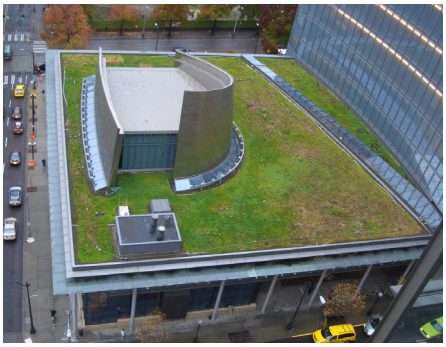
green roofs in seattle

a survey of vegetated roofs and rooftop gardens




City of Seattle
Department of Planning and Development

Seattle Public Utilities

Prepared for the City of Seattle and the University of Washington Green Futures Lab
by Annika McIntosh, August 2010

Introduction

The following information is derived from a Fall 2009 inventory of green roofs located within the City Limits of Seattle. The information presented here is the result of a collaboration between Seattle Public Utilities (SPU), the Department of Planning and Development (DPD) and the Green Futures Lab at the University of Washington. This research augments a body of current research seeking to address questions such as: How is Seattle contributing to the greening of our nation's urban rooftops? What successes and challenges are associated with the application of green roofs in existing projects and new development in Seattle? Could the combined area of existing and proposed green roofs provide significant watershed and public infrastructure benefits? This inquiry will help to develop a context for the further development of green roofs in Seattle and elsewhere.

Defining "Green Roofs"

There are multiple terms used to describe a vegetated roof, and considerable breadth in what qualifies as a green roof versus a roof-top garden. The City of Seattle uses the term "green roof" to refer to both lightweight, xeric eco-roofs and more heavily planted roofs. Many roofs in Seattle include both types, as well as planter boxes. Below are some commonly used definitions of green roofs (also referred to elsewhere as eco-roofs, vegetated roofs, and living roofs):

1. A layered system of synthetic roofing and drainage layers underlying a layer of soil and plants on a building roof.[1]

2. Plants in a growing medium (special soil mix) installed over a building's waterproofing membrane.[2]

3. A vegetated roof system used in place of a conventional roof.[3]

4. An extension of the existing roof which involves a high quality water proofing and root repellant system, a drainage system, filter cloth, a lightweight growing medium and plants.[4]

5. A roof of a building that is partially or completely covered with vegetation and soil, or a growing medium, planted over a waterproofing membrane. May also include additional layers such as a root barrier and drainage and irrigation systems. Container gardens on roofs, where plants are maintained in pots, are not generally considered to be true green roofs, although this is an area of debate.[5]

Ecosystem Services plus Economic and Health Benefits

The study of green roofs is relevant at this time in order to build our understanding of their associated costs and benefits regarding watershed health, infrastructure and building expenditures for public and private stakeholders, and air, water and habitat quality.

When Seattle receives significant rainfall during the winter months, the quantity and quality of runoff from streets and other impervious surfaces has a serious impact on the health of marine and aquatic life, and ultimately on human life. The filtering capacity of green roofs may reduce pollutant loads in receiving water bodies. Green roofs are considered to be effective Green Stormwater Inftastructure (GSI) tools for managing stormwater on-site by reducing, retaining and delaying runoff, especially for peak flows which may generate combined sewer overflow (CSO) events.

Other ecosystems services offered by green roofs include, but are not limited to: increased carbon se-

1. Taylor Associates, Inc, April 2006: Guidelines for Monitoring the Hydrologic and Water Quality Performance of Green Roofs
2. Seattle DPD website: http://www.seattle.gov/DPD/GreenBuilding/OurProgram/Resources/TechnicalBriefs/DPDS_009485.asp
3. Portland BES website: http://www.portlandonline.com/bes/index.cfm?&c=44422
4. Green Roofs for Healthy Cities website: http://www.greenroofs.org/index.php/about-green-roofs
5. Wikipedia: http://en.wikipedia.org/wiki/Green_roof

questration; urban heat island mitigation; improved air quality; and increased habitat for native plant species, wildlife and pollinators. In terms of human wellbeing, green roofs can provide recreational space and improved access to green or open spaces. In economic terms, a green roof may increase property value and extend the longevity of roofing materials.[6]

Green Roof Survey

By taking stock of Seattle's existing green roofs at this point in time, we gain insights into Seattle's growing green roof industry and its trends, creating a baseline understanding of this emerging marketplace. It also allows us to gauge the actual use of green roofs as a GSI tool. The continued use of this inventory will be valuable in determining the annual rate of green roof installation in Seattle, and will build our understanding of the advantages and challenges associated with the choice to build green roofs into certified green buildings and low impact development projects.

All of this information will be useful in tracking Seattle's progress against other American cities, and will provide grounds for comparison and collaboration as the body of knowledge regarding our city's green roofs expands. While there is yet much to learn from the experience of other municipalities and the ways in which they have incentivized the installation of green roofs, this research draws on the experience of designers, builders and engineers whose projects are specific to Seattle's codes, climate and development trends.

Methodology

The green roof survey was intended to capture existing large green roof projects with areas greater than 1,000 square feet, although smaller green roofs were included if they were identified. Information about existing green roofs in Seattle was collected using a combination of online research, phone interviews, and site visits. Designers, property managers and/or owners of all known green roofs were contacted and asked to provide certain data and background information (listed at right) on their project.
Lesser known green roofs and rooftop gardens were revealed by viewing the downtown area from the Municipal Tower's upper floor windows or by using online aerial mapping programs to conduct virtual "fly overs." Others were found simply by observation from street level or through informal communication. Information gathered during site visits supplemented what could be determined from communication with designers, managers and owners. All of this has been recorded in a spreadsheet, a GIS file and map graphics. These data will be updated as future green roofs are constructed. As more developers and designers report their projects, a clear picture of the growth of green roofs in Seattle will emerge.

The following items created a framework for the green roof survey:

Seattle Green Roof Inventory Items
- Project Name
- Address, Neighborhood, Zip Code
- Size of Green Roof (in square feet)
- % Green Roof Coverage (of total roof area)
- New or Retrofit
- Year Green Roof Constructed
- Type (Intensive, Extensive, Planter Boxes)
- Height (stories)
- Slope (%)
- System Type and Soil Depth
- Plant Type & Soil Mix
- Cost of Green Roof ($/square foot)
- Public or Private Accessibility to Roof
- Accessibility: (Walkable, Viewable, or None)
- Urban Agriculture (or potential for food production)
- Owner and Property Manager
- Designer(s) / Engineer(s)
- Builder
- Motivation to build?
  (e.g. LEED®, Built Green®, Green Factor?)
- Maintenance (Who, What type; Irrigation?)
- Monitoring Data (If so, by whom)
- Contact (Are tours allowed? Open hours?)
- Notes (establishment period, challenges, etc)
- Website or other relevant publications.

6. US EPA: Managing Wet Weather with Green Infrastructure

Types of Green Roofs in Seattle

The green roof installations in Seattle span the spectrum of extensive and intensive assemblies.

• ***Extensive green roofs or "eco-roofs"*** with a soil depth of 2-6" account for 42% of Seattle's green roof area. They are generally lightweight and low maintenance, with hardy grasses and/or succulents. Most extensive green roofs have a high percent of the total roof area covered in vegetation, and do not offer access to foot traffic. Good examples include the Ballard Library, the Hyatt at Olive 8, and the Seattle Cancer Care Alliance Patient Housing building.

Seattle Cancer Care Alliance roof. Photo: Annika McIntosh, 2009.

• ***Rooftop gardens or intensive green roofs*** account for 41% of Seattle's green roof area. These roofs are installed with soil depths of 6-36" to support more lush landscaping. They are often accented with planter boxes and sometimes trees. This type of roof is higher maintenance and often more accessible to residents and visitors. The Russell Center, M Street Apartments, and the Neptune Apartments are good examples of intensive green roofs.

Neptune Apartments roof. Photo: Annika McIntosh, 2009.

• About 7% of Seattle's green roofs have a ***combination of extensive/intensive assemblies,*** with varying soil depth and plant selection and varying degrees of human access. Mosler Lofts and Seattle Cancer Care Alliance Patient Housing have both extensive and intensive green roof areas.

• A growing interest in ***urban agriculture*** may spur the use of rooftop areas for cultivating vegetables and herbs. This survey currently includes only four buildings that support rooftop food production but due to the "do-it-yourself" nature of this type of urban food production in raised beds or planter boxes, they are difficult to track and/or observe. This use of rooftop space has great potential, and rooftop agriculture is likely to increase. At this time, Bastille Restaurant and McMahon Hall grow vegetables for food service while Alcyone Apartments and Florera Apartments are maintained by residents in a P-Patch community garden model.

Alcyone Apartments roof garden. Photo: Annika McIntosh, 2009.

• ***Lidded structures or at-grade green roofs*** comprise a separate category of green roof. They are predominantly turf or park areas with trees on top of major infrastructure such as reservoirs. They are often very large, and account for 12% of Seattle's total green roof area. Lincoln Reservoir (Cal Anderson Park) and Freeway Park fall into this category.

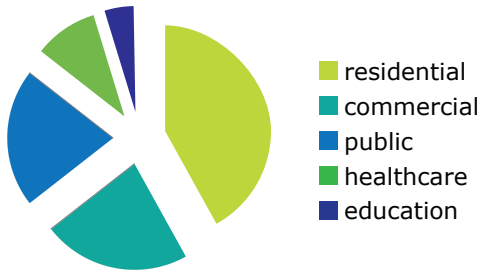
Geographic Distribution of Green Roofs

Most of Seattle's existing green roofs are found in centrally located neighborhoods, with an assortment of small scale projects in northern neighborhoods. Very few exist in Southeast Seattle or in the city's major industrial areas, which hold great potential for green roof installations and opportunities for significant improvements in stormwater management.

Green Roof Typologies and Building Uses

The size of a green roof on a building and the percentage of roof area covered by vegetation influence its performance. Roofs with higher vegetative coverage will provide better stormwater retention and provide better temperature regulation for a building and the surrounding air. Size and coverage seem to vary according to building use, which is notable because green roofs may be installed for different purposes in certain zoned areas. Various building uses also offer different levels of visual and actual physical access for monitoring and recreation. At this time, there is room for considerable growth in green roofs for industrial buildings.

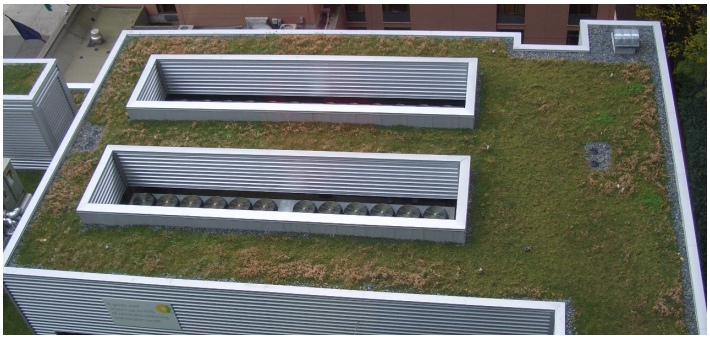
Green Roof Building Uses



Tiny green roofs, up to 300 square feet (SF) are often installed as demonstrations in easily viewable locations such as schools, parks or retail spaces. Even bird houses and dog houses have been given green roofs. These are often useful to test out materials and plants and to generate enthusiasm for green roofs.

Private garage roof. Photo: Rob Harrison (designer & owner).

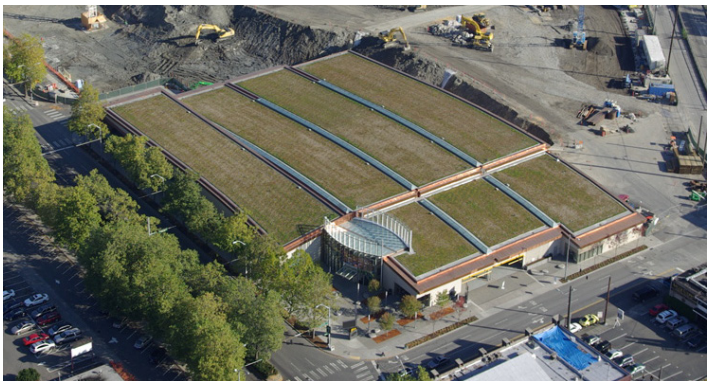
Small green roofs, between 300 and 1,500 SF, are mainly found on private residential projects. Most of these roofs are installed by homeowners, many of whom are architects or other professionals seeking to gain first hand experience. Projects of this size make up 36% of the green roof stock in Seattle.



The Hyatt at Olive 8 green roof. Photo: Annika McIntosh, 2009.

Medium-sized green roofs (between 1,500 and 8,000 SF) account for 32% of Seattle's green roofs. Buildings with mixed-use (commercial/residential) functions, multi-family housing units or condominiums are now more frequently built with green roofs as green building standards and incentives require the preservation or inclusion of green space for new development. Many planned green roofs in this category have been driven by Seattle Green Factor landscaping standards.

Green roofs with areas greater than 8,000 SF make up 26% of Seattle's green roof stock. ***Large*** green roof projects are found on civic buildings and private or corporately owned high rise buildings, mostly in the downtown area. Seattle's LEED® Silver policy for public buildings has influenced the installation of several downtown green roofs. Incentive zoning programs also allow private developers additional building height in return for the inclusion of green space.



Seattle Center 5th Ave. N. Garage. Photo: Justin Martin, 2009.

Lidded park areas and reservoirs make up the last category of Seattle's green roofs. A total of eight such vegetated areas cover 1,445,347 SF (33.2 acres), functioning primarily as public open space. While they may not fit the definition of a green roof, they do provide planted, pervious coverage over impervious infrastructure.

Survey Results

As of December 2009, the number of known existing green roofs in Seattle totals 62, including extensive and intensive green roofs plus some large rooftop gardens. The sum of the vegetated area of these roofs is 359,375 square feet. In addition, four buildings have designated space for food production in planter boxes, with a total of 3,631 square feet. The eight large at-grade green roofs, most of them reservoir lids, make up an additional 1,445,347 square feet of vegetated area.

Of the 62 green roofs and rooftop gardens, 32 are extensive, 23 are intensive, and 7 are a combination of extensive and intensive. Several of the intensive green roofs may not technically qualify as green roofs but rather as rooftop gardens. However, the vegetated area provided by these gardens may contribute benefits in terms of stormwater retention and filtration, urban heat island reduction and open space amenities.

The total area of existing green roofs, including rooftop gardens, ultimately contributes nearly 8.5 acres of pervious surfaces to the city's total roof surface area of 13,150 acres. A future increase in the number and size of green roofs would benefit Seattle's watersheds, public infrastructure, and a range of private and public stakeholders, by increasing vegetated area in the city.

Green Roofs in North American Metro Areas

The figures below were published in 2008 by Green Roofs for Healthy Cities (www.greenroofs.org) to track green roof installation of corporate members in North America. (Total area in square feet.)

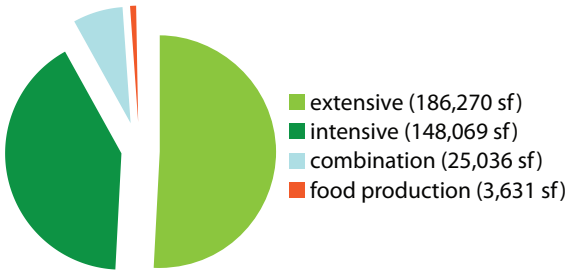
	installed in 2008
Chicago, IL	534,507
Washington, D.C.	501,042
New York, NY	358,986
Vancouver, BC	320,000
Philadelphia, PA	196,820
Baltimore, MD	150,032
Montréal, Québec	75,700
Grand Rapids, MI	74,784
Princeton, NJ	56,250
Newton Square, PA	48,130

While Seattle and Portland were not included in the above rankings, independent inventories by each municipality produced the following numbers (not including lids and at-grade green roofs):

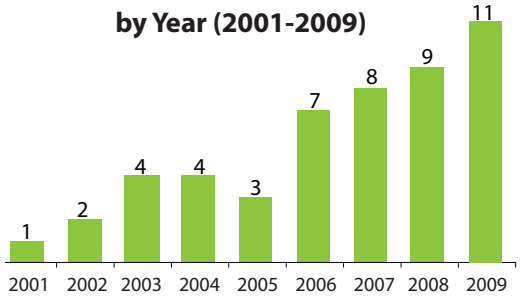
Portland, OR	117,000[1]
Seattle, WA	94,488

1. Portland Bureau of Environmental Services

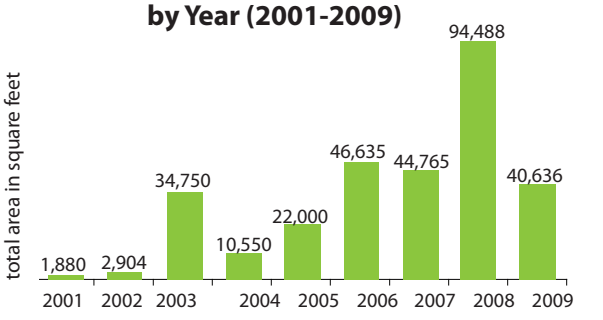
Green Roof Types by Area (square feet)



Number of Green Roofs Built by Year (2001-2009)



Green Roof Area by Year (2001-2009)



All graphs based on SPU's 2009 inventory of Seattle's green roofs and represent construction of roofs during that calendar year.

Bringing More Green Roofs to Seattle

An effort was made in completing the green roof inventory to discover whether any green building incentives or concerns for stormwater runoff control were influential in the decision to install a green roof on a given building. There was mixed response to this query. With the introduction of Seattle's Green Factor and the Built Green Certification as well as SPU's updated Stormwater Code, green roofs may be expected to appear in more retrofits and new development.

Green roofs tend to be eliminated from early plans due to initial costs and the uncertain availability of material and maintenance warranties. To date, most green roofs have been custom-designed to fit the specific requirements of each building, however there are a growing number of companies offering complete or partial green roof assemblies which relieves the responsibility of design and sourcing from architects and landscape architects. Many of the medium to larger green roofs in Seattle were installed using complete assemblies designed and tested by companies such as American Hydro Tech. Other products or green roof assemblies used in Seattle include tray systems (from Green Grid) and other designs by XeroFlor, Columbia Green, and Green Roof Blocks, among others.

While the initial cost of a green roof assembly plus installation and establishment may deter many developers and homeowners, it is generally accepted that green roofs in fact increase the longevity of the underlying roofing materials. The life cycle cost of green roofing materials is competitive with that of conventional roofing materials. Furthermore, green roofs provide an excellent opportunity to stimulate green jobs in Seattle's green building market place. In order to do this, more training programs are needed to prepare professionals for this field of work.

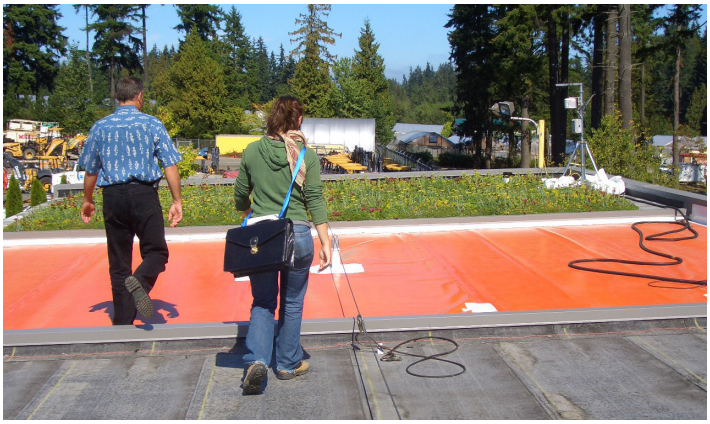
Place-Specific Green Roof Developments

Two current monitoring projects, one sponsored by Seattle Public Utilities (conducted by Taylor Associates) and one within the roofing industry (by Snyder Roofing and the University of Washington) are aimed at demystifying the performance and material requirements of green roofs in the particular climate conditions of the Seattle area. The monitoring and research by Seattle Public Utilities at the Zoomazium, Ballard Branch Library, Ross Park Shelterhouse and Fire Station 10 will help to standardize green roof modeling methods.

Private developers and designers on projects such as the Hyatt at Olive 8 and the Packard Building are also contributing to development in the green roofing field. They have installed green roofs using new materials, component configurations or planting methods, and are carrying out in-house monitoring of plant establishment and overall roof performance.

Homeowners with small-scale green roofs are also contributing to a body of knowledge leading to successful design and construction of green roofs in the region. In 2000, members of the Central Puget Sound chapter of the Northwest Ecobuilding Guild formed a group to research and build residential green roof projects. This group offers their findings to other green builders. Many of the participants in the Guild's Green Roof Project installed green roofs on their own homes and out buildings.

A growing body of local practical knowledge and experience, in combination with new products, will address requirements and constraints for a variety of building types and sizes. Increased diversity and flexibility of green roofing systems will build confidence in green roofs as affordable, viable green building features. For example, pre-planted tray systems with the essential green roof layers combined into small units or 'tiles' offer flexibility in configuration and facilitate repairs or modification. Many of the benefits of a fully installed green roof assembly are accomplished, while allowing incremental or partial installation.



Green roof test plots at Snyder Roofing. Photo: A. McIntosh, 2009.

Green Roofs in the Regulatory Toolbox

On-going monitoring of stormwater runoff, plant health, savings in energy use, and material life span will soon enable the accurate prescription and design of green roofs for a given site and desired uses. Currently, green roofs are considered a viable element in a tool kit of green building strategies that may help a project to achieve certification and/or recognition as a "green" building. The following certification programs and code requirements represent some motivating factors to encourage the growth of green roofs in Seattle:

King County/Seattle Built Green® Certification
The Master Builders Association of King and Snohomish Counties have developed this environmental building program in partnership with county and other governmental agencies to provide homeowners with rating systems for achieving environmentally friendly building practices. The four Built Green checklists include Site and Water, Energy Efficiency, Indoor Air Quality and Material Selection. Green roofs contribute to energy optimization, stormwater and erosion control, non-toxic landscapes, water-saving landscapes and heat island mitigation. Certification is intended for single- and multi-family new construction, townhomes, remodels communities or developments in Seattle and King County. [7]

LEED® Certification
(Leadership in Energy and Environmental Design)
New and renovated buildings may earn points in several sections of the LEED® rating system: in the Sustainable Sites section, under headings such as Stormwater Management and Heat Island Reduction; in the Water Efficiency section as "water efficient landscaping"; in the Energy & Atmosphere section due to the insulating properties of green roofs which help to optimize energy performance; in the Materials section, if roofing membranes include recycled content; and in the Innovation and Design Process section.[8]

Seattle Green Factor
The Green Factor is a landscape requirement designed to increase the quantity and quality of planted areas in Seattle while allowing flexibility for developers and designers to meet development standards. This land use requirement applies to new development in commercial and multifamily residential zones outside of downtown. It is proposed for additional zones and planning areas. Green roofs are included in the landscaping "menu" for Green Factor compliance, and bonus credits are available for native plants, drought tolerance, and food cultivation on green roofs.

Seattle Stormwater Code
Green roofs and rooftop gardens were recognized as "acceptable strategies" for improving on-site stormwater filtration and retention in previous code. The new Stormwater Code adopted by City Council in late 2009 requires projects to implement "GSI to the maximum extent feasible" including green roofs. To find out more about this requirement and on green roof technical information to meet this requirement, see the City of Seattle Flow Control and Water Quality Treatment Technical Requirements Manual.[9] Information can be found on green roof media specifications and media lists that meet the stormwater code for drainage requirements when the code is triggered.[10]

Regarding the Seattle Green Roof Inventory

Several questions emerged as a result of the research described here, particularly in relation to the proper definition of a green roof and the unmonitored benefits of other types of rooftop vegetation and green space. This discussion will continue as more data are available about stormwater mitigation and other benefits of green roofs in Seattle that may be extrapolated to evaluate other roof gardens.

The current green roof inventory is intended to receive regular updates as future green roofs are built, becoming a resource for planners, designers, developers, home owners and students. This inventory also establishes a standard for reporting and cataloging future green roof projects, so that successes, challenges and experiments may be shared.

7. http://www.builtgreen.net/incentive.html
8. http://www.usgbc.org/
9. http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/StormwaterCodeCompliance/CityPoliciesRequiringRelatedtousingGSI/index.htm.
10. http://www.seattle.gov/util/stellent/groups/public/@spu/@usm/documents/webcontent/spu02_019967.pdf