EON-ROSE Community Science Liaison Program; Inspired by EarthScope Education and Outreach Programs

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Abstract

Inspired by the EarthScope outreach and education programs, the Community Science Liaison (CSL) initiative will transform Canadian STEM outreach practices by guiding long-term two-way relationships between K-12 schools and scientific programs such as EON-ROSE (Earth-System Observing Network – Réseau d'Observation du Système terrestrE). The CSL concept developed from the EarthScope-inspired pan-Canadian EON-ROSE research program will monitor entire Earth Systems across the Canadian land mass. Starting in northwestern Canada, due to the presence of 36 EarthScope Transportable Array (TA) stations, local citizens interested in science will be recruited as the CSL for their community/region. EON-ROSE (and other scientific program) scientists will design training workshops, provide mentorship, and enable CSLs to lead community consultations while designing and guiding hands-on, place- and curriculum-based K-12 Citizen Science (CS: Citizen = non-scientist such as CSL K-12 groups) projects to address community concerns, questions and/or curiosity. School groups will be welcome at the annual EON-ROSE conference, completing the research cycle experience for these students. EON-ROSE (Earth-System Observing Network - Réseau d'Observation du Système terrestrE) is the combined effort of Canadian universities, government agencies, industry, and international collaborators. The vision for EON-ROSE is to install a network of ~1400 telemetered observatories across the Canadian land mass to monitor solid Earth, environmental and atmospheric processes to provide real-time, openly available data. These observatories will include sensors to address community interests as determined by CSL consultations.

Challenges Facing the Science Community in Canada

A recent 3M survey (14,000 participants - July to September 2018) revealed that while science skeptics in Canada are rare, 44% of those surveyed perceive scientists as being elitist. Furthermore, 1/3 thought that scientists had corporate agendas, 1/3 believed that scientists were influenced by government agendas and only 30% believed science that aligned with their personal beliefs (Weber, 2019). John Smol (ecologist at Queen's University, Kingston, Ontario; in Weber, 2019) observed that "There's a real disconnect between what scientists do and what is the perception in the public.

We have a real responsibility to make (science) accessible. We're still doing a relatively poor job of translating the data—by and large paid for by taxpayers—and passing it to the public." The NSERC (National Science and Engineering Research Council of Canada—science funding agency in Canada) operating budget for 2019 was \$1.2 billion; yet most non-academic Canadians do not know what NSERC is or what the significant outcomes are from NSERC-supported research.

There are critical gaps in the Canadian STEM (science, technology, engineering, and mathematics) workforce, including a growing need for a new generation of trained geodesists across North America. Many northern communities in Canada lack access to scientists and many even lack qualified science teachers; the consequence is that these communities lack the role models capable of inspiring youth to become the scientists of the future. Research indicates that effective teaching is supported when disciplinary knowledge development is authentic in the discipline (i.e. acting like a scientist), and learning tasks are designed to inform disciplinary knowledge (i.e. engage with real scientists/experts; Friesen, 2009).



Figure 1. Paul Hoffman is one of Canada's most respected geologists who is also a gifted story-teller. His keynote presentation for the 2018 Mount Royal University Faculty of Science and Technology Research Day was very well received. The following day he outlined some of the concepts behind the Snowball Earth Theory and told the story about how he was inspired to become a scientist to ~700 middle school students in Calgary. Here he is signing autographs in grade 5 science journals

Photo Credit: Katherine Boggs

Community Science Liaison Program with Citizen Science Research – One Possible Solution

One of the main goals of the Community Science Liaison (CSL) program is to address these challenges facing science in Canada. Some of the relevant goals for the CSL program include: i) making scientists household names across Canada (e.g. Figure 1), ii) providing young Canadians direct access to scientists, iii) changing Canadian attitudes towards STEM by involving Canadian youth in hands-on, place- and curriculum-based K-12 Citizen Science research programs to address community interests and curiosity.

Support for this approach: Wood Street School Grade 11 Experiential Science Program

One of the most successful high school programs for promoting enrollment into post-secondary STEM disciplines is the Wood Street School Grade 11 Experiential Science Program in Whitehorse, Yukon Territories. All students from this program graduated from high school with 60% pursuing post-secondary STEM disciplines and 10% completing graduate school or professional programs such as Medicine

(O'Connor & Sharp, 2013, 2014).

In 1989, Robert (Bob) Sharp, then Coordinator of Curriculum Development, and Superintendent with Yukon Education was tasked by the Yukon Minister of Education to design a program to improve high school graduation rates. Sharp developed the integrated experiential approach organized around place-based Citizen Science research projects (Tables 1, 2).

Course	General Description	Relevant Topic
Biology 11	Survey Course	Population Ecology, classification
Geography 12	Earth systems	Atmospheric dynamics, geomorphology, resource utilization
Chemistry 11	Quantitative Chemistry	Environmental chemistry
Art 11	Visual arts	Scientific illustration; landscape
Field Methods 11	Applied Studies	Environmental Monitoring Protocols
Physical Education 11	Physical, mental fitness	Well-being; Outdoor Education

Table 1: Courses Integrated into the Experiential Science Grade 11 Program

Theme	Location	Studies
Aquatic Environments	Spook Creek; Whitehorse	Hydrocarbons, e-coli, impacts of human modification to watershed
Forestry	Haines Junction, Yukon	Seedling growth, regeneration after fire, spruce beetle analysis
Wildlife	Various	Caribou and road salt, hare census by scat, mice genetics
Marine & Intertidal	Various	Campbell River Salmon Populations, Anenome and Star Fish Census
Atmosphere	Various	Air quality, installation of weather stations, lightning strikes
Snow	Various	Snow profiles, snow as habitat, snow and climate
Energy	Various	Production (steam vs solar vs wind), conservation (intelligent parking lot controllers)
Recreation	Various	Trail use and development, ski hill packing, environmental impacts of recreational areas

Table 2: Examples of Citizen Science Projects in Experiential Science Grade 11 Program (modified from Sharp, 2017)

Students completed two full day labs each week in facilities at Yukon College. Thirty-to-forty days of field studies a semester exposed the students to a wide variety of scientists associated with a range of environmental and geographical topics (e.g. Table 2). Students collected field data and analyzed various aspects of environmental study issues before developing strategies to address community concerns (O'Connor & Sharp, 2016; Sharp, 2017). Enrollment was open to students who felt experiential approaches that addressed real problems spoke to their interests (representing a cross-section of the Yukon population, including Indigenous students). The success of this program for engaging students in STEM disciplines speaks to the powerful nature of place- and curriculum-based hands-on Citizen Science research projects, consistent with the design of the Community Science Liaison program.

Community Science Liaison (CSL) Program Description

The target audience for the proposed Community Science Liaison program is K-12 school groups for place- and curriculum-based Citizen Science projects led by a local CSL. These hands-on Citizen Science activities will guide students and their teachers through the entire scientific process, from project design to data collection, and analysis to presentation of results (remotely to their scientist mentors or in-person at conferences). Some Citizen Science projects will address community questions, curiosity and/or concerns determined through community consultations lead by the CSLs. Scientists such as those associated with the EON-ROSE research initiative will design training workshops for the CSLs, provide mentorship for the CSLs, teachers and school groups, and visit the schools' groups whenever possible (these will also include remote interactive discussions with scientists). A CSL speaker series will have the scientists visiting schools where the school groups will present their project results to the scientists first, before the scientists. School groups will also be welcome to present their results at the annual EON-ROSE annual meetings (starting with late September, 2021 in Banff (delayed due to COVID 19) in Whitehorse). With permission, K-12 Citizen Science research projects will be featured on the CCArray website that is under development (ccarray.org).

Many of the northwestern communities in Canada have multiple unique Indigenous groups, which require careful and appropriate approaches to guide authentic, long-term relationships. Advice from the Mount Royal University (MRU) Iniskim Centre, the Aurora Research Institute, and connections with Yukon Education and Calgary Board of Education, in addition to the local school boards, will guide development of all aspects of the Community Science Liaison program. One component of the MRU Iniskim Centre's mission is to raise awareness of Indigenous peoples and their cultures. O'Connor and Sharp (Wood Street School program) have significant experience with the Yukon high

school curriculum. Clark is a past science curriculum specialist from the Calgary Board of Education, while O'Connor guides the experiential component of the Mount Royal University Bachelor of Education program; these are germane observations because the Alberta curriculum guides the Northwest Territories curriculum. The CSL network will also translate materials into local languages in order to make the website as accessible as possible for these communities.



Figure 2. City of Calgary Mayor Nenshi with "Incredibee" team at 2013 Mayor's Environmental Expo.

Photo Credit: Jesse Hamilton



Figure 3. Distribution of ~1400 EON-ROSE Earth-Systems Observatories across the Canadian land mass at a spacing of ~85km.

Courtesy of Thomas James

Case Study: Geological Bumble Bee Program

The Geological Bumble Bee (GBB) program (2012 to present; Scherger et al., 2014) involved ~800 Calgary grade 2-9 students building and installing ~800 Bumble Bee Boxes while concurrently collecting rocks to characterize glacial material deposited ~15,000 years ago. These students return to the field in the fall to collect their boxes and analyze the Bumble bee colonies that occupied their boxes. Mount Royal University Bachelor of Science (Scherger) and Education (Kurila) students have volunteered and assisted with various components of this program. Plans for the CSL program have the GBB expanding across Canada so that K-12 groups can monitor these important pollinators that are under threat from diseases and climate change (Williams et al, 2014).

In 2013, the "Incredibee" grade 2 group won the "Making a Difference Award" at the City of Calgary Mayor's Environmental Expo (Figure 2).

Feedback from this group included, "Yesterday, we built bee boxes! I think that was the best day of my life so far!" "I used to think that bees were mean, nasty...Now I know that bees are helpful to the world." These quotes speak to the power of these hands-on, place- and curriculum-based Citizen Science research projects. Parent volunteers reported a high degree of satisfaction with the GBB hands-on field study, versus what they have traditionally experienced on field trips around the city where programs were delivered, rather than generated alongside students. Educators

(teachers and curriculum specialists) emphasized the strong impact of these authentic, field-based activities versus the traditional didactic pedagogy often experienced in a science program.

EON-ROSE and Canadian Cordillera Array Research Programs

The CSL concept arose from multiple discussions within the EON-ROSE (Earth-System Observing Network/Réseau d'Observation du Système terrestrE; ccarray.org, Boggs et al., 2018a/b/c, 2019a/b, Eaton et al., 2019, Witze, 2019) collaboration.

The 300+ EON-ROSE scientists from across Canada, the USA and Europe represent expertise across all aspects of Earth System Science to support the CSL program. The EON-ROSE network of ~1400 telemetered observatories (Figure 3) will include sensors to address community interests as determined by CSL consultations. The Canadian Cordillera Array is the pilot phase for EON-ROSE; chosen in part because of the 36 USArray stations in northwestern Canada (Figure 4).

The first EON-ROSE observatories were installed in the Yukon Territory and northeastern British Columbia during the summer of 2018, followed by installation of multiple sensors in the "nested" array Mt Meager program 150km north of Vancouver, British Columbia, that started deployment during the summer of 2019 (locations in Figure 4). While EON-ROSE scientists will provide significant mentoring for the CSLs and K-12 school groups, the CSL team will include scientists from other groups working across Canada.

The Future for the Community Science Liaison Program: Community Relations

The most critical component of the CSL program are strong community relationships, which will expand on existing connections developed by the EON-ROSE collaboration. Careful consultation with the MRU Iniskim Centre and the Aurora Research Institute Coordinator will guide appropriate approaches to these communities. Community relationships started forming during Boggs' family 2018 epic summer adventure – an 8880km roundtrip from Calgary to Tuktoyaktuk. The first CSL team trip to the Yukon and Northwest Territory communities occurred in November 2019, during which the first two CSLs were recruited (with further recruitment planned at a rate of 1-3 per year afterwards).

Community Science Liaison Program Evaluation

Plans are in progress for a mixed methods evaluation of the CSL program including before, during and after



Figure 4. Distribution of ~200 stations (pale blue dots) for the Canadian Cordillera Array at a spacing of ~85km (courtesy of Bob Busby and Susan Azeveda at IRIS). The darker (red) symbols here are the current EarthScope stations in Alaska and nw Canada. There will be what EON-ROSE calls a "nested array" (or densified array) deployed at Mt Meager (box 100km north of Vancouver) to image what may be magma filling the underlying magma chamber (potentially a significant natural hazard concern). The CSL program plans to work with the Pemberton and Mount Currie communities that live in the shadow of Mt Meager and are constructed upon lahar deposits. In this case local communities will provide guidance regarding suitable preparedness for natural disasters (volcanic eruption or landslides).

questionnaires with closed- and open-ended questions for the scientists, CSLs, K-12 students, their families and teachers. CSLs, teachers and scientists will be guided to journal their experiences, observations and suggestions for improving all aspects of the CSL program. Results from these evaluations will guide improvement of all aspects of the CSL program.

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