Adapting to Climate Change:
Natural Systems Vulnerability Assessment & Applications

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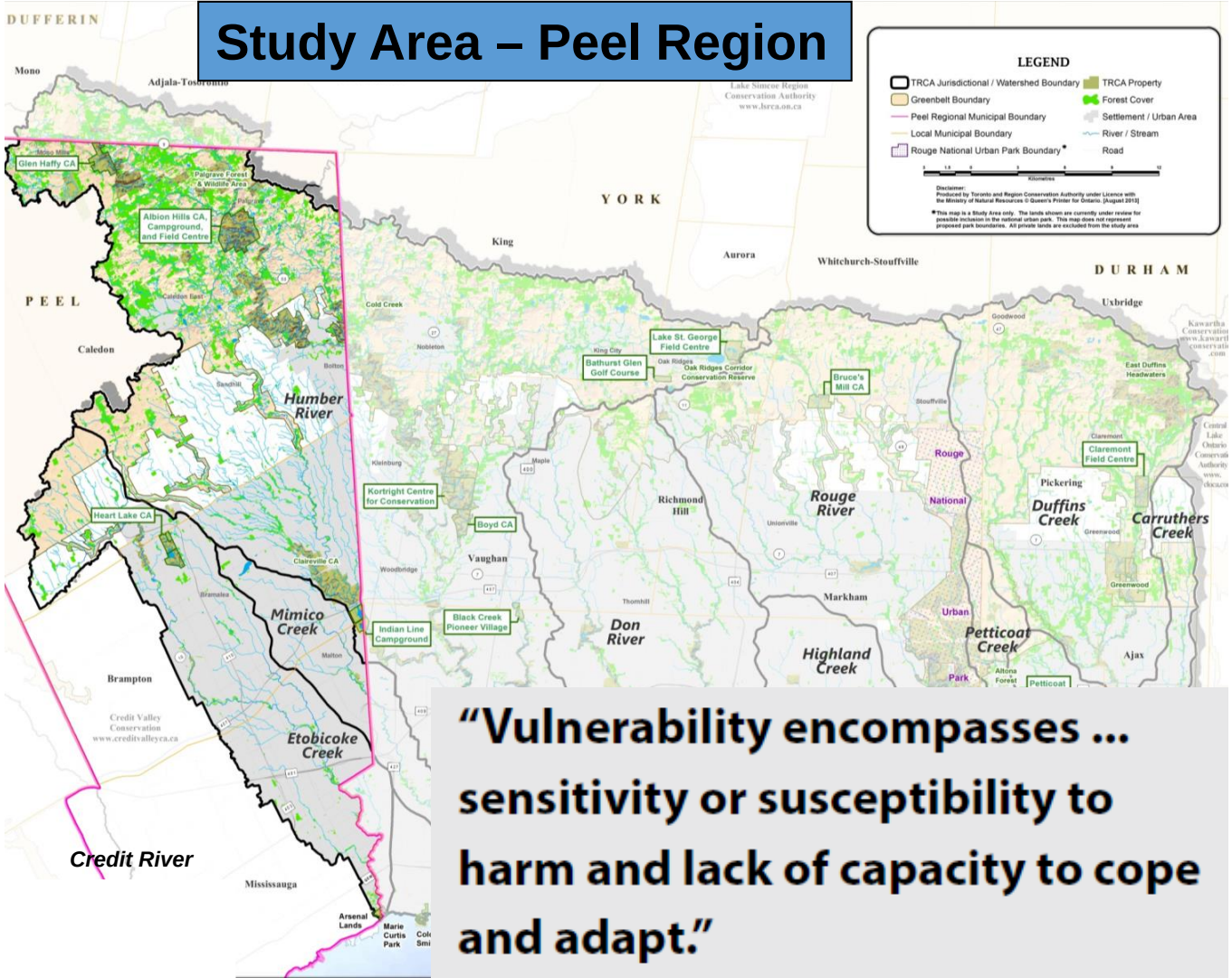
Presentation Outline

1. The Pilot Study: Region of Peel
    - Background
    - Approach
    - Results
2. Rollout to TRCA Jurisdiction & Applications
3. Moving Forward

The Pilot Study: Region of Peel

BACKGROUND & APPROACH

Study Area – Peel Region



"Vulnerability encompasses … sensitivity or susceptibility to harm and lack of capacity to cope and adapt."

Scope of Vulnerability Assessment

Study Area: Peel Region

Qualitative vulnerability assessment of natural systems (and key ecosystem services) to climate change.

Natural Systems: Groundwater, Aquatic and Terrestrial Systems

Two case studies: To quantify current and future vulnerabilities: stream temperature & mean annual GW discharge

Management Recommendations to reduce vulnerabilities.

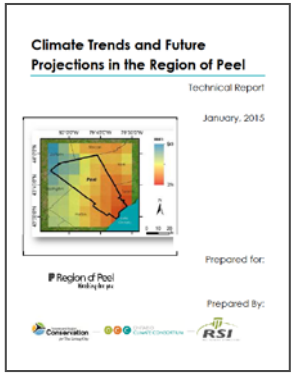
Team Structure & Overarching Guidance

Lead Authors: TRCA and Ontario Climate Consortium (OCC)

Core Advisory Team (CAT): Peel Region, CVC, MNRF, OCCIAR and University of Waterloo

Climate model: RCP 8.5 2050s

Climate Scenario: Hotter, Wetter Year; Drier Summer



Climate Variables

Climate variables had previously been made availabl through the Peel Climate Trends report and analyses conducted therein (Auld *et al*. 2015).

Climate Driver	Climate Variable (Examined Seasonally and Annually)
Increasing Temperatures	Maximum Temperature [°C]
	Minimum Temperature [°C]
	Average Temperature [°C]
Shifts in Precipitation (Increase Annually, No trend in Summer)	Total Precipitation [mm]
Drought	Consecutive Dry Days [days]
Extreme precipitation Intensity	1-day maximum precipitation accumulation [mm]
	5-day maximum precipitation accumulation [mm]
Extreme Heat	Days per Month where Max Temperature > 30, 35, 40 [°C]
Ice Storms	Ice Potential [# Freezing Rain Events annually]
Growing Season Conditions	Growing Season Length (frost-free period) [days]
	Growing Season Start Date [date of year]
	Growing Season End Date [date of year]

FUTURE CLIMATE TRENDS IN PEEL REGION

A study of predicted climate trends for Peel Region found that

By 2050

- Annual mean temperature will rise by 2°C
- The number of extreme heat days (over 30°C) will more than double
- The intensity of extreme storms will increase by 28-51%
- The growing season will be 20% longer than today

By 2080

- Annual mean temperature will rise as much as 5°C from current levels
- There will be up to five times more extreme heat days
- The intensity of extreme storms will increase by 46-90%
- The growing season will be 30% longer than today

Vulnerability Factors

“Vulnerability Factors” (VFs) concept represents a quality or characteristic of a natural component to be more or less vulnerable to a given climatic condition or event.

Such factors can be physical, chemical or biological aspects of the natural environment

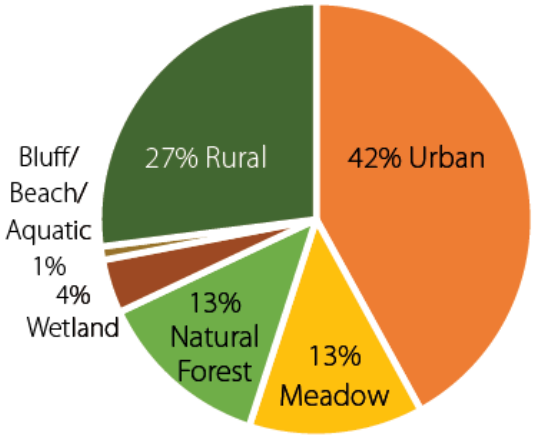
Area-to-Depth Ratio
Degree of Connectivity
Tree Canopy
Pervious Cover
Water Taking
Water Source
Soil Quality
Nutrient Availability
Topography & Grade

Water Chemistry
Low Biodiversity
Community Range
Flow Variation
Thermal Gradient/Regime
Ice Cover
Snow Cover
Rooting Depth & Strength
Native Species Specialization

Vulnerability Indicators

"Vulnerability Indicators" represent vulnerability factors locally in Peel and were selected from a long list using a set of criteria classified as *Feasibility of Assessment, Importance of Assessment* and *Scientific Validity of Assessment*.

1. Natural Cover Type and Distribution
2. Climate-Sensitive Native Vegetation
3. Wetland Type (Hydrology)
4. Land Surface Temperature
5. Soil Drainage Rating
6. Soil Organic Carbon Content in A-Horizon Layer
7. Baseflow
8. Recharge
9. Total Phosphorous (Aquatic)
10. Water Levels (surface and ground)
11. Water Temperature



LAND COVER IN PEEL REGION

POTENTIAL IMPACTS OF CLIMATE CHANGE TO NATURAL SYSTEMS


Shallow aquifers may dry out

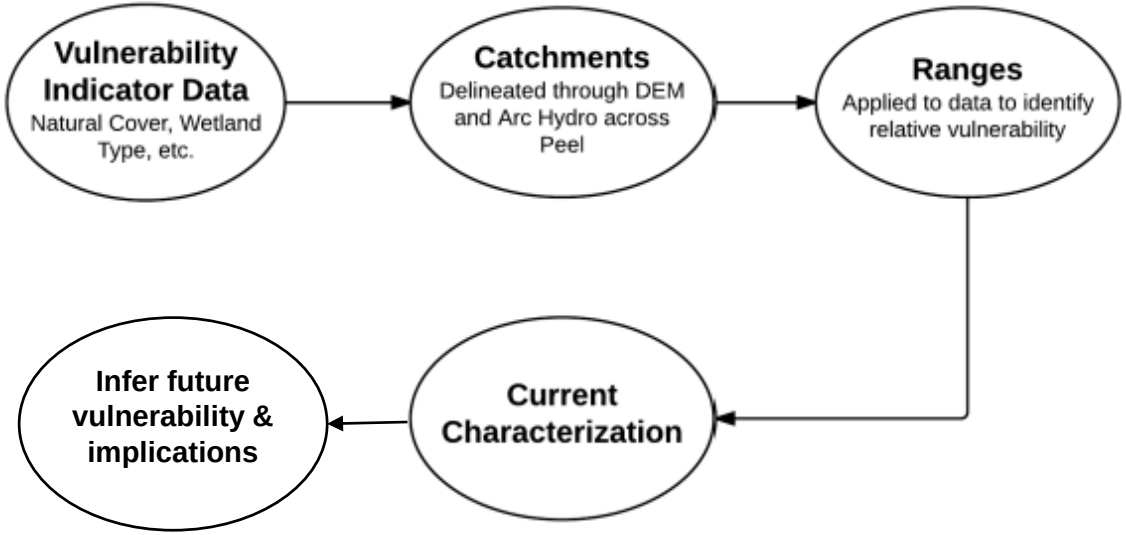

Warming surface waters


Erosion


Algal blooms


Invasive species


Heat stress to plants



Future urbanization impacts were inferred as an overlay

The Pilot Study: Region of Peel

RESULTS

Groundwater System

Component	Vulnerability Factors	Vulnerability Indicators
• Groundwater	• Area-to-Depth Ratio (Aquifer depth) • Aquifer Maintenance • Water Taking • Water Chemistry	• Groundwater Levels • Recharge • Total Phosphorus

Groundwater System

- Shallow, unconfined aquifers are more vulnerable to warming and water level decrease
- The lag time in aquifer response to recharge will affect delivery to surface water
- Predicted risk of drying out in summer affecting non-potable water use and loss of in-stream habitat

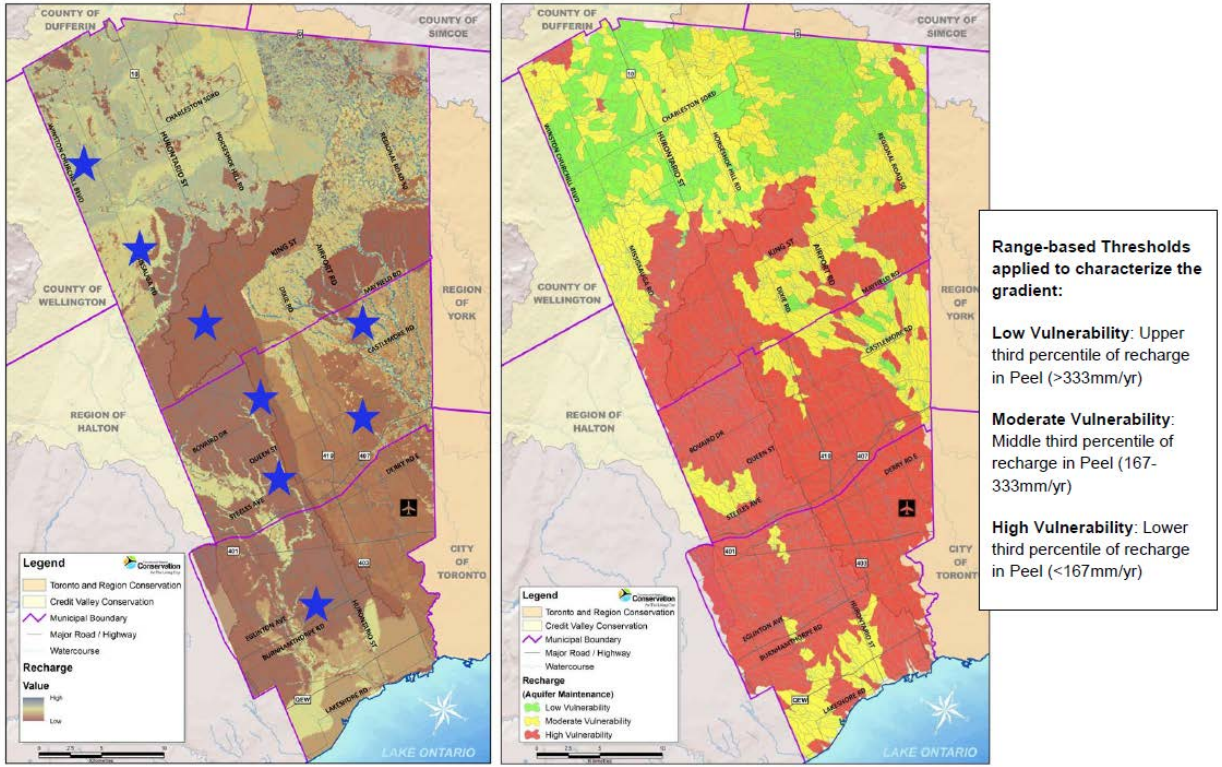


Figure 13: Modeled Recharge and Areas of Surface Water Stress (illustrated in blue stars) in Peel Region (A) and Vulnerability Characterization of Modeled Recharge at the 30ha Catchment Level (B)

Aquatic Systems

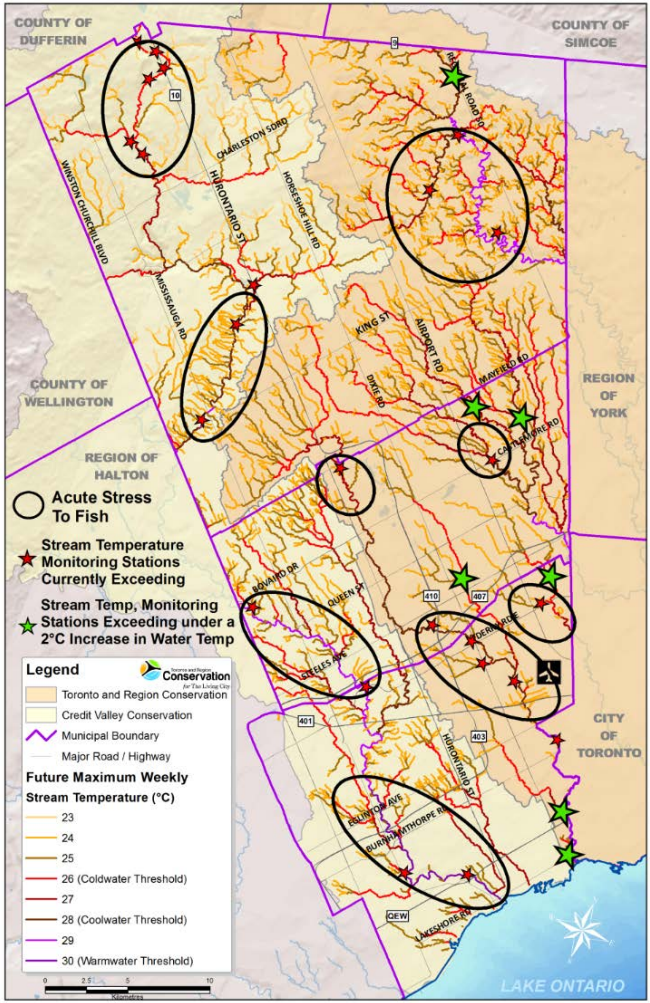
Components	Vulnerability Factors	Vulnerability Indicators
• Rivers, Streams and Valley Corridors • In-land Lakes and Ponds	• Thermal Gradient/Regime • Flow Variation • Degree of Connectivity (Hydrologic) • Water Chemistry • Community Range • Pervious Cover • Urban Forest Canopy	• Water Temperature • Baseflow • Total Phosphorus • Natural Cover • Urban Forest Canopy

Aquatic System

9 highly vulnerable streams:

- Elevated stream temperatures, low flow conditions, elevated nutrients, habitat fragmentation
- Areal extent highly vulnerable stream areas is predicted to expand due to climate change impacts
- Predicted loss of cold-water habitat, overheating of warm-water habitat, decrease in water quality, invasive spread, altered winter ecology
- Urbanization will exacerbate these conditions

Future Max Weekly Streamwater Temperature Exceeding Summer Thermal Targets



Terrestrial System

Components	Vulnerability Factors	Vulnerability Indicators
• Meadows, Grasslands, Shrublands • Natural Forests • Urban Forests • Wetlands	• Pervious Cover • Degree of Connectivity (Habitat & Hydrologic) • Topography and Grade • Soil Quality • Urban Forest Canopy • Thermal Gradient • Community Range	• Natural Cover: Forest Cover & Wetland Cover • Wetland Type • Habitat Patch Quality • Soil Drainage • Soil Organic Carbon in A-Horizon Layer • Urban Forest Canopy • Land surface temperature • Climate-Sensitive Native Vegetation

Terrestrial System: Natural Areas

- Areas with low natural cover and low quality patches have higher vulnerability
- Climate sensitive vegetation will shift in composition and will have cascade effects – also in protected areas
- Drying effects and other edge effects will exacerbate stress
- Predicted loss of quantity and quality of natural systems and ecosystem services

Figure 26: Wetland Type (A) and Vulnerability Characterization of Wetland Type (Hydrologic Connectivity) at the 30ha Catchment Level (B)

Functional Wetland Types used to Characterize Vulnerability based on water source:

Low Vulnerability: Fens, Marshes within 30m of a watercourse

Moderate Vulnerability: Marshes further than 30m from a watercourse

High Vulnerability: Bogs, Swamps

Terrestrial System: Surface Temperature

- Temperature is close to 50C in urban areas thus natural system is highly vulnerable to heat impacts
- Some urban valley corridors and Lake Ontario's shoreline has cooling effect
- Temperatures are expected to increase more in urban areas due to urban heat island effects
- Impervious surface likely to increase as urbanization expands thus increasing high vulnerable areas

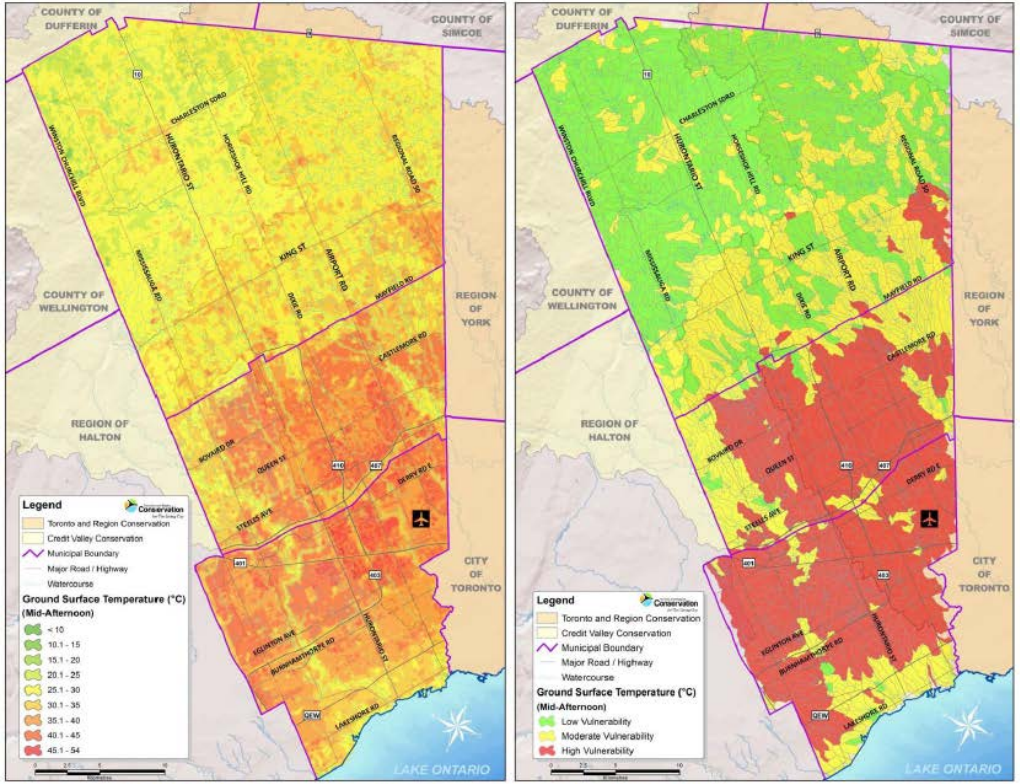


Figure 30: Mid-Afternoon Ground Surface Temperature on June 18, 2014 (A) and Vulnerability Characterization of Mid-Afternoon Ground Surface Temperature at the 30ha Catchment Level (B)

Range-based Thresholds Applied to Characterize the Gradient in Peel:

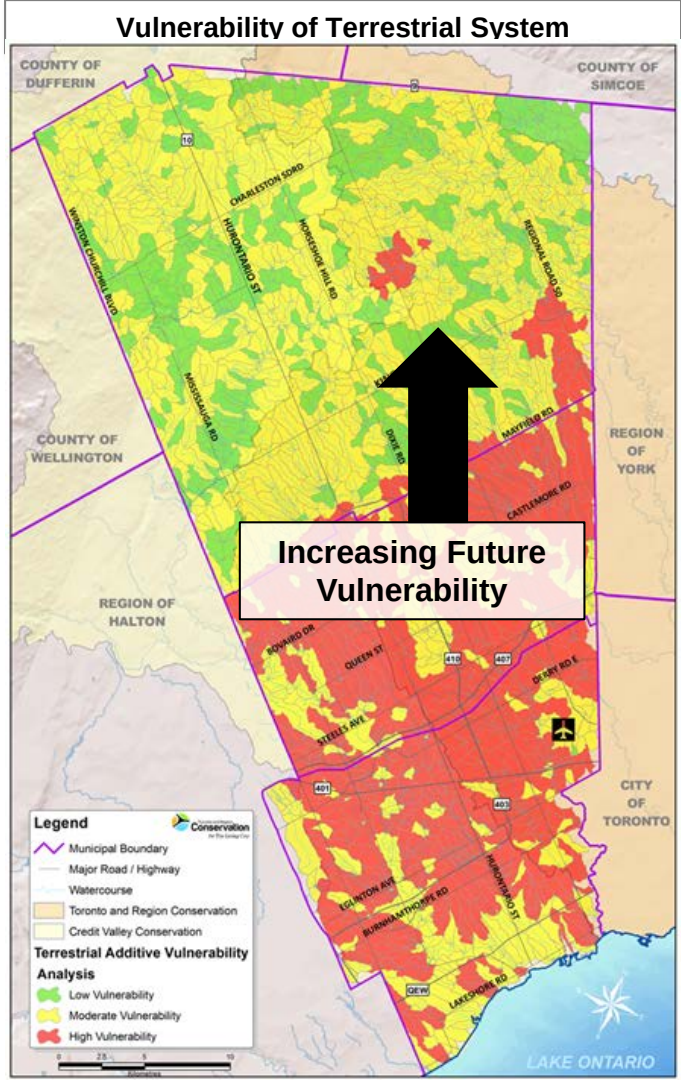
Low Vulnerability: Less than 29˚C

Moderate Vulnerability: Between 29˚C and 36˚C

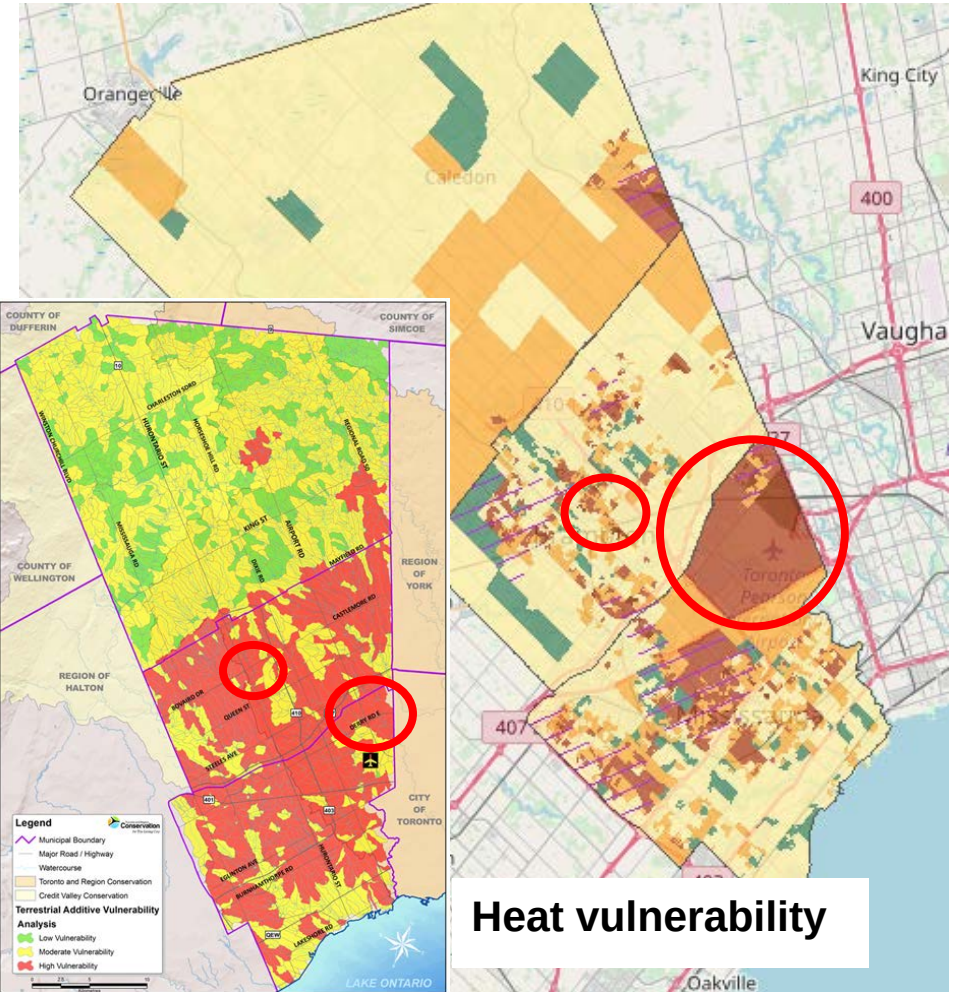
High Vulnerability: Greater than 36˚C

Terrestrial System: Overall

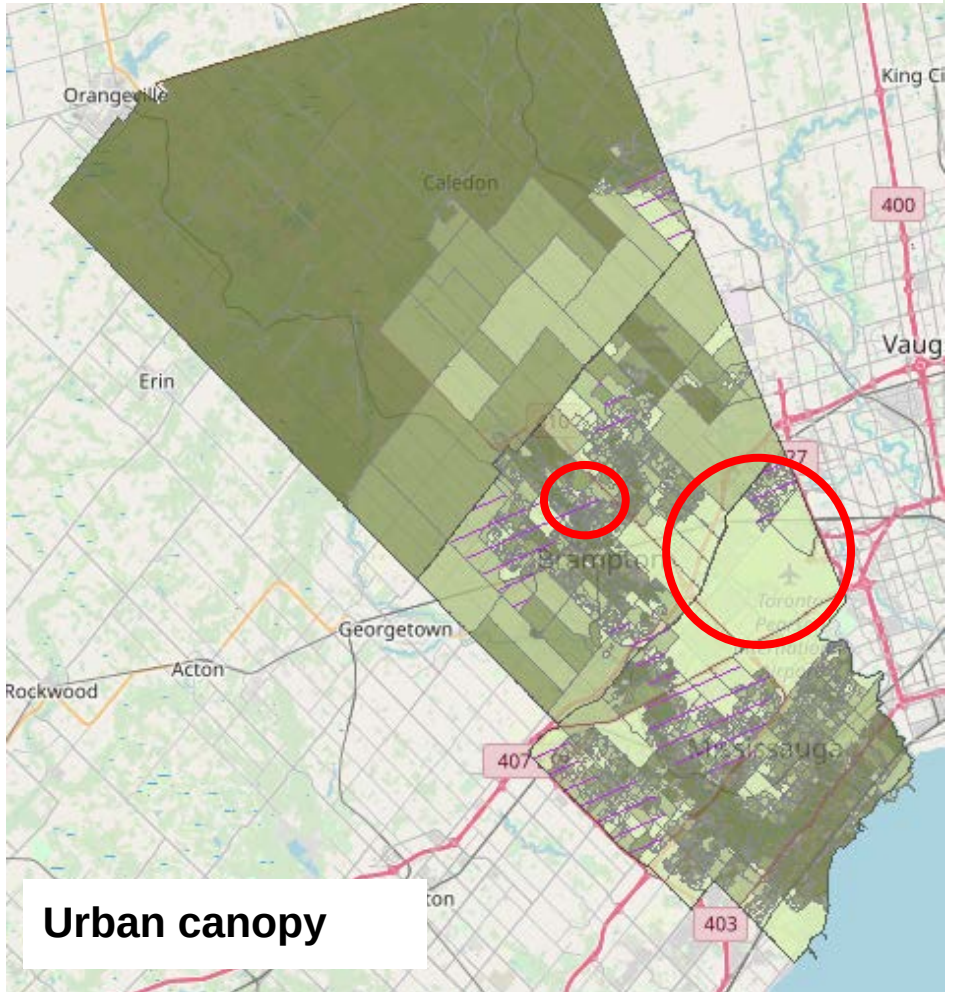
- 55% of Peel's terrestrial system is highly vulnerable, mostly in urban and urbanizing areas
- Increasing trend, especially as urbanization expands
- Complex interactions
    - Degradation of ecosystem functions and services (e.g. habitat, water management, heat regulation)
    - Decreasing landscape connectivity and fragmentation reduces adaptation capacity
    - Expanding urbanization exacerbates climate change impacts and vice versa – threat multiplier
    - Compromised resilience overall



Other Peel Application Examples



Heat vulnerability

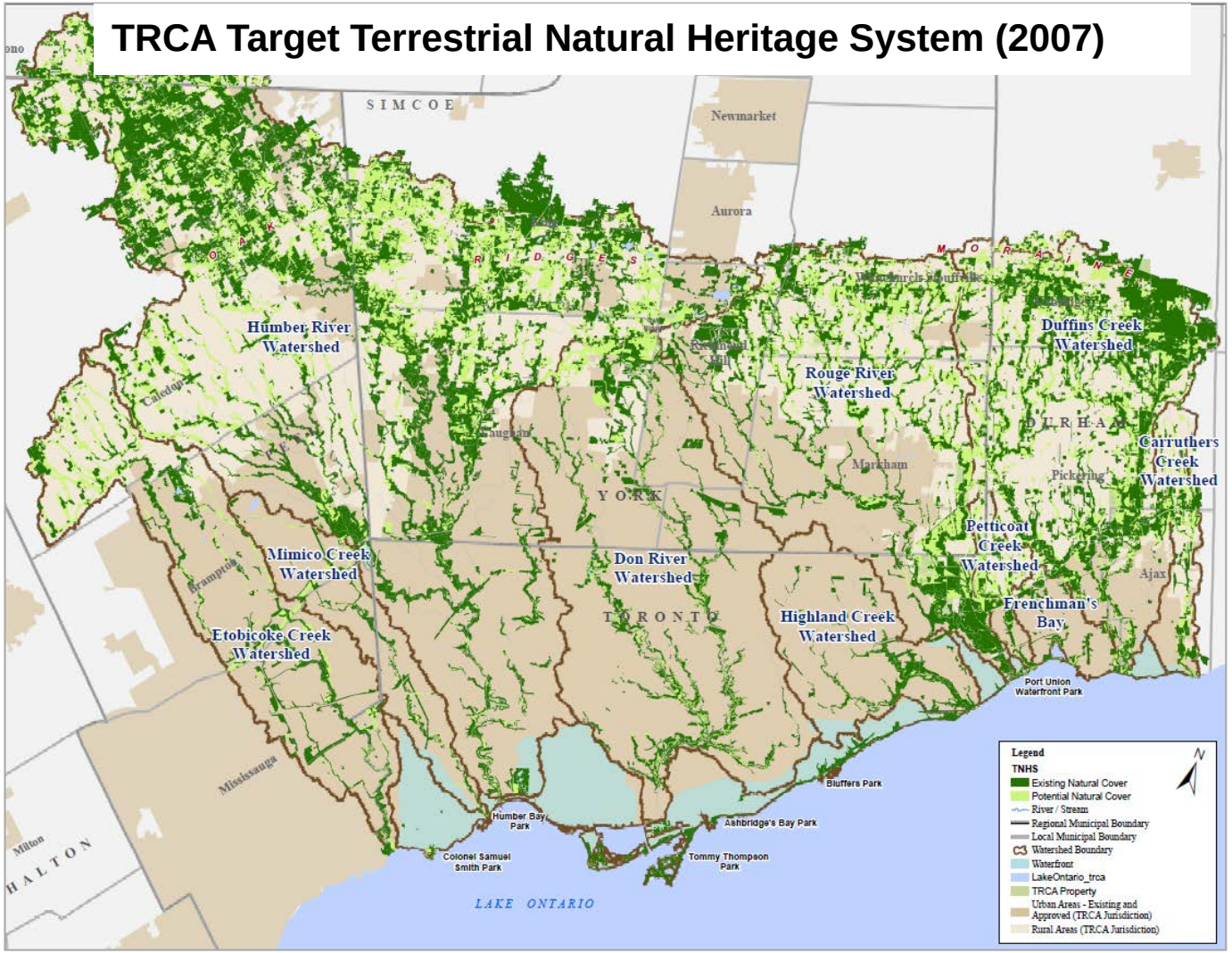


Urban canopy

Application Example

TRCA ROLLOUT & TNHS UPDATE (DRAFTS)

TRCA Target Terrestrial Natural Heritage System (2007)



TRCA
Terrestrial System
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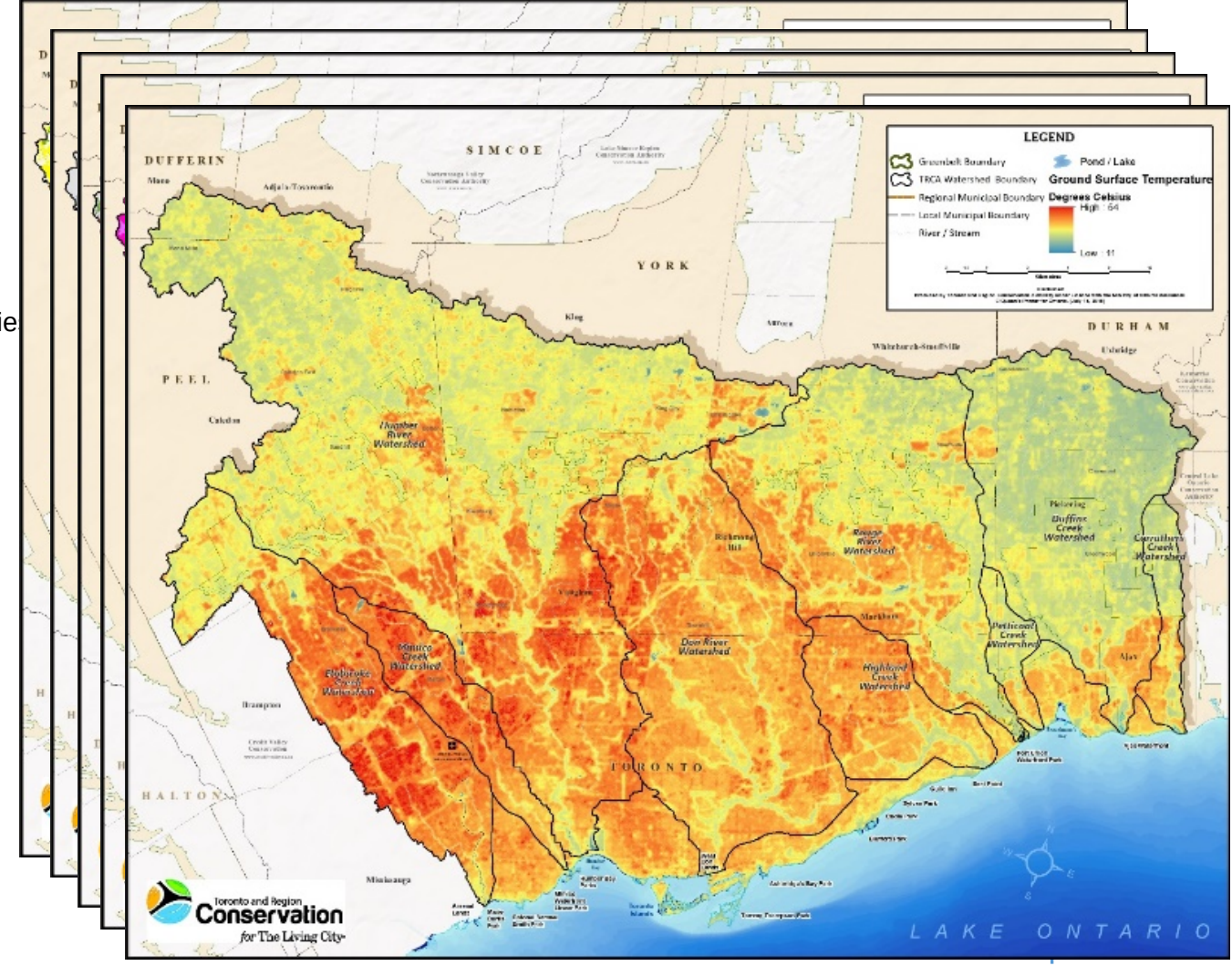
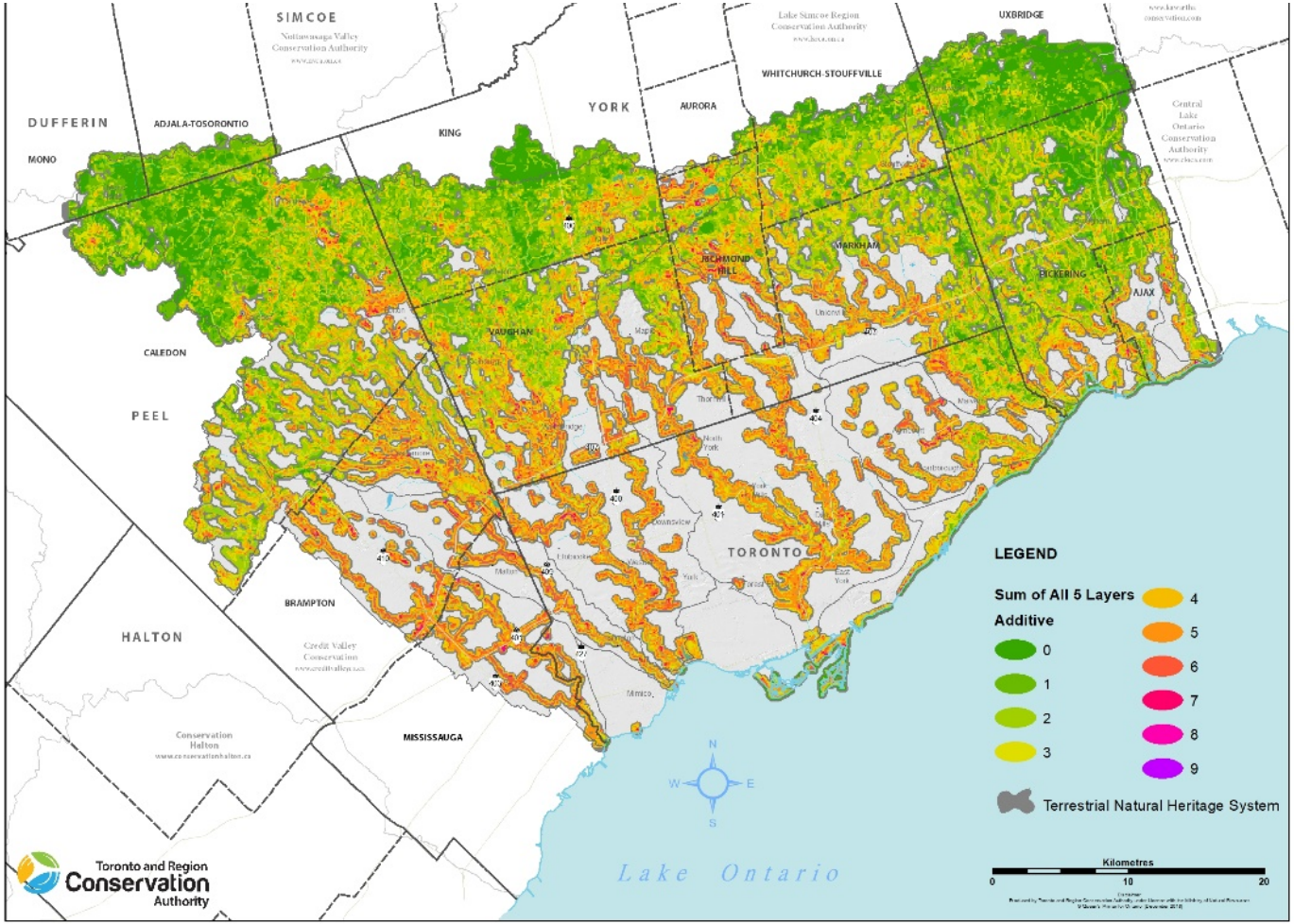
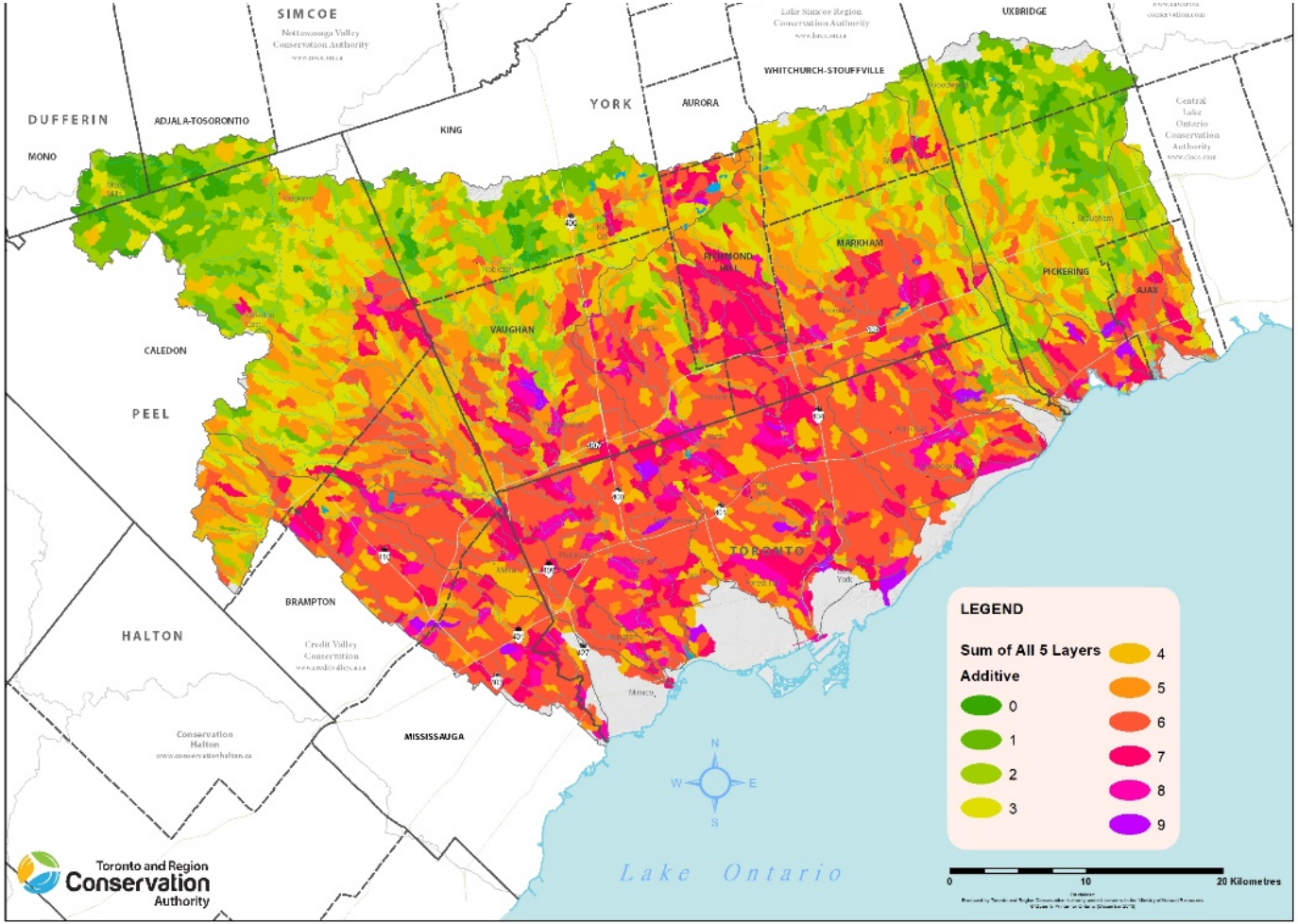
1. Habitat patch quality
2. Climate sensitive vegetation communitie
3. Wetland vulnerability
4. Soil drainage
5. Ground surface temperature



Climate Vulnerability of Target Terrestrial Natural Heritage System (2007)



Climate Vulnerabilities of the Integrated Restoration Planning Catchments



Moving forward…

1. Enhance resilience of natural infrastructures (e.g. forest, wetland, urban canopy) for ecosystem function and services
2. Account for the climate vulnerabilities in natural management (including protection, enhancement, restoration, and adaptation)
3. Incorporate climate adaptation in broader policy frameworks and implementation (including NHS, watershed planning, municipal official plans)
4. Increase connectivity of natural areas for climate adaptation and resilience
5. Promote effective collaboration and information sharing and partnership

THANK YOU!

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