URBAN HEAT ISLANDS: *A* Climate Change *Adaptation Strategy for Montreal*

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Summary

This study of climate change adaptation by a team of McGill graduate planning students evaluates urban heat islands (UHI) in Montreal. The mapping of UHI risk shows considerable variations in UHI severity and vulnerabilities across the city and within neighbourhoods. A block scale analysis of one mixed-use neighbourhood indicates that UHI severity depends on the number of trees, the extent of dark impermeable surfaces and the building size in the immediate vicinity. The team recommends a neighbourhood-focused approach to UHI adaptation, with climate-sensitive private and public investments to help increase vegetation coverage and reduce areas of dark impermeable surfaces.

Résumé

Cette étude d'adaptation aux changements climatiques, menée par une équipe d'étudiants diplômés en urbanisme de l'Université McGill, évalue les îlots thermiques urbains à Montréal. La cartographie des risques de ces îlots démontre des variations considérables de sévérité et de vulnérabilité des îlots à travers la ville et dans divers quartiers. L'analyse à l'échelle d'un pâté de maisons dans un secteur à usage mixte révèle que la sévérité de l'îlot thermique dépend du nombre d'arbres, de l'étendue des surfaces imperméables foncées et de la taille des édifices dans les environs immédiats. L'équipe recommande une approche par quartier à l'adaptation aux îlots thermiques urbains, avec des investissements privés et publics adaptés au climat visant à accroître le couvert végétal et à réduire la superficie de surfaces imperméables foncées.

Adapting to climate change is quickly becoming a major policy concern in many cities across Canada. As the climate changes, more pronounced urban heat island (UHI) effects are likely to increase human mortality and disease, air pollution, energy consumption, and to accelerate infrastructure deterioration. A UHI is the phenomenon that occurs when the air temperature in an urban area is higher than in surrounding areas. An area where the population is at risk from UHI effects is one where the occurrence, exposure, and human vulnerability to heat are most pronounced. Cities must develop effective ways to identify areas of high UHI risk and implement appropriate adaptation measures. This is a particular concern for cities in Canada that face increased risk of severe heat waves and whose populations may be less well adapted to such events.[1]

This study was carried out as part of a studio class by four McGill University graduate planning students in the fall of 2007. The focus of the study was to assess UHI risk to human health in residential areas of Montreal, and to propose physical interventions to reduce that risk. With the use of a geographic information system (GIS)-based tool, the study team created a UHI risk map for the island of Montreal by combining air temperature data[2] and select demographic data (*i.e.,* residential concentrations of low income households, infant and elderly residents, and the elderly living alone). A neighbourhood with a high UHI risk rating in the Saint Michel borough of Montreal was then studied in greater detail to determine the causes of local UHIs and to identify ways to diminish UHI risk.

Defining UHIs and the question of scale

UHIs can and should be studied at multiple geographic scales. At the regional scale, the urbanized area of a metropolitan region constitutes a UHI in its entirety. At the city-wide scale, a large industrial zone or big-box commercial development may constitute a heat island as compared to its immediate surroundings. At the city block scale, a black asphalt road may constitute a heat island in comparison with a vegetated front yard. For this study, relaive UHI risks were identified at the scale of the island of Montreal. Subsequently, the study team selected one neighbourhood for a study of UHIs at the city block scale.

Elements of risk: occurrence, exposure, and vulnerability

UHIs can occur in areas with low vegetation coverage, low albedo (*i.e.,* surface reflectivity), high thermal mass of buildings, or high waste heat production. The scientific literature reveals that the extent and severity of a particular UHI is highly localized. Therefore, the cooling effects of large parks dissipate only a few metres beyond their borders.[3] This suggests that UHIs will not be significantly reduced through a series of large parks; rather, interventions at the level of streets and buildings are necessary.

Exposure to UHIs can increase as a result of poor building conditions such as lack of ventilation and proper insulation, building height, lack of access to cool

places, and social marginalization.[4,5] Human vulnerability to UHIs is exacerbated by air pollution and poor health. Groups particularly at risk to UHIs include low income households, the sick, the very young, the elderly, and people living in areas with high air pollution.[6]

Adaptation strategies

A range of potential UHI adaptation strategies exists. They include increasing biomass through tree planting, green space creation and preservation, and the installation of green roofs and living walls.[7] To increase albedo, cities have encouraged the use of light paving materials and light-coloured roofs (*e.g.,* white painted roofs). Climate-sensitive architecture and urban design and the regulation of building materials can help counteract the effects of high thermal mass in buildings and heat trapping street geometries. Urban design studies, for example, have focused on the size of lots in new subdivisions, and the size, location and arrangement of buildings within lots.[8] Finally, waste heat reduction may be accomplished through more efficient appliances, building energy retrofits and vehicle anti-idling laws.

UHI risk on the island of Montreal

For this study, the team developed a UHI risk map for the island of Montreal utilizing a GIS tool and air temperature data. The air temperature data layer was overlaid with three human vulnerability data layers: the density of people living in poverty, children under the age of five and adults over 65, and people over 65 living alone.[9] The values from each data layer were combined to produce UHI risk ratings for each geographic unit. Figure 1 shows a map of these UHI risk ratings across the island of Montreal.

Based on the mapping of UHI risks for the island of Montreal the following key lessons were learned:

- The most severe UHIs in Montreal occur in areas characterized by large-scale industrial and commercial uses, where dark-surfaced buildings and parking lots predominate. Few people live in these areas. Therefore, vulnerable populations are rarely exposed to the most severe UHIs when at home.
- However, areas with high proportions of vulnerable individuals are often located in close proximity to industrial and commercial areas where severe UHIs occur. These heat islands may affect nearby residents who work or shop in those areas or pass through them.
- Many vulnerable residents are exposed to relatively significant UHIs in central neighbourhoods of Montreal with low vegetation coverage and high levels of dark impermeable surfaces.

A UHI adaptation plan for Saint Michel

The site selected for detailed study is located in the Montreal borough of Saint Michel. It is a densely populated area home to many immigrants. When compared with the City of Montreal, the average income of local residents is lower, and a greater proportion of residents live in poverty, as indicated by Statistics Canada's low income cut-off measure. Several of the hottest UHIs on the island dot the area.

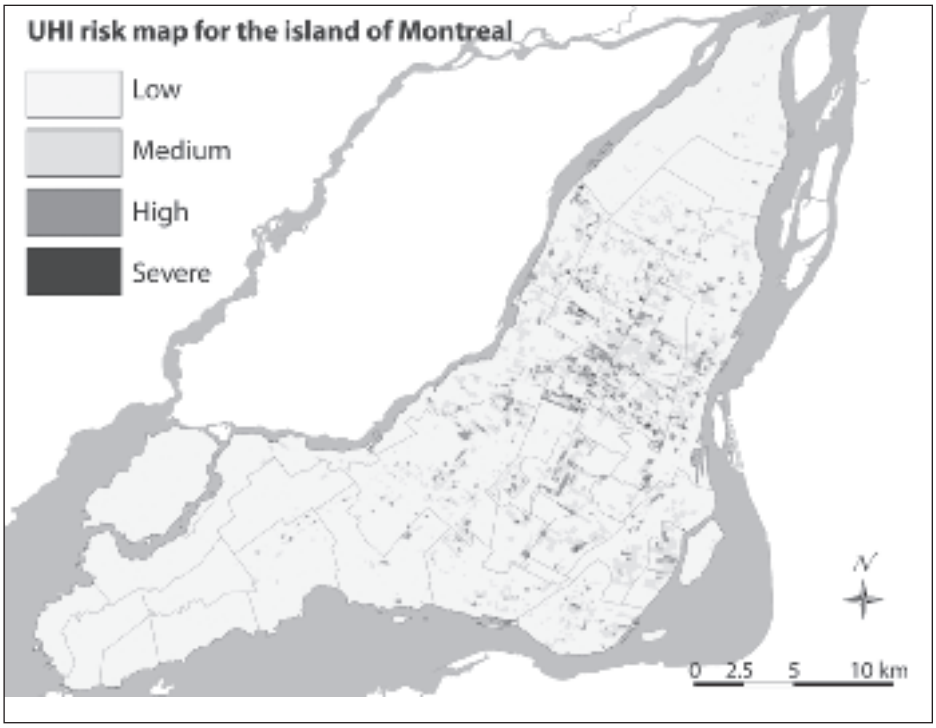
An analysis of Saint Michel's built form confirms the importance of biomass, albedo and thermal mass to the intensity of UHIs (waste heat is not known to be a significant factor on this site). The analysis was conducted by first dividing the study area's urban form into five typical block types. Each block type was defined by its most prevalent built form and use (*e.g.,* multi-unit attached residential, large scale commercial and institutional). Various physical characteristics of each block type were examined, including the number of storeys of the typical building, the nature of front and back yard uses (*e.g.,* gardens, paved driveways), the percentage of the block covered by buildings, and the prevalence of trees. Finally, the temperature map was studied to identify differences in UHI intensity from block to block.

The analysis suggests that a lack of biomass contributes to UHIs in several residential blocks. In nearby areas with more trees, lower temperatures are found. Areas with a higher percentage of impermeable, low-albedo surfaces (*e.g.,* dark coloured pavement and roofs) and with larger buildings experience higher temperatures. An example of this block type analysis showing the area covered by vegetation and various surface types can be seen in Figure 2.

The study team recommends a plan of action for reducing UHI risk in Saint Michel, grounded on four guiding principles:

- Give priority to residential areas facing the greatest risk.

FIGURE 1



- Create a new cool site with every new construction.
- Engage all stakeholders in a long-term 'Cool Saint Michel' campaign.
- Implement cooling measures for street corridors.

Because the causes and effects of UHIs are highly localized, the plan contains a separate set of recommendations for each one of five representative block types found in Saint Michel. Physical, socioeconomic and land use characteristics of each block type dictate the types of measures recommended. For example, green roofs are recommended for new development in an industrial zone. Light-coloured roofs (a less costly measure) are deemed more appropriate in residential blocks.

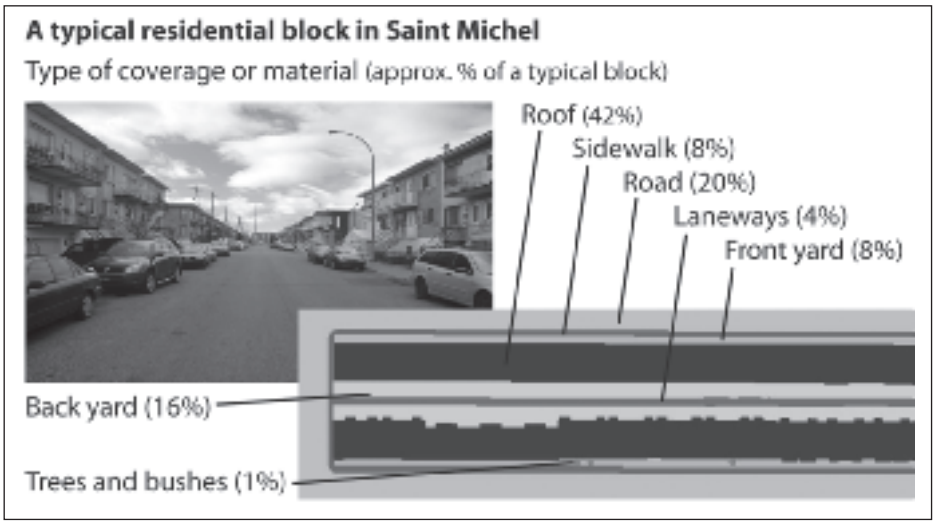
The planting, preservation and maintenance of trees throughout Saint Michel, on both public and private property, are key objectives of many of the actions recommended. One difficulty is the very limited space available for trees along certain streets. The team recommends narrowing the roadways to create wider front yards. Several blocks contain paved back alleys which are public rights-of-way. These alleys, which have no garages or driveways adjoining them and are not cleared of snow in winter, appeared to be little used. The team believes these alleys offer excellent opportunities for significant greening of the neighbourhood, through a mix of private and public planting and maintenance efforts.

With regard to new construction, of special interest is a large shopping centre proposed for a site adjacent to the study area. Given the size of the development and its proximity to vulnerable populations, it could aggravate UHI risks in the area if developed improperly. Conversely, the development could be a catalyst as well as a great resource for a neighbourhood-wide UHI adaptation campaign. The team urges careful evaluation of UHI impacts as part of the environmental assessment of this significant new development.

Conclusion

The severity of the UHI threat to human health is considerable and is likely to intensify as the climate changes. While global action may be beyond the jurisdiction of local officials, many aspects of the physical urban environment subject to local control are key causes of UHIs. These include the hard paving of surfaces, low vegetation coverage, the design and materials used in building, and the production of waste heat.

FIGURE 2



UHI adaptation must proceed at the neighbourhood scale, responding to local physical, demographic, and socioeconomic characteristics. The set of effective and possible adaptation strategies will be different from one area to another. Clearly, more and better data needs to be collected in order to assess UHIs and measure the relative temperature reduction potential of different strategies for Montreal. Specifically, all costs and benefits of various alternatives across multiple time scales and synergies with existing projects and other municipal objectives need to be considered. However, the lack of complete data cannot be an excuse for inaction. The gravity of the UHI threat demands a prompt and effective response.

While this report focuses on physical interventions, addressing human vulnerabilities directly through improved health and social services and education about climate change, presents another major avenue for UHI adaptation. It is significant that the areas of highest UHI risk are often burdened with other urban problems, including unemployment, high levels of crime, and low levels of education. The needs of places like Saint Michel are acute in many respects other than UHI risk. UHI adaptation measures that address

numerous issues should be adopted to achieve the most impacts given limited resources.

In carrying out this study, the team collaborated with geographers, health specialists, planners, and experts in other fields. It is clear that further progress requires ongoing collaboration between many different disciplines. For planners, effective adaptation will require a good understanding of complex scientific concepts. This is especially important as planners will need to explain these concepts to a public facing serious threats and possibly conflicting objectives. Ultimately, an engaged public and close interdisciplinary collaboration will be key for a successful adaptation strategy. ■

The authors are Master of Planning candidates at McGill University. Their final studio report, on which this article is based, can be viewed at: http://www.mcgill.ca/urbanplanning/research/studios/ They can be reached at: CCAP21@gmail.com

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"Wash Day" painting by Dave Squires

Clotheslines

by Ken O'Brien

A sunny day – the wind blowing – clothes flapping in the breeze. What could be more familiar? Yet in many places in Canada, clothes do not dry in the sun and flap in the wind. Whether by peer pressure or legal agreement, clotheslines are either forgotten or actively prohibited.

Solar and wind energy is freely available, so if people are burning electricity or natural gas in clothes dryers rather than hanging clothes outside, one must ask why. In Ontario, clothes dryers use about 900 kilowatt-hours of electricity per year on average, or about six percent (6%) of residential electricity consumption.[1] As planners, we should examine why this free energy is going to waste.

Some municipalities ban clotheslines in their by-laws. In other places, developers, residents' associations, or condominium corporations use legal agreements to prohibit them. These restrictions are usually in place for aesthetic reasons – people don't want to see other people's laundry on the line. However, if we are serious about reducing our energy use, we need to overcome this wasteful practice of using a clothes dryer.

Municipalities and other groups should evaluate their by-laws and agreements and repeal those which prohibit clotheslines. Several US states, such as Florida, Utah, and Hawaii, have enacted "right to dry" legislation. In Ontario and British Columbia, there are calls for a similar repeal of local restrictions.

Hand-in-hand with repeals, it would be worthwhile to promote not only the environmental benefits of outdoor clothes-drying, but also its role in reducing the household energy bill.

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Further Reading

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Government of Ontario Environmental Registry. Available at: http://www.ebr.gov.on.ca/ERS-WEB-External
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Project Laundry List. (They promote National Hanging Out Day in the US, April 19th). Available at: www.laundrylist.org