Traditional Ecological Knowledge of Moose, Other Wildlife Species, and Climate Change in Allakaket/Alatna



A project funded by the National Park Service (contract #P12PS22483), and executed by the Department of Wildlife and Parks of Tanana Chiefs Conference

TANANA CHIEFS CONFERENCE

Authors: Annette Watson, Orville H. Huntington, Stan Ned, Nicole Machuca, and Joshua Hoke, in consultation with community members and the Allakaket and Alatna Tribal Councils

Fairbanks, Alaska
May 2014

Cover image: Alatna River, just south of Malemute Creek; camped for the night

(GPS coordinates Lat 67°1’28.553 Long 153°17’27.841 Altitude 202.87)

Table of Contents

List of Acronyms……3

Abstract……4

Introduction……5

Objectives……8

Methodologies……9

"Participatory" Research Methodologies and Project Procedures of Collaboration……9

Literature Reviews……12

Agency Literature……12

Academic Literature……15

Biological and Ecological Studies of *Alces Alces* in Alaska……15

Local and Traditional Ecological Knowledge (TEK)……16

Social-Ecological Systems and Food Security……19

Participant-Observation……20

Interviews……22

Methods to Analyze the Participatory GIS……26

Methods of Non-Spatial, Qualitative Data Analysis……28

Overview of the Physical and Human Environment……29

The Physical Environment: Cycles of Change……29

The Human Environment: Prehistory to the 20th Century……33

The Modern Social-Ecological System……44

Local and Traditional Knowledge of Moose and Other Wildlife Species……56

Knowledge about Wildlife as it Relates to Climate Change……61

Discussion……65

Conclusions……68

Recommendations……69

Acknowledgements……70

Literature Cited……71

Acroynms

ADF&G	Alaska Department of Fish and Game
AM	Adaptive Management
ANCSA	Alaska Native Claims Settlement Act
GMU	Game Management Unit
GPS	Global Positioning System
IK	Indigenous Knowledge(s)
IM	Intensive Management
NPS	National Park Service
NSF	National Science Foundation
TCC	Tanana Chiefs Conference
TEK	Traditional Ecological Knowledge
USFWS	United States Fish and Wildlife Service
YRDFA	Yukon River Drainage Fisheries Association

Abstract

The purpose of this report is to gain broader perspective on the stock, status, and history of natural and cultural resources, with particular attention to moose (*Alces alces*) as well as local knowledge about ecological and social impacts of climate change by residents of Allakaket and Alatna, which lay south of Gates of the Arctic National Park. The boreal forest is said to be experiencing climate change at twice the rate of other ecosystems; this cultural resources report develops qualitative socio-cultural data from the Koyukon community of Allakaket and the Inupiat community of Alatna, and links their local and traditional knowledges to ongoing natural resource inventorying, monitoring, and assessment. Today's families of Allakaket and Alatna are a product of generations of negotiations, ritual, and intermarriage between the cultural groups. Today, these villages often share the same infrastructure—the same airport, clinic, store, and their youth all attend the same school—yet Alatna and Allakaket maintain distinct identities as communities and political bodies. Researchers found an enduring commitment to subsistence-based lifestyles by residents of both villages. But what researchers also found is that, because of the changing socio-ecological context, these communities share increasing vulnerabilities with the other biota with whom they share the land. This study articulates many challenges for these communities' food security, which include continuing challenges to access foods necessary for their spiritual and physical survival.

Introduction

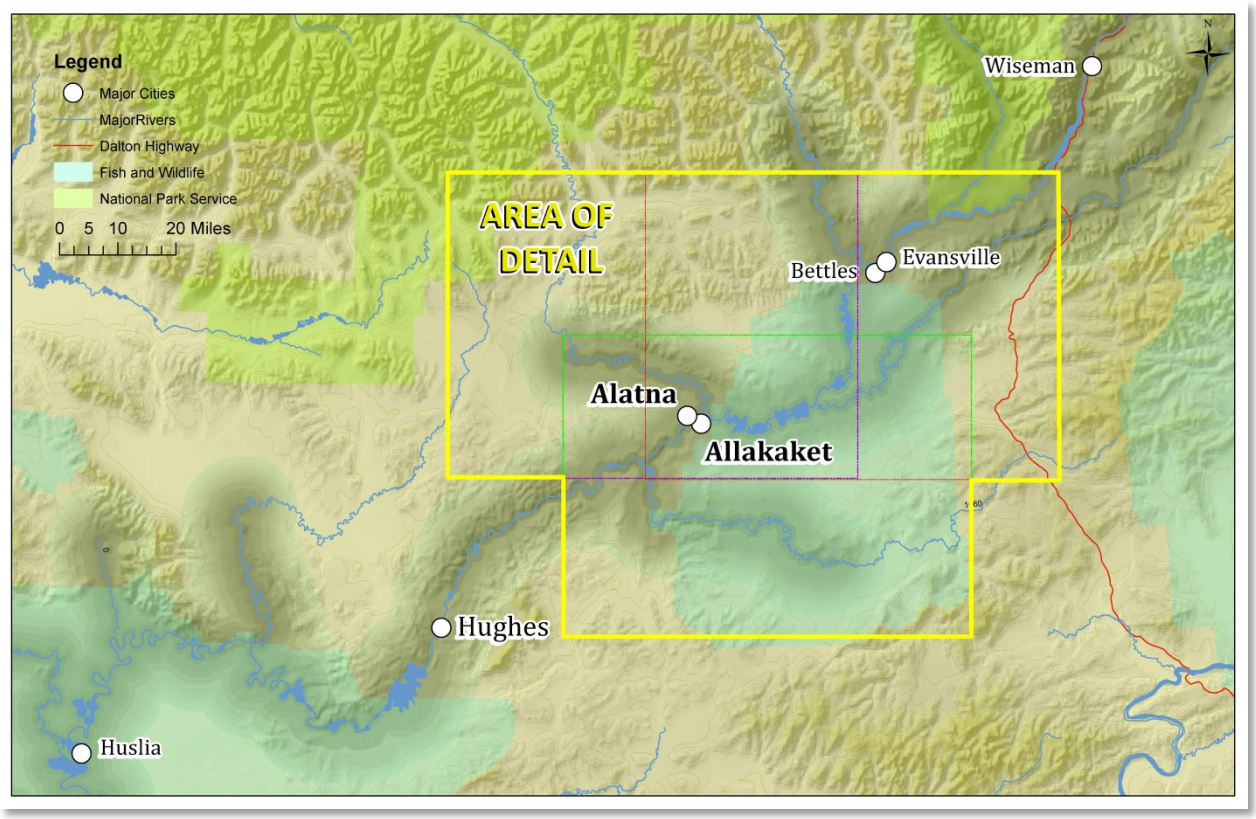


Figure 1: Study Area: Alatna and Allakaket, Alaska (map created by Machuca and Webb 2013)

The following study is part of a larger project to document the Traditional Ecological Knowledge (TEK) of communities that reside around Gates of the Arctic National Park and Preserve of the National Park Service (NPS). This cultural resources report develops socio-cultural data from the Koyukon community of Allakaket and the Inupiat community of Alatna, and links their local and traditional knowledges to ongoing natural resource inventorying, monitoring, and assessment. The purpose of this report is to gain broader perspective on the stock, status, and history of natural and cultural resources, with particular attention to moose (*Alces alces*) as well as local knowledge about ecological and social impacts of climate change.

Researchers led by Tanana Chiefs Conference (TCC), Division of Wildlife and Parks, conducted the work with particular instruction to develop a model for coordinated natural and cultural resource research that engages the NPS and local communities toward common goals of resource protection and the dissemination of research results. With this directive in mind, TCC composed a research team, and engaged the communities of Allakaket and Alatna to obtain feedback and guidance about the project during preliminary meetings held in June 2012, when leaders and tribal members from both tribes first gave additional direction to the researchers.

During these initial meetings (2 in Allakaket, 1 in Alatna), tribal elders, leaders, and other community members were invited to collaborate on the research design. Many expressed support to record their subsistence use and local knowledge because they wanted such data to contribute to studies on potential impacts of development; many community members specifically mentioned a proposed road from the Dalton Highway to Ambler. Thinking about development activities such as road-building, feedback on research design from tribal members emphasized that the Alaska pipeline greatly affected their subsistence patterns as well as animal dynamics. They therefore advised that the researchers should not just record only the recent year or years of subsistence activities, but encompass a much larger temporal and spatial scale. They did not want the study to be a "snapshot" but a study of their adaptations through time. These meetings therefore emphasized to the researchers that it was important to recognize the dynamic nature of the human-environment relationship in the analysis of this study. Another predominant concern in these meetings on research design was for the well-being of youth in the community; such concerns underscore why residents thought it was important to record their knowledge about subsistence, and also became reflected in the packaging of the information from this project into a content-based web site that is at once a repository of the products of this research, but also a site to engage the youth and other residents within these communities.

These community concerns also shaped the research opportunities during this project in concrete ways; for example, leaders especially wanted to document cultural and subsistence resources along the Alatna River, so some of the participant-observation portion of data collection was spent along this particular river during moose hunting season, September 2012. The ways in which community feedback was integrated into the research design is fully articulated in the report's methods section.

Before completing a final research design, researchers also spoke with agency representatives from the US Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADF&G) to assess management initiatives and data needs. ADF&G reported that the present study could contribute information to the agency's ongoing research for ungulate management, especially intensive management initiatives, as well as more recent interests to understand the impacts of climate change on wildlife management and economies in Alaska. Staff in the Subsistence Division were also concerned that the project not repeat their efforts, especially in ways that might produce "research fatigue." Thus we designed and timed this project to complement those ongoing efforts, gathering a larger proportion of qualitative and visual data than the ADF&G studies, and we aimed to produce a synthesis and analysis of the data and literatures in ways that can contextualize subsistence management efforts for future decision-making. When researchers approached staff with the United States Fish and Wildlife Service (USFWS), another land manager in the study area, they especially expressed interest in moose-fire dynamics, as well as interest in incorporating their prior work on fishing places and place names in the study area. This prior work had been accomplished in collaboration between the USFWS and the Yukon River Drainage Fisheries Association (YRDFA), the *Middle Koyukuk River of Alaska: An Atlas of Fishing Places and Traditional Place Names* (YRDFA 2009). The USFWS desired that the *Atlas* be reproduced in a format that facilitated its use by people in the communities, and also so this project could use its data layers to make additional maps with Native names. The idea of a website interface emerged to share the

data and project results, as well as make the information from the original *Atlas* project more accessible to the cultures whose knowledges the *Atlas* project represents.

After this initial consultation with the tribes and agencies, the research began with developing annotated bibliographies of both the agency (grey) literature as well as academic literature on the people, ecology, and wildlife of the area. Along with conducting archival research, researchers returned to Alatna and Allakaket in September 2012 for 10 days during the moose hunting season, for the primary period of participant-observation, and then in December 2012 for 15 days, to collect interview and participant-observation data. After the first period of data analysis, researchers returned in the summer 2013 to consult with tribal leaders about these findings, also holding a community meeting to discuss results and to aid in interpreting these findings.

Objectives

The objectives of this research and scope of work for this project included:

1) Developing a collaborative research practice with the tribes of Allakaket and Alatna
2) Data mining/annotated bibliography/literature reviews: The research team collected grey literature and relevant data from federal and state agencies; and oral histories and primary data/secondary literature about Allakaket/Alatna subsistence in the Polar Regions archives at the University of Alaska-Fairbanks and other databases. The research team also collected peer review literature from relevant disciplines and fields of study, across the natural and social sciences. This work is catalogued into an annotated bibliography as well as the literature reviews in this report. A review of this work allowed researchers to design additional data collection, aimed at filling data gaps and to compose an analysis that synthesizes this information.
3) Cultural ecology of moose and related species: researchers have analyzed the data, which includes existing literature as well as the primary data collected for this project; spatial data and digital video was recorded and analyzed.
4) Inventory of climate change observations: this inventory, in this report, includes observations of phenomena such as habitat changes, as well as traditional/cultural stories associated with climate change that the tribal members decided to share.

The specific products produced for this project, within and along with this report are:

GIS maps/spatial data
Analysis of cultural ecology of moose and climate change observations
Analysis of management implications (related to monitoring and regulatory decision-making)
Outreach products, including maps and video/podcast edited to tribal specifications
Website interface for public access to the report and its other products, such as maps, video

Throughout the researchers' official contact with the Tribal Council members and the tribal offices of both Alatna and Allakaket, leaders and staff stressed that they desired a "cultural impact assessment" regarding the proposed road to Ambler. The TCC researchers explained that this NPS project could provide data for that kind of study, because this NPS project aimed to document human-environment interactions across the landscape over time. Researchers explained this NPS project could contribute essential information for a future cultural or environmental impact assessment, if this NPS project were completed in a rigorous way. Researchers on this project realized this was an important opportunity to document subsistence patterns and practices amongst a willing—and even sometimes impassioned—population who desired to record these patterns so that their needs are not overlooked in the future environmental and economic planning in the region.

Methodologies

"Participatory" Research Methodologies and Project Procedures of Collaboration

The primary data-gathering and analytical methods used were literature reviews, participant-observation, interviews, ethnography (including visual ethnography), and GIS (geographic information systems); all were conducted in a "participatory" way to reflect changing practices of Arctic social sciences and collaborative practices of conducting research with Indigenous peoples (Watson and Huntington 2014; IPSG 2012; Chilvers 2009). Over the last 20 years, these changes in research practices were the result of Indigenous activism and scholarship, including arguments to "decolonize" research methods (Tuhiwai Smith 2012; Watson and Till 2009; Louis 2007) along with articulating and accepting Traditional Ecological Knowledge (TEK) or Indigenous Knowledges (IK) in understanding Arctic phenomena (Cochran et al 2013; Chapin et al 2013; ACIA 2004). Derived also from feminist methods and philosophies of "collaboration," participatory practices have the aim of empowering participants in the research process (Monk et al 2003), and these practices in the Arctic include directly involving Indigenous communities in setting research agendas (NSF 2012). Regulatory agencies have also developed similar protocols to engage with Alaska Native communities, including payment for Indigenous peoples' intellectual labor, and describe careful methods to collect and represent Native knowledges for environmental management (Martello 2008; Miraglia 1998).

This literature, derived from the discipline of geography and other Arctic social and natural sciences, informed the overall research relationship with the tribe, and therefore this project's overall design. The TCC research team traveled to Allakaket and Alatna with a focus on community engagement and building trust in the project, and not just "collecting data." This project therefore not only engaged the communities at the scale of "the community," in a meeting forum (June 2012 and July 2013), but also worked on an individual basis, researchers speaking with elders and community leaders and other members during initial contact (June 2012), the main data-gathering periods in each village (September 2012 and December 2012), and during the months subsequent to the data collection and throughout the summer of 2013, as well as in the final community feedback meeting (July 2013).

As the participatory literatures note, the most important requirement for a healthy research relationship is trust. Many say that to build trust, researchers must be "transparent" with the people they work with, and that transparency can only be broached with vigilance; in the conduct of this project, at every stage of the research, the researchers presented both a written and oral explanation about the project, its goals, updates on how money for the research is/was funneled into the community (such as research assistance, boat rentals, etc) as well as to the researchers (such as direct salaries of researchers and indirect charges claimed by TCC). The budget of our project was also designed to compensate tribal members for their intellectual labors, such as in the form of honoraria in exchange for interviews, as well as for necessities such as boat transportation; the research team presented the tribes with this budget in its initial meetings, in an effort to be fully transparent about the research process, and even negotiated certain line items within the budget when necessary, to better reflect local costs. (For example, we added to the budget the purchase of a prop, because travel up the

rocky-bottomed Alatna River can render a propeller useless—the cost to replace is far too much to expect the boat owner to bear).

To be "transparent" means not only to be explicit about where research dollars are going, but also to be explicit about how data is to be used once a study is complete. With every community meeting and research opportunity, researchers reminded tribal members of the purpose of the study, would talk about preliminary findings, but also always invited tribal members to contribute to the ongoing work of the study. If there *were* revisions or comments, researchers would summarize in the subsequent communication how researchers incorporated tribal requests/commentary. Indeed, one of the greatest benefits of employing "iterative" models of research, rather than hypothesis-driven research, allows for more effective research relationships with tribes. This does not mean that these opportunities are to be construed as a form of censorship. Rather, this "collaborative" model aims to generate new ways of knowing and mutual learning—which can only be achieved through mutual trust among research partners (Huntington and Watson 2012). The tribes also negotiated that, at the end of the project period, the data (transcripts of interviews and digital media) will be transferred to tribal archives, while this report, the non-anonymous interviews, the literature in pdf form, and some visual media will be publicly available via the website interface.

The very composition of the TCC research team aimed also to facilitate the collaboration between these agencies and tribes. Directing the project is Orville H. Huntington, the Director of Wildlife and Parks for TCC; Huntington is a Koyukon Athabascan from Huslia, just south of the project area, but related to many of the Koyukon families of Allakaket. He is obviously one of the project's key experts of Koyukon cultural and subsistence practices, also with an extensive peer-review publication record and record of leadership in subsistence management; Huntington spoke with many leaders and community members of Allakaket and Alatna throughout the project, to share information as well as collect feedback. Huntington selected this project's coordinator, Dr. Annette Watson of the College of Charleston, SC, a non-Native Geographer with over 10 years of fieldwork experience in Koyukon and other Alaska Interior communities, and with whom Huntington has often collaborated on peer review work regarding Koyukon traditions, subsistence practices, and beliefs about climate change. Watson was responsible for the final project design and execution, organized/led the research team for every trip and stage of analysis, and is lead author of this final report. Another key personnel on this research team who facilitated our collaborative relationship with the tribes was Stan Ned of Fairbanks, from Allakaket (Figure 2), who was the official community liaison; he introduced Watson to the leaders and elders in Allakaket and Alatna, and assisted with the project's orientation in in June 2012. Ned also contributed to the project's participant-observation in September 2012, and analysis during the summer of 2013, also traveling with the team in July 2013 to the villages for the final period of feedback. Other researchers on the project that were recruited and organized by Watson include Nicole Machuca (Figure 3), a paid research assistant during most of the project; Machuca traveled with Watson to the villages for the December 2012 interview phase, collecting almost half of the interview data for the project, created half of the GIS analysis in this report, and developed some of the literature reviews. Two other contributors to the GIS analysis were Joshua Hoke and Jennifer Gross. Lastly, Watson worked with Chase Hawes to create the website interface and video for the dissemination of these final results.



Figure 2: Stan Ned and Harding Sam, up the Alatna River, September 2012
(GPS coordinates Lat 67°1'28.5039, Long 153°17'28.008, Alt 204.97)



Figure 3: Nicole Machuca interviewing Lydia Bergman, Allakaket, December 2012

The Introduction of this report reviewed the main concerns raised by tribal members during the initial consultation with the tribes in June 2012: to represent their subsistence use not in "snapshot" fashion, but in ways that recognize their dynamic use of the landscape over time. These consultations and that with relevant agency staff informed the following reviews of the literature.

Literature Reviews

Researchers first began literature reviews of agency (grey) and academic literature regarding the two villages and larger Interior Alaska region. The purpose of these reviews was to provide 1) guidance for research design, including understanding the gaps in research in terms of both content and method; 2) information regarding the management context, history, and natural history of the study area; 3) resources for students, managers, and community members, collected in the form of an annotated bibliography accessible via the public web interface; and finally, these reviews provided 4) frameworks for analyses of the data and the recommendations in this report.

Agency Literature

Researchers reviewed agency (grey) literature to understand the current state of knowledge in the regulatory context: the biological trends and current scope of empirical records of cultural and subsistence activities. The most relevant agency literature allowed researchers to develop comparisons about practices over time. For example, Marcotte and Haynes (1985) mapped subsistence use in this same study area, although their study also included more communities along the Koyukuk River. Other studies produced by the Alaska Department of Fish and Game, Subsistence Division, proved useful as well (Holen et al 2012; Andersen et al 2004a, 2004b; Brown et al 2004; Wolfe 2004). Two other texts of special utility to this study is the extensive ethnographic work funded by the National Park Service, one an unpublished report by University of Alaska Fairbanks researchers using data provided by anthropologist Ernest Burch, Jr., on the early land use and territorial patterns of Inupiat and Koyukon families (Englehard et al 1993). The second project was published as *Tracks in the Wildland* (Nelson et al 1982); this text provided essential information about the practices and craft of Koyukon and Nunamiut subsistence economies—recorded at the dawn of the era of the modern oil economy in Alaska, and an early era of the mixed cash-subsistence economy in the Interior.

However, using such texts as fully representative of historic practices must be done cautiously, for no research is without flaws; no representation can be a total mirror to reality. Engaging the community and key informants about the researchers' use of these works is part of a rigorous practice of participatory research, and during the fieldwork phase of the project researchers were sometimes made aware of instances when prior research ran counter to community knowledge. For example, when one of the researchers left her copy of *Tracks in the Wildland* on a table in the Allakaket tribal office, she had the opportunity to engage in conversation with a man in his sixties, who remembered one of its co-authors, Ray Bane. "They said we don't hunt sheep. No way—that's bullshit, we hunt sheep," he said (Watson fieldnotes, *Dec 5 2012*). *Tracks in the Wildland* has extensive documentation for a variety of subsistence practices in Koyukon and Nunamiut communities, not just hunting and trapping, but also the rituals and instructions on how to make the tools for subsistence in the yearly round; it is also an

important resource for understanding the historic roles and practices performed by women in these subsistence and household economies. But as noted by the resident who saw the book on the table, the book explicitly states that the communities of Allakaket and Alatna do not hunt sheep. Our results below, as well as other sources like Marcotte and Haynes (1985), confirm what the resident so colorfully suggested: that sheep hunting is indeed regularly practiced in these communities, not a rare occurrence. Such an example serves as an important caution; we were therefore careful about what kinds of information to incorporate from any study, privileging those observations that are shared across multiple sources. Researchers identified from the literature as much consensus about the local natural and social history, placing more trust in those observations that appear virtually unchanged between sources and/or represent sources from disparate traditions, such as from agencies and oral history.

Another reason the research team engaged the grey literature is to understand the current scope of data-gathering and management initiatives within these regulatory agencies; these reviews provided windows into how the present study could extend and contribute analyses for future decision-making. Of great importance to the Alaska Department of Fish and Game (ADF&G) is ungulate management—the value of all moose (*Alces alces*) in the state, estimated at 175,000 animals, has been recently translated to be economically worth a total $28,276,000 per year (NEI 2006). Minus its costs, the benefit or value of moose was broken down in this study to highlight its consumptive values ($38,322,000), which includes its use as a food source by urban and rural residents, with non-consumptive values including wildlife viewing and photography ($3,846,000). Projected into the future, these researchers calculated increasing value for moose in the state through 2026, assuming an increasing human population in Alaska and a stable population of moose (NEI 2006). While such quantifications of value do not measure the cultural and spiritual value of moose in Native rural subsistence economies, such figures do indicate the State of Alaska's stake in managing moose into the future.

ADF&G's Big Game Harvest Assessment Project produced a five-year study in the early 2000s of harvest trends and hunter effort in Allakaket and Alatna, among other Interior villages (Brown et al 2004; Andersen et al 2004b). A significant finding in these studies was the consistent importance of moose in the local subsistence economy in our study area; in the year 2002-2003, the study recorded that 100% of households in Allakaket and Alatna relied on moose. Alatna harvested a total of 12 moose, with hunters averaging 13.7 days for each success—the largest effort measured in the study region. Hunters in Allakaket harvested 35 moose, needing an average of 11.9 days per successful harvest. The Big Game study also confirmed that Allakaket and Alatna not only had the greatest reliance on moose meat compared with other Interior villages, but also had to expend the most effort to hunt that moose and share the meat throughout the community. Significantly, the multi-year study showed that hunter effort was increasing in the whole Interior region, indicating the increasing scarcity of moose (Brown et al 2004, 25); this area included not only Alatna and Allakaket, but also the Interior villages of Bettles/Evansville, Galena, Huslia, Kaltag, Nulato, Tanana, and Ruby.

> Compared to 2000, hunters in 2001-2002 spent an additional 1,031 hunter-days in the field and by doing so managed to harvest almost the same number of moose (369 moose in 2000 and 364 in 2001-2002). To put this increased number of hunter-days in perspective, it is equivalent to a period of approximately 2.8 years of additional hunting time…. On average,… an increase of one [hunter-]day per moose. It is evident

> from these data that moose in the region are, in general, becoming more difficult to obtain. It is also clear from these data that the very stable community harvest levels described above are achieved by hunters in these communities only through dramatic increases in hunter-effort. This is a testament to the prominence of moose as a food resource in this region and the importance local hunters place on meeting subsistence needs with traditional foods (Brown et al 2004, p. 25-26).

Likewise, Holen et al (2012) report in their comprehensive subsistence harvest survey that both Allakaket and Alatna show continuing stress to meet their needs, while at the same time, tremendous use of subsistence resources. In their 2011 season of data-gathering, they found that per capita Allakaket uses the most subsistence resources in their study area of the eastern Interior (520lbs per capita). Allakaket harvested 17 moose, while Alatna harvested 3, much less than the years of the Big Game surveys; in this particular year of the household survey, residents were more successful harvesting caribou that came into the area. But 50% of residents of Alatna and Allakaket reported they used less subsistence resources overall, which this ADF&G study also measured to be less than harvests in the 1980s; and most of those interviewed said this was because there were less resources to harvest, in addition to other factors, such as the price of gas, and choosing wage labor over the time needed for subsistence. Holen et al (2012) also report that, while the two communities are relying more on big game than fishes, their type of fish harvest is changing from salmon to non-salmon species (Holen et al 2012). This is consistent with an earlier ADF&G study, coordinated with TCC and the USFWS, of non-salmon fisheries and traditional knowledge of non-salmon fish (Andersen 2004a). In this study researchers noted that while non-salmon fisheries comprised an important component of the subsistence diet in Interior villages, the pounds per year harvested rivalling that of moose, the use of fisheries have declined overall (Andersen 2004a).

The State of Alaska has played an active role in managing ungulate, including moose populations, but there has not always been trust in that management from the public. An oft-cited example of tensions between citizens and agencies followed the liberal cow harvests of 1974-1976, which because of harvesting rates and harsh winter effects, substantially lowered the moose population size (Young and Boertje, 2011). Recently, ADF&G has developed analyses of “food security” to better address rural communities’ needs in subsistence management (Holen et al 2012). They also conducted a feasibility study for intensive management (IM) near Allakaket and Alatna, and suggested that a targeted culling of wolves would improve the localized stock by approximately 300-350 moose, though because IM would only focus on a 10.1% portion of the game management unit (GMU), not impact the greater predator-prey dynamics of the larger spatial scale of GMU 24B (ADF&G 2011). Such efforts fit into recent calls to employ adaptive management (AM) strategies, whereby management actions are structured and measured as experiments, for a research-informed decision-making system (Clark et al 2010; Johnson 1999).

Lastly, ADF&G has recently begun research on the impacts of climate change on its subsistence regimes (Andersen et al 2012). Some researchers also suggest that to best position management to be responsive, adaptive management (AM) strategies might be better employed to ease decision-making in these times of more rapid ecological transitions. Such approaches also necessitate that finer-scale or “downscaled” data be available for more localized management decisions (Clark et al 2010).

Academic Literature

There are three main bodies of academic literature that we used to inform our research. The first is the peer-review biological and ecological literature on *Alces alces* in Alaska, which helped researchers design the interview questions, develop comparisons between the literature and local knowledge of moose, and develop future research questions specific to the communities of Allakaket and Alatna. The second literature on Traditional Ecological Knowledge (TEK) also informed both the research design as well as analysis; the third is a broader literature on social-ecological systems and food security, which this study employs to provide a framework to bridge the concerns of both managers and communities.

Biological and Ecological Studies of Alces Alces *in Alaska*

Peer-review literature on moose biology is often directly informed by wildlife management interests; there is often not so great a division between "grey" and academic literature in this field of study. Moose have been studied as a "model herbivore" for the last 50 years; moose browse selection practices are extensively covered in the literature, and many argue that forage availability affects population density (Seaton et al., 2011; Shenoy et al., 2011). Lord (2008) writes that moose prefer forage species like willow and aspen, and according to Shipley (2010) moose populations eat a primarily willow diet in the summer. Biologically speaking, moose are adapted to certain food sources, like willow and other hardwoods, which their bodies can easily digest and detoxify (in the case of conifer species). Certain components of browse, like lignin, tannins, and salicin, are important for moose health (Shipley, 2010). As covered in the review paper by Shipley (2010), moose are believed to typically have one preferred browse species; Shenoy et al. (2011) note that deciduous stands support higher moose population densities than conifer stands. Maier et al. (2005) also found associations to vegetative types, but suggest that moose may respond to forage at smaller scales than they investigated. Some studies have shown that moose can have a diverse diet, with some populations browsing on other species, such as Alaska paper birch, and that their seasonal browse sometimes changes, such as moose visiting willow bars along the Kuskokwim River in wintertime (Seaton et al. 2011).

Fire is known to affect browse selection by moose. MacCracken and Viereck (1990) have noted that the burning is an important element for the growth of vegetation that is preferred moose habitat. They argued the ideal post-burn habitat for moose is between 20-25 years post-burn to 50 years at most; moose have been found in areas that were burned between 10 and 30 years ago, but also found in areas burned between 31 and 40 years ago (Maier et al., 2005). MacCracken and Viereck (1990) note that if a habitat is experiencing fragmented burning, moose will be able to stay in the area during the burn. Joly et al. (2012) argue that moose select for areas that are abundant in early seral stage habitats, and argue that, because rates of fire are increasing due to changes in climate, this might impact browse selection. Shenoy et al. (2011) claim that this behavior is already happening; they suggest that moose densities have already increased where fire has increased.

But why moose select their habitat and home range is still not well understood. Recent genetic studies document the westward migration of moose across Alaska, and toward the coast (Schmidt et al 2009).

Many authors suggest that home range is determined by diet, thus impacted by fire disturbance. However, as noted by Lord (2008), moose may select habitat based off of many factors, not just including food supply but also the existence of mature stands that minimize wolf predation. Seaton et al. (2011) suggest that snow depth can impact access to foods and therefore deter habitat selection in these areas. Others have noted how moose may select habitats that are "simple" and that have less than 10 plant species (Shipley, 2010). And some authors suggest that cow and bull moose may select habitat differently; some have observed that once female offspring become independent, they establish overlapping home ranges with their mothers (Hundertmark 1998). Maier et al. (2005) suggest that females prefer heterogeneous habitat, since they found an association with females and patch richness density. They propose that heterogeneous habitats allow for females access to food and protection from predators. However, they go on to say that in their study they found that moose are in high densities in areas of moderate elevation, close to towns, near a large river margin, and avoid non-vegetated areas and variable terrain.

Like diet and fire, the biological and ecological literature explore predation as another key factor affecting moose density. In the work of Boertje et al. (2009) the authors found that low predation was the key factor that allowed moose to increase in yield and density in their research area. Through research involving the removal of different predator species, Keech et al. (2011) also concluded that predation is a predominant factor upon moose population rates; experimenting with the effect of removing predators on moose from 2001 to 2007, including wolves (*Canis lupus*), brown bears (*Ursus arctos*), and black bears (*Ursus americanus*), they found that summer and autumn survival rates of yearlings and adult females increased.

Some studies document effects of snow on moose; for example, studies that suggest how snow depths can deter habitat selection (Seaton et al. 2011; Maier et al. 2005; McCracken and Viereck 1990). Keech et al (2011) also concluded that their experimental predator treatments did not have effects on calf winter survival, which they said related to snow depth and temperature. They found that the colder the day (<28^{o}C) there was less snow depth and higher survival. However, the more days that were >28^{o}C, the lower the survival rates. They concluded that warmer winter days had greater rates of snow, thus affecting calf survival. They conclude that nutritional status could also impact the success of predator management treatments.

With this brief review of literature about the types of studies and research questions pursued about *Alces alces* in Alaska, researchers for this study designed their interview schedule to ask residents of Allakaket and Alatna about their local observations of moose in the area. In this way the project could develop potential research questions that engage both biological and local/TEK knowledge traditions.

Local and Traditional Ecological Knowledge (TEK)

Alaska, and the Arctic more broadly, has been an early site where Native knowledges were recognized by Western academics as being legitimate and comparable to Western sciences, in part because of the context of researching climate and ecosystem change (Watson and Huntington 2014). Because

subsistence-based societies out of necessity must survive from their knowledge of the land, they are now understood as knowers of ecosystem processes, and early academic work especially focused on articulating the different taxonomic systems that demonstrate how their knowledge of things organized both social and natural life (Berkes 1999). Indeed, a recent study in our project area that fruitfully took this approach was Andersen (2004a) on non-salmon fisheries, in some cases becoming the first to record use of certain fishing techniques by Allakaket and Alatna residents. But cultural ecologist Fikret Berkes (1999) also proffered a definition of TEK that recognized the ways that these taxonomies are also encompassed by "worldview," leading Berkes to call TEK a "sacred ecology."

Over the past 15 years, scholars have debated this definition of TEK (and associated literatures on IK, or Indigenous Knowledges) and/or deployed varying definitions in their studies. The debate has become whether TEK is recognizably different than "local" knowledge, and how these are similar or different from the knowledge produced by the sciences. Scholars have long argued that the "integration" of Indigenous and Western knowledge systems as if all Native knowledge were "local" observations serves to disenfranchise Native peoples (Watson 2013; Huntington and Watson 2012; Nadasdy 1999, 2003; Agrawal 1995). Many ask, what "contexts"—both cultural and spiritual contexts—are being lost when Native knowledges get translated during a study as "results" (e.g., Huntington et al 2006)?

But also in the meantime, the academic field of Native American or Indigenous Studies has also grown, representing Native experiences and ways of knowing; these literatures articulate the existence of "Native Sciences" as equal to, and the ways they are different from, Western sciences. Given the political and environmental contexts within which many indigenous peoples live, many of these scholars argue for different methodological strategies for land and resource management (Tuhiwai Smith 2012; Kovach 2009; Louis 2007; Johnson et al 2007; Kawagley 2006; Semken 2005; Howitt 2002; Cajete 2000; Deloria 1969). Two of the co-authors of this report have engaged in these more recent discussions of how to define, understand, and utilize TEK, specific to Alaska Natives and Koyukon peoples—and contribute to discussions on how to bridge these knowledge traditions to form more effective collaborations for wildlife management (Watson and Huntington 2014; Huntington and Watson 2012; Watson and Huntington 2008). Through our own research and writing collaborations over the last eight years, we have articulated how TEK presents knowledge not just about objects—the local taxonomies approach—but that Native knowledges proceed from a wholly different philosophy of knowledge than that of other Enlightenment-based sciences.

For example, in our recent study that examined climate change research in a Koyukon village, we demonstrated how oral tradition cannot always so neatly map out onto Western scientists' measurements through time. The "data" from the oral tradition was not to be found in the "facts" contained in the story, but in the ethical worldview that the elder telling the story was trying to communicate to the future generation (Watson and Huntington 2014). It is in this vein that recent scholars are experimenting with more "holistic" ways of knowing that cut across knowledge traditions (e.g., Berkes and Berkes 2009); are beginning to engage with the idea of "wisdom" as different from the "knowledge" sought by Western scientific disciplines (Chapin et al 2013; Huntington and Watson 2012); and are looking toward "Indigenous frameworks" through which to contextualize Western scientific "facts," particularly with regard to climate change (Cochran et al 2013).

For the current study the authors are thereby employing a definition of TEK as overlapping but different from local knowledges and observations of environmental phenomena. We report the existence and persistence of both local and traditional ecological knowledge of moose and climate change by the people who reside in Allakaket and Alatna. But we also attempted to engage in TEK as a framework for contextualizing the information we sought—consistent with the literature from Native Studies, the tribes desired that their own lifeways be represented holistically. That is, they wanted this study to recognize that subsistence practices change through time as well as through environmental and social context—they argued that subsistence cannot be measured in a "snapshot" fashion to understand its role in a society.

Thus this meant, in the first place, that they did not want our maps to depict their subsistence in a "snapshot" format. This is actually what agencies often refer to as "baseline" studies; the work of the Subsistence Division of ADF&G, for example, design their data collection with an accounting of that single year's harvest of whatever is the report's focus. This is true also of Marcotte and Haynes (1985), as well as Holen et al (2012), whose maps proved useful as points of comparison in our data analysis. This is not to say that such "baseline" studies are methodologically wrong, or should be replaced, but that for this particular project, the tribes wanted to direct the mapping to represent subsistence in ways that recognizes the opportunistic and flexible nature of the practice—how their activities on the landscape change through time year to year, and within a person's lifetime, in response to both ecology and household needs. The researchers realized this purpose was not at odds with the desires expressed by the Subsistence Division: that their efforts not be repeated. And methodologically speaking, staff at the Subsistence Division of ADF&G is also more capable of maintaining the consistent application of its own household survey procedures.

Thus in terms of the interview schedule for this study, when we asked participants to map their subsistence, we asked them where they "usually" go, as well as capturing information about that particular year's harvest efforts and successes. Synonyms we used during the interviews to get at this information included "often" or "habitually" or "by habit." We interpreted this to mean within a person's adult hunting life, so the picture we were able to map reflects how people understand their own current needs on the landscape, the ways in which they must be flexible and adapt to each individual year's condition. We estimate that our subsistence use maps capture up to 30-40 recent years of subsistence, since few of elders we interviewed mapped their subsistence (some had not been out on the land in the recent decade), and we did not map out where people said they went as children, unless these were the same areas that they practiced subsistence in recent times. And in the GIS representation of their subsistence pattern, the tribes participated in directing the final version of their land use pattern during the July 2013 meeting—again, their feedback was attentive to representing the pattern in ways that reflect the reality and necessity of their opportunism, as well as reflecting their responses to the fluctuations of game and other resources over time. Our maps meant to depict the human-ecological system; this approach to the mapping revealed inter-relationships with the landscape that might not otherwise have been detected had we chosen another mapping procedure, as articulated in the results.

But our engagement of TEK also meant to listen to the other main concern raised during the June 2012 consultation meeting: elders and the tribes wanted to contextualize their subsistence relationships within the history of development within the State of Alaska. They stated that their own relationships with the ecology and biota of the locale cannot be wholly divorced from the cash economy and its influence on the ecology and the subsistence economy. This, too, meant an approach that represented subsistence in a longer temporal (and spatial) dimension—and indeed, meant that the tribes wanted an *economic* analysis of the subsistence regime, as much as the NPS wanted to flesh out the cultural ecology and traditional knowledge of these communities.

Our approach, guided by the participatory literature, has been to treat these purposes as aligned. Thus our choice of theoretical literature through which to understand our "facts" about moose and climate change needed to also be consistent with the purposes outlined by the NPS, the tribes, and the other interested agencies. If we did not allow the tribes to *also* participate meaningfully in the research design, then it would not be a true research partnership. We wanted to use a theoretical framework that is consistent with the NPS and all the other agency partners, along with being consistent with Native environmental philosophies and the parameters of the project that were negotiated with the tribes of Allakaket and Alatna. The point of this study, as directed by all partners, aimed to produce a representation of the human-environment relationship that inventoried local knowledge, but also contextualized the cultural ecology as it is affected by a broader political economy. Therefore, we turned to the literature on social-ecological systems for the analysis of our data.

Social-Ecological Systems and Food Security

The theoretical literature on social-ecological systems emerged in the 1980s and 90s to bridge the natural and social sciences to address more complex environmental and social problems. Although emerging from the discipline of ecology, it is today an interdisciplinary literature with contributions from geography, anthropology, political science, and biology. By virtue of the hyphen, "social-ecological" systems understand "nature" and the "social" as inseparable ontological categories—like Native knowledges, more "holistic," or at least "complex," in its recognition of humans as ecological actors. Studies of socio-ecological systems employ these common definitions of this "system:" 1) a coherent system with biophysical and social elements that interact and persist over time; 2) a system define-able from many different spatial, temporal, and organizational scales, which may be hierarchically linked; 3) a set of resources (natural, socio-economic, and cultural) whose flow and use is regulated by a combination of ecological and social systems; and 4) a dynamic, complex system with perpetual adaptation and feedback loops that connect its biophysical and social elements (Redman et al 2004; Berkes et al 2003; Machlis et al 1997). Social-ecological systems theory provides interpretive frameworks, such as their narratives of "vulnerability" (referring to potentials to change from a particular hazards or stress), "resilience" (referring to navigating threshholds of change) or of adaptive cycles (referring to cyclical patterns of change within the system) (Chapin et al 2010). Such interpretive frameworks can allow scholars and other publics to envision possible futures and discuss tradeoffs. These scholars have contributed to emerging practices of adaptive management, co-management, and the use of scenarios in community planning workshops (Walker and Salt 2006; Folke et al 2005). These

approaches belie these scholars' commitment to enlightened democratic and participatory processes, but also to science-informed decision-making.

Cultural ecologists like Fikret Berkes were early contributors to theories of social-ecological systems; Berkes marries his training as a fish ecologist as well as his fieldwork on subsistence-based economies to understand these complex systems and their adaptations through time (Berkes and Berkes 2009; Berkes et al 2000a, 2000b; Berkes 1999). Many scholars have analyzed ways that subsistence-based societies are the world's first conservationists, even though many indigenous peoples never had such a word in their vocabularies (Alcorn 1993). Berkes et al (2000) argue that TEK is a form of adaptive management, and in recent years some global communities have been experimenting with "reconnecting" indigenous peoples with "wildlife protected areas" through hunting. They write that attempting to keep separate the natural and social communities produced a more conflictual relationship between humans and wildlife; they argued that allowing traditional practices of hunting in a game reserve in sub-Saharan Africa, for example, could also allow indigenous peoples to return to a relationship of respect and one based on mutual reliance (Hoole and Berkes 2010). The Koyukon in particular have often been written about for their beliefs that subsistence is the act of taking care of the land and biota. Anthropologist Richard Nelson articulated how, in acts such as "making prayers to the raven" and innumerable rituals, the Koyukon exhibit all the characteristics of a modern conservationist; Nelson argued that the Koyukon world is ruled by a strong sense of environmental ethics (Nelson 1986).

Recently, some cultural ecologists have been using the framework of "food security" to understand mixed cash-subsistence economies in the social-ecological system. Loring and Gerlach (2009) conclude that "there are many possible faces of food insecurity; whether quality of life suffers as a matter of chronic hunger in sub-Saharan Africa or chronic obesity, diabetes, alcoholism and depression in sub-Arctic Alaska, each represents some failure of a food system" (p. 474). Both Loring and Gerlach (2009) and White et al (2007) argue that Arctic food security is being deeply affected by a changing climate. Much of the research on both climate change and food security are situated in Inuit communities (e.g. Ford 2009; Ford et al 2008; Chan et al 2006; Theriault et al 2005), while fewer examine the implications of climate change and management to food security for Interior Athabascan communities (McNeeley and Schultzki 2011; Loring and Gerlach 2010).

After the researchers developed these reviews of the literature, they completed the fieldwork design for data-gathering, including the interview schedule and projected foci for the first period of participant-observation.

Participant-observation

To better understand the social-ecological system in terms of the villages' food security, one of the data-gathering methods that the researchers on this project utilized was participant-observation. Participant-observation is a method to understand the meanings that people attribute to their actions and cultural activities, and understand events or groups more holistically (Watson and Till 2009). For this project, Watson collected participant-observation data in the form of field notes, and digital video/still shots (with GPS locating capabilities on a Sony HD handicam) during three periods of fieldwork, although

Huntington's and Ned's "insider" experience and Watson's 10 years of participant-observation in Koyukon villages and the Alaskan Interior, including prior experience in Allakaket, is also brought to bear on these fieldwork insights and images. During the data collection period for this project, each researcher contact in and around Allakaket and Alatna constituted opportunities to conduct participant-observation, beginning with the initial three-day trip to the villages in June 2012. The official community meetings only took one afternoon, thus Watson spent the remaining time getting to know individuals in the community, visiting elders and others that could not make the meetings, and becoming oriented to the culture and history of the villages with community liaison Stan Ned.

The next period of participant-observation took place over 10 days during the moose season, in September 2012. Watson and Ned traveled to Allakaket and Alatna; they visited with residents in both villages, and Watson took notes on people's histories and practices of hunting and taking care of meat. Harding Sam of Alatna took the research party for two days up the Alatna River, "for a ride"—always prepared to have "luck" with an animal (Watson and Huntington 2008). The tribes identified this as a river important to their subsistence and to their cultures—and Harding Sam identified key sites along the route, such as fish spawning areas and sites of historical significance, most of these sites identified by the *Middle Yukon of the Koyukuk River: Atlas of Fishing Places and Traditional Place Names* (YRDFA 2009). What Watson also documented were community perceptions of the challenges and broader patterns of hunting moose, as well as observations of the 2012 moose hunting season. On the whole, the 2012 season was less difficult than in recent prior years, since most people reported it being a "high water" year—meaning their boats could access more places to meet their subsistence needs, compared to recent years.



Figure 4: Foothills of the Brooks Range, on the Alatna River, September 2012
(GPS coordinates Lat 67°1'28.454 Long 153°17'27.80 Altitude 210)

The third major opportunity for participant-observation took place while the research team also collected the community interviews, over two weeks in December 2012. Watson and Machuca stayed for five nights in the Allakaket tribal office, while Machuca stayed the remainder of the trip in a room provided by the school, while Watson stayed in Alatna to complete interviews there. Both researchers kept field notes, and collaborated on insights related to their observations.



Figure 5: At the store in Allakaket, camera pointing toward the Koyukuk River, noon, December 11, 2012
(GPS coordinates lat 66°33'42.848 long 152°39'18.969, Altitude 126.65)

Lastly, participant-observation was employed during summer 2013, when the primary research team of Huntington, Watson, and Ned presented the first draft of the data analysis to the communities. Initially the trip from Fairbanks into the villages was scheduled for early June 2013, but the communities requested to reschedule, as many would be away attending a funeral potlatch in a downriver community. But while the research team waited for this final opportunity, they made efforts to meet with those residents who happened to be visiting Fairbanks, sharing results and listening for feedback; field notes were taken by Watson after these Fairbanks-based meetings, as well as during the final three-day trip to the villages, July 2013. Notes from these encounters directed final edits to the maps and visual materials, while Watson also documented their discussions of the research findings overall.

Interviews

For the interview phase of the research, Watson and Machuca traveled to Allakaket and Alatna in early December 2012. The interviews over the first three days were performed jointly in Allakaket, an effort

to train Machuca and standardize the interviews that they would perform separately, when Watson traveled to Alatna to complete the interviews with residents of that village.

The semi-structured interview schedule was created to understand the local and traditional knowledge of moose, related wildlife species, and climate change. People were asked about their knowledge of moose migration patterns, both seasonally as well as broader patterns; they were asked about eating habits, habitat preferences, and interactions with predators. They were asked about anything they have witnessed about changes in the landscape, and changes in biota. But the interview proceeded as a fluid conversation, with other information also being captured during the discussion, these tangents pursued rather than discouraged.

Many participants also mapped the places where they practiced subsistence in the current year, as well as where they "usually" practiced subsistence. Researchers printed out maps of the area at multiple scales, collecting one group of maps for every participant. Figure 6 shows Harold David, Sr., about to draw a second line on a topographic map printed on an 11x17 sheet; the researcher would orient the interviewee to the map, asking clarification of distances and pointing out the names and features. This is because at the scale reproduced for field work, seeing all features on the topographic maps was difficult to do in some cases, not unlike other such mapping projects relying on paper in the field (Holen et al 2012). In our case, elders with declining eyesight (or no recent subsistence practice) were less likely to draw on any maps, and some homes had very little natural light during these December interviews. Therefore, participants were encouraged to describe the places and distances they had traveled, to supplement the map-drawing work.

Getting precise distances by mere description, within a few miles, was not as difficult as one would think. Hunters and other boat or snowmachine drivers are well aware of how many miles their motors get to the gallon—they learn the efficiencies of their motors given certain weather conditions, or the consequences could be hazardous. For example, researchers witnessed during the September 2012 hunting season that a party of younger hunters required rescue up the Alatna River, as they had ran out of gas. This kind of experience should not be viewed as a dysfunction, but as an important learning experience that many others have made in their youth. These youthful experiences makes one develop ever more reliable calculations of miles per gallon—and thus, asking experienced hunters how far they traveled that year, and "usually," involved sometimes a calculation of miles per gallon for any given trip, but provided very reliable spatial information that we could transform into the GIS.



Figure 6: Harold David, Sr., beginning to map the places where his family practices subsistence

Additionally, the tribes asked that researchers add a question to the interview schedule about potential impacts of the proposed road and general impacts of capitalism and development on the subsistence economy. This was done in part to measure for the tribes the community opinion about the potential road, and also to begin collecting other information the tribes desired for their future decision-making. But researchers also used the opportunity to obtain general perspectives from individuals about the impacts different kinds of development might have on subsistence economies and livelihoods. This final question and topic was always posed at the end of the interviews, so as to not directly bias the responses to the other questions regarding local and traditional knowledge of moose and climate change. However, it should be noted that each interviewee was aware that the topic was to come up in these interviews, given the community meetings and consent process at the start of the interview, which described the many purposes of the research.

As noted in the Big Game study by ADF&G (Andersen 2004b; Brown 2004) and the more recent general subsistence harvest survey (Holen et al 2012), 100% of households in both communities use moose, but not all households specialize in its hunting—indicating an active sharing network characteristic of subsistence economies, but also suggesting to us that random or total sampling strategies would not meet the project goals. Given that the kind of data the project aimed to collect was local and traditional ecological knowledge of moose and climate change, researchers aimed to work with every elder and those subsistence households that were most active on the land; thus we purposefully oversampled elders and "active" hunters, rather than do a random or total household survey. As shown in Figure 7, 68% of our interviewees were age 55 and older, representing both the most experienced hunters and elders in the community.

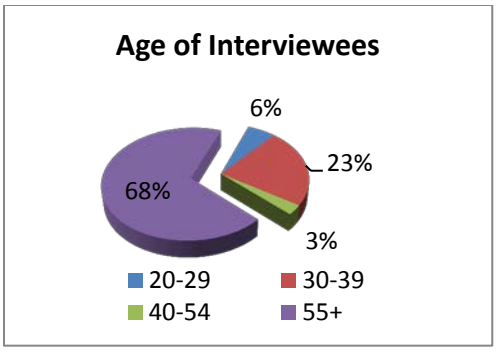


Figure 7: Age of Interviewees

In both Alatna and Allakaket, researchers worked with staff at the tribal offices, as well as with Council members, to identify the "right" people to interview, given the project goals. In Alatna these lists were generated during the September research trip; in Allakaket, this list of people to invite for an interview was generated in December, at the commencement of the interview phase. Researchers recorded a total of 35 interviews: 9 in Alatna, and 24 in Allakaket, representing 7 and 22 households in the respective villages. 2010 Census records show that the population of Alatna was 37 individuals/12 households, and Allakaket (including Allakaket City and New Allakaket) was 171 individuals/62 households (US Census 2010), but Holen et al (2012) calculated that by 2011 the population of Alatna was 32 individuals/9 households and the population of Allakaket 147 individuals/57 households, indicating the variability of numbers of households that spend the entire year in the villages year after year. These seemingly small differences in population from year to year sometimes appear significant when used to calculate response rates; in this project, calculated against the larger Census records, researchers spoke with 54% of households in Alatna, and 36% of households in Allakaket; calculated with Holen et al's (2012) records, we spoke with 78% of households in Alatna and 39% of households in Allakaket. For the purpose of our study such response rates mean less than in a household survey; not only has it been shown repeatedly in the literature that not everyone harvests moose and related game, our purpose was to understand the traditional knowledge and the local knowledge of the most active subsistence users. Thus our sampling strategy was not to be random or produce a "snapshot" of village use, but to collaborate with the tribes to select those individuals who "best" represented subsistence use for their area, because they best represent tribal knowledge of the landscape and ecosystem.



Figure 8: Annette Watson interviewing Julia Simon, December 2012

Some tribal members wished to remain anonymous for these interviews, but many wished to be credited for the knowledge they shared with the researchers. For the sake of consistency in this report, we will not attribute names to quotes in the results, but the transcripts for the public interviews are

available on the website interface created for the project, and like Figure 8, we only use pictures of people who have consented to release their names and images for the study.

Methods to Analyze the Participatory GIS

During the interviews, interviewees were asked where they hunted or gathered "usually" or in the present year. Thirteen respondents used maps and marked these locations on the map. A variety of marker colors were provided and occasionally the interviewer prompted the respondents to use different colors. Not all interviewees used the maps, as noted above, instead describing the places of their subsistence. Those that used the maps were prompted to circle or mark locations with an X, though ultimately the manner of using the maps was left up to the respondent. Some respondents wrote on their maps to indicate the activity at each location or other relevant information.

The maps were then digitized using ArcGIS software. The topographic maps that were used had grids, therefore digitizing was completed by looking at the maps and using the grid lines to match the drawn circles, points, and lines. Three types of shapefiles were created to store the data for each feature: line, point, and polygon. Each file contained an attribute table including the respondent's name, activity, season, and color (to indicate different color usage on the maps), which was edited as each map was digitized. Areas on maps that were indicated using circles were digitized as polygons, allowing the area to be shaded within the program. Points or X marks were digitized as points. Some respondents followed the path of the river using their markers and one respondent marked a large arrow on their map; these indications and markings that were clearly straight lines were digitized as lines. For interviews where spatial data was not drawn, coding the transcripts yielded an excel file for additional spatial locations to enter into the GIS.

Often interviewees mentioned the number of river-miles that was traveled for subsistence use, which because of how important such estimates are to hunting safety, are reliable sources for representing the distances that hunters travel for their subsistence. However, an additional procedure was required to load the spatial information into the GIS. Each of the rivers and trails mentioned during the interviews were digitized; once each line was created, the split tool in editor mode was used to divide the polyline into separate lines of 10-mile segments. The "feature vertices to points" tool was used to convert the end of each new polyline into a point, marking a 1-mile marker along each river. These locations were then digitized into the existing shapefiles that had been created earlier. Transcripts that located activity "100-miles up the Alatna River" were digitized as points. In transcriptions stating, "100 to 110-miles up the Alatna River" point files were digitized for the greatest distance given, which in this example was 110 miles. Considering that respondents' calculations of gas might also include extra distance for safety or changing weather conditions, the calculations may include a buffer, but participant-observation data confirms that these "overestimations" are consistently low amounts, of only a few miles.

The initial polygon files were created by using Model 1, shown in Figure 9. In Model 1 all three of the original point, line, and polygon files were manipulated. Because maps have the ability to marginalize indigenous peoples by ignoring the vital relationships between these groups and their historic lands

(Smith et al. 2012; Wood, 2010), researchers conferred repeatedly with individuals and at the July 2013 meeting about how to represent this overall subsistence pattern. Fox (1998) notes the importance of representing the fluidity and flexibility of traditional lifestyles, so the final point and line files were buffered with three-mile rings, reflecting typical distances where a subsistence user might check nearby lakes or clearings for moose and berries and fire wood—a buffer zone that was confirmed during community meetings. The two new polygon files were merged with the original polygon file and dissolved based on their ID attribute. The resulting dissolved file was run multiple times using the smooth tool with differing parameters. Ultimately, the smooth polygon with a PAEK smoothing algorithm, 15-mile smoothing tolerance, and preserved endpoints was chosen because of the model's ability to preserve the accuracy of the original polygon files.

The final smoothed polygon file was buffered with varying layers of transparency. This was done to reduce the incidence of creating a boundary, and thus a second model was run to create the varying layers of transparency. Each buffer layer was created using linear distance units of 0.5 miles and displayed with a transparency ranging between 80-95%.

At the July 2013 community meeting, however, tribal leaders argued that important edits needed to be made to the subsistence use maps. In the first draft of the maps, areas of most importance along transport routes remained unconnected, thus appearing to tribal members as if they had "helicoptered" in to these isolated areas. Of course, when community members travel to a particular location, they are not only opportunistic, but they are using ground-based transportation. They therefore might check many places along a route—and again, the tribes wanted these maps to represent their "typical" subsistence areas in ways that did not erase their potential use of the other areas. Therefore, another round of edits added transparent smoothed layers that connected these areas of most frequent subsistence.

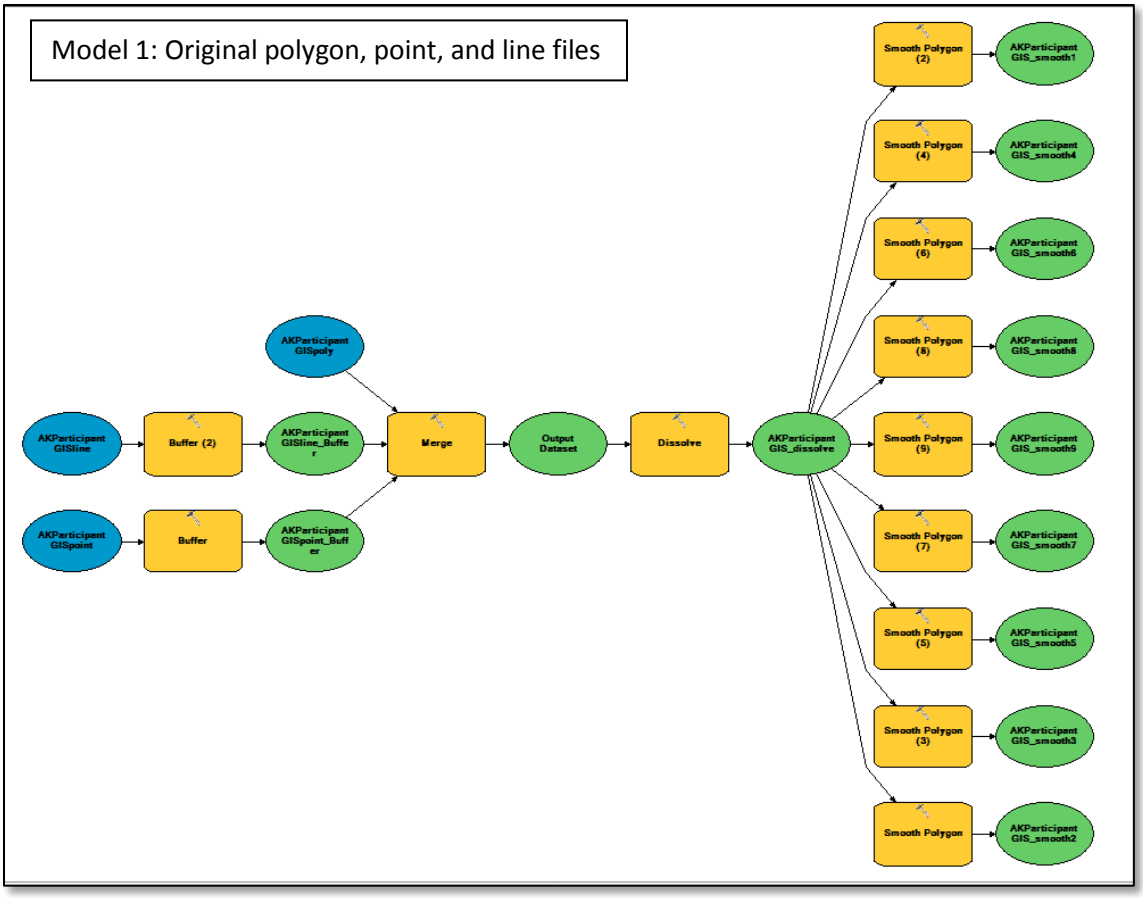


Figure 9: Model 1, first stage of creating subsistence use data layer

Methods of Non-Spatial, Qualitative Data Analysis

All interviews were transcribed using the freeware program Express Scribe. Sections of text that could be transformed into the spatial data, as described above, were catalogued for GIS analysis. The non-spatial data was analyzed via thematic coding (Cope 2010), organized by elements of the cultural ecology or type of climate change observation. A special note about our use of interview data: some people would say what they heard others' say, and we did not include this information in analysis, only what people themselves say they witnessed—with the exception of elders' telling of cultural stories. When these community observations correlated with the natural science literature, we note this in the text.

Overview of the Physical and Human Environment

The Physical Environment: Cycles of Change

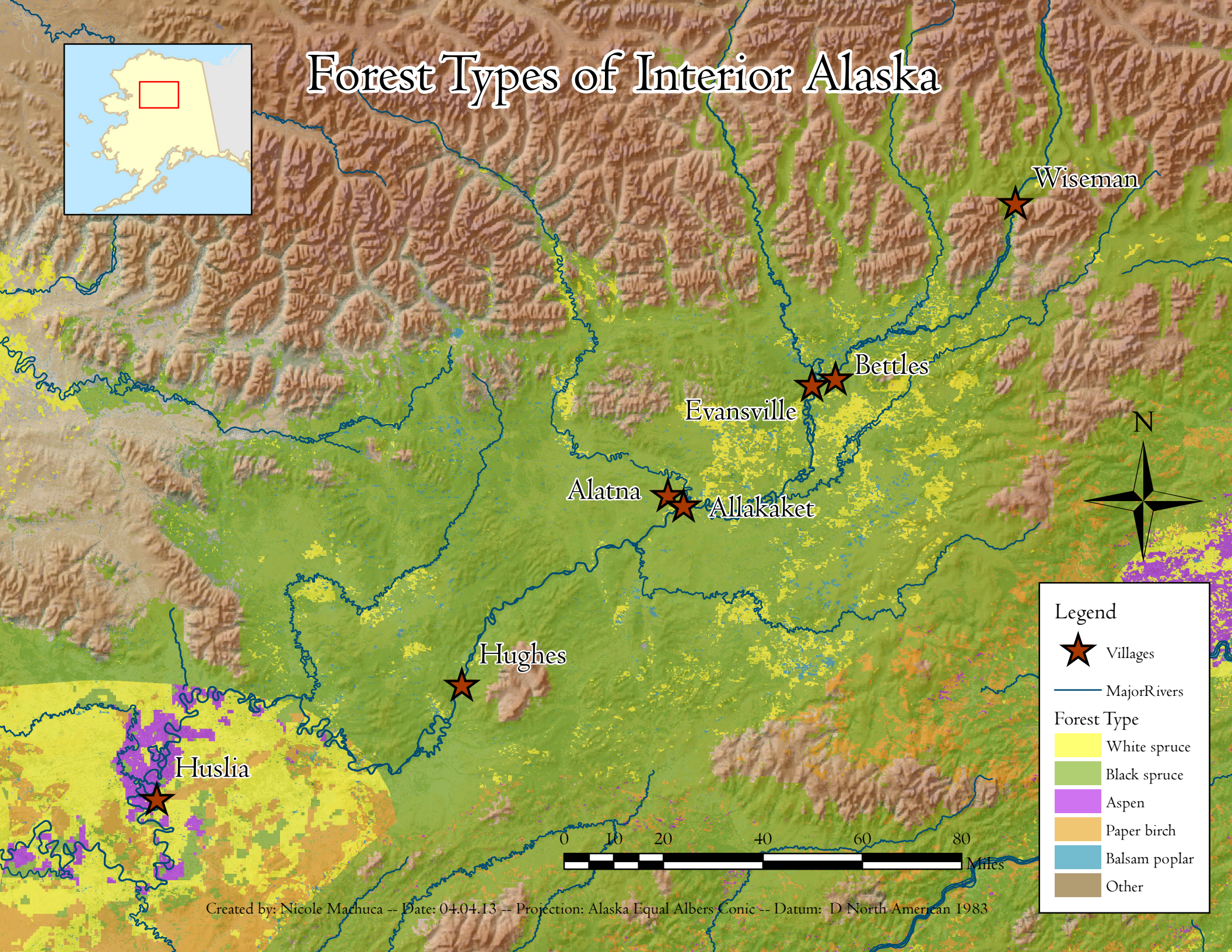
The physical environment of the study area identified in Figure 1 is characterized by the watershed drained by the Koyukuk River, moving south from the Brooks Range through a boreal forest regime toward the Yukon River. This area of Interior Alaska experiences a continental climate, characterized by hot summers and very cold winters. Residents describe the geomorphology as a "natural bowl area" where "the trees and terrain are so thick" it makes it hard to see through (Figure 10).



Figure 10: On the Alatna River, facing north (GPS coordinates Lat 66°57'57.393 Long 153°25'1.469 Altitude 210.92)

Figure 11 maps the forests in this study area: predominantly black spruce, with white spruce stands more concentrated to the east of Allakaket/south of Bettles/Evansville. Black spruce began to dominate these northernmost boreal forests between the last 5000-7000 years (Chapin et al 2010). Within the study area, as shown in Figure 11, the forests are abruptly more diverse further south along the Koyukuk River valley, toward the community of Huslia. Northward into the foothills of the Brooks Range, the forests transition to the dwarf scrub, shrubs, and bare rock of the mountains.

Overleaf: **Figure 11:** Forest type of the study area


Forest Types of Interior Alaska
Wiseman
Bettles
Evansville
Alatna
Allakaket
Hughes
Huslia
N
Legend
Villages
MajorRivers
Forest Type
White spruce
Black spruce
Aspen
Paper birch
Balsam poplar
Other
0 10 20 40 60 80
Miles
Created by: Nicole Machuca -- Date: 04.04.13 -- Projection: Alaska Equal Albers Conic -- Datum: D North American 1983

Wildlife in the boreal regime include small animals such as voles (*Muridae*) Arctic hare (*Lepus arcticus*) (Figure 12), and marten (*Martes Americano*). Waterfowl such as greater white-fronted geese (*Anser albifrons*), pintail (*Anas actua*), and tundra swans (*Cygnus columbianus*) migrate to the area for their breeding and molting cycles every spring. Fishes include a wide variety of whitefish, and sites such as Henshaw Creek are a primary spawning area for chum salmon (*Oncorhynchus keta*). Larger mammals of this boreal region include black bear (*Ursus Americanos*), grizzy bear (*Ursus arctos*), wolves (*Canis lupis*), caribou (*Rangifer tarandus*), and moose (*Alces alces*).



Figure 12: Arctic hare tracks after fresh snow, December 2012, Old Town in Allakaket

But a mere listing of occupant species is an incomplete depiction of this study area; this boreal regime is a dynamic landscape. Many mammal populations fluctuate by well-defined feedbacks from their predator-prey cycles: for example, hare and lynx (*Lynx canadensis*). Other fluctuations and changes have been noted in the oral history record: Nelson et al (1982) and Arundale and Jones (1989) note that caribou had been more plentiful in the area before the 1900s, declined, and then grew in numbers again in the 1940s. From both the literature of the broader Koyukon region and from this study's interviews, residents identified that moose (*Alces alces*) arrived in the area of modern Allakaket and Alatna in the 1930s. Recent studies by ADF&G note that residents shift their efforts/harvests between moose and caribou to meet their subsistence needs from game, depending on which species is more plentiful (Holen et al 2012).

Boreal forests themselves are dynamic, and experience an active fire regime. The study area's forest-fire dynamics are depicted through the following series of maps. Figure 13 represents the overall pattern of the study area's boreal fire regime from 1950-2006, while Figure 14 isolates the parts of the forest that have burned during this period of time, to highlight which forest types have burned where. Figures 15 and 16 provide analysis of fire by decade; Figure 15 shows the Interior's fire by decade, while Figure 16 is a time series of maps by decade. These maps show that within the study area there have been much more recent burnings compared with areas southwest of the study area, around the community of Huslia.

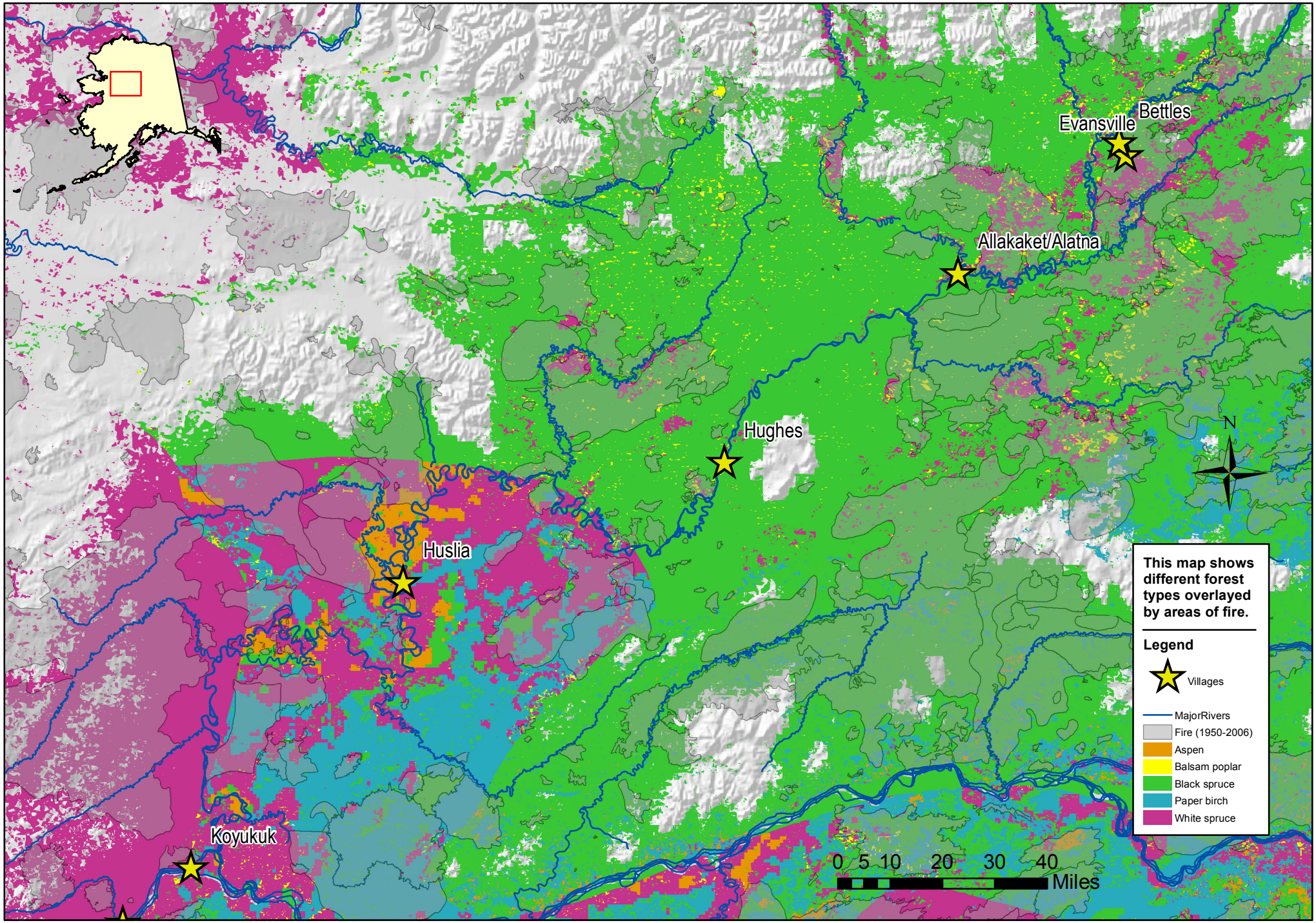
Overleaf: **Figure 13:** Boreal forest fire regime in the Alaskan Interior, 1950-2006

Figure 14: Parts of the forest that burned between 1950-2006

Figure 15: Fire by decade within the study area, 1950-2006

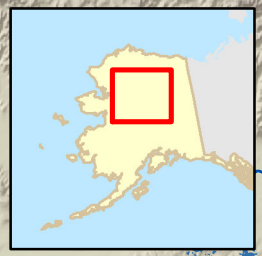
Figure 16: Time series of maps showing fire by decade in Interior Alaska, 1950-2006

Interior Alaska Fire and Forest Type



Created by Nicole Machuca -- Date: 04.05.2013 -- Projection: Alaska Albers Equal Area Conic -- Datum: D North American 1983

Fire and Forest Types of Interior Alaska



This map isolates areas of fire between 1950-2006 and their underlying forest type.

Legend

Places

MajorRivers

Forest Type

- Aspen
- Balsam poplar
- Black spruce
- White spruce
- Paper birch

Wiseman
Ambler
Kobuk
Shungnak
Evansville
Bettles
Allakaket/Alatna
Hogatza
Hughes
Huslia
Tanana
Koyukuk
Kokrines
Galena
Nulato
Ruby

0 10 20 40 60 80 Miles

Created by Nicole Machuca -- Date: 04.05.2013 -- Projection: Alaska Albers Equal Area Conic -- Datum: D North American 1983 -- Source: USDA Forest Service

Interior Alaska Fire History by Decade





Areas burned >1,000 acreas between 1950 and 1987 and acres burned >100 acres between 1988 and 2006.

Legend

- Places
- MajorRivers

Year of Fire

- 1950 - 1959
- 1960 - 1969
- 1970 - 1979
- 1980 - 1989
- 1990 - 1999
- 2000 - 2006

0 25 50 100 Miles

Wiseman
Ambler
Kobuk
Shungnak
Evansville
Bettles
Allakaket/Alatna
Hogatza
Hughes
Huslia
Koyukuk
Galena
Nulato
Ruby
Kokrines
Tanana

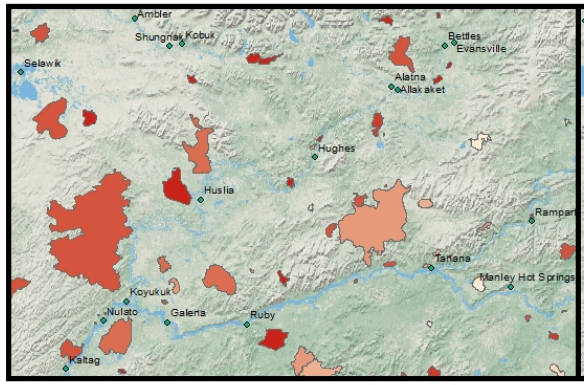
Created by: Nicole Machuca 04.04.13 -- Projection: Equal Albers Alaska -- Datum: D North American 1983

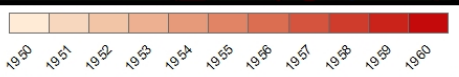
Interior Alaska Fire History by Decade 1950 - 2006

Includes areas burned greater than 1,000 acres between 1950 and 1987
and acres burned greater than 100 acres between 1988 and 2006

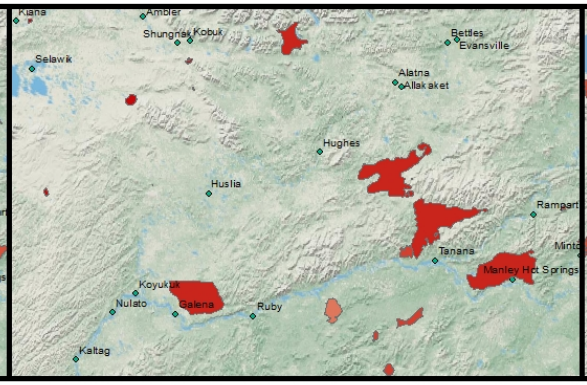


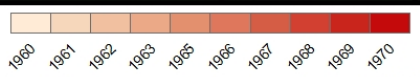
Fires 1950-1960



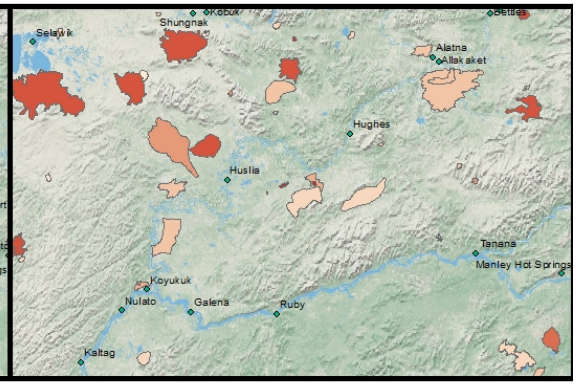


Fires 1960-1970



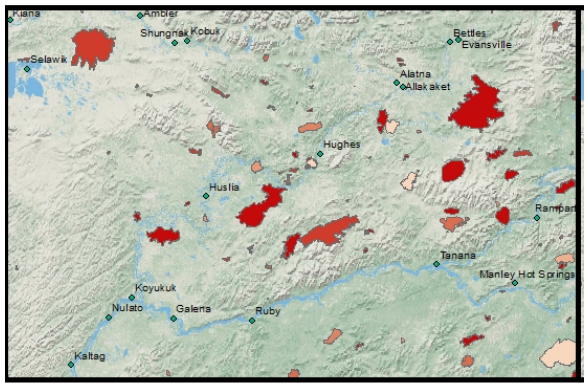


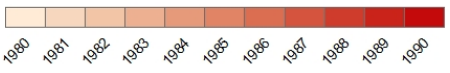
Fires 1970-1980



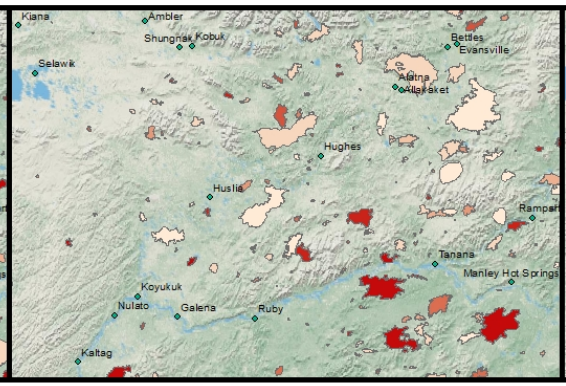


Fires 1980-1990



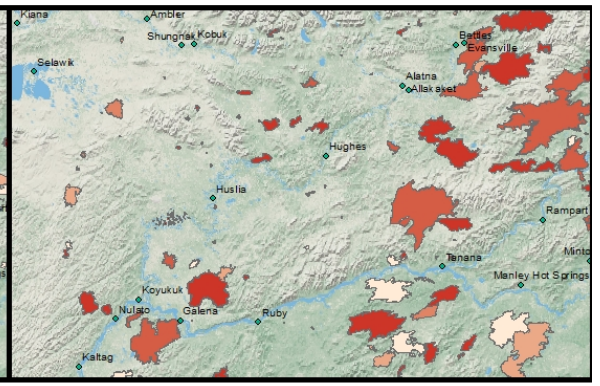


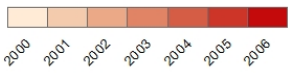
Fires 1990-2000





Fires 2000-2006





Source: BLM and Alaska Fire Service

Created by Jennifer Gross November 17, 2012

This boreal fire regime persists upon what has historically been an area of permafrost. Data recorded from 1968 locates major permafrost zones throughout the area; mountainous lands north of the Koyukuk River have continuous permafrost, within mountainous areas to the east and along many rivers lay discontinuous permafrost, while the remaining areas have permafrost categorized as thick to thin (Figure 17).

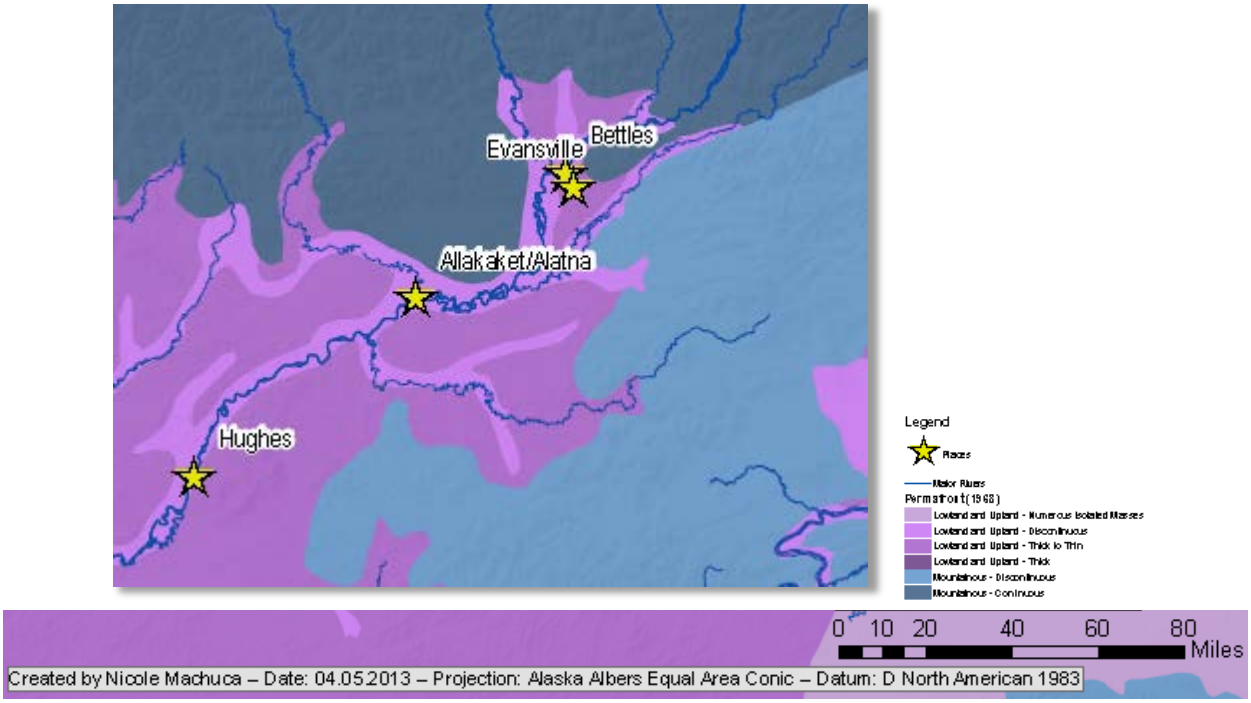


Figure 17: Permafrost pattern recorded in 1968

These patterns are of course influenced not only by geomorphology but also by the overall climate pattern. Although temperatures in the study area have been recorded as low as -70^{o} below zero Fahrenheit, it is not the extremes that matter most to understand climate dynamics, but the averages. Although residents of Allakaket and Alatna say their temperatures are often colder by 5-10 degrees than nearby Bettles, the most complete NOAA climate record in the area comes from the Bettles Station, which dates from 1951 (NOAA 2014). Figure 18 charts the average maximum and minimum temperatures per month for the last two thirty-year periods, the dashed lines representing the period 1951-1981, while the solid lines represent 1982-2014. This comparison tells a story of change in winter months, with distinctly warmer December months in the study area. These patterns correlate with a decreasing amount of snow on the ground, especially in the spring months of the year—significant because snow cover influences the rate of warming (Chapin et al 2010; Euskirchen et al 2009).

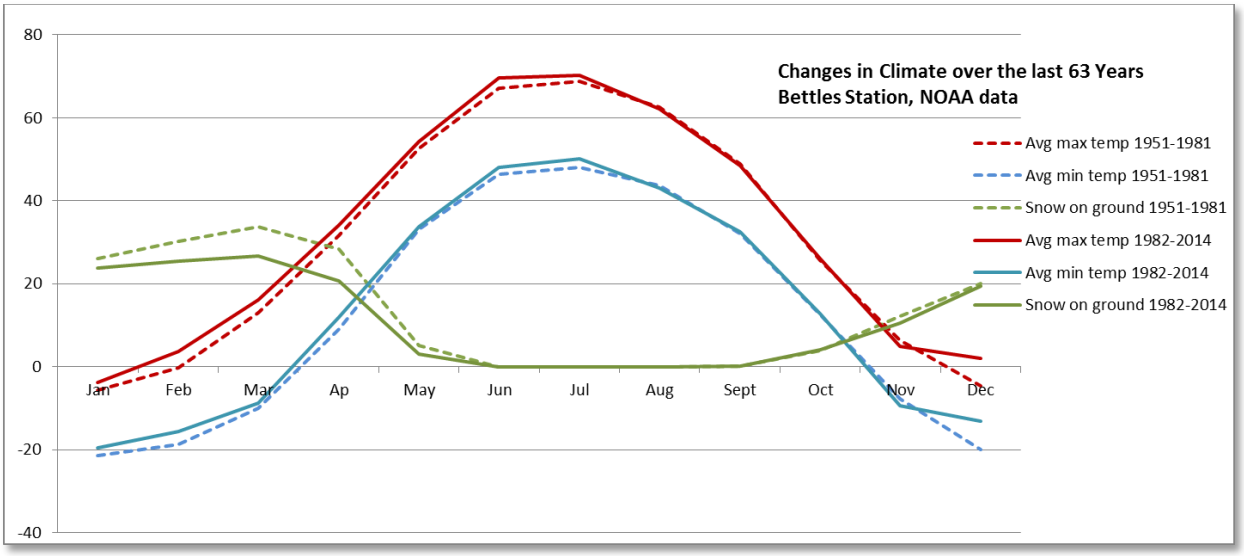


Figure 18: Climate change at the Bettles Station, in degrees Fahrenheit and inches (data from NOAA 2014).

These localized results are consistent with patterns that have been reported elsewhere in Alaska and the Arctic more broadly, with boreal forest biomes warming twice as much as the global average (Chapin et al 2010; ACIA 2004). Chapin et al (2010) explain that

> The Alaskan boreal system remains quite resilient but is undergoing changes in ecosystem and landscape structure, feedbacks, and interactions that, with continued warming, will likely cause reorganization or potential transformation to a fundamentally different system (Chapin et al 2010, 1361).

The Human Environment: Prehistory to the 20th Century

In their study of boreal ecosystem change, Chapin et al (2010) articulate their understanding of these long and short term changes in relationship to the Athabascan groups who have also lived with these changes over time. Indeed, humans have lived in the study area of this part of the boreal forest for thousands of years—even longer than the beginning of the boreal forest (Arundale et al 1989). Chapin et al (2010) therefore suggest that these social-ecological systems have co-evolved.

Like other species, variability and dynamism were also always characteristic of the peoples that lived in the area—in terms of their land use patterns as well as temporal practices during the seasonal round for subsistence. The current villages of Alatna and Allakaket, laying at opposite sides of the Koyukuk River, represent hundreds, even thousands of years of contact and interaction between the northernmost bands of Koyukuk Indians who eventually settled Allakaket, and the Inupiat nations of Alatna, who came inland to trade from the Kobuk and Selawik River areas, coming from as far west as Kotzebue Sound (Holen et al 2012; Englehard et al 1993; Clark 1970).

Near the confluence of the Koyukuk and Alatna Rivers was one of the major sites of pre-contact trade along the Koyukuk River, between coastal and Interior cultural groups, and both archaeological and oral

history evidence recount a sometimes tense history of this Inupiat and Koyukon contact, with shifting territorial boundaries between these cultural groups (Watson and Huntington 2014; Holen et al 2012; Huntington and Elliot 2002; Englehard et al 1993; Arundale et al 1989; Clark 1970).

This history of trade is significant; these lands were not settled so much because resources were plenty, like other Interior villages such as Koyukuk and Nulato, near the confluence of the Koyukuk and Yukon Rivers. This area at the confluence of the Koyukuk and Alatna Rivers was settled because of its location as a boundary, and reflective of long-standing Native territorial claims. The earliest human occupants of the study area were semi-nomadic, traveling as bands or smaller family groups, with a complicated cycle of seasonal camps, shifting throughout the winter (Holen et al 2012; Arundale and Jones 1989). Nelson et al (1982) write that before rifles were introduced as a hunting technology, the people of the Koyukuk River told of times of starvation. From late February through the spring, a family may not have cached enough—and maybe the snow was too deep to travel to a place with more food sources. Nelson et al (1982) continue:

> If the thaw began and then a cold spell set in, real hardship could result. Open water re-froze, causing waterfowl to return south and preventing the emergence of muskrat and beaver. Hares were difficult to catch in snares because crusted snow freed them from their established trails. If any…caribou were present in the area, they could not be approached on the noisy crust….people were sometimes reduced to searching the bare places beneath trees for little migratory songbirds that froze to death there (Nelson et al 1982, 220).

Although Russian explorers never arrived to the confluence of the Koyukuk and Alatna Rivers, after the purchase of Alaska by the United States in 1867, non-Natives came to the area in rapid succession. After a year-long wave of disease, in 1884 the first whites reached the mouth of Lake Creek to trade, while in 1885 US Lieutenant Henry Allen journeyed to the Koyukuk and drew the earliest maps and images of the land and its peoples—the Koyukuk and the "Allenkaket," or Alatna River, shown in Figure 18 (Watson and Huntington 2014; Arundale and Jones 1989; Allen 1887). Allen described the Alatna River in such a way as to foreshadow the misunderstandings between Natives and whites for the next hundred years:

> The mouth of the Allenkaket is in approximate latitude 66°37', longitude 151°16'. Below it is a very high cut bank of clay, called by the natives Unatlotly. Why this should receive a name when prominent mountain peaks did not I could not ascertain (Allen 1887, 81).

Here is evidence of what landscape features were most important to the people of the area to practice their subsistence—and evidence of non-Natives' conflicting ideas about naming places. What Allen did not realize is that the Inupiat and Koyukon of this area had layered the landscape with names that denote their use of and spiritual associations with the landscape, what Arundale and Jones (1989) would begin collecting, and later staff with the USFWS and the Yukon River Drainage Fisheries Association would publish as the *Middle Koyukuk River of Alaska: An Atlas of Fishing Places and Place Names* (YRDFA 2009). But Allen does document a landscape alive with both Koyukon and Inupiat travelers, numerous villages, trails, and camps along the Koyukuk, mapping his explorations of the river (Figure 19).

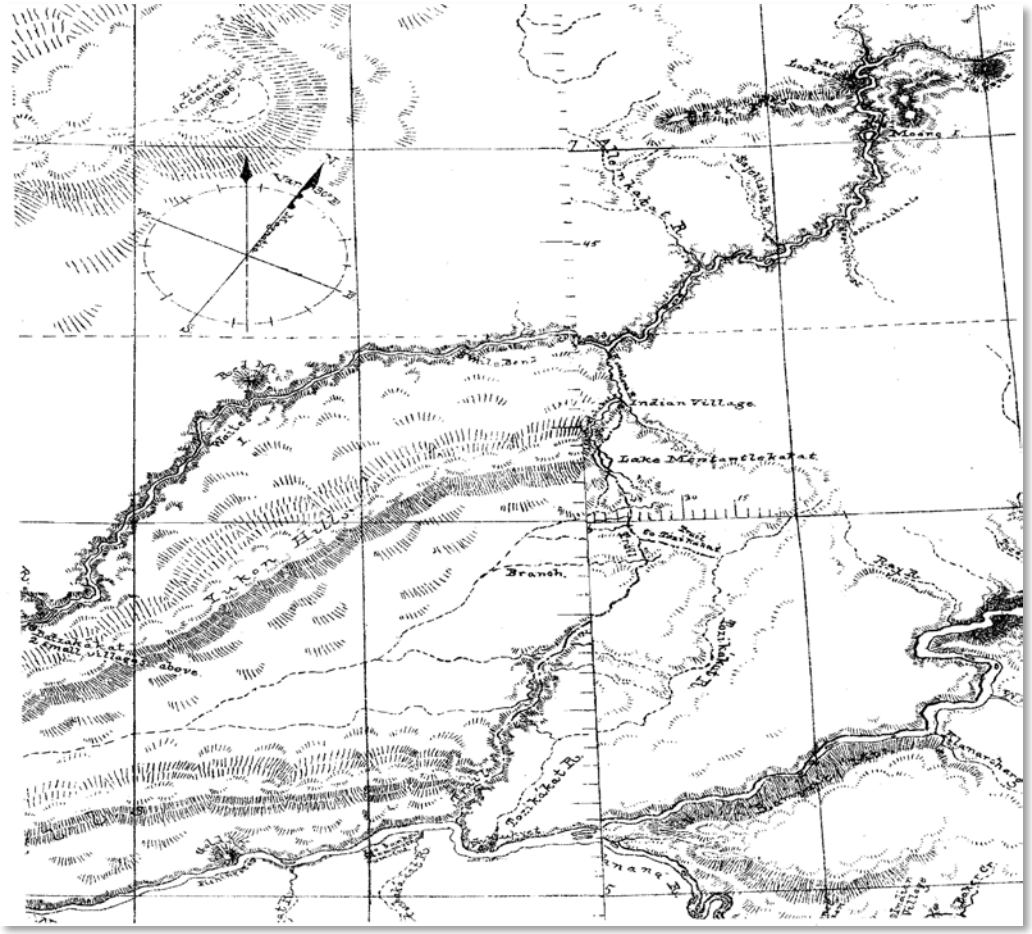


Figure 19: US Lieutenant Henry Allen's drawing of the Allenkaket (Alatna) and Koyukuk Rivers, 1885 (Allen 1887)

After Allen's journey, gold prospectors travel into the country, first around Hughes, then up the Alatna (still called the Allenkaket) by 1897 (Arundale and Jones 1989). At the turn of the 20th century, people still used their subterranean homes, scattered across many areas of prime subsistence (Morlan 2000; Arundale and Jones 1989; Clark and Clark 1974). But the gold rush history is not exclusively a non-Native history of the region, as Native peoples took the opportunity to incorporate gold into their livelihoods. For example, when one of our interviewees described his use of areas on the maps, he included this use and history as well:

> Yea here's… back Old Man [Kanuti] right there I went back almost a year ago mining too... and then Indian Mountain's right there. The reason they call it Indian Mountain, my Mom's grandpa discovered gold in 1909. They never gave him his name because he was as Indian. So he sold it. They still didn't recognize Alfred Isaac. That it was him... They just said an Indian. And then he sold it in 1910. But I was right there at Black Creek, uh, this summer and, uh, I got some gold. That's kind of funny because 100… and 103, or 1909. So that's, uh, 102 years later. I was where my great grandpa discovered gold so that was pretty cool.

As the gold rush began, Native peoples in the area began to take up longer residence in those places that become the modern villages of Alatna and Allakaket. Holen et al (2012) recount that the Alatna River area had become known as the territory of Eskimo groups from the Kobuk area at least by the 1850s, and by early 1900 these are the families that settled in the village today known as Alatna.

The first Episcopal missionaries in the area established St. John's-in-the-Wilderness in Allakaket in 1906, near present day Allakaket, prompting people to move there from their camps that lay south. And although people through the present day use some "old village" sites and seasonal camps located in traditional areas of resource availability, Arundale and Jones (1989) recount a history of decreasing mobility after Allakaket became a winter village. They write that the store in particular drew more and longer winter residence in the village. Figure 20 shows their typology of settlement patterns during key times during this transition to a mixed cash-subsistence economy. In the 1890s, of special note is the regular pattern of shifting winter camps with the larger family units, reflecting the need to move for both food and timber for fires; the subsequent time periods reflect the emergence of the trapping/cash economy, and along with regular school attendance by children, accompanied less movement of whole families and more and smaller short or overnight trips just by men.

Residential progression					Ancillary sites			
1890								
Site type:	Winter gathering site (small village)	Winter base camp (small village)	Winter traveling/ foraging camp	Winter gathering site (small village)	Men's traveling camp and others almost certainly existed but Clark does not describe them			
Dwelling type:	Semi-subterranean house or skin tent if visiting others	Semi-subterranean house	Conical skin tent	Semi-subterranean house				
Size:	Several households	4-8 households	1 or more households	Several households				
Duration:	1-2 weeks	Semi-permanent but used 1-2 months	Usually one night, occasionally longer	Gathering 1-2 weeks Village semi-permanent				
Example:	None given	None given	None given	None given				
Notes:	May or may not be the same as winter base camp			Same gathering site as earlier in winter				
1932								
Site type:	Winter gathering site (village)	Winter base camp	Winter hunting/ trapping camp	Winter gathering site (village)	Men's traveling camp	Alternate hunting/ trapping camp	Family traveling camp	Temporary gathering site
Dwelling type:	Log cabin	Log cabin	Canvas tent	Log cabin	Temporary "siwash" shelter	Canvas tent	Canvas tent	Canvas tent
Size:	Several households	One household	Single household	Several households	Usually 1-4 men	Usually 1-2 men	1 to several households	Several households
Duration:	1-2 weeks	Permanent but used about 1 month	2-4 weeks	Gathering 1-2 weeks	One night	1-2 nights	1-2 nights	1-3 nights
Example:	Allakaket	Henshaw	Holil Yeet	Allakaket	No name given	*Minkokk'a*	*Minkokk'a*	*Too Kkaan'*
Notes:	May also serve as a winter base camp	Other winter base camps like South Fork had more residents		Same winter gathering site as earlier in the winter; used by some as winter base camp		One of the winter hunting/trapping camps where a tent was left up all winter	One of the winter hunting/trapping camps	A specialized version of the family traveling camp
1948								
Site type:	Winter gathering/ base camp (village)		Winter trapping/ hunting camp	Winter base camp (village)	Men's traveling camp	Alternate trapping/ hunting camp	Family traveling camps were probably used but are not described in the narrative because the winter trapping/hunting camp was within a day's travel of Allakaket	
Dwelling type:	Log cabin		Canvas tent, log cabins	Log cabins	Temporary "siwash" shelter	Canvas tent (left up for winter)		
Size:	Several households		3-4 households	Several households	Usually 1-4 men	Usually 1-2 men		
Duration:	Permanent; gathering lasts 1-2 weeks; many women and children stay all winter		3 months (also used at other seasons)	Permanent	One night	Used one night at a time throughout winter		
Example:	Allakaket		Blackjack	Allakaket	None given	None given		
Notes:								
1953								
Site type:	Winter gathering/ base camp (village)		Winter trapping/ hunting camp	Winter gathering/ base camp (village)	Men's traveling camp	Alternate trapping/ hunting camp	Family traveling camp	
Dwelling type:	Log cabin		Log cabin	Log cabin	Temporary "siwash" shelter	Canvas tent (left up for winter)	Canvas tent or cabin	
Size:	Several households		Two men; for 1 week, 1 household	Several families	Usually 1-4 men	Usually 1-2 men	Usually 1 household	
Duration:	Permanent; gathering lasts 1-2 weeks; many women and children stay all winter		1- to 2-week periods throughout winter	Permanent	One night	Used one night at a time throughout winter	1-2 nights	
Example:	Allakaket		*Ts'ibaa Nagga*	Allakaket	None given	None given	None given	
Notes:							Wherever possible, people used existing cabins or camps along their travel route	

Figure 20: Arundale and Jones (1989) typology of late winter subsistence and settlement patterns

These winter traveling patterns were of course followed by travels in spring, summer, and then fall—called the seasonal round for the hunter-gatherer subsistence economy. Spring was time to harvest

waterfowl in lakes, and summer was time for fish camp (Figure 21). Fall was the time to hunt bear, and prior to the 1900s and after the 1940s, caribou was a major source of winter game (Nelson et al 1982). Corresponding with their increasingly more sedentary life, moose (*Alces alces*) arrived into the country in the 1930s, and families in the area incorporated this new source of food in ways that maximized the efficient use of the entire animal, although fish provided about an equal share of provisions for the year (Nelson et al 1982).



Figure 21: Bergman family, heading to fish camp from Allakaket in handmade boat, June, early 1930s (Bertha Moses collection, University of Alaska Fairbanks (UAF-1985-67-1)).

The development of permanent homes in the big "winter camp" was oriented to most easily access sites of subsistence, and thus the log buildings of both Alatna and Allakaket were built close along the shores of the Koyukuk, the main route of transportation (Figures 22 and 23).



Figure 22: Allakaket, June 1961 (Fritz Milo, Ward Wells Collection, Anchorage Museum, AMRC-wws-3380-116A)



Figure 23: Location of "Old Alatna," along the bank of the Koyukuk, behind Oscar Nictune's parents (Peter Nictune (Niugtuun) and his wife (Tikichuaq)), in the early 1940s
(Bertha Moses Collection, Polar Regions Archives, Rasmusen Library, University of Alaska Fairbanks, Photo # 85-067-9)

In springtime, however, ice jams sometimes causes flooding on parts of the Koyukuk; Clark (1970) records that a significant flood affected both villages in 1964. But in 1994 a tremendous flood inundated both villages and changed the way both villages developed.

After the 1994 flood, the people of Alatna relocated their entire village to the ridge that lay behind the original village (Figure 24); the original village is now referred to as “Old Town” (Figure 25).



Figure 24: Site on the Allakaket side of the Koyukuk, one place where people ferry across the river to reach Alatna, located now on the ridge running parallel to the river; note boat landing area on opposite shore; from there it is a 3-minute drive to the new village of Alatna



Figure 25: Old town of Alatna, September 2012, now a site for harvesting highbush cranberries (GPS coordinates lat 66°33’47.171 long 152°40’16.599, Altitude 117.26)

But unlike Alatna, the “old” Allakaket was not abandoned as residences; while all new structures are built upon a ridge south of the original town footprint (Figure 26), many residents (but especially elders) remain living in homes along the river, in some cases in structures that pre-date the 1994 flood. The overall change in footprint of both villages was accomplished through federal and state relief and development programs—which only funded building and renovating away from flood zones. Not only do many residents of Allakaket still live in the old town, but the store, post office, and school remain near their original sites, and the Allakaket tribal hall (Figure 27) is now approximately a midpoint between the old and new town. With about a mile now separating the new and old town, transportation has become more of a daily burden that requires either a vehicle/gas or time/warm clothes, whether the purpose is to get to and from work, or to and from the boat; more often, it is a combination of these transportation needs within the week or even a day’s labor that must be budgeted.



Figure 26: Facing south, the road leads past the Allakaket tribal hall (log structure in foreground) to residences built after 1994, on the ridge south of the airport and the old town; with the larger footprint, many people walk the multiple miles to get where they need to go (photo from March 2005).



Figure 27: Facing north, the Allakaket tribal hall (octagonal log building) and city office across the street; the road continues toward the left of the picture, toward the old town
(GPS coordinates of the photo lat 66°32'30.738 long 152°39'15.520, Altitude 180.86)

Along with these changes to the spatiality and rhythms of life were also changes to how the land became managed, and what emerged was the modern regulatory and land ownership context (Figure 28). Especially after Alaska becomes a State in 1959, many of the areas that once were occupied and managed only by Inupiat or Athabascan society, had become owned or managed to serve many more publics than the local peoples living on the Koyukuk. Gates of the Arctic National Park and Preserve today lies to the north and west of Alatna and Allakaket, while the Kanuti National Wildlife Refuge forms its boundaries to the southeast, named for the Kk'toonootne River ("well-traveled river by both man and animals"). The Alaska Native Claims Settlement Act (ANCSA 1971) also created Native administrative agencies who also became land owners and managers in the study area: the regional for-profit corporation Doyon, and the village corporation K'oyitl'ots'ina, whose lands are managed within the State of Alaska system for wildlife.

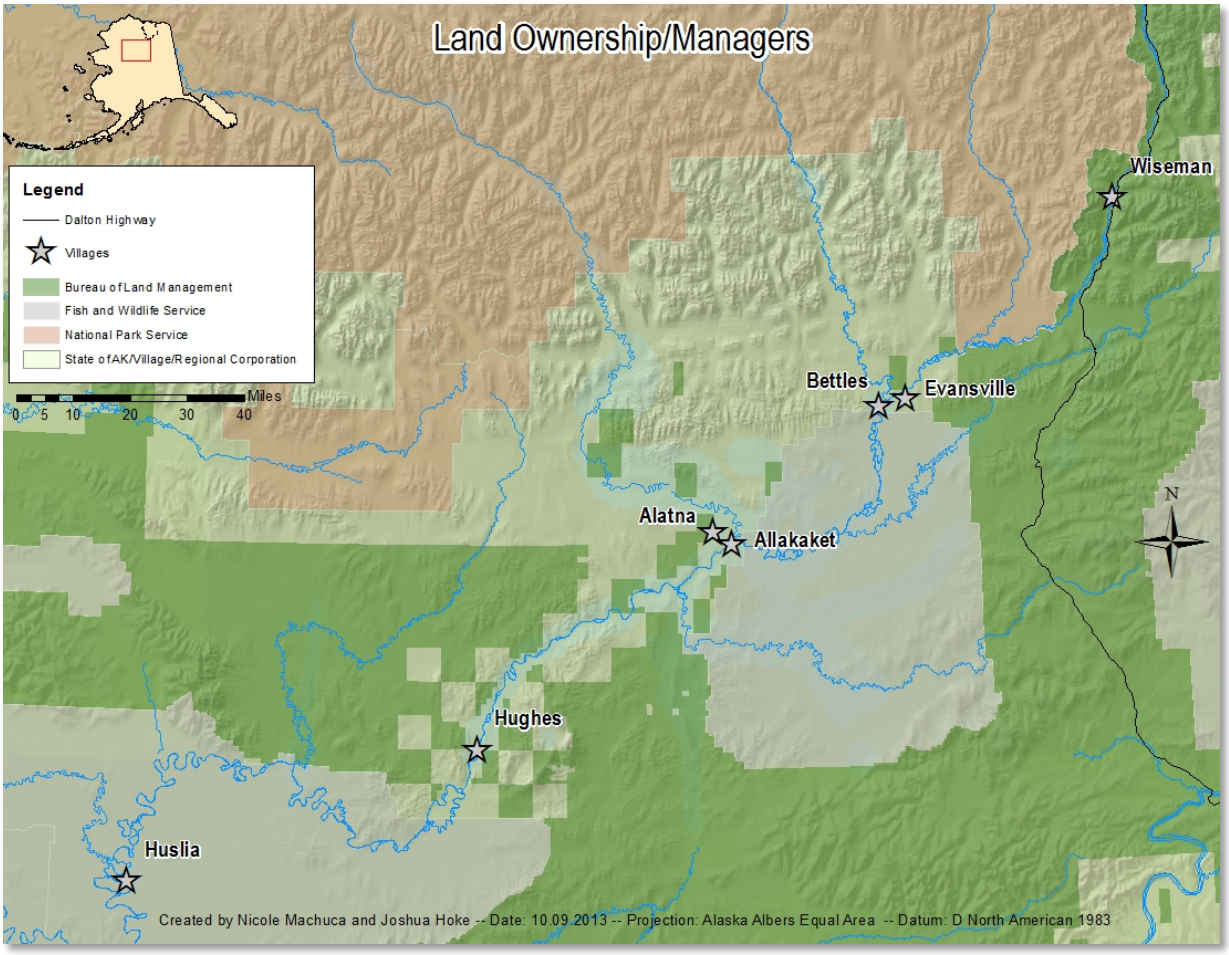


Figure 28: Map of land "owners" and managers within the study area, post-ANCSA and ANILCA

The Modern Social-Ecological System

Nelson et al (1982) write about how living a more sedentary life might make subsistence more difficult, because resource availability in this part of the Alaskan Interior exhibits the greatest shifts in both space and time. In this final section of the "Overview of the Physical and Human Environment," we articulate the current social-ecological system as revealed through our primary data collection and analysis in Alatna and Allakaket.

Figure 29 presents the overall map of current subsistence use of the landscape by Alatna and Allakaket residents: where people said they "usually" go. This map represents the entire spatial area that the tribes say is currently required for their yearly subsistence—this includes the entire modern subsistence round as it is practiced by these tribes of Inupiat and Koyukon. Where the white areas are more opaque means that more of our respondents reported using these areas. Maps are not mirrors but representations of the overall pattern, thus we have a caution when reading these maps: what appears to be a "ghost line" along Hogatza River is an unavoidable effect of our digitization of the hand drawn

maps, and is representing travel along that river.

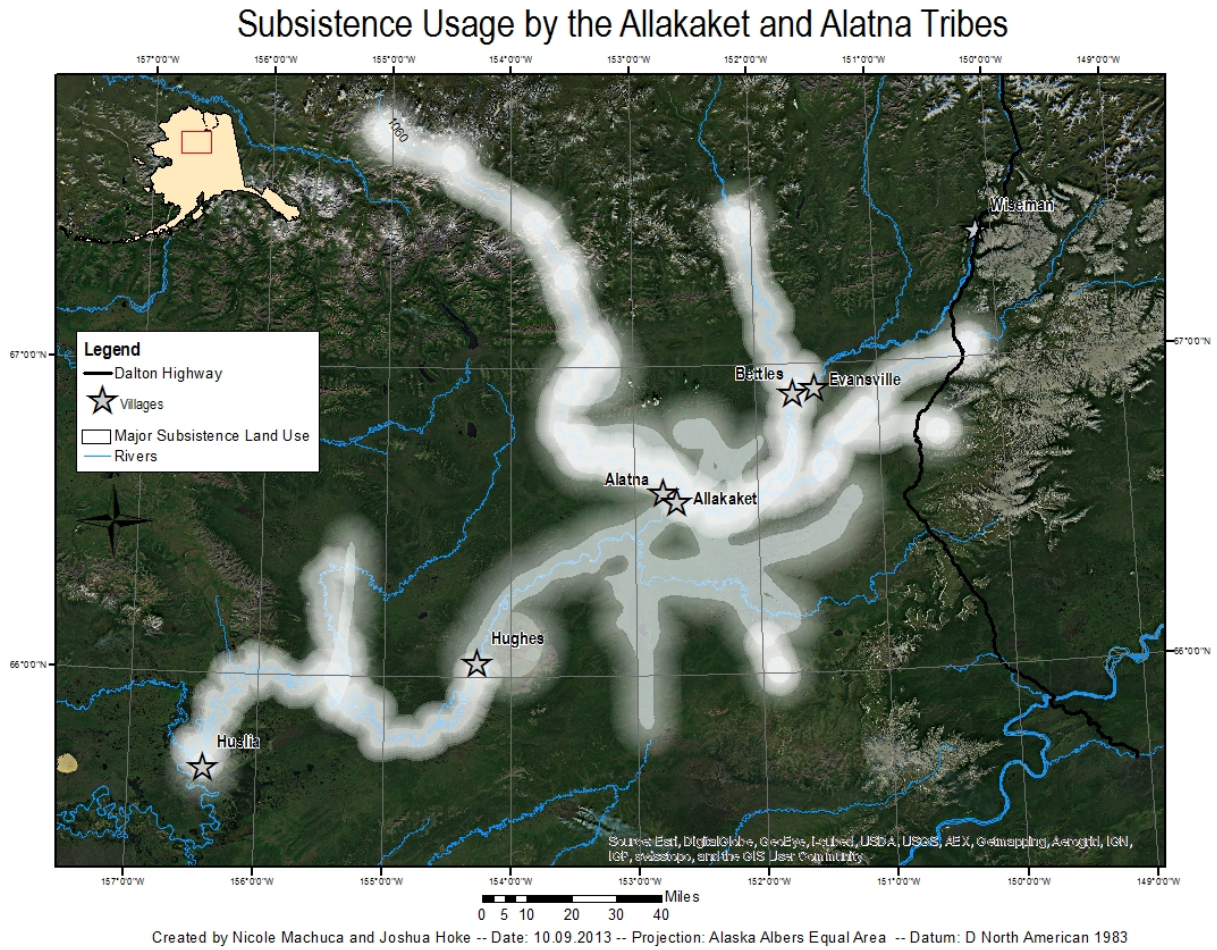
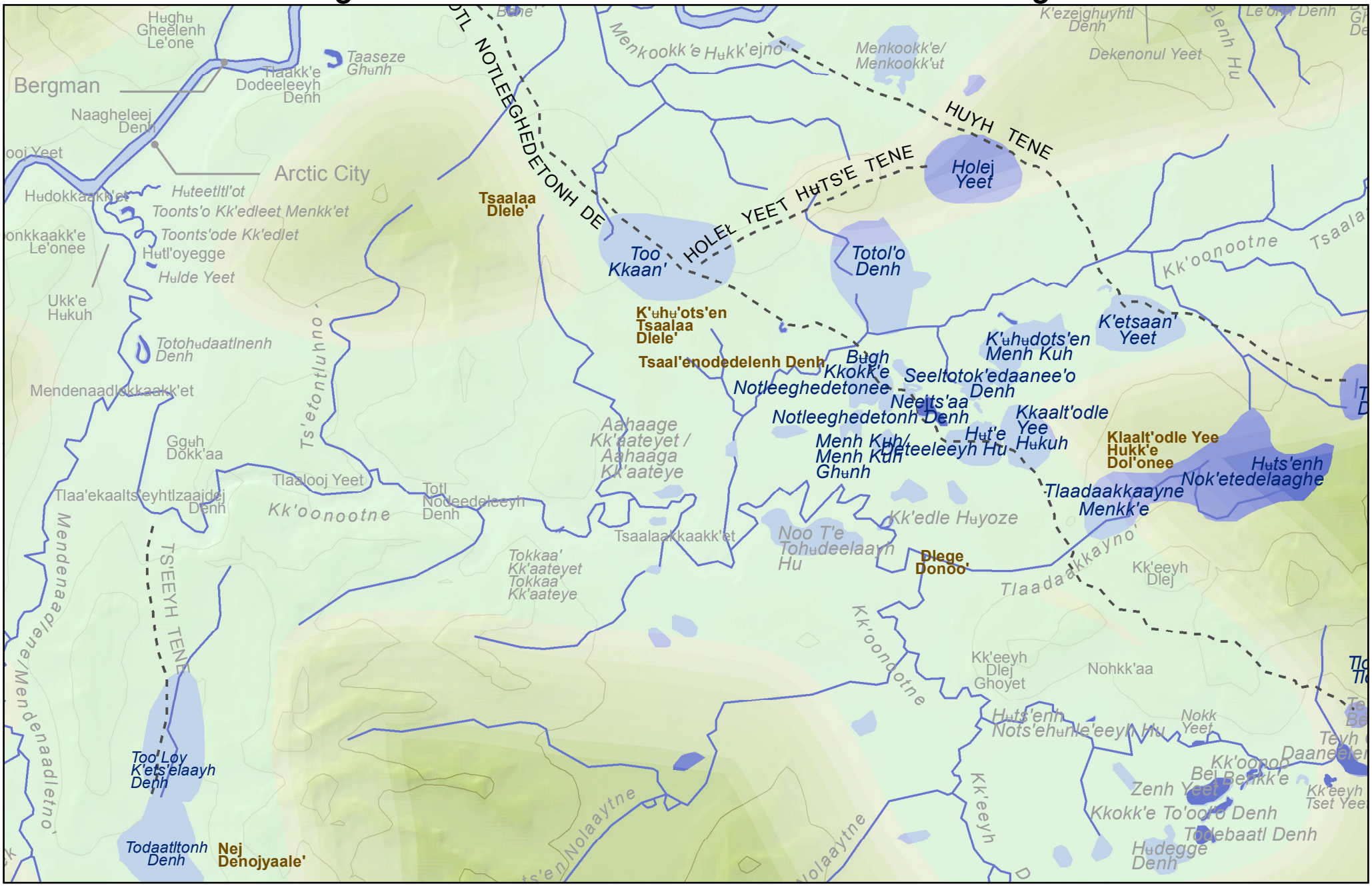


Figure 29: Map of Subsistence Use by Allakaket and Alatna Tribes (what looks like a ghost line near Hogatza River, north of Huslia, is a legacy of the digitization process, and should be read as aligned with the Hogatza River)

This representation of current subsistence use correlate with past subsistence use (Figure 30). Figure 30 overlays our subsistence use information with one of the maps with Native names of features on the landscape—showing these current areas of subsistence use correlate to many of these areas whose names were documented in the 1980s-90s (YRDFA 2009).

Overleaf: **Figure 30:** Subsistence Use in the Kanuti Area

Subsistence Usage of the Allakaket and Alatna Tribes along the Kanuti River



Legend

Land Usage

0 3 6 12 Miles

N

Created by: Melanie Smith & Nicole Machuca
Date: April 26, 2013
Projection: NAD 83 Alaska Albers
Datum: D North American 1983

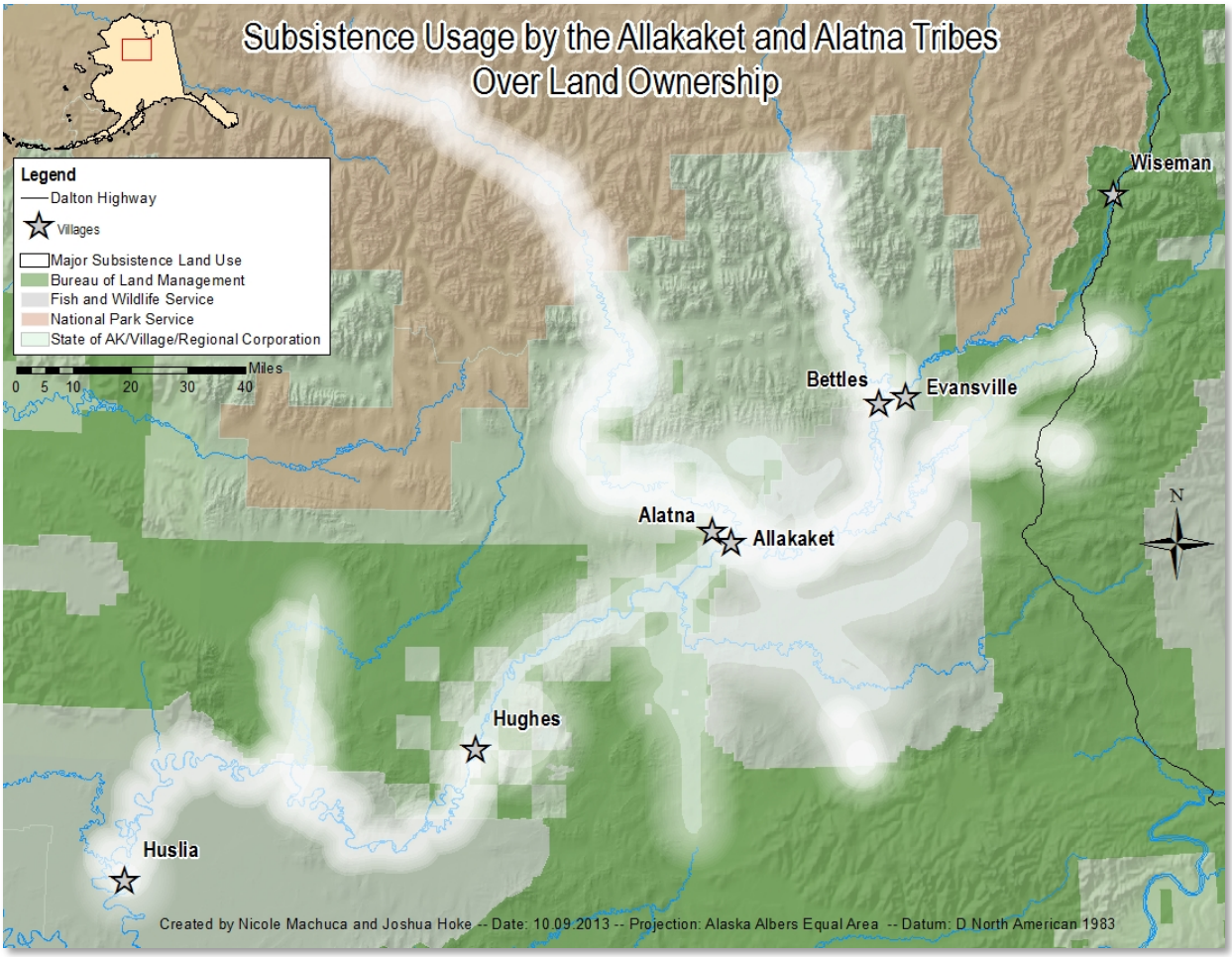


Figure 31: Subsistence use and land management boundaries

Figure 31 shows this pattern of subsistence use over the land management boundaries. In our interviews, people described their use of the different areas for their subsistence as they drew or spoke about the places where they practiced subsistence. Many areas closest to town were the places for summer and fall berry picking activities. Areas deeper into the Brooks Range via the Alatna and John Rivers were places for sheep hunting and some bear hunting, and (though limited) moose hunting; along all the rivers were areas people said they would hunt moose (Figures 32 and 33). Most of the subsistence use south of Hughes, up Hogatza River and south into Huslia is for moose in the falltime; these areas are a different game management unit, and have a greater abundance of moose than in Allakaket and Alatna's GMU, so it is unsurprising that use by the residents of Allakaket and Alatna would extend to these areas, and to the people with whom they are also closely related.



Figure 32: Bull shot September 20, 2005 between Hughes and Huslia, on the Koyukuk River south of Cutoff. This moose shows evidence on the back haunch of being in rut; moose roll in their urine to increase their scent during the rut.

Interviewees also identified places where recently caribou had come back into the area, which include more mountainous areas, including around Hughes. In making these subsistence use maps people would also identify areas of wolf kills, beaver and other trapping activities, and bear hunting activities near the villages and throughout the Kanuti area, where also they documented hunting waterfowl. People also pointed out important fishing locations (Figure 34).



Figure 33: "Larry's Cabin," on the Alatna River—a key site for community subsistence
(GPS coordinates lat 66°43'3.951 long 153°16'57.444 Altitude 167.08)



Figure 34: Traveling to a site to set a net in falltime near Alatna; the next day's catch included whitefish and chum salmon, distributed to elders and relatives in both villages.

When layered on top of the forest type (Figure 35), the overall subsistence use pattern reveals how forest diversity is highly correlated to these decisions about where to subsist. Subsistence use targets areas of higher forest diversity; this is even reflected when you layer the subsistence use over the maps

of historic fires in the area (Figures 36 and 37). Since most of the subsistence activity in the northern parts of the Alatna and John Rivers involve non-moose species, the areas where people do go for most of their subsistence needs are areas that are potentially better habitat for moose.

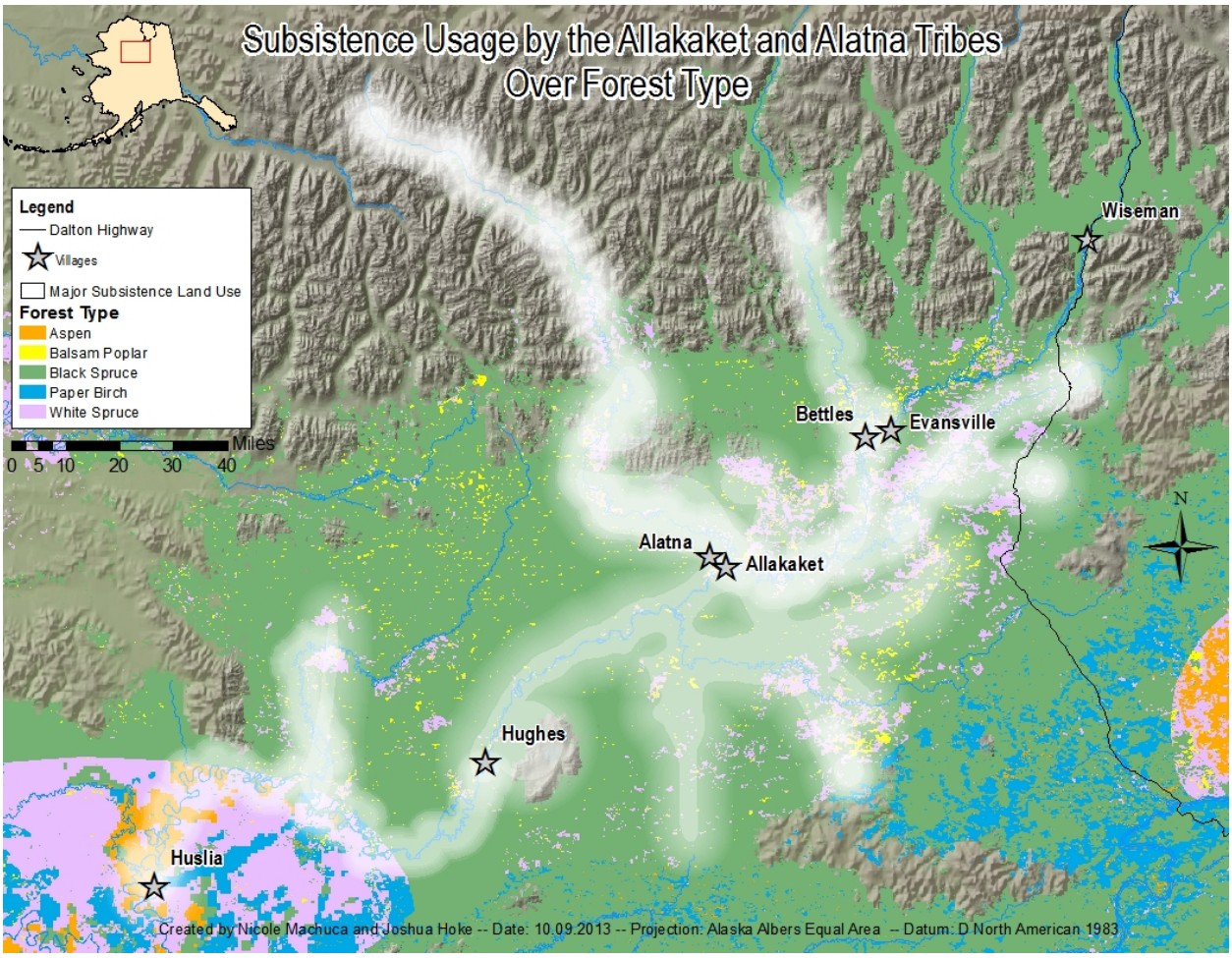


Figure 35: Subsistence use and forest diversity

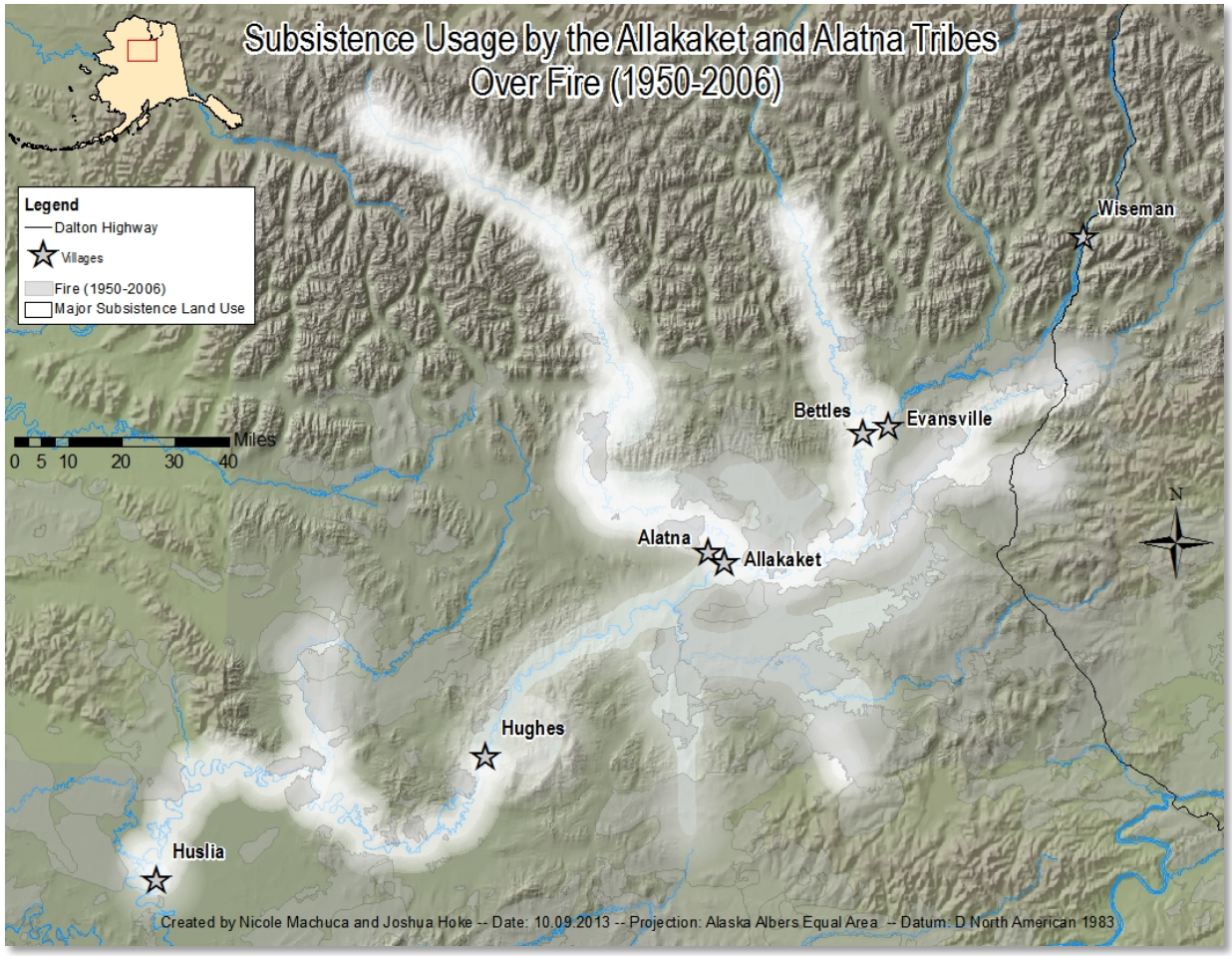


Figure 36: Subsistence use and where forests have burned, 1950-2006

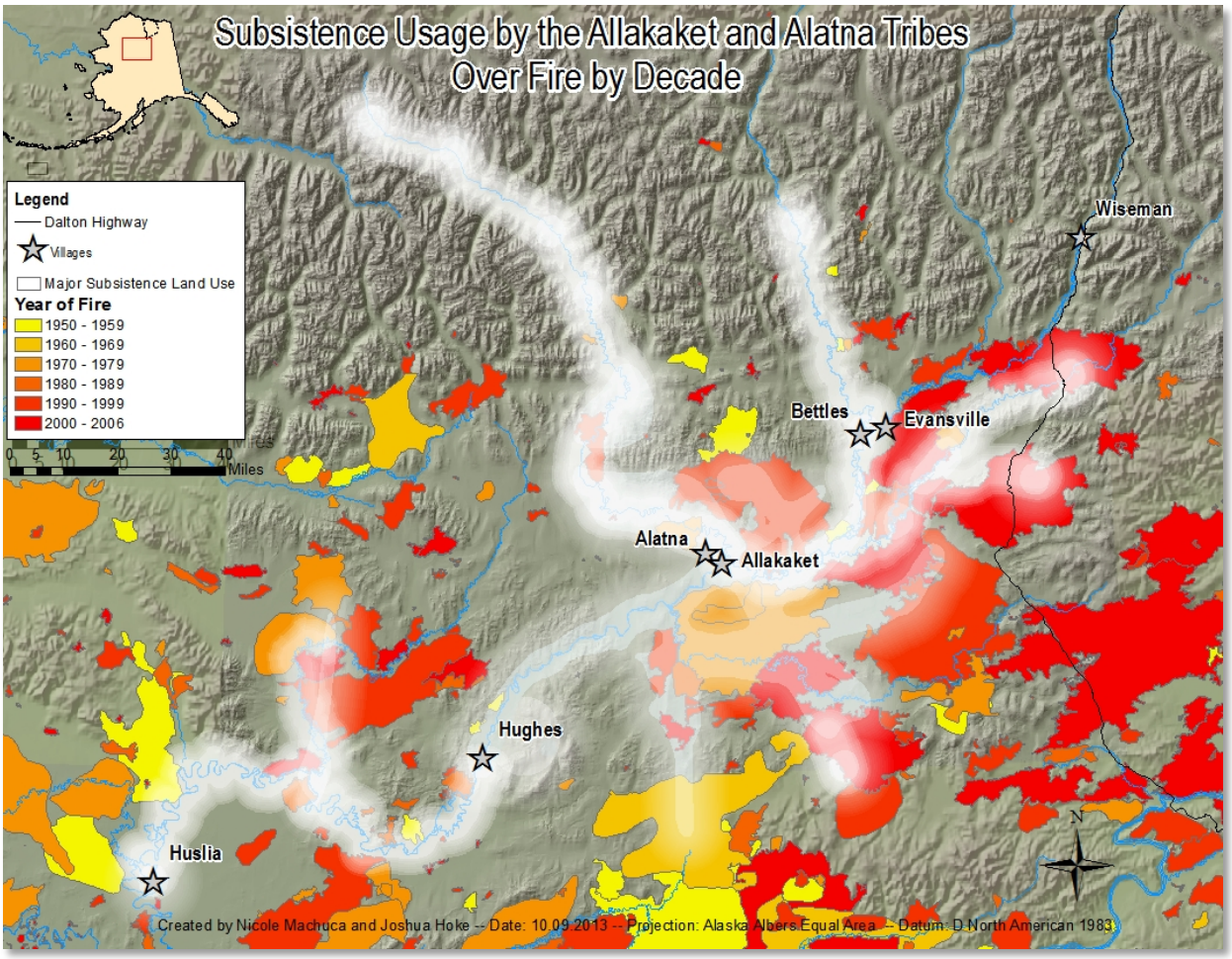


Figure 37: Subsistence use and forest fires by decade, 1950-2006

When compared with the prior baseline study by Marcotte and Haynes (1985), what is immediately apparent is that the area in which people recorded subsistence use has grown southward past Hughes and to Huslia, whereas all other areas of subsistence have remained relatively stable. This growth is primarily for moose hunting in the fall.

Interviews revealed that, rather than interpret the increase in range as just an effect of technology (gas, motors), it is an effect of a changing ecology, and an ecosystem that has fewer moose in the immediate local area—and yet an increasing dependence upon moose for the communities' food security. When moose became a subsistence resource, this was still at the time of a trapping economy—but trapping would not last as a source of cash income for the communities; one of our interviewees claimed to be the last man to make a living off of trapping, and he quit in the early 1990s.

Significantly, researchers found an enduring commitment to eating Native foods and partaking in the culture:

> "My grandparents raised me up and all they had all native food. And so I like to eat meat all the time you know. And my grandchildren, I got what about eight of them around here now, they like uh, like moose meat soup too, you know. They come here all the time because their grandmother make big pot of soup you know. I, I just like, I like to eat native, native foods you know. I have to really, that's all it is for me."

> "And then if we don't uh get our subsistence food it just seems like you know not eating right. Then we get quick tempered and all that. [Laugh.] Bloated! Like, like I am now, cause I just went on 10-day trip and put on about 12 pounds you know just eating, eating the food from restaurant."

This commitment to subsistence was often expressed along ideas about the necessity to change and to adapt to changing circumstances. When asked how important subsistence was to his family, one man responded,

> "It's pretty… it's probably really important you know uh... we, we eat a lot of native food…. But we don't… you know Christ look at what I'm wearing … all kinds of clothes you know. Yea so we're not 100% subsistence but… You know they all say take what you can get, work with what you got, and do the best you can. And that pretty much sums it up for what my parents have done. You know, my dad is an old school traditional man and it's whatever he does, I try to do. Emulate him. But, you know I don't want to be exactly like him. I've got my own ideas and how things go, and.. That's just uh.. What you call a, not innovation, and but uh, how people go to the next level and you know….'Cause the world's changing. I mean cultures change. Everything changes. And you either gotta address those concerns or you know, uh, deal with it in your own way. But subsistence is really important to, to my parents anyway. To me, I hunt all the time. I pretty much hunt year round. I hunt, whatever, you know. Spring geese, to dip netting in Chitna ...to catching salmon here. I made a salmon fish trap this summer. I was catching 500 salmon a night…

Eating Native foods was not just seen as a constant cultural value and good for an individual's general health, but subsistence is expressed as a socio-economic choice, involving complicated decisions about budgeting both money and time:

> "Well you know, without subsistence, I don't think we could make because we, there's very little jobs in the village. And gas, electricity, and transporting our kids to school you know, that pretty much takes the bulk of whatever we make. So sometimes in fall time we uh, you know we just, different families just put there monies together, get uh more gas to go out, go out to better moose hunting places."

> "To me, right when I was growing up it was always subsistence, meat and fish and berries, and a lot of wood. It's very important right now….If we got cut off from society, there's a, we don't have stores with food, or it's really cold, planes can't fly. We should have some meat and fish in our smokehouse to go, and we could survive. …Without that um we would be poor."

Asked how important was subsistence to their family, all interviewees reported that it was very important, and would often emphasize this point:

> "Very important. Very important. Cause that's what we eat, most of the winters, moose and um ducks and geese. My husband, he brings a lot of ducks and geese home in the springtime and we have to save it for throughout the winter too. So, ducks and geese and moose. Um caribou if it's close enough that we, that the guys can get it, then caribou. That's really, yeah that's a treat to us. (Laugh)."

Indeed, many interviewees reported that, although many families used to rely on caribou long ago, caribou had declined in their area, making moose hunting more essential. Many causally related the decline of caribou to the construction of the Alaska Pipeline and Dalton Highway. In our interviews, many said that all kinds of impacts from development affect the ecology of Alatna and Allakaket, and thus their own abilities to subsist. Some talked about how events like the Exxon Valdez or the Gulf Oil Spill have influenced both migrations and abundance of bird populations, while others spoke about the difficulties with competing with non-local hunters. In the researchers' trip up the Alatna River in September 2012 to hunt moose, for example, a trip that did not reach even halfway to where people documented the extent of their subsistence on that river, we encountered about four different camps of hunters that had been flown into the area around Malemute Creek. We had to take some time to locate a camp site for our own needs, since the spots we first tried were either occupied or absent enough firewood for the night.

In addition to the lists of stresses on their subsistence economy that the interviewees described as coming from outside their area, the interviewees also described other changes to their rhythms of life, particularly having to do with school attendance. Education is highly valued in Allakaket and Alatna; interviewees reported a deep respect and great need to educate their youth in the formal K-12 system. But the school calendar was never made for the subsistence calendar in Allakaket and Alatna, with one interviewee explaining of families, "They don't go out like they used to you know, cause usually they come in probably about uh Christmas, New Year, and 4th of July. They [were] pretty much out there most of the time." Indeed, one elder explained, "I used to just stay in camp, you know, with my dad …. He used to stay in camp all winter. Never come back for month." One interviewee says that the pattern is now just the opposite: with those holidays being "off" from school, it allows families to leave if they wanted—but that movement is opposite their traditional pattern of mobility.

Moving from a semi-nomadic camp-based life to a village life adhering to K-12 school schedules created a greater dependence on gasoline, and thus an even greater need for the cash economy. With the decline of moose and other subsistence resources, people have to now travel long distances for a successful harvest, sometimes pooling their money for gas. And while many talk about taking out the youth for moose hunting, others say they cannot because of the need to return for school; some lament not being able to teach the youth how to live out on the land, because many of the longest trips out of the villages now occur during moose season, in falltime. One younger hunter (in his 30s) stated, "You stay longer, or plan to stay longer cause you're not gonna go back and forth burning all that gas."

Some interviewees describe the moose hunting season as an economic risk, because of how much hunters/families might spend on gas, yet not be able to stay out long enough, or at the right time, to accept an animal:

> "Gas prices, it's about a big problem, gas prices…Uhh well, to go 120 miles one way, that's 30 gallons of gas….To go one way and that's $210. Then you need another 20 to make it back, so that's 50 gallons. So that's $350 just for one trip. And if I don't get anything you know, that's $350 that's just spent for nothing actually. Cause I don't get any meat or anything out it. So usually I have to take some long trips and wait until I do get something."

Having the available cash to purchase gas is certainly a large factor that contributes to local stresses (or successes) for the subsistence economy. It is an economic stress, and it can be difficult to plan for enough gas for moose hunting in the family budget. This is one key reason why these families are sensitive to any "disturbance" upon their hunts, such as with low flying aircraft that might "scare off" the game that they thought were nearby. In some cases, hunters only get the weekend, or a few days, during the season—this time on the river in fall becomes very important to survive the winter.

But also the methods and conditions of travel are also highly important for successful subsistence. In this study area, the two most important types of travel is over river and snow—and the year we collected data, the river was high in falltime, allowing a lot of people to travel to places for moose where their boats are usually unable to go, particularly in the Kanuti NWR. Yet access does not guarantee luck:

> "Well lately you know, for last couple, years, 5, 10 years, there's hardly no moose around you know. So you have to really go out. [This year] the water was good and high during the moose season. Uh so I was all over the country, but I couldn't afford to buy any more gas, you know. It cost too much. Gas and oil. And I didn't see no moose… Nothing. [I went] all over. Up Koyukuk River, back South Fork, Alatna River, way up. Kanuti River, down Koyukuk River towards Hughes you know. I was all over the place….Yeah I couldn't afford to pay for gas anymore, so I had to let it go. And that was really something cause that is the first time I didn't see, uh too many moose tracks. So I actually didn't see any moose tracks you know. You'd see where they, where they cross you know. But nothing this time."

> "I went back again to our place where we have cabin at the mouth of ___ Creek, trapping cabin. And stayed a couple nights and then just traveled around, floating, checking lakes, for about 3 days. …And still there was no luck, not even, not even bear or ducks. Oh, there were ducks, they were wild. But totaled out, the time I spent back there was about 6 or 7 days total. Water was good, it was high…. But just no luck….it's been good and bad that area for years since I can remember, the Kanuti River area."

But this wet summer and early fall was also accompanied by a dry late fall to winter—in fact, there was no snow on the ground in the study area in early December 2012, when the research team began interviewing for the project. Thus mobility, as an important practice of subsistence, arose throughout the interviews:

> "When's there's high waters we can go through a lot of places with boat. And then like right now there's no snow at all, so we don't go a lot places we usually go with snow machines. Um, not like way out of town. Usually I go and travel, I mean, drive around with snow machine all over the place with my uncle and my dad. But this year we stay along the river where there's good going. Without the snow all the tussocks in the flats, they're really high, so it's hard to [go] over with snow machine, you know."

The lack of snow that December affected families' ability to use snow machines to obtain wood to keep the stoves full—costing more money in fuel to heat their homes. By mid-December it was often just too cold for keeping four-wheelers and trucks working; only a few were still operational in town when we conducted our interviews.

Cash poverty increases the need for subsistence foods, but at the same time prevents the most poor families from accessing subsistence foods for themselves; if there was not a vibrant sharing network, certain families' food security would certainly be worse. That cash poverty negatively affects subsistence use/access is not only because of being less able to spend money on gas, but also because of increasing reliance on food stamps, administered in Alaska through the "Quest Card." Throughout the interviews and informal discussions, people said that the food stamp program only provided access to expensive and unhealthy foods, encouraged a less healthy lifestyle, and the money did not go far. But equally, others claimed that many had little choice, and needed to rely on the welfare. A few spoke about how a dependence on the Quest Card could create an incentive to avoid the work required for subsistence. In the past, you could buy ammunition with the Quest Card, but that policy changed and limited how the Quest Card could assist families in their food security through practicing subsistence.

Despite these concerns, our research shows that overall, the people of Allakaket and Alatna today express the same spiritual connection to the land and animals as had been shown in prior studies, and maintain their subsistence practices throughout much of their historic hunting/gathering areas. People do not trap or hunt small game like hares as much as they used to; there are fewer practices like skinning muskrat, in part because there are fewer muskrat. They have developed a greater reliance on moose because of the decline of these other species, but especially because of the decline in caribou and King salmon. Despite these changes in the subsistence economy, across both societies we found a continuity of beliefs in subsistence as a cultural value, as part of a healthy economy, and as essential to a healthy way of life.

Local and Traditional Knowledge of Moose and other Wildlife Species

The qualitative and spatial data were also analyzed to assess the local and traditional knowledge of moose and other wildlife species. Some people spoke about how moose are migrating north and west of Allakaket and Alatna, toward the coast. One elder told a story about such moose migrations; when he was working on a barge in the lower Yukon area, he had heard

> "there were stories long long time ago about when moose disappeared down there… They said that they would notice that when moose go to the ocean and then they go straight out into the ocean and then would disappear. In fact …Fish and Game people, I guess, … they turned some moose around. …They were going out into the ocean. The ice. …So they turned around. …In fact there's one guy from … a place close to Emmonak… This one guy from there he was out, he was out in the ocean, he said he was 12 miles out, and he saw little dots so he went to go look at it and, 'hey there's a muskrat.'… Twelve miles out in the ocean. So, I don't know, moose is not the only one that's going out in the ocean I suppose."

Besides such stories that caution care for wildlife—and indicating that something is "wrong" in the ecosystem—the interviews revealed a very detailed local knowledge of moose behavior and preferences for the local area. As documented in Watson and Huntington (2008), Native hunters do not really think *like* an animal, as much as they are thinking *as* an animal would think—they share their identities with animals to "know" them, which is a very different approach to the studies of wildlife biology. We found similar ideas in our interviews in Allakaket and Alatna:

> "When I go around sometimes if I'm just scouting around in the woods, if I want a certain animal I kinda, I just think like animal. Think like, 'where would I want to make a den or where would I wanna look for food?' I thought about that and I thought about that and uh, if I was a bear, when I'm out there, I'm looking for bear den sometimes. And uh when I get a chance, if I'm not doing something else, I think, 'Where would I want to make a den on a hillside?' I'd look for a lot of grass and uh leaves, what a bear would use inside of its den. It's like uh, I don't know, it's like a hide and seek. I try to think like—you can't think *like* bear—but if I *was* a bear I'd want a den where nobody would find me. So I'll look around on little banks or high ground. Where I know there's mud and where would I want to make my den."

It is this kind of intimate knowledge of animal behaviors—because hunters share their identities with these animals—that assists a hunter in procuring a subsistence opportunity.

Interviewees describe the following spatiality and yearly cycle for moose:

The highest density of moose in the immediate area is in the Kanuti NWR. Some people can tell the difference between cow and bull easier than others, and so are able to report that, while bull moose are often seen around the same places, cows and cows with calves are more mobile around the country. During winter, moose try to avoid deep snow, but wolves travel easily through snow. Moose stay up in the hills as long as there is no snow and it stays warm; but then when it cools off or the snow is high,

they come down to the river to forage near the sandbars. This movement up and down the hills and to the rivers can happen multiple times in a season, given the wide availability of browse.

> "Uh one spring, end of March I think. I was riding around with snow machine, but it getting to be crust out there, really hard crust and uh I climbed a hill up here a couple miles and ran into about 8 moose up there. There was no snow in there you know, so they were just parking there. And there's lot of willows in there too, you know. So I guess they just stayed there you know."

> "I've seen em you know in like real brush areas and then like um when there's no snow they kind of stay up higher in the hills and not down in the drainage hardly um flats as much. But then when there's starting to get a lot of snow they come down and then they'll hang out along the drainage and the willow, willow bars."

Moose eat the willows year round, and by early springtime through the fall, moose around Allakaket and Alatna feed at the lakes.

> "I saw them [moose] eat willows, and one time I went sheep hunting way up Alatna River. And we were walking by this little, kind of small lake, not a super giant lake, but there was a young moose, and there was not that big of a horns, and it was eating, inside, it was in the middle of that lake and it was eating plants from in the bottom of the lake. It would stick its head under water and come up and it would be munching out ..."

Another interviewee described eating and traveling behaviors of moose in fall:

> "In the fall time I know that they, they stay in the lakes. They only use the rivers and the banks for easy walking. They walk easier around the banks and stuff. …Usually what they do, they move back there, way back there you can just see nobody 's been up there in years. You can see compact trails from one lake to another lake. That's how I was finding the lakes, I just following these big paths like that. Grass that went over my head. I just following this path. And what it did was go from lake to lake. This one trail, I think that's how they do it, go from one lake to the other. Lay around in lakes on hot days and just eat and eat, that's all, and walk back and forth."

Moose go to places where there is available willow, and eat the plants from the lakes. But many of these lakes are drying, or places that were drier are becoming more wet. In one interview, a respondent described how the loss of lakes meant that moose might be more hurt during a wildfire:

> "Once we get the fire, the forest fire, the moose and animals instinctively goes towards the water you know. Like last uh spring we had huge fire if you can see it right behind the dump yard….It goes right beyond our building. We can see moose tracks running towards the lake as we were working on the fire. Just they know what to do for some reason…. Getting to the water, getting out of the path of the fire and all that. They know there's danger so. In case of all these lakes dry out, there's no place for them to hide or get uh you know out of the way of the fire. "

Although this interviewee heard and believed biologists who said that moose will eat browse in the years after a fire, he also thinks the recent fires have killed off some of the young moose, “up to 75%” he said—citing imagery of Smokey the Bear and the animals running away from fire to make that point.

The maps of subsistence show that people go to most areas where there were fires—both recent fires and not as recent. Yet except for the above interviewee, all other people interviewed did not think there was a relationship between the fire regime and the moose population. Some said that they know how fires cause new growth, but also observed, “there are willows everywhere.”

But interviewees all reported a decline in moose:

> “In the 90's, I was in my 40's by then, I used to be just like them, just cruising the river. Then I start paying attention to what the bull moose do and then I found out that they can, I see them over and over in this same area. And then I realize that this is where they hang out. So this is where I'm going to hunt for them. You know. So I was doing that. I was getting moose, lot of moose, every year. But then the bull moose start, even then, running out, so then I never see nothing in the spring time anymore. So I don't know where to hunt. So I start camping out next you know. Wherever I see their tracks I start camping out.”

In general, interviewees suggested that the moose decline appeared steep to them in their area, happening over the past 10 years, and overwhelmingly attribute this decline to an increase in predator species of wolves and bears.

> “I think those wolves, they, they really, really going after our uh moose and caribou especially, there so many of them, they don't collapse. … If there's food there's food. They don't have to wait to get it right. And um, they, they work as teams, I notice you know. They get uh pesky animal and just start running and running. They keep switching off, switching off. And they eventually they get whatever they are going after….Their success rate is lot higher than me. [Laugh.]… I think it's been on the increase steadily for fifteen years, I think. Yeah, I'd say 15 years. Cause, you know, usually they, they're pretty quiet animals and that, you know when you go camping, pretty soon you hear one, pretty soon you hear them all around the camp. [Laugh.]”

People reported at least four packs of wolves in the area; on their first and only trip upriver, researchers filmed three pups of a pack on the Alatna River. Interviewees reported that they observed other packs in the Kanuti area, in the Henshaw Creek area, and in the Fish Creek area. In one interview conducted with two young (in their 30s) hunters, they described how they noticed an

> A: “increase in predators. When I went up this year I seen in two days like 3 black bears, and we seen wolves every time we went up Sivaanaqat up that way.
>
> B: Wolves.
>
> A: And less moose, less signs of moose. Everywhere you know we usually hunt and check for their tracks, there's less this year. …

B: Wolves, they really multiplied and multiplied and multiplied. The bears too. That one fall, gee, we had uh, had an accident and had like search and rescue [2011], … And that, while we're searching, I think like every day someone was getting an animal. That's like, that's pretty rare. To see that many animals in one fall…. and uh the wolves, they been, gee, that one year we were following, uh coming down, floating, and we heard some wolves. And then pretty soon we got like surrounded by them. There must have been about 20 in that pack…. so you know they're eating up all the moose and stuff.

A: Especially right now with no snow.

B: hmm hmm

A: They [wolves] can run real easy right now…. Couple of years ago I was going to the wood yard and uh I was driving. And I look over, and it just snowed too, so I seen something sticking out of the snow so I walked over there, got off the trail and walked over there, and there's uh, the wolves got a moose and they just ate the tongue."

Another interviewee similarly reported:

"The wolves are a problem, they get dinner every day….I've seen dead moose before, half eaten. Guess the wolves, or whatever get 'em then leave, or they hear my snow machine and take off. And I come, when I leave they probably come back and stay there until it's just bones. …And that's more than once, not only that I hear there are other people that cross a scene like that."

Snow depth is very much a factor for moose survival, according to these interviewees. As one person explained,

"wolves, they got big paws and they usually hunt in packs so they leave their trail. So first one might have a hard time [traveling over snow], but everything behind that one has got a trail to walk on."

He contrasts that with a moose and calves, who do not get their trail stamped down by traveling in large packs like wolves.

Additionally, because of the shape of the landscape (geomorphology) and the difficult terrain, it can be very difficult to hunt wolves compared to "them other places. It's a lot of open country that the hunters can track them down easier. [But] up here it's just a natural bowl area that the trees and terrain are so thick that we can't see them or spot them." Other villages in other places have flatter open country in which to hunt wolves, compared to the lands around Alatna and Allakaket.

But people spoke about more than just the problem with wolves:

"you know we're blaming uh, wolves all the time. Pretty much wolves, but I think it's animals, black bears and grizzlies too you know. Because there's lot of those animals around now, a lot of grizzlies around…. maybe last 10 years ago you know, there was not too many around. Now

> when travel with boat you see the tracks anywhere almost… And they even come around here too now, [in the village], grizzlies, yeah. Hmm hmm. Yeah I think they're back for the, you know, uh young moose, calf, you know."

Elders reported that taking care of game not only meant how to respect that animal after it gave himself to you—taking care of game also means to take care of predators. Almost all interviewees reported that both wolves and bear increased in the area, some time in the last 10-20 years.

> "there's a lot of predators. I, um, I did pretty good with bears this year, and I seen a lot of wolves. Real lot of wolves. And I seen a lot of bears, too. I think I must've seen 15 bears, 16 bears, this spring and fall hunting …this spring, I shot a bear and it was laying on top of two fresh moose calves. After we shot it, we went up, ran a little ways, and it didn't really get up when we seen it and it just laid there. So we went to go to where it was and it had two fresh calves that it just killed laying there."

Interviewees also said that they competed with non-local hunters and poachers. Almost everyone interviewed were positive about the efforts of regulatory agencies and biologists, though many said that when "game management" flies low over them, it can really disrupt their hunting.

But overall, people were positive about local agencies and their abilities to work with the tribes on wildlife management. Every person interviewed said that it was necessary to conduct predator management in their area. Some had described how the moose population was healthy in the 1950s when the State of Alaska conducted aerial hunting. Many say that intensive management policies are a form of traditional management. Some mentioned how other current regulations overlapped with traditional knowledge of managing animals. For example, one interviewee explained,

> "And I'm definitely against killing cow moose, you know. If I know who kills cow moose, then I turn them in. Because a long time ago, when uh, there's a lot of old people you see living here. This one old guy said, I was what 14 years old, he said 'when you guys hunt moose just hunt for the Bull Moose, while cow moose is the one that give us more moose,' he said. That's what he told us."

One elder summarized his thoughts about the necessity of a good working relationship between biologists and Native communities:

> "So game wardens are really good you know to have. But they don't know too much like the native people who live in the area…. So you put those two together, the native people might know a little bit more than game wardens….They [Natives] know about hunting and how to, how to keep, watch your animals. What it look like out there."

But he also said that it was important to keep a larger scale view by talking to other villages, and to use the knowledge of fish and wildlife agencies. That, he said was how people can best "take care of animals."

Knowledge about Wildlife as it relates to Climate Change

The interviews and participant-observations were also coded to reveal community knowledge about the ecosystem as it relates to climate change. Like many Native peoples across Alaska and the Arctic more broadly, the people of Alatna and Allakaket are noticing changes in temperature and the pattern of the seasons, and it is far less stable than it once was:

> "It's different. It's different. It seem like we never know what kind of weather will come around…. You don't trust it if it's 40 [below zero] now it might be 60 [below zero] by tomorrow instead of 0."

One interviewee described,

> "the weather has changed a lot from 1950 to now. I remember in the 50s I froze my throat when I was little kid…. Playing outdoors in 70 below, so that's why I kind of have hoarse voice…. Anyway, so um, it used to be 70 below a lot. Starting from November, it would stay cold until February. Now it doesn't do that. This is not cold weather here, everybody say it cold but they're just used to—I don't know what they're used to. But if they grow up in the 50s then they would know what cold weather was, 'cause it was cold. … You know that changed, that changed, I can see the difference now."

Interviewees consistently remarked that the freeze up is getting later. One interviewee said that "It takes longer for it get cold now in the fall time." Another said, "it didn't freeze up [this year, 2012] until Halloween. It's been getting later and later every year, the freeze up. And there's no snow right now and [it's] December 9th." Yet another calculated that it takes about two weeks longer for the Koyukuk River to freeze. These changes are not only significant to their subsistence—but also for their whole social system. For example, the kids in Alatna have to attend the school located in Allakaket; these instabilities are having an effect on their school attendance, if not their performance. Another said, "And in the springtime, springtime is coming earlier. It's getting warmer faster." Given that Alatna does not have its own school, store, clinic, gas station, or airport, being cut off during an unstable freeze-up or break-up can matter to the whole family and community.

As noted above, many interviewees reported that lakes were drying. Some lakes fill up with water at times and places they are not expected to fill up, such as in places where moose are known to bed down. While some people say that the lakes are filling up with willow, others say that even the willow in those lakes are drying up. Some have used their opportunities flying to Fairbanks to look at land that they had once traveled extensively during the height of the trapping economy:

> "So you know a lot of lakes are really drying up. And when you fly with airplane you could see that too. You know between here and Fairbanks, there's lot of lakes where you could go trapping long time ago for uh beaver you know. All those, a lot of those lakes are drying."

He also connected this to the decrease in permafrost—and a decrease in forage for moose: “And that’s, you know, the moose they like the grass and stuff in lakes too. Willows and all those are drying up now. The lakes dry up you know, and all those willows are drying up food for you know, drying up too.”

Another interviewee suggested which kind of lakes were likely to dry, and to what effects:

> The only lakes that's not doing that is the big lakes, or the lakes that are deep….Cause there's more and more grass and the lakes, and a lot lakes are just dried up, they're just getting grown over…. when I'm scouting the country I run into some lakes that were lakes, but they're all grown up with big, big diamond willows now. And uh, I did you know, walk around the edge of it where the big trees start and, and inside of it, it's just grown up. Grass that grew into solid ground and uh, big diamond willows…. Really big.”

Another interviewee was careful in describing the effect of drying lakes on moose during a time of high precipitation or high water:

> “Sometimes we get flooding and that's opposite [of lakes drying], and it just wipe out the uh ponds. Especially if they dry out they fill up with water and they swish right down to the river. It wash out quite a bit.”

This interviewee noted that many areas up the Alatna River during the study year (2012) he witnessed places where moose beds—which were usually dry places—ended up wet, with barely a dry spot. The changes in hydrology, in other words, were affecting moose habitat.

Many report observing where permafrost has melted. Some have reported particular locations near their fish or trapping camps where they saw newer “holes” where the ground melted underneath. Others notice this phenomena because of its potential to affect their mobility:

> “I’ve noticed in the past maybe 5 years I’ve noticed that a lot of the lakes are getting like sunk in… Yeah, and a lot of the trails just go through the lakes and with all the water not there and the permafrost is not there, I think, yeah. That's um getting more difficult to drive into the lakes with snow machines…. And then come up the other side…. And um, I've seen like you know our snow machine trails, go, and you could see them along like in the woods as you’re flying. I could see those more in the past couple years.”

Another interviewee reported similar problems with winter travels associated with this landscape change:

> “some of them, the banks are getting steeper. …River and lakes…. I had to make some trails, new formed trails to some different lakes. And I get there and [it’s] …not really a cliff. But you know sometimes you get lucky and then you, you, you, you want to come back up that bank. [Laugh.]”

One person described that an area he knew got “sunk to the ground:”

> "You know, making holes and um, it make things rougher, but you can just go around it….I guess there's some holes starting somewhere. Holes on the ground. …I would think it is, something is uh developing holes in the land….one I've seen, I cover on a trail back here just about every winter, is from here to the door….Maybe um 15 feet and 10 feet wide, and about 3 feet deep. It's a dip anyway. I just throw snow on it, if there was snow, and flatten it out. …It used to never be there….And it's other places along the trail too….I'm pretty sure it's around just about all over our land."

These changes in temperature, precipitation, hydrology, and permafrost is observed as correlating to the abundance of berry patches around the villages—not only are there less "wet" patches to host ripening berries, but also people report that the temperature instabilities might freeze off the berry blossoms, or a windy, cold and rough storm timed during blossoming will decrease berry production that year.

These changes also are affecting waterfowl, according to the interviewees. Although some people reported an increase of white-fronted geese in their area, overall people reported that they were witnessing fewer of the birds that they traditionally relied upon for springtime subsistence. One elder said,

> "these uh birds are not coming around you know and what not. That really something that all those birds you know. You used to them in the springtime, those ducks you know. You'd heard them the lakes down here, never hear them no more."

One of the birds that many Natives all along the Koyukuk say whose behavior has changed is the American Robin. Like in other Koyukon areas, many talk about the changing of the robin's song over time. Interviewees reported here, as in other places along the Koyukuk, that the robin's song has changed: they stopped singing their whole song.

> "Oh they don't sing it, every spring they [used to] sing their whole song, but [now] they go so far and they quit….Something going on. It's, we've all listen for. But no it go so far and quit. What's going on? they ask me, and I say I don't know. [Laugh.] Something's got to them, they forgot how to sing."

People also reported witnessing more "new" or "rare" birds, including cardinals and hummingbirds, and an increase of eagles.

In general, many of the species that people reported were increasing are considered predator species: not just eagles and wolves and bear, but also lynx and Northern pike are the predators reported to be increasing in the project area. Hunters also reported witnessing more coyotes: "They're smaller, they're like not that big," he said, indicating about 2 feet off the ground. "little bigger than a fox, not as big as a wolf….Yeah. They don't have big feet like a wolf either…Yeah, like a dog or something."

Some of these increases, of course, have more to do with changing subsistence patterns than directly with climate change:

> "Some places we do some fishing out in the lakes and there's huge pikes there that just eat anything, maybe ducklings and muskrats or baby beavers. Or anything like that…They're so huge, their mouth is [indicates with hands a circle of 8 inches wide]...Cause um I notice some uh baby ducks got eaten up. We seen them swimming around the lakes or whatever. You know long time ago all the villagers and uh I believe we go fishing in the springtime and summer time, fall time. And nowadays no one goes out, not many people goes out living near the creeks nowadays. But we do take fish net up here, up to Fish Creek Lake in the springtime and catch huge ones [indicates pike three feet long]…In earlier years, like I said, we had dog teams and we had to feed them regularly, so pike was one of the food we go after. And then we quit going after them [after many people stopped running dogs] and they [the pike] start growing bigger and bigger…. Maybe within 10 years."

Things like the increase in pike might have more to do with the decrease in dog mushing as a major form of transportation in the area—which required more fish as "fuel." But interviewees suggest that *declines* in beaver and mink are when people *do not trap* them as much, and some have said the decline of the trapping economy happened *before* the decline of these animals that were trapped. This expression of hunting/trapping as *productive* of game is common across all Koyukuk River communities, and often is an expression of the belief in the human role as actors in the ecosystem: trappers took the "extra" beavers out of the system so they did not reach a carrying capacity by "eating up all the willows and stuff, you know there so many of them."

Our analysis finds that these changes in the mixed cash/subsistence economy intersect with changes in climate; we found that the social-ecological system as a whole is deeply impacted by climate change.

A few elders remembered another December in the 1950s when there was no snow, like the December we conducted our interviews. One elder and experienced hunter spoke extensively about the potential effects that the current conditions of the interview—snow-less and cold (approximately -40^{o}F) December days—might do to the ecosystem. In the first place, he suggested that with less snow, both wolves and bears are more mobile on the landscape, the bears delaying or ceasing their hibernation in search of food. He thought that because it was snow-less in December, it would mean that precipitation will be delayed until later in the winter, but in the meantime, without the extra insulation of snow, many small mammals probably had frozen to death. These small mammals, such as mice and voles, are food to owls and other predators in the food web. In addition, less snow in a cold environment would cause the ice to freeze thicker, causing hardship for beaver—and perhaps encourage more ice jams in the spring.

Interviewees report that the changes in winter climate and snowfall also have other effects on the social system—in that hunters/trappers are less able to travel in certain temperatures and snow conditions to practice subsistence. Unlike when people ran dogs or even walked, snow machines and four-wheelers cannot effectively and reliably operate in temperatures much below -20^{o}F. Some do not want to take the risk of being caught out in unpredictable weather with such machinery—any unpredicted temperature drops or storm might mean death to the winter traveler.

Discussion

"We're an adaptive people," said one of our interviewees, but most spoke of adaptation. Many of the authors who researched and wrote in the times of the early cash economy in rural Alaska often revealed the worry of the audiences to whom they were writing: would these tribal peoples persist, given the changes wrought by a modern capitalist economy? Certainly in the history of humankind, many cultures and peoples went extinct in the transition. Yet Nelson et al (1982) wrote to their audiences,

> If the villagers [of Allakaket and Alatna] had a choice today between continuing with subsistence and adopting a viable cash economy, which would they select?...Our studies among the Athabascans and Eskimos clearly indicate a commitment to subsistence. This is partly because of a need for Native foods, partly because of a desire to continue an accustomed lifestyle, and partly because of cultural and personal associations with living from the land. Koyukon culture, for example, ties people closely to a life on the land. The prime avenue to satisfaction and prestige is through providing resources from the environment. This is the deepest and most pervasive theme of life. It is manifested to some extent in an emphasis on developing the pragmatic skills of hunting and survival. It is also revealed in the elaborate religious observances that bring luck in subsistence pursuits, that make hunters quick and agile, and which ensure against alienating the game. This theme is expressed finally in ideal concepts of personality, which emphasize hard work, foresight, striving toward security, and the sharing of food (Nelson et al 1982, 293-294).

Because of evidence such as reported by Nelson et al (1982) of the persistence of Native cultures in the face of capitalism, the rise of the Indigenous Studies literature provided a new framework for understanding the Indigenous experience: that of adaptation rather than that of the "vanishing Indian." Instead of research designed to "capture" their knowledge before it "disappears," the study of Native Americans and other Indigenous peoples worldwide focus more on understanding their "beliefs" and the intellectual traditions that have allowed them to persist over time (Tuhiwai Smith 2012; Watson and Huntington 2008; Deloria 1969). Certainly, the work of the early ethnographers, anthropologists and oral historians provide key data sources—excellent sources that we have used in creating this report. But a different framework for understanding these sources has also since developed to understand Native experience just as Nelson et al (1982) suggested, as peoples who, like any modern peoples, experience both continuity and change. As noted by another of our interviewees from Allakaket: all we can do "is adapt. Adapt to the changes."

In this present study, we found both continuity and change among the peoples in Alatna and Allakaket. Certainly, the tribes and individuals have adapted to given circumstances, such as some of the tradeoffs associated with the cash economy, changes to and away from a trapping economy, and changes from dog team travel to travel that relies more on gasoline. But significantly, we also found tremendous continuity in terms of cultural practices and beliefs, in both our participant-observation and interview data.

Although a lot of concern was expressed about the younger generations learning subsistence, the evidence showed that youth are continually taught about the practices of subsistence, and the kids learned and enjoyed subsistence. It is more of a challenge to teach youth subsistence today, with school schedules, required curriculum, the price of gasoline, the types of subsistence activities more available, and even, like youth anywhere, competing with video games. But there were numerous dedicated adults who talked about taking youth out hunting or teaching them subsistence tasks and the knowledge to survive out on the land. Interviewees consistently reported that in their own lives, if they had left village life for extended periods of time, such as for going to boarding schools or for work in cities or for military service, they re-adjusted to a subsistence-based lifestyle when they returned. Sometimes returning caused great anxiety, feeling out of place when they returned, but this did not impact their interest or abilities to do subsistence. Many described how they had to "re-learn" certain subsistence techniques they had forgotten—but their identities as Native peoples nevertheless endured, and thus their commitment to subsistence lifeways.

Throughout all major periods of study in this report, the residents of Allakaket and Alatna have been shown to adapt to changing ecological and social conditions in ways that maintain their subsistence-based livelihoods. They have developed as a part of the social-ecological system of this changing boreal forest. And it is their continued commitment to subsistence that has allowed these people to learn and share so much of their knowledge about the land, and thus about these changing ecosystems.

In this study area, there is not one single "cause" of the decline of moose in the area. But it would seem that it is not so much fire as it is climate change (in terms of snow depth and lake hydrology) that might be contributing factors to the moose decline. But the residents of Alatna and Allakaket have observed an abundance of predators, including the hunters from other areas, increasing and competing with locals over use of the resource. The interviews indicate that climate change might not only be impacting the vegetation that moose rely on as their nutrition from lakes, but the changing snow depths might also be impacting how vulnerable moose are to predation.

The largest challenge these communities face in this social-ecological system are the changes in their mobility patterns. It should not be stated that these cultures have become "sedentary;" even though they have permanent homes in Alatna or Allakaket, the maps of subsistence indicated that these cultures have become *more* mobile, and mobile in different ways, with different impacts on the social system (such as more difficulty with teaching youth subsistence practices). The timing and spatiality of this mobility has changed—and because of these changes, the subsistence economy has become more vulnerable to fluctuations in the moose population, as well as vulnerable to the other declines in caribou and (more recently) salmon populations. In prior eras, living farther apart and out at camp, smaller collectives of families could hunt smaller game and move around to find them; being more village-based, and because other resources have declined, families now depend upon the large amount of meat that a moose can provide, and sometimes spend tremendous amounts of money traveling the Koyukuk drainage, "banking" on that one hunt, which might—but only might—carry them through the winter. For as one interviewee noted, in December:

> "Cause right now our freezer is basically, basically empty. And uh, there's food in there, but it's special food like for special times and special occasions. But not bulk food, like moose leg, or you know. Bunch of fish we don't have a bunch of that…. Yeah. Not something that last us for couple, 2, 3 months."

Indeed, our study is perhaps an excellent qualitative complement to the Holen et al 2012 study by ADF&G, which began to quantify the food insecurity of these villages—these villages measured as more insecure than the average across the State of Alaska or the nation as a whole. Subsistence is getting harder in Allakaket and Alatna because of changes in this social-ecological system.

Both Loring and Gerlach (2009) and White et al (2007) argue that Arctic food security is deeply affected by a changing climate. White et al (2007) suggest that

> "to assure food security for arctic communities, especially in the face of the rapid and often unpredictable ecological trends like those" experienced in the Arctic, "communities need both the freedom to innovate and adapt, and access to quality climate and weather information so that they might predict … conditions and make the best decisions about where and when to hunt and fish in times of uncertainty."

They continue, "for planning purposes it will be useful when fine-grained local and regional climate and seasonal weather information is integrated with community-based knowledge through hunter experimentation and testing in the field" (White et al 2007, 3).

Conclusions

The persistence of tribal cultures and subsistence lifeways is striking in the villages of Allakaket and Alatna. Rather than see subsistence as a cultural phenomenon, however, it must be understood as an economic means to a "good life." Statistics such as unemployment rates and income do not reflect how the Inupiat and Koyukon peoples of these villages want to measure their entirety of livelihoods or their happiness. Subsistence is not a "lack" of opportunity in a capitalist system, but seen as a pathway to both take care of the land, as well as take care of one's extended family, including the game and fishes that feed their people. The relationships created through a subsistence economy contribute to both an individual's and community's enduring identity—even if the particulars of the practice might adapt to the ecological and social context from year to year or generation to generation.

Thus analyses of the "social-ecological system" might be better employed to theorize how to manage this environment for the good life of all resident biota, human and non-human. Many of these scholars contend that Western conceptual models and ontologies about nature, environmental change, and humanity's role in the system must be revised to develop more flexible social-ecological systems that can be "resilient" to change, that is, "absorb disturbance and still retain its basic function and structure" (Walker and Salt 2006: 1; see also Brand and Jax 2007; Carpenter 2001; Holling 2001, 1973). Specific to the Alaskan Interior context, Loring and Gerlach (2010) document how salmon management along the Yukon River has produced crisis in communities in the upriver portion of the Drainage who had depended on salmon. Similarly, McNeeley and Schultzki (2011) address how ungulate management is not in itself flexible enough to account for climate change, which detrimentally impacts the food security of Koyukon because of more rigid season dates to harvest moose. As one of our interviewees noted, "sometimes regulations you know are the wrong time you know." Through using such frameworks as food security, agencies and managers might better understand the perspectives of these tribes, better to understand these ecosystems, continue to cultivate working relationships with tribes, and align conservation, cultural, and economic needs for the local area.

Recommendations

This study engaged local and traditional ecological knowledge of the communities of Allakaket and Alatna to understand the changing social-ecological system. Future studies might employ greater use of fieldwork and GPS equipment to document finer-scale knowledge and mapping for decision-making. For example, a project could record phenomena such as changing permafrost locations and places where melt has impacted community infrastructure and transportation routes. Or mapping specific changes in lake hydrology (wet vs. dry lakes) might also be useful to understand the changes to moose habitat. Additionally, future studies might examine through fieldwork those places with Native names mapped long ago, that are no longer "usually" visited; there were not many, but investigating those places might reveal other patterns to analyze landscape change. The use of a newly-developed Ipad-based interface to collect mapping data during interviews will be of great utility in future baseline or other community mapping exercises, a technology not yet available for this work, but now available for future researchers; a digital interface would be self-illuminated and allow participants to zoom in or out in scale to record phenomena.

Researchers from this project recommend that issues of community food security be included in the process of wildlife management decision-making. One of the problems of the complicated wildlife management system in Alaska is not only dual land management, but also management that focuses on single species or limited types of species (for example, migratory birds as separate from ungulate management). The way decision-making is often divided across these management regimes does not afford much opportunity to understand the impacts of those decisions at the community-scale, and within a single subsistence economy or multi-village economy. Discussions that involve calculations of food security, such as performed by Holen et al (2012), might be better utilized to understand more holistically the resource needs in a given local community, such as to better assess when "rural priorty" becomes a viable discussion for management.

These recommendations align with that of agency studies that recommend "localized" approaches to resource management (Wolf 2004), as well as peer-review studies that recommend more flexible management strategies that allow Interior Native communities to meet their subsistence needs in the face of a changing climate (Kofinas et al 2010). In pursuing future studies on moose ecology, agencies and academics are also advised to look at the relationship between snow depth and predation on moose in GMU 24B and other GMUs that face rapidly declining populations of moose and low calf survival—for even though the NOAA data indicates that snow depth is decreasing in winter, this might mean it gets deep in particular places or times, and not others. Our recommendations also include continuing with a predator management initiative in GMU 24B; as a science-based initiative, adaptive management-type approaches, such as ADF&G's Intensive Management initiatives, are supported in these villages. According to many people of these villages, intensive management techniques is seen as an extension of traditional management practices, because both presume there is a role for humans as decision-makers in the ecological system. Like any of the other technologies and techniques introduced to tribal peoples, intensive management is spoken about as an important adaptation that the tribes would like to pursue as an option to help manage the changing social-ecological system.

Lastly, this research suggests that the arbitrary calendars followed by the local school system might be revisited, and perhaps re-structured to be more flexible and responsive to a family's subsistence needs. Likewise, curriculum in schools might be developed to better facilitate teaching subsistence values and ecological practices, and emphasize a more "place-based" education, as is sometimes pursued at the undergraduate level (Semken 2005). As it is already, climate change is impacting school attendance; and in some key ways might actually be preventing youth from learning some important lessons of survival. One of the reasons that this project developed a website interface for its products is to facilitate a better bridge between the most active subsistence users and the youth of the communities. Our hope is that the project resources, such as the interview transcripts, maps, and literature, could be used by teachers to create student assignments attentive to learning the particulars of that changing social-ecological system. In these and other ways, leaders and educators might be encouraged to be more creative in addressing the local needs of rural communities. To continue to be adaptive, the elders and active hunters need to transfer their skills and experiences to future generations, so that their cultures continue to co-evolve with the landscape.

Today's families of Allakaket and Alatna are a product of generations of negotiations, complicated rituals, and intermarriage between the cultural groups (Holen et al 2012; Englehard et al 1993). Today, the villages often share the same infrastructure—the same airport, clinic, store, and their youth all attend the same school—but Alatna and Allakaket maintain distinct identities as communities and political bodies. What they also share today is a persistent commitment to subsistence foods, yet increasing vulnerabilities within their food system. Researchers recommend engaging these communities in developing more flexible policies that can enhance their opportunities to practice subsistence, for these villages are likely to face continued and numerous challenges to access the foods necessary for their spiritual and physical survival.

Acknowledgements

The authors thank the elders, community leaders, the Tribal Councils, and all tribal members of Allakaket and Alatna.
Mike Spindler, Kanuti National Wildlife Refuge
Catherine Moncrieff, Yukon River Drainage Fisheries Association
Jennifer Gross
Transcriptionists, especially Megs Eichorn
Melody Webb
Maura Miller and the Riley Center for Livable Communities, Charleston, SC
Master of Environmental Studies Program, College of Charleston, SC
Department of Political Science, College of Charleston, SC

Literature Cited

Agrawal, A. (1995). "Dismantling the Divide Between Indigenous and Scientific Knowledge," *Development and Change*, 26, 413-439.

Alcorn, Janis. (1993). "Indigenous Peoples and Conservation," *Conservation Biology* 7 (2): 424-426.

Andersen, D.B., B. Retherford, C. L. Brown. (2012). "Climate Change and Impacts on Subsistence Fisheries in the Yukon River Drainage, Alaska," April 2012 Annual Report, Fisheries Resource Monitoring Program Project 10-250.

Andersen, D. B., Brown, C. L., Walker, R. J., & Elkin, K. (2004a). Traditional Ecological Knowledge and Contemporary Subsistence Harvest of Non-Salmon Fish in the Koyukuk River Drainage, Alaska," Alaska Department of Fish and Game, Division of Subsistence, Technical Paper 282.

Andersen, David B., Caroline Brown, Robert Walker, and Gretchen Jennings. (2004b). The 2001-2002 Harvest of Moose, Caribou, and Bear in Middle Yukon and Koyukuk River Communities, Technical Paper No. 278, Division of Subsistence, Alaska Department of Fish and Game, Juneau.

Arctic Climate Impact Assessment (ACIA). (2004). *Impacts of a Warming Arctic: Arctic Climate Impact Assessment*. Cambridge: Arctic Council, Cambridge University Press.

Arundale, W. H., & Jones, E. (1989). "Historic land use processes in Alaska's Koyukuk River area," *Arctic*, 42(2), 148-162.

Arundale, W. H., Clark, D. W., & Quick, P. M. (1989). Current perspectives on western boreal forest life: Ethnographic and ethnohistoric research in late prehistoric and historic archaeology—a preface. *Arctic*, 42(2), 85-96.

Berkes, F. (1999). *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. New York: Taylor and Francis.

Berkes, F., and M. Berkes. (2009). Ecological complexity, fuzzy logic, and holism in indigenous knowledge. *Futures*, 41(1), 6-12.

Berkes, F., Colding, J., and Folke, C. (2003) Navigating social–ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge, UK.

Berkes, F., Colding, J., & Folke, C. (2000a). Rediscovery of traditional ecological knowledge as adaptive management. Ecological applications, 10(5), 1251-1262.

Berkes, F., Folke, C., & Colding, J. (Eds.). (2000b). Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press.

Boertje, R. D., Keech, M. a., Young, D. D., Kellie, K. a., & Seaton, C. T. (2009). Managing for Elevated Yield of Moose in Interior Alaska. *Journal of Wildlife Management*, 73(3), 314–327.

Brown, Caroline L., Walker, R. and Vanek., B. (2004). "The 2002-2003 Harvest of Moose, Caribou, and Bear in Middle Yukon and Koyukuk River Communities: Results of the 2003 Big Game Harvest Assessment Project," Division of Subsistence, Alaska Department of Fish and Game (ADF&G), Technical paper 280.

Cajete, G. (2000). *Native Science: Natural Laws of Interdependence*, Santa Fe: Clear Light Publishers.

Chan, H. M., et al. (2006). "Food security in Nunavut, Canada: barriers and recommendations." *International Journal of Circumpolar Health*, 65(5).

Chapin, F. Stuart III, A.D. McGuire, R.W. Ruess, T.N. Hollingsworth, M.C. Mack, J.F. Johnstone, E.S. Kasischke, E.S. Euskirchen, J.B. Jones, M.T. Jorgenson, K. Kielland, G.P. Kofinas, M.R. Turetsky, J. Yarie, A.H. Lloyd, and D.L. Taylor. (2010). "Resilience of Alaska's Boreal Forest to Climatic Change," Can. Journal of Forest Research 40: 1360-1370.

Chapin III, F. S., Cochran, P., Huntington, O. H., Knapp, C. N., Brinkman, T. J., & Gadamus, L. R. (2013). "Traditional Knowledge and Wisdom: A Guide for Understanding and Shaping Alaskan Social-Ecological Change." In *Linking Ecology and Ethics for a Changing World* (pp. 49-62). Springer Netherlands.

Chilvers, Jason. (2009). "Deliberative and Participatory Approaches in Environmental Geography." In *A Companion to Environmental Geography*. Edited by Castree et al., 400-417. New York: Wiley-Blackwell.

Clark, A. McFadyen. (1970). "The Athabascan-Eskimo Interface," *Bulletin* (Canadian Archaeological Association) No. 2 (1970), pp. 13-23.

Clark, A. M., & Clark, D. W. (1974). Koyukon Athapaskan houses as seen through oral tradition and through archaeology. *Arctic Anthropology*, 29-38.

Clark, Robert, Alvin Ott, Mary Rabe, Douglas Vincent-Lang, and Douglas Woodby. (2010). "The Effects of a Changing Climate on Key Habitats in Alaska," Special Publication No. 10-14. Alaska Department of Fish and Game, Divisions of Sport and Commercial Fisheries, Habitat and Wildlife Conservation, Anchorage.

Cochran, Patricia, Orville H. Huntington, Caleb Pungowiyi, Stanley Tom, F. Stuart Chapin III, Henry P. Huntington, Nancy G. Maynard, Sarah Trainor. (2013). "Indigenous Frameworks for Observing and Responding to Climate Change in Alaska," *Climatic Change* 120(3), 557-567.

Cope, Meghan. (2010). "Coding Transcripts and Diaries," In *Key Methods in Geography*. Edited by Clifford et al., 440-452. London: Sage.

Deloria, Vine, Jr. (1969). *Custer Died for Your Sins: An Indian Manifesto*. New York: Fulcrum Publishing.

Englehard, Michael, Linda Ellanna, George Sherrod, in collaboration with Ernest S. Burch, Jr. (1993). Ethnohistoric Insights into Indigenous Contact and Land Use on the Upper Kobuk and Koyukuk Rivers, University of Alaska Fairbanks; unpublished report with data from the "Northwest Areas Ethnographic Project" funded by the National Park Service.

Euskirchen, E. S., A. D. McGuire, F. S. Chapin, III, S. Yi, C. C. Thompson. (2009). "Changes in Vegetation in Northern Alaska under Scenarios of Climate Change, 2003–2100: Implications for Climate Feedbacks," *Ecological Applications*, Vol. 19, No. 4 (Jun., 2009), pp. 1022-1043.

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour*., 30, 441-473.

Ford, J. D. (2009). Vulnerability of Inuit food systems to food insecurity as a consequence of climate change: a case study from Igloolik, Nunavut. *Regional Environmental Change*, 9(2), 83-100.

Ford, J. D., et al. (2008). Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *The Geographical Journal*, 174(1), 45-62.

Fox, J. (1998). Mapping the Commons : The Social Context of Spatial Information Technologies. *The Common Property Resource Digest*, *45*, 1-4.

Holen, D., S.M. Hazell, and D.S. Koster, editors. (2012). Subsistence Harvests and Uses of Wild Resources by Communities in the Eastern Interior of Alaska, 2011. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 372. Anchorage, Alaska.

Hoole, Arthur, and Fikret Berkes. (2010). "Breaking Down Fences: Recoupling Social-Ecological Systems for Biodiversity Conservation in Namibia," *Geoforum* 41: 304-317.

Howitt, R. (2002). *Rethinking resource management: Justice, sustainability and indigenous peoples*. Routledge.

Hundertmark, K. J. (1998). Home range, dispersal and migration. *Ecology and management of the North American moose*. Smithsonian Institution Press, Washington, DC, USA, 303-335.

Huntington, J., with Elliott (2002). *On the edge of nowhere*. Epicenter Press.

Huntington, H.P., S.F. Trainor, D.C. Natcher, O.H. Huntington, L. DeWilde, and F.S. Chapin. (2006). The significance of context in community-based research: understanding discussions about wildfire in Huslia, Alaska. *Ecology and Society*, 11(1), 40: [online] http://www.ecologyandsociety.org/vol11/iss1/art40/

Huntington, O.H., and Annette Watson. (2012). "Interdisciplinarity, native resilience, and how the riddles can teach wildlife law in an era of rapid climate change," *Wicazo Sa Review* 27 (2), 49-73.

Indigenous Peoples Specialty Group (IPSG) of the Association of American Geographers. (2012) "AAG Indigenous Peoples Specialty Group's Declaration of Key Questions About Research Ethics With Indigenous Communities," accessed April 2012 online; available at http://www.indigenousgeography.net/IPSG/pdf/IPSGResearchEthicsFinal.pdf

Johnson, B. L. (1999). Introduction to the special feature: adaptive management—scientifically sound, socially challenged. *Conservation Ecology*, 3(1), 10.

Johnson, J., G. Cant, R. Howitt, and E. Peters. (2007). “Guest Editorial: Creating Anti-Colonial Geographies: Embracing Indigenous Peoples’ Knowledge and Rights,” *Geographical Research* 45(2), 117-120.

Joly, K., Duffy, P. A., & Rupp, T. S. (2012). Simulating the effects of climate change on fire regimes in Arctic biomes: implications for caribou and moose habitat. *Ecosphere*, 3(5), 1–18.

Kawagley, A. O. (2006). *A Yupiaq worldview: A pathway to ecology and spirit*. Waveland Press.

Keech, M. a., Lindberg, M. S., Boertje, R. D., Valkenburg, P., Taras, B. D., Boudreau, T. a., & Beckmen, K. B. (2011). Effects of predator treatments, individual traits, and environment on moose survival in Alaska. *The Journal of Wildlife Management*, 75(6), 1361–1380.

Kofinas, Gary P., F. Stuart Chapin, Shauna BurnSilver, Jennifer I. Schmidt, Nancy L. Fresco, Knut Kielland, Stephanie Martin, Anna Springsteen, T. Scott Rupp. (2010). “Resilience of Athabascan subsistence systems to interior Alaska's changing climate,” *Canadian Journal of Forest Research* 40(7): 1347-1359.

Kovach, M. (2009). *Indigenous Methodologies: Characteristics, Conversations, and Contexts*. Toronto: University of Toronto Press.

Lord, R. E. (2008). Variable Fire Severity in Alaska’s Boreal Forest: Implications for Forage Production and Moose Utilization Patterns. (Thesis) University pf Alaska-Fairbanks.

Loring, P. A., & Gerlach, S. C. (2009). :Food, culture, and human health in Alaska: an integrative health approach to food security,” *Environmental Science & Policy*, 12(4), 466-478.

Loring, P. A., & Gerlach, C. (2010). Food security and conservation of Yukon River salmon: are we asking too much of the Yukon River? *Sustainability*, 2(9), 2965-2987.

Louis, R.P. (2007). “Can You Hear Us Now? Voices From the Margin: Using Indigenous Methodologies in Geographic Research.” *Geographical Research* 45: 130–139.

McNeeley, Shannon and Martha Schultzski, (2011). “Anatomy of A Closing Window: Vulnerability to Changing Seasonality in Interior Alaska,” *Global Environmental Change* 21: 464-473.

MacCracken, J. G., & Viereck, L. A. (1990). Browse Regrowth and Use by Moose After Fire in Interior Alaska. *Northwest Science*, 63(1), 11–18.

Machlis, G.E., Force J.E, and. Burch, W.R Jr. (1997). “The human ecosystem part I: The human ecosystem as an organizing concept in ecosystem management,” *Society and Natural Resources*, Vol.10, pp.347-367.

Maier, J. A. K., Hoef, J. M. V., Mcguire, A. D., Bowyer, R. T., Saperstein, L., & Maier, H. A. (2005). Distribution and density of moose in relation to landscape characteristics : effects of scale 1. *Canada Journal for Research*, 35, 2233–2243.

Martello, M.L. (2008). Arctic Indigenous Peoples as Representations and Representatives of Climate Change. *Social Studies of Science* 38(3), 351-376.

Miraglia, R. (1998). *Traditional Ecological Knowledge Handbook: A Training Manual and Reference Guide for Designing, Conducting and Participating in Research Projects Using Traditional Ecological Knowledge*. Anchorage: Alaska Department of Fish and Game, Division of Subsistence.

Morlan, Richard E. (2000). "The Siruk Site, Alatna River, Alaska: A Koyukon Winter House," *Arctic Anthropology*, Vol. 37, No. 1 (2000), pp. 43-59.

Nadasdy, P. (1999). The Politics of TEK: Power and the "Integration" of Knowledge. *Arctic Anthropology*, 36 (1-2), 1-18.

Nadasdy, P. (2003). *Hunters and Bureaucrats: Power, Knowledge, and Aboriginal-State Relations in the Southwest Yukon*. Vancouver: University of British Columbia Press.

National Oceanic and Atmospheric Association (NOAA). (2014). Alaska Climate Database, Bettles Station data, available at http://www.arh.noaa.gov/cliMap/akClimate.php.

National Science Foundation (NSF). (2012). Principles for the Conduct of Research in the Arctic. Online: http://www.nsf.gov/od/opp/arctic/conduct.jsp, Office of Polar Programs, date accessed October 2012.

Nelson, R., K. Mautner, and R. Bane. (1982). *Tracks in the Wildland: A Portrayal of Koyukon and Nunamiut Subsistence*, Anthropology and Historic Preservation, Cooperative Park Studies Unit, University of Alaska, Fairbanks.

Nelson, R. (1986 [1983]). *Make Prayers to the Raven: A Koyukon View of the Northern Forest*. Chicago: University of Chicago Press.

Northern Economics, Inc. NEI (2006). *The Value of Alaska Moose*. Anchorage, Alaska: Prepared for the Anchorage Soil and Water Conservation District and the Alaska Soil and Water Conservation District.

Redman, C., Grove, M. J. and Kuby, L. (2004). "Integrating Social Science into the Long Term Ecological Research (LTER) Network: Social Dimensions of Ecological Change and Ecological Dimensions of Social Change," *Ecosystems* Vol.7(2), pp. 161-171.

Schmidt, J. I., Hundertmark, K. J., Bowyer, R. T., & McCracken, K. G. (2009). Population structure and genetic diversity of moose in Alaska. *Journal of Heredity*, 100(2), 170-180.

Seaton, C. T., Paragi, T. F., Boertje, R. D., Kielland, K., DuBois, S., & Fleener, C. L. (2011). Browse biomass removal and nutritional condition of moose Alces alces. *Wildlife Biology*, 17(1), 55–66.

Semken, Steven. (2005). "Sense of Place and Place-Based Introductory Geoscience Teaching for American Indian and Alaska Native Undergraduates," *Journal of Geoscience Education* 53(2): 149-157.

Shenoy, A., Johnstone, J. F., Kasischke, E. S., & Kielland, K. (2011). Persistent effects of fire severity on early successional forests in interior Alaska. *Forest Ecology and Management*, 261(3), 381–390.

Shipley, L. A. (2010). Fifty Years of Food and Foraging in Moose: Lessons in Ecology from a Model Herbivore. *Alces*, 46, 1–13.

Smith, D. A., Herlihy, P. H., Viera, A. R., Kelly, J. H., Hilbum, A. M., Robledo, M. A., & Dobson, J. E. (2012). Using Participatory Research Mapping and GIS to Explore Local Geographic Knowledge of Indigenous Landscapes in Mexico. *Focus on Geography*, 55(4), 119-124.

Theriault, S., Otis, G., Duhaime, G., & Furgal, C. (2005). Legal Protection of Subsistence: A Prerequisite of Food Security for the Inuit of Alaska, *The Alaska L. Rev*., 22, 35.

Tuhiwai Smith, Linda. (2012). *Decolonizing Methodologies: Research and Indigenous Peoples*, New York: St. Martin's Press.

Young, D. D., & Boertje, R. D. (2011). Prudent and Imprudent Use of Anterless Moose Harvests in Interior Alaska. *Alces* 47, 91–100.

Yukon River Drainage Fisheries Association (YRDFA), (2009). *Middle Koyukuk River of Alaska: An Atlas of Fishing Places and Traditional Place Names*, Fairbanks: Alaska.

Walker, Brian, and David Salt. (2006). *Resilience Thinking: Sustaining Ecosystems and People in a Changing World* (Washington, DC: Island Press).

Watson, Annette. (2013). "Misunderstanding the 'Nature' of Co-Management," Environmental management 52 (5), 1085-1102.

Watson, Annette, and OH Huntington. (2008). They're here—I can feel them: the epistemic spaces of Indigenous and Western Knowledges," Social & Cultural Geography 9 (3), 257-281.

Watson, Annette, and Orville H. Huntington. (2014). "Transgressions of the Man on the Moon: Climate Change, Indigenous Expertise, and the Posthumanist Ethics of Place and Space," *GeoJournal*, published online March, http://link.springer.com/article/10.1007/s10708-014-9547-9, p 1-16.

Watson, A., and K. Till. (2009). "Ethnography and Participant-Observation." In DeLyser et al, eds, *Handbook of Qualitative Research in Geography* (pp. 121-137), London: Sage.

White, D. M., et al (2007). Food and water security in a changing arctic climate. *Environmental Research Letters*, 2(4), 045018.

Wolf, Robert J. (2004). "Local Traditions and Subsistence: A synopsis from twenty-five years of research by the State of Alaska," Technical Paper No. 284, Alaska Department of Fish and Game, Division of Subsistence.

Wood, D. (2010). *Rethinking the Power of Maps.* New York: Guilford Press.