CAN GREEN ROOFS HELP CITIES RESPOND TO CLIMATE CHANGE?

CASE STUDY

A portion of the new Vancouver Convention Centre green roof - Credits :Maxvis

SUMMARY

Green roofs are being built around the world, but many people do not realize how valuable they will be in addressing the challenges of climate change. Green roofs can help cool the air, absorb excess water, and reduce energy use while supporting biodiversity and making our cities more liveable. Toronto led the way with its innovative Green Roof bylaw, and there is no reason why others cannot follow. While developers and building owners face barriers to investing in green roofs, governments at all levels can help them to overcome constraints by providing clear direction and incentives.

This case study is part of a collaborative series between the Canadian Institute for Climate Choices and the Smart Prosperity Institute exploring the value of urban natural infrastructure within the context of climate change and other economic, environmental and societal objectives. Other case studies in the series cover wetlands and urban forests.

CANADIAN INSTITUTE FOR CLIMATE CHOICES

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WHAT ARE GREEN ROOFS?

Green roofs are contained areas of vegetation – such as trees, shrubs, crops, or grasses– planted on human-made structures, such as government buildings, schools, libraries, community centres, private residences, and commercial buildings.

There are three broad categories green roofs, classified based on their usage, construction factors, and maintenance requirements. (The Delphi Group , 2020):

- **Extensive green roofs -** shallow, require no irrigation, and consist of relatively small plants
- **Semi-intensive green roofs -** deeper, require some irrigation, and have larger plants
- **Intensive green roofs -** deepest, with the highest capacity for irrigation and large plants

Extensive green roofs are typically cheaper and simpler to install relative to intensive green roofs. Extensive green roofs are also more suited to spaces where there is less foot traffic and as a result are more often used for single-family and multi-family residential buildings. Intensive roofs tend to be more widely used on commercial buildings that have larger area and space where people can interact with their natural surroundings. Of course, not all buildings can accommodate green roofs, and it is more cost effective to incorporate them into initial design rather than retrofit an existing building. Structural capacity will influence whether retrofitting, and an important consideration when selecting roof type.

Squamish Nation reimagines residential living

The Sen̓áḵw development of over 6000 residences in an area of 10.5 acres in Vancouver challenges the concept of apartment living with a "Towers in the Park" approach that celebrates the values of the Squamish Nation and their deep embrace of nature. Multi-tiered landscaping incorporates plants and vegetation into all levels of the complex. It is not only the largest net zero residential project in Canada, but also the largest First Nations economic development project in Canadian history (Senakw, 2021).

WHAT ARE THE BENEFITS OF GREEN ROOFS?

Green roofs can help cities manage the impacts of a changing climate, while absorbing greenhouse gas emissions and providing multiple other health and biodiversity benefits. The table below highlights some of the main benefits of green roofs.

Table 1: Benefits from Green Roofs

Benefit	Why it Matters
Limit flooding	Climate change will increase the frequency and intensity of rainfall in some regions, raising the risk of flooding in cities. Green roofs absorb rainwater, reducing pressure on stormwater management systems.
Reduce energy use	Green roofs can reduce greenhouse gas emissions from buildings by lowering energy consumption requirements.
Cool the air	Climate change will worsen heatwaves and exacerbate urban heat islands. Green roofs can offer a cool sanctuary and reduce surrounding temperatures.
Clean air and water	Climate change will exacerbate poor air quality and could increase runoff entering lakes and streams. Green roofs help filter out air and water pollutants.
Support pollinators	Pollinators are essential to maintaining our food supply and supporting healthy ecosystems yet have faced significant declines in North America. Green roofs on lower buildings or terraces using native flowering plants that bloom at different times of the year can support pollinators.
Species habitat	A network of green roofs can create a habitat corridor that simulates a larger ecosystem, helping species adapt to a changing climate and urban expansion.
Recreation and social connection	Green roofs can enhance the liveability of dense cities, providing space for gardening and social interaction, and offering green space health benefits.

Sources: (Feng & Hewage, 2018), (The Delphi Group , 2020), (Grant & Gedge, 2019), (DSF, 2021), (Howell, Drake, & Margolis, 2017)

ARE GREEN ROOFS TOO EXPENSIVE?

The benefits of green roofs generally exceed costs, particularly when public benefits such as those listed in table 1 are included. In one study, the private net cost for green roofs over 40 years was between $42.30 and $978.80 per square metre, depending on which benefits were included. At the lower cost estimate, it would take 13 years for private benefits to balance the cost of green roofs. If public benefits such as reduction in stormwater runoff and improvement of air quality are included, the payback timeframe is reduced to three years. At the higher cost estimate, benefits would only exceed costs over the lifetime of the green roof if both private benefits and public benefits are included (Feng & Hewage, 2018).

Similar studies that compare the lifecycle costs of green roofs to conventional roofs have also found net savings. The University of Michigan, for example, calculated that while the installation costs of a 1951 m^2 green roof at $464,000 was higher than the $335,000 cost of a conventional roof, the green roof would deliver over $200,000 in lifetime savings. Nearly two-thirds of the savings were calculated to be from reduced energy needs for the building (Gerrity, et al., 2012).

Public benefits include broader societal or environmental benefits.

Private benefits are those borne directly by the owners of the building.

Table 2 highlights some of the estimates that have been used to calculate the benefits of green roofs. These represent only a subset of all private and public benefits of green roofs. Many public benefits, such as improvements in urban biodiversity and improvements in social cohesion that come from community interactions on green roofs are difficult to measure and monetize. As a result, the full range of benefits are rarely considered when determining the business case for green roofs.

CASE STUDY

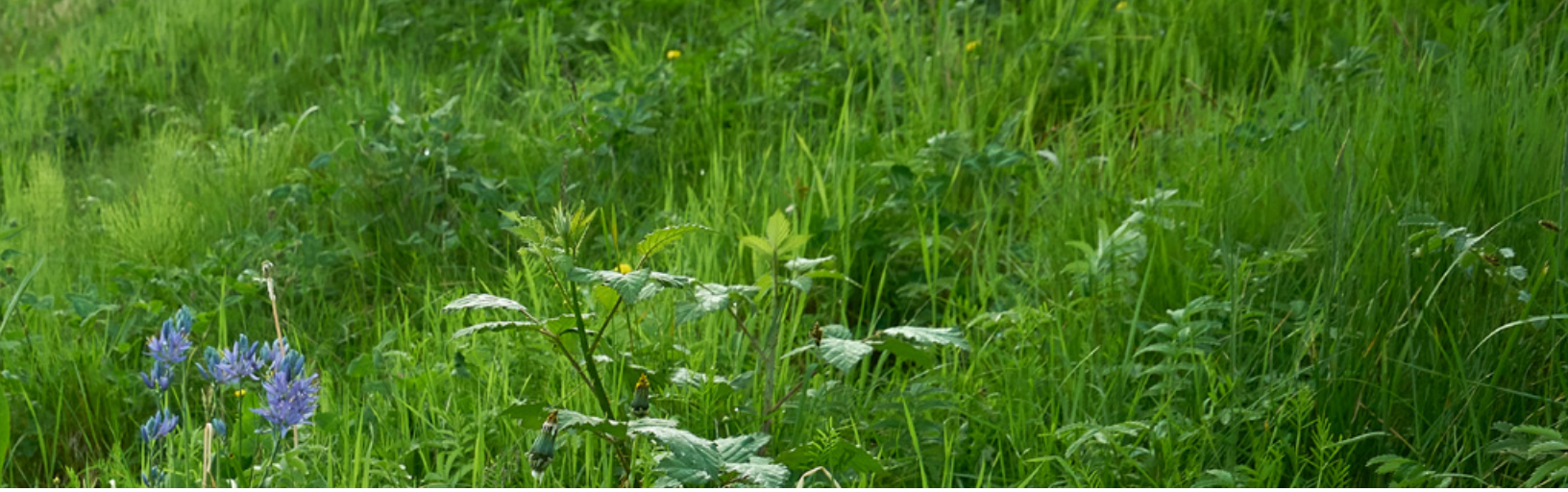


Table 2: Estimating the Benefits of Green Roofs

Benefits	Value*	Source
Private Benefits		
Energy saving from cooling	$0.20 to 0.75 per m^2 annually	(Bianchini & Hewage, 2012)
Energy saving from heating	$0.24 per m^2 annually	(Bianchini & Hewage, 2012)
Delayed roof replacement	$177 per m^2	(Bianchini & Hewage, 2012)
Noise insulation benefit	$31.80 per m^2	(Nurmi, Votsis, Perrels, & Lehvävirta, 2013)
Appreciated property value	$2.90 to $9.20 per m^2 (Extensive green roofs), $9.20 to $47.94 per m^2 (intensive green roofs)	(Bianchini & Hewage, 2012)
Public Benefits		
Stormwater management savings	$16.65-31.07 per m^2 annually	(Feng & Hewage, 2018)
Improved air quality	$0.04 per m^2 annually	(Yang, Yu, & Gong, 2008)

* Values adjusted to 2019 dollars.

The costs of green roofs can be very variable depending on the design and type of green roof (simple or complex), accessibility and depth of material used, and whether the project is new construction or a retrofit to an existing structure. In Canada, green roof pricing ranges from $129 to $538 per m^2 (Bleasby, 2015). Another source estimates the cost of green roofs in Alberta to be $108 to $430 per m^2, compared to the cost of installing traditional residential waterproof roofing membrane ($65 per m^2) (Land Stewardship Center, n.d.).

CITY OF TORONTO GREEN ROOF PROGRAM

The City of Toronto has one of Canada's leading green roof programs and is a hotspot for the green roof industry.

In 2006, Toronto City Council adopted a Green Roof Strategy that encouraged the construction of green roofs through incentives, public education, and a streamlined development approval process. The strategy laid the foundation for the City's Green Roof Bylaw (a first in North America) and the Eco-Roof Incentive Program adopted in 2009.

Green Roofs as Job Creators?

In 2018, green roofs installed in Ontario created 842 direct jobs and contributed $51.2 million to provincial GDP (The Delphi Group , 2020).

The Green Roof Bylaw requires green roofs for new development or additions with a gross floor area greater than 2,000 m^2. It covers residential, commercial, institutional, and industrial developments. The required coverage for a green roof ranges from 20-60 per cent of the gross floor area, increasing with a building's footprint. However, the Bylaw includes an option for developers to seek an exemption. The exemption allows a smaller amount of Green Roof, provided the owner makes a cash-in-lieu payment of $200/$m^2$ of reduced green roof area. The funds collected are directed to the Eco-Roof Incentive Program. (City of Toronto, n.d.)

Difference between Green Roofs and Cool Roofs?

Green roofs, also known as living roofs or vegetated roofs, support the growth if vegetation. A cool roof or white roof is a roofing system with an exterior surface that reflects the sun's rays and reduces heat build-up from the sun's thermal energy. (City of Toronto, n.d.)

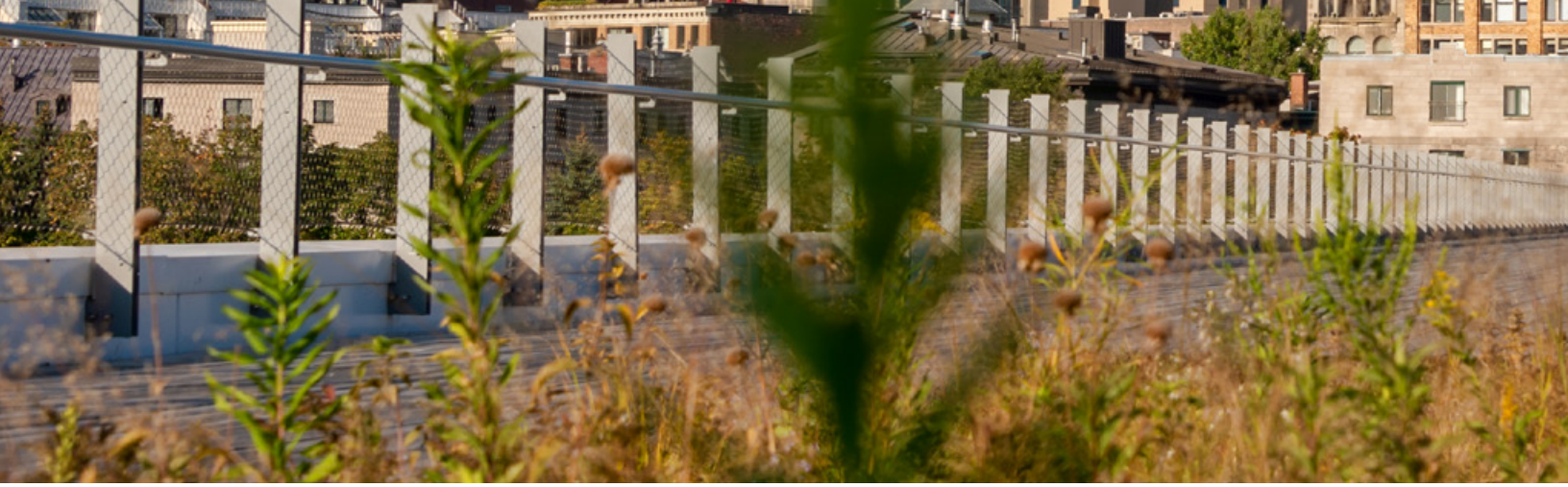
The Eco-Roof Incentive Program encourages the installation of green roofs and cool roofs (with reflective surfaces) on existing buildings and smaller new buildings with a gross floor area of less than 2,000 m^2. It also applies to all new construction projects by Toronto School Boards and not-for-profit organizations. It offers $100/$m^2$ for green roof projects and $2-5/$m^2$ for cool roof projects. In addition, applicants who want to construct a green roof on an existing building may also be eligible to receive a Structural Assessment Grant, which provides up to $1,000 to help offset the costs associated with determining whether the building is suitable for green roof construction (City of Toronto, n.d.). To govern the design and construction of green roofs and ensure they meet minimum requirements, all green roofs in Toronto must conform to the Toronto Green Roof Construction Standard (City of Toronto).

As a result of these initiatives, green roofs have become a rapidly growing industry in Toronto. Since 2010, approximately 850 green roof permits have been issued in Toronto, totaling 750,000 m^2 of green roof space (City of Toronoto, n.d.). Since 2009, the Eco-Roof Incentive Program has received over 500 applications and successfully supported 336 eco-roof projects (C40 Cities , 2018). Table 3 below summarizes the benefits of projects funded by the Eco-Roof Incentive portion of the program (Stern, Peck, & Joslin, 2019)

If all flat roofs across Toronto were greened, it could translate to savings of between $41.8 million and $118 million in avoided grey infrastructure costs (Grant & Gedge, 2019).

Table 3: Benefits Attained from Eco-Roof Incentive Program Projects	
Storm-water management	· 222 million litres of stormwater retained annually
Energy efficiency	· 3.2 million kWh of annual electricity savings for the buildings with green roofs · 1.6 million kWh of annual electricity savings for surrounding buildings due to a reduction in the urban heat island effect
GHG mitigation	· 225 tons of carbon sequestered annually
Jobs	· 1,618 FTE jobs in construction · 25 FTE jobs annually in maintenance

Being one of the early adopters of a green roof policy, Toronto is today considered a global leader in green roofs. Toronto is also home to the Green Roof Innovation and Testing Laboratory at the University of Toronto — a global leader in research to optimize green roof performance.

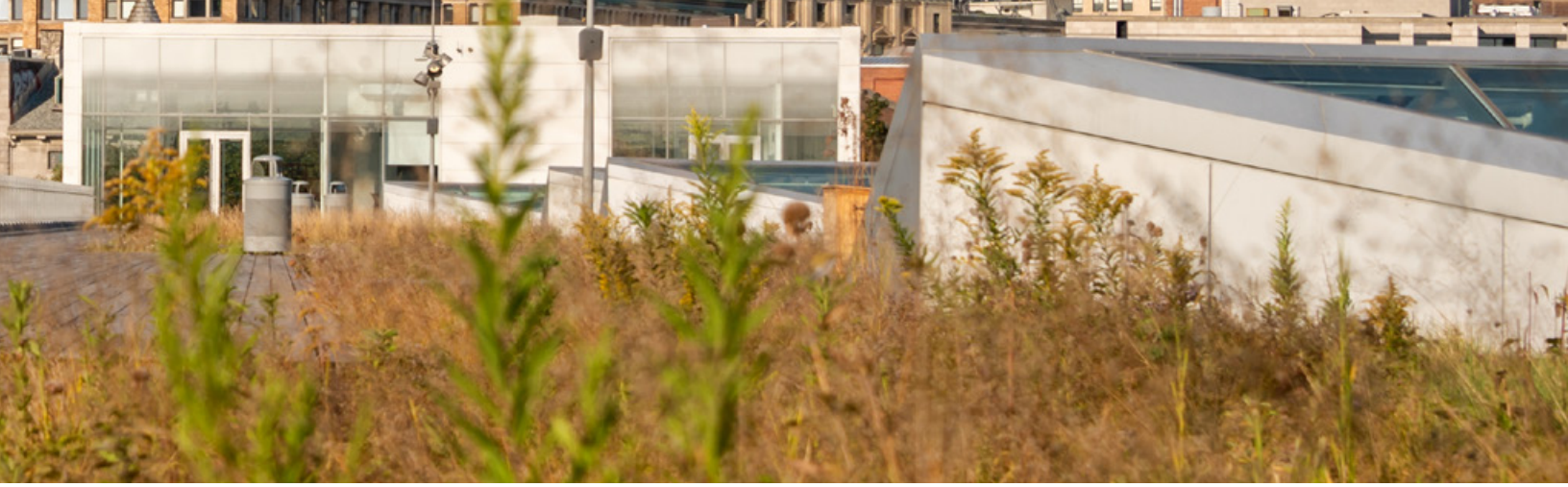


LEADING INTERNATIONAL GREEN ROOF POLICIES

In 2019, New York City passed two new laws as part of NYC's Climate Mobilization Act. Together, the laws require solar panels or green roofs on all new construction as well as buildings undertaking major roof renovations (The Nature Conservancy , 2019). In addition, the City offers subsidies for green roofs through the Green Infrastructure Grant Program, while the State of New York recently passed a green roof tax abatement of up to $15 per square foot (The Nature Conservancy , 2019).

In London, the government promotes green roofs through the land-use planning system. The City of London introduced the Living Roofs and Walls Policy into the London Plan in 2008. The policy stated that *"The Mayor will, and boroughs should, expect major developments to incorporate living roofs and walls where feasible and reflect this principle in Local Development Framework policies."* The city reviewed and updated the plan in 2011, with a new policy on urban greening and a specific policy on green roofs. Additionally, both the urban greening and green roof policies were set within the context of an overarching green infrastructure policy. As of 2017, the city had doubled the area and density of green roofs (Grant & Gedge, 2019).

These examples stem from large urban metropolises, where concerns associated with urban heat island effects and the scale of stormwater management challenges likely contribute to proactive policies. However, similar bylaws are being applied in smaller cities and towns as well, where the public and private co-benefits are applicable and valued by local communities.



WHAT IS HOLDING GREEN ROOFS BACK?

Cost: The biggest deterrent to the adoption of green roofs is the cost associated with design, installation, and maintenance. Even the simplest and least expensive design requires a higher upfront cost than conventional roofs. While cumulative private and public benefits of green roofs can outweigh costs, building owners usually only consider private benefits.

Resistance to change: Since it is still not a mainstream approach with upfront costs, there can be reservations that green roofs do not offer enough value to offset the initial investment. There have been cases in Canada where building developers have grouped together to challenge green roofs and stall progress.

A lack of capacity and skills: Given that green roofs are still considered unusual within the construction industry and throughout government or local permitting offices, there are limited skills and capacities amongst architects, engineers, construction workers, and city staff to conceive, plan, approve, install, and maintain green roofs.

Weak policy, programs, and regulations: Most Canadian municipalities do not have detailed design guidelines and clear, generally accepted standards for green roofs like Toronto's Green Roof Construction Standard. A lack of regulations and standards make it difficult to establish liability, warranty, and insurance for green roofs.

WHAT CAN GOVERNMENTS DO TO EXPAND THE USE OF GREEN ROOFS?

Legislate or regulate — Require green roofs on large buildings through municipal bylaws or building codes.

Show leadership — Government policies to invest in – and showcase – green roofs on public buildings can increase demand and help to demonstrate the feasibility and benefits to others.

Invest in skills training — Provide support for green roof professional training and accreditation, and incentives for those in the construction industry to become accredited.

Modify building codes — Include green roof considerations in provincial building codes to drive large scale uptake of the practise across municipalities.

Tax credit/abatement — Provide deductions from taxes (credit) or a reduction of taxes (abatement) for the construction of a green roof.

Establish a national construction standard — Develop a construction standard for green roofs tl alleviate warranty and insurance concerns, while reducing the perceived risk to builders and developers. Toronto's Green Roof Construction Standard could serve as a model to be adapted to other contexts.

Residential stewardship programs — Provide financial incentives or technical support to inspire property owners to volunteer to install and/or maintain green roofs.

Incorporate into infrastructure funding — Green roofs could be a requirement for financing large buildings and the federal government could better incorporate natural infrastructure in its Climate Lens for federally-funded infrastructure projects.

Natural infrastructure financing — Given the significant public benefits associated with natural infrastructure, governments can play an important role in helping overcome the cost barrier faced by building developers and owners. Financing could be structured like Toronto's Eco-Roof Incentive program or through programs that provide grants or low-cost loans.

The new federal Natural Infrastructure Fund announced in Budget 2021 could be an opportunity to expand investment.

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