

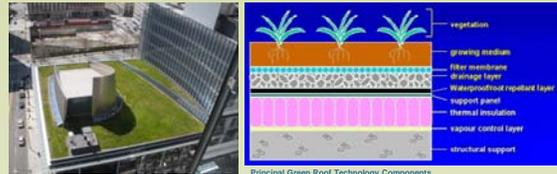
GREEN ROOF

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GREEN ROOF:

consist of plants in a growing medium(soil mix) installed over a building's waterproofing membrane. Green roof is also referred to as **eco-roof, vegetated roof, living roof or greenroof.**



Principal Green Roof Technology Components
Source: National Research Council, Institute for Research in Construction

Three Topics:

- 1) General information
- 2) Benefits of having a Green Roof
- 3) Maintenance issues/challenges

General information



A 16th-century hand-colored engraving of the "Hanging Gardens of Babylon" by Dutch artist Martin Heemskerck.

First recorded green roof can be traced back to the Hanging Gardens of Babylon around 600 BCE.

Villa of the Mysteries, Pompeii



Photos from James W. Jackson

Oldest building with green roof that is still standing. Dates to before the eruption of Mount Vesuvius in A.D. 79

Northern Europeans have utilized sod roofs (green roof) for centuries



Photo from Greenroof.com

Sod houses (Soddies) were built by early Pioneers on the Great Plains



Photo from Wyoming Tales and Trails

Sod House, near Chadron, Neb.

One of the first large commercial bldg. w/green roof in USA was installed at Rockefeller Center in NYC in the 1930's.



Photo from Greenroof.com



Photo by David Shankbone

Gardens on the roofs of Rockefeller Plaza buildings

Union Square Plaza, San Francisco



Photo from wikimedia

It was the world's first underground parking garage and was designed by Timothy Pflueger in 1939. First Garage with a Green Roof.

Modern Green Roof Movement started in Germany in early 1970's



Photo from Michigan State University

A meadow-like roof on top of a commercial building in Kassel, Germany

Two examples of Seattle's Green Roofs that were built in the mid-1970's: Harborview Parking Garage and Freeway Park



Photos by P. Jau

Seattle Justice Center Green Roof was installed in Oct. 2002



Photo by P. Jau

One of the earliest Commercial Bldg. in Seattle with a Green Roof

Seattle Justice Center Green Roof



Seattle Justice Center



How many LEED credits for having a Green Roof?

Green roofs can facilitate a significant improvement in the LEED rating of a building, contributing as many as **15 credits** under the system, depending on design and level of integration with other building systems. In some instances, while green roofs may not contribute directly to achieving points under the system, they contribute to earning LEED credits when used with other sustainable building elements. For example, green roofs can earn direct credits under the following:

- Reduced Site Disturbance, Protect or Restore Open Space
- Landscape Design That Reduces Urban Heat Islands, Roof
- Storm Water Management
- Water Efficient Landscaping
- Innovative Wastewater Technologies
- Innovation in Design

(the above is an excerpt from Green Roofs and Maximizing Credits under the LEED Green Building System, by Richard Kula in The Green Roof Infrastructure Monitor, Spring 2005)

Seattle City Hall Green Roof was installed in July 2003



Seattle City Hall Green Roof



Seattle City Hall Green Roof



Seattle City Hall



Photo by P. Jui

Seattle Emergency Operations Center and Fire Station #10



Photo by P. Jui

3 Types of Green Roofs



Extensive

Photo by P. Jui



Intensive

Photo from Greenroof.com



Semi-Intensive

Photo from Wikimedia

Extensive Green Roof:

- Light weight design
- Saturated weight of 15-30 lb/sq.ft.
- Maximize performance and environment benefits
- **Growing medium of 1 – 6 inches**
- Generally planted w/sedums and draught tolerant plants
- Generally not accessible to the public
i.e. Seattle City Hall and Ballard Library

Extensive Green Roofs



Photo by George Gray



Photo from Ecogreen.org



Photo by P. Jui



Photo from Greenroof.com

Semi-Intensive Green Roof:

- More maintenance, higher costs and more weight than Extensive Green Roof
- Saturated weight of 30-50 lb/sq.ft.
- **Growing medium 6 – 12 inches**
- More maintenance, higher costs and more weight than Extensive GR
- Deeper substrate allows herbaceous perennials and smaller shrubs

Semi-Intensive Green Roof

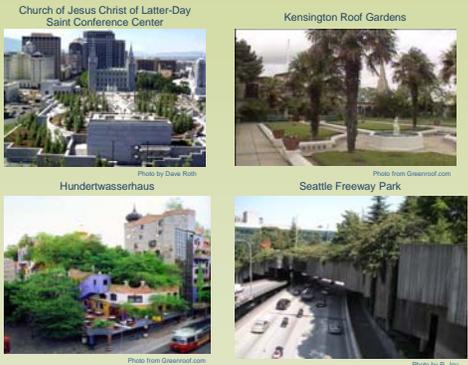


Vancouver (B.C.) Public Library

Intensive Green Roof:

- Design to be accessible to public
- “Park-like setting”
- Saturated weight is 70 lb/sq.ft.
- **Deeper layer of medium; 1 - 4 ft.**
- Wider variety of plants (trees & shrubs)
- Greater need for irrigation and maintenance
i.e. Seattle Freeway Park, and Hundertwasserhaus

Intensive Green Roofs



Green Roofs around Puget Sound area (next several slides)

Zoomazium at Woodland Park Zoo



Seattle Ballard Library



Washington Park Arboretum Pavilion



Harborview Medical Center Parking Garage



Photo by P. Jau



Photo by M. Skorge

Russell Investments Center (WaMu Center)



Photo from Wikimedia



Photo by P. Jau



Photo from Wikimedia

Hyatt at Olive 8



Native and adapted plants provide crucial habitat for birds, bees and butterflies, and promote biodiversity.



Photos by P. Jau

Seattle Center 5th Avenue North Garage



Photo by P. Jau

Seattle's Largest Extensive Green Roof (60,000 square feet)



Photo by Matt Flor

Freeway Park 5-acre Intensive Green Roof



Photo by P. Jau

5th and Madison Condominiums



Photos by P. Jau

M-Street Apartments

Photo by P. Jau

Photo by P. Jau

Ronald Bog Park (Shoreline)

Photo by P. Jau

Photo by P. Jau

Cedar River Watershed Education Center

Photo by P. Jau

Photo by P. Jau

Reservoirs with Lids (Green Roofs)

Cal Anderson Park (Lincoln Reservoir) Jefferson Reservoir

Photo by Jerry Klock

Photo by P. Jau

Photo by P. Jau

Reservoirs with Lids (Green Roofs)

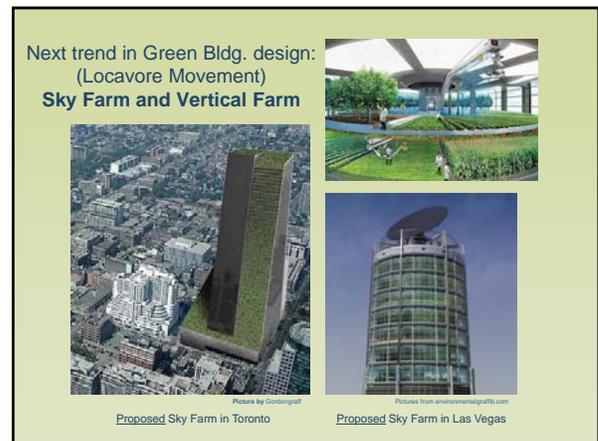
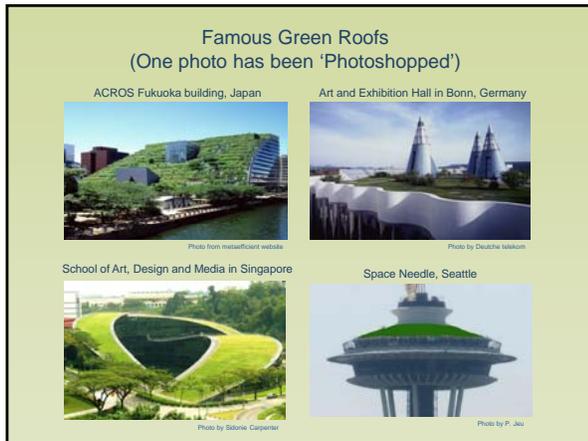
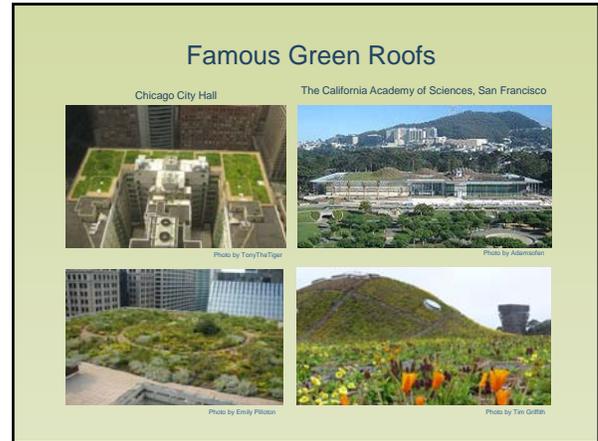
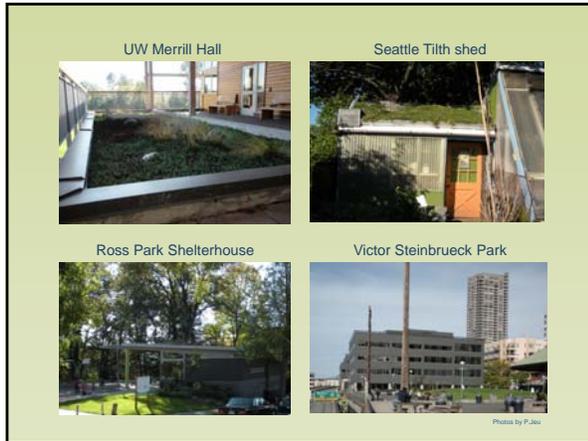
Westcrest Reservoir Myrtle Reservoir

Photo by P. Jau

Bertschi School Mukilteo City Hall

Bannan Biology Building (Seattle U) Snohomish County Parking Garage

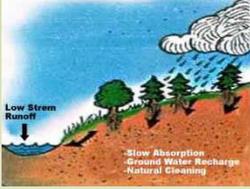
Photo by P. Jau



Benefits of having a Green Roof

Benefits of having a Green Roof:

- **Stormwater runoff reduction:** and delay peak flows during storms
- **Quality control:** filter pollutants and heavy metals from entering our waterway system



Low Stream Runoff

Slow Absorption
Ground Water Recharge
Natural Cleansing

Natural Runoff



Erosion
Flooding
Pollution

More and Faster Runoff
No Recharge/Absorption
Pollutant Washoff

Built Up Development Runoff

Pictures from Greenroof.com

Benefits of having a Green Roof:

- Improved Air Quality

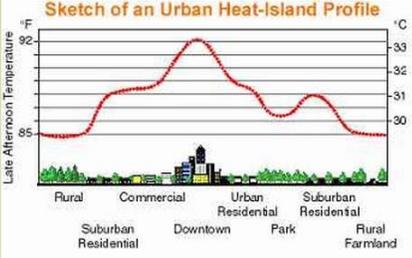
Carbon dioxide and other airborne toxins from the city air are absorbed through the foliage, naturally cleansing the air.



Photos by P. Jau

Benefits of having a Green Roof:

- Heat reduction: moderation of Urban Heat Island effects



Urban Heat Island Profile [LBNL website <http://eetd.lbl.gov/HeatIsland/>]

Benefits of having a Green Roof:

- **Energy conservation:** better insulator than conventional roof thus reducing heating and cooling cost
- **Cost savings:** reduces cost of roof maintenance and repair




Photos by P. Jau

Benefits of having a Green Roof:

- **Sound Insulation**

A green roof with 5 inches substrate layer can reduce sound by 40 decibels; 8 inches substrate layer can reduce by 46-50 decibels.




Photos by P. Jau

Benefits of having a Green Roof:

- Aesthetic Benefits
- Better work environment



Photos by P. Joo

Benefits of having a Green Roof:

- Food Production



Photo by David Walker

Herb Garden on Vancouver's Fairmount Waterfront Hotel

Benefits of having a Green Roof:

- **Wildlife Habitat:** create habitat for birds and invertebrates



Photos from Greenroof.com

Benefits of having a Green Roof:

- Create 'Green' Jobs



MS Clip Art

Benefits of having a Green Roof:

- Storm Water runoff reduction
- Filter Pollutants
- Improved Air Quality
- Mitigate Urban Heat Island effects
- Energy Conservation
- Cost savings in Roof Maintenance
- Sound Insulation
- Aesthetic Benefits
- Food Production
- Wildlife Habitat
- Create 'Green' Jobs

Maintenance issues/challenges

Maintenance issues/challenges: Irrigation

MUST irrigate the first 2 years of planting and thereafter irrigate as needed. Otherwise expect high plant mortality rate and/or live with 'Brown' Roof during the summer months.

Seattle Justice Center (w/irrigation)



Seattle City Hall (w/no irrigation)



Photos by P. Jau

Maintenance issues/challenges: Inadequate Irrigation System

Example: Micro-sprayer sprinkler system in a windy location where most of the water mists are blown away before landing on plants



Photo by P. Jau

Maintenance issues/challenges: Fire Hazard



MS Clip Art



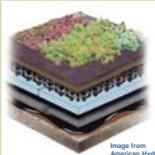


Image from American Hydrotech





Photos by P. Jau

Weeds

Dandelion	Thistle	Alder	Blackberry
			
Scotch Broom	Pearly Everlasting	Grasses	Clover
			

Photos by P. Jau

Maintenance issues/challenges: Weeds

- Dispersed by wind (alder, grasses)
- Dispersed by bird droppings (blackberry, English holly)
- Brought in with new plant materials



Photo by P. Jau

Maintenance issues/challenges: Weeds with Long Tap Roots

Weeds with deep tap roots such as Alder, Scotch Broom, English Holly, Blackberry must be removed right away to prevent damages to roof membranes or structures.




Image from American Hydrotech
Photo by P. Jau

Maintenance issues/challenges: Grass Weed Domination

Wind-blown grass weeds are dominate plants on many green roofs around Puget Sound area. Tall Grasses smothers and kills desirable plants



Photo by M. Sborga



Photo by P. Jau



Photo by P. Jau

Maintenance issues/challenges: Poor plant selections

Fescue plants are very drought tolerant in normal settings but not on Extensive Green Roof



Peter's garden in July '05



Photo by P. Jau

Seattle City Hall Green Roof in July '05

Plants that have done well



Photos by P. Jau

Maintenance issues/challenges: Birds



Crows



Photo by P. Jau



Seagulls

Crows likes to pull out newly planted plants thus making the roots dry-out.

During nesting season, Seagull Parents are very aggressive and territorial

Maintenance issues/challenges: Birds



Photo by P. Jau

Roof damages from Seagulls repeatedly using Green Roof plants for their nesting material and in the process removing 'soil' and exposing roofing materials.

Maintenance issues/challenges: Difficult Access

Must design for easy access to Green Roof for maintenance workers. Many Green Roofs do not have easy access with the concept of 'Low/No Maintenance' Green Roof



Photo by P. Jau

Maintenance issues/challenges: Maintenance Plan

Lack of or conflicting policy in regards to Green Roof Maintenance Plan may create Maintenance issues.

Maintenance issues/challenges: Regional Differences

(Green Roof Designers not familiar with Seattle's climate)

- Irrigation
- Maintenance
- Plant Selections



Maintenance issues/challenges

- Questions about the Green Roof
Why is the Green roof Brown?



Green Roof Q/A End

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