Extreme weather: envisioning Ontario agriculture

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Agriculture et Agroalimentaire Canada

Purpose -> constraints

- "… create and deliver information about prospective climate extremes that will affect Ontario's agriculture sector and rural communities. We will develop a decision support model (DSM) to characterize risk and vulnerabilities associated with climate change and extremes in agriculture, allowing users to plan for and mitigate risks by evaluating different adaptation choices."
  - spatial scenario modelling framework – impacts on crops and livestock*
    - map-based, field-level mapping; expectations
    - data realities: weather stations (time), GCM resolution
    - temporal scales at which can say much about future extreme events are hard to translate to impacts to crops and livestock
- use of seasonal, phenology-linked indices with links to specific crops

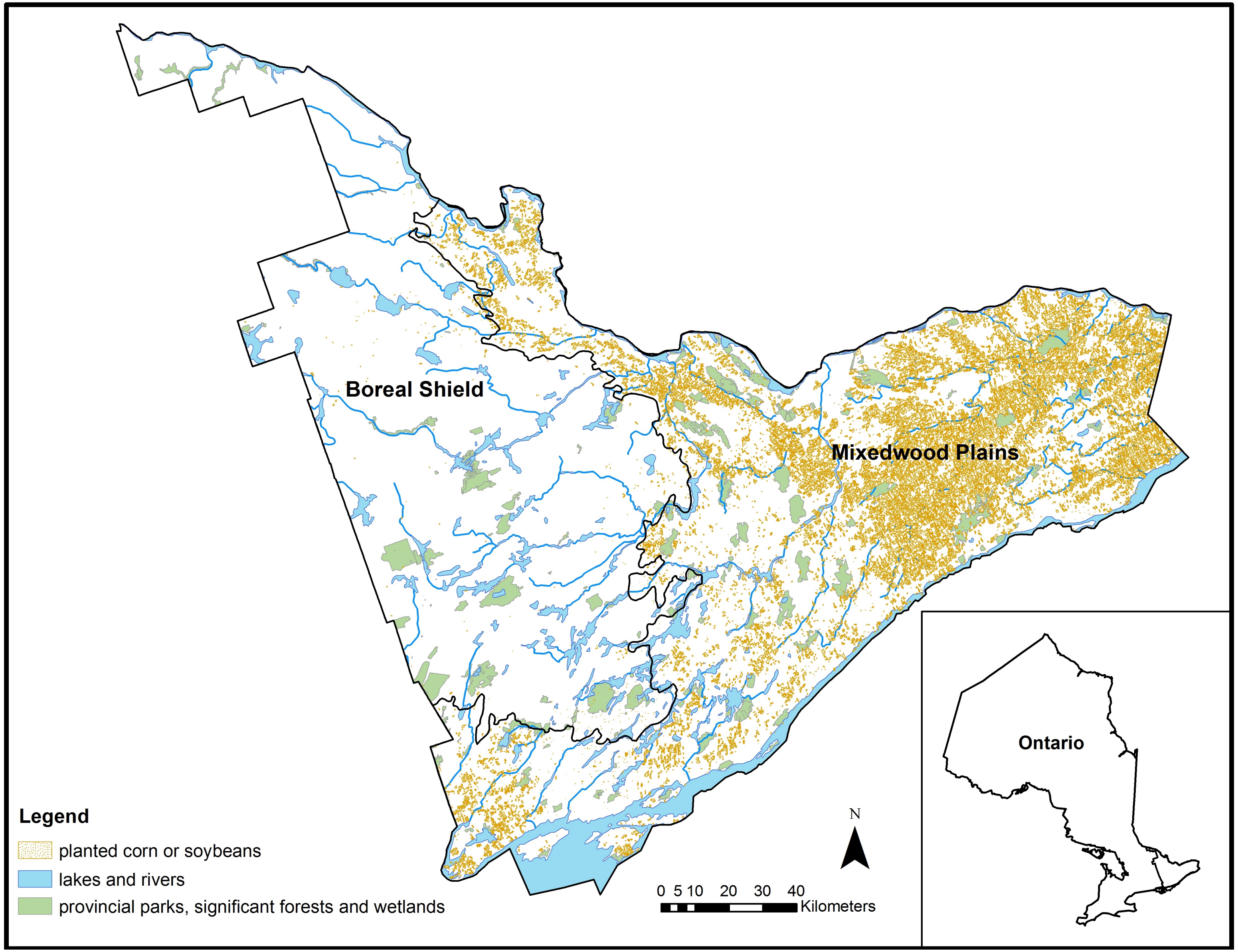
(some) Issues with existing information

- (as you've heard) there are limitations in using limited weather data, or climate model projections, to characterize extreme weather
  - how extremes usually considered? (climate model variability)
  - spatial-temporal resolution issues/discrepancies
  - how are those relevant to farm-scale / local level planning?
- some of the options we've considered
  - GCM output: custom downscaling, PCIC downscaling (to station or grid)
  - past weather data: everything available? "cleaned" data?
    - station-based or grid (10 km regular grid used by AAFC, EC) ?
  - temporal resolution: aggregate summaries? Daily variability?
- scenarios:
  - GCM: AR4/AR5? All models? Subset?
  - agriculture, demographics, economic (scale)

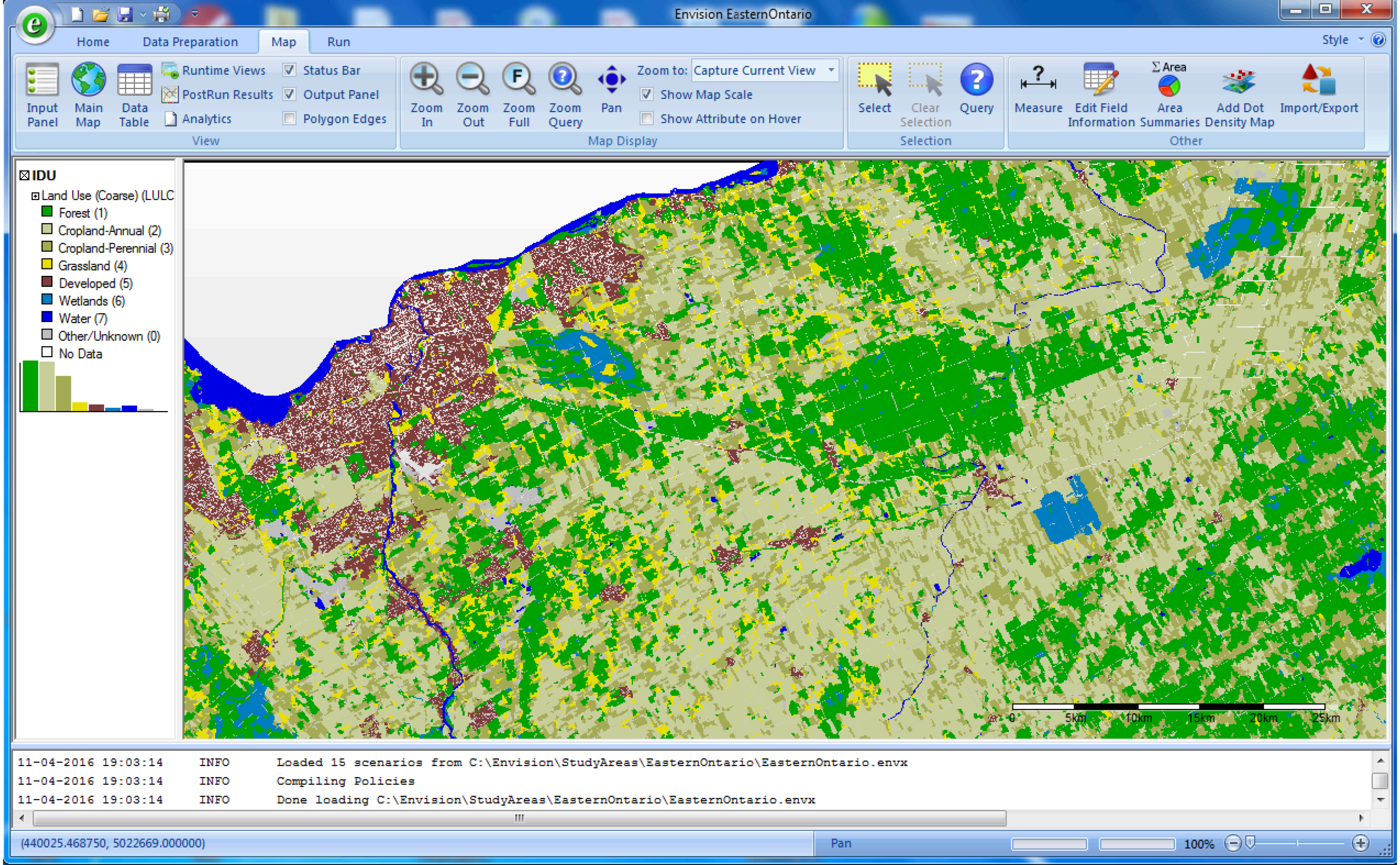
Why focus on scenarios and phenological impact modelling?

- every GCM model run is a scenario, not a prediction
  - ecosystem response on top of that impacted by range of possible reactions / adaptation from all ecosystem components, including humans
- GCMs lack spatial and temporal detail, **but** there is demand for information relevant to locally evaluating levels of risk and potential tradeoffs
  - finer resolutions (space & time) → assumptions & potentially very high data needs
  - usually can't confidently fill all those needs, but can explore a likely range, consider sets of likely parameters under future alternate scenarios
- crop modelling typically focuses on yield, using either a process-based approach (high uncertainty in parameterization across large regions) or empirical models (usually assuming stationary conditions)
  - phenological impact modelling allows us to identify times when crops are particularly vulnerable to climatological events, and assign a typical impact to crop yield; concentrate on relative impacts rather than specific physiological processes

Study area: eastern Ontario



A. Zaytseva's DRAFT M.Sc. Thesis (Carleton University).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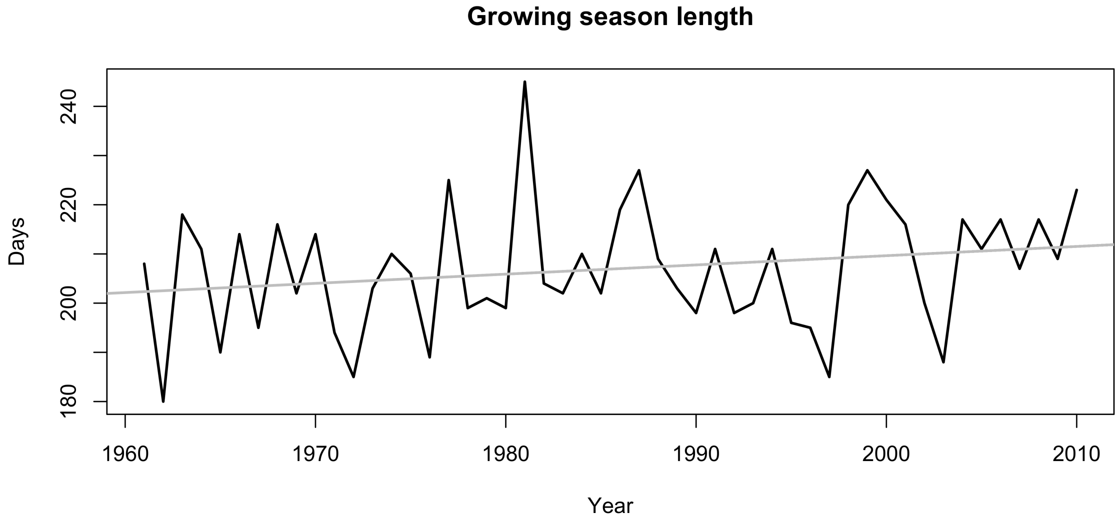
Indices derived from “just” weather data

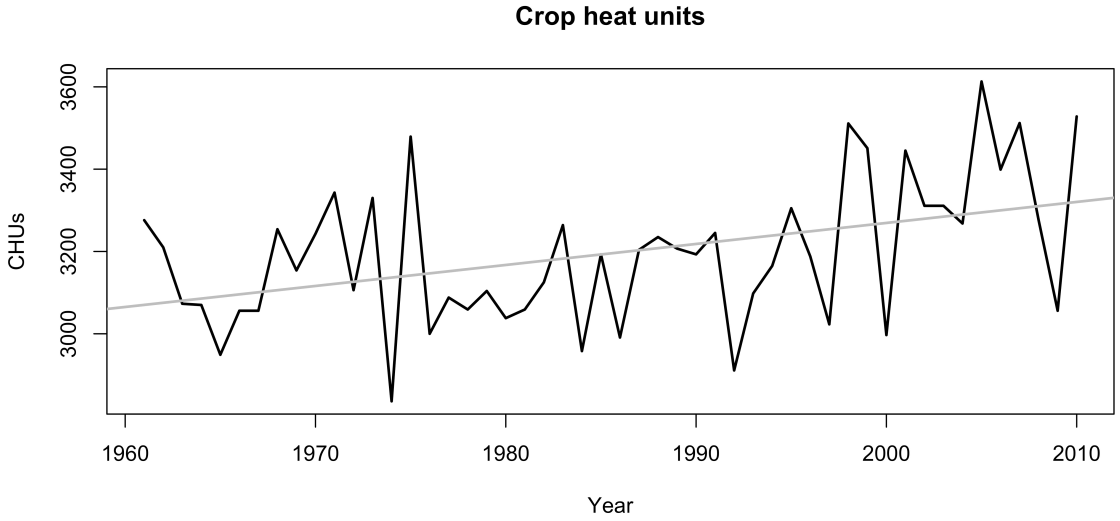
- E. Ontario not expected to be a hotspot of weather extremes
  - but types of extremes of particular relevance in “regular” agricultural operations are not necessarily what people first think of as “extreme”

- “standard” indices are available to analyse and compare weather / extremes
  - useful to describe general trends

- some, however, mask processes that are important to agriculture

Why extremes? This is NOT the whole story!





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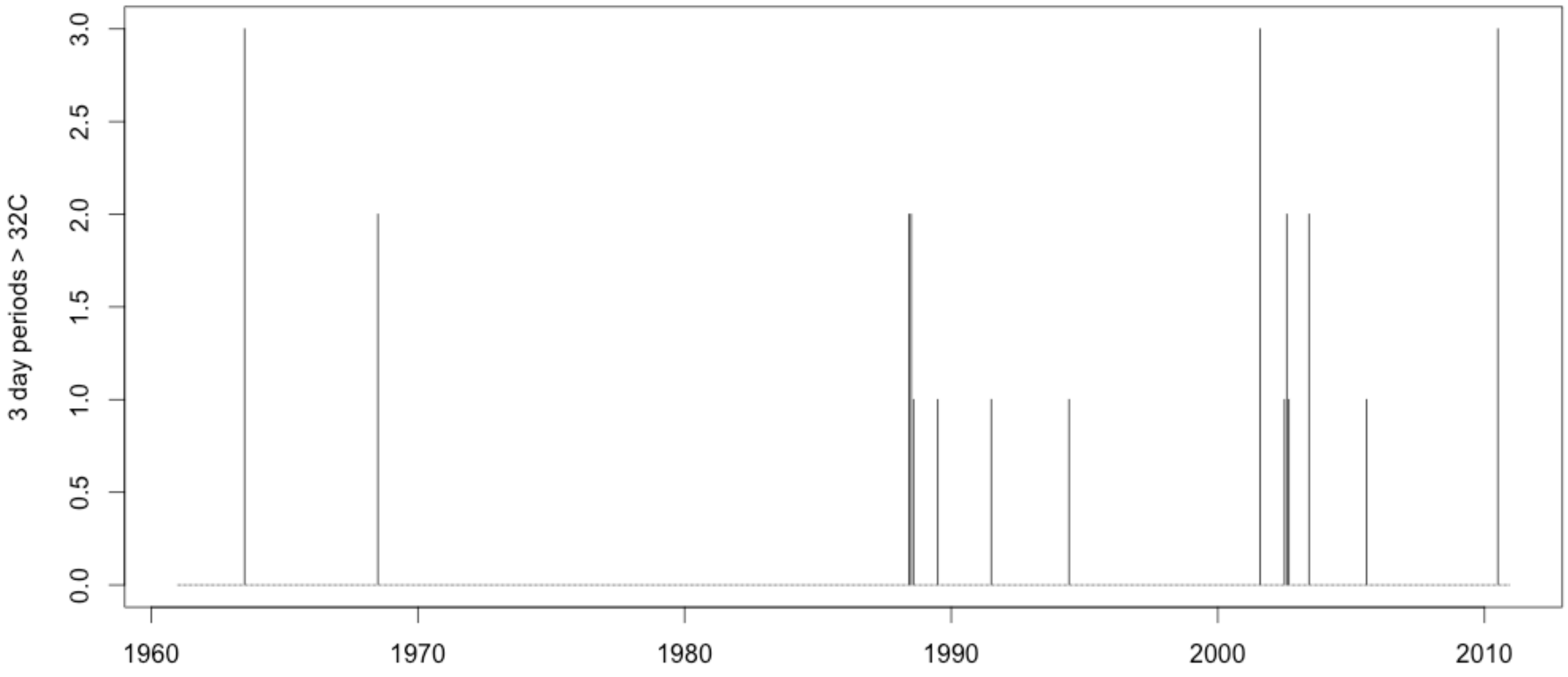
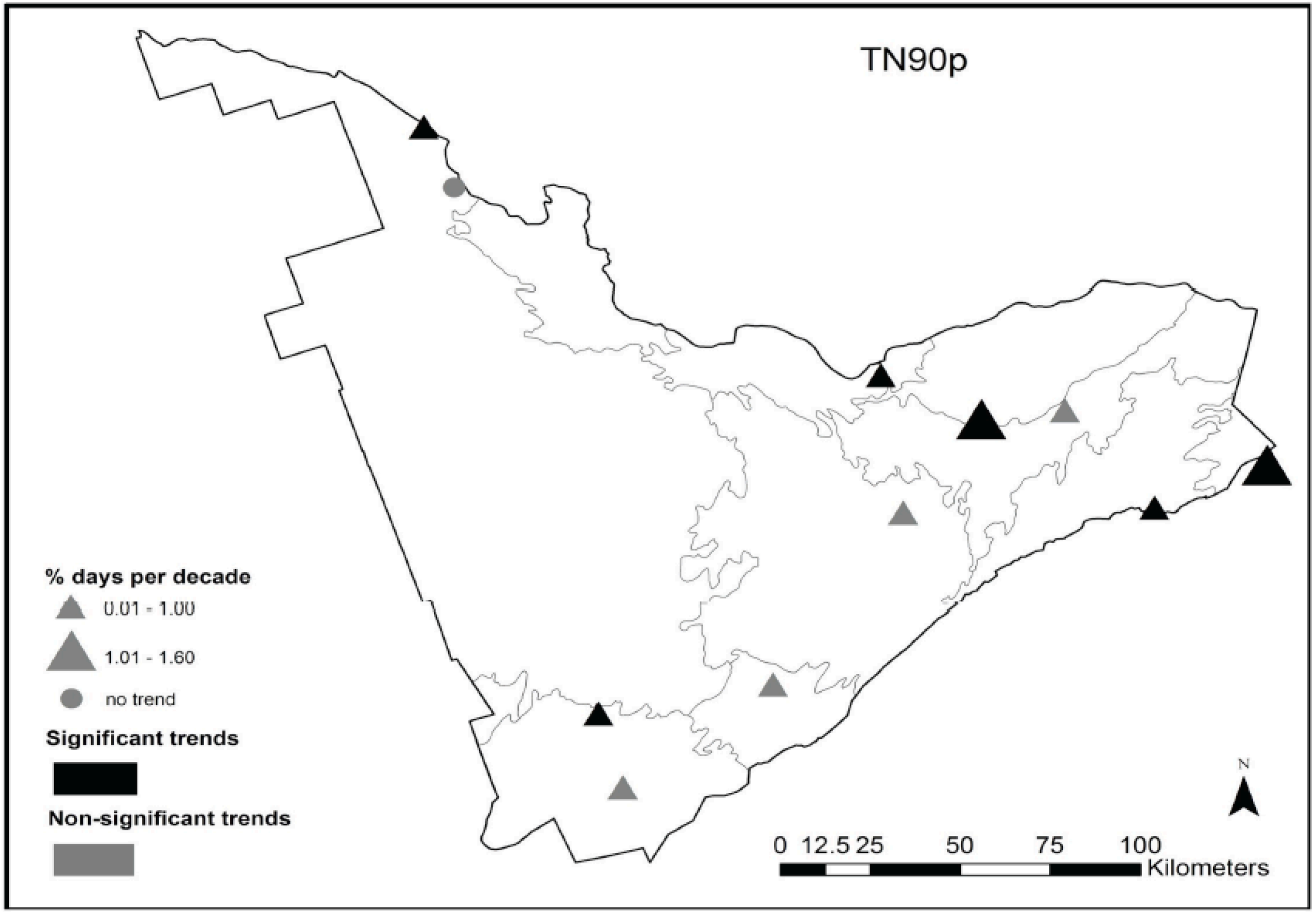
Example: general index relevant to human health

- 3 day periods where T_{max} > 32°C



Example: extreme index: warm nights



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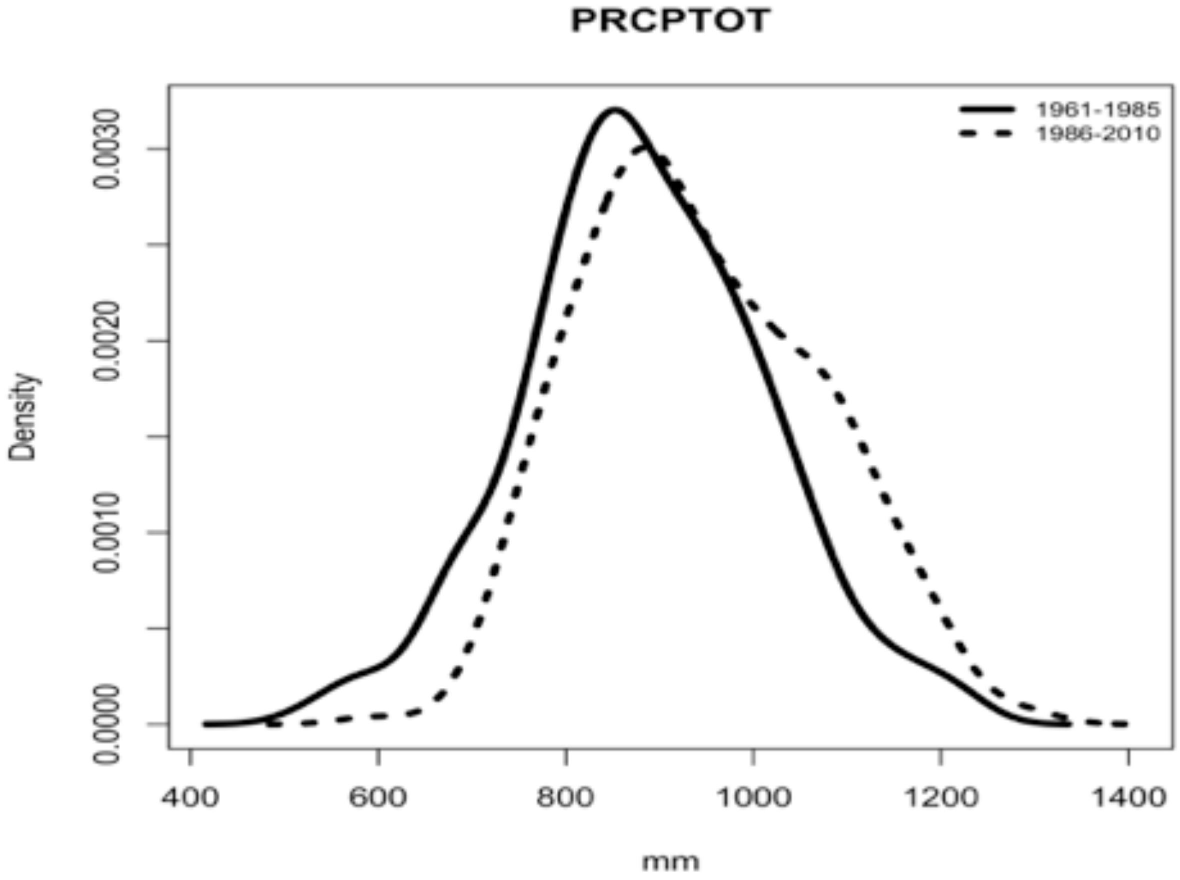
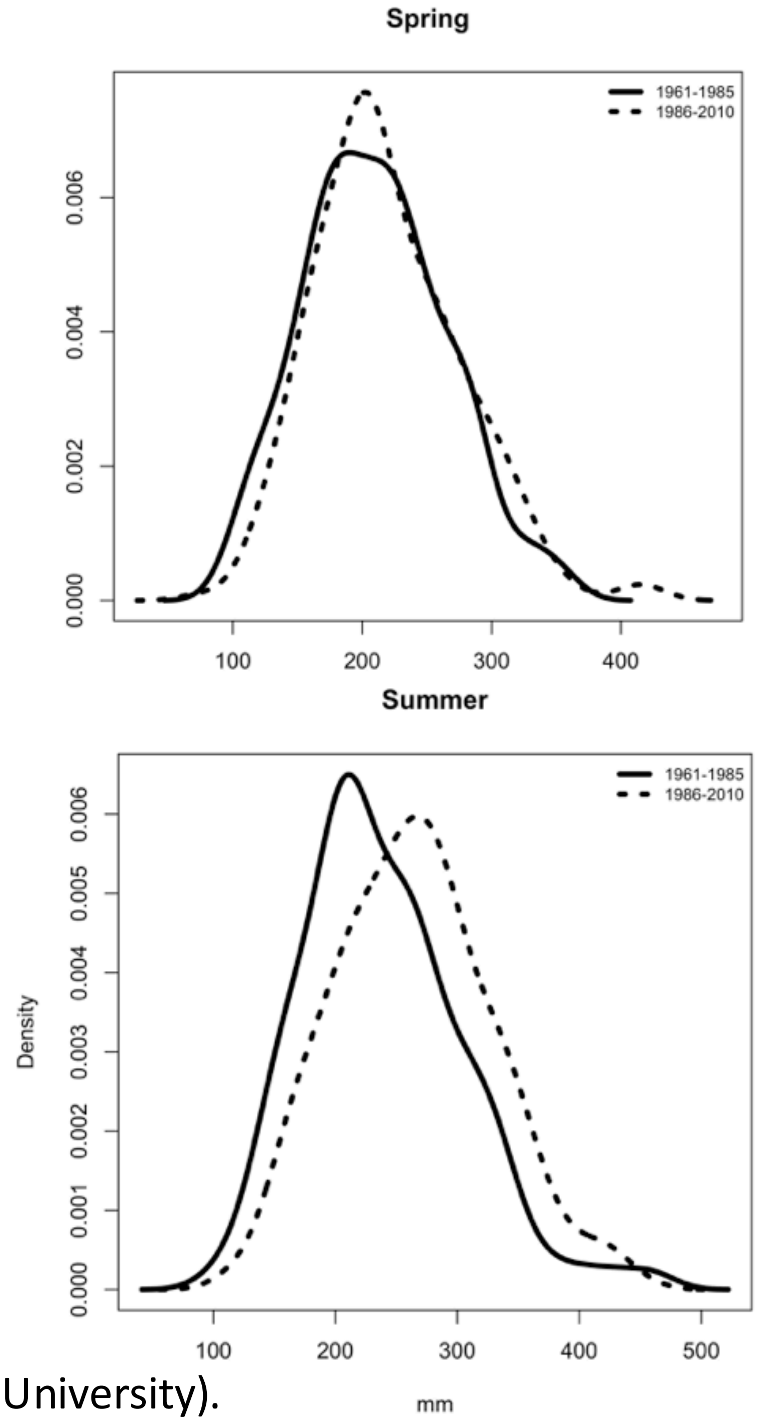
Example: precipitation





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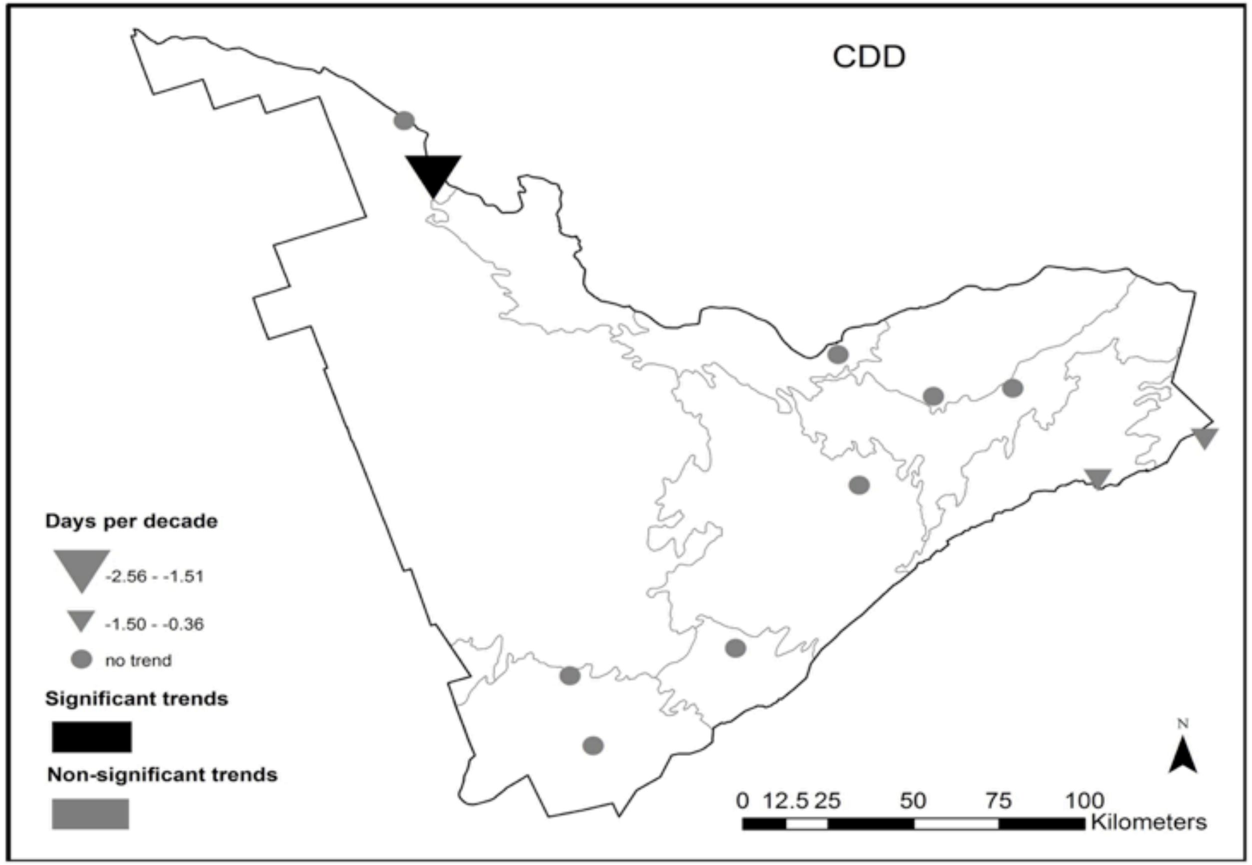
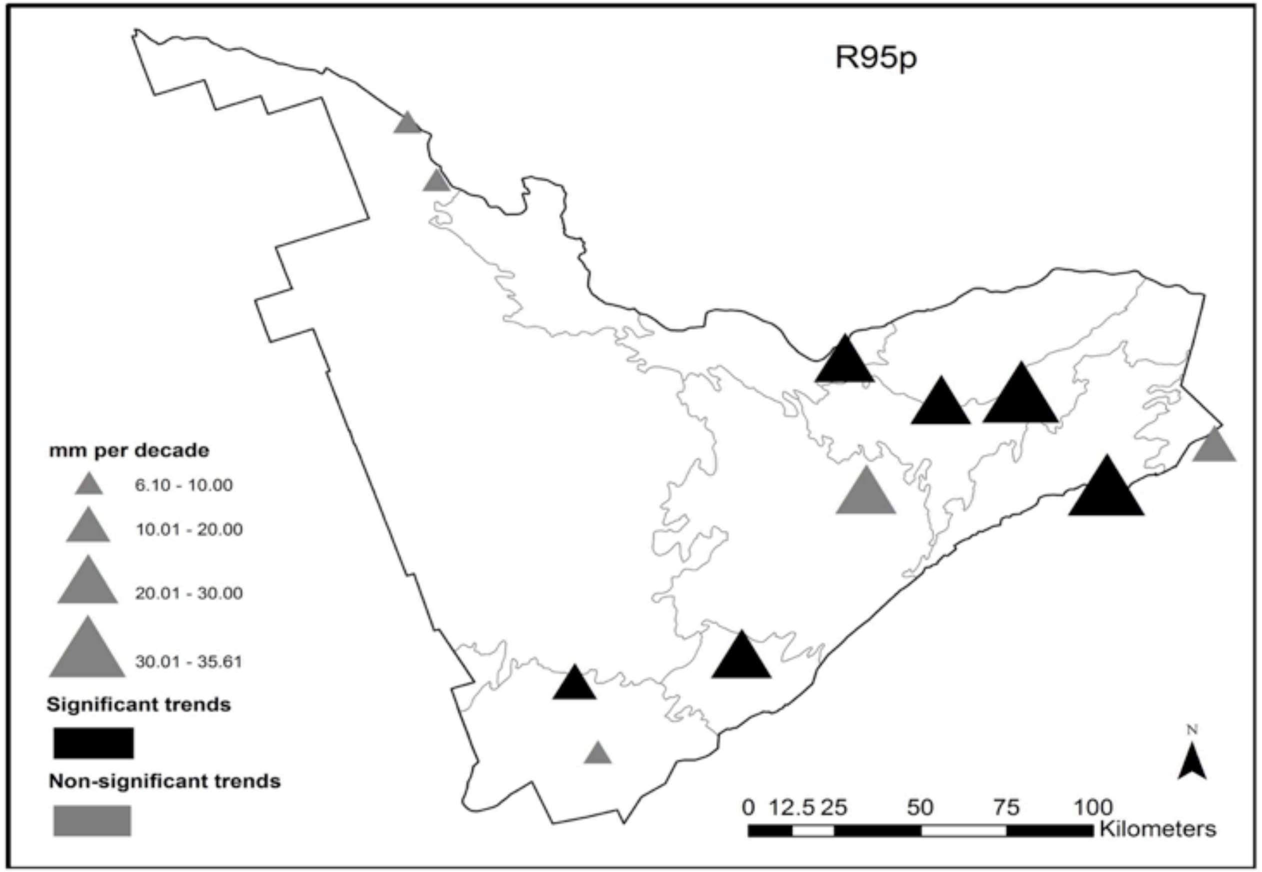
Example: precipitation



CUMULATIVE DRY DAYS



VERY WET DAYS

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MORE CROP RELEVANT: SEASONAL PHENOLOGY INDICES

- Corn (for example):

Index name	Definition	Units
Corn:		
Poor seeding conditions	Weekly precipitation 30% greater than weekly mean precipitation (between April 23 and May 20)	weeks/year
Early flooding	Weekly precipitation 30% greater than weekly mean precipitation with 1 to 780 accumulated CHUs	weeks/year
Pollination drought	CDD >10 with 1,301 to 1,600 accumulated CHUs	annual occurrence (Yes or No)
R2 (blister) drought	P<45mm with 1,601 to 1,825 accumulated CHUs	annual occurrence (Yes or No)
R3 (milk) drought	P<45mm with 1,826 to 2,000 accumulated CHUs	annual occurrence (Yes or No)
Early killing frost	Tmin <=-2°C with 2,165 to 2,475 accumulated CHUs	days/year
R4 (dough) drought	P<8mm with 2,001 to 2,165 accumulated CHUs	annual occurrence (Yes or No)
Fall killing frost	Tmin <=-2°C with 2,476 to 2,600 accumulated CHUs	days/year

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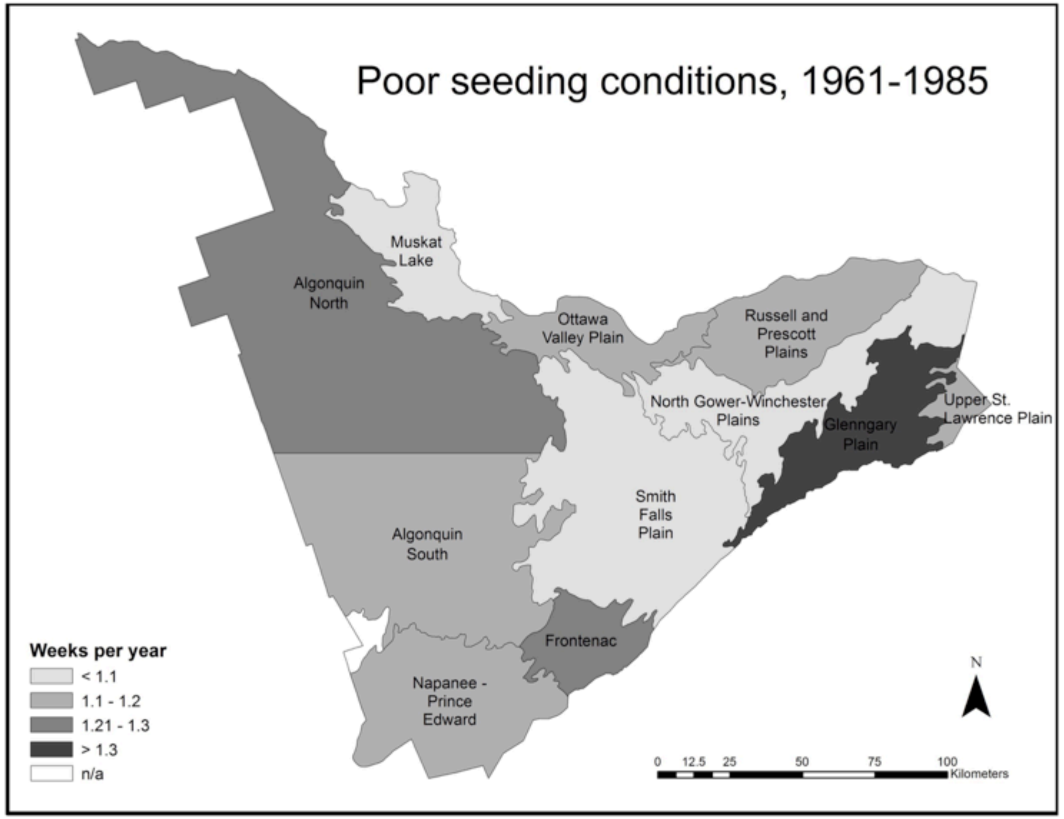
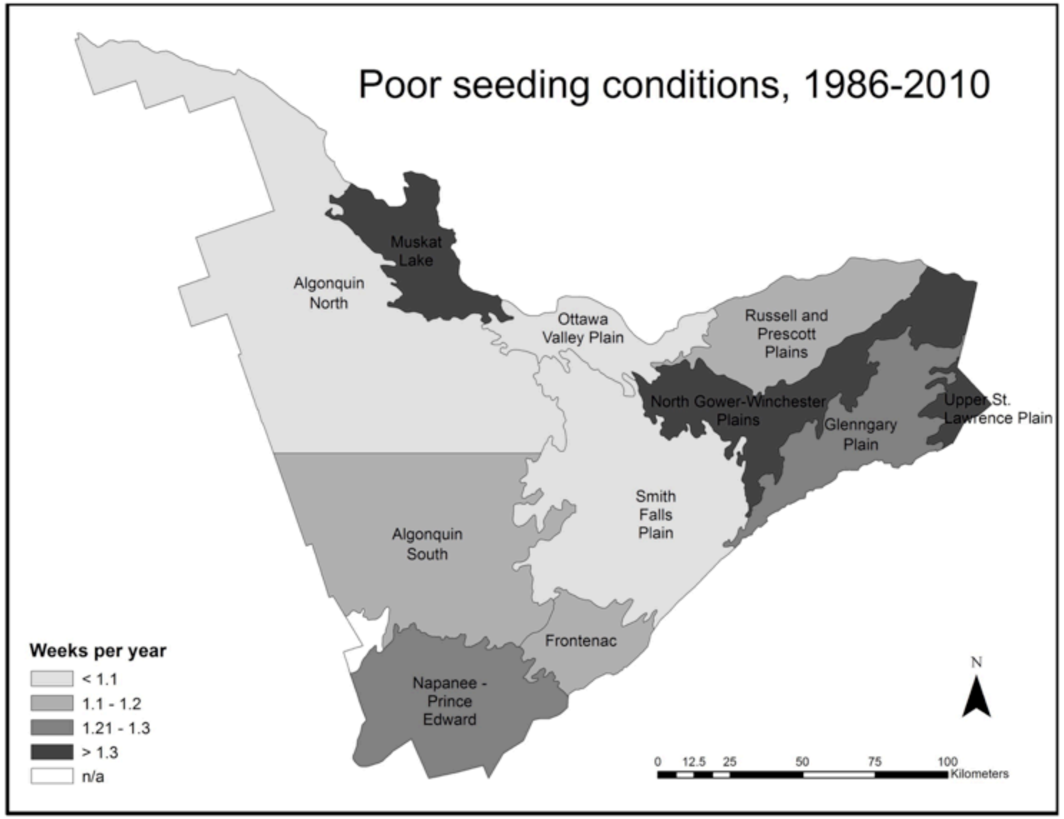
Example: poor seeding conditions





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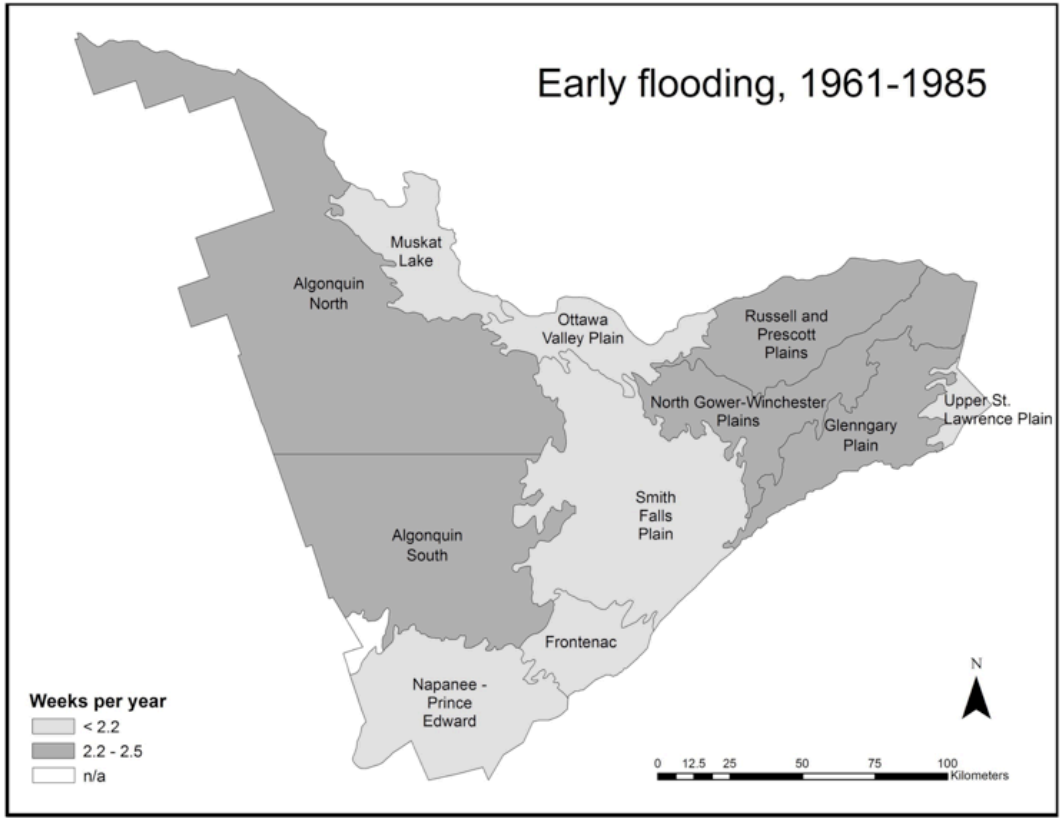
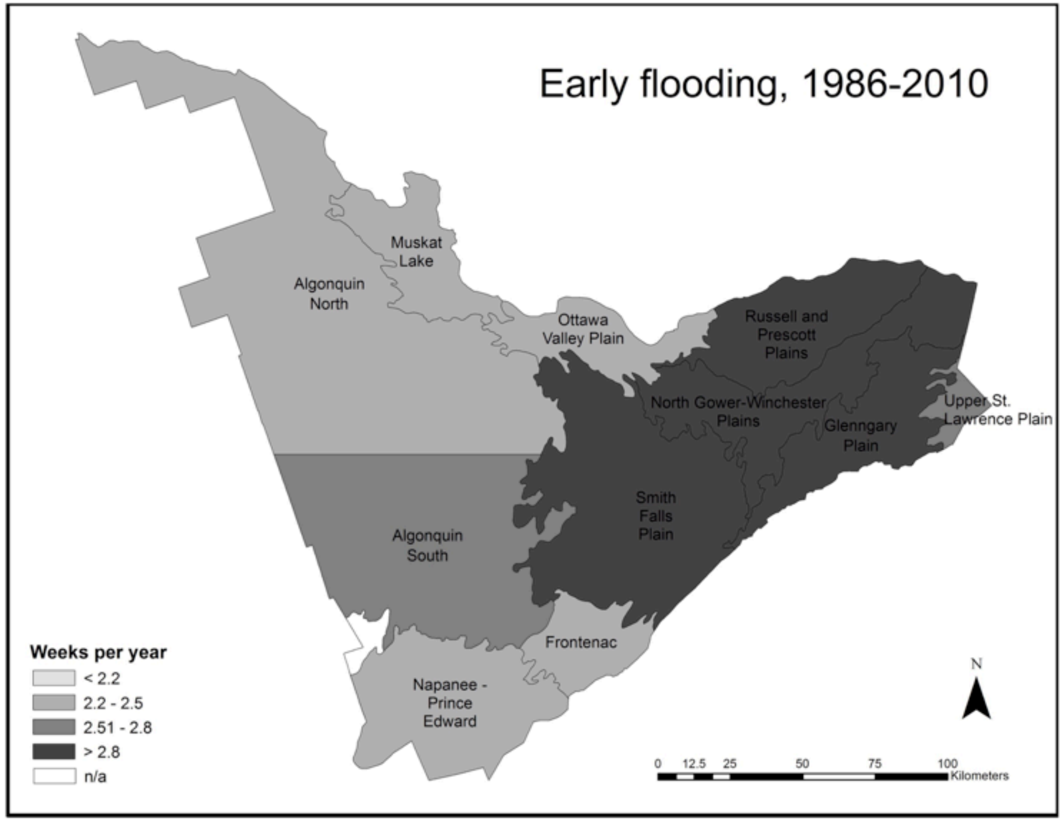
Example: early flooding





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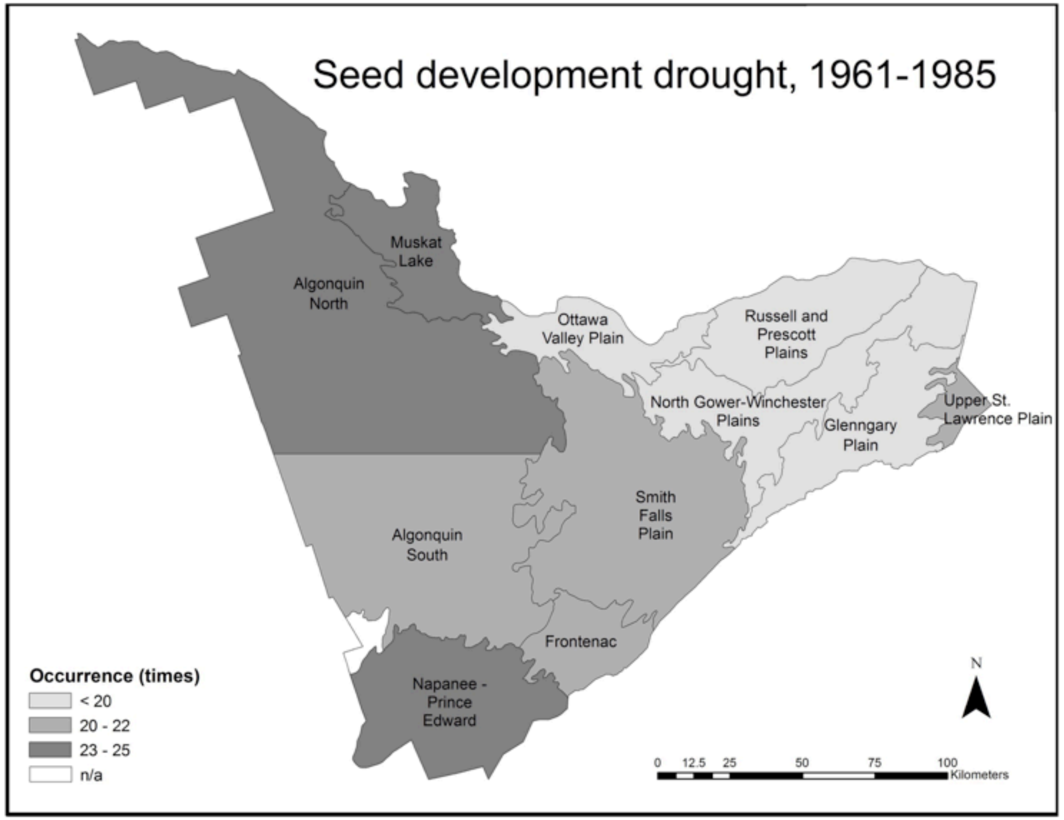
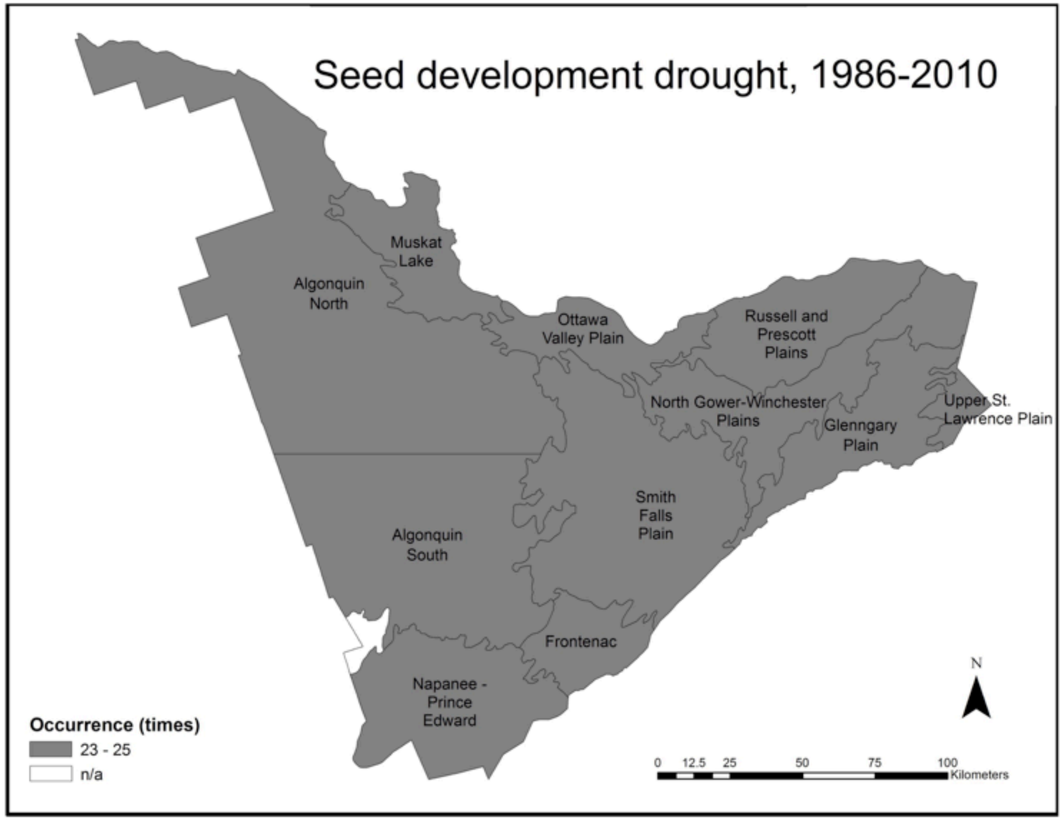
Example: seed development drought





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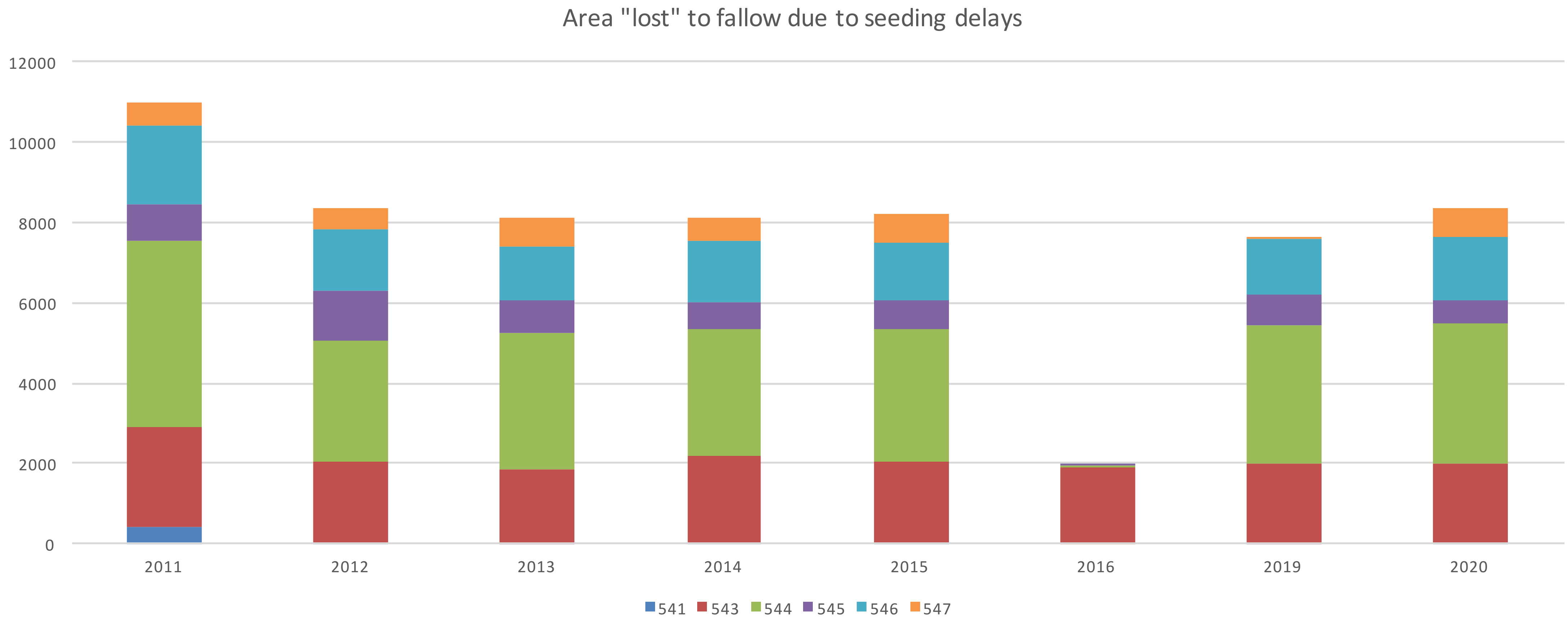
Example: projected seeding delays



Lessons and future considerations:

- crop- and phenology-specific, scenario impact-based approach to extremes allows us to highlight relative risks of “subtle” but agriculturally relevant shifts in climate
  - relevance: impact on farm operations
  - potential to evaluate switching to (or need to develop) different varieties
- scenario modelling: uses field-level decisions but does not rely on needing to confidently parameterize field-level details with a specific “reality”
  - relevant to categories of farming operations as they exist in this region, with real biophysical constraints
  - allows us to manage uncertainty, and concentrate on scenarios that have relevance to adaptation planning

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“Scenario-based risk assessment decision support modelling tools for regional climate change and climate extremes, impacts and adaptation in agricultural watersheds” is a project funded by the Ontario Ministry of Agriculture, Food, and Rural Affairs’ New Directions Research Program. One of our main objectives is to provide a clearing-house for information and resources that are useful for evaluating climate change in Ontario, starting with our pilot program in eastern Ontario.

Several parallel sub-projects have been launched to help meet our objectives. We have characterized the changing climate in eastern Ontario, with a focus on extreme weather. To help with this, we are developing and