November 2019

2019 ANNUAL GREEN ROOF INDUSTRY SURVEY

GREEN ROOFS
FOR HEALTHY CITIES
www.greenroofs.org

ON THE COVER: Green Roofs for Healthy Cities 2019 Awards of Excellence winning projects

Top Row: (Left) 510 West 22nd St, image courtesy MKM Landscape Architecture PC; (Right) Boston Medical Center Rooftop Farm, image courtesy Recover Green Roofs
Upper Middle Row: Garage Apartments, image courtesy Living Roofs, Inc
Lower Middle Row: (Left) Health Education Building, image courtesy Jeffrey L. Bruce & Co (Right) International Flavors & Fragrances Lobby Green Wall, image courtesy urbanstrong
Bottom Row: Room For A View, image courtesy Green Roofs of Colorado

Acknowledgements

This report was prepared by Blaine Stand, Professional Resources Manager and Steven W. Peck, GRP, Honorary ASLA, Founder and President, Green Roofs for Healthy Cities.

Green Roofs for Healthy Cities would like to thank its corporate members for their participation in the 2018 Annual Green Roof Industry Survey.

2019 Annual Green Roof Industry Survey

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Foreward

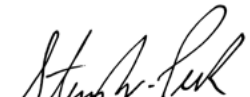
December 9, 2019

Green Roofs for Healthy Cities is the non-profit industry association for the green roof and wall industry in North America. We develop and protect the market through education, advocacy, and celebrations of excellence. One of our initiatives is the Annual Green Roof Industry Survey. This represents the 16th year that Green Roofs for Healthy Cities has surveyed the development and growth of the green roof market in North America.

Green Roofs for Healthy Cities would like to thank its corporate members for their participation which makes this survey report possible and encourage more members to participate next year.

We look forward to working with you all to advance the industry through education, advocacy, celebrations of excellence, and events; and encourage everyone to download the 2020 Engagement and Planning Guide, and become more involved in developing the industry with us.

Sincerely yours,



Matt Barmore,
GRP
Board Chair

Steven W. Peck,
GRP, Honorary ASLA
Founder & President

Executive Summary

Green Roofs for Healthy Cities is a member-based non-profit industry association dedicated to the growth and development of the green roof and wall industry in North America.

Every year, Green Roofs for Healthy Cities conducts an annual survey of its Corporate Members in order to collect data on the growth and composition of the green roof industry across North America. 2019 marks the 16th year that Green Roofs for Healthy Cities has conducted this Survey of its members and shared the results with a wide range of stakeholders. The data in this report should be considered conservative, as only a portion of our membership participates in the survey, however, a number of conclusions can still be drawn about the overall shape and composition of the industry.

In 2019, 14 respondents recorded 763 projects in 34 US states and three Canadian provinces across North America, installing 3,112,818 square feet of green roofing. This represents a decrease from data reported from 2017, particularly impacted by a limited sample size of the Canadian market. Long range analysis continues to indicate an estimated 5-15% overall industry growth trend since 2013, although this is a conservative estimate, as indicated in Figure 1 below.
Some market stabilization compared to previous years is occurring due to corporate acquisitions and mergers, limited federal funding support, global economic uncertainty, and the activation of multiple municipal policies impact development cycles and specification that will not be reflected in survey data for another 1-2 years.

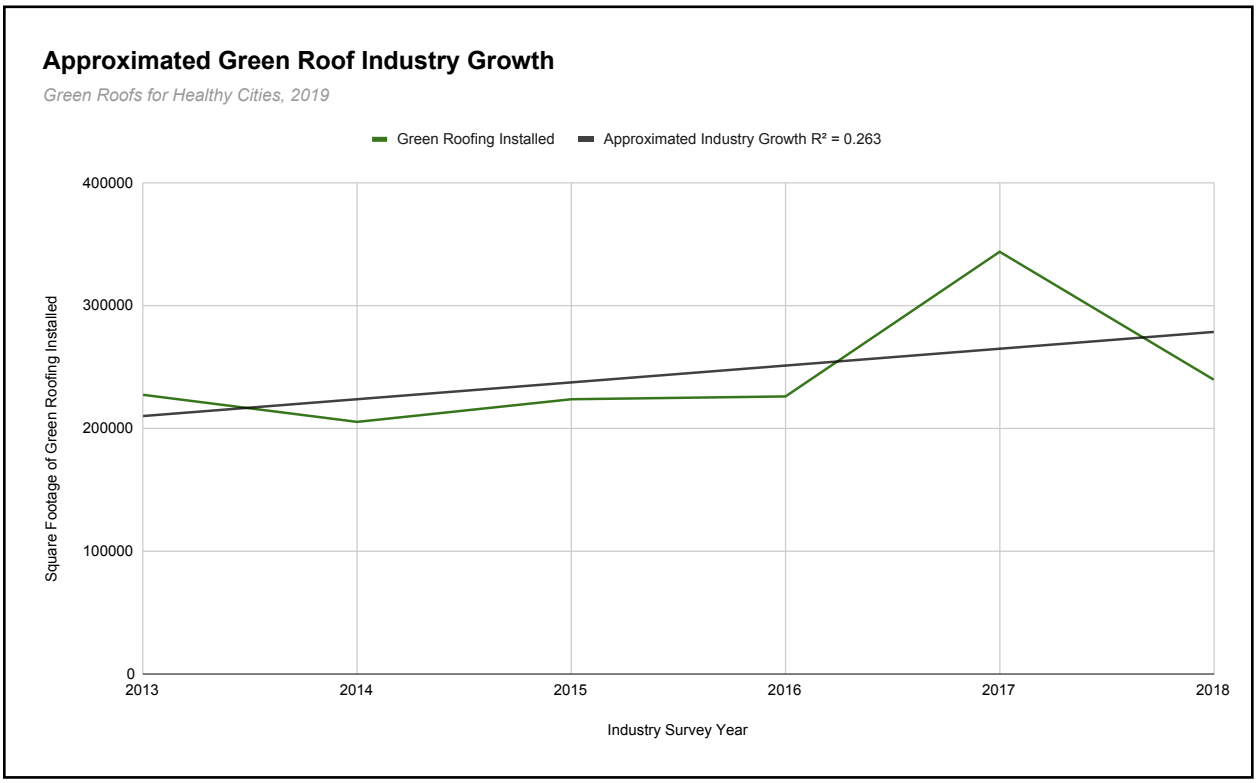


Figure 1 - Approximate North American green roof industry growth since 2013.

Based on average green roof performance data, Green Roofs for Healthy Cities estimates that the 3,112,818 square feet of installed green roofs will yield the following approximate benefits:

- 36.9 million gallons of stormwater retained per year;
- 120 tons of carbon sequestered every two years;
- 5.06 million kWh (equivalent) of energy saved per year;
- 1,199 full-time equivalent (FTE) construction jobs;
- 45 full-time equivalent (FTE) maintenance jobs annually.

As shown in Figure 2, below, and as observed in previous years, Washington, D.C. continues to report the most square footage of green roof installations, followed by Chicago, IL; Toronto, ON; New York, NY; and Seattle, WA. Municipalities with supportive green policies continue to dominate annual green roof installations.

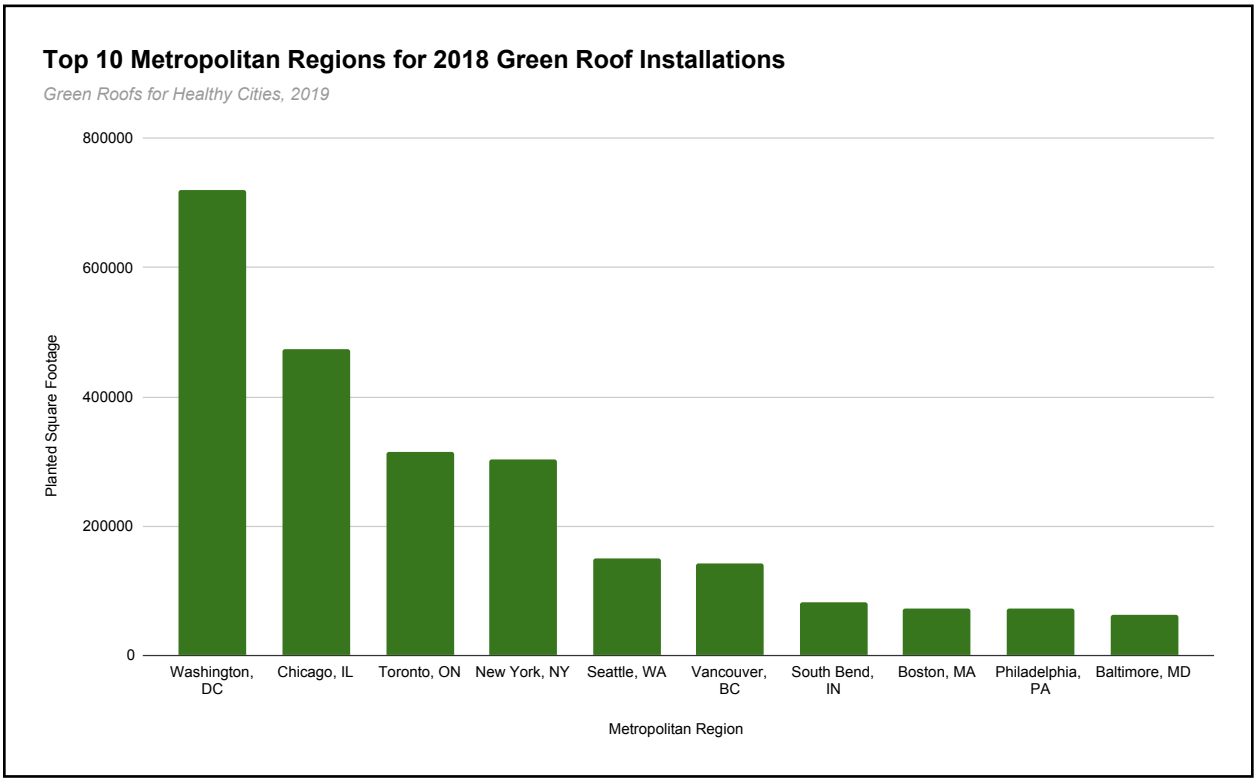


Figure 2 - Top 10 metropolitan regions recorded installed in 2018.

In 2019, Green Roofs for Healthy Cities released its first North American Policy Guide, designed to provide professionals in the green infrastructure industry with information about where to source supportive policies and programs for green roof and wall installation across North America. It is also designed as a resource for policy makers and advocates that are interested in establishing or updating green roof and wall policies and programs. More than 31 North American jurisdictions have targeted green roof requirements or incentives in place, all detailed in the report available at https://greenroofs.org/policy-document.

Figures 3 and 4, below, show the breakdown of top ten metropolitan regions in the United States and top five metropolitan regions in Canada respectively. Both graphs show several new municipalities reporting green roof construction in 2018.

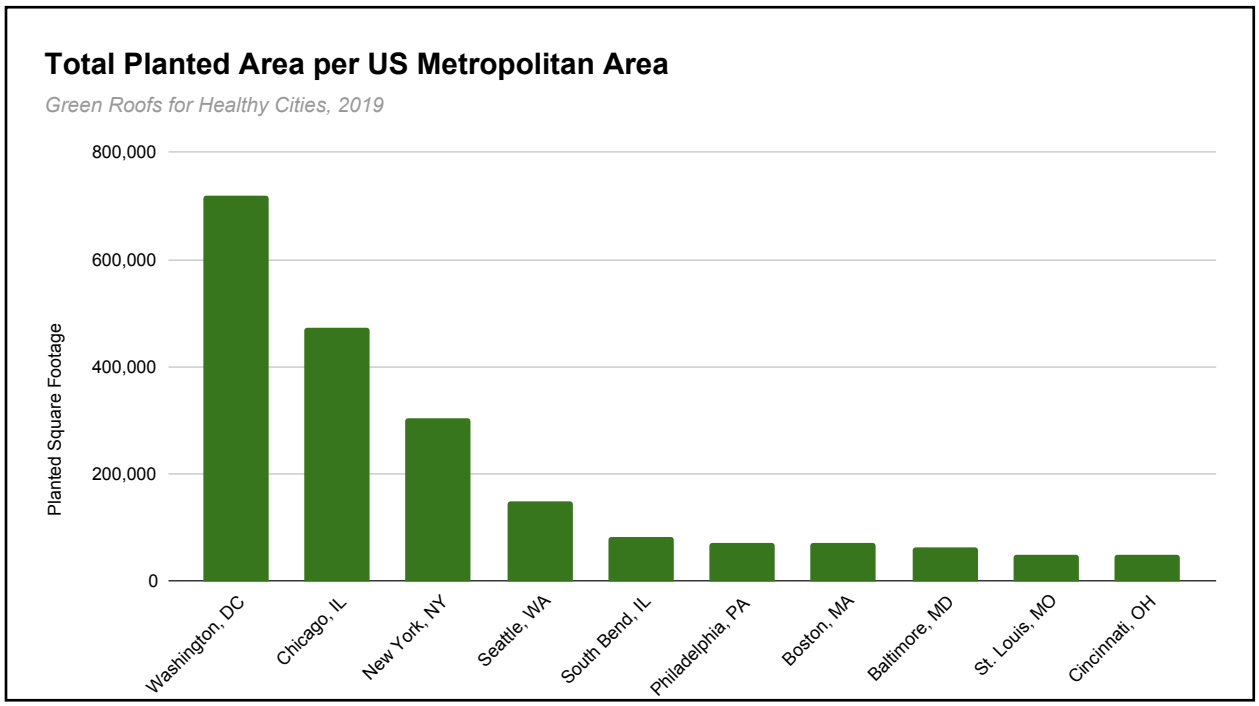


Figure 3 - Top 10 US metropolitan regions recorded installed in 2018.

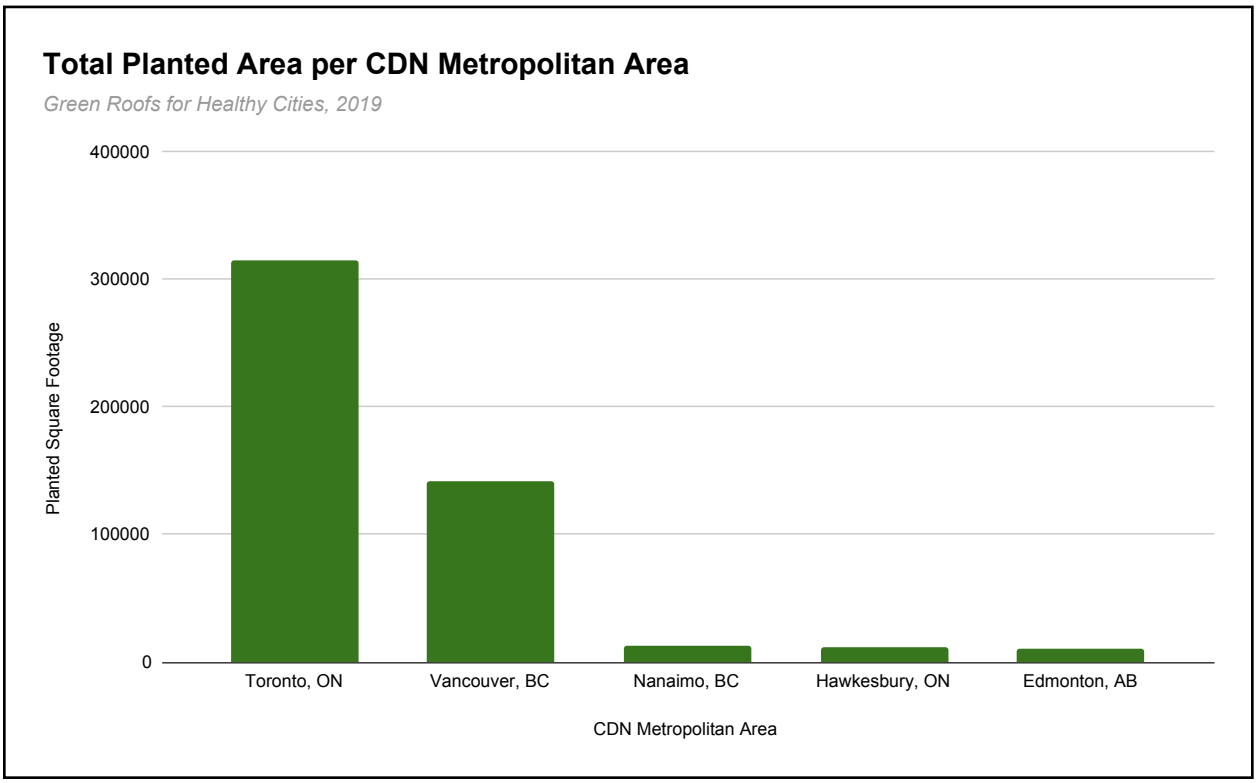


Figure 4 - Top 10 Canadian metropolitan regions recorded installed in 2018.

There is still an enormous potential for new green roofs to be installed on tens of billions of square feet of roof area across North America. With growing urgency around the climate crisis, urban sustainability, and resilience, it is imperative that these technologies be adopted at a more rapid rate. Green roofs have a variety of social, economic, and ecological benefits that impact our communities, and regions. With trends showing increasing frequency of heat waves, record breaking storm activity, intensifying urban heat islands, diminishing habitat for pollinators, and a number of other deleterious impacts of climate change, widespread green roof installation and maintenance plays a pivotal role in making our cities more livable for residents, and less damaging to the global ecosystem.

Strong policy support in cities like Washington, D.C. and Toronto is driving market growth in these jurisdictions. Green Roofs for Healthy Cities encourages municipalities, regions, states, and provinces to adopt policies in support of green roofs and green walls in order to build healthier, more sustainable and resilient communities.

Public policy support has proven to help reduce the upfront costs of green roofs and monetize their many public benefits. The Benefits and Challenges of Green Roofs on Public and Commercial Buildings, a study by ARUP for the United States General Services Administration in 2011, found that over the course of 50 years an extensive light weight, low maintenance green roof would generate the equivalent of $38 per square foot of public benefits.

With multiple municipalities adopting a suite of new green roof regulations in 2018 and 2019 such as Denver, CO; Portland, OR; and New York City, NY; as well as several more on the horizon, we are confident that the industry will continue strong market growth in the years to come. Green Roofs for Healthy Cities encourages more municipalities to explore supportive policy options around green roofs, green walls, and other forms of green infrastructure as a solutions to achieving their sustainability goals. These technologies offer a multitude of benefits at a fraction of the cost of traditional grey infrastructure systems, and easily integrate with existing systems.

Introduction

Green Roofs for Healthy Cities is a member-based non-profit industry association dedicated to the growth and development of the green roof and wall industry in North America. Green Roofs for Healthy Cities' mission is to develop and protect the market by increasing the awareness of the economic, social and environmental benefits of green roofs, green walls, and other forms of living architecture through education, advocacy, professional development, and celebrations of excellence.

To this end, Green Roofs for Healthy Cities has developed many resources to quantify and evaluate the green roof and wall market to facilitate strategic expansion of developers and manufacturers in the field. One of these resources is the Annual Green Roof Market Survey, which provides green roof installation data from the previous calendar year, sourced from a representative sample of Green Roofs for Healthy Cities corporate members. This survey provides valuable market intelligence on green roof installation hot-spots, and tracks the size, source and variety of green roofs that have been installed. To ensure the security of the provided data, all responses to the survey are anonymous, and all project names and addresses are removed from the distributed data and reports. 2019 marks the 16th Annual Green Roof Industry Survey, conducted by Green Roofs for Healthy Cities, through member participation with results shared with a wide range of stakeholders.

Participation rates differed this year for a variety of reasons including staffing and administrative changes amongst survey participants. Details on growth rate calculations can be found in the methodology section.

Benefits of Green Roofs

Green (vegetated) roofs can be divided into three primary categories: extensive, intensive, and semi-intensive. Extensive green roofs have a growing medium depth of six inches or less, and are generally lighter weight than the alternatives. Intensive green roofs have a growing medium depth of more than six inches, and provide the ability to sustain a broader range of plants, including trees and shrubs. Semi-intensive green roofs are a combination of the two systems with 25 per cent of the total greened area as extensive or intensive, and include benefits from both systems.

Green roofs provide a variety of both public and private benefits. Chief amongst these benefits are their use as a stormwater best management practice (BMP), reducing or preventing combined sewer overflow (CSO) events, particularly in urban areas with aging infrastructure, and minimize the impact of water supply contamination and wastewater treatment costs. Green roofs work to reduce the overall runoff volume; attenuate peak runoff; delay the onset of runoff; delay peak runoff; and extend the duration of runoff from conventional rooftops, greatly reducing flow rates into combined sewer systems. Based on the intensity and duration of the rain event, some water will slowly drain and some will be retained on the rooftop. Depending on several other variables, the retained water will evaporate or be transpired by plants. The total runoff reduction from green roofs corresponds to the volume of water evaporated or transpired. Studies have shown that water detention rates can range from 27-81 per cent of total annual precipitation on extensive green roofs with a growing media depth of four inches, and 65-85 per cent on intensive green roofs with a growing media depth of six inches. Additionally, as drainage layer and water retention mat technology improves, so to do the stormwater capture capabilities of green roofs. Furthermore, the emergence of blue-green roof innovations combining the retention capabilities with temporary water detention, which provide even greater levels of stormwater management closer to the source of runoff, further displacing the need for cisterns or other grey infrastructure stormwater management solutions.

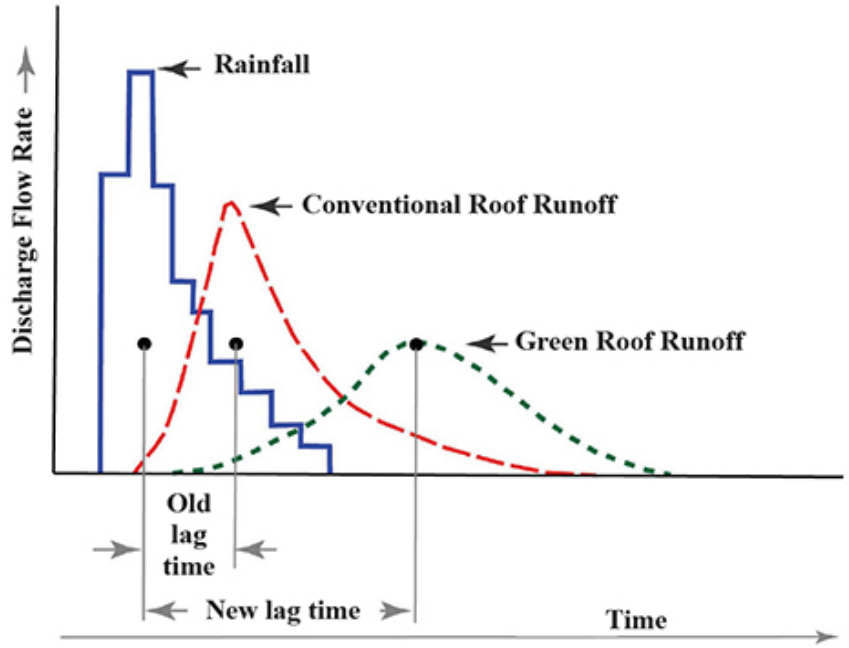


Figure 5 - Green roof performance hydrograph
Credit: University of Nebraska

In addition to stormwater retention, green roofs also offer the ability to reduce the urban heat island effect through the daily dew and evaporation cycle, absorbing sunlight that would otherwise be converted into heat. These rooftop plants also provide insulation and cooling benefits to the buildings on which they are installed, by providing insulation in the winter months and transpiration cooling in the summer months. These insulation layers also provide a natural acoustic buffer to mitigate noise levels for the spaces they occupy. Because of this provided insulation, green roof layers can greatly reduce the amount of energy required by structures, with some systems reducing daily energy demands by up to 75 per cent. These vegetative surfaces also divert particulate matter and capture airborne pollutants, providing a natural filtration system for local air quality and decreasing the amount of carbon dioxide released into the air.

Green roofs stimulate local and regional job creation in manufacturing, installation and maintenance sectors. Vegetative roofs also reduce wear and tear on conventional roofing membranes, reducing the impact of rainfall events and UV damage, improving the overall lifespan of a given roof. Green roofs also activate a great deal of otherwise unused space in dense urban areas. These unused spaces then become biodiversity opportunities to enhance local ecosystems and unlock the potential for new opportunities such as urban agriculture projects, local amenity spaces, and educational opportunities.

Public policy support helps to reduce the upfront costs of green roofs and monetize their many public benefits. The Benefits and Challenges of Green Roofs on Public and Commercial Buildings, a study by ARUP for the United States General Services Administration in 2011, found that over the course of 50 years an extensive green roof would generate the equivalent of $38 per square foot of public benefit.

Annual Survey Methodology

Each year, Green Roofs for Healthy Cities' corporate members voluntarily and confidentially provide basic information on a range of categories for each project installed or supplied in the previous year. Once submissions are closed, the data is reviewed. Duplicate entries which occasionally arise from sourcing data from both suppliers and installers are removed from the data set to minimize the possibility of double counting projects by comparing the type, size, and location of each project.

The annual growth rate provides a broad look at the overall health of the green roof market in North America. This growth rate is determined by comparing the previous year's results with the current year's results, controlled for respondents and total installation size. Annual industry growth rates are derived by determining the growth rate of a cross section of participant installation averages recorded by a median sample range of respondents. Installation totals are determined per data sheet and controlled for outliers, with the three largest and smallest values removed from the calculations, to obtain the most accurate overall average.

This method of growth rate is employed because of the anonymous survey submission process. In previous years individual growth rates were determined for participatory companies, but in an effort to ensure anonymity of the submission process for participants, these individual growth rates cannot be determined. Utilizing average installation values allows for growth rates to be determined while controlling for a variable sample size.

The square footage of reported green roof installations is then aggregated against several reported categories such as city; building type; green roof type; to analyze installation trends that may arise. Data is then parsed geographically to determine the top ten metropolitan regions for green roof installations in the United States, Canada, and North America as a whole. Metropolitan region aggregates are determined by mapping the project cities and then finding the largest metropolitan center in a 25 mile radius within the same province/state.

Green Roofs for Healthy Cities estimates that the data in this report significantly understates the market activity by anywhere from 25 to 50 per cent. This is because not all firms in the industry are members of Green Roofs for Healthy Cities and not all members are able, or willing, to participate. Nonetheless, the data does provide important insight into the composition of the industry and its development. Due to the relatively small sample size of the submitted data, and the inability to collect installation data from every green roof company in North America, industry forecasting is not provided in the results of this survey, and observations are based purely on comparative reporting and current market state.

The survey report is made available to all Green Roofs for Healthy Cities corporate members as a membership benefit, along with access to all previous survey reports. The full data set is made available only to all of the participants of the survey.

Annual Survey Findings

In 2019, 14 respondents recorded 763 projects in 34 US states and three Canadian provinces across North America, installing 3,112,818 square feet of green roofing. While this represents a decrease from data reported from 2017, particularly impacted by a limited sample size of the Canadian market, long range analysis continues to indicate an estimated 5-15% overall industry growth trend since 2013, although this is a conservative estimate

Compared to previous years, we have observed some market stabilization occurring due to corporate acquisitions and mergers, limited federal funding support, global economic uncertainty, and the activation of multiple municipal policies which will impact development cycles and specifications that will not be reflected in survey data for another 1-2 years, such as in Denver, Portland, San Francisco, and New York.

Based on average green roof performance data, Green Roofs for Healthy Cities estimates that the 3,112,818 square feet of installed green roofs will yield the following approximate benefits:

- 36.9 million gallons of stormwater retained per year;
- 120 tons of carbon sequestered every two years;
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- 1,199 full-time equivalent (FTE) construction jobs;
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Washington, D.C. continues to hold the top spot for green roof installations, followed by Chicago, IL; Toronto, ON; New York, NY; and Seattle, WA. Municipalities with supportive green policies continue to domination annual green roof installations.

Results by Geographic Location

One of the primary functions of this annual survey is to look at where in North America projects are being installed. This data allows us to examine what policies are effectively promoting growth in that market, where development hotspots independent of policy may be, and what markets represent new opportunities for growth.

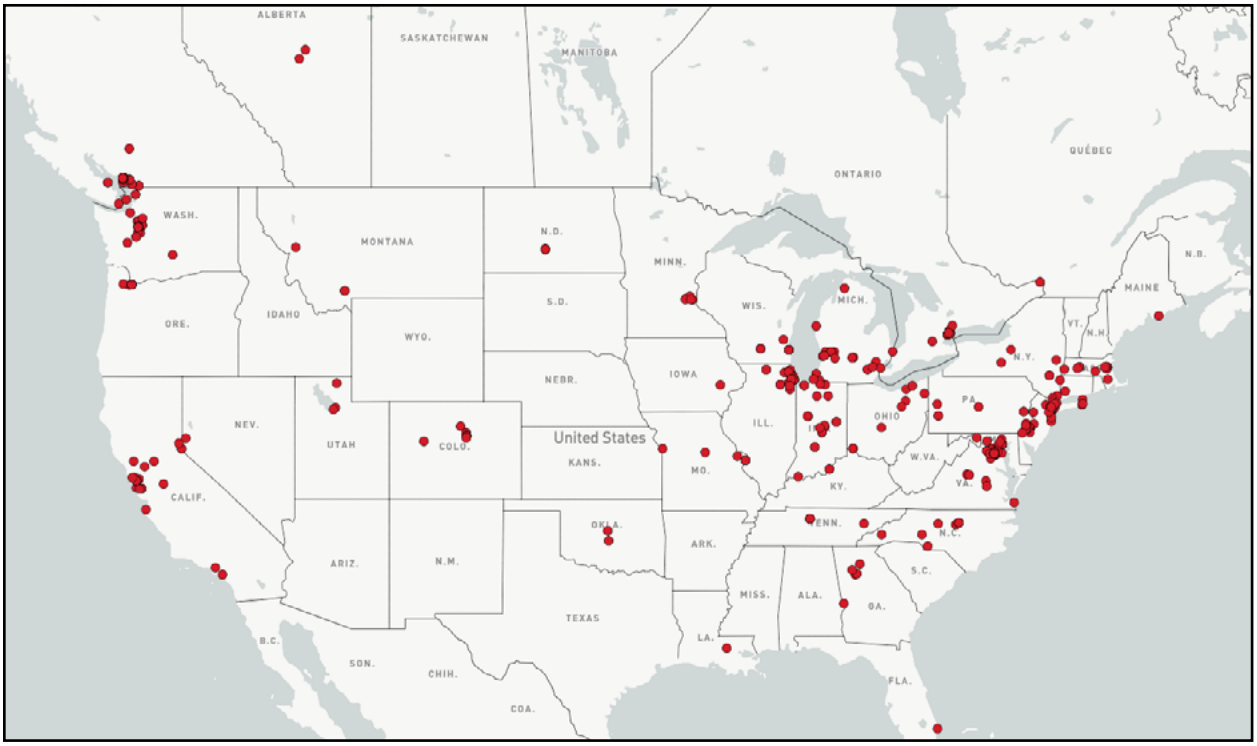

Figure 6 - Green roof installations reported in 2018.

Figure 6 displays an overlay of all cities in which Green Roofs for Healthy Cities has recorded green roof installations for 2018. Each point on the above map represents an installed green roof in 2018.

As has been seen in previous years, market activity is highest primarily on the northeast coast of the United States, and secondarily in major urban environments across the country. The cities in the northeastern United States tend to be older, and thus have more aged infrastructural systems and combined sewers which can be quickly overwhelmed by stormwater flow across impervious surfaces. The northeast is also subject to a relatively higher amount of annual precipitation, either in terms of rain or snow, contributing to the demands on infrastructure systems which can be eased through the implementation of green infrastructure.

Large cities and metropolitan regions face many of the same infrastructural challenges, independent of their location, which contribute to development hotspots observed in and around cities like Chicago, Seattle, Vancouver, and San Francisco. Population density and increased impervious surfaces often go hand in hand, and in arid climates like those found in California, increased green space can help preserve the natural water balance, keeping water in water scarce areas rather than diverting it elsewhere.

An alternative method of visualizing this data is seen in Figure 7, which shows a heatmap of the green roof installations completed in 2018, providing a better look at development intensity across the continent.

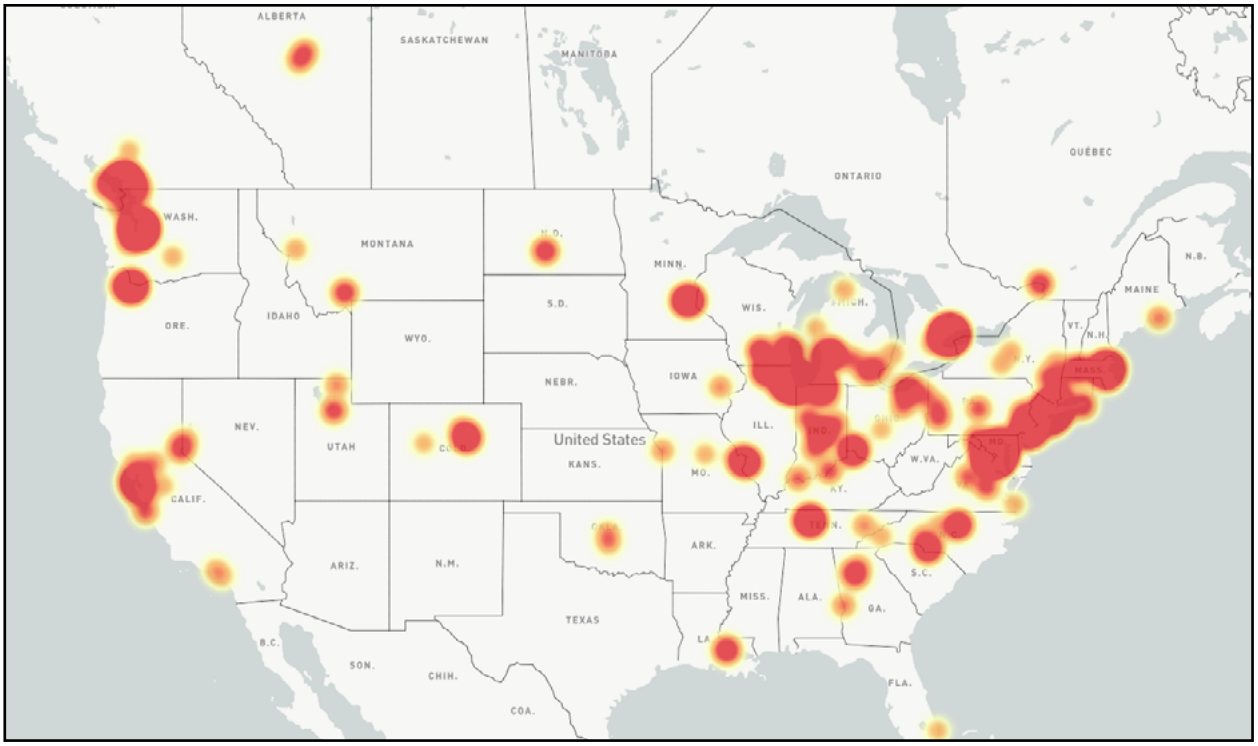

Figure 7 - Heat map of green roof installations reported in 2018.

This heat map helps visualize the size and concentration of reported green roof installations in North America, highlighting the trend of green roof installations around major metropolitan areas and highly dense regions.

During 2018, green roof installations occurred in 35 American states and three Canadian provinces. Installations are found predominantly in urban centers for their ability to reduce the urban heat island effect, provide amenity space, manage stormwater and reduce combined sewer overflow (CSO) events.

Policy is one of the largest observed drivers of green roof market growth in North America, promoting local development in municipalities.

There are seven primary market-based policy tools for encouraging green infrastructure implementation:

1. **Stormwater user fees and fee discounts**. Allow municipalities to charge for services provided
2. **Stormwater credit trading**. Third party managed system that allows for the generation, transaction or trade of stormwater management capacities, driven by regulations.
3. **Grants, rebates, and installation financing**. Provide funding for particular forms of

green infrastructure

4. **Development charges**. Charges that can be reduced to account for green infrastructure provisioning
5. **Development incentives**. Such as density bonuses which can allow variances if certain features are incorporated
6. **Habitat compensation banks**. Compensation funding for development caused damage which allows complimentary habitats to be restored or enhanced in other locations
7. **Regulatory Requirement.** Mandatory implementation legislation, often focused on new construction.

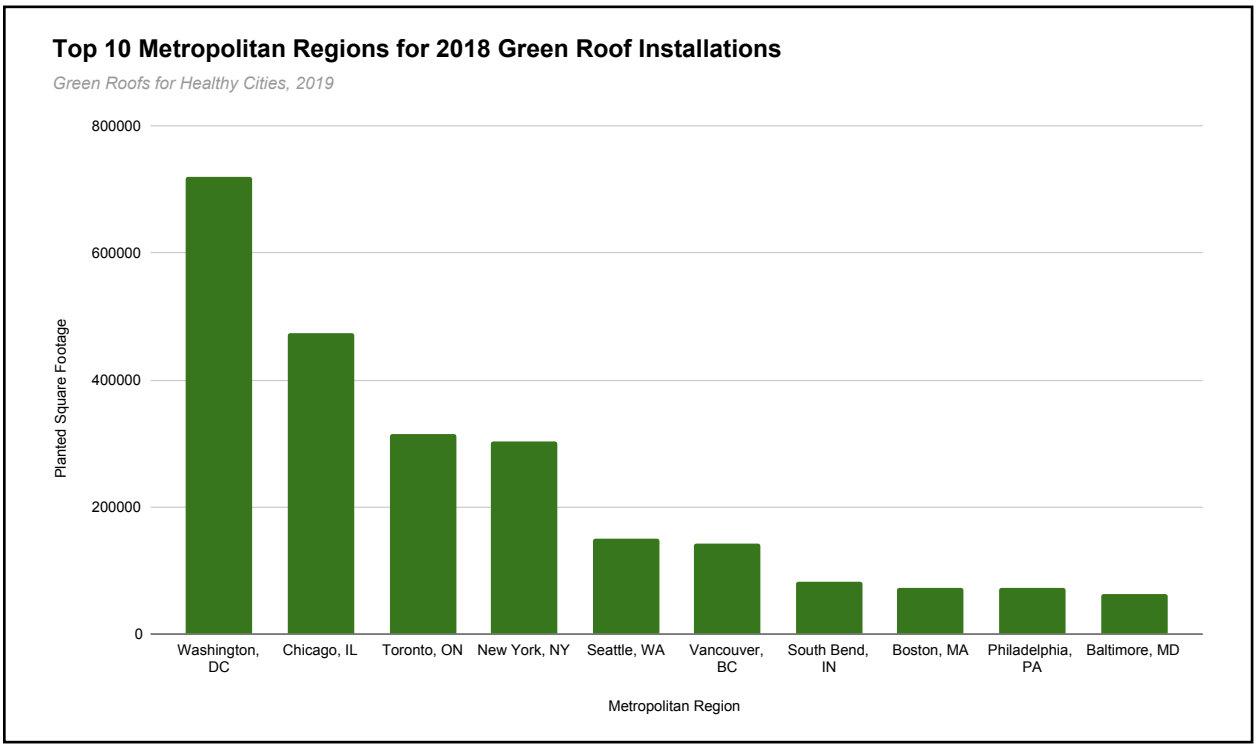

Figure 8 - Top 10 metropolitan regions for green roof installations

Figure 8 demonstrates the top ten North American metropolitan regions by installed square footage of green roofs in 2018.

As in many years prior the Washington, D.C. metro area saw the largest amount of green roof square footage installed in North America. This is because Washington D.C. has a variety of policy approaches that have helped develop and expand the green roof market across the metropolitan region such as:

- **Stormwater Runoff Fees and Credits** along with a robust credit trading aftermarket which leverages traditional market economics to incentivize on-site retention of stormwater.
- **Minimum Storwmater Management Requirements** for new developments.
- **Green Roof Rebate** for voluntary installation of green roofs.
- **Green Roof Requirement** in specified watershed areas to help improve permeability.
- **Green Area Ratio** specified a particular vegetative coefficient required on sites.

These approaches have both directly and indirectly enhanced the green roof market by providing a variety of compliance pathways for which green roofs with their multitude of benefits are often the best fit. As such green roof market activity in the metropolitan area has grown, and remained strong, particularly as new policies come online.

Completing the top five are Chicago, IL; Toronto, ON; New York, NY; and Seattle, WA. Each of these cities has implemented policies or regulations that support green roof installations. Similarly, of the top ten metropolitan regions, nine have some manner of policy supportive of or enhanced by green roofing.

Figure 9, below shows the distribution of green roof installations in the top ten United States metropolitan areas.

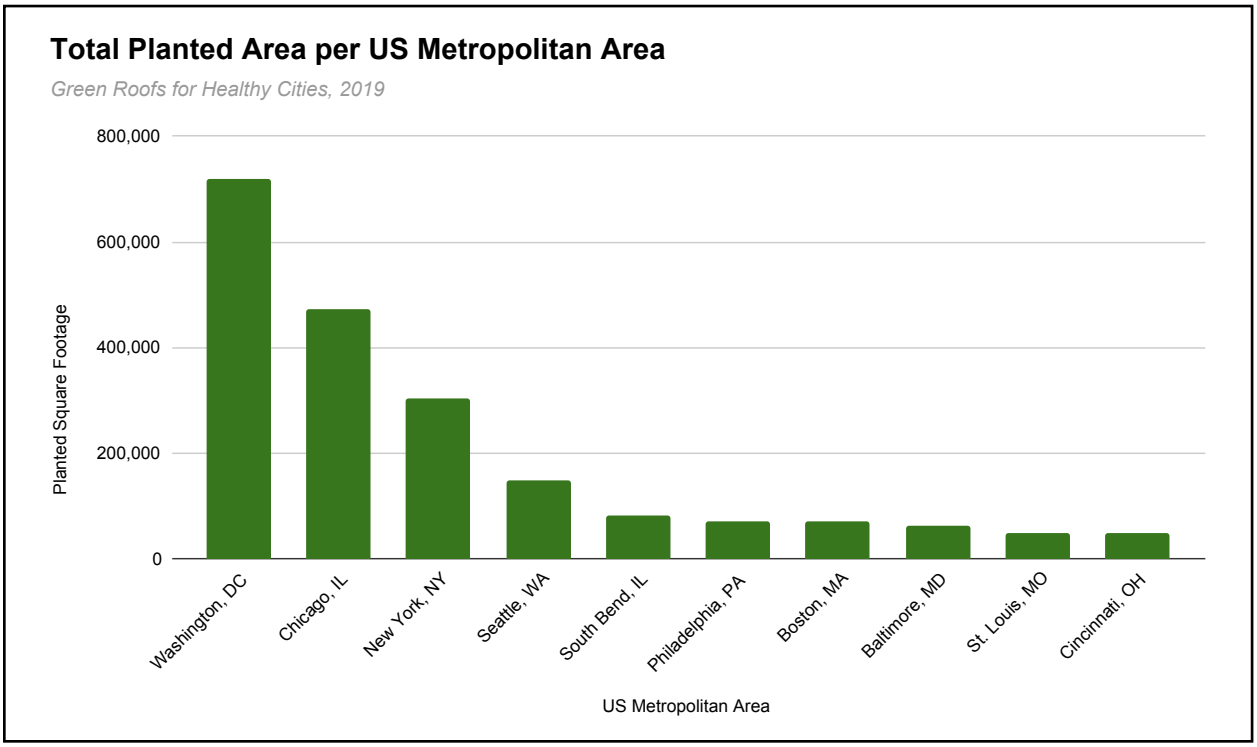

Figure 9 - Top 10 US metropolitan regions for green roof installations.

Figure 10, on the following page, shows the distribution of green roof installations in the top five Canadian metropolitan regions.

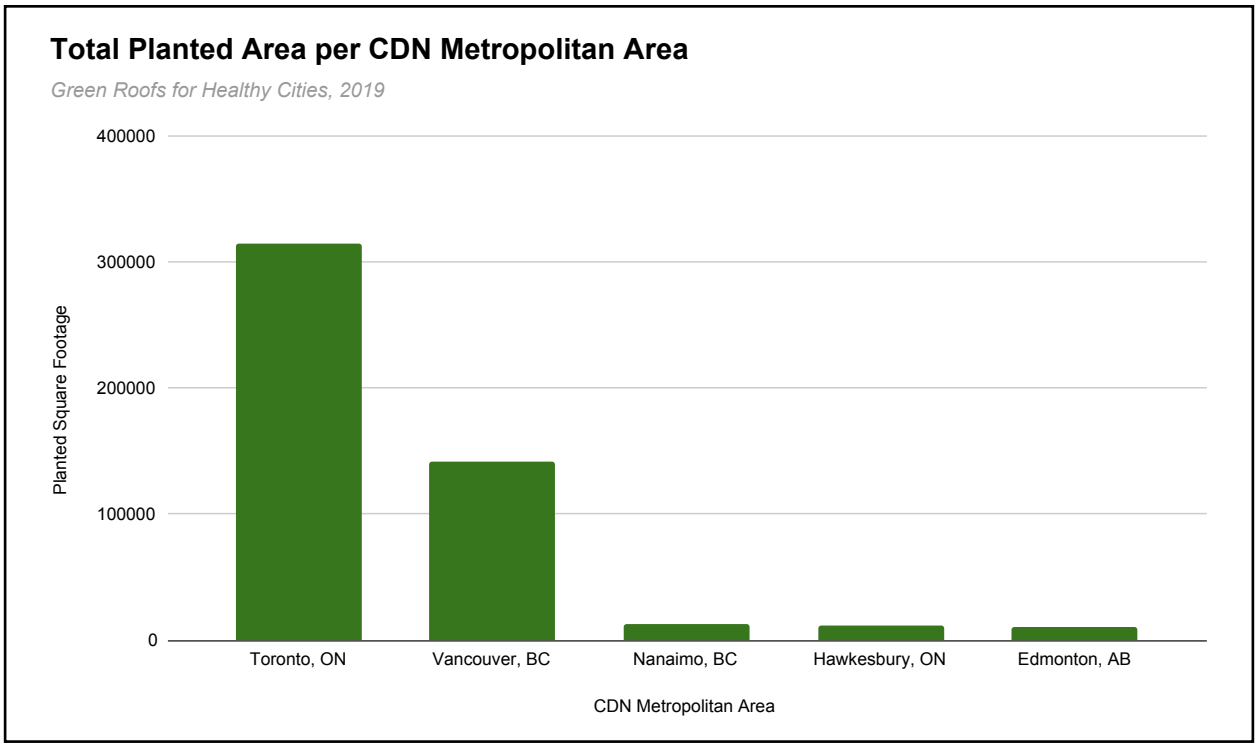

Figure 10 - Top 10 Canadian metropolitan regions for green roof installations.

As mentioned previously, green roof installations were reported in 34 US States and 3 Canadian provinces in 2016. Figure 11 demonstrates the distribution of green roof installations across all reporting US states.

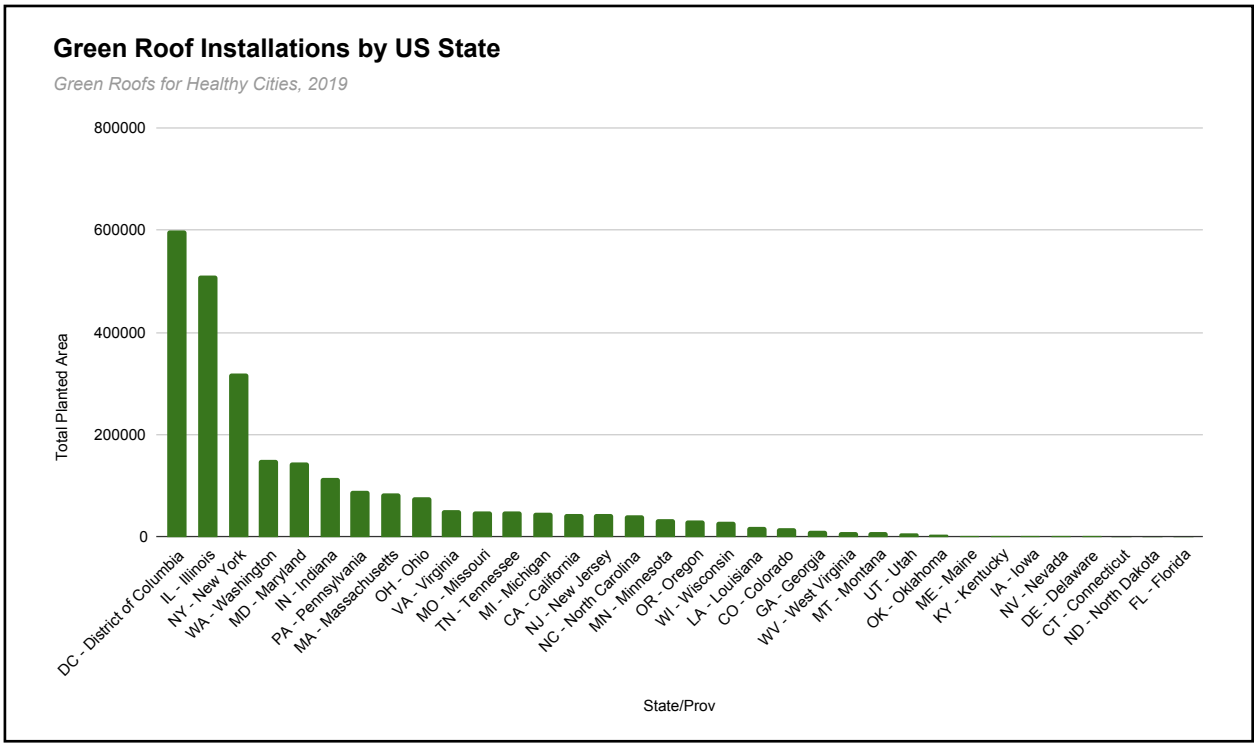

Figure 11 - Green roof installations by US State.

Development and installation distributions speak to several different elements of green roofs abilities to improve the local environment. The eastern seaboard of the United States has a significantly higher population density and more overlapping metropolitan areas. Green roofs can help mediate local temperatures by reducing the impact of the urban heat island effect contributed to by increased population densities and a higher ratio of paved versus green space from contiguous urban areas.

The northeastern seaboard of the US is also subject to a high amount of precipitation and storm activity from annual rainfall and hurricane landfalls. Green roofs are a very effective stormwater BMP in these environments, working to delay, slow and retain stormwater and reduce peak flow rates by up to 65 per cent. Green roofs increasing the amount of time it takes for stormwater to enter into the local sewer system and slowing its progress, further reducing peak flows.

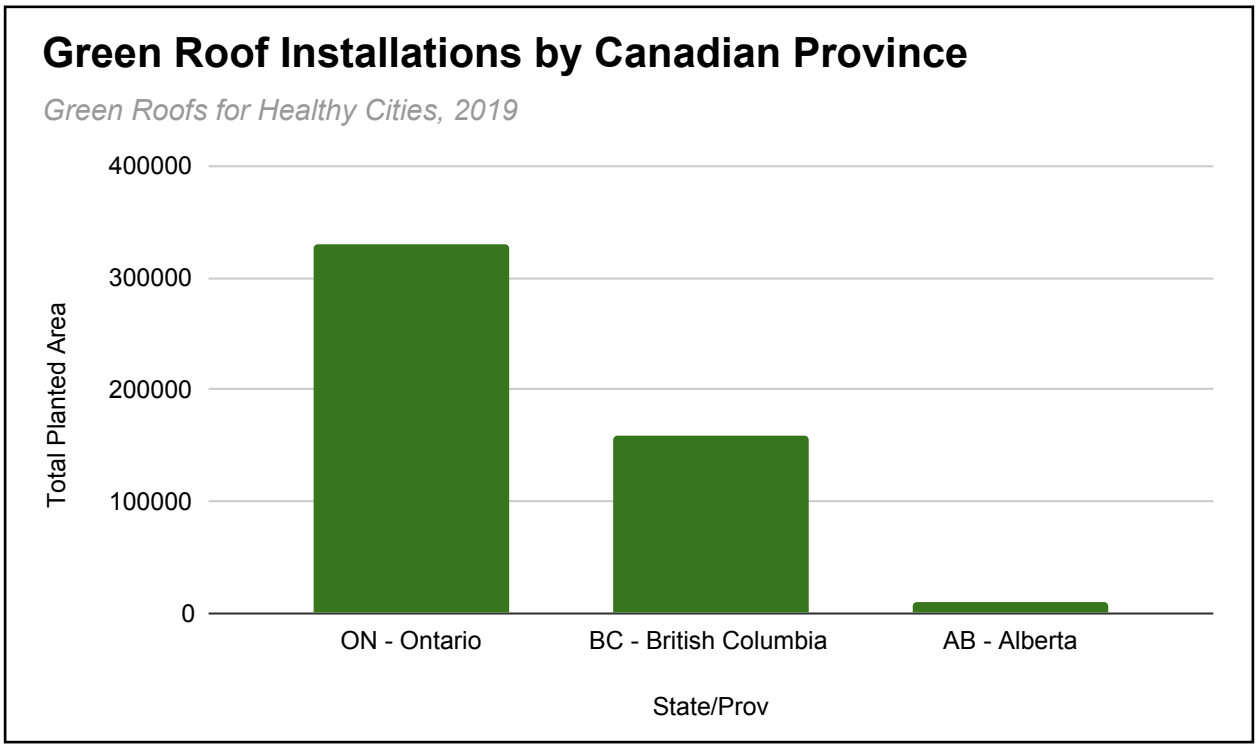

Figure 12 - Green roof installations by Canadian Province.

Figure 12, above, shows the distribution of green roof installations across all reporting Canadian provinces. Currently, there are relatively few supportive policies for green roofs in Canada outside of Ontario, although the City of Vancouver is currently exploring options for policy implementation as part of their broader effort to manage stormwater and mitigate heat islands the city currently experiences.

Results by Roof and Planting Type

Green roofs are categorized according to the depth of their growing media, as being either extensive, semi-intensive, or intensive. Extensive green roofs are installed with six inches of growing medium or less; generally weigh between 13 and 30 pounds fully saturated per square foot; and support sedums, herbs and grasses. Intensive green roofs are roofs installed with six inches of growing medium or more; generally weigh between 35 and 100 pounds fully saturated per square foot; and support sedums, perennials, shrubs, and even small trees. Semi-intensive green roofs are roofs that have a mixture of extensive and intensive systems; generally weigh between 25 and 40 pounds per square foot; and support plantings seen on both extensive and intensive green roof installations.

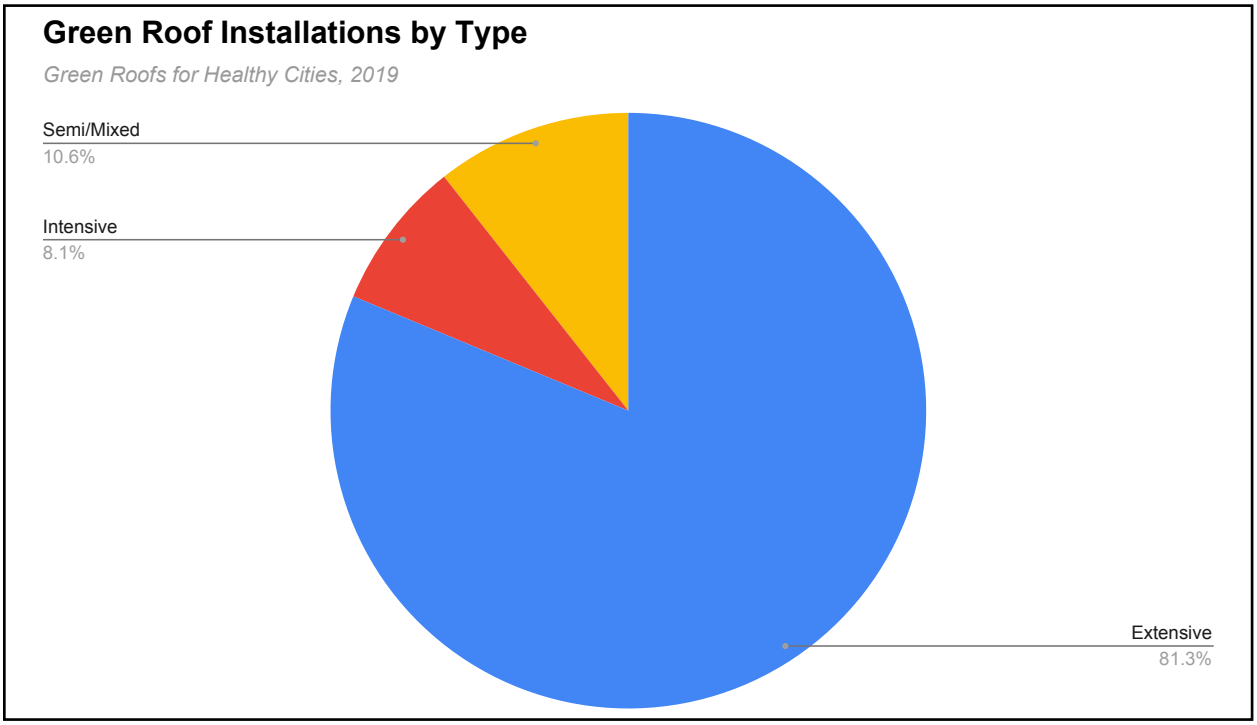

Figure 13 - 2018 reported installations by green roof type.

Figure 13 demonstrates the distribution of green roof installations reported in 2018, excluding those which were unspecified. As in previous years, more than 80% of reported installed green roofs were extensive systems. These systems are traditionally lower cost per square foot to install and maintain compared to intensive and semi-intensive systems. They also have lower structural loading requirements on the building, and hence, a much larger market.

Of these systems Green Roofs for Healthy Cities has also observed trends in the way in which the plants on these extensive and intensive systems are initiated. Green roof planting types are divided into multiple categories; including cuttings, plugs, pre-grown modules, seeding, and vegetative mats. Cuttings are trimmed sedums that are planted or cast on growing medium. Plugs are small plants with a soil and root ball that are planted into the growing medium. Pre-grown modules are trayed plantings that can be placed or interlocked to provide planted coverage, growing media, and drainage. Seedings are installations grown from seeds cast or blended into growing medium. Vegatative mats are pre-grown sedum blankets that can be laid over growing medium.

Pre-vegetative systems traditionally require less maintenance when they are first installed compared to seeding the roofs or using plugs. Pre-vegetative systems can also be grown off-site and transported to the building easily and installed quicker than individual seedings or transplants.

For simplicity's sake, we have condensed several categories of planting type. Vegetative Mats includes installations of sedum tiles, sedum mats, and other types of woven vegetative systems. Similarly, container grown plants includes all individual plantings such as installation by plug, or root ball in burlap. We feel that the distinction between these systems does not reflect a substantive difference in planting type, but instead a different in plant selection.

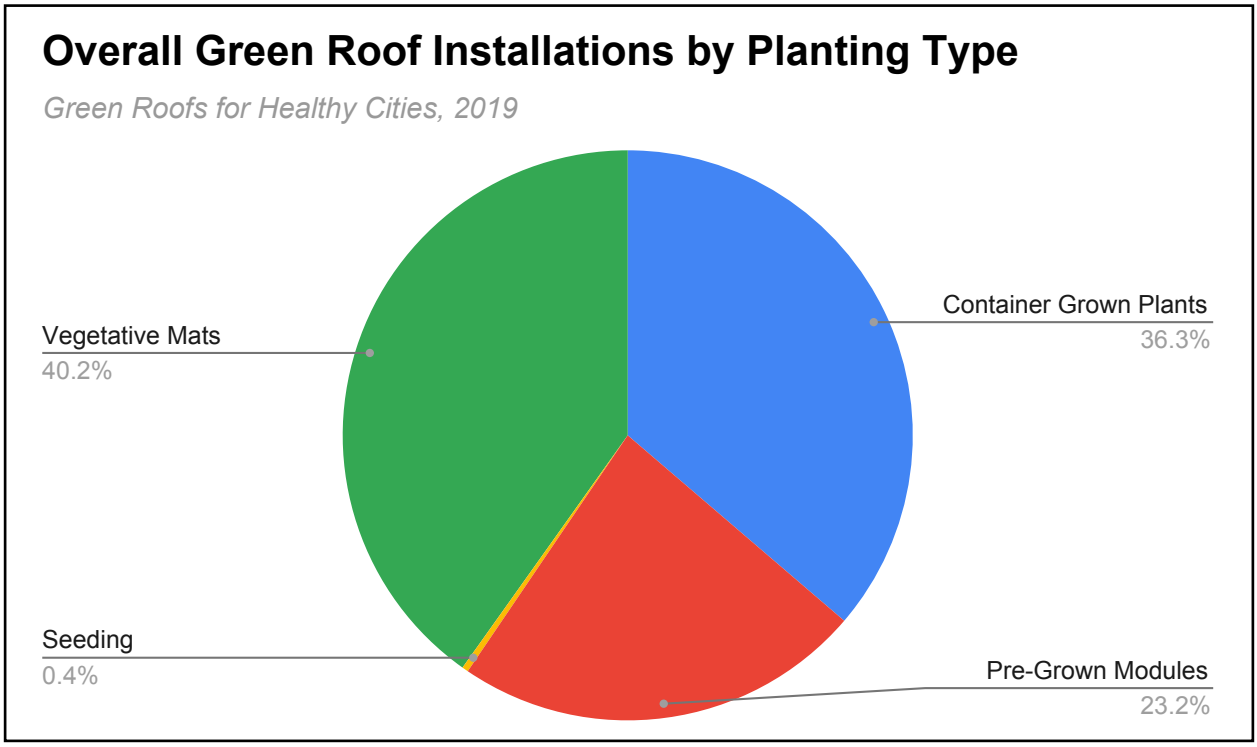

Figure 14 - 2018 reported installations by planting type.

Figure 14 is a chart highlighting the distribution of planting methods for installed green roofs, excluding instances where the planting type was unspecified. Overall vegetative mats are the dominant planting type for green roofing, followed by container grown plants and pre-grown modules, and a very small percentage of seeding. This speaks to the speed with which these planting can be deployed across an installation with an easily estimated plant coverage percentage. This planting type also benefits from requiring less labor to install, as well as less maintenance up front.

Although this distribution is consistent with previous years, the percentage share has changed over time, with container grown plants and pre-grown modules representing and increasingly large percentage of installed square footage.

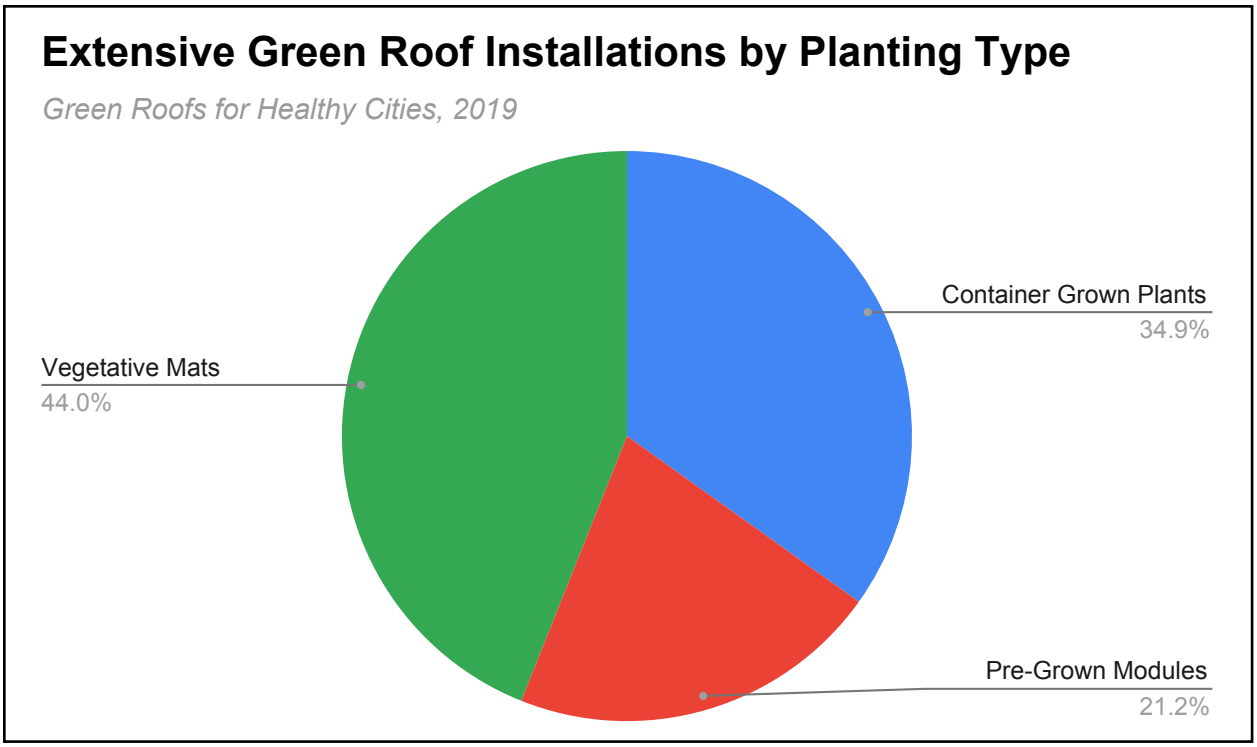

Figure 15 - 2018 reported planting type on extensive green roofs.

We also explored reported planting types by type of green roof, to determine if there were any differences in approach between intensive, extensive, or mixed installations. Figures 15 and 16 show the distribution of planting type by extensive installations, intensive installations.

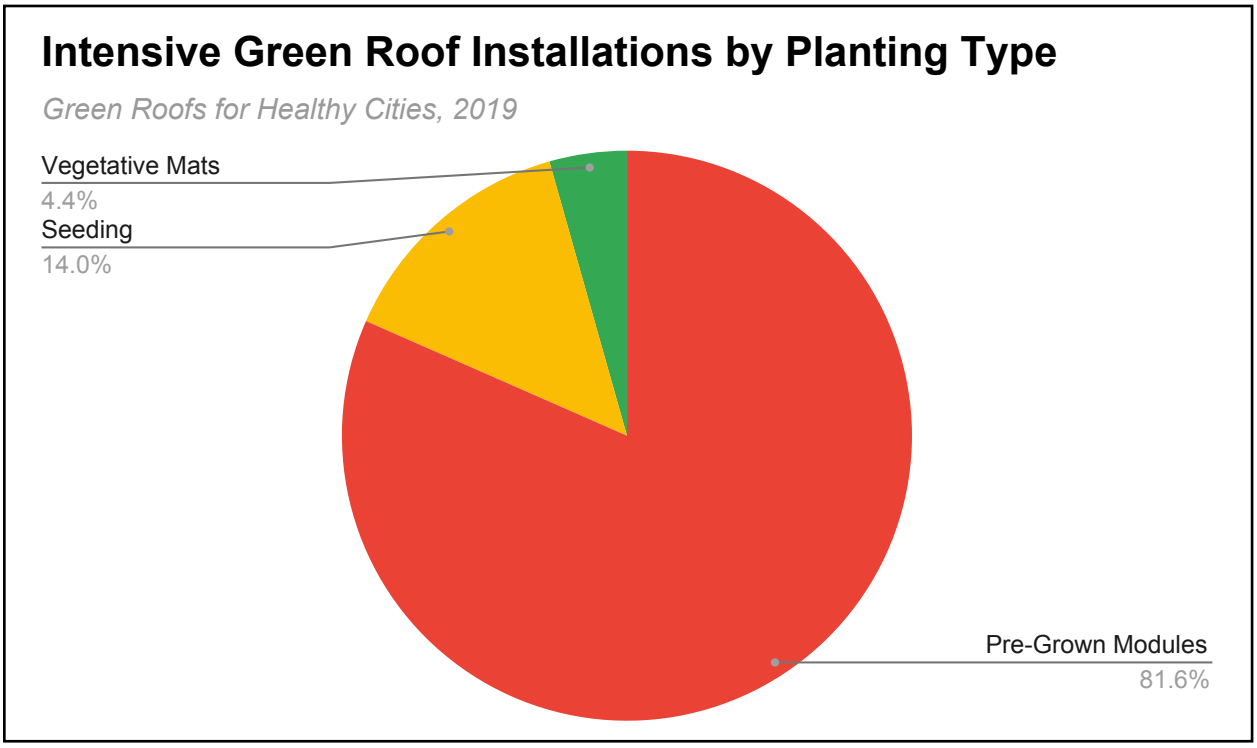

Figure 16 - 2018 reported planting type on intensive green roofs.

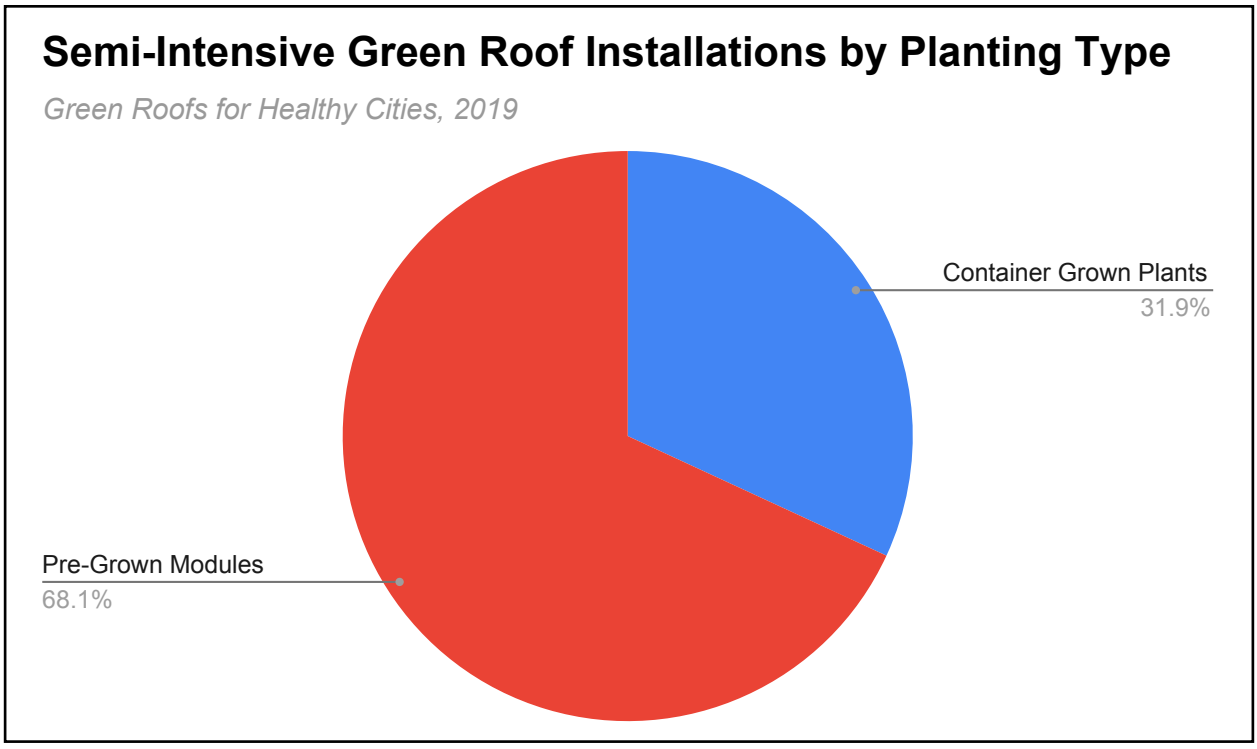

Figure 17 -2018 reported planting type on semi/mixed green roofs.

Figure 17, shows the distribution of planting type by semi-intensive installations respectively.

Looking at reported plantings by green roof type reveals that pre-grown modules are more commonly utilized in installations that are partially or entirely intensive, likely due to the fact that vegetative mats are most commonly shallow rooted sedums which would not take advantage of the soil depths found in intensive installations. These depths allow for a larger plant diversity, and a flexibility in planting type not afforded by extensive green roof installations.

Results by Development and Project Type

The type of development on which green roofs are installed allow us to better understand what building types are driving green roof installations, and to see what proportion of those buildings are new construction or retrofits.

Responses were divided into five categories: commercial, such as retail or office spaces; industrial, such as warehouses or factories; institutional, such as municipal or federal infrastructure buildings, churches, and other public spaces; multi-unit residential, multi-family homes such as apartments or condominiums; and single family homes and other small residential properties.

We asked respondents to report the building type on which the installation was completed.

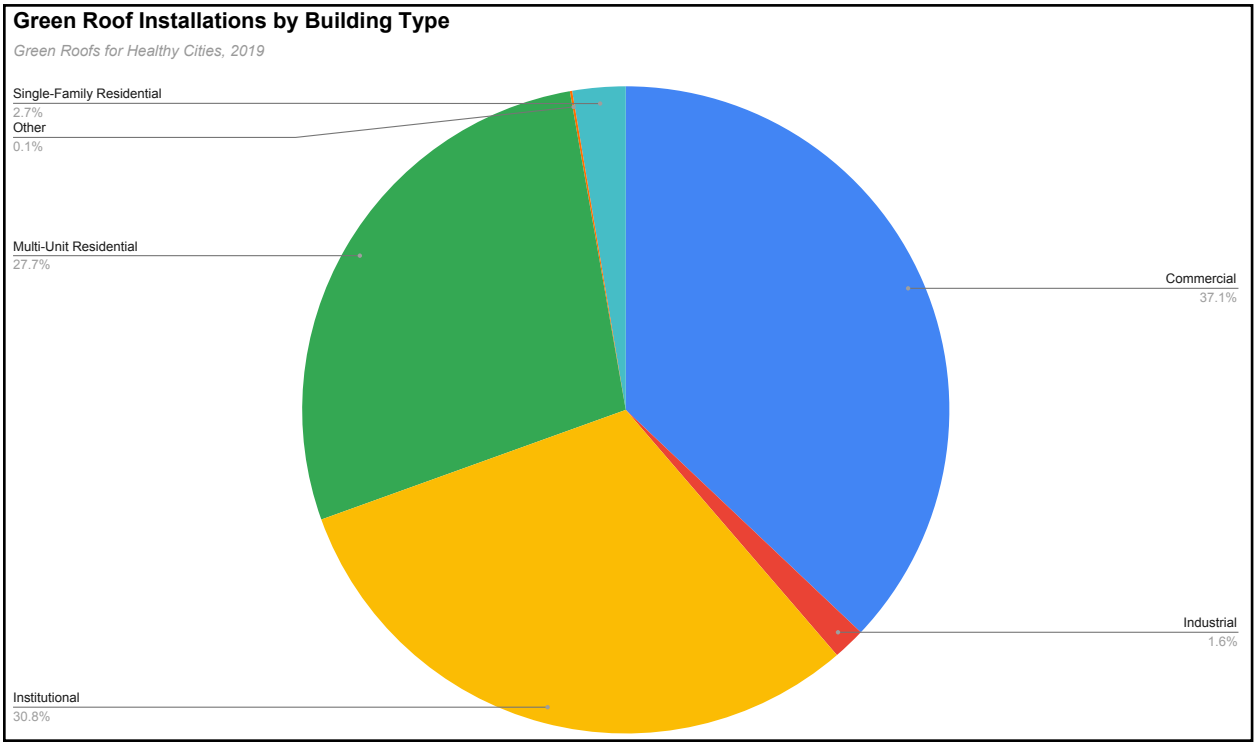

Figure 18 - 2018 reported installations by building type.

This year, unlike previous years, installations on commercial buildings represented the largest amount of square footage installed in 2018. As shown in Figure 18, commercial installations represent 37.1% of the installed square footage, compared to 30.9% on institutional buildings. Prior to 2017, institutional buildings represented the largest percentage of installed green roof coverage, accounting for 36% in 2016. 2017 saw that trend change to commercial installations, which represented 35% of installed square footage, up from 29% in 2016. Green roof installations on multi-unit residential buildings still represent a significant proportion of installations, likely due to green roofs ability to improve property values, and provide highly valuable amenity space, particularly in dense urban environments.

Installations are further categorized by their development type, defined as public or private projects. Private projects are privately owned developments (for example, business or housing), whereas public developments are generally government owned or funded projects that are often open to the public.

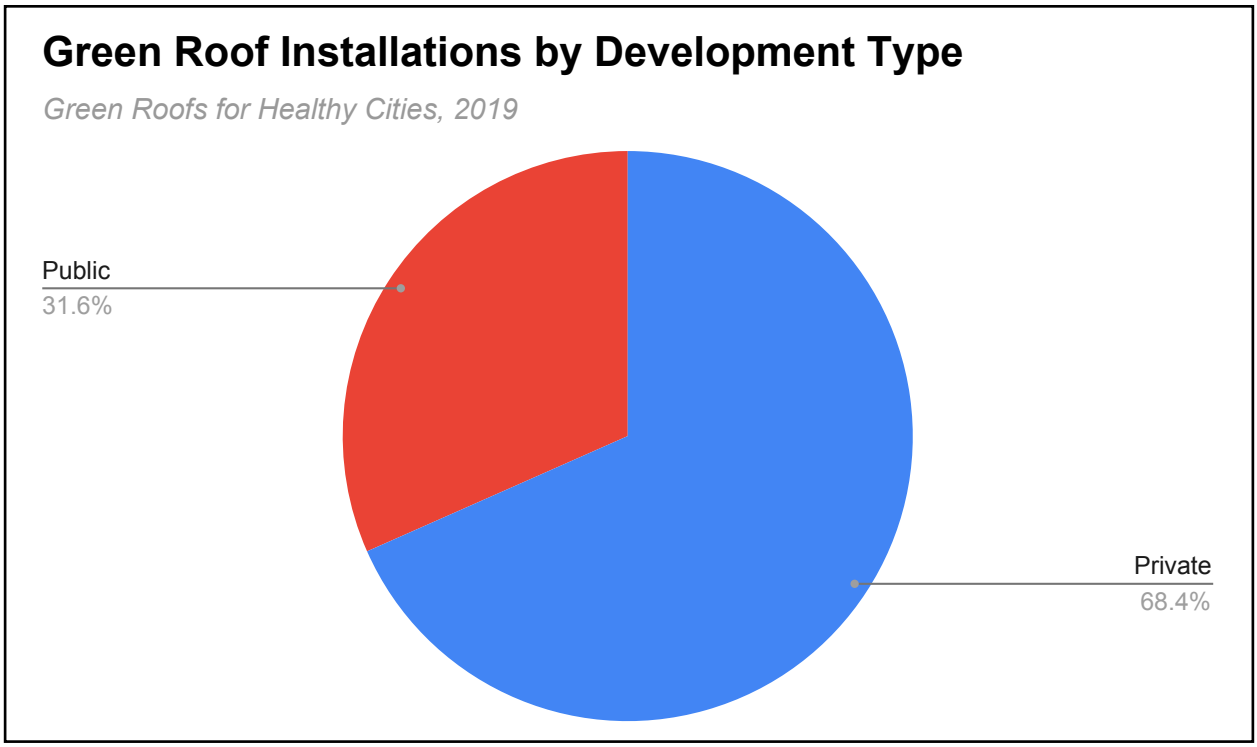

Figure 19 - 2018 reported installations by development type.

When compared to the previous data distribution, Figure 19 shows that, while institutional projects represent a significant proportion of installed green roof projects, there is a larger variety of private projects, which combined, exceeds the installation footprint of public projects. Green roof installations on privately owned projects continue to dominate this category.

Installations are also defined by their project type, whether they are new or retrofit construction projects. Retrofit construction are projects that, for one reason or another, revisited to have a green roof added to an existing structure, while new projects are begun with a green roof included in the design.

Figure 20, below, shows the distribution of new versus retrofit green roof installations. As in previous years, the majority of green roof installations in 2018 took place on new construction

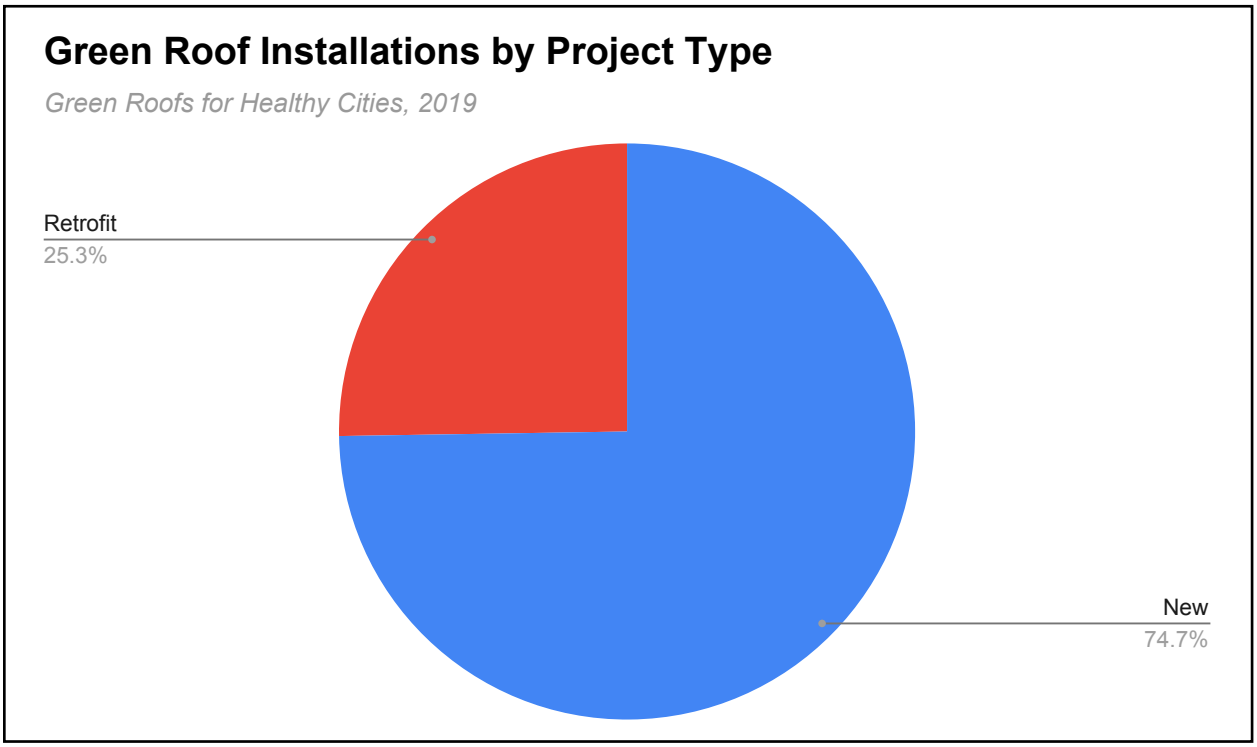

Figure 20 - 2018 reported installations by planting type.

projects, as opposed to retrofit. Green Roofs for Healthy Cities notes that green roof policies often require or provide incentives for new construction projects requiring them to have a percentage of roof coverage to be vegetated.

Aggregate Green Roof Benefit Analysis

One of the difficulties to green roof market expansion is the perception that they are expensive relative to the benefits they provide. In many instances, the long term benefits of green roofs are not realized in the face of short term costs. The Green Infrastructure Cost-Benefit Matrix was developed by the Green Infrastructure Foundation (GIF) for use in the Green Infrastructure Charrette program to help better understand the many costs and benefits associated with various levels of green infrastructure investment, at an aggregate scale.

This section presents what is theoretically possible with the installation data provided for 2018 and highlight some of the analysis that the Cost-Benefit Matrix is capable of. Further information about the Cost-Benefit Matrix, and the Green Infrastructure Charrette program, can be found online at greeninfrastructurefoundation.org or by contacting Rohan Lilauwala, Program Manager at rlilauwala@greenroofs.org.

The Green Infrastructure Cost-Benefit Matrix monetizes the multi-dimensional benefits of green infrastructure by identifying average values for a variety of benefits conferred. The values that the Matrix uses are averages, reflecting large scale implementation, rather than project specific values; analyzing fifteen generic living green infrastructure types against average high, medium and low reference values. For this, property tax considerations were ignored and medium values were used to reveal some estimated cost-benefit analysis data for the green roof installations that were reported by respondents in the 2019 Annual Green Roof Industry Survey.

The Green Infrastructure Cost Benefit Matrix allows us to examine the different forms of types of green infrastructure individually as well as together. According to the survey, 1.4 million square feet of extensive green roofing; 140,000 square feet of intensive green roofing; and 180,000 square feet of semi-intensive green roofing, and 1.4 million square feet unspecified, were installed in 2018 across North America. Abstracted from individual projects, installations of these sizes would offer several different payback values reflected through national averages.

The 3.11 million square feet of green roofs installed in 2018 will:

- Retain 36.9 million gallons of stormwater annually;
- Sequester of 120 tons of carbon;
- Save 5.06 million kilowatt hours of energy from building HVAC for heating and cooling.

1.4 million square feet of extensive green roof would provide:

- Approximate capital public benefits valued at $719,000;
- Annual public benefits valued at $485,000;
- Annual private benefits valued at $237,000;
- 462 full-time equivalent (FTE) construction positions for the project installation;
- 8 annual maintenance positions beginning after the first year.

140,000 square feet of intensive green roof would provide:

- Approximate capital public benefits valued at $466,000;
- Annual public benefits valued at $75,000;
- Annual private benefits valued at $28,000;
- 86 full-time equivalent (FTE) construction positions for the project installation;

- 7 annual maintenance positions beginning after the first year.

180,000 square feet of semi-intensive green roof would provide:
- Approximate capital public benefits valued at $88,000;
- Annual public benefits valued at $27,000;
- Annual private benefits valued at $152;
- 90 full-time equivalent (FTE) construction positions for the project installation;
- 6 annual maintenance positions beginning after the first year.

Conceptualizing the benefits of green roofs in this manor allows us to see how incredibly valuable they are not only at the time of their installation, but annually. Green roofs provide incredible benefits to the health of the local environment as well as the municipality in which they are built.

Conclusion

The green roof market continues to show net positive growth across North America, particularly as concerns regarding the climate crisis and local resilience play an increasingly large role in planning decisions and economic forecasts. There are, additionally, a variety of economic, climatic and policy drivers at play in an increasing number of municipalities across the continent.

2018 saw many trends continue, cities that have public policy support for green roofing have the largest green roof markets; new construction represented the largest percentage of installed green roofing; extensive green roofing is the most common installation type, and within that, vegetative mats are the most common green roof application. In a departure from previous years, green roof installations on commercial buildings represent an increasing share of installed green roofing, with institutional green roofs, while still a significant portion, less prevalent than they were in previous years. Green roofing provides a variety of private benefits to the property owner that would be realized by commercial business, such as energy use reductions, heating and cooling cost reductions, among many others.

As has been observed, the best way to protect annual market growth and reap the public benefits is through strong policy support from governments. Strong policy measures will encourage the widespread adoption and installation of green roofs and allow cities to reap all the various benefits they provide, particularly in the face of more extreme weather events. More municipalities have adopted or begun considering supportive green roof policy measures in 2018 and 2019, and several private market initiatives have been launched which can be expected to further fuel growth of the market in North America, such as PACE financing.

Green Roofs for Healthy Cities would like to thank its corporate members for their ongoing commitment to supplying data for this annual survey (see Appendix I), and also recognize the many contributions of Green Roof Professionals (GRPs) in the marketplace, who contribute significantly to the growth of the industry.

Appendix I

Green Roofs for Healthy Cities would like to thank these companies for their participation in the 2019 Annual Green Roof Industry Survey.

In alphabetical order:

• Architek	barrettroofs.com
• Eco-Roofs	eco-roofs.com
• Elevation Green Roofs	www.elevationgreenroofs.net/
• Emory Knoll Farms/Green Roof Plants	greenroofplants.com
• Etera	etera.com
• Ginkgo Sustainability	ginkgosustainability.com
• Greenrise Technologies	greenrisetech.com
• Green Roof Outfitters	greenroofoutfitters.com
• Jeffrey L. Bruce & Co	jlbruce.com
• LiveRoof	liveroof.com
• Omni Ecosystems	omni-ecosystems.com
• Recover Green Roofs	recovergreenroofs.com
• Sempergreen/Moerings USA	sempergreen.com/us
• Xeroflor America	xeroflornorthamerica.com

Participants and Advanced Corporate members receive a detailed database of projects.

The Green Pages Industry Directory, a full directory of GRHC Corporate members can be found at http://issuu.com/grhcna/docs/grhc.

Appendix II

Annual Survey Methodology

Each year, Green Roofs for Healthy Cities' corporate members voluntarily and confidentially provide information on a range of categories for each project installed or supplied in 2018. Once submissions are closed, the data is reviewed. Duplicate entries which occasionally arise from sourcing data from both suppliers and installers are removed from the data set to minimize the possibility of double counting projects by comparing the type, size, and location of each project.

The annual growth rate is determined to give a broad look at the overall health of the green roof market in North America. This growth rate is determined by comparing the previous year's results with the current year's results, controlled for respondents and total installation size. Annual industry growth rates are derived by determining the growth rate of a cross section of participant installation averages recorded by a median sample range of respondents. Installation totals are determined per data sheet and controlled for outliers, with the three largest and smallest values removed from the calculations, to obtain the most accurate overall average.

This method of growth rate is employed because of the anonymous survey submission process. In previous years individual growth rates were determined for participatory companies, but in an effort to ensure anonymity of the submission process for participants, these individual growth rates cannot be determined. Utilizing average installation values allows for growth rates to be determined while controlling for a variable sample size.

The square footage of reported green roof installations is then aggregated against several reported categories such as city; building type; green roof type; to analyze installation trends that may arise. Data is then parsed geographically to determine the top ten metropolitan regions for green roof installations in the United States, Canada, and North America as a whole. Metropolitan region aggregates are determined by mapping the project cities and then finding the largest metropolitan center in a 25 mile radius within the same province/state.

Green Roofs for Healthy Cities estimates that the data in this report generally understates the market activity by anywhere from 25 to 50 per cent given that not all firms in the industry are members of Green Roofs for Healthy Cities and not all members are able, or willing, to participate in the annual survey. Nonetheless, the data does provide important insight into the composition of the industry and its development. Due to the sample size of the submitted data, and the inability to collect installation data from every green roof company in North America, industry forecasting is not provided in the results of this survey, and observations are based purely on comparative reporting and current market state.

The survey report is made available to all Green Roofs for Healthy Cities corporate members as a membership benefit, along with access to all previous survey reports. The full data set is made available to all participants of the survey. Current and previous reports are available for purchase online at greenroofs.org.

Appendix III

Cost-Benefit Methodology

The *Green Infrastructure Cost-Benefit Matrix* encapsulates a wide range of economic and biophysical research data tied to fifteen generic types of green infrastructure. The Matrix comprises the following components:

- Fifteen generic living green infrastructure types;
- Two cost values per square foot derived from literature and peer reviews for capital and maintenance;
- Eleven benefit values for each type of generic green infrastructure that are evaluated as either public or privately realized benefits;
- Values for most costs and benefits are expressed in dollars per square foot of implemented green infrastructure;
- Values for job creation are expressed in person years of employment based on the investment made;
- Values are often provided in high, medium, and low ranges to facilitate customization. Custom values based on local numbers are also possible, and increase the accuracy of the matrix; and
- Values may be expressed as one time capital cost or benefit or an annual cost or benefit.

The Matrix expresses most costs and benefits in dollars per square foot. This facilitates our ability to quickly provide aggregate estimates of significant green infrastructure deployment at various scales.

The Matrix does not incorporate inflation rates, rising utility costs or discount rates on capital. Monetary values presented in the literature have not been adjusted for currency differences or the impact of inflation except where it has been deemed that the gap in time has become too significant.

When it comes to green infrastructure benefits at an aggregate scale precision is costly to attempt, impossible to achieve, and ultimately, unnecessary to the task at hand. Many important benefits cannot be expressed in monetary terms. For example, the Matrix does not include the human health benefits that will result from widespread green infrastructure development, such as reduced rates of asthma in children or decreased levels of stress, because such benefits are difficult to quantify. Similarly, extending the serviceable life expectancy of roads due to shading, or pipes due to reduced water flows is not incorporated in the Matrix.

For the purposes of this analysis, since the Matrix only considers intensive and extensive green roofs, the installation quantity for semi-intensive installations was split in half; a cost-benefit analysis was run on both and the results were combined.

To download an example of the Cost-Benefit Matrix applied to the Harlem Green Infrastructure Charrette, visit http://www.greeninfrastructurefoundation.org/

Green Roofs for Healthy Cities, 2019