycles (Bryant 2009).

1

2 **Table. 2.** Summary of adaptations to past social change and present vulnerabilities

Social Change	Adaptation/Coping Mechanism	Impact	Present Vulnerability	Climate Impact
Sedentization or settlement in a central village location.	Use of snowmobiles to maintain seasonal rounds.	Dependence on gas and market economy.	Vulnerability to fluctuations in market economy.	Reduced access and predictability in subsistence livelihoods can mean that people need to travel longer periods of time or distances to obtain their harvest. Their capacity to do so is limited by access to cash and other resources.
Increased presence of the market economy.	Development of a "mixed economy."	Dependence on market economy.		
Creation and enforcement of subsistence harvesting regulations.	Changes in timing, intensity, and location of harvesting.	Reduced flexibility of (control over) subsistence harvesting (intensity, timing, and location).	Restricted ability to adapt subsistence harvesting to ecological change.	Reduced predictability and access highlight challenges associated with the loss of flexibility or control over subsistence.

3

4

[1] Icons were adapted from land use mapping projects conducted in Wainwright, Alaska, and Hay River, Northwest Territories (Kassam and the Wainwright Traditional Council 2001; Kassam and the Soaring Eagle Friendship Centre 2001).

[2] Significant social change occurred prior to this era, including during the gold booms of 1906 and 1910. At its peak, the population in the region surrounding Ruby is estimated to have been as high as 10,000 (Larson 2006). However, the 1950s are used as a baseline for this study because the majority of changes in subsistence livelihoods identified by community experts occurred after this date.

[3] Mapping for past land use was not conducted, but interviews reveal that present land use is not as extensive as it used to be. However, the people of Ruby continue conduct subsistence livelihood activities within the majority of their traditional territory.

[4] Interview narratives indicate that while the people of Ruby were previously able to hunt moose at any time of year, they would primarily hunt moose during the fall (August and September), as they do now, and in the spring (February and March). Cow moose were primarily hunted during this time because they are typically in better shape than bull moose, with more fat, after the winter. Moose would also be hunted after breakup if there were no other food sources available.

[5] Moose hunting is one of the most significant subsistence livelihood activities for the people of Ruby. In a 2004 study, it was found that approximately 88 percent of the people of Ruby use moose meat. At that time, 64 percent of households participated in hunting and 40 percent had successfully hunted a moose. Of those who had hunted a moose, 60 percent reported sharing moose meat (Brown, Walker, and Vanek 2004). Moose hunting is not only important as a means of meeting the nutritional needs of the people of Ruby, it is also a culturally important activity and considered part of a way of life.

[6] The open season for moose hunting occurs during the fall. In the area around Ruby, ADF&G regulates an open season from August 22 to 31 and September 5 to 25 (on state and private lands, including lands held by native corporations) and U.S. Fish and Wildlife regulates a hunt from September 26 to October 1 (on federal lands) (AFWS 2010). Moose hunting is no longer permitted at any other time of year, with the exception of taking a moose for community potlatches or other traditional purposes. The harvest is limited to one moose per person. People are only allowed to hunt bulls with antlers. Hunting cow moose in the area near Ruby is prohibited. Hunting regulations, seasons, bag limits, and means of hunting are determined by both the state and federal boards of game and implemented by their respective agencies (Carey 2009)

[7] Livelihood activities were borrowed from Nelson 1986 and adapted to the context of Ruby Village.

[8] All Koyukon names sourced from The Koyukon Athabascan Dictionary authored by Eliza Jones and Jules Jetté (2000).