POLARIS: The Pursuing Opportunities for Long-term Arctic Resilience for Infrastructure and Society

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Abstract

Alaskan coastal Indigenous communities face severe, urgent, and complex social and infrastructural challenges resulting from environmental changes. However, the magnitude and significance of impacts are unclear; as is how local communities will respond to resulting disruptions and disasters. The Pursuing Opportunities for Long-term Arctic Resilience for Infrastructure and Society (POLARIS) project investigates how interconnected environmental stressors and infrastructure disruptions are affecting coastal Arctic Alaskan communities and identifies the important assets (social, environmental, infrastructural, institutional) to help them adapt and become more resilient to climate-related changes. The POLARIS project has identified three convergent research pillars to help communities adapt: environmental hotspots of disruption to communities and infrastructure, food in complex adaptive systems, and migration and community relocation. The pillars are interconnected and build upon the convergence of social and natural systems and built environments. Research will integrate the pillars where system responses and uncertainties will be predicted under several socio-environmental scenarios. We will work directly with local stakeholders in three study communities representing different regions of the coastal Bering Sea and Arctic, with varying social, cultural, demographic, and ecological characteristics. We will combine data from surveys, interviews, focus groups, and economic experiments with environmental and secondary social data, to be analyzed with a combination of spatial analysis, agent-based modeling, and scenario planning within a complex systems framework. The co-produced knowledge will be generalized and transferred to other Arctic Indigenous communities. This integrated research project will enable communities to become more resilient with both stronger societies, civic culture, and improved infrastructure needed as the new Arctic continues to emerge.

Background

Arctic Alaskan temperatures are rising two to three times faster than in the mainland United States [1,2]. The impacts create complex convergent research problems with important societal implications, raising critical social, natural, and engineering science questions. This is particularly true because some of the hardest hit places are rural coastal, predominantly Indigenous, communities with vital, vibrant cultures that closely intersect with local land and seascapes. Many face urgent challenges from multiple climate-related changes [3–6].Together with permafrost thawing, sea level rise, and declining sea ice cover, extreme storms are rapidly eroding some Alaskan coasts and damaging community infrastructure and cultural heritage [4]. Furthermore, diminishing sea ice is disrupting marine food chains that many rural Alaskan communities rely upon [1,2,7–11]. Our project has the potential to identify some critical solutions.

One response to increased environmental variability and associated livelihood security loss is to migrate to a new community. Widespread impacts may induce coastal Alaska Native households to bypass other rural Arctic communities, leading to significant rural to urban migration as residents, especially younger ones, search for jobs [3,6,7,9]. In contrast, rising temperatures may make some parts of Alaska more attractive to in-migrants over this century. Community relocation for particularly vulnerable communities is another option, but such moves generally require enormous amounts of government funding and are unlikely to be practical in the near future [3,5,12]. Despite these issues, there is no evidence of large-scale Arctic Alaskan rural out-migration, even from the most threatened communities; making understanding the drivers and determinants of this outcome a critical research need [12]. Food insecurity and migration are two closely intertwined outcomes of these environmental stressors and ecological and infrastructure disruptions [13]. Threats to traditional livelihoods and food sources, including declining reliability of safe and healthy traditional foods, may lead to greater reliance on alternative, more expensive, food sources and activities. Other factors that influence responses to climate-induced insecurity include macroeconomic trends and conditions at state, national, and global levels; community governance, practices, and resource management; local and Indigenous knowledge critical in sustaining an Indigenous lifestyle; and household dynamics including age and gender-related divisions of labor. Subsistence activities along with institutional resources, such as the Alaska Permanent Fund Dividend, Alaska Native Corporation dividends, and other state and federally funded projects, are critical components of Alaska Native livelihoods and incomes. These communities face complex trade-offs in livelihood and diet choices as they seek ways to adapt to changing conditions with implications for their health and well-being [12,14].

Socio-ecological monitoring capacity is a key element of community adaptation [15,16]. However, the degree to which these communities have this capacity is unknown, problematizing our understanding of their ability to adapt to changes [12]. Learning the degree to which they have adaptive capacity is itself difficult. First, conducting social science research in Alaskan Native communities requires an "engaged community research approach" grounded in trust and deep cultural understandings of diverse communities. Second, existing Arctic social science research is more limited than Arctic natural and engineering science research. Third, understanding gaps in community adaptive capacity requires often difficult convergent, transdisciplinary research that our team is uniquely qualified to carry out.
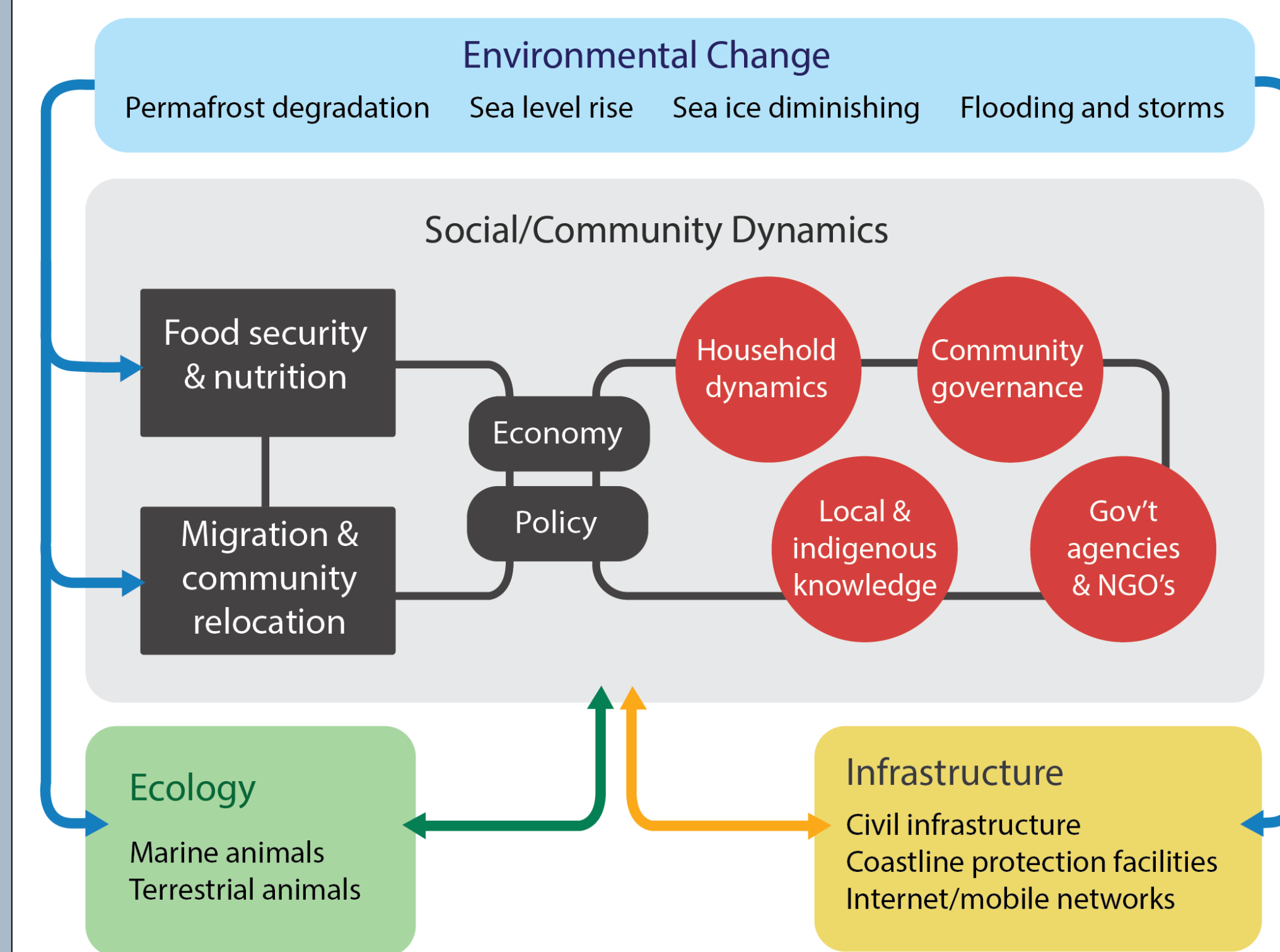
Conceptual Framework

Figure 1. Conceptual diagram showing the complex integrated dynamics of the social system and the natural and built environments in coastal Artic Indigenous communities.

Research Objectives

Pillar 1 Identifying and Predicting Hotspots of Disruption to Communities and Infrastructure due to Environmental Changes: How can we co-produce knowledge of historical shoreline change and identify areas vulnerable to environmental stressors by engaging with local stakeholders?

Pillar 2 Food Security and Nutrition: If and how do environmental changes impact food security and nutrition through changes in availability, accessibility, convenience, and preference?

Pillar 3 Migration and Community Relocation: What roles do sociocultural, policy, economic, and environmental factors, and their interactions, play in migration decision-making in the Arctic communities and at what scales?

Integration and Synthesis: We will also use a transdisciplinary approach to integrate our three research pillars. Drawing upon a recent call for an integration of different modeling techniques [17], our work is designed to set up a spatially-explicit, system-based, multi-level modeling approach to capture the relationships within and between social and natural systems and built environments. POLARIS aims to develop a compelling theoretical framework that links complex dynamics among environmental changes, ecological and infrastructure disruptions, food security and nutrition, and migration. We will answer an integrated research question: What are the important assets (social, environmental, infrastructural, institutional) that Alaska coastal communities can rely on to help them adapt and become more resilient to climate-related environmental change? We will predict a POLARIS framework condition and associated uncertainties under several SES scenarios determined from answers to the question above. The thresholds in systems dynamics will be explored for nonlinear relationships among variables in space and time. By systematically modeling endogenous and exogenous social, economic, ecological, infrastructural, and climatic factors at multiple scales, the POLARIS project will have broad implications for the study of dynamics of the integrated social system and natural and built environments in the Arctic.
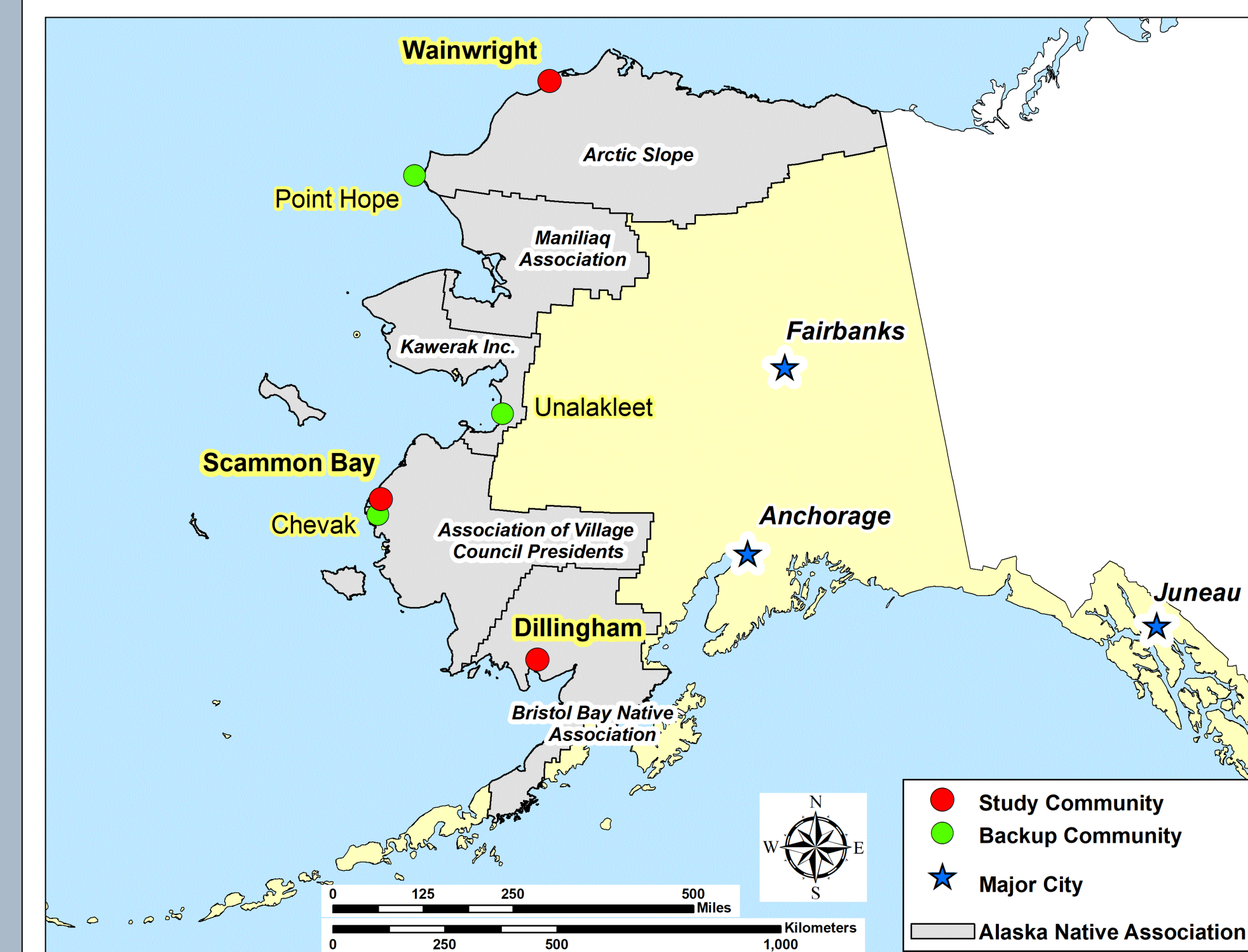
Study Communities

Figure 2. The study communities and backup communities in Alaska

Table 1. Selected characteristics of Alaska communities

Community	Population in 2017	Median Age	Average HH Size	Alaska Native (%)	Median HH Income	Estimated Harvest per Capita (lbs)
Study communities						
Wainwright	513	27.6	3.7	91.7	65,156	751.2
Dillingham	2,209	32.8	2.7	66.5	74,828	212.1
Scammon Bay	537	17.6	4.9	99.6	43,750	188.6
Backup communities						
Chevak	1,271	26.8	4.62	85.1	40,855	--
Unalakleet	865	33.1	3.1	83.4	47,222	601.1
Point Hope	629	25.6	3.74	64.4	60,417	451.1
Major cities						
Fairbanks	32,651	27.9	2.52	14	51,320	--
Anchorage	294,436	32.9	2.6	12.4	73,004	--
All of Alaska	738,795	33.8	2.65	19.5	66,521	--

Note: All figures use 2010 data unless noted otherwise. Canadian communities use 2016/2011 data. HH = Households.

Community Engagement and Outreach: Community engagement will be one of the most important components of POLARIS success. Three communities have been selected to represent variation in key ecological, cultural, and demographic, substance practice, and demographic characteristics. We will also be sensitive not to overburden local communities, rather, we will be their partners to conduct meaningful research and produce beneficial and immediate outcomes for them. The knowledge and products produced will be shared with other Arctic communities.

International Collaboration: By collaborating with two international consultants, we will compare the results to the findings from two coastal Indigenous communities in Canada to assess how generalizable and transferable results are to other Arctic Indigenous communities. The models and protocols to be co-produced are replicable. The POLARIS project aims to serve as a model for exploring the dynamics of SESs in the Arctic as well as provide a valuable protocol for effectively engaging local communities to measure/identify environmental stressors and ecological and infrastructural disruptions and to recommend policy strategies to cope with the foreseeable disruptions and disasters.

Fieldwork and Data Collection

To address our research objectives, we will first collect and integrate four types of existing data: publicly available data (Census Bureau, Bureau of Labor Statistics, Alaska state agencies, and remote sensing images; restricted microdata from PSU's Federal Statistical Research Data Center (FSRDC)); and existing surveys of the local study communities including harvest assessments by the Alaska Department of Fish and Game, Division of Subsistence (ADFG) that also includes demographics, economics, and assessments of change over time. Further, we will conduct our own surveys and data collection, which includes four waves (twice a year for Years 2 and 3) of linked household surveys of Bering Sea and Arctic coastal communities, and environmental surveys. We will use an innovative combination of individual and group interviews and surveys, both ethnographic and participatory, participatory mapping activities, and activity space to collect socioeconomic data. We will use field sampling, remote sensing (including unmanned aerial vehicles (UAVs)), modeling, to collect environmental data.

Notes