Adapting the ELOHA Framework for the Wolastoq | St. John River

Key Findings & Recommendations

The St. John River Society / La Société du Fleuve Saint-Jean
Organisme de bassin versant du fleuve Saint-Jean
Canadian Rivers Institute
ACAP Saint John
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Key Findings and Recommendations: Adapting the ELOHA Framework for the Wolastoq | St. John River

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Introduction

Environmental flows describe the quantity, quality, and timing of water flows and levels required to sustain freshwater ecosystems and the human livelihood, culture, spirituality and well-being that is dependent upon these ecosystems. Information about environmental flows can be used in river management to ensure the hydrologic regime supports a healthy, resilient, and biodiverse river ecosystem that meets the economic, social, and cultural needs of the community. Such an approach to river flow management is particularly important in impounded rivers.

Recent developments in the research and application of environmental flows have led to a framework that examines linkages between river flow and ecosystem structure and function at the watershed scale, and considers both societal values and environmental needs. One such approach is the Ecological Limits of Hydrologic Alteration (ELOHA) framework that combines data, modelling, and analysis with expert judgement and workshop discussion to develop a balanced, watershed-scale strategy that integrates an environmental and a social-cultural component.

The environmental component of ELOHA includes several steps aimed at moving from developing an understanding of flow dynamics and the effects of flow alteration on the hydrologic regime to the creation of relevant flow-ecology relationships that describe the ecosystem response to altered flows (Figure 1). The social-cultural component of ELOHA can be developed through consideration of Ecosystem Goods and Services (EGS), which describe the benefits that humans receive from nature, which are categorized as provisioning, regulating, supporting/habitat, and cultural. Through engagement with the community, stakeholders and rights holders, EGS for a river can be identified and prioritized to describe the importance of flows in a social-cultural context.

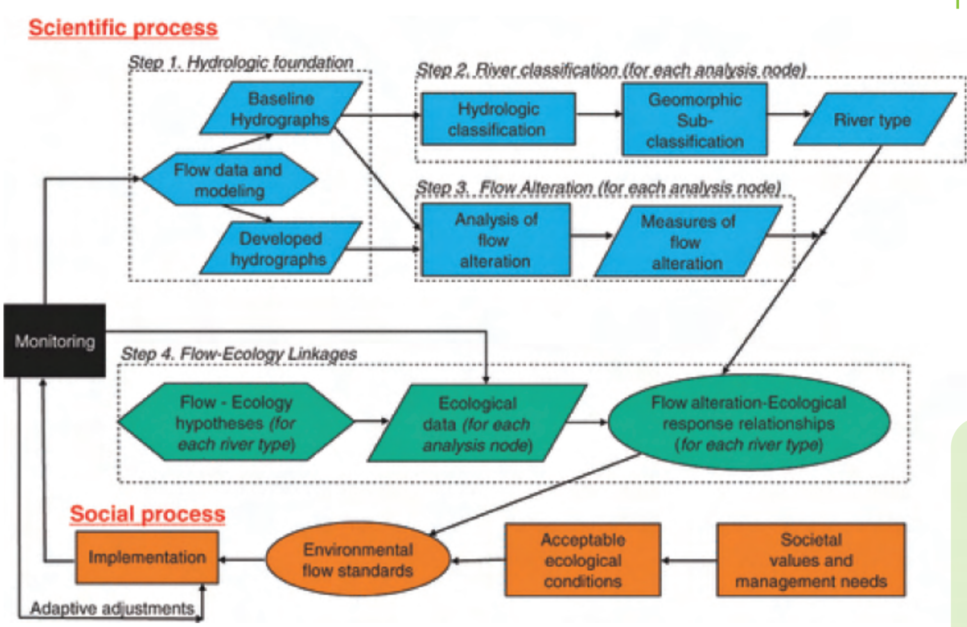

Figure 1. The ELOHA framework, with a focus on the environmental components of the scientific process, inclu ding the hydrologic foundation (blue), river classification (blue), flow alteration (blue), and flow-ecology relationships (green). Outputs of these steps are combined with outputs from the social-cultural process to develop environmental flow standards (orange). Figure reproduced from Poff et al. (2010).

In this report, we describe the development and adaptation of the ELOHA framework for the Wolastoq | St. John River. The Wolastoq | St. John River is one of the largest rivers in Atlantic Canada, flowing 673 km from its headwaters in Maine, USA to its outlet in the Bay of Fundy in Saint John, New Brunswick, Canada. The mainstem river and several tributaries are regulated for hydropower generation with tributary facilities and three mainstem hydropower facilities, including the largest at Mactaquac (668 MW).

The goals of the project were to adapt the ELOHA framework to meet the needs of the Wolastoq | St. John River watershed and to develop the environmental and social-cultural components of the framework. The environmental framework has been under development since 2014 as part of the Mactaquac Aquatic Ecosystem Study (MAES), and we report key findings from the work completed over this period. The social-cultural component of the ELOHA framework was developed as part of this project through public surveys and participatory mapping exercises.

Through this project, we were able to develop one of the first watershed-level ELOHA applications in Canada.The framework supports our five watershed priorities: (i) understanding of water quality and quantity; (ii) building towards reconciliation through water; (iii) understanding of climate change impacts and mitigation; (iv) quantifying biodiversity loss and invasive species; and (v) developing respectful and inclusive governance within the watershed. This adaptation of an ELOHA model framework for the Wolastoq | St. John River also supports the development of sustainable flow thresholds as part of a wider watershed management approach.

More details of this process can be found at
https://storymaps.arcgis.com/stories/6f04c13c501f4a71917f6966479176dc and
https://www.canadianriversinstitute.com/maes

Photo Credit: Graeme Stewart-Robertson

Key Findings

Environmental Component

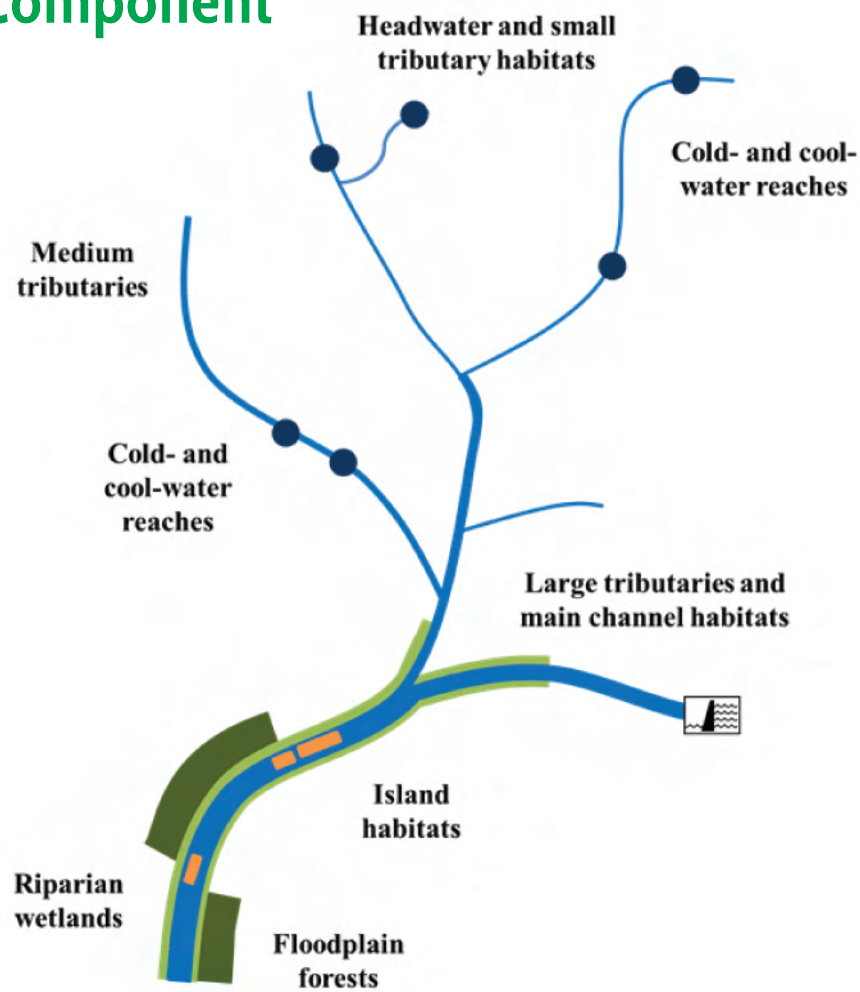

Figure 2: Schematic representing the six different habitat types identified within the Wolastoq | St. John river watershed

Six habitat types were identified in the river

- *Habitats in the Wolastoq | St. John River were classified based on hydrology, habitat data, and discussion with experts, stakeholders, and rights holders at a series of workshops.*

- *River habitat types include: mainstem and large tributaries (e.g. mainstem Wolastoq), medium tributaries (e.g. Aroostook, Nashwaak Rivers), small tributaries and headwater systems (e.g., Nashwaaksis Stream), island habitats (e.g., islands found throughout the lower mainstem of the Wolastoq | St. John River), and riparian wetlands and floodplain habitats (e.g., Grand Lake Meadows) (Figure 2).*

Flow variability and the magnitude of low flows are altered downstream of dams

- *Comparison of flows before and after dam construction indicated little change in flow metrics at an upstream reference site (Fort Kent), but changes in 26 flow metrics at a location downstream of the three mainstem impoundments (Fredericton).*

- *Operation schedule of the downstream hydropower generation stations has led to some flow alteration, for example increased magnitude of minimum water levels during the summer low flow period as required by DFO for fish attraction purposes, and increased non-peak water level variability likely reflecting hydropeaking activities (Figure 3).*

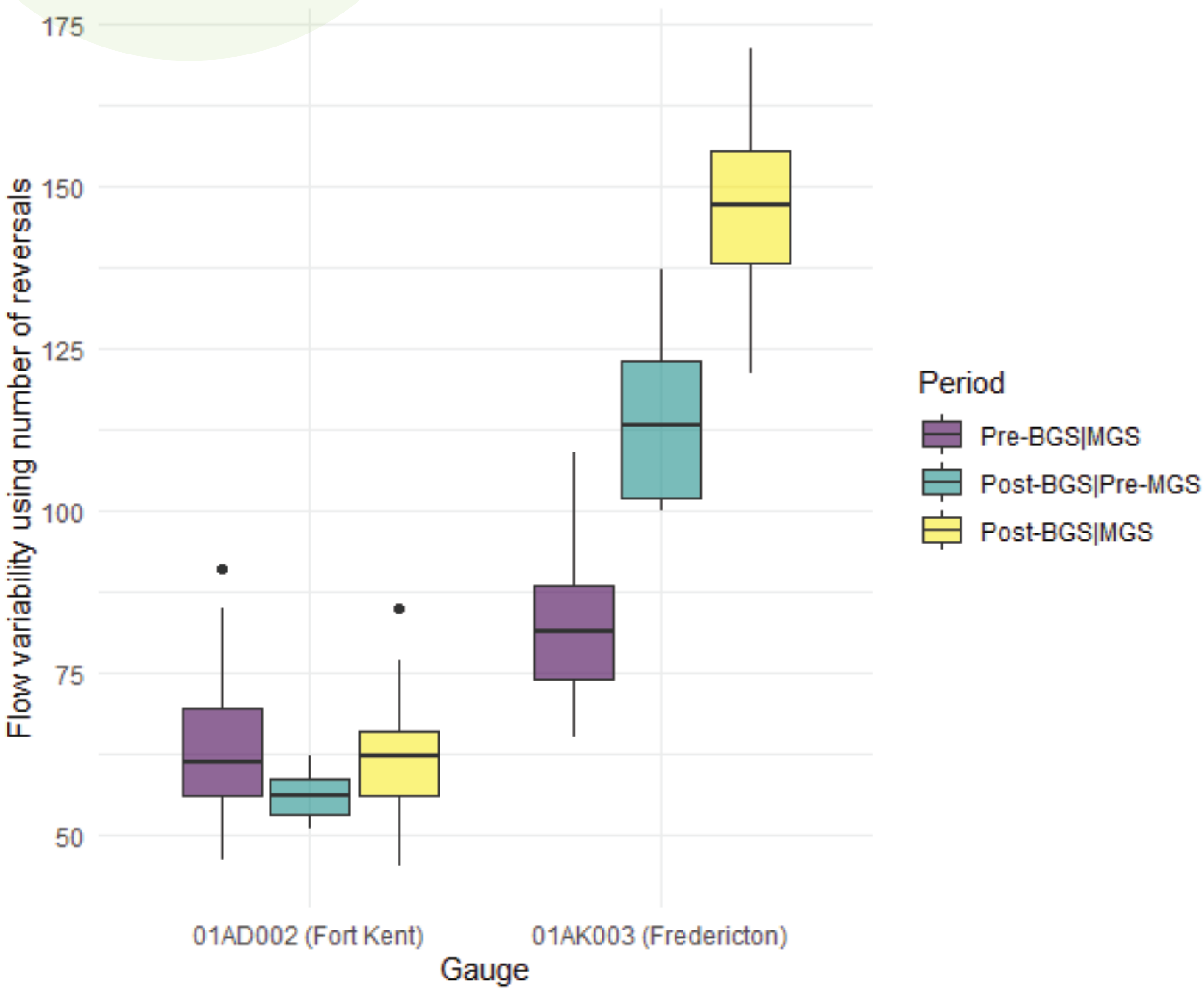

Figure 3. Comparison of flow variability as quantified by the number of reversals in either flow or water level between the Fort Kent Water Survey of Canada gauge (01AD002) upstream of all hydropower generation stations and the Fredericton Water Survey of Canada gauge (01AK003) downstream of all hydropower generation stations. BGS = Beechwood Generating Station; MGS = Mactaquac Generating Station

Water quality in the river basin appears stable, though nutrient levels are increasing

- *Long-term trends in water quality data from across the Wolastoq | St. John River basin indicate that a number of parameters were stable across the period of record.*
- *Nutrient levels (phosphorus and nitrogen) were above provisional chemically-derived thresholds at several locations in the basin, and there was evidence of significant increasing trends over time.*
- *Several metals (Al, Cu, Fe, Zn) showed significantly decreasing long-term trends in many sub-basins of the Wolastoq | St. John River.*

Expected ranges for nutrients provide river-specific guidelines for levels of concern

- *Historical water quality data were used to estimate the normal range of variability in nutrients to identify water quality triggers, or levels above which additional monitoring or management action should be considered.*
- *Site-specific water quality triggers were developed for total ammonia, total nitrogen, total phosphorus, and total aluminum for water quality monitoring sites throughout the basin, and these levels can be used in the management of water quality in the basin, and can be further refined as more data are collected.*

Photo Credit: Graeme Stewart-Robertson

Photo Credit: Graeme Stewart-Robertson

The framework is built on our understanding of the connections across the watershed, and work is ongoing to develop and test these connections to help us identified targeted flow needs for the watershed

- *Through MAES-led workshops, flow-ecology and temperature-ecology hypotheses were developed and refined to support the identification of targeted flow needs, with an initial list of 500 developed hypotheses condensed to 69 testable hypotheses through a process of discussion and expert judgement.*
- *The final hypothesis selection targeted local-to-watershed-scale responses structured by both major habitat type and core flow components (i.e., seasonal flows, low flows including extreme low flows, high flows including extreme high flows, and ice-affected conditions) for general ecosystem and target taxa group responses.*
- *Each hypothesis was part of one of 10 flow needs identified for the river, representing different ecosystem components that contribute to the final environmental flows framework (for example, habitat connectivity, thermal habitats, ice processes, spawning and emergence).*
- *Testing of flow-ecology hypotheses is ongoing through MAES.*

Key Findings

Social Cultural Component

Participatory mapping highlighted locations where activities such as recreation, aesthetics, hunting, and fishing take place in the watershed

- *The largest activity areas mapped by participating stakeholders included those representing land-based recreation (cultural EGS), hunting, and fishing (cultural/provisional EGS), with recreation areas in particular overlapping with parks and protected areas (Figure 4).*

- *The density of mapped activities along the river was greatest close to the largest populations, supporting the idea that the use of cultural EGS is affected by the distance from home or roads.*

- *Specific locations, such as those provided for water-based recreation and aesthetic and cultural activities, can be used to understand how changes to flows will potentially impact these activities and the EGS and values derived from them.*

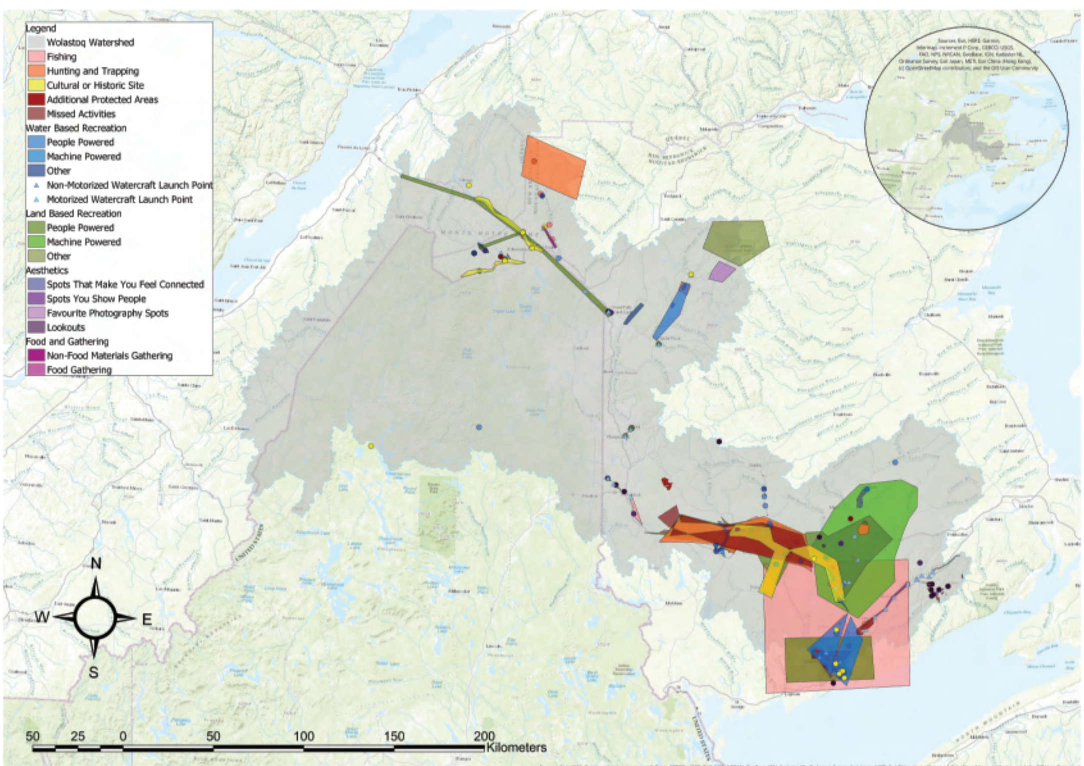

Figure 4. Results of the participatory mapping with all stakeholder activities mapped as points (specific locations) or polygons (areas), depending on information provided by the 45 stakeholder groups that contributed to the exercise. Points and polygons are coloured by category.

Relationships with the river were predominantly described in the context of recreation and aesthetics

- *In the public survey, the most commonly used descriptions of the river by participants included 'beauty', 'fishing', 'boating', 'scenery', 'swimming', 'wildlife', and 'recreation opportunities' (Figure 5), representing cultural EGS as well as supporting/habitat EGS that are necessary for ecosystem health and function.*

- *Survey respondents most often viewed the river from the community or watershed perspective, and indicated that from the community perspective, the river is significant to the community identity, a large concern due to flooding, and important for wildlife.*

- *Summer and fall were most commonly chosen as the best season on the river due to recreation and aesthetics, whereas barriers to enjoyment of the river in winter and spring included flooding and lack of access due to ice or unsafe conditions.*

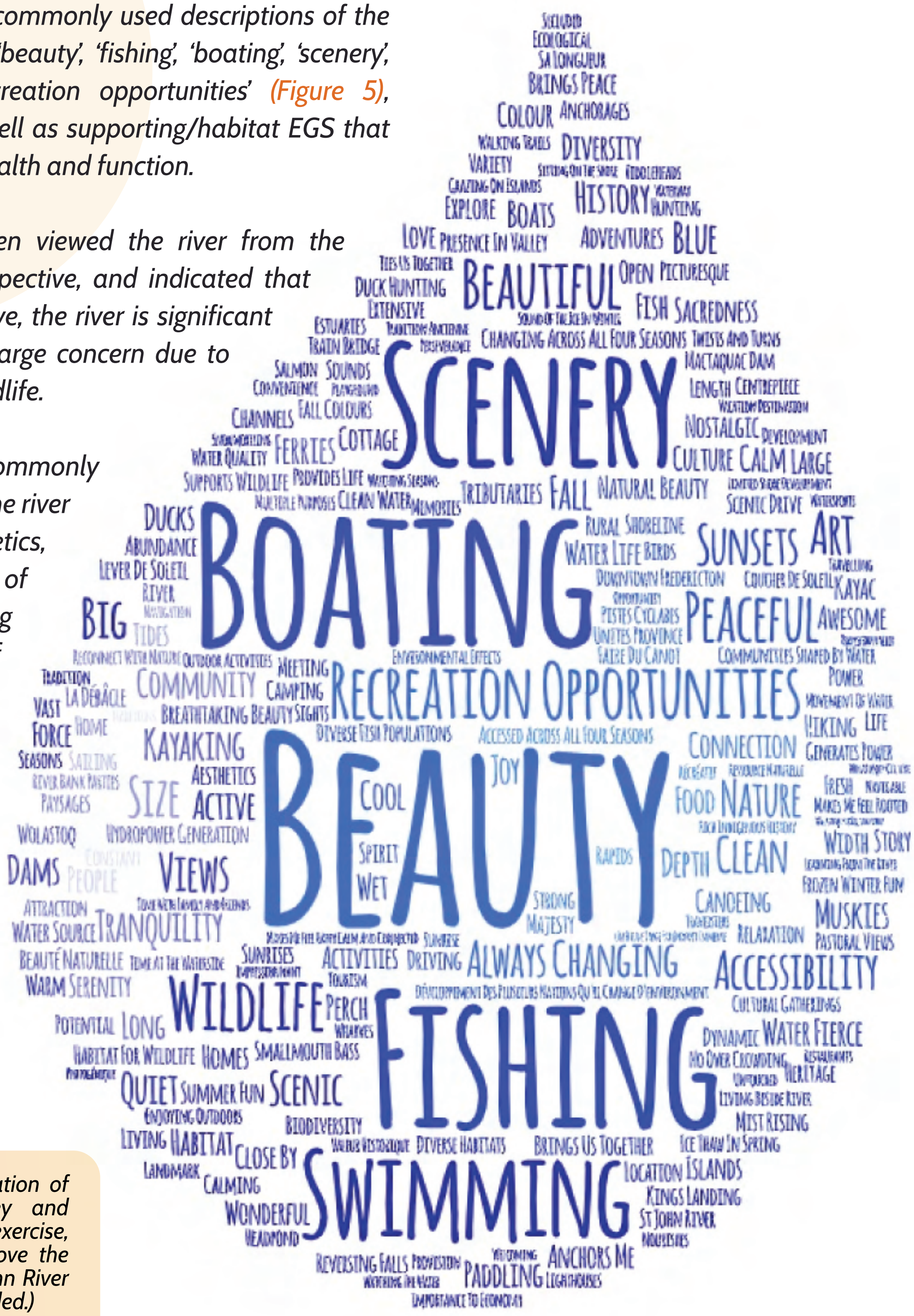

Figure 5: A Word Cloud presentation of results from the public survey and participatory mapping exercise, representing what respondents love the most about the Wolastoq | St. John River (English & French responses included.)

Photo Credit: N. Brunet

Public and stakeholder concerns about the river highlighted the importance of water quality and the interconnectedness of ecological services in supporting social benefits

- *Water quality, including cyanobacteria, pollution, and runoff, was the most common category of river concerns chosen by respondents followed by water quantity, whereas concerns related to access and recreation were among the least commonly chosen.*

- *Stakeholders selected invasive species as the most common concern, though water quality, water quantity, and biodiversity loss were also important.*

- *Common concerns were closely linked to regulating EGS, which includes water flow regulation, water purification and waste treatment, and natural hazard mitigation, as well as supporting and habitat EGS, whereas recreation and other cultural EGS were less frequently chosen.*

- *The results highlighted the important supporting role of regulating and supporting/habitat EGS, which are necessary for the use of cultural EGS, and reinforced the importance of scale of perspective whereby participants tended to connect with the river from the larger scales of watershed and community, rather than from the personal scale.*

Benefits obtained from the river reflected use-based benefits (recreation) and intangible benefits (mental health, well-being)

- *Public survey respondents indicated that the river was most important to them because of its beauty, the ability to connect with nature, recreation, and the social, cultural, and spiritual interactions and connections, all reflecting cultural EGS.*
- *From the community perspective, the river was viewed as being significant to community identity, iconic, and important for wildlife, though concerns about flooding were also highlighted.*
- *Personal benefits that survey respondents obtained from the river included mental health, peace of mind, recreation, and sense of place*

Connecting site substitutability to flow alteration identifies where changes have a significant impact on social-cultural benefits and values

- *Respondents indicated locations on the river where EGS were derived, and correlations between EGS, benefits, and site suitability was explored to identify whether a value can be provided at an alternative site.*
- *Site substitutability was high for benefits related to activities, as these can be replaced or reproduced in other areas of the river, but site substitutability was lower for benefits associated with place and heritage.*

Photo Credit: Graeme Stewart-Robertson

Next Steps

The work undertaken in this project has included the assessment of both ecological flow needs, through the environmental component of the ELOHA model, and social benefits, through the assessment of EGS with a particular focus on the often intangible cultural EGS. Our work is starting to explore the interconnectedness of the environmental and social-cultural components, and we are clearly seeing the importance of these connections. The next steps in the development and adaptation of the ELOHA framework to the Wolastoq | St. John River include testing of additional mechanistic pathways supporting the framework, expanding the social-cultural data developed through this project, and completing the integration of the framework to develop flow recommendations.

We explored a novel approach to understand the mechanistic connections between changes to the watershed and resulting ecological and social-cultural impacts through the development of a framework that visualises the highly complicated connections between the different components (Figure 6). The framework represents the wider watershed drivers (e.g., agriculture, hydroelectricity generation, and climate) and their subsequent pressures (e.g., flow regulation), the stressors that reflect changes in drivers and pressures (e.g., water chemistry, flow magnitude and variability), the ecosystem and service states that are affected by changes in stressors (e.g., biodiversity, EGS, Rightsholder and recreational use), the resultant ecological and social impacts (e.g., ecosystem health and resilience) and the management responses (e.g., mitigation and technological development) (Figure 6).

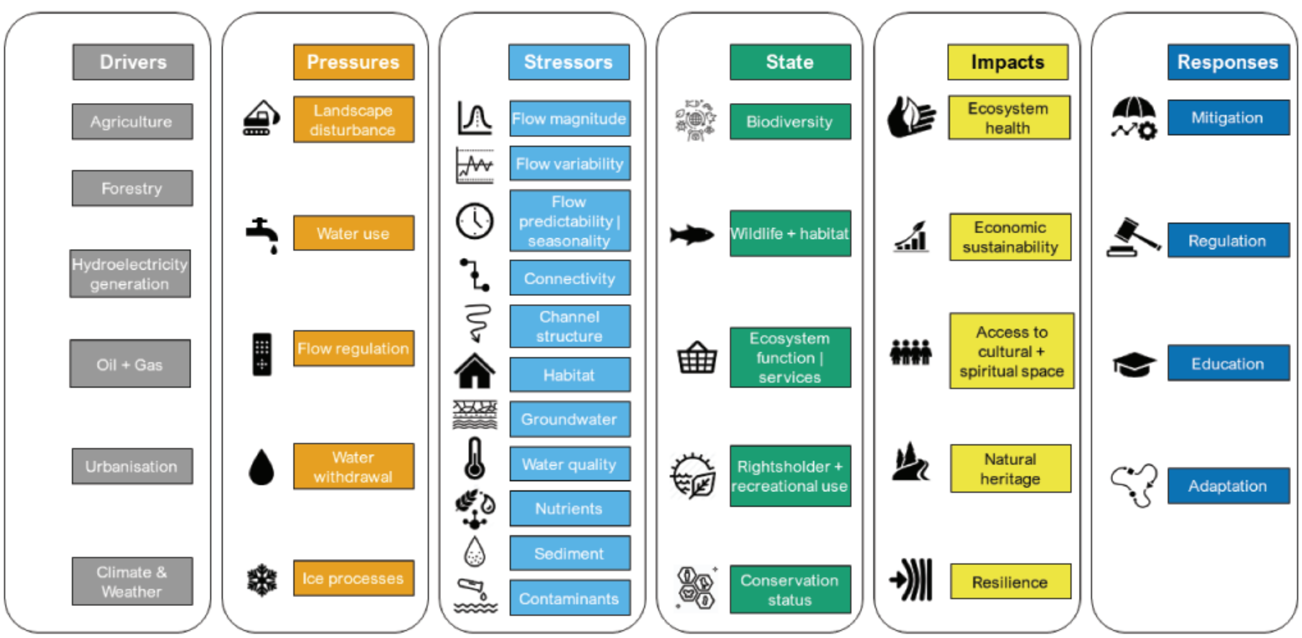

Figure 6: Adapted Driver-Pressure-Stressor-State-Impact-Response framework to support the Wolastoq | St. John River environmental flows process.

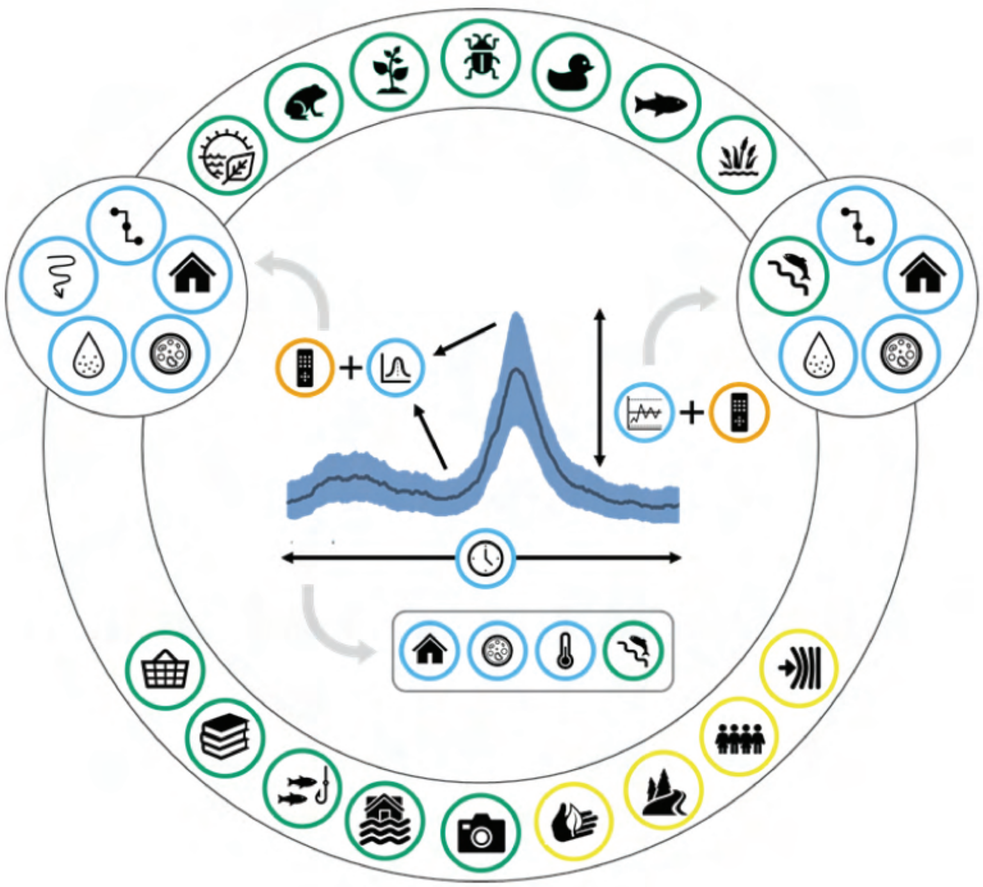

Figure 7: Understanding the components and connections to flow management. Note that the colours and most icons can be linked to Figure 6 (orange = pressures, blue = stressors, green = state or receptors; and yellow = impacts)

Following this framework, we developed a conceptual model for the Wolastoq | St. John River focusing on the mechanistic linkages between drivers of change within the watershed and resultant pressures, stressors, responses and impacts (Figure 7). Changes to flow magnitude can lead to changes in habitat, water quality, sediment movement and channel structure. Similarly, increased flow variability affects connectivity and leads to habitat loss. The conceptual model also highlights that the natural range of flow predictability and seasonality is important to provide cues for ecological processes such as fish migration. Each of these stressors in turn can affect the state of the ecosystem for both environmental and social-cultural components. For example, they can cause changes to ecosystem function and services, and reduced capacity for fishing and recreational space, leading to declines in ecosystem health and reduced access to cultural and spiritual space (Figure 7).

By identifying the key pathways through this mechanistic understanding (Figure 7), we can start to highlight areas of potential concern and work with flow regulators and watershed users to address these concerns to benefit the ecosystem, social-cultural needs, while meeting the needs for hydropower generation.

Recommendations for Future Work

The ELOHA framework was adapted for the Wolastoq | St. John River by following separate processes for the environmental and social-cultural components. However, this approach has led to difficulties in bringing these two critical pieces together for the final environmental flows framework. Moving forward, we strongly recommend developing the environmental and social-cultural pieces in tandem as they are closely linked, and we present an adapted ELOHA framework to meet these proposed changes (Figure 8).

We identified six core processes that draw upon workshop-, data- and knowledge-led processes (Figure 8), namely:

A

Gathering information about the historical, current and future status of the watershed, including identification of the different environmental and social-cultural pieces of the model and their connections within the watershed;

B

Identification of core habitat types that can be linked to existing data and local observation of the space;

C

Assessment of historical, recent and future flow alteration;

D

Assessment of individual ecosystem and social-cultural components and their pathways via the Driver-Pressure-State -Impact-Response approach;

E

Identification of water needs and objectives supported by data and knowledge, that can form the core of the final environmental flows framework;

F

Development of an adaptive watershed framework with paired monitoring plan.

Building on the previous work completed through MAES research, this project has supported the successful adaptation of an ELOHA framework for the Wolastoq | St. John River, including development of the environmental and social-cultural components. Making values, benefits and cultural EGS evident throughv this process has provided the necessary inputs to integrate the social and cultural piece with the environmental piece, and highlights the importance of the river and how it is managed to those who live within its watershed. We will continue to build upon this work by quantifying some of the hypotheses that form the core of the framework through the MAES project, collaborating with Wolastoqey communities through Wolastoqey Nation in New Brunswick, and continuing to identify and develop a long-term monitoring plan to support this work including the development of core metrics to support this assessment.

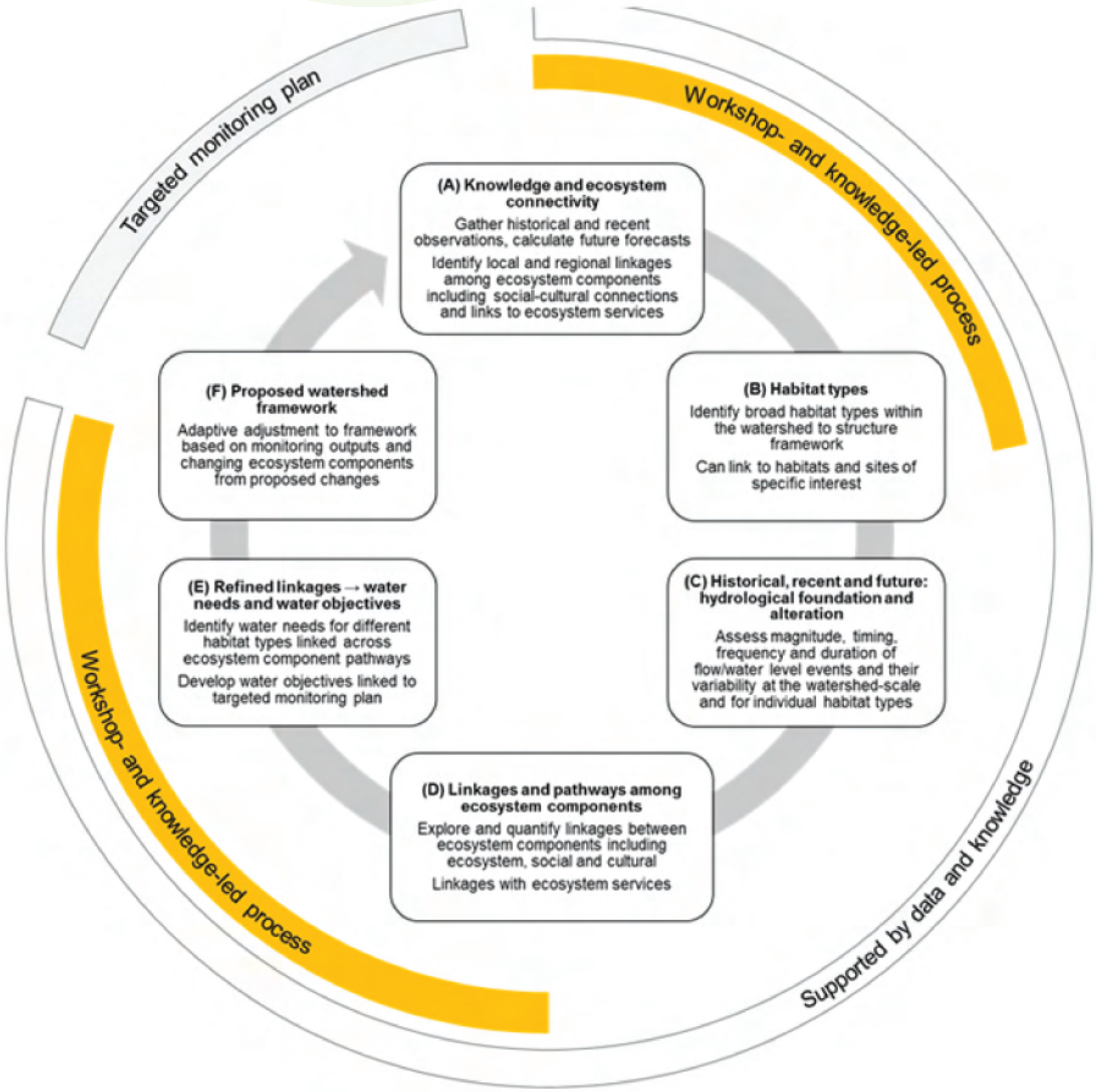

Figure 8: Adapted ELOHA framework for the Wolastoq | St. John River

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