

Jessica Abrera

Green Roofs – LID & Sustainable Design

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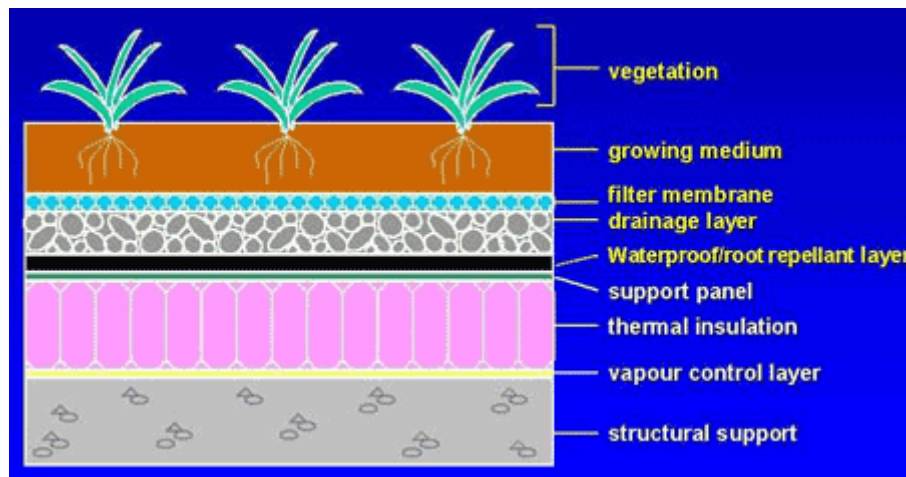
Green roofs are involved with low-impact development (LID) and sustainable design. Their primary use is retaining storm water and decreasing the runoff to treatment facilities. Green roofs also have many other advantages such as energy savings, water and air filtration, a reduced Urban Heat Island Effect, and sound insulation. They have therapeutic effects for many people and serve as a home to many species of insects and birds. The design and development of green roofs is comprehensive, but it is a booming green technology that will aid in LID and sustainability for cities and other urban areas.

Vegetated roofs, commonly termed as green roofs, are roofs covered with vegetation and plants. Green roofs are described as “a distinct type of urban habitat” (Oberndorfer et al. 823). They are not seen as “ecological systems,” but as “an engineering or horticultural challenge” (Oberndorfer et al. 823). There are plants and vegetation growing on top of soil. A waterproof membrane, root barrier, drainage, and irrigation systems compose the other layers of the green roofs.

There are two kinds of green roofs—intensive and extensive. A hybrid exists that has properties of both intensive and extensive green roofs. Intensive green roofs demand more time, money, and energy than extensive green roofs. Intensive green roofs provide “living and recreation space” in populated areas and “require substantial investments in plant care” (Oberndorfer et al. 824). Oberndorfer et al. stresses the “active use of space” and high “aesthetic expectation” in intensive green roofs that sets it apart from extensive green roofs (824). The Environmental Protection Agency also pinpoints that intensive green roofs are “complex,” and extensive green roofs are “simple” (EPA). Extensive green roofs do not need much structural support and can be applied to sloping roofs and very tall buildings (Wilson 107). While

intensive green roofs may serve more for public use, extensive green roofs are primarily utilized for LID or sustainable design.

There are universal parts of a green roof system that can be found in both an intensive and extensive green roof. The picture below shows the set-up of the green roof layers.



<greenroofs.org>

All green roofs have a waterproof membrane, insulation, drainage mat, soil, and plants. The kind of plants, or vegetation employed depends on many different factors. Access and maintenance needs affect the variety of plants grown (Blick et al. 2-10). The rooftop environment is crucial to plant survival and growth (Oberndorfer et al. 825). Determinants of vegetation include moisture stress, severe drought, extreme temperatures, high light intensities, and high wind speeds (Oberndorfer et al. 825). Oberndorfer et al. suggests vegetation that can “survive in harsh conditions,” such as “low, mat-forming or compact growth; evergreen foliage or tough, twiggy growth, and other drought-tolerance or avoidance strategies, such as succulent leaves and water storage” (825). The substrate depth, also known as the soil depth, “dictates vegetation diversity and the range of possible species” (Oberndorfer et al. 825). The most “common” green-roof substrate materials are light expanded clay granules and crushed brick, and they hold many minerals (Oberndorfer et al. 826). Indigenous vegetation would seem like a viable choice, but

according to Oberndorfer et al., “native plants appear to be unsuitable for conventional extensive green-roof systems because of the roofs’ harsh environmental conditions and typically shallow substrate depths” (826). Plant selection for green roofs is also dependent upon climate, type and depth of growing medium, loading capacity, the slope and height of the roof, how well it can be maintained, and if there is an irrigation system (greenroofs.org). Horticulturalists and installers can help developers decide the best type of plants to use.

The structure of the building and other components of the system are important in the green roof’s function. A tall building can handle the weight of a green roof, but a one-story building covering a large area will have a “lower loading capacity” (Toronto and Region Conservation 6). When there is an appreciable distance between column supports, the building will “require structural support” (Toronto and Region Conservation 6). Some green roofs may need erosion protection because its slope, horizontal to vertical, can range from 12:1 to 4:1, and must not exceed a 1:1 ratio (Blick et al. 2-10). During the design and installation of a green roof, there must be enough room and easy access to the irrigation system such as the gutters, underdrains, and downspouts (Blick et al. 2-10). The building’s dynamic plays a critical role in the set-up of the green roof.

The growing medium of the vegetation plays a very significant role in LID and sustainability. In densely populated areas, the hard, nonporous surfaces yield heavy runoff, which can “overburden existing storm-water management facilities and cause combined sewage overflow into lakes and rivers” (Oberndorfer et al. 827). Green roofs decrease the load of storm-water runoff to the wastewater treatment plants. They help “relieve the pressure on urban storm-drain systems” (Loomis 104). The rate of runoff is determined by substrate depth, the slope of the roof, the type of vegetation used, and the area’s precipitation pattern (Oberndorfer et al. 827).

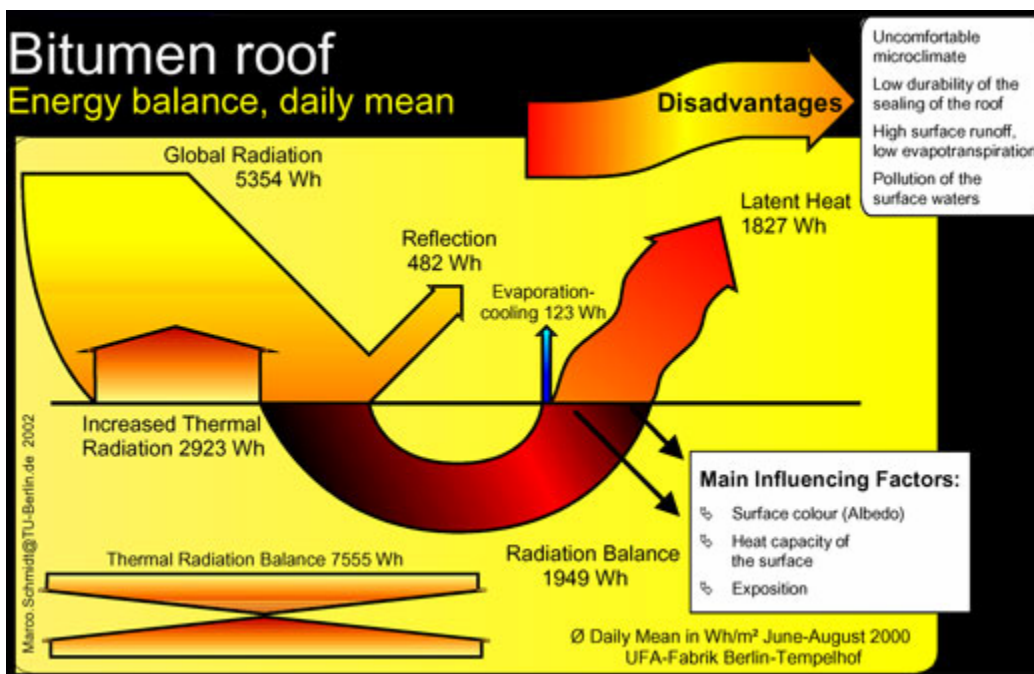
The size of cisterns and storm-water management ponds are also reduced. The precipitation is absorbed by the substrate for the vegetation and then is “released through evapotranspiration” (Blick et al. 2-10). Green roofs hold 70-90% of the precipitation during the summer, and 25-40% of the precipitation during the winter is retained (greenroofs.org). For some scenarios, the substrate depth is the “main determinant of runoff retention” (Oberndorfer et al. 829). In relation to storm-water management, green roofs are considered “ideal” because they implement roof space readily available for use (Oberndorfer et al. 827). Green roofs also serve as “natural” filters for any pollutants carried in by the rain (greenroofs.org). Bioremediation and phytoremediation are described as “natural filtering processes” performed by the bacteria and fungi in the substrate (EPA). Storm-water retention and pollutant filtration are some of the parameters of LID and sustainability involving green roofs.

Air filtration of pollutants also is possible with green roofs. Loomis cites that one square meter plot of grass can remove up to 0.2 kilograms of airborne particulates from the air (104). The vegetation on green roofs takes up carbon dioxide and converts it into oxygen when they perform photosynthesis. A 1.5 square meter plot of uncut grass generates a sufficient amount of oxygen per year to one human with their yearly oxygen intake requirement (greenroofs.org). Plants of green roofs can filter the air of pollutants and can provide oxygen.

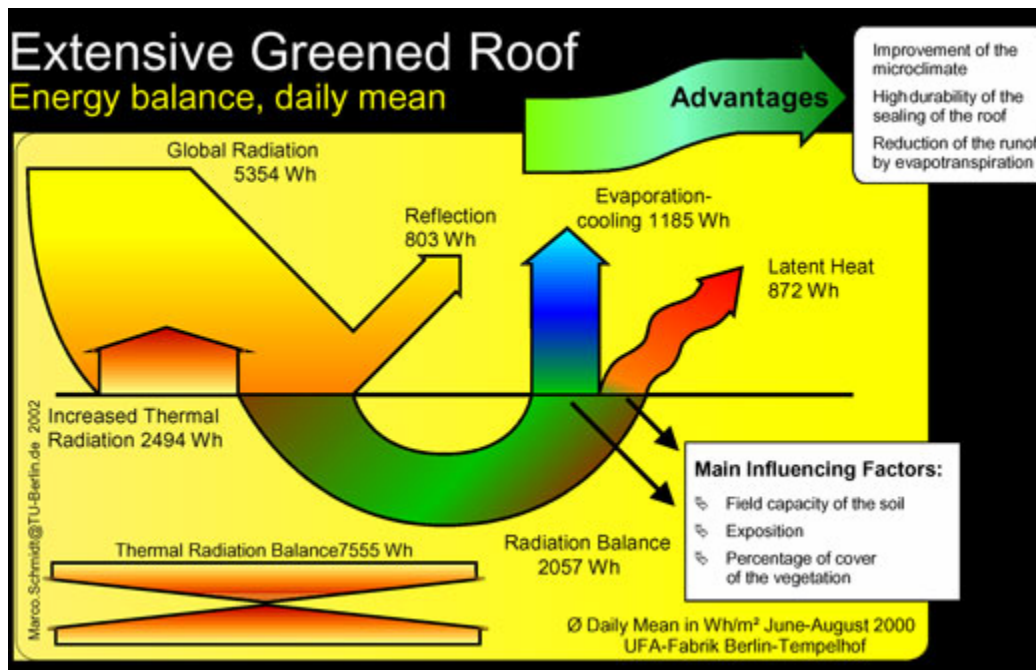
Green roofs protect rooftops and extend their use. The roofs can be sustained for long periods of time “without needing major repairs” (Oberndorfer et al. 828). Traditional rooftops are exposed to the sun’s UV light and experience temperature fluctuations. Green roofs “improve building energy conservation” and rooftops with green coverage can last more than 20 years (Oberndorfer et al. 828). The changes in temperature induce expansion and contraction of

the rooftop and the UV light makes the rooftop more brittle (Oberndorfer et al. 828). Green roofs protect the rooftops from damaging sunrays.

Green roofs are also great insulators, reducing the amount of energy used by the building. Loomis asserts that a conventional roof can reach up to 180° F, while a green roof will only warm up to 80° F (104). They also greatly impact buildings with relatively high roof-to-wall area ratios (Oberndorfer et al. 829). There is a reduction in heat flux because the green roof promotes evapotranspiration, shades the roof, and increases the insulation and thermal mass (Oberndorfer et al. 829). Transpiration can be “boosted further” with plant species that have high leaf conductivity or large surface areas (Oberndorfer et al. 830).



<greenroofs.org>



<greenroofs.org>

The two diagrams above display the energy balances of a conventional roof and a green roof.

The Extensive Greened Roof has more evaporation and cooling than the Bitumen roof, and it

also has less latent heat. Green roofs not only keep the building cooler during the hot summer

seasons, but they also moderate the Urban Heat Island Effect. The Urban Heat Island Effect is

the temperature difference between an urban area and a rural, less populated area. Solar

radiation is absorbed by roads and buildings then re-radiated back as heat. One meter-squared

area of vegetation can evaporate 0.5 liters of water on a hot summer day and 700 liters annually

(greenroofs.org). Dust and particulate matter in the air contributing to smog will decrease

(greenroofs.org). Green roofs help keep urban regions cool by evapotranspiration and increasing

albedo.

Although green roofs are used for insulating a building from extreme temperatures, they

can also be used to insulate for sound. Sound waves generated from machines, traffic, and

airplanes can be absorbed, reflected, or deflected with green roofs (greenroofs.org). The

vegetation of a green roof can block higher frequencies than the substrate and a substrate layer that is 12 cm thick can reduce sound by 40 decibels and a 20 cm thick substrate layer can decrease sound by 46-50 decibels (greenroofs.org). Green roofs block noise pollution from the heavily congested urban areas.

Energy conservation is not the only benefit from green roofs, but also habitat conservation as well. Green roofs can be modeled to “mimic endangered ecosystems/habitats, including the prairie grasslands of the Midwest US, the rocky alvars of Manitoulin Island and the Great Lakes Region in Canada” (greenroofs.org). “Rare and uncommon species” of insects can be found in green roofs (Oberndorfer et al. 829). Insects thrive in this type of environment because the substrate is “less likely to be disturbed” (greenroofs.org). Green roofs provide a safe haven for different species of birds, insects, and plants and they promote biodiversity.

There is a psychological benefit in green roofs involved with horticultural therapy. While most green roofs are aesthetically pleasing providing “visual relief,” they can “improve human health” with relaxation and restoration as well (Oberndorfer et al. 829). There are also “therapeutic benefits” from tending to a roof garden (greenroofs.org). Green roofs used for recreational purposes also contribute to de-stressing for many people. Some corporate buildings have a small golf course on their green roof. This improvement in health is a benefit that is “difficult to quantify” (Oberndorfer et al. 831). Green roofs offer people a community place to relax, to tend to a garden, or to play golf.

Another benefit of green roofs is food production. Growing herbs, fruits, flowers, and vegetables on a green roof helps make produce more “accessible”(greenroofs.org). This is also an economic benefit because there is “support of the local economy”(greenroofs.org). Green roofs provide “fresher” produce, limit the food miles, or distance produce is transported, and

give more “control of soil, fertilizer, and pesticides” (greenroofs.org). Green roofs make produce readily available to the public and decrease the time, money, and energy needed to transport them.

Growing produce is not the only economic benefit from green roofs. Energy savings from insulation, a reduction in cost for not replacing or maintaining a conventional roof, and savings derived from not treating large amounts of storm water runoff are some of the economic advantages of green roofs. Other unforeseen economic benefits are a reduction or elimination of roof drains and standard insulation, new job opportunities, a reduction in cost of meeting the greenhouse gas requirements, decreased construction for storm water related infrastructure, and recycling of aggregate and compost (greenroofs.org). Green roof technology also has a large “marketing value” for businesses, schools, and cities to appeal to clients, students, and tourists (Oberndorfer et al. 831). There are many economic benefits of green roofs.

The benefits of green roofs are long term and will outweigh the cost of implementing and maintaining a green roof. Costs are variable and are influenced by the depth and type of the substrate, the type of vegetation, the size of installation, whether irrigation is used or not, and if it is extensive or intensive (greenroofs.org). The Toronto and Region Conservation included in their report of an economic analysis of green roofs that building height, special features such as edging, walking paths, a safety fence, accessibility of materials, machines and tools such as a growing media blower truck, and changes in the infrastructure of the building to suit the green roof are all factors in cost (4-5). The price range of green roofs is from \$8 to \$28 per square foot, with \$10 to \$12 around the average (Wilson 107). The cost of maintenance must also be included in the cost analysis of green roofs. Watering, weeding, pruning, re-application of organic fertilizer, and de-clogging drains and gutters are all a part of maintaining a green roof

(Toronto and Region Conservation 6). Toronto and Region Conservation claim that the first two years of maintenance is when the price is the highest (6). A green roof must be maintained four to five times a year (Toronto and Region Conservation 6). The monetary value of a green roof is hard to define and the savings incurred from a green roof are long term (Toronto and Region Conservation 6).

Green roofs offer more than low-impact development in their function. With green roofs come energy savings, roof longevity, a reduced Urban Heat Island Effect, air and water filtration, an establishment of ecosystems, and a recreational place for people to relax. The design and installation of a green roof is very complex. Structural engineers, horticulturalists, and landscape architects are required to make sure the green roof can fit the building specifications, the materials are used properly, and that the layout of the irrigation system will maximize the green roof's function. Green roofs are a promising new green development for sustainable design that is still being researched. Aside from mitigating storm water, there are many advantages to the environment and communities from a green roof.

Works Cited

Blick, Sandra A., Fred Kelly, and Joseph J. Skupien. New Jersey Stormwater Best Management Practices Manual. Rep.No. Division of Watershed Management, New Jersey Department of Environmental Protection. Trenton, NJ, 2004.

Loomis, John. "Green Roofs Take Root In U.S. Building Design." NREI May 2008: 104.

Oberndorfer, Erica, Jeremy Lundholm, Brad Bass, Reid R. Coffman, Hitesh Doshi, Nigel Dunnett, Stuart Gaffin, Manfred Kohler, Karen K. Liu, and Bradley Rowe. "Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services." Bioscience 57 (2007): 823-33.

Wilson, Marianne. "Going Green on Top Eco-friendly roofs offer operational benefits." Chain Store Age Dec. 2007: 107.

"Green Roofs." Heat Island Effect. U.S. EPA. 8 Sept. 2008
<<http://www.epa.gov/hiri/strategies/greenroofs.html>>.

"About Green Roofs." Green Roofs for Healthy Cities. 2005. 8 Sept. 2008
<http://greenroofs.org/index.php?option=com_content&task=view&id=26&itemid=40>.

Toronto and Region Conservation. An Economic Analysis of Green Roofs: Evaluating the costs and savings to building owners in Toronto and surrounding regions. Rep.No.

Sustainable Technologies Evaluation Program, Toronto and Region Conservation Authority.

Toronto, 2007. 1-15.