Research Protocol – Nunavut Research Permit Application - 2026

People: Florence Gagné (MSc, PI), Laurence Godbout (BSc.), Laurane Gélinas (BSc), Vincent Maire (Prof.)

Schedule:

- 13 July – 26 July (Vincent, Laurence – main experiment)
- 8 August – 10 August (Florence, Laurane – logger removal)

1. Project Overview

This project aims to quantify the photosynthetic response of Arctic shrub species to environmental gradients, with a particular focus on temperature and soil fertility contrasts within Sylvia Grinnell (Iqaluit Kuunga) Territorial Park, Nunavut. The rapid warming of Arctic regions is driving significant vegetation changes, notably the expansion of shrub species (shrubification), which can alter carbon cycling, surface energy balance, and ecosystem functioning. Despite these changes, the physiological mechanisms underlying shrub responses to environmental conditions remain insufficiently understood.

This study focuses on leaf-level processes (photosynthesis, stomatal conductance, and biochemical capacity) and their relationship with soil properties and microclimate. By combining field measurements and laboratory analyses, the project will contribute to improving our understanding of Arctic ecosystem responses to climate change. All activities are designed to minimize environmental disturbance and comply with Nunavut research regulations and best practices.

2. Study Design and Site Selection

Three study sites will be selected within Sylvia Grinnell Territorial Park to represent environmental variability across the landscape. At each site, two contrasting soil fertility conditions will be identified:

- Mineral soils associated with silty deposits, generally well-drained and relatively low in organic matter;
- Organic soils characterized by high water saturation and accumulation of organic matter.

These contrasts are expected to capture key gradients in nutrient availability and soil moisture that influence shrub physiological functioning. Site selection will be based on field observations, vegetation structure, and in situ measurements of soil moisture and temperature. A local guide will be consulted and involved in the identification of appropriate study sites, to ensure that site selection is informed by local knowledge and conducted in a respectful and context-appropriate manner. GPS coordinates, vegetation descriptions, and environmental conditions will be recorded for each site. GPS coordinates, vegetation descriptions, and environmental conditions will be recorded for each site.

3. Vegetation and Soil Sampling

Four shrub species will be targeted:

- *Salix arctica* (prostrated shrub)
- *Salix reticulata* (prostrated shrub)
- *Salix richardsonii* (erect shrub)
- *Betula glandulosa* (erect shrub)

For each species and fertility condition, two individuals will be selected. In total, we will study 48 individuals (3 sites * 2 fertilities * 4 species * 2 individuals). Before branch sampling, stomatal conductance and leaf temperature will be recorded with the porometer LI-600 (LI-COR Inc.) and plant height will be measured. Then, one branch per individual will be sampled. This sampling strategy is non-destructive, as only a small portion of biomass is removed, ensuring that plants remain alive and functional.

Soil sampling will be conducted to characterize edaphic conditions. Three soil cores per fertility condition will be collected (10 cm depth, 6 cm diameter). This represents a small and localized disturbance. All sampling locations will be restored immediately after collection by refilling holes with surrounding substrate, thereby maintaining surface integrity.

All samples will be labeled and associated with detailed metadata including site, species, and environmental conditions.

4. Microclimate Measurements

Microclimatic conditions will be monitored using compact temperature and relative humidity sensors (2 × 2 × 2 cm). Sensors will be installed approximately 20 cm above the ground surface, which corresponds to the height of the shrub canopy layer.

Sensors will be protected using a small wire mesh enclosure to prevent disturbance by wildlife. They will be deployed for approximately one month during the growing season. All sensors will be removed at the end of the measurement period by Florence and Laurane. No permanent installations will remain on site.

5. Photosynthesis Measurements

Photosynthetic measurements will be conducted using a portable gas exchange system (LI-6800, LI-COR Inc.). Collected branches will be stored under humid and cool conditions immediately after sampling and transported to a laboratory facility in Iqaluit (e.g., Arctic College), where they will be maintained under controlled conditions. Upon arrival, stems will be recut under water to restore hydraulic continuity and minimize embolism. Samples will then be allowed to reacclimate for approximately 24 hours prior to measurement to ensure stable physiological conditions.

Measurements will include net photosynthesis (Asat), stomatal conductance (gs), and transpiration under controlled environmental conditions, including saturating light and standardized CO_2 concentration. CO_2 response curves (A–Ci curves) will be performed to estimate key physiological parameters such as maximum carboxylation capacity (Vcmax) and electron transport capacity (Jmax). Measurements will be conducted across a range of controlled leaf temperatures (7, 10, 13, 16, 19, 22, 25, and 28°C) to characterize the temperature response of photosynthesis.

6. Laboratory Analyses

Following gas exchange measurements, leaf samples will be processed to determine morphological traits. Leaf area will be measured using digital imaging, and leaf fresh mass will be weighed. Then, samples will be dried to determine dry mass, allowing calculation of leaf mass per area (LMA).

Chemical analyses will be conducted on dried and ground leaf samples to determine carbon (C), nitrogen (N), and phosphorus (P) content. Soil samples will be analyzed for physicochemical properties including organic matter content, nutrient concentrations, pH, and moisture content.

7. Environmental Impact and Mitigation

The project is designed to have minimal environmental impact. Vegetation sampling is non-destructive and limited in scope. Soil sampling is small in scale and all sites are restored immediately after sampling. Temporary sensors will be removed after use, and no permanent infrastructure will be installed.

Access to the park will be conducted by ATV, while all activities within study sites will be performed on foot to minimize disturbance. No hazardous substances will be introduced into the environment.

8. Community Relevance and Inuit Qaujimajatuqangit

This project contributes to understanding environmental changes affecting Arctic ecosystems, which are directly relevant to northern communities. Shrub expansion influences snow accumulation, soil conditions, and carbon cycling, all of which can affect land use, wildlife habitat, and ecosystem services.

The project will be conducted with respect for Inuit Qaujimajatuqangit (IQ) principles, including respect for the land, environmental stewardship, and knowledge sharing. Observations and knowledge from the local context will be considered when interpreting environmental variability and selecting study sites.

9. Knowledge Sharing and Community Engagement

Results from this project will be shared with the local community and relevant organizations through accessible formats such as summary reports or presentations. Efforts will be made to communicate findings in a clear and meaningful way.

Opportunities for collaboration or interaction with local organizations, including the Nunavut Research Institute, will be explored. The project aims to contribute to knowledge exchange between scientific research and local perspectives.