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Arctic Resilience: Fire, Food, Contaminant, and Education Nexus along the Yukon River Watershed

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Abstract

River watersheds are among the most complex terrestrial features in Alaska, performing valuable ecosystem functions and providing services for human society. Rivers are vital to both estuarine and aquatic biota and play important roles in biogeochemical cycles and physical processes. The functions of watersheds have been used as indicators for ecosystem health. Running through the boreal forest, the Yukon River watershed has a long history of human activity, but has not been given the holistic and interdisciplinary research attention of the other great American river systems. By using hypothesis based monitoring of key watershed functions, we can gain insights to regime shifting stresses such as increasing fire on the movement of toxins, impact on subsistence plants and animals, as well as domestic species. The Yukon watershed provides a broad scale topic for research. More research would establish or expand:

1. A baseline against which future resilience related change can be more accurately assessed;
2. Promote interdisciplinary research;
3. Expand graduate and undergraduate opportunities;
4. Advance rural education opportunities and sustainable regional economic analysis; and
5. Promote citizen science.

Keywords: Yukon River; Ecotoxicology; Arctic; Global Climate; Holistic; Rural Education; Subsistence

Introduction

Rivers are among the most important geographic features in Alaska as watersheds perform valuable functions for society. The majestic Yukon River is a key geographic, economic and cultural feature of Arctic and subarctic Northwest America [1]. The Yukon River Watershed is one of 12 major river systems which organize Alaska's three thousand rivers. In the past, the Yukon River boasted the largest stocks of migrating runs of Chinook (King), Coho (Silver), and Chum (dog) salmon in the world. The source of Alaska's largest river is in British Columbia, Canada; it bisects Canada's Yukon Territory and Alaska before emptying an estimated 1.9 million gallons of water per second into the Bering Sea, south of Norton Sound, at the Yukon-Kuskokwin Delta. The Yukon's drainage is approximately 321,500 square miles and it drains about one-third of Alaska, including major rivers such as the Tanana and Koyukuk. The "Great River" as it is called in the Athabascan language is roughly 1,980 miles long with many rural communities scattered along it's

shores. For the King salmon, the Yukon is one of the longest fish migrations in the world. As the longest river in Alaska and the Yukon Territory, it served as a principal means of transportation during the early part of the twentieth century and remains a major transportation corridor for interior Alaskans, Canadian and tourists.

There is a long standing relationship between the Athabaskan, Inupiaq, and Yupik people living along the Yukon who rely on the river's salmon. Hunter-gatherers along the river have been harvesting King salmon for over 8,000 years. The salmon fishery has been important to the ecological integrity and cultural traditions; even today, human activity along the river continues to focus around salmon. Communities along the river eat significant amounts of subsistence food per week of which 60 percent is fish [2].

The Yukon is the fifth largest river in North America and the third largest in the United States. While generally considered pristine, the Yukon has had a legacy of pollution from mining and military development. As the extraction and processing of metals, coal, oil and natural gas increases, water quality is at risk for degradation by contaminant release into the watershed. Several tribal organizations along the river work to sustain the Yukon River salmon fishing in partnership with state, provincial and international treaties and laws. The Yukon River Inter-Tribal Watershed Council is a cooperative network of First Nations in Canada and tribes in Alaska whose goal is to maintain the river as a source of drinking water and healthy salmon, and to monitor governmental agencies management of the river.

The river flows through parklands and refuges in both Alaska and Canada traveling diverse ecosystems such as boreal forest and tundra. There are no dams along the river and only one car ferry at Dawson City, Canada. There are now a total of four vehicle bridges: one crossing the Alaska Highway; one crossing the Klondike Highway; one crossing the Dalton Highway; and one crossing in Whitehorse.

Today, pollution enters the river by global transport from other regions, especially Asia with its recent energy and economic development. Industrially created persistence organic chemicals (POPs) and metal like lead and mercury are being reported both in Arctic water and related food sources, such as salmon. The Arctic is projected to warm more than twice the global average and the increasing number of forest fires will increase the release of elements such as carbon and mercury.

Yukon River communities tend to be on the north side of the Yukon River and residents typically live a subsistence lifestyle while maintaining traditional, cultural and spiritual values. People along the river use Fish wheels and set nets to harvest the salmon. In the 1990's, the use of drift nets increased on the lower Yukon, and coupled with climate change and stock management mistakes, returning King salmon harvest decreased on the Upper Yukon in both Alaska and Canada.

The Yukon River not only is important to local and regional ecosystem issues, but also has global economic and industrial implications. As commercial fishing groups increased their political pressure on management, salmon declines continued. Currently, the Yukon River watershed is caught between shifting climate regimes and increasing political and industrial attention, as regulators are tasked with managing a complex social economic and ecological system. Having lost key fisheries in the lower latitudes, the Yukon River, with its cultural and spiritual connection to the people and the land, should become a focus of understanding how to maintain a resilient system during rapid environmental change seen in the boreal forest. Commercial downriver interests, river subsistence users and multiple corporate and political stakeholders will benefit from results of a resilience focused research.

Scientific Merit of Monitoring

The Arctic system is undergoing significant transformation, warming at twice the rate of the rest of the world due to anthropogenic climate change. Large gaps exist in our knowledge of the Yukon Watershed [1,3]. Since the rate of high-latitude warming and fire incidence is unprecedented in recent recorded history, there is considerable uncertainty about how the rate and pattern of climate warming will influence the flow of nutrients and contaminants in the Yukon Watershed and impact ecosystem services. Subsistence plants along the lands bordering the river will be contaminated.

These socioeconomic and health promoting benefits of the Arctic plant ecosystem are currently under threat due to widespread, yet little understood, shifts in environmental parameters, including changes in permafrost, fire regime, and eroding coast lines. These rapidly changing ecologies together with other economic and social stressors may interface in ways that critically influence growing regimes and community resilience. We therefore hypothesize that berries as an indicator plant group, will respond (in terms of sustainability of yield and retention of potent health promoting capacities) to directional environmental change, such as climate warming. For example, berries will be strongly influenced by disturbance events like fire that trigger shifts in soil and water system profiles. We further hypothesize that these changes will be more evident in areas of rapid environmental shifts caused by forest fires and water changes as compared to undisturbed sectors. This nutrient-

laden river water provides a flux of chemicals and habitat for ecologically important biota.

Community resilience to environmental change is in part determined by the ability to accumulate knowledge, act collectively, and participate in the decisions that affect the flow of resources. We therefore encourage evaluation of the combined effects of rapid environmental shifts in several key sites along the Yukon River for: 1) Impacts on salmon and berries; 2) Wild and domestic animal species including dogs, and 3) Impacts on community health and lifestyle.

Broader Impacts

Bringing together faculty from diverse academic disciplines, graduate and undergraduate trainees, and representatives from Alaska Native communities in educational exchanges will be critical to synergies of their knowledge and skills toward maximizing resiliency and reducing the impact on the sustainability and productivity of the Yukon ecosystems. This will provide predictive empirical data for the development of models of adaptation strategies and support for sustainable rural economies under variable and changing climates. By integrating traditional knowledge with natural resource education and inviting community participation, collaborative opportunities will actually shape future management suggestions and outcomes. Teasing out the ongoing competitive and complex resource management between commercial fishing, tourism, mining and subsistence use will provide additional documentation of management approaches that will be relevant to other regions of the country.

People living in the Arctic face many challenges posed by economic circumstances; lifestyle; exposure to contaminants and climate change; dietary changes; as well as geographic isolation. Indigenous peoples, with their continuing ties to the land and traditional food are generally the most affected by these challenges.

Educational Benefits

Increasing Indigenous knowledge and stores in the western education system by river science camps would improve both knowledge and awareness [4]. In addition to promoting traditional undergraduate and graduate level education at Arctic institutions increased studies, will promote place-based scientific research and citizen science. By partnering with the rural campuses and native associations much of the knowledge learned will remain in the region. This concept will build the human and social capital in the areas of resource management and will introduce promising students to the world of interdisciplinary sciences by exploring topics not found in the traditional classroom settings. There is a need for rural communities to have a more effective voice and role in resource development decisions; and, local environmental and socioeconomic expertise is an important component for this to happen. This concern is voiced by local community residents, primarily involve rural and indigenous students in developing scientifically sound approaches to address environmental issues in rural subsistence communities, such as Alaska. It should also be noted that large developments tend to be funded by international corporations in which local input is limited.

Potential Specific Aims

One major objective could be to determine the physiological basis of adaptation to abiotic stresses in different ecosystems in areas of rapid environmental shifts caused by forest fires, for example. Such studies could include: 1) metal and phytochemical profiles of berries and other plants; 2) elucidating health protective properties against metabolic syndrome and cardiovascular disease risk factors in dogs and human cell culture; 3) salmon and dog lipid profiles; 4) monitor increases in exposure to contaminants in food systems, and 5) other undefined hypotheses [5].

A sample list of potential aims, non-prioritized, is as follows:
Aim 1: Assess dietary mercury and omega-3 fatty acid levels in spring and Fall Chums, Chinooks and Silver Salmon along the Yukon River.
Aim 2: Study the influence of fire generated toxic substances (POPs and metals) on Fish, red fox and dogs in the Yukon Watershed.
Aim 3: Develop a set of cultural and management techniques and recommendations that incorporate resource management strategies of indigenous people employed to insure an increase in resiliency and sustainability of berry barrens, Fish and wildlife and community values under changing environmental regimes
Aim 4: Maximize local education and increase skills with the goal of implementing a plan for future conversion of these aims to a resource for the global scientific community and ecosystem manages interested in developing sustainable production systems that promote wellness and prevent disease.
Aim 5: Develop an undergraduate curriculum and certificate in sustainability by involving rural students in researching increased fire and the transport of elements along the Yukon River. Findings will be presented by the students at Tribal health consortiums, at their village, a scientific conference and will lead to publications and Art in Science creations.
Aim 6: Create citizen science research networks throughout the Yukon River Watershed.
Aim 7: Initiate environmental microbiology analysis at selected sites.
Aim 8: Graduate and Post-Doctoral research involving

contaminant increase (specifically POPs and metals), due to environmental and anthropogenic changes along the Yukon River.

Conclusion

Even though this current situation is located in the Arctic, that of Alaska, the criteria and aims presented here can be applied to any and all indigenous populations throughout the world that are enduring changes in their subsistence foods caused by fires and/or climate change. Since watersheds have been used as indicators for an ecosystems health, studying the functions of these watersheds will help the local communities to maintain a healthy subsistence lifestyle. Therefore, by using the skills and knowledge of resource management strategies of indigenous people, hands-on education with undergraduate and graduate curriculum, citizen science research networks, including students who work closely with Tribal health consortiums in their local village, everyone can gain insights to regime shifting stresses of fire and toxins on subsistence plants and animals for the now, and future, during climate shift changes.

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