# NRI: Collaborative Research: Adaptive multi-Robot Configurable Teams Investigating Changing Ecosystems

Brittany Duncan, Justin Bradley, and Carrick Detweiler
School of Computing
University of Nebraska, Lincoln

Ken Tape
Geophysical Institute
University of Alaska Fairbanks

## Motivation

Low-land Arctic ecosystems are being colonized by North American beaver populations as climate change redistributes their habitat; however, access to measure their impact on a changing landscape is difficult for humans and presents an opportunity to develop a capable heterogeneous multi-robot system comprised of flying, floating, and underwater robots to augment human observations.

## Key Problems

This proposal presents a vision aimed at integrating heterogeneous Uninhabited Aerial, Surface, and Underwater Systems (collectively, UxS) technologies, practices, and understanding to track the impacts of invasive wildlife in Arctic tundra for monitoring in unique, difficult to access environments.

The vision addresses key goals in co-robotic system development:

- assessing user goals and collaboratively achieving proficiency,
- coordination and decision-making by heterogeneous systems in unknown environments,
- and improvements in robot design and decision making for deploying, moving, and recovering UxS.

These goals will be developed in local environments before being refined in yearly tests in the harsh, cluttered environments of Alaska, while contributing to progress in fundamental co-robotic challenges.

## Scientific Impact

Access is limited due to:

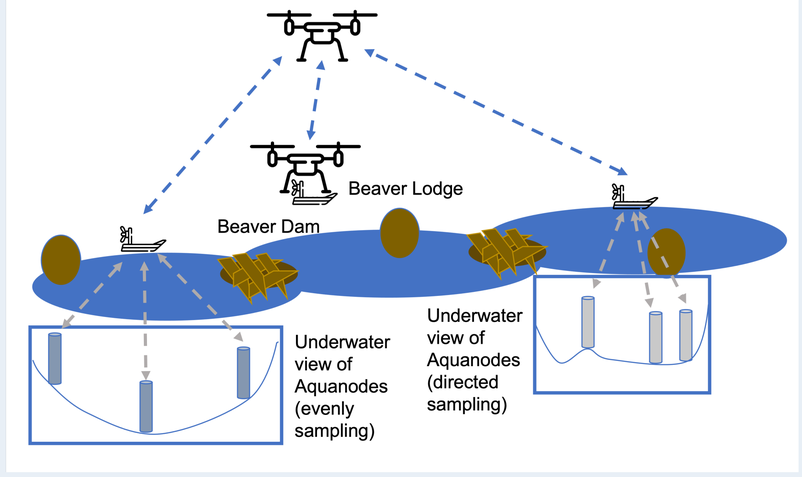
- remoteness,
- inability to collect underwater measurements,
- and complexity of mixed aquatic and terrestrial wetland

Currently, most data is collected within defined field campaigns and at accessible beaver ponds, limiting both the spatial and temporal coverage of measurements.

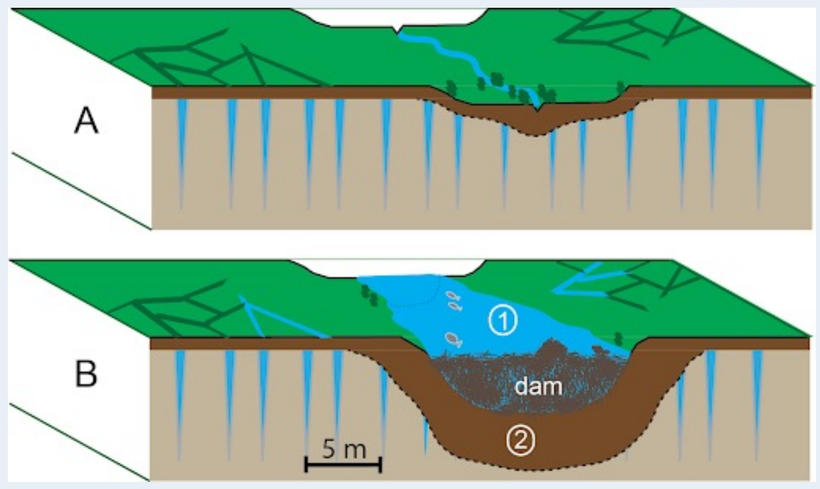
UASs have been used by these scientists for remote visual sensing. Delivering and retrieving robotic subsystems at precise locations is a recent development by the project team.

This system will aid in obtaining underwater, surface of the water, and aerial observations from coordinated sites to ensure coverage, enabling spatially distributed collection in areas where it is currently too costly or dangerous.

Expected terrain for deployment.




Concept design for UxS.




Projected underwater changes we will observe.

## Solution

The proposed activities will result in:

1. Understanding of user proficiency, mental models, and mutual adaptation for improved system performance,
2. Online replanning and retasking of sampling based on environmental and vehicle observations,
3. Vehicle innovations to improve mechanisms and algorithms for UxS deployment in new contexts, and
4. Improved data collection in tundra water environments to advance the science of permafrost thaw and ecosystem formation.

The proposed work will advance the NRI 3.0 integrative robotic agenda, through focusing on ubiquity of robotic systems impacting the ability to gather scientific data, increasing scalability to include multiple stakeholders, and extending the ability of robots to monitor novel environments, inspired in the context of UxS-based lowland Arctic monitoring, taking a multidisciplinary approach that requires efforts at the intersection of robotics, computer science, systems engineering, and tundra ecosystem science.

## Broader Impact

- A group of approximately 20 arctic scientists will be exposed to the technology, trained through field trials and given access to the unique dataset produced through this work, and 10 will be more extensively trained on the UxS.
- Data will reach a broader community through the planned participation in workshops and the curation of the collected data and experiences, which will be made available online.
- At least four graduate students will be directly involved in conducting multidisciplinary research, along with undergraduates at an REU site.

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