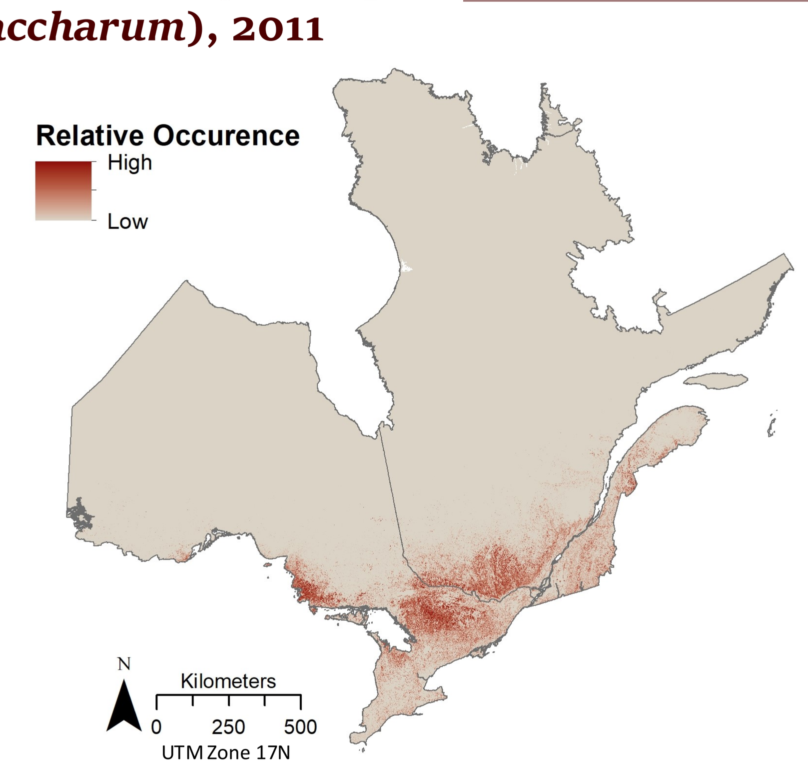
# Tapped Out : Future Sugar Maple Migration Patterns under Climate Change in Ontario and Quebec, Canada

## Background

Sugar maples are sensitive to their environment and their long lifespans and slow reproductive cycles restrict their capacity to quickly adapt to change. Climate change may impact the range of suitable sugar maple habitat in Ontario and Quebec, inducing migration rather than adaptation. Modeling the potential impacts of climate change on sugar maple range suitability could help to inform adaptation strategies for the maple syrup industry, which plays an important economic role in Ontario and Quebec, Canada.

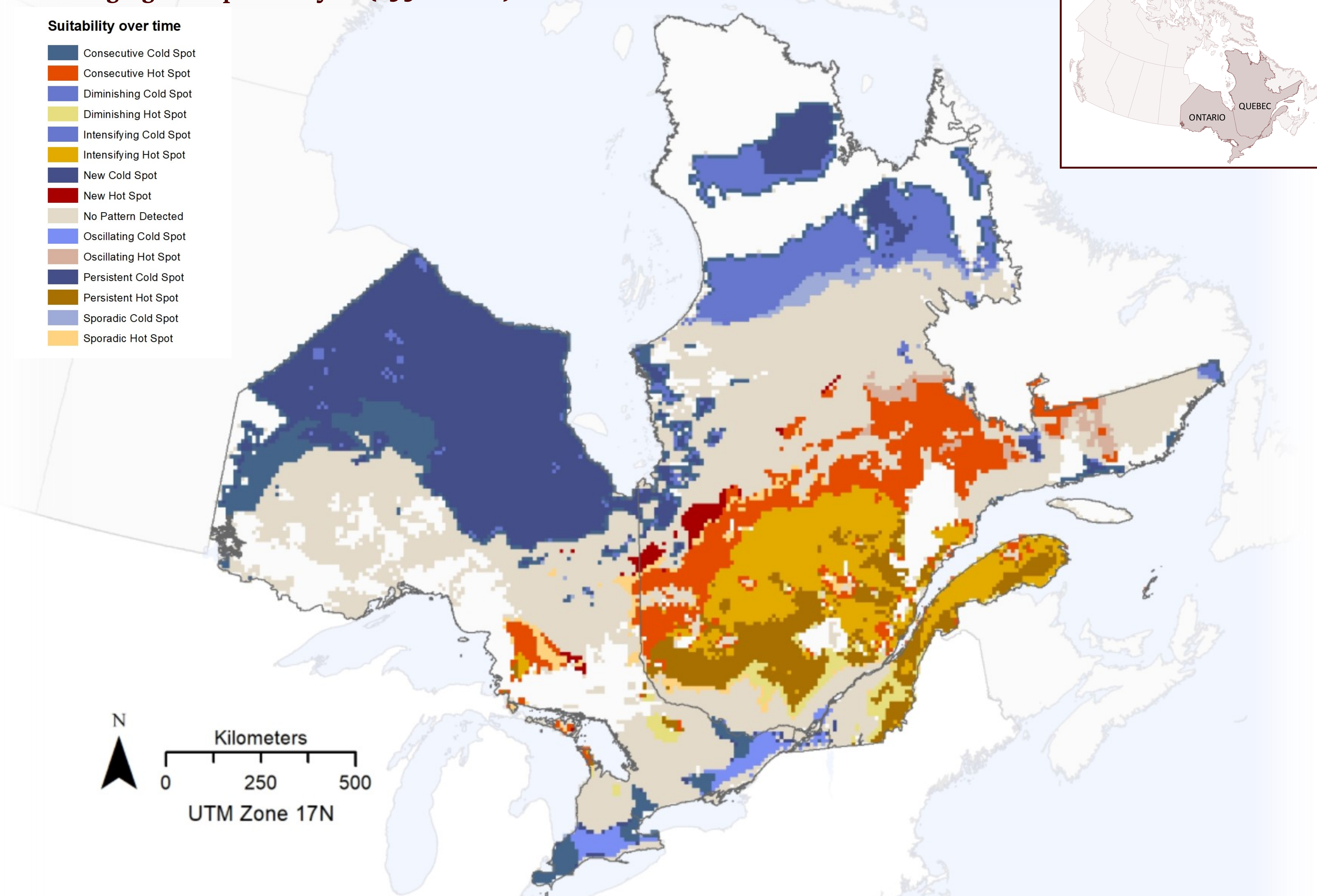
### Distribution of Sugar Maple (*Acer Saccharum*), 2011




### Research Question

How does the distribution of suitable sugar maple range in Ontario and Quebec change over time under the IPCC fifth assessment report (AR5) representative concentration pathway 4.5 (RCP4.5)?

### Emerging Hot Spot Analysis (1996—2100)




**Cartographer: Jessica Wallingford**

Class: Advanced GIS 102, Spring 2019

Sources: Stats Canada, Province Boundaries, Hydrography, 2016; Agriculture and Agri-Food Canada, Soil Landscapes of Canada, version 2.2, 1996; Government of Canada, Statistically Downscaled Climate Scenarios, n.d.; Canada's National Forest Information System, 2011; Brown et al. (2015) Projecting a spatial shift in Ontario's sugar maple habitat in response to climate change: a GIS approach. The Canadian Geographer 59(3):369-381.

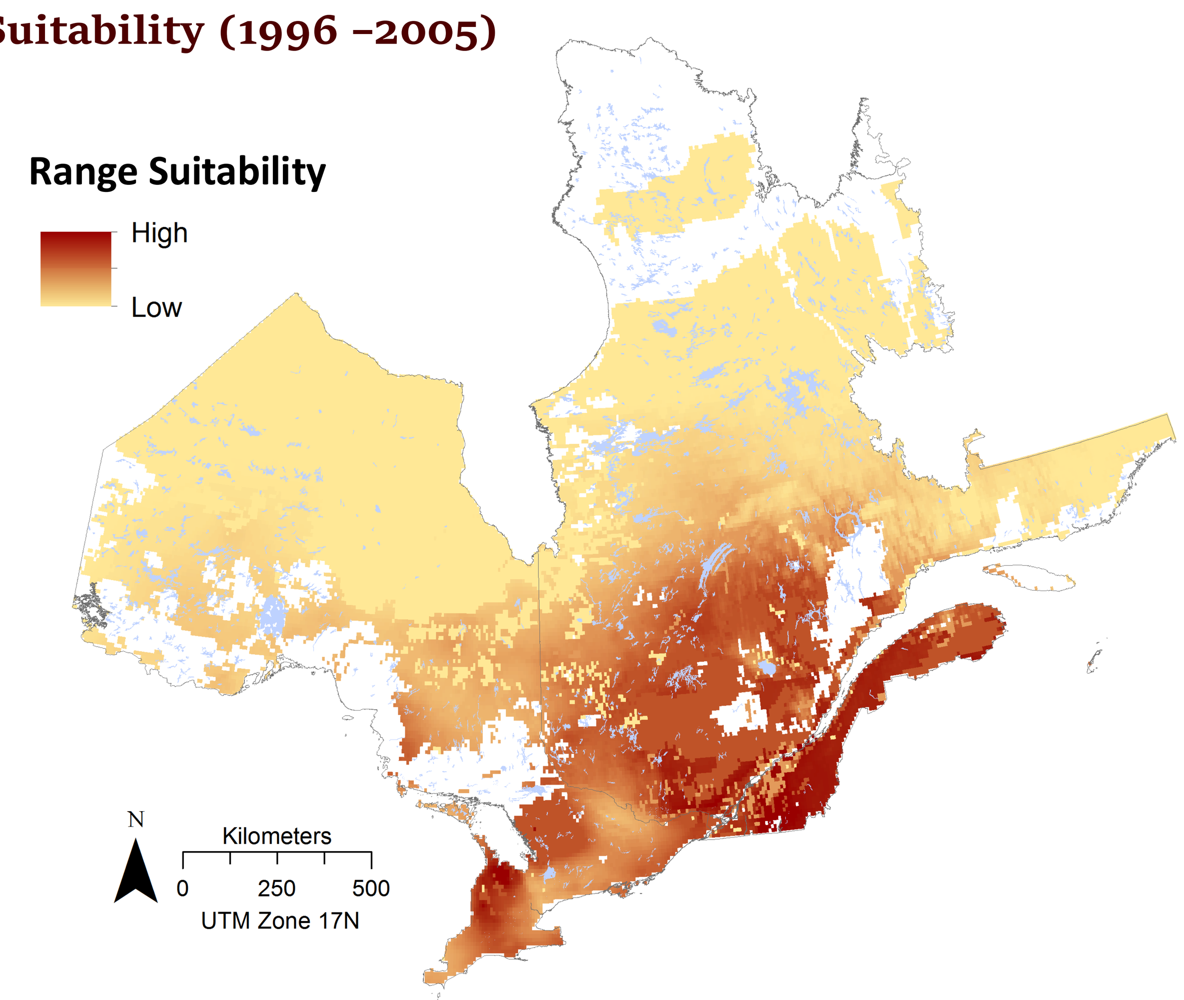
### Sugar Maple Range Hot Spots

| Classification | Total Land Area (km²) |
|---|---|
| New Hot Spot | 14,200 |
| Persistent Hot Spot | 116,700 |
| Diminishing Hot Spot | 28,800 |

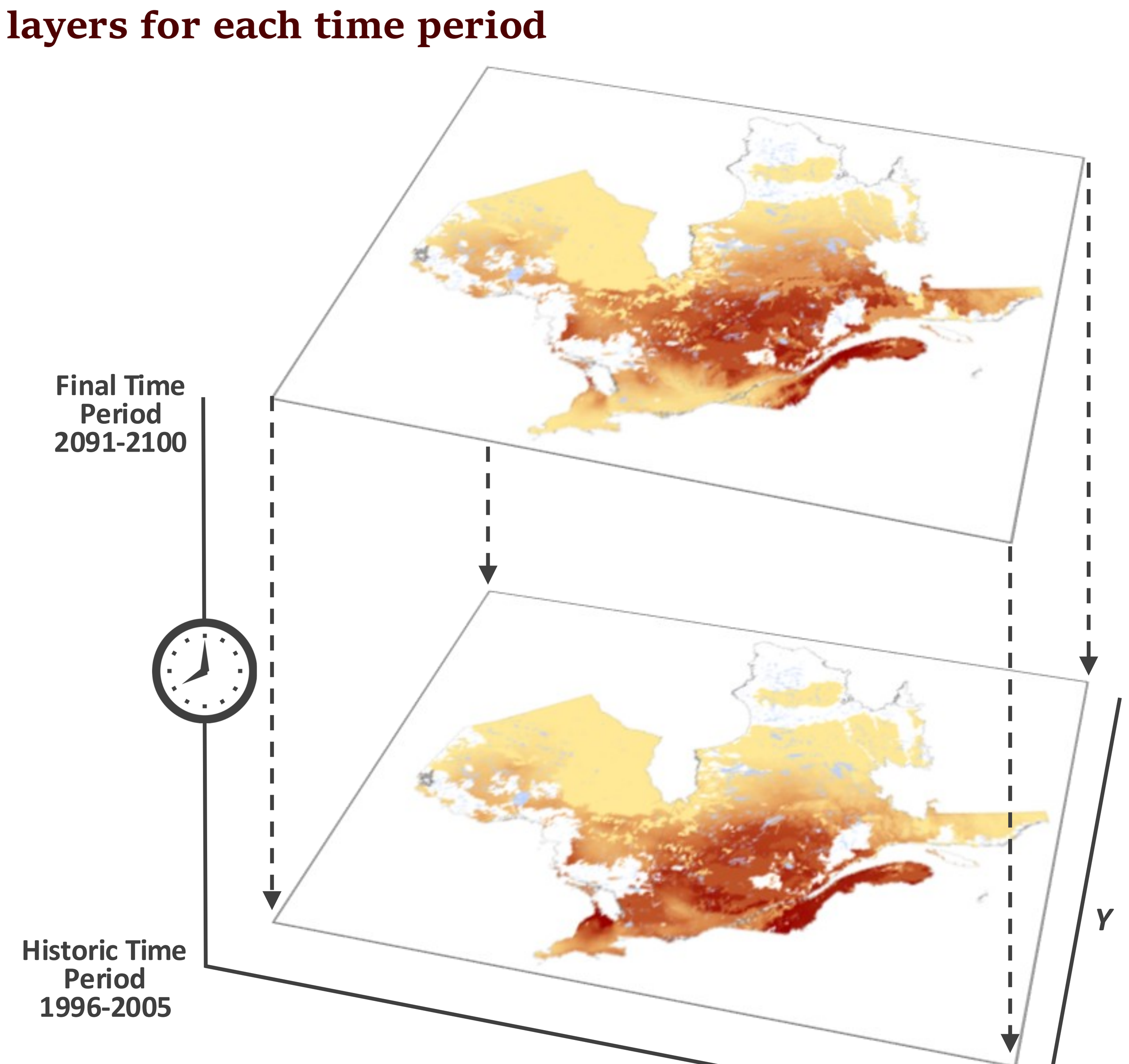
## Methods

The model used in this study estimates the distribution of suitable sugar maple habitat ranges occurring over future 10-year time periods (2011-2020, 2021-2030, 2031-2040, 2041-2050, 2051-2060, 2061-2070, 2071-2080, 2081-2090, and 2091-2100) as well as an historic time period (1996-2005). Suitability analysis used methods adapted from Brown et al. (2015), and used static landscape factors as well as dynamic climate factors based on model output from the Coupled Model Intercomparison Project Phase 5 Projections in accordance with the IPCC AR5 RCP4.5, which assumes moderate emissions. Fuzzy membership and fuzzy overlay tools were used to create the final fuzzy suitability layer for each time period. All suitability layers were used to create a space time cube, which was inputted into the emerging hot spot analysis tool to visualize potential changes in hot spots over time, at a 10km resolution.

### Historic Period Range Suitability (1996 –2005)




### Space—time cube with suitability layers for each time period




### Range Suitability Factors

| Climate factors | Landscape factors |
|---|---|
| Average annual precipitation | Drainage |
| Average max summer temperature | Rooting depth |
| Average min spring temperature | pH |
| | Slope |

## Findings & Conclusions

There is an overall northward-moving trend in the distribution of suitable sugar maple habitat ranges. The emerging hot spot analysis predicts that approximately 116,700 km² of land will be persistent hot spots, and 14,200 km² of land, mostly located in Northern Quebec, will become new hot spots of suitable habitat. Alternatively, just south of the area characterized as persistent hot spots, approximately 28,800 km² of land is characterized as diminishing hotspots. Additionally, new cold spots (unsuitable land) are predicted to emerge in Southern Ontario, and to a lesser degree in Southern Quebec. Land-use and population distribution patterns will likely change over time and were not taken into account by this model, though these would be important considerations for developing appropriate adaptation strategies for the maple syrup industry. Importantly, this model is based only on RCP4.5 projections and results would likely differ across different climate change scenarios. In addition to the uncertainty inherent in predictive models, another limitation of this study was the lack of more recent landscape factor data with complete coverage for Ontario and Quebec. According to this model (and keeping in mind its limitations), maple sap harvesters with sugar maple stands located in areas predicted to become less suitable in the future should consider transitioning their land to other uses.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