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ANALYSIS

Hunting for models: grounded and rational choice approaches to analyzing climate effects on subsistence hunting in an Arctic community

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Abstract

Climate change and uncertain economies challenge small Native communities of the North American Arctic, with their reliance on local fish and wildlife resources. Methodological boundaries of single-discipline analyses limit the contribution of academic research to the real-world questions facing Arctic residents. Oversimplified assumptions and lack of data hamper mainstream economic approaches based on rational choice, while more grounded approaches suffer from inability to generalize. We attempt to integrate these two approaches to project the effects of climate change on subsistence hunting in a Canadian Arctic community. In our collaboration, we find that rational choice modeling suggests specific questions that help direct the grounded research. Grounded methods provide general relationships and hypotheses as well as data for economic modeling. Using local knowledge (LK) obtained from grounded methods, we estimate a discrete-choice travel-cost model of subsistence hunting, projecting that climate warming may cost a typical household the equivalent of a half day of lost time during a hunting season. Besides providing data needed to make rational choice applications realistic, grounded methods reveal qualitative information essential for understanding relationships. We conclude that integration and synthesis of these disparate analytical approaches provides insights that neither method alone could have produced.

Keywords: Subsistence hunting; Climate change; Travel cost; Local knowledge; Arctic Canada

1. Introduction

Small Native communities of the North American Arctic maintain a long-standing reliance on fish and wildlife resources as an important food source and as a central feature of their cultural identity. Today these communities actively seek involvement in the cash economy as a means of supporting subsistence activities (Langdon, 1986, 1991; Kruse, 1992; Meyers, 1988), while wishing to sustain subsistence resources. These communities express concern about observed trends of climate change and the possible effects of these changes on northern ecosystem health and community sustainability (Krupnik and Jolly, 2002; Peterson and Johnson, 1995; Nuttall et al., in press;

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Jolly et al., 2001). Emergent conditions raise important questions about the impacts of climate change on northern people and their subsistence way of life (Cohen, 1997).[1] These changes challenge researchers to address community climate concerns in ways that are holistic in approach and relevant to policy.

In this paper, we describe the results of collaboration between a cultural ecologist and an economist to assess the implications of economic and climate change on subsistence hunting in a small community in Canada's Western Arctic. Following Zhang et al. (2000), we assume a scenario of climate change of warmer and longer summers, more years of deep and low snow, and greater variability (fewer "average" years). Associated locally with this scenario, we assume an increasing frequency of delayed freeze-up of rivers, which we hypothesize may affect caribou hunting success. We consider the effects of this climate change scenario on households with different levels of participation in the cash economy. In undertaking this collaboration, we examine whether the integration of our two approaches provides a set of robust interdisciplinary insights that one method alone could not have produced.

In the sections that follow, we first present some of the methodological problems and their historical roots that motivated us to undertake our collaboration. We then provide some background on Old Crow, Yukon, the community that is the subject of our analysis and a partner in our research. Next, we outline the methods and findings of our respective disciplinary efforts, and discuss how they complement each other. We conclude by reflecting on the implications of our integrated approach for future research.

2. Limitations of disciplinary approaches in studies of Arctic change

For nearly a century, Arctic public policy studies have recommended initiatives that are inappropriate in the northern context. In many cases, these problematic studies resulted when non-local researchers and policy-makers defined terms of well-being for indigenous communities based on worldviews that differed from those of local residents. As a result, indigenous northerners have had to cope with relocation of complete villages (Tester and Kulchyski, 1994), enrollment in oppressive residential schools (Coates, 1991), and state hunting regulations that are inconsistent with traditional methods of harvesting (McCandless, 1985; Freeman, 1989; Usher, 1995; Huntington, 1992).

Flawed studies of the Canadian Western Arctic make inappropriate applications of analytical approaches and lack local knowledge, which often leads to incorrect predictions. For example, Balicki (1968) attempted to explain apparent individualization and local conflict with a Durkheimian model of social anomie (Netro, 1988), while Murphy and Steward (1956) and Stabler (1990) suggested that participation in the cash economy would decrease subsistence involvement. Among the most well-known and criticized policy recommendations are associated with economic development projects such as the Mackenzie Valley Pipeline and Arctic Gas Projects (Berger, 1977). These policies emerge from underlying analytical approaches based on out-of-context assumptions about human motivation and behavior. Other problems have arisen from the application of ecological assumptions that failed to capture fully the uncertainty of conditions or account for local knowledge of ecological dynamics (e.g., Freeman, 1989).

In our review of these discussions, we find that the traditions of social anthropology and economics come with their respective strengths and limitations (see Table 1). For example, rational choice models with assumptions of utility maximization developed from the neoclassical tradition can support quantitative hypothesis testing, provide the ability to address complex interaction of multiple forces for change, and offer some predictive strength. On the other hand, they impose oversimplified behavioral assumptions and require quantitative data that may be difficult to obtain. As a result, availability of data may determine the reliability of hypothesis testing.

A "Grounded Theory" approach to analysis (Glaser, 1994; Strauss and Corbin, 1990), undertaken in close cooperation with local community members, provides an opportunity to capture the specific context

[1] Recent research suggests that climate change is likely to have some of its most dramatic effects in the northern latitudes, with potential shifts in key Arctic ecosystem functions. In addition to an overall increase in variability and trends in permafrost temperature, precipitation, snow cover (Brown and Braaten, 1998), and greenness (Serreze et al., 2000), evidence shows a regime-like change near 1989 associated with stratospheric cooling and an increase in the polar vortex (Hare and Mantua, 2000).

Table 1
Comparisons of research approaches

Approach	Advantages	Disadvantages
Neo classical	• Supports quantitative hypothesis testing • Gives ability to address complex interaction of multiple forces for change • Espouses predictive capacity	• Imposes assumptions on human behavior that may be false • Requires quantitative data that may be difficult to come by, so hypothesis testing often limited by data available • Difficult to include local knowledge derived from a completely different world view
Grounded	• Captures situationally specific conditions of phenomenon • Assumes complexity from the outset • Assumes that history matters • Includes cultural perceptive • Includes institutions as shaping behavior • Can serve to generates "middle range theory"	• Not broadly predictive • Limited in extent to which it can be generalized • Can provide too many details to identify the key driving factors • Closely tied to a local situation

of observed phenomena. Such research begins with the assumption that systems are complex and generally include people acting within an institutional landscape. Our interest in an analysis based on grounded theory also recognizes the value of local knowledge in ecological and social research and in policy-making (Berkes, 1999, 1993).[2] While a grounded analyst generates context-specific propositions that can guide public policy-makers, this approach claims less predictive power and is less easily generalized than the rational choice approach.

Acknowledging the strengths and limitations of grounded theory and rational choice approaches, we propose to test whether integration and synthesis of the two academic traditions might produce insights not available if each of us were working separately. While much of our endeavor fits the "iterative field research" approach described by Udry (2003), we go beyond just involving locals in the production of a statistical analysis. Aware of hazards to integrating culturally based knowledge systems (Nadasdy, 1999; Cruikshank, 1981, 1998), we avoid melding grounded theory and rational choice approaches into a single system. Instead, we maintain parallel research efforts, using learning from one approach to inform work with the other.

3. Community case study: the Vuntut Gwitchin of Old Crow, Yukon territory

Situated on the confluence of the Old Crow and Porcupine Rivers, the community of Old Crow supports a mixed economy in which wild food resources and wage-based jobs together provide essential needs (Stager, 1974; Murphy, 1986; Kofinas, 1998). The community is not accessible by road, and relatively homogeneous in composition; most residents (population 275) are Vuntut Gwitchin ("People of the Lakes"), who have inhabited the region continuously for several thousand years (Acheson, 1981; Morlan, 1973).[3] In 1994, Old Crow's cash economy provided about 90 total jobs, most of which are part-time or seasonal, amounting to 53 full-time equivalent jobs. Most of the jobs in Old Crow depend directly or indirectly on funds allocated through the Vuntut Gwitchin First Nation Land Claims agreement.

The Vuntut Gwitchin identify as "caribou people," comprising one of five primary user communities of the internationally migratory Porcupine Caribou herd (Kofinas, 1998). Subsistence caribou hunting remains strong in Old Crow, despite the growth of the cash economy. Annual harvest averages about two animals per-capita (Yukon First Nations Harvest Surveys, 1988–1994). Wein (1994) found that caribou is the most frequently consumed wild food in Old Crow, with survey households serving caribou on average 241 times per year. Caribou hunting in these commu-

[2] The contributions of local knowledge in climate change studies are especially important in addressing the problem of scale and adding new dimensions overlooked by researchers who are more distant from the observed phenomena (Jolly et al., 2001; Krupnik and Jolly, 2002; Kofinas et al., 2002; Fox, 2002; Thorpe et al., 2002).

[3] The Vuntut Gwitchin are a part of the Gwich'in culture group, formerly referred to as "Kutchin" and "Louchioux" and found in villages of northeastern Alaska and the western Canadian Arctic.

nities is not undertaken for sport or recreation, but as an activity central to one's sense of self, to the transmission of cultural traditions, and to overall community well-being. Local and traditional knowledge of the social, economic, and ecological processes of the region, including observations and explanations of environmental change, reflect the historic relationship between caribou and people (Kofinas, 1998).

The Vuntut Gwitchin have articulated local observations of climate change and their implications to caribou availability for almost a decade (See Arctic Borderlands Ecological Knowledge Co-op: www.taiga.net/coop/). Concern about the effects of climate change on community sustainability takes its place among a set of community issues. These other concerns include the impacts of proposed oil development in the calving grounds of the Porcupine herd, successful implementation of self-government agreements with the Canadian and Yukon Governments, and socio-economic change at the community and regional level. Climate change may interact with economic change to affect the community's future subsistence patterns. Former Vuntut Gwitchin chief, Randall Tetlichi, framed the challenges of integrating traditional and local knowledge with the work of science and policy as a need to "double understand" (Kofinas et al., 2002). Our exploration of methods for integrating grounded theory and rational choice methods, in part, speaks to this goal.

4. A grounded approach

4.1. Theoretical orientation and local knowledge

Grounded theory is a strategy for qualitative analysis rooted in the traditions of social anthropology and sociology (Glaser and Strauss, 1967; Strauss and Corbin, 1990). Grounded Theory is generally comparative in its approach, assumes that all social phenomena are complex, and traditionally has relied on participant observation. Grounded theory is "generative" to the extent that grand theory informs it, while empirical observations guide it. Observations and analyses generate propositions that are descriptive enough to be meaningful to research subjects, yet analytic enough to be valued by others interested in the phenomenon (Strauss, 1987; Strauss and Corbin, 1990). For this project, we used a modified approach to grounded theory, which was participatory with local knowledge holders and made few distinctions between research subjects and objects (Whyte, 1991). Because we wanted to base our Grounded Theory analysis on participants' local knowledge, we directly engaged community members as key players in the research.

We define local knowledge (LK) as an interacting system of individually and collectively held observations, theories, and local preferences, underpinned with an ideological perspective.[4] We recognize that local culture brings a distinct mode of learning and thought, intimate relations with land and resources, and time-tested strategies of human survival. We also acknowledge that LK, like all knowledge, is limited, dynamic, and to a great extent bound to the social institutions from which it is derived. Given the breadth of topic areas generally encompassed by LK (vs. the narrow scope of disciplinary science), we expected that it would address a range of subjects related to our study of caribou availability. We also expected that community members would be in an ideal position to contribute to modeling at the community scale.

4.2. Community-based research

We worked with local research associates and community members from Old Crow, as well as Fort McPherson, NT, Arctic Village, AK, and Aklavik, NT.[5] We drew from historical records, docu-

[4] The terms local and traditional ecological knowledge have generated considerable debate in recent years (Cruikshank, 1981; Freeman and Carbyn, 1988; Johnson, 1992; Berkes, 1993; Inglis, 1993; Scott, 1996; Stevenson, 1996; Cruikshank, 1998). We elect to use the term "local knowledge," rather than the more restrictive "traditional ecological knowledge" in recognition that small Arctic communities can work with researchers to address social and economic questions as well as those that are primarily ecological.

[5] Field work was undertaken from April 1997 to April 1998 by Gary Kofinas (all communities) and Stephen R. Braund and Associates (Aklavik and Arctic Village) in collaboration with local research associates. Community research associates working with the project were Joe Tetlichi (Old Crow), Billy Archie (Aklavik), Johnny Charlie, Sr. (Fort McPherson) and Sarah James (Arctic Village). Findings are also informed by field work and data conducted in the MAB Sponsored Porcupine Caribou Herd (PCH) co-management research from 1993 to 1996 (Kofinas, 1998).

mented oral histories, and conducted focus group interviews to develop an overview of the system's key components and generate a set of propositions about key relationships critical to caribou availability. Our initial discussions with local hunters revealed that the availability of caribou was not simply a wildlife ecology question. While certain environmental conditions (e.g., fall storms, snow depth, rate of spring snow melt) affect the Porcupine Caribou herd's seasonal and annual distribution and movements (see Fancy et al., 1986; Eastland, 1991; Russell et al., 1993), a related set of conditions (e.g., timing of freeze-up and break-up, shallow snow cover, and the presence of "candle ice" on lakes) affect hunters' access to hunting grounds. Individual and community economic conditions also affect hunters' access to equipment and time available for hunting.

Based on previous research and our initial meetings with community residents, we selected five questions to guide our research.

Availability: What are the conditions that make caribou available and unavailable to communities?

Distributions and movements: What are the conditions affecting the distribution and movements of caribou?

Hunter access: What are the conditions affecting hunter access to caribou?

The effects of jobs: How does participation in the wage work affect caribou hunting?

Access to cash: How does having access to cash affect caribou hunting?

To represent what communities perceived as the key relationships of community-caribou availability, local experts from the four partner communities participated in group discussions and completed a mapping exercise to document current-day hunting patterns and environmental conditions affecting herd movement and distribution. In each of the four communities, we employed a modified "focus group" research method (Morgan, 1988, 1993; Agar and MacDonald, 1995) by conducting small-group workshops that address research questions on caribou availability. Two to eight "local experts" (Ferguson and Messier, 1997) were assembled at each meeting; 64 experts in all participated in 16 meetings. Local research associates in consultation with local organizations selected participants (e.g., the Aklavik Hunters and Trappers Committee). Workshops lasted 2.5 to 4 h. Participants received a cash honorarium for their participation in the workshops. Additionally, individual interviews were conducted with key locals (e.g., political leaders) who did not participate in focus groups.

Each group started with an overview of research objectives. We designed open questions to direct discussion to research-related topics (Huntington, 1998). We documented information using overlays on a topographic map to facilitate collection of spatial data and to facilitate general discussions. Mapping was cumulative; new overlays were added at the end of each interview to build knowledge. Mapping and discussions focused on seasonal and annual variation in caribou movements, major travel routes used by hunters, means of transportation, and environmental conditions that constrain hunting in community hunting grounds. While differences emerged from community to community, commonalities also arose. For example, local experts from all groups discussed how early winters of low snowfall make some areas virtually inaccessible to hunters for hunting because of rough trail conditions, in spite of the presence of caribou. Elders noted that marginal snow conditions made some areas inaccessible to older hunters because of the physical hardship of traveling rough trails, while younger hunters were willing to endure these difficulties. Hunters also discussed the economic costs of marginal snow conditions because of the greater wear and increased likelihood of damage to snowmachines. Caribou hunters described how freeze-up conditions with low variance in early winter temperature result in "smoother" (i.e. less overflow and therefore faster) winter travel on rivers, which generally allow for good travel conditions throughout the winter. Smoother travel conditions were described as the result of a freeze-up temperature regime of variability. In such conditions, areas otherwise "far" from the community would become "near." Warm summer conditions were referenced with the limitations to harvest that come when high temperature spoil meat while being butchered and transported from the field.

After the first group's discussion in each community, a community associate and researcher generated a list of propositions, which were posted for group review and refined by other groups at subsequent meetings. For example, a local in an initial group expressed the proposition,

Proposition 1. *If a local hunter has a full-time job, the hunter has little time for hunting.*

Responding to the proposition, participants of subsequent groups elaborated with corollaries:

Corollary 1. *Those with full-time jobs have equipment that allows for fast access to hunting grounds distant from communities.*

Corollary 2. *Those with full-time jobs hunt on weekends in crowded and unsafe conditions.*

Corollary 3. *Those without full-time jobs avoid hunting on weekends because conditions are less crowded and caribou meat is of a better quality when not "overworked" by other hunters.*

Corollary 4. *Those without full-time jobs without their own hunting equipment commonly borrow gear from members of their family who may hold full-time jobs.*

Community members engaged in open discussions about related topics, such as the functional value of spending time on the land and the transmission of ecological knowledge, and the cultural traditions of respect for animals—all of which were related to caribou availability. Because all discussions were not easily captured as propositions (e.g., life history accounts), open discussions allowed participants to "tell their stories" with follow-up opportunities for comments, questions and answers. Other discussions addressed community changes in modern-day social conditions and hunting patterns, and what were described as resultant changes in young people's attitudes about hunting and animals.

Focus group participants reviewed findings from other studies, when available to prompt discussions or suggest interpretation. In a few cases, participants openly disagreed, but such differences usually resulted in exchanges of perspectives and a consensus for acceptance of the propositions. Where possible, we strove for agreed-upon and theoretically linked set of propositions. Where possible, a focus group or elected leaders (e.g., Renewable Resources Councilors) reviewed our findings and commented further.

The results of this research process did not lead to a single model of understanding, but a set of causally linked propositions and rich individual narratives that reflect hunters' observations of climate change, communities' current and anticipated adaptations to these changes, and concern for rapid climate change in the future.

5. Rational choice approach

The rational choice economic approach assumes that individuals maximize well-being based on defined sets of preferences and opportunities, subject to one or more constraints. In this section, we first outline a general rational choice model for participation in subsistence hunting in a mixed subsistence-market economy. Then we define a specific travel-cost model (Clawson, 1959) for Old Crow hunting using a discrete-choice approach (Domencich and McFadden, 1975).[6] After discussing our data sources, we estimate the model and consider some implications of its results.

5.1. Travel-cost model of subsistence hunting

Following convention, we assume that the participant in the mixed economy maximizes utility, U, which is a function of participation in subsistence hunting, all other activities, A, a vector X of household characteristics, and a vector Z of environmental factors: $U = U(S,A,X,Z)$. Since our principal interest lies with caribou hunting, we define a unit of S to be a caribou hunting trip.

As noted by local knowledge holders, participation in subsistence activities requires an expenditure of time and money. The ratio of money to time depends on the technologies people use. Over the time horizon,

[6] Broadway and Bruce (1984) present a detailed description of the neoclassical approach to economic well_being based on rational choice. Freeman (1993, ch. 13) discusses in depth the issues involved with the use of various types of travel cost models to measure values of natural resource activities and assets.

we consider (several years), technologies change little, so we can measure the "cost" of a hunting trip in terms of an amount of household resources, r (a combination of time and money), required to complete the trip.[7] If we maximize $U(S,A,X,Z)$ subject to a constraint on total household time and money resources R, we may substitute for S and A to obtain the *indirect utility* function, $V(r,R,X,Z)$.[8]

The data we observe on subsistence consist of individual caribou harvest records in a geographic area for each hunter. *Discrete-choice models* (Ben-Akiva and Lerman, 1985; Domencich and McFadden, 1975) are well suited to analyzing data consisting of observed choices selected from a finite set of alternatives with geographic variation.[9] One type of discrete-choice model—the *Random Utility Model* (RUM) (McFadden, 1981)—has been used extensively over the years to study participation in non-market activities, such as recreational hunting and fishing. Extending the model to Old Crow subsistence hunting is straightforward.

Under the assumptions of RUM, welfare gained from participating in a particular hunting choice j has two predictable components and a "random" component, ε_j:

$$V(r,R,X,Z) = V^1(R - r_j, X) + V^2(X, Z_j) + \varepsilon_j \qquad (1)$$

The first term, V^1, refers to the component of welfare gained from other activities using time and money resources not used in that hunt, while the second term V^2 refers to the welfare gained from the hunting choice j. The RUM makes the additional simplifying assumption that V^1 is a linear function of $R-r$.[10] The random component, ε_j, represents uncertain factors such as weather and health. The RUM assumes that ε_j is independent of V^1 and V^2, and revealed to the decision-maker (hunter) at the time of the decision, but unobserved by the analyst.

In this application, we are interested not only in the geographic reallocation of hunting effort associated with climate-related changes in access, but also in potential effects on overall hunting effort. We therefore consider two separate but related choices: choice of hunting area, and frequency of participation. Researchers typically address this type of dual choice by assuming a nested choice structure: (1) hunters choose a participation level based on overall hunting quality, and (2) hunters choose an area in which to hunt, given their choice of participation level.

Under the usual assumption that the ε_j are independently and identically distributed with a type one extreme value distribution, the probability π_j that the hunter selects hunting area j from the set of J hunting areas, given the choice of participation level n is:

$$\pi_j \mid n = \frac{e^{V(r_i,R,X,Z)/(1-\sigma_n)}}{\sum_{i=1}^{J} e^{V(r_j,R,X,Z)/(1-\sigma_n)}}; \quad j = 1,2,\ldots,J \qquad (2)$$

A subscript for the time period—one of five seasons per year—is implied in Eq. (2), but left out for ease of exposition. The probability of selecting one of three participation levels n—not hunt, hunt once, hunt more than once that season—is:

$$\pi_n = \frac{e^{\varphi_n X_n + (1-\sigma_n) I_n}}{\sum_{m=1}^{N} e^{\varphi_m X_m + (1-\sigma_m) I_m}}; \quad n = 1,2,3 \qquad (3)$$

The *inclusive value* I_n in Eq. (3), given by the formula,

$$I_n = \ln \sum_{i=1}^{J} e^{V(r_i,R,X,Z)/(1-\sigma_n)} \qquad (4)$$

represents an index of the overall quality of hunting opportunities available for participation level n.

[7] The household production model (Becker, 1965; Gronau, 1986) provides a rational choice treatment of the allocation of time in a household between income-producing and other activities. Kirkvliet and Nebesky (1997) and Berman (1998) discuss applications of the household production model to Arctic mixed economies. If jobs are not available, so that the household cannot increase income by increasing work time, then we would need to split the variable r into two separate components, time and money, both of which are limited.

[8] The function, $U(S,A)$, is assumed to be concave in its arguments to ensure that the maximization yields an indirect utility function, $V(r,R,X,Z)$.

[9] McFadden (1981) provides a comprehensive discussion of the formal assumptions and theoretical properties of discrete choice models.

[10] As explained by McFadden (1981) a linear term, V^1, in the standard RUM model is associated with the assumption of a constant marginal utility of income. Here this term depends on time and money effort, so we assume a constant marginal utility of effort.

Through its coefficient $1-\sigma_k$ $(0 \leq \sigma_k \leq 1)$, I_n provides the mechanism by which the quality of hunting in the various hunting areas affects participation.

To apply the RUM model to the activities of hunters for a particular community, we estimate Eqs. (2) and (3), where $V(r,R,X,Z)$ takes the form of Eq. (1). This requires observations on hunting activities recorded by geographic area as well as the r, X, and Z variables. Since the measure of total household resources, R, does not vary across alternatives and therefore does not influence the relative probabilities of different choices, we do not need to measure it.

5.2. Participation of community experts in the travel-cost study

Direct collaboration with local knowledge holders produced spatially explicit data at a scale relevant to hunters' decisions. We compared locally generated propositions and maps produced from group interviews with past biological studies on Porcupine caribou herd (PCH) migration (Fancy et al., 1986; Eastland, 1991; Russell et al., 1993), delineating 12 PCH range-wide zones that captured seasonal movements and annual variation of distribution in various environmental conditions. We then used agency survey data (Russell et al., 1992) to identify seasonal distribution in those zones in each year. Local hunters in five communities within the PCH range delineated 38 community-specific hunting zones nested within the 12 range-wide zones, reflecting both variation in animal distribution in different environmental conditions and hunting effort required. When possible, we asked hunters in focus groups to draw boundaries around spatially displayed harvest data. In other cases, researchers delineated zones and presented them to locals for review and refinement.

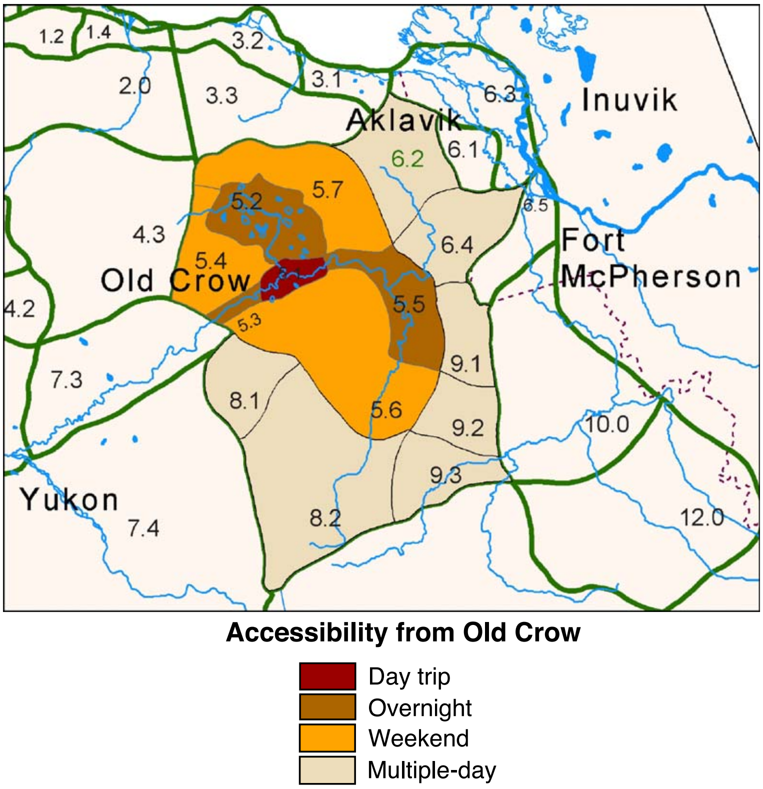

Fig. 1. Old crow hunting area alternatives and accessibility in late winter, as defined by local hunters. Note: zones represent hunting areas for Porcupine caribou user communities, as delineated by local hunters. Accessibility from Old Crow generated from focus groups of Old Crow hunters. Map produced by Stephen R. Braund & Associates.

Table 2
Description of variables used in the travel-cost model

Variable name	Description	Source
Hunting area (dependent, Eq. (2))	Hunting area of the harvest: one of 10 areas regularly used by Old Crow hunters	a
Remoteness (*r*)	Minimum number of days required to travel to and hunt in each hunting area in a given season: 1 = day trip, 2 = overnight, 3 = weekend, 4 = multi-day	a
Caribou probability (*Z*)	Probability that caribou are present in a given hunting area if observed by remote sensing that season in the Yukon Game Management Zone (GMZ) that includes the hunting area; 0 if not observed in the GMZ that includes the hunting area	a, b
Near community (*Z*)	1 if hunting area = 5.1 (near community), 0 for other hunting areas	
Downriver (*Z*)	1 if hunting area = 5.3 (downriver), 0 for other hunting areas	
Weights for hunting area equation	Probability that harvest took place in a given hunting area, given the Yukon Game Management Subzone recorded for the harvest	a
Participation level (dependent, Eq. (3))	Number of days in a season that a household reported a caribou harvest: 0 = not hunt, 1 = hunt once, 2 = hunt more than once	c
Not hunt constant	Constant term for the not hunt alternative	
Inclusive value, hunt (*I*)	Index of hunting quality derived from estimated coefficients of the hunting area equation for the two hunted alternatives, 0 for the not hunt alternative	
Household need, hunt (*X*)	Projected annual caribou need (Eq. (5)), minus cumulative number of caribou killed that year; 0 for the not hunt alternative	d
Household kids, hunt (*X*)	Number of children under 18 in the household; 0 for the not hunt alternative	d
Full-time worker, not hunt (*X*)	Number of full-time workers in the household, not hunt alternative; 0 other alternatives	d
Full-time worker, hunt often (*X*)	Number of full-time workers in the household, hunt more than once alternative; 0 other alternatives	d

Sources: (a) Old Crow hunters (Key informant-based data of Old Crow household composition and employment status, documented by Kofinas; (b) Russell et al. (1992); (c) Yukon First Nations Harvest surveys, 1988–1994; (d) Kofinas (1998).

Old Crow hunters evaluated the time and material resources needed to travel to each of the 10 hunting zones potentially accessible to them, accounting for seasonally varying environmental conditions and different transportation gear. Hunters explained the factors underlying their decisions with propositions such as:

Proposition 2. *Hunting up river in fall from Old Crow is more cost efficient (time and money) because it allows travel upstream with an empty boat and a return home down stream fully loaded with meat. A successful hunt down stream requires "pushing water" to get home.*

Working in this way with hunters, we were able to measure the remoteness, *r*—time and money effort to reach each hunting zone by season and gear type (travel cost)—in terms of a "day trip," "overnight trip," "weekend trip" or "multiple-day trip". Fig. 1 illustrates the hunting zones and travel cost for Old Crow for the late winter season.

5.3. Combining local knowledge with other data

Table 2 summarizes the definition and primary source of the data series used in the empirical analysis. The basic observations on hunting activities consist of individual caribou harvests by hunter, date and geographic area, over the period 1988 through 1994. Harvest surveys were initially undertaken by Yukon Territorial Government. The Vuntut Gwitchin First Nation acquired ownership of the data in 1993 and generously gave us permission to use the data. Harvest locations are recorded by Yukon Game Management Subzones (GMS's). The dates are grouped into five hunting seasons according to access conditions and timing of caribou movements. Long-distance travel is generally by water along rivers and lakes during the summer and fall seasons, and by snowmachine in winter and spring. Snow and ice conditions ease snowmachine travel in late winter. Long daylight hours and moderating temperatures facilitate long-distance travel in spring, when caribou also frequently move through the area.

We derived an index of the likelihood of encountering caribou in different areas during different seasons from published data on Porcupine caribou movement (Russell et al., 1992). This index along with two dummy variables constitute the set of Z variables. We constructed dummy variables for two hunting areas: near community and downriver. The area surrounding the home community is accessible for partial day trips at all times of the year, so its remoteness cannot be easily compared to that of the other areas that require long distance travel. The downriver area, although relatively close, is truncated by the US border, and local hunters consider upstream travel with loaded boats hazardous in that stretch of the Porcupine River.

We were able to match data from a survey of the 77 Old Crow resident households in 1993 (Kofinas, 1998) with the harvest survey data to obtain demographic and employment information. Since the 1993 survey data may not represent household status in other years, we use only the 1992 and 1993 hunting participation information to estimate Eq. (3). We projected annual household need from the following equation for self-reported household caribou needs estimated with data from a PCH regional caribou user survey of 90 hunters (Kofinas, 1998) (t statistics in parentheses):

$$\ln(\text{annual caribou need}) = 1.30(7.93) + 0.47 * \ln(\text{household size})(4.01). \quad (5)$$

Local hunters describe their hunting area options in quite different terms from the geography used in the harvest data. For example, GMS boundaries follow rivers that hunters use as travel corridors to access hunting areas on either bank. Caribou distribution is published only by Game Management Zone (GMZ), of which the GMSs are subsets. Hunters' local knowledge of seasonal caribou movements provided us with the probability that caribou are present in each of their hunting areas if present generally in the GMZ. Hunters also helped us address the problem of overlapping geography of GMS and hunting area by providing the probability that a harvest in each GMS would have occurred in each hunting area, by season. We record each harvest as a set of fractional observations distributed among hunting zones, with the fractions (probabilities) adding to one. In this way, we use all the information at hand without making arbitrary choices to allocate individual harvests to particular hunting areas.

5.4. Results

Table 3 shows the distribution of 332 caribou hunting trips across the 10 hunting areas, and displays

Table 3
Choice of hunting area (weighted maximum likelihood estimates dependent variable: hunting area each trip)

Hunting area	5.1	5.2	5.3	5.4	5.5	5.6	5.7	6	8	9
Sample proportions	37.6%	14.8%	5.6%	13.4%	12.4%	10.9%	1.7%	1.9%	0.8%	0.9%

Variable	Coefficient	Standard error	t-ratio	Prob. (%)
Remoteness (days)	− 0.447	0.088	− 5.059	0.00
Caribou probability	5.141	0.971	5.296	0.00
Near community	1.600	0.323	4.955	0.00
Downriver	− 1.118	0.274	− 4.074	0.00

	Initial	At convergence
Log-Likelihood	− 763.6	− 620.8
Chi-Squared (4)		285.7
Observations (trips)		332

the results of estimating Eq. (2) for the choice of hunting area. The remoteness coefficient is negative and significantly different from zero, with a coefficient of about -0.45. The dummy variable for the near-community hunting area is significantly positive, while the downriver dummy variable is significantly negative. The coefficient on the probability of caribou being present in the area is significantly positive and quite large. The estimated equation suggests a tradeoff between the likelihood of finding caribou in a hunting area and its remoteness from the community, consistent with the assumptions of the travel-cost model. The likelihood ratio test ($\chi^2(4)$) is highly significant, indicating that the equation has statistical power to explain the distribution of hunting trips across the various hunting areas.

The participation data includes 378 observations, consisting of 54 hunters observed over seven hunting seasons. We computed the inclusive value as specified in Eq. (4) from the estimated hunting area equation. The inclusive value represents the quality of hunting conditions, based on the relative accessibility of caribou. Table 4 shows the distribution across the three participation categories as well as the participation equation results. Except for the constant term and full-time worker indicator, all coefficients represent the effect of the respective variable on the two hunt alternatives combined. We normalize the constant term to the "not hunt" alternative.

Table 4 suggests that hunting conditions strongly influence participation. The coefficient for inclusive value is about 0.9 and highly significant, consistent with the assumptions of the RUM. While hunting quality has the strongest statistical correlation with participation, household characteristics also appear to be relevant. Household caribou need—equal to projected annual need from Eq. (5) less cumulative harvests since the previous fall—is positively associated with hunting participation. Hunters with children are also more likely to hunt.

We have reason to expect that full-time work might have an ambiguous effect on participation, since work provides earnings to finance the hunt but uses up potential hunting time (see Kirkvliet and Nebesky, 1997). We found that having a full-time worker in the household reduced the likelihood of not hunting at all but reduced the likelihood of hunting often by an even greater amount. This suggests that hunters with full-time work may be more likely than unemployed or part-time-employed hunters to go hunting once in a season, but less likely to hunt more often.

Overall, the equation results shown in Tables 3 and 4 provide strong statistical support for the rational choice model. The likelihood ratio test for the participation equation ($\chi^2(6)=467$) suggests that the hunting participation and area choices of Old Crow hunters are consistent with the two-level RUM model. We illustrate applications of the quantitative results with two examples. First, we project the effects of hypothetical local climate and development effects on hunting participation. Second, we invoke the RUM

Table 4
Choice of participation level (maximum likelihood estimates dependent variable: participation level each season)

Participation level	Not hunt	Hunt once	Hunt 2–3 times	
Sample proportions	82.3%	13.0%	4.8%	
Variable	Coefficient	Standard error	*t*-ratio	Prob. (%)
Not hunt constant	7.049	0.836	8.432	0.00
Full-time worker, not hunt	−0.774	0.374	−2.067	3.87
Inclusive value, hunt	0.908	0.158	5.763	0.00
Household need, hunt	0.143	0.050	2.845	0.44
Household children, hunt	0.279	0.135	2.069	3.85
Full-time worker, hunt often	−1.674	0.629	−2.661	0.78
	Initial	At convergence		
Log-Likelihood	−415.3	−181.8		
Chi-Squared (6)		466.9		
Observations		378		

assumptions to estimate a value or cost of these effects to local hunters.

During the first few months of winter when the snowpack is light, hunters rely on frozen rivers for long-distance travel. While a hard freeze enabling safe travel has historically come by the beginning of November, warmer temperatures in recent years have occasionally left areas of thin ice or open water well into December. If significant climate warming occurs, these late freeze-up events could become more common. Table 5 shows the projected probabilities of early winter hunting participation under normal and late freeze-up conditions. We compute the probabilities in Table 5 from the coefficients in Tables 3 and 4 applied to a household with three adults and two children, no fall caribou harvest, and assuming the distribution of caribou in 1993.

The projected probability that a member of the household will hunt at least once under these assumptions is about 27% if at least one household member is employed full-time. The probability of hunting more than once is only about 4%. If no one in the household has full-time work, the equations project that somewhat fewer households are likely to hunt, but a far higher percentage—11%—will hunt two or three times in the season. During years when freeze-up comes late, only the near-community hunting area is accessible. The equation projects that less than 10% of households will hunt under these circumstances.

Using the same set of assumptions about the household situation and caribou distribution, we can derive from the RUM model a measure of the change in household welfare—*compensating variation*—implied by a change in the timing of freeze-up and difference in work patterns. Estimates of compensating variation for the change from scenario A to scenario A′ may be estimated directly in the RUM model from integration of Eq. (3) as follows:

$$CV = \frac{\ln\left(\sum_{m=1}^{3} e^{\varphi_m X_m + (1-\sigma_m) l_m (V^{A'} - V_0)}\right)}{-(1-\sigma)\alpha} - \frac{\ln\left(\sum_{m=1}^{3} e^{\varphi_m X_m + (1-\sigma_m) l_m (V^{A} - V_0)}\right)}{-(1-\sigma)\alpha} \tag{6}$$

where $V^{A} - V_0$ and $V^{A'} - V_0$ are the values predicted from the estimated coefficients of the area-choice Eq. (2) under freeze-up scenarios A and A′. The denominator of both terms of Eq. (6), $-(1-\sigma)\alpha$, equals minus one times the coefficient on the remoteness variable in Eq. (2), and is an estimate of the marginal utility of household resources.[11] Since remoteness is measured in days of effort, the compensating variation estimated with Eq. (6) represents an equivalent of days of time saved or lost from the change in work or hunting opportunities.

Fig. 2 shows the compensating variation estimated for the changes in work and climate patterns for which Table 5 projects participation outcomes. The numbers in Fig. 2 suggest that late freeze-up costs the example household the equivalent of about half a day in lost leisure or family time each year that it occurs.[12] The

Table 5
Projected probabilities of hunting caribou in early winter (Household with three adults, two children, no fall harvest; 1993 caribou distribution)

Scenario	Not hunt (%)	Hunt once (%)	Hunt 2–3 times (%)
Normal freeze-up, full-time job	73.03	22.71	4.26
Normal freeze-up, no full-time job	77.71	11.15	11.15
Late freeze-up, full-time job	90.48	8.02	1.50
Late freeze-up, no full-time job	92.44	3.78	3.78

[11] The equation for the compensating variation of a change in employment is similar, except that X_m changes to $X_{m'}$ in the first term, while $V_A - V_0$ remains unchanged in both terms. McConnell (1995) has shown that compensating variation—the measure of welfare change economists generally prefer—is identical to consumer surplus under the assumptions of RUM. See Small and Rosen (1981) for a discussion of the properties of estimates of welfare from logit models.

[12] This estimated loss of value does not refer directly to the cost of obtaining food. Rather, it values the reduced quality of hunting opportunities, taking into account everything (including cultural reasons) affecting the desire to hunt. Given the mixed economy of Old Crow, we believe it more appropriate to measure the compensating variation in units of time instead of money. One can convert the compensating variation in units of time into units of money by multiplying the numbers in Fig. 2 by the hunter's potential earnings. For example, the 0.48 days per year would translate into a $48 loss to a hunter who could have worked for $100/day.

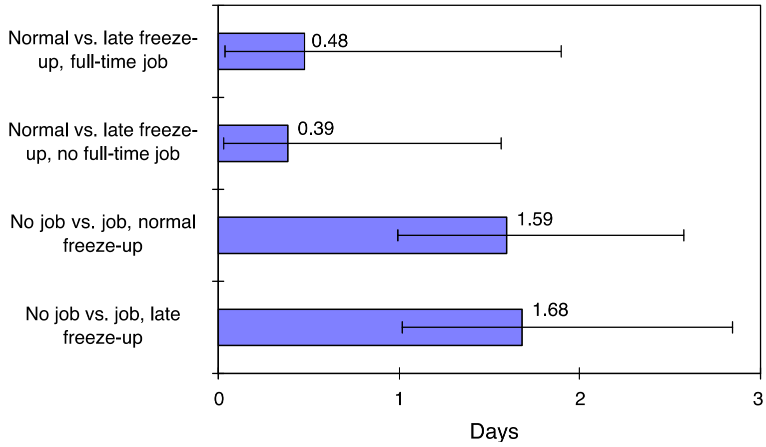

Fig. 2. Change in value (compensating variation), in days per year, from early winter caribou hunting. Household with three adults, two children, no fall harvest; 1993 caribou distribution. (Error bars bracket bootstrapped 95% confidence intervals).

loss is slightly less if no one in the household has full-time work. The loss due to climate change is relatively modest because restricting hunters to the area near the community when there is some probability that caribou are present there still leaves substantial hunting opportunity available. (Table 3 shows that nearly 40% of all harvests were recorded in the near-community area.)[13] The error bars in the figure show bootstrapped 95% confidence intervals for the estimates ranging from a loss of 1 h to loss of nearly 2 days. The confidence intervals suggest that although the direction of the change in value is unambiguously negative, the amount remains uncertain. The compensating variation for a full-time job during the early winter season is also negative: about three times larger than the cost of the late freeze-up. The loss of time to hunt from obtaining a full-time job in this case substantially exceeds the monetary gain, reducing the household's welfare overall.

6. Conclusions

In our case, local knowledge contributed with the grounded theory approach informs the development of a rational choice model. We are able to draw the two traditions of inquiry together to produce an integrated assessment the effects of climate change on subsistence caribou hunting in an Arctic community. We demonstrate that documenting local knowledge and building middle-range theory can supply a rich and complex base for understanding caribou availability. In addition, local knowledge provides a realistic choice set of hunting areas and seasons that local experts consider relevant to their decisions. It also describes hunting effort (time, money, gear), and climatic conditions likely to affect caribou movements and accessibility of caribou hunting areas. More generally, local knowledge contributes by generating relevant variables to model, reconciling discrepancies among data sets, and establishing parameter values, allowing us to take advantage of the strengths of the rational choice approach (see Table 1).

Informed by local knowledge, the quantitative analysis of hunting participation data provides results that are consistent with the travel-cost model. In particular, we can quantify a tradeoff in the choice of hunting areas between the likelihood of success and travel cost. We also can quantify an increase in hunting participation when overall hunting conditions improve and when household need rises, consistent with the rational choice approach. The strong statistical power of the estimated relationships allows us to project with confidence that later fall freeze-up associated with climate warming would increase travel costs enough to reduce hunting participation and harm the community. How-

[13] The estimates in Fig. 2 assume that all the near-community area would likely be accessible under late freeze-up, which is probably optimistic, give the location of Old Crow at the confluence of two rivers. These figures therefore likely underestimate the loss of opportunity under climate warming.

ever, the projected loss for the example household—half a day in lost leisure or family time each year that it occurs—remains highly uncertain.

The two analytical approaches produce consistent results, therefore validating each other. However, they generate qualitatively different information: the grounded approach supplies a more holistic and complete understanding of the relationships estimated by the rational choice approach. For example, the choice model estimates a net loss of value for having a full-time job during the early winter season: about a day and a half annually for an example household. Focus groups used in our grounded approach provide an elaborated explanation of how full-time workers substitute money for time in ways that qualitatively affect their hunting experience.

As noted in Table 1, the rational choice model leaves out details community experts consider critical to caribou harvest: i.e., the capacity of a community to self-organize with group hunts when faced with caribou scarcity, and notions of luck associated with reciprocity in human–animal relations. Inclusion of only select aspects of local knowledge is hardly surprising given the reductionist nature of neoclassical economics. For the authors of this paper, the problem of reductionism remains unresolved, and reflects an unreconciled cultural difference between research science and the knowledge systems of indigenous hunters.

That said, it is clear from our experience that integration, when considered as a process of communication occurring between researchers and community members, may advance our collective understanding of the problem and each other. While some scholars consider knowledge integration as potentially another subjugation of indigenous culture, our experience indicates that the co-production of knowledge can offer those involved innovative insights to common problems. Collaborating researchers who subscribe to differing disciplinary traditions of analysis can produce results that are not available from their work individually, and better meet the needs of the communities they study. Based on our work, we conclude that combining a grounded theory approach to documenting local knowledge with quantitative modeling of rational choice is worthy of further exploration. Given the interest among researchers and community members in learning from each other, the time may be appropriate to pursue such efforts with humility and sensitivity.

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References

Acheson, A.W., 1981. Old Crow, Yukon territory. In: Helm, J. (Ed.), Handbook of North American Indians. Volume 6: Subarctic. Smithsonian Institute, Washington, D.C, pp. 694–703.

Agar, M., MacDonald, J., 1995. Focus group research and ethnography. Human Organization 54 (1), 78–86.

Balicki, A., 1968. Perspectives on the atomistic-type society. Bad friends. Human Organization 27 (3), 191–199.

Becker, G., 1965. A theory of the allocation of time. Economic Journal 75, 493–517.

Ben-Akiva, M., Lerman, S.R., 1985. Discrete Choice Analysis: Theory and Application to Travel Demand MIT Press, Cambridge, MA.

Berger, T., 1977. Northern Frontier, Northern Homeland: The Report of the Mackenzie Valley Pipeline Inquiry. Printing and Publishing, Supply and Services, Ottawa, Canada.

Berkes, F., 1993. Traditional ecological knowledge in perspective. In: Inglis, J.T. (Ed.), Traditional Ecological Knowledge; Concepts and Cases. International Program on Traditional Ecological Knowledge, Ottawa, pp. 1-10.

Berkes, F., 1999. Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Taylor and Francis, Philadelphia.

Berman, M., 1998. Sustainability and Subsistence in Arctic Communities, paper presented to the annual meeting of the Western Regional Science Association Monterey, California. February.

Broadway, R., Bruce, N., 1984. Welfare Economics. Blackwell, Oxford.

Brown, R.D., Braaten, R.O., 1998. Spatial and temporal variability of monthly Canadian snow depths, 1946–1995. Atmosphere-Ocean 36, 37–54.

Clawson, M., 1959. Methods of Measuring the Demand for and Value of Outdoor Recreation. RFF Reprint No. 10 Resources for the Future, Washington, D.C.

Coates, K.S., 1991. Best Left as Indians. McGill-Queen's Univ. Press, Montreal.

Cohen, S.J., 1997. What if and so what in northwestern canada: could climate change make a difference to the future of the mackenzie basin? Arctic 50 (4), 293–307.

Cruikshank, J., 1981. Legend and landscape: convergence of oral and scientific traditions in the Yukon territory. Arctic Anthropology 18 (2), 67–93.
Cruikshank, J., 1998. The Social Life of Stories. University of Nebraska Press, Omaha.
Domencich, T.A., McFadden, D., 1975. Urban Travel Demand: A Behavioral Analysis. North Holland, Amsterdam.
Eastland, W.G., 1991. Influence of Weather on Movements and Migration of Caribou. University of Alaska, Fairbanks, p. 111.
Fancy, S.G., Pank, L.F., et al., 1986. Seasonal movement of Caribou in Arctic Alaska as determined by satellite. Canadian Journal of Zoology 67, 644–650.
Ferguson, M.A.D., Messier, F., 1997. collection and analysis of traditional ecological knowledge about a population of arctic caribou. Arctic 50 (1), 17–28.
Freeman, M., 1989. Graphs and gaffs: a cautionary tale on the common property resource debate. In: Berkes, F. (Ed.), Common Property Resources: Ecology and Community-Based Sustainable Development. Belhaven Press, London, pp. 92–109.
Freeman, M., Myrick III, M., 1993. The Measurement of Environmental and Resource Values: Theory and Methods. Resources for the Future, Washington, D.C.
Freeman, M., Carbyn, L., 1988. Traditional Knowledge and Renewable Resource Management in Northern Regions. Boreal Institute for Northern Studies, University of Alberta, Edmonton.
Fox, S., 2002. These are things that are really happening: Inuit perspectives on the evidence and impacts of climate change in Nunavut. In: Krupnik, I., Jolly, D. (Eds.), The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change Arctic Research Consortium of the United States, Fairbanks, Alaska, pp. 12–53.
Glaser, B.G., 1994. More Grounded Theory Methodology. Sociology Press, Mill Valley, CA.
Glaser, B.G., Strauss, A.L., 1967. The Discovery of Grounded Theory: Strategies for Qualitative Research. Adline and Atherton, Chicago.
Gronau, R., 1986. In: Ashenfelter, O., Layard, R. (Eds.), Home Production—a Survey, Handbook of Labor Economics, vol. 1, North Holland, New York, pp. 273–304.
Hare, S.R., Mantua, N.J., 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Progress in Oceanography 47 pp. 103-145.
Huntington, H.P., 1992. Wildlife Management and Subsistence Hunting in Northern Alaska. Bellhaven Press, London.
Huntington, H.P., 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51 (3), 237–242.
Inglis, J.T. (Ed.), 1993. Traditional Ecological Knowledge: Concepts and Cases. International Program on Traditional Ecological Knowledge, International Development Research Centre, Ottawa.
Johnson, M. (Ed.), 1992. Lore: Capturing Traditional Environmental Knowledge. Dene Cultural Institute and the International Research Center, Yellowknife.
Jolly, D., Berkes, F., Castleden, J., Nichols, T., Harbor, T.C.O.S., 2001. We can't predict the weather like we used to: inuvialuit observations of climate change, Sachs Harbor, western Canadian Arctic. In: Krupnik, I., Jolly, D. (Eds.), The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks, pp. 92–125.
Kirkvliet, J., Nebesky, W., 1997. Whaling and wages on Alaska's north slope: a time allocation approach to natural resource use. Economic Development and Cultural Change 46, 651–665.
Kofinas, G.P., 1998. The cost of power sharing: community involvement in canadian porcupine caribou co-management. PhD dissertation, Faculty of Graduate Studies. Vancouver: University of British. 471.
Kofinas, G.P., 2002. Community-Based Ecological Monitoring: A Summary of 1996–97 Observations and Pilot Project Evaluation. North Yukon Ecological Knowledge Co-Operative, Whitehorse, p. 29.
Krupnik, I., Jolly, D. (Eds.), 2002. The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks.
Kruse, J.A., 1992. Alaska North slope inupiat eskimo and resource development: why the apparent success? presented to American Association for the Advancement of Science 1992 Annual Meeting, Chicago, IL.
Langdon, S.J., 1986. Contemporary Alaska Natives Economies University Press of America, New York.
Langdon, S.J., 1991. The integration of cash and subsistence in southwest Alaska yup'ik eskimo communities. Senri Ethnological Studies 30, 269–291.
McCandless, R.G., 1985. Yukon Wildlife: A Social History. The University of Alberta Press, Edmonton.
McConnell, K.E., 1995. Consumer surplus from discrete choice models. Journal of Environmental Economics and Management 29 (Nov), 263–270.
McFadden, D., 1981. In: Manski, C., McFadden, D. (Eds.), Econometric Models of Probabilistic Choice. in Structural Analysis of Discrete Data: With Econometric Applications. MIT Press, Cambridge, Mass pp. 198-272.
Meyers, F.R., 1988. Critical trends in the study of hunter–gatherers. Annual Review of Anthropology 17, 261–282.
Morgan, D.L., 1988. Focus Group as Qualitative Research. Sage Publications, Newbury Park.
Morgan, D., 1993. Successful Focus Groups. Sage Publications, Newbury Park.
Morlan, R.E., 1973. The Later Prehistory of the Middle Porcupine Drainage, Northern Yukon Territory. Archaeological Survey of Canada, Mercury Series, Paper 11 National Museum of Man, Ottawa.
Murphy, S.C., 1986. Valuing Traditional Activities in the Northern Native Economy: The Case of Old Crow Yukon Territory. University of British Columbia, Vancouver, p. 189.
Murphy, R., Steward, J., 1956. Trapper and trappers: parallel process in acculturation. Economic Development and Cultural Change 4, 393–408.
Nadasdy, P., 1999. The politics of TEK: Power and the "integration" of knowledge. Arctic Anthropology 36, 1–18.
Netro, E., 1988 (Winter). A critique of bad friends, by asen balikei. The Northern Review 2, 99–103.

Nuttall, M., Berkes, F., Forbes, B., Kofinas, G., Wenzel, G., Vlassova, T., in press. Hunting, Herding, Fishing and Gathering, in *Arctic Climate Impact Assessment*. International Arctic Research Center, Fairbanks, Alaska.

Peterson, D.L., Johnson, D.R. (Eds.), 1995. Human Ecology and Climate Change: People and Resources in the Far North. Taylor and Francis, Washington.

Russell, D.E., Martell, A.M., et al., 1993. The range ecology of the porcupine caribou herd in Canada. Rangifer. Special Issue 6, 168.

Scott, C., 1996. Science for the west, myth to the rest. Naked science: anthropological inquiry into boundaries, power, and knowledge. In: Nader, L. (Ed.), Roultledge, New York, pp. 69–86.

Serreze, M.C., Walsh, J.E., Chapin, I.F.S., Osterkamp, T., Dyurgerov, M., Romanovsky, V., Oechel, W.C., Morison, J., Zhang, T., Barry, R.G., 2000. Observational evidence of recent change in the northern high latitude environment. Climatic Change 46, 159–207.

Small, K.A., Rosen, H.S., 1981. Applied welfare economics with discrete choice models. Econometrica 49, 105–130.

Stabler, J., 1990. A Utility Analysis of Activity Patterns of Native Males in the Northwest Territories. Economic Development and Cultural Change 39, 47–60.

Stager, J.K., 1974. Old Crow, YT, and the proposed northern gas pipeline, Environmental–Social Committee, Northern Pipelines. Task Force on Northern Oil Development. Report No. 74-21.

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

Strauss, A.L., 1987. Qualitative Analysis for Social Scientists. Cambridge Univ. Press, Cambridge.

Strauss, A., Corbin, J., 1990. Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Sage Publications, Newbury Park.

Tester, F.J., Kulchyski, P., 1994. Tammarnit (Mistakes): Inuit Relocation in the Eastern Arctic, 1939–63. UBC Press, Vancouver.

Thorpe, N., Eyegetok, S., Hakongak, N., Kutikmeot Elders, N., 2002. Nowadays it is not the same: Inuit Quajimajatuqangit, climate and caribou in the Kitikmeot Region of Nunavut, Canada. In: Krupnik, I., Jolly, D. (Eds.), The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change, pp. 198–239 Research Consortium of the United States, Fairbanks, Alaska.

Udry, C., 2003. Fieldwork, economic theory and research on institutions in developing countries. American Economic Review 93 (2), 107–111.

Udry, C., 2003. Fieldwork, economic theory and research on institutions in developing countries. American Economic Review 93 (2), 107–111.

Usher, P.J., 1995. Co-management of natural resources: some aspects of the Canadian experience. In: Peterson, D.L., Johnson, D.R. (Eds.), Human Ecology and Climate Change: People and Resources in the Far North. Taylor and Francis, Washington, pp. 197–206.

Wein, E.E., 1994. Yukon First Nations food and nutrition study. Report to the Champagne and Aishihik First Nations, the Teslin Tlingit Council, the Vuntut Gwich'in First Nation, the Yukon Department of Health, and the National Institute of Nutrition. National Institute of Nutrition Post-doctoral Fellow: 102.

Whyte, W.F. (Ed.), 1991. Participatory Action Research. Sage Publications, Newbury Park.

Zhang, X., Vincent, L.A., Hogg, W.D., Niitsoo, A., 2000. Temperature and precipitation trends in Canada during the twentieth century. Atmosphere-Ocean 38, 395–429.