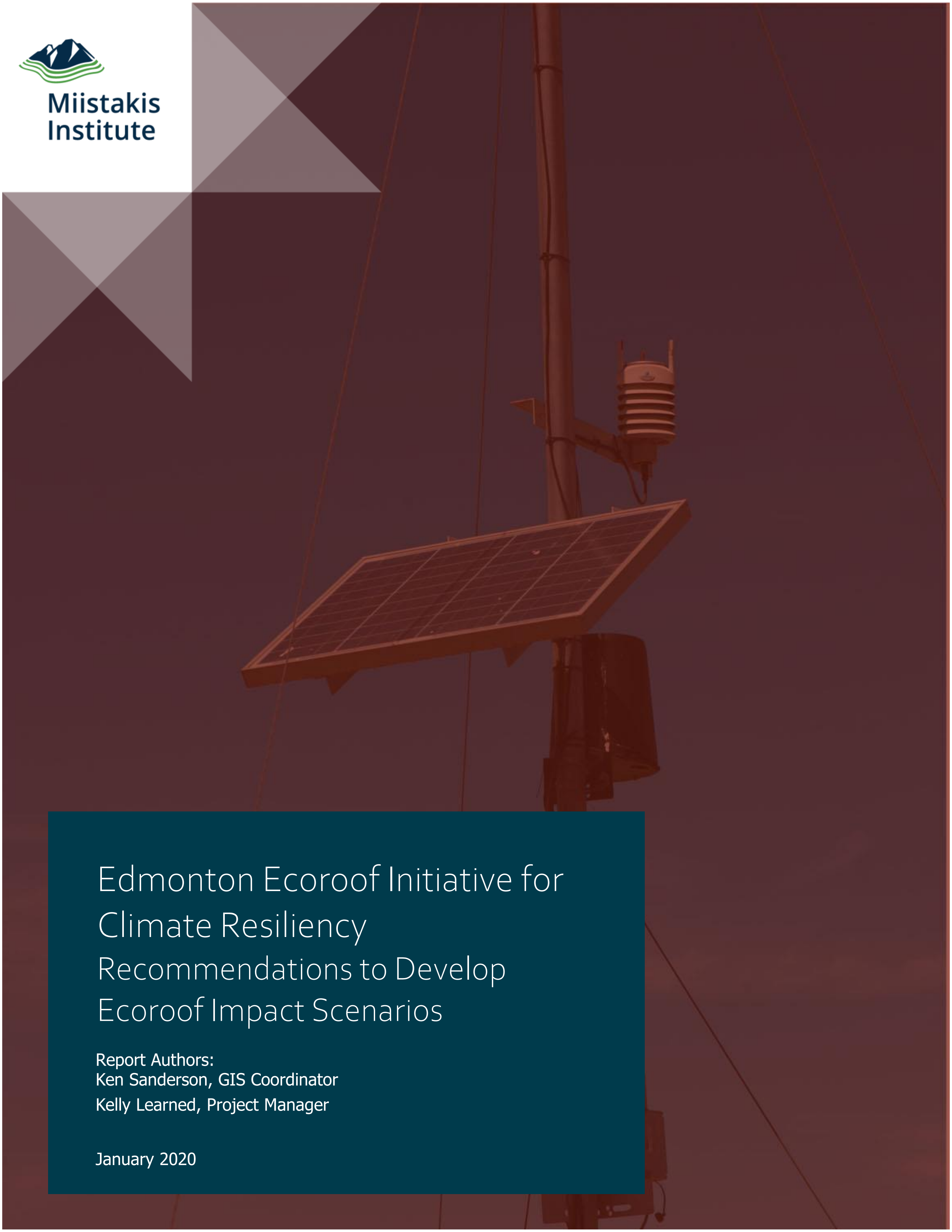

Miistakis Institute

Edmonton Ecoroof Initiative for Climate Resiliency

Recommendations to Develop Ecoroof Impact Scenarios

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January 2020

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Edmonton Ecoroof Initiative for Climate Resiliency: Recommendations to Develop Ecoroof Impact Scenarios

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January 2020

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Introduction

When the *Ecoroof Initiative for Climate Change Resiliency Initiative* was initially proposed, one of the objectives was to develop scenarios to measure the impacts of ecoroofs in Edmonton's context. As the project progressed, it was confirmed the baseline data required to do this work did not exist or was not available for the project team to use. Therefore, the focus shifted to recommending what data is required, and how to use the data to measure ecoroof impacts for Edmonton. To illustrate the methodologies, Miistakis used the Downtown Neighbourhood to establish roof area for 30% and 50% ecoroof coverage examples.

The project team chose the Downtown Neighbourhood due to the high percentage of permeability, potential for Urban Heat Island effect as more hard surfaces are introduced to the neighbourhood, density and building typology. In the context of the Downtown Neighbourhood, ecoroofs can potentially assist in offsetting the negative public impacts related to air quality, urban heat island, reduced green space, biodiversity and habitat, stormwater retention, and private impacts such as energy used for heating and cooling.

Figure 1: Downtown Neighbourhood Roof Area Calculations

Roof Area Downtown Neighbourhood (m^2)	10% Reduction in total roof area for HVAC, setbacks	50% Ecoroof Coverage (m^2)	30% Ecoroof Coverage (m^2)
645,288	661,055	322,644	187,134

The purpose of this document is to provide the City of Edmonton administration with a starting point if they decide to develop scenarios to demonstrate the impact ecoroofs could have on climate adaptation.
Each section has the following components:

Establishing a Baseline outlines data requirements for creating a baseline for scenario development. Within this component, data gaps or additional questions the City should consider are noted. The known data sources are also provided.

Impact Methodology Demonstration Based on Function Report Research is an attempt to demonstrate how the City might use the methodologies found in the research to calculate the impact for Edmonton. It is important to note these methodologies are often not primary research and need to be further refined. Here is a link to the Function Report for more details: https://www.rockies.ca/miradm/uploads/1b2d96aee74962c26c368f911c0d81617684b866.pdf).

The *Recommendations* provide City administration with suggestions on what needs to be done to move forward with scenario development in the specific ecoroof impact area.

Air Quality Scenario Development

In 2014 Edmonton identified that they had exceeded the Canadian standards for fine particulate matter in several parts of the city and were close to that in other areas. A response plan was created to reduce ambient fine particulate matter concentration and remain below Level 4 at all monitoring stations within the Capital Region (Alberta Environment and Sustainable Resource Development, 2014).

Plants have been used in urban environments to remove air pollutants - ecoroofs are a surface area that can provide vegetation to assist with improving air quality. In the Function Report produced by the Miistakis Institute it was outlined that researchers estimate that a 1,000-square foot (93 m^2) ecoroof can remove about 40 pounds [(18kg)] of Particulate Matter (PM) from the air in a year, while also producing oxygen and removing carbon dioxide (CO2) from the atmosphere. Fourty pounds [(18kg)] of PM is roughly how much 15 passenger cars will emit in a year of typical driving (Learned & Kinas, 2019).

Establishing a Baseline

The methods used to calculate the fine particulate matter levels in the report *Capital Region Fine Particulate Matter Response* and the values from the *Air Quality Data Warehouse* are not directly comparable, likely due to a collation of values. Unfortunately the methods are not referenced in the Capital Region Fine Particulate Matter Response report so at this time we are unable to determine how the report compares to how air quality data is reported.
As vegetation type, style of ecoroof, air quality and local environment all effect how much PM is removed by an ecoroof it is important that this be reviewed for the Edmonton context. Because Edmonton specific data is measured differently than the methodologies used in the Function Report, it is suggested a methodology be discussed and established by air quality experts.

Data Gaps or Questions
• In the report *Capital Region Fine Particulate Matter Response* how was air quality data used to calculate the fine particulate matter annual averages?
• Evaluate information on the removal of PM by ecoroofs to fit it to the City of Edmonton context
Known Data Sources
• Alberta's Ambient Air Quality Data Warehouse: http://airdata.alberta.ca/

Impact Methodology Demonstration Based on Function Report Research

The impacts of increased numbers of ecoroofs in the Downtown neighbourhood can be roughly estimated for different percentages of implementation using the research findings from Green Plants for Green Buildings, 2014 that 93 m^2 of ecoroof installed can remove roughly 18kg of Particulate Matter annually.

Using that outcome, the City of Edmonton could extrapolate a rough estimate of the amount of PM removed annually with 30% and 50% ecoroof coverage. Using the City of Edmonton's Rooflines 2017 dataset its possible to calculate the surface area of roof space within the Downtown Neighbourhood. Reducing the area by 10% to account for areas required for HVAC equipment and setbacks, leaves us with a sum of 661,055 m^2 in total.

Selecting roofs randomly for 50% and 30% ecoroof coverage of rooftop area in the Downtown Neighbourhood would have the following potential impact:

Method of calculation: **(Ecoroof area m^2/93 m^2) x 18kg= PM removed annually**		
Detail	**50% Coverage**	**30% Coverage**
Area of Ecoroof m^2	322,644	187,134
Particulate Matter removed annually	62,447 kg	36,219 kg
Passenger car equivalent emissions removed	52,039 cars	30,182 cars

Recommendations for Edmonton

- Because Edmonton specific data is measured differently than the methodologies used in the Function Report, it is suggested a methodology be discussed and established by air quality experts.
- Question the assumptions used in the table above: is it is acceptable to use the calculation of 18kg of PM being removed annually per 93m^2 of ecoroof planted to illustrate a rough estimate of the impact ecoroofs have on PM removal annually in the Edmonton context?

Stormwater Retention Scenario Development

Ecoroofs have the ability to capture and store water during weather events that stress the stormwater system. Given an ecoroofs limited retention capacity it is important to look at significant individual precipitation events and sustained events separately.

Ecoroofs allow for enhanced retention of water from both large and small precipitation events, along with delaying peak flow rate time. This lag time allows stormwater infrastructure time to recover from a precipitation event, which is important where infrastructure is nearly at capacity and could result in localized flooding.

The Alberta Ecoroof Initiative research roof in Calgary, AB found total retention capacity for two test roofs were 66% and 59%, respectively. The retention capacities of the ecoroofs for July to

September were much higher (81-99%) likely due to less rainfall and increased evapotranspiration with the higher summer temperatures (Learned & Kinas, 2019).

Understanding the benefits of ecoroofs on stormwater also requires an understanding of local weather and frequency of heavy and sustained precipitation events. Given that ecoroofs have a finite carrying capacity their ability to retain water and slow its movement across the landscape is directly related to how wet or dry it has been (Learned & Kinas, 2019). Stormwater systems, adversely, are negatively affected by sustained precipitation.

Establishing a Baseline

No stormwater data for the City of Edmonton was made available and the stormwater data obtained for other cities was infrastructure focused, with no temporal information on volume or when the system capacity was exceeded. Temporal flow information is needed to accurately assess ecoroof impact, or at least estimates of how much precipitation is needed to stress stormwater systems within the Downtown Neighbourhood.

What was made available was the historical and projected precipitation rates from the Climate Resilient Edmonton Adaptation Strategy and Action Plan (p. 18, City of Edmonton, 2018):

Time Period	Average Annual Precipitation Level	Maximum 1-day precipitation from very heavy rain	Maximum 5-day precipitation from very heavy rain	Total Annual Precipitation from very heavy rain
1961 – 1990 (Historical Baseline)	458 mm	28 mm	43 mm	96 mm
2041 - 2070	498 mm	31 mm	51 mm	118 mm
2071 - 2099	512 mm	32 mm	51 mm	127 mm

Methodology and/or Data Gaps
• How does the City of Edmonton measure stress on the stormwater system and how is this measured and documented? • Can this information be used to better evaluate the impact of ecoroofs?
Known Data Sources
• City of Edmonton Stormwater drainage zones and infrastructure for the Downtown Neigbhourhood (EPCOR) • City of Edmonton climate change projected precipitation to 2099

Impact Methodology Demonstration Based on Function Report Research

As outlined in *Edmonton Ecoroof Initiative for Climate Change Resiliency: Ecoroof Function Research* there are a number of potential methods.

One approach might be to compare an estimated value of precipitation required to stress stormwater systems with different ecoroof area in different types of weather events to compute estimated water retention and how that might change the amount of precipitation the stormwater system can handle before being stressed.

The US Department of Energy study found that an ecoroof with 76.2mm - 101.6mm (3-4 in) of soil can retain about 25.4mm (one inch) of rainfall. 25.4mm (one inch) of rain is equivalent to about 2.6L (0.6 gallons) of water per .09m^2 (square foot) of ecoroof area. The report concludes that a typical ecoroof will absorb, filter, retain and store up to 75% of the annual precipitation that falls on it under conditions prevalent in most areas of the United States (US Department of Energy, Energy Efficiency and Renewable Energy, Federal Energy Management Program).

Recommendations for Edmonton

- Work with EPCOR to explore a suitable methodology for measuring the impact ecoroofs could have on precipitation events.

Building Energy Efficiency Scenario Development

The amount of energy needed to heat or cool a building is a measurement of the building's energy efficiency; the less energy required, the higher the efficiency. Ecoroofs can increase building efficiency through direct shading of the roof, evapotranspiration and improved insulation values. Both plants and the ecoroof growing medium contribute to the insulation value of an ecoroof (Learned & Kinas, 2019). With the growing commitments to reduce GHGs, ecoroofs can play an important role in this reduction as "buildings account for approximately 30% of energy use and 27% of greenhouse gases emission in Canada" (Natural Resources Canada 2004 as cited in K. Liu & Baskaran, 2005).

As outlined in *Edmonton Ecoroof Initiative for Climate Change Resiliency: Ecoroof Function Research* there are a number of published research projects that evaluated the positive impact of ecoroofs on building energy efficiency. For example research in Ontario determined ecoroofs required 13-33% less energy to maintain the testing room temperature; energy savings of about 24% and 10% of the total heating energy used may be realized over the winter months, with more savings possible when considering summer cooling needs (Lanham, 2007).

Establishing a Baseline

Unfortunately no Edmonton specific data could be obtained for energy use by building typology. Ideally data could be found to corroborate existing research or adjust that research to an Edmonton context.

Data Gaps or Questions
• Pre and/or post installation energy use of buildings with ecoroofs within a local context such as City of Edmonton or Alberta • Energy use of buildings within Edmonton's Downtown Neighbourhood
Known Data Sources
• It is understood by the research team the City has completed an analysis on energy use by building typology.

Impact Methodology Demonstration Based on Function Report Research

The availability and type of data will determine the best way analyze building energy efficiency within the City of Edmonton and how to predict the positive impact of a larger number of ecoroofs.

A likely scenario, would be to determine the energy use of each building within Edmonton's Downtown Neighbourhood. Using values from existing research, or data gathered from local ecoroof implementations, determine how ecoroofs of various types would impact the energy efficiency of each of the buildings. This could be collated to determine how a larger numbers of ecoroofs would positively impact overall energy consumption and reduce greenhouse gas emissions in the City of Edmonton.

This would be useful information to share with building owners to encourage ecoroof implementation.

Energy savings from a Chicago Walmart store case study were modeled at $0.05/sf/yr for the year in which air temperature data were collected. This was the low end of the range expected based on typical weather data, $0.05 - $0.15/sf/yr. If the same metrics were applied to the Edmonton Downtown Neighbourhood 50% and 30% ecoroof coverages, the following dollar values would be the outcome.

Detail	50% Coverage	30% Coverage
Ecoroof area m^2	322,644	187,134
Potential Annual Energy Savings Based on a single storey warehouse structure at $.05/sf/yr	$179,246.67	$103,963.33

Recommendations for Edmonton

- Confirm building energy use by typology using available data from the Energy Transition Team
- Establish and acceptable method to calculate building energy savings with the installation of ecoroofs by building types. There are a number of studies completed on building energy efficiency referenced in the Function Report, or available online.

Biodiversity Scenario Development

There is no better example of a novel ecosystem than an ecoroof; it is human-altered human-designed, contains a unique composition of species, and has widely variable site characteristics (Learned & Kinas, 2019). Given this variability, it is important to define your biodiversity goals before determining the best way to measure and predict ecoroof benefits.

Researchers have only recently begun to study the ability of ecoroofs to contribute to conservation of biodiversity and habitat within the urban environment, where green space is scarce. Evidence suggests that ecoroofs can provide habitat for plants and highly mobile animal (i.e. bird) and insect species (Learned & Kinas, 2019). Ecoroofs could be used to create native habitat for specific species or groups, connectivity of habitat patches to support movement, or to enrich Edmonton's overall biodiversity.

Establishing a Baseline

The data required as a baseline for measuring the benefits of ecoroofs on biodiversity depends on the overall biodiversity goals and what specifically needs to be measured. The Natural Connections Strategic Plan (2007), outlines a number of strategic indicators that the installations of ecoroofs could contribute to for a very limited, specific group of species. For example, page 41 of the Plan states:

Outcome 1:
The protection of Edmonton's existing natural areas has been maximized, and restoration of additional lost, degraded or fragmented areas is increasing.

Indicator:
- area of land restored to a natural state

Outcome 2:
Connectivity within Edmonton's ecological network is increasing.
Indicators:
- "nearest neighbour" index (proximity of each stepping stone to others in area, # stepping stones within a given radius of a given natural area/core area)
- structural/functional connectivity – gap tolerance

Edmonton's active naturalist community and the University of Alberta provide a wealth of biodiversity information in and around the city of Edmonton. Citizen science projects like the Christmas Bird Count have been reporting annually on bird diversity since 1955 (Audubon Society, n.d.). iNaturalist has documented 4,387 observations of 1,232 species in and around Edmonton in the last 12 years (iNaturalist, n.d.).

Data Gaps or Questions
• What biodiversity goal(s) would be most beneficial for ecoroofs to impact in the City of Edmonton? This could be specific species, species groups like pollinators, or connectivity.
Known Data Sources
• University of Alberta published and grey literature • City of Edmonton • Government of Alberta • Edmonton Nature Club • Citizen Science datasets such as Christmas Bird Count and iNaturalist

Impact Methodology Demonstration Based on Function Report Research

Creating habitat will undoubtedly contribute positively to Edmonton's biodiversity. The design and implementation of the ecoroof and the biodiversity goals will need to be determined in order to determine if there is available baseline information, a way to measure success and how to predict the positive impact of a larger number of ecoroofs. If ecoroofs are considered as contributors to restoring and connecting natural areas lost to development, they could be measured as part of the Natural Areas Strategy Indicators:

Detail
• area of land restored to a natural state
• "nearest neighbour" index (proximity of each stepping stone to others in area, # stepping stones within a given radius of a given natural area/core area) • structural/functional connectivity – gap tolerance

Recommendations for Edmonton

- The Biodiversity Action Plan and Natural Areas Strategic Plan could be used to further support ecoroof implementation. It is recommended the ecoroof project team meet with the team responsible for the Biodiversity and Natural Strategic plans and discuss the potential to collaborate going forward and to potentially establish biodiversity goals related to ecoroofs.

Urban Heat Island Scenario Development

Urban Heat Island (UHI) is when an urban area is warmer than the areas surrounding it. Less vegetation, more impermeable surfaces, waste heat, and surfaces that absorb heat all contribute to increasing the urban areas ambient temperature.

Ecoroofs can reduce the UHI as vegetation on an ecoroof shades surfaces and reduces surface temperatures, through evapotranspiration. The surface of a vegetated rooftop can be cooler than the ambient air, whereas conventional rooftop surfaces can exceed ambient air temperatures by up to 50°C (U.S. Environmental Protection Agency, 2008). Reducing temperatures of the roof surface will reduce the temperatures of the surrounding air, thereby assisting in lowering air temperature in areas of the city where ecoroofs are present (Learned & Kinas, 2019).

Establishing a Baseline

In order to understand the beneficial impacts of ecoroofs on Edmonton's UHI it needs to be properly analyzed and mapped. When considering the best approach to analysis the UHI it is important to consider that the data needs to be extrapolated into the future.

Very little data exits on Edmonton's urban heat island. A local weather enthusiast, Edmonton Weather Nerdery, analyzed weather station data of Edmonton and surrounding weather stations to determine the UHI impact upon the city (Edmonton Weather Nerdery, 2016). Three nearby weather stations were compared with an Edmonton weather station with an 87 year overlap between 1915 and 2002 (Edmonton Weather Nerdery, 2016).

While Edmonton's current UHI has not greatly increased in comparison to the surrounding areas, ecoroofs can be used to mitigate those increases in the future as the city continues to grow and is impacted by climate change:

- Edmonton is projected to grow by 1% to 2.1% per year until at least 2040, which will likely increase the percentage of non-permeable surfaces, which in turn will impact its UHI.
- Edmonton's number of very hot days (+30°C) is expected to increase from a current approximate 1-3 per year to an estimated 10-16 in 2050's and 16-34 in the 2080's depending on the climate model and scenario (Climate Resilience Consulting, n.d.; Prairie Climate Centre, 2018).
- Edmonton's hottest day historical baseline is 30°C and is projected to be 35°C by 2050, and 38°C by 2080.

Impact Methodology Demonstration Based on Function Report Research

A modeling study for Toronto, predicted that adding ecoroofs to 50% of the available surfaces downtown would cool the entire city by 0.1°C to 0.8°C. Irrigating these roofs could further reduce temperatures by about 2°C and extend a 0.5°C to 1°C cooled area over a larger geographic region (Learned & Kinas, 2019).

With appropriate UHI data extrapolated into the future, taking into account city growth and climate change, the impact of various implementations of ecoroofs can be evaluated using the results from recent research or by implementing similar methodologies within the Edmonton context.

Recommendations for Edmonton

- Work with a post-secondary institute to develop a methodology for creating a baseline for UHI in Edmonton. From that baseline, use the modeling study from Toronto to create scenarios for Edmonton.

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Additional Resources

Government of Canada Historic Climate Data: https://climate.weather.gc.ca/

Weather Underground: https://www.wunderground.com/history/daily/ca/edmonton/CYEG

WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: https://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=81DDAFF66732063B4DD0F1763E522637?sequence=1