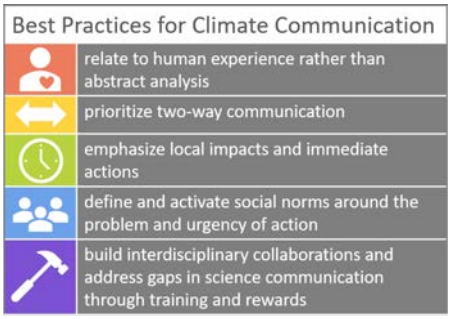
Best practices in Great Lakes climate communication

Communicating environmental problems with slow impacts has long been a challenge because the time delay of consequences can dilute the urgency to act. We reviewed the climate change literature for best practices that could also be used in communicating other environmental threats, such as nutrient pollution, that have a disconnect in time between release into the environment and impact. Our study, recently published in *Frontiers for Environmental Science*, identified five recommended practices. As applied to communication about climate change impacts on the Great Lakes, these recommendations are as follows:

1) Relate scientific findings to human experiences rather than just providing more abstract analyses that may be difficult for people to internalize. For example, the Great Lakes are a cherished source of sustenance, spiritual value, and recreation to many residents. Highlight how these uses and values could be impacted by climate change.



2) Engage in two-way communication early in your work and throughout projects. Potential stakeholders include anyone who can affect or who would be affected by impacts from climate change. They include all levels of government, including Tribes and First Nations, nongovernmental organizations, local community members, business, and other interested parties.

3) Because the global causes and implications of climate change can overwhelm many people, emphasize localized actions for your audience and highlight the urgency of those actions. Communicate the specific potential mitigation and adaptation efforts that individuals or communities can make.

4) Define and activate social norms (community attitudes and behaviors) to mobilize around pride in the Great Lakes' environment and its role in people's communities. For example, celebrate climate adaptation projects like the development of effective task forces or restoration programs to emphasize the role and value of local action in climate resilience.

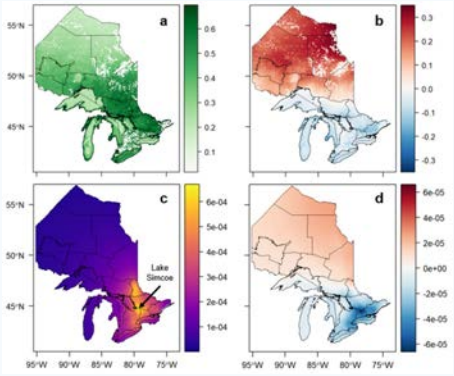
5) Build collaborations across scientific disciplines and prioritize scientific communication expertise. Effective science communication requires specific skills and takes time. Many scientists received no formal communication training yet are expected (and want!) to share their work with decision makers and the public. Budget for this in your staffing and funding of Great Lakes climate research.

By Kaytee Canfield and Kate Mulvaney, Atlantic Coastal Environmental Sciences Division, U.S. Environmental Protection Agency

Vulnerability to aquatic invasive species under human population and climate change

Aquatic invasive species (AIS) have led to fundamental changes in the structure, function, and composition of Ontario's aquatic ecosystems. Preventing the arrival of future AIS and controlling the spread of existing AIS are management priorities to protect Ontario's ecological resources. However, how climate change will affect the vulnerability of Ontario to species invasions remains uncertain. Moreover, as the effects of climate change are increasingly realized over the next several decades, other factors, such as changes in human population density, will also influence AIS arrival and spread.

We modeled the vulnerability—potential for arrival, survival, and spread of invasive aquatic invertebrates, plants, and fishes—of Ontario's aquatic ecosystems under baseline (2018) and future (2041–2070) conditions. The assessment was based on three components: describing the spatial distribution and movement of people associated with human-mediated pathways of propagule delivery; estimating the relative suitability of recipient ecosystems for AIS survival, including changes in climatic conditions over the projection interval; and estimating natural dispersal as a function of habitat suitability.



Habitat suitability for known and potential invasive baitfish (a) is expected to decrease in the south and increase in the north in the future (2041-2070, b). Under a scenario of initial release by boat-based fishers near Lake Simcoe (c), future vulnerability is expected to increase in the north and decrease in southern Ontario due to the combined effects of not only changing habitat suitability but also shifts in angler distribution and activity patterns.

We found that the locations of greatest pathway activity (i.e., aquarium and water-garden ownership, boat-based fishing, and all recreational boating) were spatially concentrated toward the most populous areas of Ontario. In areas currently supporting the most activity across the projection interval, propagule pressure from these pathways was likely to increase. With projected climate change, habitat suitability was also likely to increase, though not uniformly, and the location and magnitude of increase was less predictable across Ontario. Taken together, the baseline (2018) and future vulnerability of Ontario's landscapes to AIS showed strong spatial patterning and differed by pathway, indicating that prevention management necessitates a pathway- and species-specific focus.

Copies of the full report are available (tim.johnson@ontario.ca). Authors of the report include Jeff Buckley, Len Hunt, Jenny Rodgers, and Tim Johnson of the Ontario Ministry of Northern Development, Mines, Natural Resources, and Forestry; and Andrew Drake of the Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada.