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Evaluating Differences in Household Subsistence Harvest Patterns between the Ambler Project and Non-Project Zones

Natural Resource Report NPS/GAAR/NRR—2016/1280

ON THE COVER
Cow and calf moose (Alces alces) crossing a stream
PHOTO: K. Joly

Evaluating Differences in Household Subsistence Harvest Patterns between the Ambler Project and Non-Project Zones

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Contents

Figures

Tables

Page

Tables (continued)

Page

Abstract/Executive Summary

Western Alaska is one of largest inhabited, roadless areas in North America and, indeed, the world. Access, via a new road that would transverse Gates of the Arctic National Park and Preserve (GAAR), to a mining district in a vast roadless section of northwest Alaska has been proposed. Given the potential effects of the road on nearby communities, we analyzed how communities connected to the road system compare to their unconnected counterparts. Specifically, using zero inflated negative binomial models, we analyzed subsistence harvest data to understand factors that influence subsistence production at the household level. We found substantial difference in these factors between communities near the proposed road (project zone (PZ) communities and a comparable set of road accessible communities outside the region, and were affected by household characteristics such as the gender of the head of household, number of children, and income. Total subsistence production of project zone communities was 1.8 – 2.5 times greater than that of non-project zone communities. Communities with a higher percentage of Alaska Native residents had greater per capita subsistence harvests. Higher household income levels were associated with lower subsistence harvest levels. Roads can provide access for hunters from outside the region to traditional subsistence hunting grounds used by local residents that would not be very accessible if not for the road. Our proxy for competition (number of non-local moose hunters) indicates that resident moose harvest amounts are inversely related to the number of hunters in a particular area. If subsistence harvest patterns for project zone communities currently off the road changed to mirror existing non-project zone harvests due to the road, the financial cost would be USD $6,900 – 10,500 per household per year (assuming an $8/lb. 'replacement' cost for subsistence harvests). This represents about 33% of the median household income. Taken together, our results suggest that the proposed road should be expected to substantially impact subsistence production in communities that are not currently connected to the road system. The scale of our data did not allow for the comparison of the impacts of the different proposed routes but the impacts of different routes is likely minor in relation to the presence or absence of the proposed road.

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Introduction

The Ambler Mining District, located in the northwest Alaska Kobuk River valley south of the Brooks Range in the Northwest Arctic Borough (Figure 1), has been an area of great interest to the State of Alaska due to its rich copper, zinc, lead, gold and silver mineralization. NovaCopper Inc., in partnership with the Alaska Native regional corporation Northwest Alaska Native Association (NANA), has proposed a large scale mine in the Ambler Mining District. The area is remotely located approximately 168 miles east of Kotzebue, a western Alaska regional center, and approximately 292 miles northwest of Fairbanks, the regional center for the Alaska interior.

The Ambler Mining District currently lacks the necessary infrastructure, including surface transportation access to support mine development. The State has investigated a variety of surface transportation options including rail and road corridors. The Alaska Industrial Development and Export Authority (AIDEA), a public corporation of the State of Alaska, applied for a right-of-way for an industrial road leading from the existing contiguous road system to the Ambler Mining District in north-central Alaska in November, 2015 (Figure 1). The road would connect the Dalton Highway (i.e., the Alaska Pipeline Haul Road), at mile 161 (approximately 240 miles north of Fairbanks) south of the Brooks Range, and the Ambler Mining District, 220 miles to the west (Figure 1). Currently, this region is one of the largest roadless blocks of its kind in North America and perhaps the world. The proposed route would go along the southern foothills of the Brooks Range and traverse the southwestern preserve section of Gates of the Arctic National Park and Preserve (GAAR). The application initiates a National Environment Policy Act Environmental Impact Statement (EIS) and ANILCA Title XI review of a proposed road corridor to the Ambler Mining District. In support of its permit application, AIDEA has undertaken extensive preliminary work to identify the road corridor and engaged in public informational exchanges.

GAAR is the second largest and northernmost US national park. The mineral potential of the Ambler Mining District was known prior to park establishment, thus its enabling legislation, the Alaska National Interest Lands Conservation Act (ANILCA), included a provision that mandated the National Park Service (NPS) provide a right-of-way across the preserve.

> *"Congress finds that there is a need for access for surface transportation purposes across the Western (Kobuk River) unit of Gates of the Arctic National Preserve (from the Ambler Mining District to the Alaska Pipeline Haul Road) and the Secretary shall permit such access in accordance with the provisions of this subsection." – ANILCA Sec 201.4.b*

ANILCA also mandated that "an environmental and economic analysis" (EEA) be prepared so that "most desirable route" and that "terms and conditions" for the operation of road could be determined. The analysis must consider ways to minimize the impacts to "wildlife, fish, and their habitat, and rural and traditional lifestyles including subsistence activities".

Construction and operation phases of a road project have the potential to affect a range of social resources, including the formal and informal (cash and non-cash) local economies, the character of public services by local, state and federal governments; community health and safety; and traffic levels and capacity of transportation resources including roads, airports, rail, and local river transportation. Here we focus on the local economic effects, specifically those related to subsistence activities and resources utilized by project zone (PZ) communities.

The Proposed Road and Mine

According to the Preliminary Economic Assessment (PEA) (TetraTech 2013), the proposed Arctic Deposit project would be an open pit mine. The estimated capital cost for the mine (in 2013) is $717 million with total direct project costs of $476.3 million and average annual operating costs for the included 12 year life-of-the-mine (LOM) of $63.93 million (see the PEA for further detail on the proposed mine estimated mineral deposits and recovery methods). The Arctic Deposit has an estimated pre-tax net present value of $927.7 million at an 8% discount rate (TetraTech 2013). There are other prospects, in addition to the Arctic Deposit, in the Ambler mining District including Bornite, Sun and Smucker (AIDEA 2014), which could be developed.

The state of Alaska would be responsible for financing and building the road from the Dalton Highway to the Ambler Mining District. According to AIDEA, the initial plan is to build a single lane road that could be improved to two lanes. The right-of-way application states the road would not provide direct access to any community along the road corridor. However, spur roads are a possibility and were assumed when Cardno (2015) calculated potential benefits to communities. In lieu of spur roads, staging areas for fuel and freight are discussed in the right-of-way application. AIDEA indicates they would seek a public-private partnership to be involved in construction, operation and toll collection (AIDEA 2014). AIDEA has suggested the road would not be open to the public. The Dalton Highway, initially started off as an industrial use only road, but was opened to public use in relatively short order, within 7 years with a permit and 20 years without. Seeing as public usage of the proposed road to the Ambler Mining District cannot be categorically ruled out, we analyzed data assuming the possibility of public access exists.

There are varying cost estimates of the proposed northern road. The Alaska Department of Transportation and Public Facilities (DOT) estimated in 2012 that the 220 mile road project, which would have 13 large river crossings, would have a construction cost of $430 million and annual maintenance cost of $8.5 million (DOT 2012; DOWL HKM 2012). Subsequently, at a June,2014 meeting of Citizens Advisory Commission on Federal Areas, AIDEA provided a range of road costs between $190-330 million and noted this to be a rough estimate, which other AIDEA representatives indicated would be revised once a EIS is completed. This estimated cost is for a multi-phased development of the road and could be different if a phased approach was not used. A representative of Dowl HKM, the firm hired to manage the right-of-way application, indicated a more conservative range of road cost of $200-400 million. (Hughes 2014a).

According to AIDEA, the road would provide up to 300 jobs per years during the 2-4 year road construction period and additional long-term employment in road maintenance and operation. They estimate a developed and operating mine would provide an additional 300-400 jobs, of which 50% would likely be local hire (AIDEA 2014). A study funded by the State of Alaska suggests that up to 13 jobs for PZ communities may be directly created for the operation and maintenance of the road, which constitutes a local hire rate of about 30% (Cardno 2015). A 2011 cooperative agreement between Nova Copper Inc. and NANA stipulates that Nova Cooper Inc. will promote employment of NANA shareholders through hiring and contracting preferences (Nova Copper 2015).

Study Area

The study area lies entirely above the Arctic Circle (Figure 1) and is bounded to the north by the central Brooks Range; sparsely vegetated, rugged mountains that reach up to 8,533 ft. The area is bounded to the south by extensive boreal forest habitats interspersed with minor mountain ranges. The Dalton Highway forms the eastern boundary and the village of Ambler the western boundary. Within the study area, boreal forest, dominated by black spruce (*Picea mariana*), carpets the lowlan999333ds while wetland and riparian complexes are extensively interspersed. Tundra communities dominate areas where permafrost is prevalent. At higher elevations, boreal forests transition into sub-alpine shrublands and alpine tundra. The climate is strongly continental, with winter temperatures dropping below -40° C and highs in summer reaching more than 20° C. Snow cover typically lasts from October-May; with a mean annual snowfall of about 120 cm million(National Climate Data Center, Bettles, AK 1951-2014; http://www.ncdc.noaa.gov/, accessed 8 Dec 2015).

The region contains the full complement of native fish and wildlife species. Critical subsistence species include caribou (*Rangifer tarandus*), moose (*Alces alces*), salmon (*Oncorhynchus* spp.), sheefish (*Stenodus leucichthys*) and other whitefish, waterfowl, furbearers, and berries. Subsistence activities occur on a year-round basis. Access to this region by non-rural hunters is primarily limited to airplane landings.

Communities

Road access would have a profound affect not only on the GAAR, but also communities near the proposed road and mine (project zone [PZ] communities). A list of PZ communities are presented in Table 1 and shown in Figure 1. The villages of Allakaket, and Evansville are dominated by Alaska Native Athabascan people. The village of Alatna is dominated by Alaska Native Inupiat people. Community residents from each of the communities are members of the Doyon native regional corporation. The village of Anaktuvuk Pass lies within the Brooks Range and Gates of the Arctic National Park and Preserve and is largely populated by Alaska Native Inupiat people, who are members of the Arctic Slope native regional corporation. Bettles, Coldfoot and Wiseman residents are largely non-Alaska Native. All of these communities are on the east side of the project zone and are within the Koyukuk River drainage. To the west, Ambler, Kobuk, and Shungnak are dominated by Alaska Native Inupiat people and residents are members of the NANA native regional corporation. These communities are within the Kobuk River drainage and nearest the mine.

Table 1. Composition of GAAR project zone communities. "HHs" represents households. Alaska Native HHs defined as households where at least one household head is Alaska Native.

Community	Survey year	HHs in community	# HHs surveyed	Pop	Ave surveyed HH size	% Surveyed HHs AK Native
Alatna	2011	9	6	32	3.5	100.0
Allakaket	2011	57	42	147	2.6	88.1
Ambler	2012	76	53	282	3.7	67.9
Anaktuvuk Pass	2011	85	62	310	3.6	83.9
Bettles	2011	8	8	12	1.5	0.0
Coldfoot	2011	5	4	10	2.0	0.0
Evansville	2011	13	13	20	1.5	46.2
Kobuk	2012	36	30	164	4.6	66.7
Shungnak	2012	69	46	275	4.0	76.1
Wiseman	2011	5	5	13	2.6	0.0

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

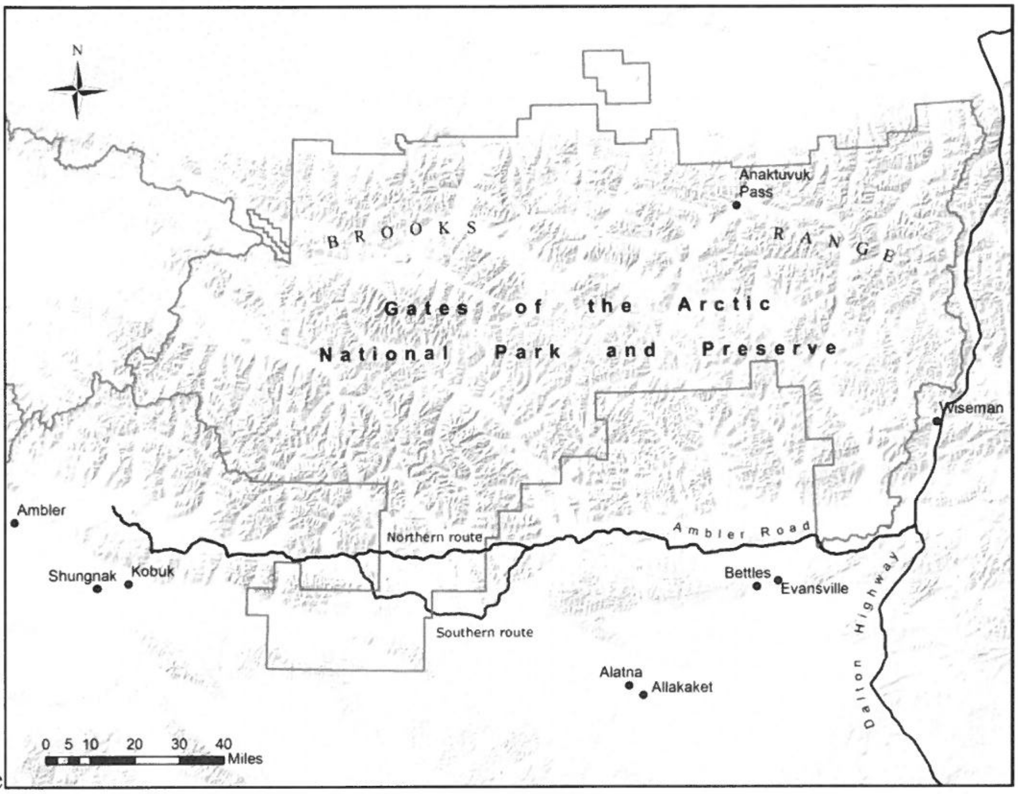

Figure 1. The study area for assessing the potential economic impacts on subsistence from a road connecting the existing road network to the Ambler Mining District, north-central, Alaska.

Many of the communities have common features, including dependence on subsistence hunting, fishing and gathering activities that are an integral part of the community culture, identity, structure and economies. Most of the local community economies are dominated by subsistence and public sectors (including transfer payments) for employment and income and have attenuated private market sectors. The possible effect of a road to subsistence resource production in these communities is a complex issue. The most comprehensive source of information on subsistence activities in rural Alaska communities has been provided by the Alaska Department of Fish and Game Division of Subsistence (ADFG-SD) through its community harvest surveys (community level survey results are available online through its Community Subsistence Information System (CSIS)). ADFG-SD works in cooperation with local communities using trained community residents to assist in conducting in-person household surveys. The household surveys, in addition to information on wild resource harvests, uses and distribution, provide socio demographic and economic information about the communities (Fall 1990; Wheeler and Thornton 2005). This study relied upon household level data not publically available for the referenced communities that was provided by ADFG- SD through a data sharing agreement with conditions in place to protect anonymity of respondents and confidential information (referenced in this report as ADFG-Division of Subsistence confidential household survey database, 2015) to describe and analyze subsistence production of community households. Individual household level information is the most reliable and cost effective way to collect and analyze harvest data. It should be noted, however, that subsistence production is often a cooperative activity among community households. Braem et al. note that "While subsistence harvest surveys collect information based on individual households, in reality, much of the production (harvest and processing) of subsistence foods is achieved by households within a community that work cooperatively (2015, pg. 109)." Magdanz et al. (2002) in a report on the production of wild foods in Wales and Deering, note that harvests occur within extended family networks that extend beyond a single household. While ADFG-SD has expanded its household survey to include information on network sharing relationships, the standard household survey does not document quantities harvested, distributed, and used across households and therefore could not be employed in this study.

Currently, the absence of road access provides a natural buffer for the PZ communities that limit in-migration and competition for subsistence resources from non-locals. Regional access for outside hunters and fishers is expensive, requiring plane travel and/or lengthy river travel. Some community residents are concerned that a road could interfere with local subsistence production and traditional community identity due to an influx of hunters and to some extent fishers, and road impacts including noise that could affect caribou. (Buxton 2014a; Buxton 2014b; Rogers 2014; Jillian 2014; Hughes 2014b, Braem 2105). This concern is present despite assurances by AIDEA that road access would be restricted to commercial traffic associated with the mining activities and that there would be minimal impact to subsistence resources

The presence of a road and associated development of the Ambler District also promises increased economic opportunities and capital for PZ communities. These communities currently experience high levels of unemployment in the cash sector (private and public), and low average incomes. The communities also experience high costs of living. In addition to employment and capital opportunities, the presence of a road may lower transportation costs for good and services to the region and lower costs of accessing goods and services from outside communities, including the urban centers of Fairbanks and Anchorage. However, an influx of new residents can create social turmoil in small towns and villages (Power, 1996; Mittermeier et al. 2003). Rural residents living off the road system are tied to the landscape around them and may have very different traditions, practices and norms than those arriving from new areas (Berger and Daneke 1988; Fuller 2007). Thus, the establishment of roads into previously roadless areas can have both positive and negative elements.

The potential benefits and costs of a road have been the subject of great debate within the region with some communities and public groups taking firm stances in opposition to the road while in other communities the views of residents are mixed. This mixed reaction in the communities of Ambler, Shungnak and Kobuk was noted by Braem et al. (2015). The Allakaket Tribal Council and Evansville, a Native Village Corporation Inc., passed a resolution in opposition to the road (ibid), and The Brooks Range Council, a citizens group, was formed to oppose the road.

This study attempts to identify the factors that affect subsistence production at the household level. To provide an array of communities that includes both those with and without road access, additional communities from the Interior and Cooper River Basin region of Alaska, were included in the analysis. Almost all of these communities have road access, with the exception of Beaver. Wolfe and Walker (1987) examined the relationship between subsistence production and various factors at the community level and Wolfe et al. (2009) extended this analysis to the household level for an array of communities across the state using a different modelling framework than the one presented in this report.

Background

Project Zone Communities

The description of the PZ communities is complicated by the small population of several eastern communities. According to the ADFG-SD data, the eastern communities, with the exception of Allakaket and Anaktuvuk Pass, have less than 40 residents (ADFG-SD 2015). While these smaller communities (defined here as communities with populations less than 50 residents) are discussed in this section, it must be recognized that their community characteristics may be particularly unstable over time, and susceptible to significant changes based on the actions of few people and households. Furthermore, wide seasonal fluctuation of community populations is common. Anaktuvuk Pass is included as a PZ community even though it is not located in close proximity to the proposed road because it lies within GAAR and is considered by NPS as a Park resident-zone community. The Inupiat community of Alatna and the Athabascan community of Allakaket are located across the Koyukuk River from one another and share infrastructure such as a school and airport. Similarly, the small eastern communities of Evansville and Bettles are located adjacent to one another. Bettles has a predominantly Euro-American population while a majority of Evansville's population is Alaska Native. In the eastern region, as noted, the communities of Wiseman and Coldfoot are located on the Dalton Highway and there is an ice road accessible from the Dalton Highway to Evansville and Bettles in winter for several months. The larger eastern communities of Anaktuvuk Pass, Allakaket and Alatna, as well as the western communities of Alatna, Kobuk, and Shungnak do not have road access. Local carrier air service is the primary means of transportation and supply for most of these communities.

Included in Table 1 are the number of households surveyed and the percentage of surveyed households that were reported in either 2011 or 2012 to be Alaska Native (defined by ADFG as a household where the ethnicity of at least one household head is Alaska Native). Greater than 66% of the western community households were Alaska Native (Table 1). The data for the eastern communities is more variable (Table 1). The larger communities of Allakaket and Anaktuvuk Pass, as well as the smaller community of Alatna reported > 80% Alaska Native households. The remaining smaller eastern communities reported no Alaska Native households with the exception of Evansville (53.8% Alaska Native. Across the region, 71.4% of all households were reported to be Alaska Native.

The limited extent and diversity of the formal component of rural Alaskan economies along with their relative remoteness produces a number of inter-related challenges that have come to define life in the Alaska bush. As noted by Huskey (1992a; 2004b) and Goldsmith (2008), the constraints of small population and distance from larger markets translate into limited income producing economic opportunities and a high cost of living. For PZ communities, household incomes tend to be well below the Alaska average. In the three western communities, the median household income ranges from 51.2% to 71.5% of the Alaska median (American Community Survey (ACS) 5-year estimates 2009-2013); and for the larger eastern communities of Allakaket and Anaktuvuk Pass, household median income was 49.7% and 74.2%, respectively, of the Alaska median. For the smaller eastern communities of Bettles and Evansville, median income is 106.3% and 43.3% of the Alaska median (the ACS does not report median incomes for Alatna, Coldfoot and Wiseman). Poverty rates tend to be high in the PZ communities ranging from 50.8% in Kobuk to a 15.5% in Anaktuvuk Pass (Table 2) (USCB 2013). In comparison, the 2013 poverty rate for Alaska and the United States was 9.9% and 15.4%, respectively.

Table 2. GAAR project zone communities, median household (HH) income, and poverty rates.

Community	Median HH income ($)	Persons below poverty level (%)
Alatna	na	na
Allakaket	25,179	27.3
Anaktuvuk Pass	52,500.00	15.5
Coldfoot	na	na
Bettles	75,250	na
Evansville	30,625	na
Wiseman	na	na
Ambler	38,750	43.1
Kobuk	36,250	50.8
Shungnak	50,625	17.1
Alaska	70,760.00	9.9
US	--	15.4

Source: U.S. Census Bureau, 2009-2013 5-Year American Community Survey.
Data for Evansville was unavailable.

The top 3 industries in 2013 by percent of workers for each of the study region communities (ALARI 2013) are provided in Table 3. For the larger communities in the study region, local government is the most prominent source of employment, averaging 45% of all jobs for the western communities and 71.4% of all jobs for the larger eastern communities of Anaktuvuk Pass and Allakaket. The professional and business service industry is also a significant source of employment in many of the communities. The leisure and hospitality industry is an important source of employment in several of the smaller eastern communities. For example, in Bettles and Evansville many of the commercial businesses cater to hunters, fishers and adventure travelers and services include lodging, guiding and air charter. Natural resources and mining was reported as one of the top industries only in Ambler and the smaller communities of Coldfoot and Wiseman.

Table 3. Top 3 Industries by percent of workers in 2013 for GAAR project zone communities.

Industry	Alatna (%)	Allakaket (%)	Anaktuvuk Pass (%)	Coldfoot (%)	Bettles (%)	Evansville (%)	Wiseman (%)	Ambler (%)	Kobuk (%)	Shungnak (%)
Local Government	87.5	77	65.8	--	28.6	na	--	49.2	50.0	37.7
State Government	--	--	--	--	--	na	14.3	--	--	--
Professional & Business Services	--	--	21.1	8.3	42.9	na	14.3	15.9	16.7	21.1
Natural Resources and Mining	--	--	--	8.3	--	na	28.6	9.5	--	--
Construction	--	--	4.6	--	--	na	42.9	--	13.9	--
Financial Activities	--	--	--	--	--	na	--	--	--	22.8
Leisure & Hospitality	12.5	--	--	83.3	14.3	na	--	--	--	--
Trade, Transportation & Utilities	--	7.1	4.6	--	--	na	--	--	--	--
Education and Health Services	--	6.2	--	--	--	na	--	--	--	--
Top 3 total	100	90.3	91.5	99.9	85.8	na	85.8	74.6	80.6	81.6

Source: ALARI, Alaska Dept. of Labor and Workforce Development, 2015.

While rural economies in the region are monetized through employment income, a significant source of household income comes from transfer payments made through alternative channels such as Alaska Permanent Fund Dividend, Native Corporation Dividend, Food Stamps, and Social Security. Transfer payments averaged 28.7% of household income for surveyed households in the western communities and 22% for surveyed households in the larger eastern communities of Anaktuvuk Pass and the combined communities of Alatna and Allakaket (ADFG-Division of Subsistence 2015).

Unemployment rates in the study region communities exceed those of the Alaska average. Unemployment rates for individual communities that are comparable to the reported United States and Alaska rates are unavailable. However, comparable unemployment rates are available at the Borough and Census Area levels. The unemployment rates (ALARI 2013) in the Northwest Arctic Borough, which includes the western communities, and the Yukon Koyukuk Census Area, which includes all of the eastern communities except Anaktuvuk Pass (part of the North Slope Borough), are 16.3% and 18.2%, respectively. This compares with the Alaska 2013 unemployment rate of 6.9%. Calculation of unemployment rates is complicated by the fact that many individuals hold seasonal jobs and may hold several jobs during a year. Heads of the surveyed household in the surveyed year worked an average of 7.9 months in the western communities and 8.2 months in the larger eastern communities. Many of the jobs held by household heads are not full time. This is shown in Table 4. Full time employment in the western communities ranged from 31% of the jobs in Shungnak to 78% in Kobuk. For the larger eastern communities, full time employment accounted for 33.7% and 77.6% of the jobs in Allakaket and Anaktuvuk Pass, respectively. In the case of the smaller eastern communities, on average, 34.2% of the jobs were full time.

Table 4. GAAR project zone communities, average number of months worked (Months) and percentage of job types held by heads of surveyed households. Households may be headed by multiple individuals.

		Job types by percent				
Community	**Months**	**Full time %**	**Part time %**	**Shift (full time) %**	**Shift (part time) %**	**On-call (variable) %**
Alatna	7.8	41.7	33.3	0.0	25.0	0.0
Allakaket	6.6	33.3	42.9	3.2	20.6	0.0
Ambler	9.0	50.0	7.6	9.1	31.8	1.5
Anaktuvuk Pass	9.7	77.6	14.9	0.0	7.5	0.0
Bettles	10.7	66.7	33.3	0.0	0.0	0.0
Coldfoot	9.0	42.1	15.8	0.0	42.1	0.0
Evansville	7.6	66.7	15.6	2.2	15.6	0.0
Kobuk	8.1	78.0	14.0	2.0	6.0	0.0
Shungnak	8.2	30.8	15.4	0.0	53.8	0.0
Wiseman	7.8	41.7	33.3	0.0	25.0	0.0

Source: ADFG-Division of Subsistence confidential household survey database, 2015

The high cost of living in the PZ regions was documented by the Alaska Geographical Differential Study 2008 (McDowell Group 2009). This study provided the cost of living differential between different areas of the state in comparison to that of Anchorage. While cost of living differential are not provided for specific PZ communities, we can note that cost of living differential for Kotzebue (a northwestern Alaska regional center), the Arctic, and the Roadless Interior regions are estimated to be 1.61, 1.48 and 1.31, respectively. The high cost of living is further underscored by examining directly the cost of store purchased food and cost of gasoline. For example, the June, 2011 cost of groceries for a family of four with two young children in Anaktuvuk Pass was estimated to be $323.8/week (based on the USDA Thrifty Food Plan). In comparison, the comparable Anchorage food cost was $142.7/week (Luick 2015). Food cost estimates are unavailable for other study region communities, however, the comparable 2011 weekly food costs for a family of four in Kotzebue was $303.9 and $365.6 9(for September, 2011) in the northwest community of Selawik (ibid). The 2012 prices for gasoline in Ambler and Shungnak were $10.75/gal. and $10.59/gal., respectively, and the Ambler 2012 heating oil price was $11.00/gal. (Braem, et al. 2012). The January 2015 price of gasoline in Anaktuvuk Pass, Alatna, and Kotzebue was $9.49/gal., $6.52, and $7.00/gal. (ADCCED 2015), respectively. For Interior Alaska, the January, 2015 average gasoline prices were $4.06/gal. for communities on the road system and $7.24/gal. for communities off the road system. A similar price differential was found for heating fuel with a reported average prices of $3.95/gal. for interior Alaska communities on the road system and $7.24/gal. for communities off the road system.

Despite the high cost of living, low average incomes and limited employment opportunities, the communities along the study region have remained viable as indicated by stable and even growing populations. Interestingly, a 2009 report on populations found that while many rural regions of Alaska had experienced significant population declines from 2000-2008, the rural interior region's population had only declined -0.4% and the northwest region's population had increased by 3.1% (DCRA 2009). Among the study communities, population trends for the larger communities are reported in Table 5. The population estimates show that in general there has been recent growth in the western communities and a general trend of population growth in the larger eastern communities of Allakaket and Anaktuvuk Pass since 2000. The smaller eastern communities of Alatna, Bettles, Coldfoot and Wiseman have experienced population declines since 2000. Again, population trends are difficult to assess in these small communities in which populations not only vary inter-annually, but across seasons intra-annually.

Researchers have long sought solutions to the Alaskan pattern of economically underdeveloped micro-economies (Huskey 1992a; McDiarmid 1998; Goldsmith 2007; Goldsmith 2008). Expanded extractive resource development has been suggested as a solution for the region's economic maladies (McDowell Group 2012; Alaska Miners Assoc. 2013). As just one example, proponents of this approach point to the Red Dog mine, which operates outside of Kotzebue, Alaska as a successful resource development project that has increased employment, incomes, and opportunity for residents of Northwest Alaska. The Red Dog Mine is operated through a partnership between NANA regional corporation and Teck Alaska Inc. The proposed development of the Ambler Mining District has been highlighted as a similar opportunity to help local communities develop economically through introduction of a basic industry that provides jobs, economic opportunities, and infusion of income from outside the region, while exporting all its production outside the region. The regional economies have few other private industries, beyond tourism that provide infusion of outside income. In its absence, the regional economies developed to become heavily reliant on transfer payments, the public sector, and the subsistence sector.

Table 5. GAAR project zone community populations for selected years.

	Population				
Community	**1980***	**1990***	**2000***	**2010***	**2012/11****
Ambler	192	311	309	258	282
Kobuk	62	69	109	151	164
Shungnak	202	223	256	262	275
Allakaket***	163	170	133	171	147
Anaktuvuk Pass	203	259	282	324	310
Alatna	--	29	35	37	32
Bettles	--	36	43	12	12
Evansville	94	33	28	15	20
Coldfoot	--	--	13	10	10
Wiseman	--	--	21	14	13

Sources:

* US Census Bureau.

** ADFG-Division of Subsistence confidential household survey database, 2015.

*** 2000 and 2010 population includes Allakaket City and New Allakaket CDP

From the outside, this is not just a problem of community size, but one of infrastructure. Most of the PZ communities are located on waterways and, as a consequence, are more exposed to ecological and climatic factors which can negatively impact the efficacy of waterborne transport. When combined with the scale of distances that must be covered, the construction of the Ambler road would, from the outside, appear to provide a solution to a number of problems.

For communities in the study region, transportation infrastructure is practically non-existent. The Dalton highway extending north from Fairbanks is the only major road in the region and provides year-round access to only a few of the PZ communities. The proposed Ambler Road would substantially increase regional infrastructure. However, community accessibility to the road depends on the route and the planned use. As currently proposed the road would provide direct access to only the small western community of Kobuk. Other communities would need to build spur roads for access. Furthermore, AIDEA indication of limiting road access to commercial traffic could exclude local communities from use. As such, the proposed route as well as planned use limits the potential benefits to regional communities while not minimizing any of the costs. However, as previously noted, the Dalton Highway was at one time a special permit only road limited to commercial and industrial use only to subsequently have the State change it to a general use highway open to the public.

The opposition to potential road development from many residents of the region is notable. In other economic development contexts, introducing transportation infrastructure such as provision of a road and the access it provides for local populations to access outside areas is viewed as an important tool to improve local conditions (Vickerman et al. 1999; Donaldson 2010; Banerjee et al. 2012; Shrestha 2012). However, in the case of the proposed Ambler road corridor, the prospect of road access to outside areas is viewed with great caution by many residents, in large part the lack of access protects a basic industry, the subsistence economic system.

From the prior discussion of typical measures of community economic health, an obvious question is "how do communities function given the economic deficiencies in the monetized economy coupled with the high cost of living?" An important part of the answer is the long held reliance on subsistence activities as a mainstay of community resilience and economies. Loring and Gerlach (2009) note, aptly, that rural Alaskan communities are places where personal well-being is achieved through 'social cohesion' and 'support,' and where livelihoods are 'interlinked' and tied to the surrounding geography. Within this context, maintaining productivity and access to local subsistence resources is critical to the communities' mixed economies. Subsistence harvest is a culturally important practice that provides a connection between residents and provides an identity for many communities (Nutall et al. 2004; Kruse et al. 2004). The connection between community well-being and subsistence productivity has been studied extensively (Wolfe 1987; Wolfe and Walker 1987; Nutall at al. 2004; Kruse et al. 2004, Wolfe et al. 2009) and helps to explain the persistence of the small, geographically isolated villages in the study region. In a place where the availability of purchasable foods can be uncertain owing to financial constraints and the cost and complexity of long-distant transport, food insecurity can be a serious problem. Subsistence harvest plays an important role as a risk mitigation tool and efficient (low cost) production method to provide a stable source of affordable year round food that is shared among community members. The mixed subsistence-market economy is well described by Fall (2014), who notes that families in subsistence areas "...follow a prudent economic strategy of using a portion of the household monetary earnings to capitalize in subsistence technologies for producing food." The subsistence component of the economy offsets many of the deficiencies of the monetized component, providing non-wage employment and import substitution of non-local food production. The importance of mixed subsistence market economies in rural Alaska has been described in numerous studies (Wolf and Walker 1987; Fall 1990; Magdanz et al. 2002, Goldsmith 2008).

Subsistence food production has been identified as a major source of nutritional requirements in rural Alaska and is reported to meet 189% of the protein requirements and 26% of the caloric requirements of rural population (Fall 2014). Fostering subsistence food production was identified as a key strategy to achieving food security in Alaska (Meter and Phillips Goldenberg 2014). The efficiency and effectiveness of subsistence production is directly tied to the productivity of the habitats, which surround the communities. In fact, the locations of many of the region's communities were selected because of the quality and productivity of local subsistence resources (Huskey 1992a).

This concept of subsistence food production as a risk mitigation tool is supported by the cooperation of households in the production of subsistence resources and the extensive distribution of subsistence harvests that occurs within rural Alaska. ADFG-SD reports that this cooperation "is often organized along kinship lines or based on other important social ties found in communities with Alaska Native histories (Braem et al. 2015, pg 109)." The important role of subsistence food distribution in rural Alaska through sharing, barter and trade in rural Alaska has been widely documented (Wolfe and Walker 1990; Magdanz et al. 2002; Wheeler and Thornton 2005; Fall 2014).

The ADFG-SD has reported that subsistence production in rural Alaska is significantly higher than that of urban Alaska. For example, in 2012 it was estimated that annual wild food harvest were 295 lbs. per capita and 22 lbs. per capita in rural and urban Alaska, respectively (Fall 2014). This characteristic of substantial subsistence food production in rural Alaska is present for most of the PZ communities, particularly the larger communities. Average per capita subsistence harvests (in edible pounds) of surveyed households in the larger resident communities ranged from 2,267.9 lbs. in Ambler (610.1 lbs. per capita) to 1,154.7 lbs. in Anaktuvuk-Pass (316.8 lbs. per capita) (Table 6). Each of these communities exceeded the overall Alaska rural average per capita harvests of 295 lbs. and were among the highest per capita rates in the state (Fall 2014, Fall 2016). There is greater variation among the smaller communities with almost all having substantially lower levels of production. Large land animals and fish account for the vast majority of subsistence production. These two resource categories average 91.0% of all subsistence production in the larger PZ communities, and 81.7% of resource harvest in the other smaller communities (Table 7). The importance of fish production to many of community households is further underscored by examining the proportion total subsistence production comprised of fish. For several communities, average household fish harvest exceeds that of the large land animals (Allakaket and Kobuk).

Table 6. GAAR project zone communities, surveyed household average per capita and household, subsistence harvest of all resources, surveyed household average harvest of fish, land animals, and large land animals, and percentage of total subsistence production comprised of fish and large land animals. All weights in edible pounds.

Community	Per capita all resources (lbs.)	HH all resources (lbs.)	HH Fish (lbs.)	HH large land animals (lbs.)	HH, fish & large land animals (%)
Alatna	273.6	957.53	170.72	675.00	88.3
Allakaket	520.3	1,337.92	839.61	425.55	94.6
Ambler	610.1	2,267.90	782.98	1,343.63	93.8
Anaktuvuk Pass	316.8	1,154.65	68.11	1,057.21	97.5
Bettles	175.3	262.96	18.03	232.50	95.3
Coldfoot	38.1	76.25	0.00	65.00	85.2
Evansville	52.8	81.27	19.76	41.54	75.4
Kobuk	308.7	1,409.52	805.34	508.93	93.2
Shungnak	367.5	1,461.92	568.89	818.65	94.9
Wiseman	293.7	763.70	64.68	577.60	84.1

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

Table 7. GAAR project zone communities, surveyed households percentages of subsistence production of all resources comprised of fish, large land animals, salmon, sheefish, whitefish (other than sheefish), caribou and moose.

Community	Fish (%)	Large land animals (%)	Salmon (%)	Sheefish (%)	Whitefishes (%)	Caribou (%)	Moose (%)
Alatna	17.8	70.5	10.0	2.1	4.4	43.0	18.8
Allakaket	62.8	31.8	29.2	13.9	14.4	16.2	12.5
Ambler	34.5	59.2	5.9	7.5	18.9	54.1	4.5
Anaktuvuk Pass	5.9	91.6	0.6	0.0	0.9	79.2	3.0
Bettles	6.9	88.4	2.4	0.0	0.0	37.1	51.3
Coldfoot	0.0	85.2	0.0	0.0	0.0	85.2	0.0
Evansville	24.3	51.1	13.9	3.4	0.0	0.0	51.1
Kobuk	57.1	36.1	29.8	23.3	2.5	31.9	3.8
Shungnak	38.9	56.0	15.3	17.2	5.4	53.3	2.4
Wiseman	8.5	75.6	4.0	0.0	0.3	13.6	56.6

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

Caribou and moose are the two most prominent large land animals harvested by PZ communities. The composition of large land mammal harvests varies by community location. For example, the Western Arctic Caribou herd migrates through the Kobuk River valley twice a year and caribou are a prominent subsistence food resource for the three western communities (Table 7). Caribou is also reported to be an essential resource for Anaktuvuk Pass households not only as a food resource but also as an essential part of community identity and culture for the Nunamiut residents who "have lived alongside caribou for thousands of years" (Holen et al. 2012, pg. 130). Caribou and moose were the most important large land animals harvested by the other eastern community households, with their contribution to household food production varying by community. It must be recognized that the subsistence harvest surveys provide a snapshot in time and may not be representative of longer term trends. For example, it was reported that an unusual caribou migration in 2011 brought caribou close to the communities of Allakaket and Alatna and led to higher than typical harvests of other recent years (Holen et al. 2012, pg.96).

The most prominent fish species harvested, with few exceptions, by the communities are salmon, sheefish and whitefishes (other than sheefish) (ADFG-SD 2015). Similar to land animals, the composition of species harvested by households depends on community location and resource availability. The key fish species vary among the western communities. Whitefishes are the most prominent fish harvested in Ambler. In contrast, salmon and sheefish, which spawn in the Kobuk River, were the key fish species harvested by Kobuk and Shungnak households (see Georgette and Shiedt 2005, for an informative discussion of subsistence whitefish harvest in the Kobuk Valley). On average, fish accounted for 40.1% of surveyed household's subsistence production in these three western communities. Fish was a less prominent subsistence resource for eastern community households with the exception of Allakaket. Surveyed households in the other eastern communities had relatively small estimated average household fish harvests and salmon was the principal type of fish harvested.

The importance of subsistence food production in the PZ communities can be further seen by examining the number of households that engage, use, receive, and giveaway subsistence harvest of large land animals and fish. Table 8 and Table 9 provide the percentages of surveyed households that reported partaking in these activities with respect to fish and large land animals for either the 2011 or 2012 survey years. For the western communities, from 63% (Shungnak) to 83.3% (Kobuk) of surveyed households attempted to harvest fish and 52.2% (Shungnak) to 73.6% (Ambler) attempted to harvest large land animals. In the eastern communities, a majority of surveyed households reported attempting to harvest large land animals and fish with the exception of the smaller communities of Bettles and Evansville and Coldfoot (for fish). Examination of the tables also shows it is common across most of the communities for households to giveaway and receive subsistence harvests of large land animals and fish. This sharing activity is illustrated by greater than 76% of the households reporting using fish, with the exception of households in the small eastern communities of Bettles and Coldfoot, and almost all surveyed households (90%+) reported using large land animals.

Table 8. Percent of GAAR project zone communities' surveyed households that used, attempted to harvest, harvested, received, and gave away subsistence produced fish.

Community	%Used	%Attempted Harvest	%Harvested	%Received	%Gaveaway
Alatna	83.3	83.3	66.7	66.7	66.7
Allakaket	85.7	64.3	61.9	81.0	52.4
Ambler	92.5	79.2	73.6	75.5	58.5
Anaktuvuk Pass	88.7	80.6	71.0	69.4	59.7
Bettles	62.5	37.5	25.0	50.0	12.5
Coldfoot	25.0	0.0	0.0	25.0	0.0
Evansville	76.9	38.5	38.5	69.2	38.5
Kobuk	100.0	83.3	83.3	86.7	70.0
Shungnak	91.3	63.0	63.0	84.8	63.0
Wiseman	100.0	80.0	80.0	100.0	60.0

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

While participation in, and distribution of, subsistence harvests is pervasive in rural Alaska communities, most of the production occurs from relatively few households (Wolfe 1987; Wolfe et al. 2009). Wolfe et al. (2009) reported that approximately 33% of the households produced 76% of the subsistence harvests. This characteristic is present in the each of the project zone communities and shown for the larger communities in Figure 2. For the larger western and eastern communities, approximately 30% of the households were estimated to produce between 74% and 87% of the subsistence resources.

Table 9. Percent of GAAR project zone communities' surveyed households that used, attempted to harvest, harvested, received, and gave away subsistence produced large land animals.

Community	%Used	%Attempted Harvest	%Harvested	%Received	%Gaveaway
Alatna	100.0	83.3	83.3	100.0	83.3
Allakaket	90.5	76.2	42.9	88.1	64.3
Ambler	94.3	73.6	64.2	71.7	64.2
Anaktuvuk Pass	95.2	62.9	53.2	80.6	56.5
Bettles	87.5	37.5	37.5	87.5	37.5
Coldfoot	100.0	50.0	25.0	75.0	50.0
Evansville	92.3	15.4	7.7	92.3	53.8
Kobuk	96.7	73.3	60.0	80.0	60.0
Shungnak	95.7	52.2	47.8	87.0	43.5
Wiseman	100.0	80.0	60.0	60.0	60.0

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

The issue of food security is rural Alaska has a different context than that of the contiguous United States because of the mixed subsistence-market economy and prevalence of subsistence food production. Food security is defined as "**access by all people at all times to enough food for an active, healthy life** (ERS 2015)." ADFG-SD in their household surveys asked a series of questions regarding food security. Based on replies, households were placed in categories consistent with those reported by USDA as Food Insecure, either very low or low, or Food Secure, either marginal or high (Braem et al. 2015; Holen et al. 2011). Examination of the survey finding (Table 10) shows that food insecurity in general is very high across the communities and much more common than elsewhere in Alaska and the United States. Over 30% of the surveyed households were considered food insecure in the larger eastern and western PZ communities, with the exception of Shungnak, whose percentage of food insecure households, 14% approached that of Alaska as a whole and the United States. This underscores the importance of subsistence food production to the regional communities and the concern community members express about maintaining local sources of wild food as an integral part of the local food system.

Table 10. Percentage of GAAR project zone community households in surveyed years and Alaska and US households that reported to be food insecure as denoted by very low or low food security.

Community	Year	Food insecure (%)	Very low (%)	Low (%)
Alatna*	2011	34	17	17
Allakaket**	2011	31	5	26
Anaktuvuk Pass**	2011	37	18	19
Coldfoot**	2011	25	0	25
Bettles**	2011	13	13	0
Evansville**	2011	8	0	8
Wiseman**	2011	20	0	20
Ambler*	2012	34	14	20
Kobuk*	2012	45	17	28
Shungnak*	2012	14	7	7
Alaska*	2012	12	4	8
US*	2012	15	6	9

Sources: Alaska and US, USDA, ERS Definitions of Food Security, http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx.

* Braem et al., 2015.

** Holen et al., 2011.

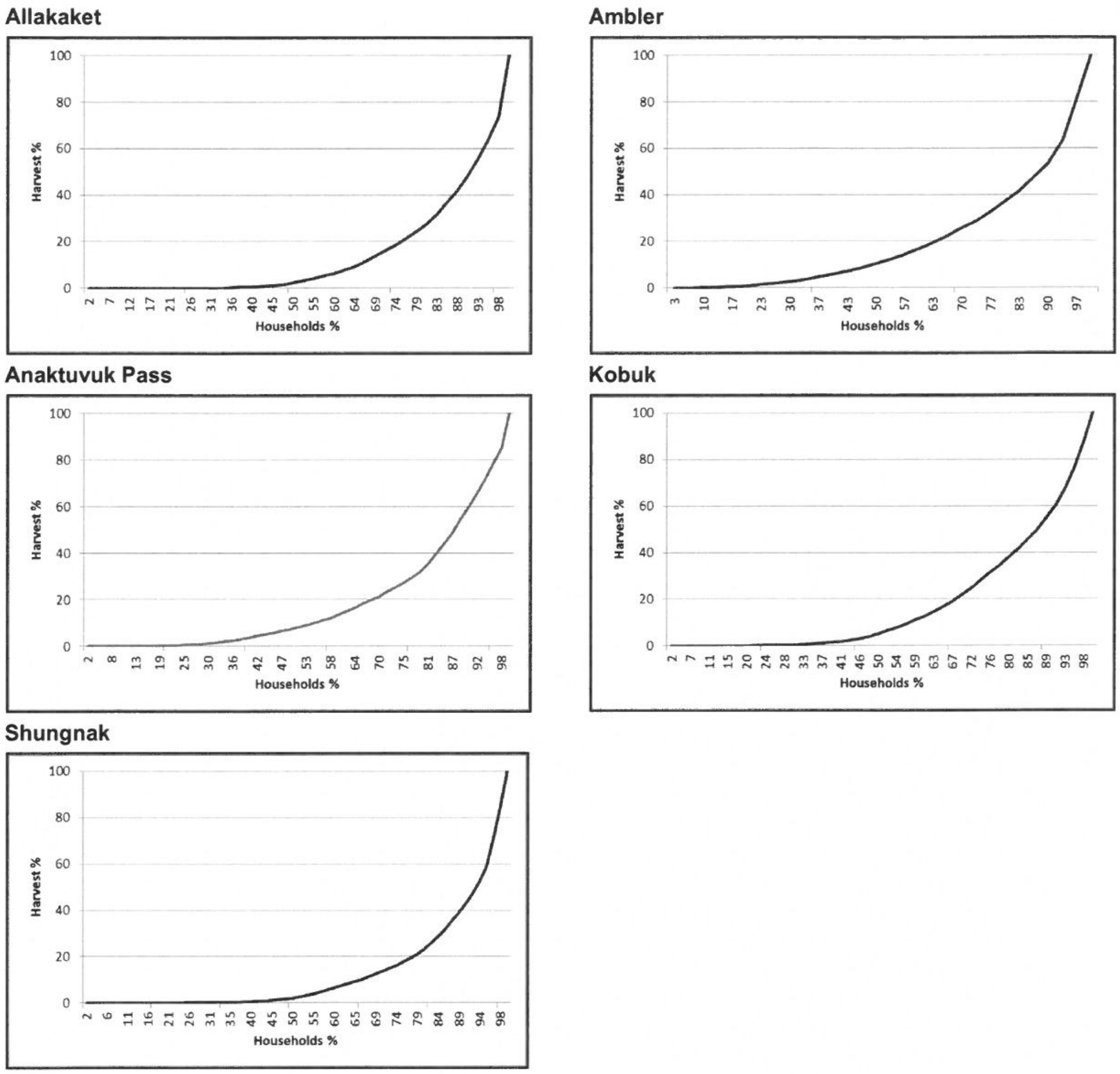

Figure 2. GAAR project zone large communities—Allakaket, Ambler, Anaktuvuk Pass, Kobuk, and Shungnak, cumulative percent of subsistence production of all resources by percentage of community surveyed households. Source: Alaska Department of Fish and game Division of Subsistence, community household surveys database, 2015.

Non-Project Zone Communities

To broaden the evaluation of subsistence production and give context to economic patterns in PZ communities, we included in the study household information from 22 communities principally from the Copper River Basin (non-project zone [NPZ] communities) (Table 11). Many Copper River Basin communities existed long before they got connected to the contiguous road system, therefore they provide for a good comparison. Those NPZ communities outside the Cooper River Basin were located in the area of Interior Alaska southeast of Fairbanks (southeast interior), Tok, Dot Lake and Dry Creek, and northwest of Fairbanks, Beaver. All communities except Beaver have road access that connects the regional communities to the larger urban communities of Fairbanks and Anchorage.

Beaver is a special case among the considered communities because of its distant location from the other communities and its relative isolation due to the lack of road access. In general, NPZ communities have better access to salmon and moose resources than PZ communities, but poorer access to whitefish and caribou. These communities also face a more complex regulatory environment for large-game hunting that includes smaller bag limits and shorter seasons.

The NPZ community populations, as estimated by ADFG-SD in the surveyed years, range from 1,312 in Tok to 24 in Tolsona. We note that in some cases there is considerable variation between in the reported population sizes and the current community populations as reported by the state of Alaska (DCCED 2015). The median surveyed household size across all communities is 2.50 residents and in general average household size is less than that for the PZ communities. The majority of the NPZ communities had populations that are predominately non-Alaska Native. Table 11 provides the percentage of surveyed households classified as Alaska Native based on having one or more Alaska Native household head. Alaska Native households were a majority in only four of the 22 NPZ communities, although they did represent a considerable portion of households in several additional communities. The largest communities of Tok and Glenallen had predominately non-Alaska Native populations. In contrast, all households were reported to be Alaska Native in Beaver.

Table 11. Non-project zone communities year of ADFG-SD household survey, Alaska region in which located, population size, number of households, number of households surveyed, surveyed household average size, and % surveyed households that are Alaska Native (defined as households where at least one household head is Alaska Native).

Community*	Study Year	Region	Population	Number of HHs	Number of surveyed HHs	Surveyed HH size	% Surveyed HHs AK Native
Beaver	2011	Interior	72	36	25	2.0	100.0
Chistochina	2009	Copper River Basin	87	33	27	2.6	40.7
Chitina	2012	Copper River Basin	134	54	46	2.5	28.3
Copper Center	2010	Copper River Basin	431	158	80	2.7	32.5
Dot Lake	2011	Interior	50	21	14	2.4	57.1
Dry Creek	2011	Interior	91	30	27	3.0	0.0
Gakona	2012	Copper River Basin	202	77	42	2.6	14.3
Glennallen	2013	Copper River Basin	384	140	77	2.7	3.9
Gulkana	2013	Copper River Basin	104	33	29	3.1	72.4
Kenny Lake	2012	Copper River Basin	218	93	32	2.4	3.0

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

* ADFG study communities sometimes do not match US census CDPs; e.g. ADF&G "Copper Center" includes Silver Springs CDP, Dot Lake includes two CDPs, etc. This means caution is needed when comparing census information and ADFG-SD survey information.

Table 11 (continued). Non-project zone communities year of ADFG-SD household survey, Alaska region in which located, population size, number of households, number of households surveyed, surveyed household average size, and % surveyed households that are Alaska Native (defined as households where at least one household head is Alaska Native).

Community*	Study Year	Region	Population	Number of HHs	Number of surveyed HHs	Surveyed HH size	% Surveyed HHs AK Native
Lake Louise	2013	Mat-Su	27	14	10	1.9	0.0
McCarthy Road	2012	Copper River Basin	103	58	39	1.8	2.6
Mendeltna	2013	Copper River Basin	34	14	10	2.4	0.0
Mentasta Lake	2010	Copper River Basin	106	36	23	3.0	82.6
Mentasta Pass	2010	Copper River Basin	35	12	9	2.9	11.1
Nelchina	2013	Copper River Basin	76	29	18	2.6	0.0
Paxson	2013	Copper River Basin	32	11	8	2.9	0.0
Slana	2010	Copper River Basin	176	86	62	2.0	4.8
Tazlina	2013	Copper River Basin	352	120	79	2.9	32.9
Tok	2011	Interior	1,312	555	143	2.4	7.0
Tolsona	2013	Copper River Basin	24	12	8	2.0	0.0
Tonsina	2013	Copper River Basin	90	39	23	2.3	4.3

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

* ADFG study communities sometimes do not match US census CDPs; e.g. ADF&G "Copper Center" includes Silver Springs CDP, Dot Lake includes two CDPs, etc. This means caution is needed when comparing census information and ADFG-SD survey information.

The median household income showed tremendous variation across the NPZ communities, as reported by the American Community Survey (ACS) 5-year estimates 2009-2013 (Table 12). In general, the communities had median income well below that of Alaska, with the exception of Gakona and Kenny Lake. For the other communities, the median income ranged from a low of 31.8% to a high of 70.1% of the Alaska median (there were several communities not included in the ACS). Poverty rates were also highly variable across communities ranging from a high of 51.3% in Mentasta Lake to 2.5% in Gulkana. The variation in income and poverty rates reflects that the NPZ communities have highly diverse socio-economic characteristics. It was noted in a recent Alaska Economic Trends report (Sandberg and Hunsinger 2014) on the Copper River Basin that this region has an aging population, which when coupled with strong subsistence participation leads to relatively low rates of participation in the labor force.

Table 12. Non-project zone communities, median household income and poverty rates.

Community	Median HH income ($)	Persons below poverty level (%)
Beaver	22,500	34.7
Chistochina	33,750	15.9
Chitina	42,917	19.7
Copper Center	47,946	17.9
Dot Lake	na	na
Dry Creek	na	20
Gakona	100,625	6.6
Glennallen	47,500	na
Gulkana	49,583	2.5
Kenny Lake	82,833	16.8
Lake Louise	22,964	51.5
McCarthy Road	35,907	na
Mendeltna	na	na
Mentasta Lake	12,060	51.3
Mentasta Pass	na	na
Nelchina	na	na
Paxson	33,238	na
Slana	14,883	39.2
Tazlina	33,195	7
Tok	47,946	14.9
Tolsona	na	na
Tonsina	32,835	na

Source: U.S. Census Bureau, 2009-2013 5-Year American Community Survey.

Access to roads and Alaska urban centers lessens the cost-of-living in the communities connected to the road system in comparison to those of PZ communities. The Alaska Geographical Differential Study 2008 (McDowell Group 2009) reported that the cost of living were similar in the Glennallen (cost of living differential 0.97) and Delta Junction/Tok (cost of living differential 1.04) regions to that of Anchorage, Alaska. Food prices, in these two regions, did exceed that of Anchorage, however, the cost differential was much less pronounced than that for the PZ communities. For example, the 2011 USDA Thrifty Food Plan cost of groceries for a family of four in Tok was $161.46 in comparison to the Anchorage, Alaska cost of $140.26 (Luick 2015). The comparative lower cost-of living for NPZ communities is also reflected by lower fuel prices. The January, 2015 price of gasoline in Tok and Glennallen was $4.02/ gal. (ADCCED, 2015). In contrast, the cost of gasoline in Beaver of $9 was more similar to the high prices found in many of the PZ communities.

Subsistence production data for the surveyed NPZ community households are presented in the Table 13. The average household production ranges from a high of 717.6 lbs. pounds in Beaver (the only off-road NPZ community) to 126.4 lbs. in Mendeltna. Large land animals and fish were the two most prominent resources harvested, accounting for greater than 80% of total subsistence harvest in each of the communities and greater than 90% of total subsistence harvest in many of the communities.

Table 13. Non-project zone communities, surveyed household per capita and household average subsistence harvest of all resources, surveyed household average harvest of fish, land animals, and large land animals. All weights in edible pounds.

Community	Per capita all resources	HH all resources (lbs.)	HH Fish (lbs.)	HH large land animals (lbs.)	HH, fish & large land animals (%)
Beaver	358.8	717.6	336.0	312.9	90.4
Chistochina	161.6	424.9	290.0	66.7	84.0
Chitina	245.8	609.3	502.7	72.2	94.3
Copper Center	211.1	575.3	399.0	142.5	94.1
Dot Lake	118.9	280.3	123.7	118.4	86.4
Dry Creek	142.9	434.1	62.5	328.6	90.1
Gakona	171.4	449.0	295.0	107.5	89.6
Glennallen	97.6	267.5	170.0	77.9	92.7
Gulkana	144.2	452.5	333.9	98.1	95.5
Kenny Lake	136.9	328.5	249.2	59.7	94.0
Lake Louise	73.0	138.7	57.7	58.0	83.4
McCarthy Road	86.8	153.5	87.9	41.4	84.2
Mendeltna	52.6	126.4	79.6	26.0	83.5
Mentasta Lake	150.9	446.2	158.8	212.6	83.2
Mentasta Pass	189.6	547.7	113.1	350.3	84.6
Nelchina	128.4	335.2	94.4	195.7	86.5
Paxson	214.0	615.3	280.0	242.5	84.9
Slana	203.2	416.2	275.5	81.1	85.7
Tazlina	150.1	440.7	328.4	89.5	94.8
Tok	218.7	520.5	207.0	269.2	91.5
Tolsona	310.8	621.5	344.6	232.3	92.8
Tonsina	199.3	459.3	282.8	140.0	92.0

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

The majority of the subsistence production was of salmon, caribou and moose. Together these three resource categories had a median value of 77% of total subsistence production across surveyed household in NPZ communities (Table 14). Salmon, with a NPZ community average of 44.2% of all subsistence harvested resources, was the dominant subsistence resource in most of the surveyed community households. This is not surprising, given that the Copper River Basin contains several rivers that have productive salmon runs (principally sockeye and Chinook) including the Copper, Chitina and Gulkana rivers, which are easily accessible to most of the NPZ communities. Moose was the dominant large land animal harvested, with a NPZ community average of 24.0% of total subsistence harvest. Caribou were not harvested in several of the communities, including Beaver, and was a much less pronounced subsistence resource in the NPZ region in comparison to the PZ region.

Figure 3. Subsistence user processing caribou meat. Photo courtesy of G. Halas (UAF).

Table 14. Non-project zone communities, surveyed households percentage of subsistence production of all resources comprised of salmon, caribou and moose.

Community	Salmon (%)	Caribou (%)	Moose (%)
Beaver	43.0	0.0	33.1
Chistochina	58.3	0.0	15.7
Chitina	77.9	7.4	3.2
Copper Center	61.2	8.5	15.6
Dot Lake	37.1	13.2	27.5
Dry Creek	12.1	10.0	64.5
Gakona	56.0	6.9	16.7
Glennallen	58.4	9.5	17.5
Gulkana	63.6	3.0	17.1
Kenny Lake	66.5	8.2	10.9
Lake Louise	12.2	9.4	32.4
McCarthy Road	52.8	6.5	15.0
Mendeltna	48.4	20.6	0.0
Mentasta Lake	28.8	3.8	43.8
Mentasta Pass	14.4	15.8	45.6

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

Table 14 (continued). Non-project zone communities, surveyed households percentage of subsistence production of all resources comprised of salmon, caribou and moose.

Community	Salmon (%)	Caribou (%)	Moose (%)
Nelchina	21.6	12.9	44.8
Paxson	26.6	21.1	18.3
Slana	47.1	4.5	13.9
Tazlina	68.1	4.5	12.9
Tok	25.9	14.5	35.2
Tolsona	41.0	0.0	36.2
Tonsina	51.1	17.2	8.5

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

The importance of subsistence food production was highlighted previously for the PZ communities by examining the percentage surveyed households that engaged, used, received, and gave away fish and large land animals. Similar information is provided in Table 15 and Table 16 for NPZ communities. A majority of surveyed households reported being engaged in attempting to harvest fish and large land animals in almost all NPZ communities. Sharing activity of subsistence harvests were also reported to be common as indicated by the high percentage of NPZ households within communities that reporting receiving and using subsistence harvested resources. Furthermore, 55.0% and 39.9% of NPZ community surveyed households reported giving away subsistence harvested fish and large land animals, respectively.

Table 15. Percent of non-project zone communities surveyed households that used, attempted to harvest, harvested, received, and gave away subsistence produced fish.

Community	% Used	% Attempted Harvest	% Harvested	% Received	% Gaveaway
Beaver	100.0	48.0	48.0	68.0	32.0
Chistochina	85.2	66.7	66.7	59.3	33.3
Chitina	95.7	73.9	69.6	69.6	63.0
Copper Center	92.5	73.8	71.3	77.5	58.8
Dot Lake	100.0	50.0	50.0	85.7	21.4
Dry Creek	100.0	51.9	44.4	96.3	29.6
Gakona	95.2	83.3	83.3	88.1	69.0
Glennallen	87.0	62.3	51.9	75.3	49.4
Gulkana	96.6	55.2	55.2	89.7	69.0
Kenny Lake	89.6	71.6	67.2	70.1	56.7
Lake Louise	100.0	80.0	80.0	90.0	40.0
McCarthy Road	94.9	66.7	61.5	89.7	48.7
Mendeltna	100.0	90.0	90.0	70.0	70.0
Mentasta Lake	100.0	73.9	56.5	100.0	65.2
Mentasta Pass	100.0	100.0	77.8	100.0	77.8

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

Table 15 (continued). Percent of non-project zone communities surveyed households that used, attempted to harvest, harvested, received, and gave away subsistence produced fish.

Community	% Used	% Attempted Harvest	% Harvested	% Received	% Gaveaway
Nelchina	83.3	66.7	66.7	61.1	55.6
Paxson	100.0	75.0	75.0	75.0	62.5
Slana	93.5	80.6	74.2	75.8	58.1
Tazlina	93.7	81.0	78.5	75.9	73.4
Tok	76.8	64.8	62.7	54.2	40.1
Tolsona	100.0	75.0	75.0	100.0	62.5
Tonsina	91.3	65.2	65.2	82.6	52.2

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

Table 16. Percent of non-project zone communities surveyed households that used, attempted to harvest, harvested, received, and gave away subsistence produced large land animals.

Community	% Used	% Attempted Harvest	% Harvested	% Received	% Gaveaway
Beaver	100.0	72.0	44.0	80.0	36.0
Chistochina	74.1	66.7	14.8	59.3	33.3
Chitina	76.1	56.5	21.7	65.2	41.3
Copper Center	73.8	67.5	31.3	62.5	33.8
Dot Lake	92.9	50.0	21.4	78.6	14.3
Dry Creek	100.0	51.9	37.0	92.6	44.4
Gakona	83.3	57.1	33.3	73.8	33.3
Glennallen	81.8	46.8	22.1	67.5	35.1
Gulkana	89.7	51.7	20.7	79.3	41.4
Kenny Lake	71.6	41.8	20.9	61.2	29.9
Lake Louise	70.0	70.0	10.0	60.0	20.0
McCarthy Road	71.8	41.0	10.3	64.1	20.5
Mendeltna	100.0	80.0	10.0	90.0	40.0
Mentasta Lake	95.7	73.9	39.1	91.3	60.9
Mentasta Pass	100.0	88.9	66.7	88.9	88.9
Nelchina	72.2	66.7	55.6	44.4	55.6
Paxson	75.0	75.0	62.5	50.0	50.0
Slana	77.4	72.6	21.0	69.4	33.9
Tazlina	88.6	65.8	25.3	77.2	40.5
Tok	78.9	62.0	49.3	50.0	35.2
Tolsona	87.5	50.0	25.0	75.0	50.0
Tonsina	82.6	47.8	30.4	56.5	39.1

Source: ADFG-Division of Subsistence confidential household survey database, 2015.

Modeling Household Harvest

This section describes findings derived from a set of subsistence harvest estimates. These models were estimated in order to develop a better understanding of how the pattern of observed subsistence harvest relates to household and community characteristics. The intent of this modeling effort is not to establish a pattern of causality in regards to the subsistence choices pursued by households. Instead, this assessment is descriptive in nature, identifying relationships between reported harvest levels, the community's location in either the PZ or NPZ, household income and other socio-demographic characteristics, and the level of hunting pressure in the game management unit in which the community is located. We developed models to highlight linkages between observed household and community characteristics and subsistence production. For each model, reported household harvests (edible weight) in pounds served as the dependent variable. Models conformed to the general equation [1]:

$$y_i = \alpha_i + \beta_1 X_i + \beta_2 C_i + e_i \qquad [1]$$

Where y_i was the number of edible pounds reported for household i, X_i represented the set of household level characteristics for household i, and C_i was the set of community level characteristics associated with household i (variable definitions are provided in Table 17.

Table 17. Variable definition for household harvest models.

Variable	Definition	Total mean (std. dev)	NPZ mean (std. dev)	PZ mean (std. dev)
Caribou	Pounds of Caribou Harvested by Household	191.38 (748.92)	37.12 (98.38)	697.230* (1,428.32)
Moose	Pounds of Moose Harvested by Household	94.23 (233.28)	96.90 (236.22)	85.46 (223.54)
Salmon	Pounds of Salmon Harvested by Household	205.92 (497.34)	213.81 (465.53)	180.02 (590.02)
Whitefish	Pounds of Whitefish Harvested by Household	37.24 (324.65)	6.72 (36.89)	282.586* (659.29)
Totless10	Number of children age 10 and less in the household	0.46 (0.95)	0.36 (0.82)	0.80* (0.95)
Fem HH	Indicator for female head of household (1= yes, 0 else)	0.18 (0.38)	0.16 (0.37)	0.22* (0.38)
HH size	Total number of individuals living in the household	2.96 (1.90)	2.76 (1.69)	3.63* (1.90)
Ak nat	Indicator for Alaska Native Household (1=yes, 0 else)	0.32 (0.46)	0.20 (0.40)	0.72* (0.46)
HH inc	Reported annual household income	51,63 (46,664)	51,327 (48,519)	52,653 (46,664)

Standard errors in parentheses

*Significant at P<0.05 levels Standard errors in parentheses

Number of hunters in GMU drawn from ADFG Harvest Lookup database, available at: https://secure.wildlife.alaska.gov/index.cfm?fuseaction=harvest.lookup

Table 17 (continued). Variable definition for household harvest models.

Variable	Definition	Total mean (std. dev)	NPZ mean (std. dev)	PZ mean (std. dev)
Age	Average age of individuals living in household	51.98 (15.19)	52.587 (14.88)	49.99* (15.19)
Mhunters	Six year average number of hunters pursuing moose in the game management sub-unit	520.67 (421.44)	605.42 (437.81)	242.73* (421.44)
Chunters	Six year average number of hunters pursuing caribou in the game management sub-unit	272.57 (522.03)	328.35 (577.11)	89.68* (522.03)

Standard errors in parentheses

*Significant at P<0.05 levels Standard errors in parentheses

Number of hunters in GMU drawn from ADFG Harvest Lookup database, available at: https://secure.wildlife.alaska.gov/index.cfm?fuseaction=harvest.lookup

A total of six models, with the following dependent variables, were estimated: (1) the sum of combined household harvest of caribou and moose, (2) the sum of combined household harvest of salmon, whitefish, and sheefish, and then for specific species, (3) the quantity of household moose harvest, (4) the quantity of household caribou harvest, (5) the quantity of household salmon harvest, and (6) the quantity of household whitefish harvest (including sheefish). A model using the sum total pounds of household subsistence harvest was also estimated. Findings from that model are consistent with those presented and are available by request. The set of covariates used in the analysis, their definitions, and descriptive statistics were broken down by study region (PZ versus NPZ; Table 18). Variance weighted t-tests were used to identify statistically significant differences in means between the PZ and NPZ subsamples ($P < 0.05$ levels).

Figure 4. Subsistence fish drying on racks along the Kobuk River. Photo by K. Joly.

Table 18. Estimated proportional changes (and standard errors) in the likelihood of a household reporting a subsistence harvest of zero given a one unit change in covariate.

Variable	Land	Fish	Caribou	Moose	Salmon	Whitefish
Project Zone	0.376 (0.073)*	1.506 (0.243)*	0.194 (0.041)*	1.694 (0.446)*	2.576 (0.451)*	0.236 (0.046)*
Female Head	2.775 (0.592)*	1.513 (0.251)*	2.59 (0.642)*	2.440 (0.703)*	1.370 (0.232)	1.785 (0.444)*
Number of children < 10	1.067 (0.103)	1.168 (0.111)	0.948 (0.096)	1.334 (0.152)*	1.152 (0.107)	1.066 (0.116)
Alaska Native	0.980 (0.166)	0.860 (0.113)	1.39 (0.277)	0.880 (0.181)	1.067 (0.166)	0.477 (0.096)*
25,000<Income<50,000	1.540 (0.296)*	0.753 (0.127)	1.392 (0.307)	1.333 (0.310)	0.773 (0.133)	0.884 (0.208)
50,000<Income<75,000	1.122 (0.225)	0.566 (0.123)*	0.907 (0.202)	1.357 (0.338)	0.578 (0.105)*	0.832 (0.211)
75,000<Income<100,000	1.361 (0.336)	0.749 (0.168)	1.087 (0.299)	1.305 (0.380)	0.679 (0.152)	1.313 (0.432)
Income>100,000	1.072 (0.24)	0.439 (0.099)*	0.935 (0.242)	1.305 (0.362)	0.421 (0.094)*	0.854 (0.257)
Average Age	1.005 (0.005)	1.010 (0.005)*	1.004 (0.006)	1.003 (0.006)	1.007 (0.005)	1.000 (0.006)
HH Size	0.752 (0.038)*	0.833 (0.041)*	0.788 (0.042)*	0.768 (0.042)	0.867 (0.042)*	0.818 (0.047)*
Log #Caribou Hunters	--	--	1.011 (0.040)	--	--	--
Log #Moose Hunters	--	--	--	1.120 (0.122)	--	--
Log # Total Hunters	0.950 (0.070)	--	--	--	--	--
Constant	4.643 (2.476)*	0.976 (0.290)	6.397 (2.480)*	3.007 (2.162)*	1.146 (.345)*	17.132 (6.766)*
Households	1134	1134	1134	1134	1134	1134
HHs Reporting Harvest	384	607	277	188	541	152
Vuong Statistic	12.25	14.00	9.42	5.57	13.14	2.39

Standard errors in parentheses

*Indicates significance at P<0.05

For the set of household characteristics(X_i), reported household income from all sources was separated into five categories (< \$25,000, \$25,000-50,000, \$50,000-75,000, \$75,000-100,000 and > \$100,000) and modelled using a set of indicator variables (taking the value of 1 if income falls inside the bounds of the income grouping and zero otherwise). A total of four indicator variables accounting for income categories are included in each model estimate and are interpreted relative to households reporting less than \$25,000, which fell into the first income category and served as the baseline of comparison. The number of individuals living in a household, as well as the number of children age 10 years and younger in each household, were identified and incorporated into model estimates. Alaska Native households (as determined by ethnicity of household head), as well as female headed households, were identified using dichotomous indicator variables. To better anticipate how the proposed road might affect household subsistence production, the set of community level variables (C_i) consist of two variables. The first was an indicator variable, which identified households located in PZ communities. The inclusion of a specific regional control allowed for an estimate of the extent to which subsistence participation and harvest production differed between the two regions. Second, for models where the level of household harvest of combined caribou and moose, as well as caribou and moose separately served as the dependent variable, a six-year average of the number of caribou and moose hunters who reported hunting in game management sub-units in which study communities are located were included. Where the combined total of caribou and moose harvest served as the dependent variable the sum of caribou and moose hunter averages are used in the analysis. The initial right-of-way application called for the road open only to industrial usage – not the general public. The Dalton Highway, leading to the oil fields on Alaska's North Slope, was initially developed as an industry-only road but became open to public use. Given this precedent, the incorporation of six-year averages for caribou and moose hunters served as a proxy to assess the influence outside competition might have on reported subsistence participation and harvest quantities.

Two factors complicated model estimation. First, a significant number of surveyed households either did not pursue or report the subsistence harvest of moose, caribou, salmon, or whitefish. As a consequence there is a prevalence of zeros in the harvest data. Second, reported harvest quantities were not normally distributed across households. For a large number of households reporting subsistence harvest, the quantities were relatively small and mass towards zero. This was consistent with the observed pattern of the bulk of subsistence harvest being concentrated within a relatively small proportion of community households. These data characteristics can lead to biased estimates when evaluated using traditional linear regression. To avoid this potential, our approach used the Zero Inflated Negative Binomial (ZINB) model to obtain parameter estimates. The ZINB framework involves the estimation of two separate models; one which controls for the presence of zeros in the harvest data and a second which modeled the positive harvest count (equation 2).

$$y_i \sim \begin{Bmatrix} 0 \; with \; probability \; \pi_i \\ f(y_i|\boldsymbol{x}_i) \; with \; probability \; (1-\pi_i) \end{Bmatrix} \qquad [2]$$

Where y_i was the harvest quantity for household *i*, $\boldsymbol{x}_i$ was a vector of covariates for household *i*, and π_i was the probability of zero harvest being associated with household *i*. In the first stage, a logit model was used to estimate the probability a household did not report a harvest quantity for the species harvest being modeled. The logit model regressed a dichotomous dependent variable on the set of household and community level covariates. The dichotomous dependent variable was given a value of one when household harvest quantity was reported as a zero and the value of zero when a positive harvest quantity was reported so that:

$$q_i \sim \begin{Bmatrix} 1 \; if y_i = 0 \\ 0 \; if \; y_i > 0 \end{Bmatrix} \qquad [3]$$

Where q_i was the dichotomous left-hand variable that indicated the presence of a zero in the harvest variable. A zero value of harvest ($q_i = 1$) was recorded if a household either did not pursue the specific species of interest or did pursue the particular species but did not report a harvest quantity for the resource in question (e.g., they were unsuccessful). In the second stage, parameters relating the covariates to reported household harvest quantity were obtained through the use of a truncated Negative Binomial (NB) count data distribution. The truncated NB distribution is suitable for addressing situations where the dependent variable is represented by the number of event occurrences or a count (i.e., the count of pounds harvested by a household for each of the four modeled species). In effect, the ZINB approach conditioned estimated covariates in the harvest model upon the likelihood that the household reported a harvest quantity.

Vuong test statistics (Vuong 1989) were used to compare the ZINB specification against the more traditional standard negative binomial model to evaluate goodness of fit. The test result was used to evaluate whether model fit improves by controlling for the presence of zeroes in the dependent variable. Positive values for the Vuong statistic were taken to favor the ZINB specification, while negative values indicated that model fit was improved through standard NB estimation. In each case, controlling for the presence of excess zeroes (by estimating a separate logit equation) improved model fit. Likelihood factors were calculated by taking the exponential of the estimated parameters for both the logit and count components of the ZINB models.

To provide an indication of the economic importance of subsistence harvest, model estimates were used to calculate a set of hypothetical replacement values for each PZ community. It is important to note that a direct monetary value of subsistence food production was unavailable since no formal exchange markets exist. Estimated models were used to generate two sets of mean household harvest predictions for PZ communities for both the total harvested combined weight of caribou and moose and total harvested combined weight of salmon and whitefish (including sheefish). In the first set, the mean prediction for harvested household weight was calculated evaluating model parameters at their data means and the baseline household income category (< $25,000). The second set of mean harvest predictions were derived by evaluating the PZ indicator variable at a value of zero and remaining model parameters at their data means. In effect, the second set of harvest predictions describes the estimated pattern of harvest for PZ communities under the assumption that they are located in the road accessible NPZ. The difference in predicted means were then calculated and multiplied by a "replacement value" in recognition that food would have to be purchased in the absence of local subsistence production. Fall (2014) provided a range of subsistence harvest replacement values for Alaska regions based on expense equivalences of USD $4 or $8/lb. Drawing on the upper bound of $8/lb (reflecting the higher cost of purchasing fish or meat in these remote villages), we calculated an approximate replacement cost of subsistence production to individual households in PZ communities.

PZ households were larger, had more children under 10, and had a higher proportion of female heads of household than NPZ households (Table 17). The proportion of Alaska Native households was also significantly higher in PZ communities. Average household income, both earned and unearned, were not statistically different between the PZ and NPZ communities. Finally, the six-year averages of the number of moose and caribou hunters accessing game management sub units in the NPZ were significantly higher than PZ game management sub-units. Greater road accessibility was correlated to an increased number of hunters accessing a game management sub-unit; however, it was not possible to discern if those road communities had more hunters prior to the introduction of a road with our data.

The likelihood factors for each subsistence species for the logit estimates are presented in Table 18 and the negative binomial count estimates are found in Table 19. For the logit estimates, likelihood factors represent the likelihood that a household did not report harvest relative to the likelihood that a household did report harvest, for a one unit change in the explanatory covariate. A value < 1 indicated that a household was more likely to have reported a harvest. Likewise, those factors with a value > 1 indicated that a household was more likely to have reported a zero harvest. For the negative binomial estimates, likelihood factors are directly interpreted as the multiplicative scalar associated with a one unit change in the covariate. Statistical significance is reported for $P < 0.05$ levels across all models.

Table 19. Estimated proportional changes (and standard errors) in household subsistence harvest for a one unit change in covariate.

Variable	Land	Fish	Caribou	Moose	Salmon	Whitefish
Project Zone	2.422 (0.270)*	1.816 (0.242)*	4.093 (0.718)*	1.001 (0.075)	1.145 (0.167)	9.377 (1.980)*
Female Head	0.897 (0.118)	0.826 (0.120)	0.709 (0.111)*	1.091 (0.096)	0.816 (0.121)	0.973 (0.279)
# of children < 10	0.890 (0.044)*	0.852 (0.066)*	0.918 (0.052)	0.938 (0.034)*	0.829 (0.636)*	1.010 (0.154)
Alaska Native	1.354 (0.141)*	1.545 (0.182)*	1.528 (0.256)*	1.032 (0.059)	1.632 (0.191)*	1.133 (0.247)
25,000<Income<50,000	0.723 (0.092)	0.894 (0.124)	0.717 (0.119)*	0.922 (0.064)	0.952 (0.140)	1.114 (0.293)
50,000<Income<75,000	1.029 (0.128)	0.968 (0.136)	1.030 (0.109)	0.867 (0.061)*	0.931 (0.140)	1.112 (0.305)
75,000<Income<100,000	0.967 (0.146)	1.072 (0.189)	0.974 (0.142)	0.839 (0.070)*	1.162 (0.176)	0.661 (0.252)
Income>100,000	0.889 (0.128)	1.097 (0.175)	0.891 (0.164)	0.841 (0.065)*	1.030 (0.158)*	1.247 (0.480)
Average Age	0.998 (0.003)	1.004 (0.004)	0.998 (0.004)	0.995 (0.002)*	1.000 (0.004)	1.019 (0.007)*
HH Size	1.086 (0.036)*	1.104 (0.046)*	1.058 (0.036)*	1.017 (0.018)	1.077 (0.044)	1.089 (0.082)
Log #Caribou Hunters	--	--	0.972 (0.036)	--	--	--
Log #Moose Hunters	--	--	--	0.918 (0.029)*	--	--
Log #Total Hunters	.973 (0.023)	--		--	--	--
Constant	274.009 (80.22)*	239.780 (55.009)	235.09 (54.74)*	1264.73 (265.60)*	322.543 (76.78)*	15.011 (6.312)*
Households	1134	1134	1134	1134	1134	1134
HH Reporting Harvest	384	607	277	188	541	208
Vuong Statistic	12.25	14.00	9.42	5.57	13.14	4.41

Standard errors in parentheses

*Indicates significance at P<0.05

For model estimates where the total harvested lb. of moose and caribou served as the dependent variable (Land), a total of 384 households reported harvest. Our results indicated that PZ households were more likely to have reported the harvest of moose or caribou and reported greater quantities (in total). Households in the PZ were roughly 2.5 times less likely to have reported a harvest value of zero (Table 18), while the estimated average reported harvest for PZ households was approximately 2.5 times larger than that of NPZ households (Table 19). The regional difference is explained by differences in the specific species harvested (e.g., caribou v. moose). Households in the PZ were both more likely to have harvested caribou and estimated to report greater quantities. Households in the PZ were roughly 5 times less likely to report that they did not harvest caribou (Table 18); and, when compared against NPZ households that did harvest caribou, harvested 4.1 times more (Table 19). This pattern did not hold for reported moose harvest where PZ households were estimated to be 1.7 times more likely to report a moose harvest value of zero (Table 18). There was no significant difference estimated between moose harvest quantities reported by PZ and NPZ households (Table 18). Although Alaska Native households were estimated to be equally likely to have reported a combined total caribou and moose harvest of zero, these same households were estimated to harvest approximately 1.4 times more in total pounds than non-native households (Table 19). The difference in harvest quantities is attributable the significant difference in caribou harvest where Alaska Native households were estimated to harvest approximately 1.5 times the quantity of caribou harvested by non-native households (Table 19). Household moose harvest was not estimated to be different between Alaska Native and non-native households. Bag limits may impact harvest levels but bag limits are also reflective of relative availability of the resource. Thus having a bag limit of 1 caribou may reduce harvest versus an area with a bag limit of 5 but that lower bag limit reflects the lower relative abundance of caribou in that region as well.

Household income is estimated to have little relative effect on the likelihood a household pursued either caribou or moose or the total harvested quantities of moose and caribou, overall. When compared against households reporting less than $25,000, households earning $25,000 - $50,000 were estimated to be approximately 1.5 times more likely to have reported a harvest of zero for the combined harvest caribou and moose (Table 18). Likewise, estimated combined harvest quantities for moose and caribou for this household income grouping were approximately 1.4 times less than that of households earning under USD $25,000 (Table 19). While caribou harvest followed a similar pattern, moose harvest was estimated to be sensitive to increases in household income. Higher income households that fell into categories covering ranges greater than $50,000 were estimated to harvest 1.14 to 1.16 times less moose (by weight) than households in the lowest income category ($0 - 25,000; Table 19).

Increased pressure from outside hunters was not estimated to have a significant impact on either the probability a household reported a harvest of zero for moose or caribou or the quantity of moose and caribou (combined) harvested, overall. The estimated quantity of moose harvested (Table 19), however, was inversely related to the number of moose hunters. For each 1% increase in the number of moose hunters in a game management sub-unit, households were estimated to harvest about 1.2 times less moose.

For the remaining covariates, the likelihood a household reported a harvest as well as the total reported harvested weight of moose and caribou was estimated to increase with household size. Overall, the addition of one individual to household size reduced the likelihood that a household did not harvest moose or caribou. Overall harvest of caribou and moose was estimated to increase approximately 1.09 times for each additional individual in the household. This effect was also seen in the caribou only model, where the addition of one individual to household size was estimated to increase the harvest of caribou by a similar factor

A total of 607 respondent households indicated the harvest of salmon, whitefish, or sheefish (All Fish). The estimated overall model for fish indicated that PZ households were approximately 1.5 times more likely to have reported a harvest value of zero (Table 18). While PZ households are less likely to have reported the harvest of fish, those that did report harvest were estimated to harvest 1.8 times the quantity of NPZ households. Again, the differences in regional harvest patterns are driven by differences in the fish species pursued. Specifically, households in PZ communities harvested close to 10 times the quantity of whitefish (including sheefish) as NPZ households (Table 19). While PZ households are approximately 2.6 times more likely to have reported a harvest of zero for salmon (Table 18), no statistically significant difference in the estimated quantities of salmon harvested by PZ and NPZ households was evident (Table 19). Alaska Native households were equally likely to report a zero value for fish overall, and salmon and whitefish in particular, as non-native households (Table 18). Estimated harvests by Alaska Native households, however, were 1.5 times larger than those of non-native households (Table 19). The overall difference in fish harvest between Alaska Native and non-native households was driven by the significantly larger harvest of salmon. Alaska Native households were estimated to harvest 1.6 times the quantity of salmon as non-native households (Table 19). Households headed by females were estimated to be 1.5 times more likely to report a zero harvest of fish, overall, and 1.9 more likely to report a zero harvest for whitefish (Table 19). No statistically significant differences in harvest quantity between female headed households were estimated.

Households with incomes between $50,000 - $75,000, when compared against households earning <$25,000, were estimated to be approximately 1.8 times less likely to report a zero harvest for all fish (Table 18). Relative household income is not estimated to be significant in the whitefish model. Subsequently, the estimated effects of household income on fish harvest overall can be attributed to the estimated relationship between salmon harvest and relative household income. Compared against the baseline income category (< $25,000) households with incomes of $50,000 - $75,000 and those with incomes > $100,000 were approximately 1.75 and 2.5 times less likely to have reported a harvest of zero for salmon. Household income was not estimated to affect the quantity of salmon harvested.

For the remaining covariates, household size was estimated to reduce the likelihood of observing an overall fish harvest level of zero (Table 18). Similar outcomes were estimated for both the likelihood of reporting a zero harvest of salmon as well as a zero harvest of whitefish (Table 18). Overall household fish harvest quantities were estimated to increase by a factor of 1.09 for each additional individual living in the household. The change in overall fish harvest associated with household size is also seen in the whitefish model where each additional person in the household was estimated to increase reported whitefish harvest by a factor of 1.086.

Predicted harvest means, associated difference in harvest, and replacement values for the combined harvest of moose and caribou are presented in Table 20. Predicted harvest means, associated difference in means, and replacement value for the combine harvest of salmon and whitefish are presented in Table 21.

Table 20. Predicted harvest means (and their standard deviations) for combined caribou and moose harvest and value difference (and their standard deviations) using Fall's (2014) replacement value of $8/lb.

Community	Mean prediction	Mean prediction evaluated as npz	Difference in means	Value of difference
Alatna	1424.551 (253.552)	585.567 (104.226)	838.94 (149.33)	6711.52 (1194.60)
Allakaket	1432.72 (272.062)	588.943 (111.836)	843.78 (160.23)	6750.21 (1281.81)
Ambler	1349.865 (350.150)	554.884 (143.935)	794.98 (206.22)	6359.84 (1649.72)
Anaktuvuk Pass	1527.787 (341.317)	628.022 (140.304)	899.77 (201.01)	7198.12 (1608.11)
Bettles	1015.841 (165.988)	417.579 (68.232)	598.26 (97.76)	4786.10 (782 .05)
Coldfoot	476.871 (14.378)	196.026 (5.910)	280.85 (8.47)	2246.76 (67.74)
Evansville	1112.698 (227.299)	457.392 (93.435)	655.31 (133.86)	5242.44 (1070.91)
Kobuk	1362.279 (482.538)	559.987 (198.355)	802.29 (284.18)	6418.33 (2273.46)
Shungnak	1329.344 (329.768)	546.449 (135.557)	782.89 (194.21)	6263.16 (1553.69)
Wiseman	1113.174 (204.598)	457.589 (84.104)	655.59 (120.49)	5244.68 (963.96)

Standard deviations in parentheses

Table 21. Predicted harvest means (and their standard deviations) for combined salmon and whitefish harvest and value difference (and their standard deviations) using Fall's (2014) replacement value of $8/lb.

Community	Mean prediction	Mean prediction evaluated as npz	Difference in means	Value of difference
Alatna	781.941 (149.309)	430.600 (82.222)	351.341 (67.087)	2810.73 (536.70)
Allakaket	921.067 (218.696)	507.214 (120.432)	413.853 (98.264)	3310.82 (786.12)
Ambler	918.469 (276.902)	505.783 (152.485)	412.686 (124.417)	3301.49 (995.34)
Anaktuvuk Pass	928.118 (240.399)	511.097 (132.383)	417.021 (108.016)	3336.17 (864.13)
Bettles	597.866 (125.662)	329.234 (69.200)	268.633 (56.462)	2149.06 (451.70)
Coldfoot	375.266 (13.202)	206.652 (7.270)	168.614 (5.932)	1348.91 (47.46)
Evansville	685.436 (167.264)	377.456 (92.109)	307.980 (75.155)	2463.84 (601.24)
Kobuk	918.626 (386.917)	505.870 (213.068)	412.757 (173.849)	3302.05 (1390.79)
Shungnak	945.947 (326.489)	520.915 (179.791)	425.032 (146.698)	3400.26 (1173.58)
Wiseman	663.620 (114.510)	365.442 (63.059)	298.177 (51.451)	2385.42 (411.61)

Standard deviations in parentheses

Replacement values for the predicted difference for combined caribou and moose harvest ranged from $2,246 – $7,198/household/year and $1,348 – $3,400/household/year for the combined harvest of salmon and whitefish (including sheefish). When combined total replacement cost at the community level range from approximately $6,900/household/year (Bettles) to $10,500/household/year (Anaktuvuk Pass), excluding the road accessible community of Coldfoot.

Conclusions

Roads have far-ranging, complex and penetrating effects on human lifestyles, wildlife, their habitat, and how people interact with wildlife, including subsistence activities. Driven largely by greater caribou and whitefish harvest we found that total household subsistence harvest levels were 2.5 times greater in PZ communities than road accessible NPZ communities. Biological productivity sharply declines at higher latitudes (Fields et al., 1998). Thus, both ungulate and fish resources should be more plentiful for the NPZ communities than PZ communities. That we found the opposite relationship highlights the importance of human influence (increased access, harvest and competition) on subsistence resources. While smaller bag limits and shorter hunting seasons are found near NPZ communities, they are not the root cause of lowered subsistence production. Smaller bag limits, shorter seasons, and lower subsistence harvests may be the product of diminished wildlife populations. Aside from natural fluctuations, increased access and larger numbers of hunters and fishermen may reduce populations of subsistence species. Thus, if access increased and greater pressure arose in areas around PZ communities one should expect that region would get more restrictions on harvests.

Our analyses show PZ communities are heavily reliant on subsistence harvest, in concurrence with other studies (Wolfe and Walker, 1987; Huskey, 2004; Goldsmith, 2007; Fall, 2014; Braem et al., 2015; Fall, 2016). Likewise, Alaska Native households were estimated to have higher levels of subsistence production. While a large percentage of households reported being engaged in the harvest of fish and large animals, most of the harvest is collected by a relatively small proportion of households. Wolfe et al. (2009) reported that approximately 33% of the households produced 76% of the subsistence harvests, which is very similar to our results. This suggests that community welfare can depend upon the success and or failure of a small number of households.

Our findings suggest that participation in subsistence activities differs between PZ and NPZ communities and that household characteristics affect both participation and the amount harvested. We found that households with more children 10 and younger had greater subsistence productivity but households headed by females reported lower harvest of big game species such as moose and caribou.

One of the primary perceived benefits of building a road to the Ambler Mining District is the potential for increased economic opportunities. Indeed, one economic impact analysis suggests that up to 13 jobs for the entire PZ may be directly created for the operation and maintenance of the road (Cardno, 2015). However, when changes to the (non-cash) subsistence economy are taken into account a more complex picture of both positive and negative economic effects emerges. For example, households with higher incomes do not necessarily have higher subsistence harvest relative to lower income households. To the contrary, we found for caribou and moose that PZ and NPZ households with higher relative incomes were estimated to have lower harvests when compared against households earning < $25000. The inverse relationship between harvest and community income has been reported in other instances notably, Wolfe and Walker (1987), and Wolfe (2004). However, our finding of higher household incomes not being associated with higher subsistence incomes are at odds with those of Wolfe et al (2004). A number of key differences in the two studies' modelling approaches may explain the difference. The model presented here effectively compares only households that reported harvests. In contrast, the Wolfe et al. model does not control for differences between households that reported harvest and those that did not. Additionally, we model all household income (not just wage income). Last, we use a narrower set of communities. At this time it remains an open question as to what is driving the relationship between subsistence harvest and household income.

A limitation of our use of household data to examine subsistence production is that it does not incorporate subsistence production that occurs cooperatively across households within a larger community subsistence network. The importance of household cooperation within a community and extended family networks to subsistence production has been highlighted in other studies (Braem et al. 2015, Magdanz et al/ 2012). Although, household surveys have expanded to include information on network sharing relationships, they do not document quantities harvested, distributed, and used across households. Subsequently, it was not possible to incorporate unobserved social connections within our models.

The productivity of the habitat and relative lack of competition help to explain a portion of the significant differences in harvest levels between the PZ and NPZ households. Households in Ambler, Kobuk, and Shungnak benefited from access to productive whitefish fisheries that remain relatively unaffected by outside competition due to the lack of roads in the region. Similarly, these communities have better access to the Western Arctic Caribou Herd, which was, for several decades, the largest caribou herd in the state (Wilson et al., 2014). Fewer hunters may also correlate with higher hunter success rates. Moose and salmon abundance is greater in the NPZ region.

In our analysis, we assumed that the road would eventually be open to public access. Road access could facilitate competition from non-local hunters (i.e., hunters that are not eligible to partake in subsistence as outlined by ANILCA) residing outside the study area for finite subsistence resources. While our non-local hunter proxy was not estimated to significantly impact the combined harvest quantity of moose and caribou or of caribou individually, the quantity of moose harvested was inversely related to the six-year average number of moose hunters accessing game management sub-units in which the communities are located. In other words, our results suggest that if the road facilitates an increase in the number of moose hunters, the amount of moose harvested by PZ households should be expected to decline. Specifically, for every 1 % increase in the number of moose hunters, we estimated that PZ households would harvest about 1.09 times less moose than if those hunters were not provided access to the region. While our results are not causal, they suggest that already vulnerable areas may be further jeopardized by additional outside stresses and that the effects of the additional competition will be unevenly distributed relative to household composition. NPZ communities are closer to the population centers of Alaska (particularly Anchorage) than PZ communities and accessed on well-maintained roads, which could dampen the impacts of competition on PZ communities relative to NPZ communities

Finally, drawing on Fall's (2014) results and assuming that the pattern of subsistence production for off-road PZ communities would be similar to that of NPZ communities after a road to the Ambler

Mining District was built, we calculated that an average household that is currently off of the existing road system may see a loss of subsistence production valued at $6900 – 10500/household/year. This loss is roughly equivalent to 33% of the median income for these households (US Census Bureau, 2010). The percentage is greater in the Interior villages – with the loss representing 62% of the median income in households in Allakaket (US Census Bureau, 2010). Though the proposed road would not directly reach any PZ community, if fuel could be shipped from the road to communities (perhaps via an ice road), it has been estimated that there could be a savings on heat and electricity of $2755 – 3737/household/year (Cardno, 2015) which is roughly 1/3 to 1/2 of the lower end value of subsistence production we estimated. Potentially, store-bought food could be shipped as well to replace reductions in subsistence harvests for communities nearby the proposed road. For communities further from the proposed road, such as Allakaket, complete replacement should not be expected. Indeed, scenarios for even partial replacement are difficult to ascertain. A comprehensive review of the interplay between the possible reduction in commodity prices and the added hunting pressure is beyond the scope of our analysis but highlighting the contributing factors affecting harvest participation and harvest amount of households in the region should assist policymakers in thinking about the implications of the Ambler Road project. Our results suggest that a road through this region could have substantial impacts on subsistence production of affected communities.

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