Urban Heat Island Mapping Workshop

What We Heard

In partnership with

Centre d'enseignement et de recherche en foresterie de Sainte-Foy inc.

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Intact Centre on Climate Adaptation

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EXECUTIVE SUMMARY

What?	The effects of urban heat islands pose a threat to Canadians, our infrastructure, and environment. The Standards Council of Canada, alongside four leading organizations from across Canada, hosted a workshop in Fall 2022 to discuss how strengthening and standardizing urban heat island mapping practices and uses can contribute to safer and more climate-resilient communities across Canada. This report summarizes what we heard from over 40 subject matter experts and acts as a launching point for next steps to move towards national mapping standardization.
When & Where?	The workshop was conducted virtually, via Zoom, over two half-days: • Day One: Tuesday, October 4, 2022 from 1 p.m. to 4 p.m. • Day Two: Thursday, October 6, 2022 from 1 p.m. to 4 p.m.
Who?	The workshop was conceptualized and co-hosted by Centre d'enseignement et de recherche en foresterie de Sainte-Foy (CERFO), Health Canada, the Intact Centre on Climate Adaptation, National Research Council of Canada and Standards Council of Canada. Invited experts from federal, provincial, municipal, private sector and not-for-profit organizations joined from across Canada.
Why?	The objectives of the workshop were to: • Capture the current state of and demand/need for UHI mapping and related topics • Establish requirements for standardization of UHI mapping and related guidance • Identify potential challenges, opportunities and a path forward for standardization and guidance
How?	The workshop included introductory presentations about urban heat islands. During the workshop, participants shared their thoughts in small group discussions and contributed to a digital group whiteboard.
What We Heard	Several key themes emerged out of the ideas and insights generously shared by participants: • Consensus to move forward with national mapping standardization • A recognition of diverse users for UHI maps, who may have common needs and training and guidance requirements • The need to consider multiple variables and methodological considerations, and • Suggestions about improving effectiveness
Contact	Please direct all questions and comments about the workshop and the report to info@scc.ca

ABOUT

Communities across Canada are experiencing the effects of climate change. One anticipated consequence of climate change is an increase in the duration, frequency and intensity of extreme heat events. On average, Canada is warming at twice the global rate. By the mid-21st century, many parts of the country are projected to experience a doubling in the annual number of very hot days.[1]

The urban heat island (UHI) effect refers to warmer temperatures in urban areas compared to surrounding rural areas.[2] UHIs occur in highly developed areas where humans have altered the surface of the land through the construction of buildings, roads and other infrastructure.[3] In urban areas, surface daytime temperatures can be 10-15° hotter than in surrounding rural areas, and nighttime temperatures up to 12° hotter.[4]

Canadian cities face the greatest risk from extreme heat because of the UHI effect. Almost three in four Canadians live in cities: in 2021, 73.7 percent of Canadians lived in large urban centers. Furthermore, from 2016 to 2021, these cities accounted for most of Canada's population growth (+5.2 percent).[5]

One tool to better understand how communities will be impacted by increasing temperatures is the development of UHI maps. Diverse mapping methods exist in this area. As a result, comparability between maps can be challenging.

CONTEXT

In October 2022, Standards Council of Canada (SCC) hosted an Urban Heat Island Mapping Workshop to address these challenges. SCC hosted the workshop in partnership with Centre d'enseignement et de recherche en foresterie de Sainte-Foy (CERFO), Health Canada, the Intact Centre on Climate Adaptation and the National Research Council of Canada (NRC). The workshop was conducted entirely virtually, which allowed participants to use a digital whiteboard to capture their diverse thoughts and ideas.

Strengthening and standardizing UHI mapping practices and uses can contribute to safer and more climate-resilient communities across Canada. The **objectives** of the workshop were to:

- Capture the current state of UHI mapping and related topics
- Establish requirements for standardization of UHI mapping and related guidance
- Identify potential challenges, opportunities and a path forward for standardization and guidance

Approximately 40 participants attended the workshop. The invited experts represented federal, provincial, municipal, private sector and not-for-profit organizations across Canada. A **list of attendees** is included in Appendix A.

[1] *Reducing urban heat islands to protect health in Canadians*
[2] IBID
[3] IBID
[4] *Irreversible extreme heat: protecting Canadians and communities from a lethal future*
[5] Canada's large urban centres continue to grow and spread

Extremely hot temperatures can have a severe impact on human health, infrastructure, the natural world and municipal/government operations. Extreme heat:

- Is a significant public health issue in Canada; prolonged exposure to very hot temperatures without cooling intervals can pose a critical risk to human health
- Increases the demand for healthcare, emergency and social services
- Has a detrimental effect on the infrastructure and services that Canadians rely on; extreme heat can cause power outages, disrupt digital and telecommunications services, affect transportation infrastructure (such as warped rail tracks) and affect the quality of potable water
- Has a severely negative effect on natural systems (plants, animals, insects and bodies of water)

UHI mapping is one of many practical actions that can be taken to understand, communicate and reduce risk to Canadians, our urban environments and critical infrastructure. Some Canadian provinces and municipalities, such as Toronto, Vancouver and Montreal, have already created urban heat island maps. While there is a growing body of knowledge and a general awareness of the need for more mapping, there is currently no national-level guidance on how to develop and apply it.

To ensure the climate resiliency of Canada's built and natural infrastructure, it is critical to develop standards. Much of the infrastructure that exists today was designed, built and operated using standards that were developed for a stable climate. As our climate changes, older standards are no longer enough to keep Canadians safe.

Since 2016, SCC's Standards to *Support Resilience in Infrastructure Program* has been working on addressing this gap. The program has led the development of standards and related guidance to help communities, businesses, builders and infrastructure operators adapt to climate change.

The intent of the Urban Heat Island Mapping Workshop was to determine a need for standardization, identify possible audiences, clarify their needs and develop an actionable roadmap to enable and accelerate coordinated action on UHI mapping across Canada.

WHAT WE HEARD: THEMES

The following five key themes emerged from the workshop:

- There was widespread **consensus** to move forward with national mapping standardization
- A recognition that the users of UHI maps are, and will be, diverse and that they use mapping for different purposes; however, these audiences may have **common needs** and similar training and guidance requirements
- There are **many possible mapping variables to consider** when moving forward with standardization, and these will need to be reconciled
- There are **multiple mapping methodologies** in use across Canada and these will also need to be reconciled
- Focusing on the **effectiveness of UHI mapping**, and the resultant risk reduction, will also be important

Support for national mapping standardization

There was consensus amongst participants that there is a need for a standardized approach to developing UHI maps.

Participants noted that there is no clear threshold for defining an urban heat island, and that although various jurisdictions have already created urban heat maps, it's not clear how existing mapping tools compare. There is a need to consolidate, analyze and reconcile the various definitions and methodologies currently used in Canada.

Participants also indicated that there appears to be no coordinated effort amongst the different entities involved in current UHI initiatives. Several participants observed that although Environment and Climate Change Canada (ECCC) has nearly completed surface temperature mapping across Canada that can be scaled to the municipal level, this information may not fit communities' needs for future heat mapping.

Organizations from across Canada shared a desire to work together to develop an integrated approach to developing useful, accurate, and effective urban heat maps. SCC, given its mandate, could play a role in facilitating this process.

Participants observed that the data collection techniques used to create UHI maps can be expensive, making it difficult for smaller municipalities to develop urban heat maps on their own.

Participants also noted that in terms of UHI mapping advancement, there is significant disparity between different provinces and territories. The availability of relevant and reliable data also varies by province and territory. To overcome these challenges, a national, coordinated effort is required to
1) determine an agreed-upon methodology(ies) to develop UHI maps, and
2) ensure the data required to develop these maps is made available to communities and organizations across the country.

Diverse mapping users

There are diverse users and audiences who would benefit from a standardized approach to UHI mapping.

These include users in sectors such as health and social services, public and residential infrastructure, urban forestry, municipalities, provincial and federal governments and the general public.

One of the main challenges to standardizing urban heat mapping is that these users and audiences have differing (and evolving) needs.

Participants in **health and social sectors** expressed a need to:

- Identify populations and areas vulnerable to extreme heat, to prioritize the implementation of climate adaptation/mitigation measures and UHI-reduction actions
- Forecast extreme heat events, to plan mitigation measures
- Evaluate the effectiveness of UHI adaptation and reduction efforts

Participants representing the **environmental sector** expressed a need to:

- Understand the impact of urban trees and vegetation on extreme heat and represent these impacts in forecasting models
- Measure the ecological services of trees (such as cooling benefits and impact on human health)
- Model ecosystem response and spread of invasive species
- Identify suitable locations for reforestation / tree planting efforts
- Determine the life span of trees and vegetation coverage

Participants from the infrastructure and urban planning sectors shared a need to:

- Understand the impact of temperature extremes on infrastructure such as housing, buildings, and bridges and the durability of materials (for example, sun kinks in rail lines)
- Identify infrastructure that is most vulnerable to the effects of extreme heat, to target retrofits and interventions
- Understand how climate change will affect indoor heat, energy consumption and greenhouse gas (GHG) emissions
- Combine multiple hazard data (flood and wildfire data, for example) to inform multi-faceted risk assessments
- Understand the impact of the physical / spatial environment on the UHI effect (for example, paved areas, bodies of water and greenspace) to adapt urban planning to mitigate the effects of extreme heat
- Assess a community's vulnerability to climate change, as well as its adaptive capacity
- Use UHI mapping to inform municipal building policies that guide developers (such as Official Plans)

Other **orders of government** (including provincial, territorial and federal) expressed a need to:

- Understand projected heat risk to develop and enact effective policy and programs
- Understand the big picture; a uniform integrated risk index, that can be adopted by all jurisdictions, similar to the Air Quality Health Index, would be an efficient way to address government needs in mapping
- Be able to layer urban heat maps with other datasets relevant to the context and jurisdiction in question
- Understand end-user needs to develop useful UHI maps (since higher levels of government tend to be producers, rather than users, of UHI maps)

Members of the **public** need:

- Clear, accessible information to understand risks associated with extremely hot temperatures where they live
- Current and projected information on local extreme heat events (an extreme heat forecasting system, for example)
- The ability to locate critical resources, such as cooling centres and shade structures
- The ability to identify adaptation/mitigation measures that can be undertaken at the individual and community level

After discussing their unique needs, participants were asked if these sectors required a separate map. Of the categories discussed, the only group that participants (unanimously) felt would have a need for a distinct map was the general public.

Some of the **training-related ideas** that were mentioned included using or developing:

- Videos to demonstrate how to use maps
- Interactive elements such as buttons to explain functions
- End-users as testers
- A basic user guidebook
- An open-source portal for users to download information

Results of in-workshop voting

Sector	Does this audience require a **unique map?**	Does this audience require **unique training or guidance** on creating maps?
Health and Social Services	**Yes** (majority)	**Yes** (majority)
Infrastructure, Buildings & Housing	**No** (unanimous)	**Yes** (majority)
Urban Forestry	No (unanimous)	**Yes** (majority)
Municipalities	**Yes** (majority)	Undecided
Government	**No** (majority)	**No** (majority)
General Public	**Yes** (unanimous)	**No** (majority)

Variables to consider

There are many variables (and resolutions) to consider when standardizing mapping and overlaying relevant data/indices to support different users. As the standardization process moves forward, these will need to be reconciled with subject matter experts. These variables include, but are not limited to:

Observational weather data:

- Outdoor temperature measurements, including: surface temperature, air temperature, canopy temperature, land temperature and radiant temperature
- Indoor temperature
- Nighttime temperatures
- Temporal variables: past, current and forecast (short-term and long-term) temperatures
- Data on air quality

Calculated indices:

- Thermal comfort and related variables, such as humidity and air velocity
- Heat Stress Index
- Universal Thermal Climate Index (UTCI)

Human variables that could be reflected

- Demographic data, such as age, race and gender
- Socioeconomic data, such as education, income and employment
- Health data, such as data on the social determinants of health and pre-existing health conditions
- Qualitative data on people's lived experience

Environmental data:

- Variables related to urban trees such as canopy coverage, tree species and location of specific trees
- Data on other urban vegetation coverage
- Data on bodies of water, such as lakes and streams (also referred to as "blue infrastructure")
- Variables that are relevant for reforestation and tree planting efforts, such as data on soil type, soil volume and the presence of utilities, including overhead wires

Features related to the built environment:

- Data on buildings and housing, such as use and density
- Availability of active/passive cooling/air conditioning
- GHG emissions
- Impervious surface coverage
- Location of cooling centres, water fountains, and shade structures
- Data related to materials, such as thermal performance, heat threshold, heat transfer and insulation measures

Climate data:

- Severity of heat waves in urban areas (for example, the number of extremely hot days experienced per year)
- Duration of UHI effect (hours per day, for example)
- Vulnerability to climate change (data on a community's exposure, sensitivity and adaptive capacity)

Participants raised questions about the quality of data that would be included in standardized maps:

- Is point-in time-data, such as nighttime temperature, acceptable?
- Should maps differentiate surface temperature and thermal comfort?
- How important is the currency of data?

Other issues related to variables noted by participants included:

- There are varying definitions of what constitutes a safe temperature
- Consider the use of absolute vs. relative temperature measures
- There is a need for higher resolution data and more granular data (at the neighbourhood or building level, for example)

Participants reported that all audience types would benefit from temperature mapping and that all users, with the exception of the general public, where the results were uncertain, would value thermal comfort information.

Results of in-workshop voting

Sector	Does this audience require **temperature mapping**?	Does this audience require **thermal comfort information**?
Health and Social Services	**Yes** (majority)	**Yes** (majority)
Infrastructure, Buildings & Housing	**Yes** (unanimous)	**Yes** (majority)
Urban Forestry	**Yes** (unanimous)	**Yes** (majority)
Municipalities	**Yes** (unanimous)	**Yes** (majority)
Government	**Yes** (unanimous)	**Yes** (majority)
General Public	**Yes** (unanimous)	Undecided

Methodological considerations

Participants observed that there are different mapping methodologies in use across Canada. Currently, no single methodology fits the needs of all potential users. A number of these mapping initiatives are included in Appendix B.

As standardization moves forward, methodologies are available to build on, including:

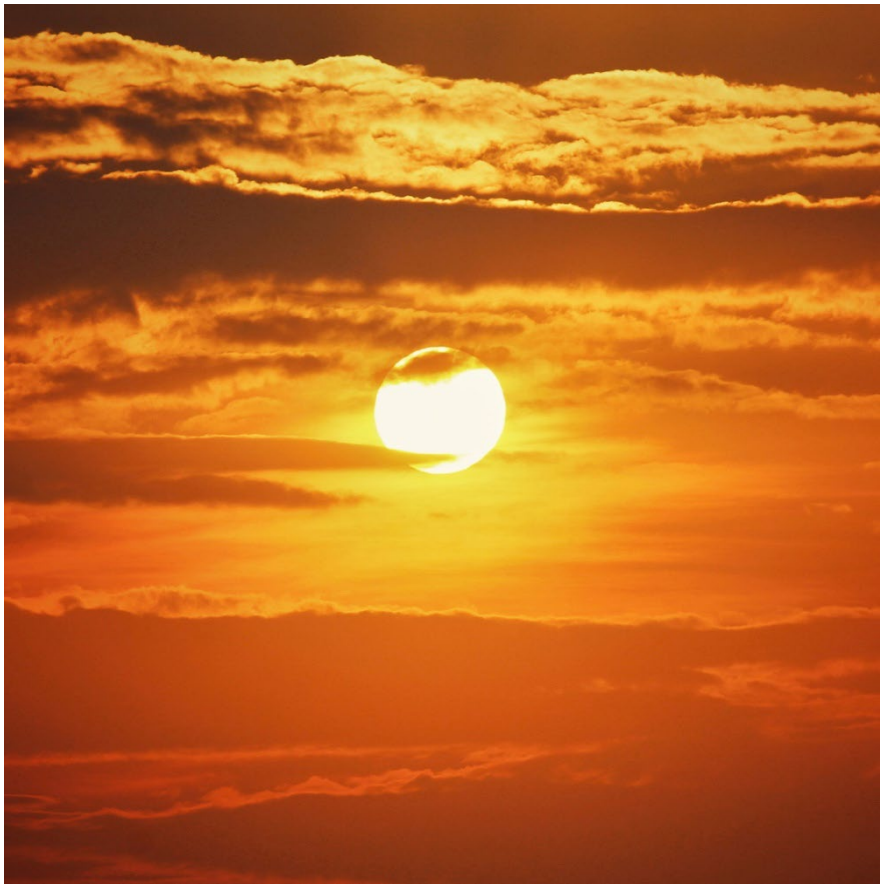
- Satellite imagery (Landsat and MODIS)
- Airborne imagery, such as thermal hyperspectral and thermal band imaging
- Sensors (such as remote sensors, ground-based sensors, and air temperature sensors)

To optimize the utility of the resultant mapping tool(s), participants noted that any proposed methodology should:

- Allow users to overlay maps with different datasets and toggle between layers
- Take into consideration the subjective human experience (thermal comfort, for example) as well as more objective indicators/measures
- Include the UTCI and/or Heat Stress Index as parameters
- Be coupled with satellite data that will be updated based on demographic and land use changes in urban areas
- Fit Canada's climatic conditions from coast to coast
- Include the ability to track changes of specific indicators over time

Participants also noted that:

- The process of converting data into useful information needs to be automated as much as possible ("automate processes to make the data speak")
- It may be worth examining other standardized approaches used to assess climate hazards, such as flood risk mapping or the Saffir Simpson hurricane wind scale, to see if they offer useful principles or elements that could be incorporated into UHI mapping



Improving effectiveness

Participants flagged the need to focus on the effectiveness of UHI mapping, including the resultant risk reduction associated with using maps.

Participants recognized that urban heat mapping has limitations and there is no current one-size-fits all mapping tool or methodology. However, there was a consensus that to accurately assess the impacts of UHIs, integrated analysis is required. Participants agreed that there is a need to develop a clear and simple integrated risk index that can be applied uniformly across Canada, similar to the Air Quality Health Index.

To be effective, a standardized mapping tool will need to:

- Utilize the most robust datasets
- Focus on and prioritize areas of greatest need
- Allow users to overlay heat maps with data from other sources, so they can see multiple layers of information in a single portal and tailor the information to their specific needs

Participants also discussed how UHI maps could be used to evaluate the effectiveness of risk reduction and adaptation strategies. To assess the effectiveness of specific strategies, any proposed mapping tool(s) will need to:

- Track and measure how key indicators change over time
- Track changes "on the ground," at a neighbourhood level ("satellite level [information] is not enough")
- Enable users to identify and assess linkages ("connect the dots") between different datasets (for example, the correlation between health indicators and increased urban greenery)

Participants also observed that:

- Any proposed mapping tool(s) should be regularly assessed (every five years, for example) to track its impact and measure success
- Other sectors have implemented codes and standards for assessing the effectiveness of climate mitigation strategies such as the Cool Roof Rating Council and their specific rating programs. Some of the principles used in these assessment schemes could be applied to a proposed mapping tool.
- Case studies may be a useful tool for measuring effectiveness and supporting the development of standards
- Maps may be useful tools for promoting transparency of available data

NEXT STEPS

This workshop resulted in a clear conclusion that there is a need for national urban heat island mapping standardization.

As seen in the advancement process image from SCC, below, there are many more steps before wider adoption of mapping standards.

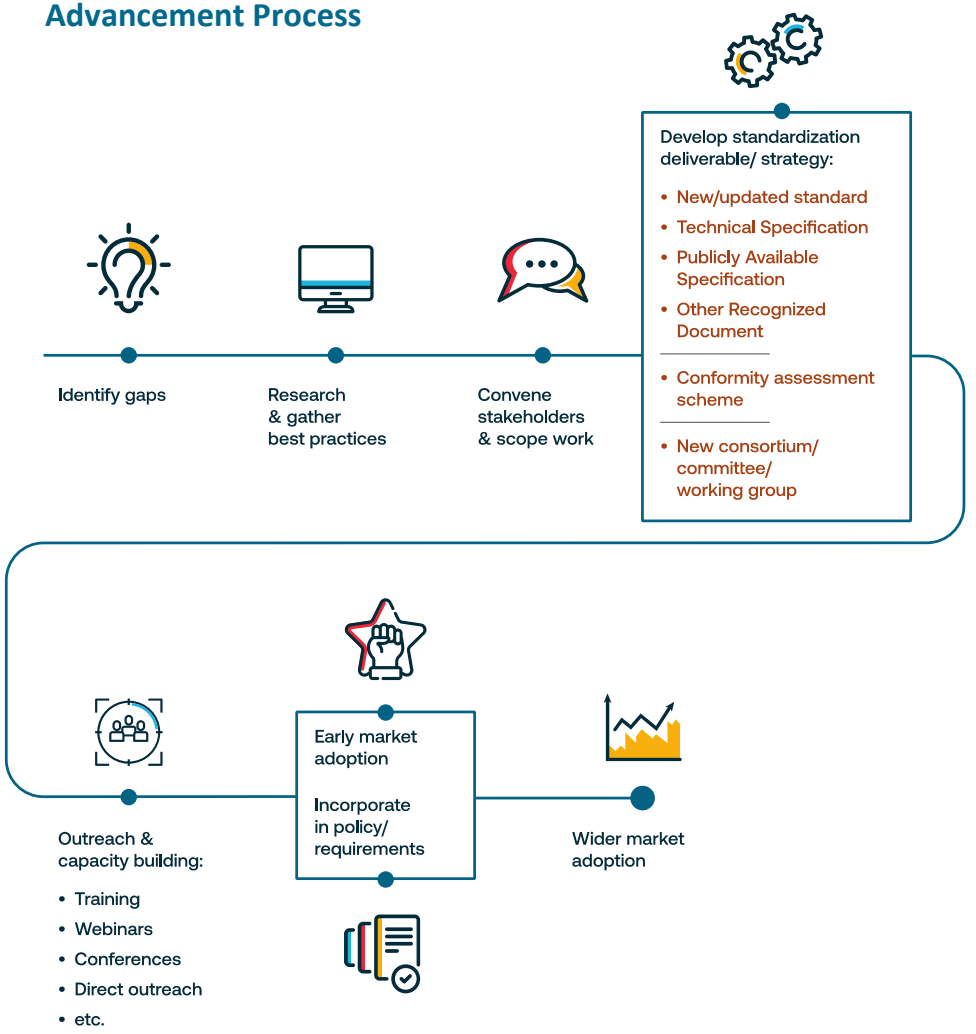
There is a role for many organizations across Canada to play in the next steps to advance that process.

This workshop served to explore some of the objectives and needs that will feed into the development and refinement of UHI mapping standards.

Questions and comments on this report are welcome.

Please contact info@scc.ca

National Standardization Strategies Advancement Process



APPENDIX A: PARTICIPANTS AND PROJECT TEAM

Participants

Name	Position	Organization
Abhishek Gaur	Research Officer	National Research Council of Canada
Alex Hayes	Research Associate	National Research Council of Canada
Anders Knugby	Associate Professor	University of Ottawa
Anil Parekh	Senior Researcher, Buildings and Renewables Group	Natural Resources Canada
Aziz Laouadi	Senior Research Officer	National Research Council of Canada
Birgit Isernhagen	Program Planning and Evaluation Officer, Health Hazard Response, Health Protection Services	Ottawa Public Health
Brooklyn Rocco	Planner, Healthy Environments	Vancouver Coastal Health
Connie Pinto	Forestry Policy and Planning	City of Toronto
Daniel Thompson	Forest Fire Research Scientist	Natural Resources Canada
Daniel Figueras	Canadian Centre for Meteorological and Environmental Prediction	Environment and Climate Change Canada
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Elaine Barrow	Senior Advisor, Canadian Centre for Climate Services	Environment and Climate Change Canada
Elly Tseng	Environmental Health Officer	Vancouver Coastal Health
Emily Rideout	Sustainable Development Programs Officer	National Capital Commission

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Heather Macdonald	Interdisciplinary Social Scientist	Natural Resources Canada
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Marianne Armstrong	Initiative Leader, Climate Resilient Built Environment (CRBE)	National Research Council of Canada
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Megan Ho	-	City of Toronto
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Ray Bustinza	Physician	Institut national de santé publique du Québec (INSPQ)
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Rong Yu	Senior Planner, Programs and Strategies, Urban Design, City Planning Division	City of Toronto
Sharon Lam	Project Manager, Ecosystem and Climate Science	Toronto and Region Conservation Authority
Shayna Stott	Environmental Planner	City of Toronto
Sylvie Leroyer	Research Scientist	Environment and Climate Change Canada
Victor Daramola	Geo-Environmental Technologist	City of Edmonton

Project Team

Name	Position	Organization
Paddy Enright	Policy Analyst, Climate Change and Innovation Bureau	Health Canada
Joanna Eyquem	Managing Director, Climate-Resilient Infrastructure	Intact Centre on Climate Adaptation
Zahra Jandaghian	Research Officer, CRBE – Nature-Based Solutions Leader, Construction Research Center	National Research Council of Canada
Kala Pendakur	Sector Specialist	Standards Council of Canada
Gregory Richardson	Senior Policy Analyst	Health Canada
Samuel Royer-Tardif	Director of Applied Research, Global Change and Forest Environment	CERFO
Mathieu Varin	Director of Forest Remote Sensing Research	CERFO
Amanda Kennedy and Mollie Roskies	Planning, logistics and facilitation	Kennedy Consulting
Daniele and Pascale	Simultaneous translators	RWS

APPENDIX B: ONGOING MAPPING INITIATIVES

National-Level Initiatives

Organization	Name	Description
Environment and Climate Change Canada	MSC GeoMet	• The MSC GeoMet platform provides public access to the Meteorological Service of Canada and ECCC data via interoperable web services and application programming interfaces • Through open standards, users can freely and quickly access thousands of real-time and archived weather, climate and water datasets and products and integrate them in their domain-specific applications and decision support systems
	UHI map for the Greater Toronto Area	• UHI map at 2.5 km resolution • Includes prototype at 250 m based on historical datasets of humidity, irradiance and surface temperature
	Urban GEM Surf model	• Has the capability to map all Canadian cities and to provide modelled values of air temperature, humidity, surface temperature and thermal comfort measures (for example, UTCI, humidex)
	Ongoing R&D projects	• Ongoing projects based on model results, observations and urban environment variables (such as buildings and roads)
Health Canada	Urban heat islands tools and resources	• Tools and resources to help public health professionals advance actions to reduce UHIs
Nature Canada	*Canada's Urban Forests: Bringing the Canopy to All*	• Analyses of tree canopy coverage in in Vancouver, Abbotsford, Calgary, Toronto and Montreal

Provincial/Territorial-Level Initiatives

Organization	Name	Description
University of Laval	Atlas de vulnerabilité aux chaleurs extreme	• An interactive atlas of the vulnerability of the Quebec population to climatic hazards
CERFO and INSPQ	Mapping of heat and cool islands in urban Québec	• Mapping of relative temperature differences and classification of heat and cool islands. Two time periods are studied and compared (2013-2014 and 2021-2022)

Regional/Municipal-Level Initiatives (Canadian)

Organization	Name	Description
City of Montreal	Stations to measure summer temperatures	• Municipal initiative to study the impact of urban development on heat
City of Montreal	Vulnérabilité aux aléas climatiques de l'agglomération de Montréal	• Mapping tool that analyzes Montreal's vulnerability to climate hazards, including extreme heat
City of Toronto	Thermal Comfort Study	• Intended to address thermal comfort in the public realm and shared outdoor amenity spaces, taking into consideration future climate projections and the impacts of surrounding built form
Green Infrastructure Ontario	*State of the Urban Forest in the Greater Toronto Area* (report)	• Provides an overview of the state of the Greater Toronto Area urban forest
HealthyDesign.City	https://healthydesign.city/	• Learn about how your neighbourhood affects your health
Radio Canada	Here's who lives in your city's worst heat islands	• CBC News data analysis shows that immigrants and people with low income are most likely to live in the hottest urban areas
Regional Municipality of Peel	Peel Tree Planting Prioritization Tool	• A strategic decision-making tool for prioritizing possible tree planting
Vancouver Coastal Health	Climate Vulnerability Index Community Health & Climate Change (map) *Mapping spatial patterns in vulnerability to climate change-related health hazards* (technical report)	• Maps climate change-related health vulnerabilities • Measures how susceptible communities in the Vancouver Coastal Health and Fraser Health regions are to the health effects of extreme heat, wildfire smoke, flooding and air pollution
Toronto and Region Conservation Authority	Peel Heat Vulnerability Index	• A GIS-based extreme heat vulnerability index

Other Initiatives

Resource	Type	Description
ClimateData.ca	Website	• Provides high-resolution climate data to help decision makers build a more resilient Canada
Heat Story NYC	Website	• A story map combing UHI mapping with personal experience stories about extreme heat, as well as historical and demographic information that show how heat connects to social inequities and health disparities
Is the Urban Heat Island intensity relevant for heat mitigation studies?	Journal article	• Abstract can be found here
MyHEAT	Website	• Uses thermography to map energy loss of buildings
Risk Factor	Website	• Past, present and future risk projections based on peer-reviewed research from the world's leading climate modelers
Tree Equity Score	Website	• A map of tree cover in any city in the United States is too often a map of race and income
The Urban Climatic Map: A Methodology for Sustainable Urban Planning	Book	• Blurb can be found here
United States Geological Survey, Nighttime Landsat scenes	Website	• Search for and download nighttime Landsat scenes
World Meteorological Organization, Guide to Instruments and Methods of Observation	Report (see chapter on 'Urban Observations')	• Report can be found here
World Meteorological Organization, Guidance to Measuring, Modelling and Monitoring the Canopy Layer Urban Heat Island	Report – to be released shortly	• Draft document can be found here