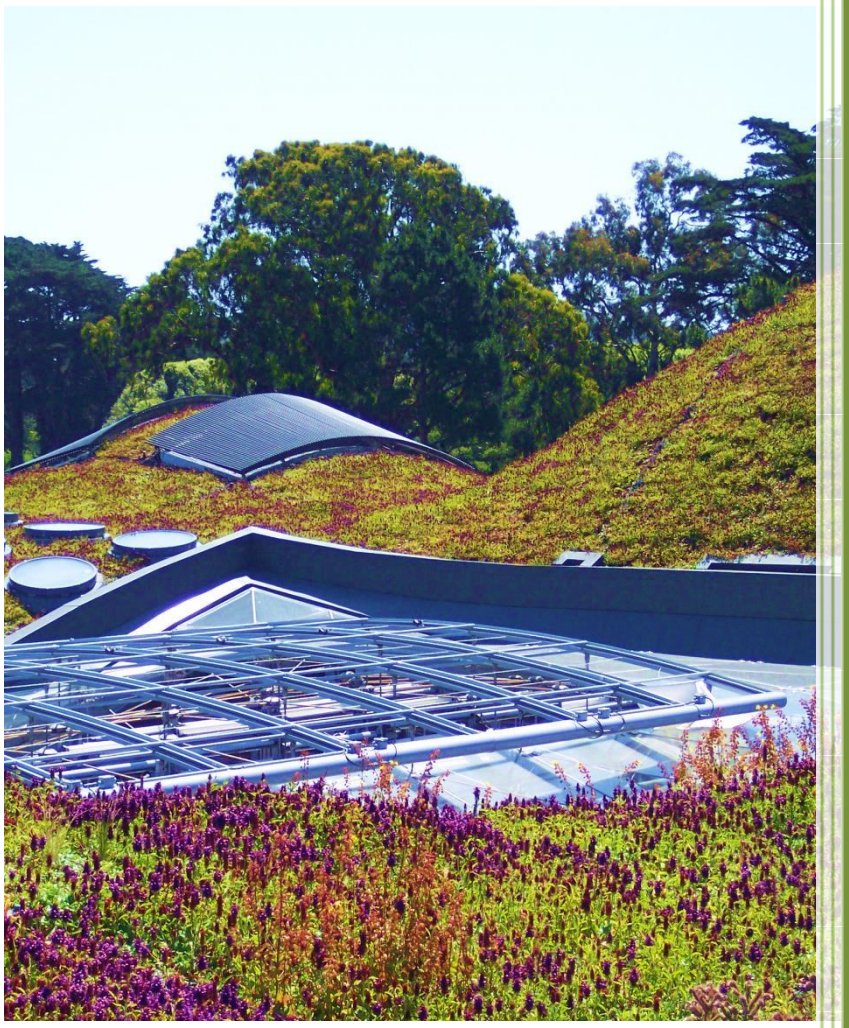
GREEN PLANTS for GREEN BUILDINGS

White Paper

Green Roofs



Communicating the aesthetic, environmental, productivity and health benefits of plants in the built environment.

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Communicating the aesthetic, environmental, productivity and health benefits of plants in the built environment.

Green Roofs

Green Roofs are also known as Vegetated Roofs, Eco-roofs or Living Roofs. A green roof or living roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. Green roofs have been recorded in history as early as 600 BC – the Hanging Gardens of Babylon, one of the Seven Wonders of the Ancient World.
In most cities, roofs account for 40-50% of the impermeable surface area.[1]

This white paper presents a summary of the following:

- The research being done on green roofs
- The requirements and design features for successful plantings
- The best practices for designing, building and maintaining these systems
- The financial and economic benefits
- General costs of the systems
- And the positive effects of green roofs on the environment and the community.

This paper will also present the differences present in various green roof systems and how those systems are appropriate for differing needs.

Benefits of Green Roofs

Aesthetic Improvement

Urban greening has long been promoted as an easy and effective strategy for beautifying the built environment and increasing investment opportunity. Even where roofs are inaccessible but clearly visible (i.e., outside your hotel room window), attractive plantings can be beneficial.

Waste Diversion and Increased Roof Longevity

Green roofs protect against ultra-violet rays, heat stress, and wear and tear from temperature fluctuations, all of which can contribute to the deterioration of roofing materials and the waterproofing membrane. This can result in a longer material lifespan beyond the current average of 10-15 years, meaning less old roofing material winding up in the landfill. In fact, it is estimated that green roofs will last up to twice as long as conventional roofs, thus decreasing maintenance costs and increasing savings in replacement costs.[2]

In addition, with lower ambient temperatures inside the building, the HVAC systems run more efficiently. This also increases landfill diversion and decreases maintenance costs, as well as increasing savings in replacement costs.

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[1]Stovin, Virginia, Nigel Dunnett and Adrian Hallam, "Green roofs—getting sustainable drainage off the ground," 2007.
[2]Environmental Protection Agency, 2012. "Reducing Urban Heat Islands-Compendium of Strategies for Green Roofs."

Storm Water Management

Storm drains can be flooded due to increased flow during a storm event, causing run-off and flooding. A green roof manages storm water by absorbing and storing up to two thirds of a rain event, delaying run-off into the storm drains until after the event has passed and filtering out particulate matter.

Numerous studies have been conducted on storm water management by green roofs. In one study in the United Kingdom the green roof tested retained 34% of the rainfall with an average peak reduction of 57%.[3]In another study, Moran et al. reported 60% total rainfall retention and an 85% reduction in peak flow rate.[4] Liptan suggests in his study that 10-35% volume reduction in the wet season and 65-100% reduction in the dry season is possible.[5]

Temperature Control, Energy Efficiency and Reduction of the Urban Heat Island Effect

Climatic data shows that cities are getting hotter. More pollution and greater energy consumption is one outcome of climate change. The end result is a greater potential for unhealthy living environments. Green roofs, urban forests, and reflective roofing all help to reduce the urban heat island effect. Green roofs not only reduce ambient temperature through the reintroduction of vegetation, but also contribute to the mitigation of UHI (Urban Heat Island) by covering some of the hottest surfaces in the urban environment – rooftops. Traditional black roofs can reach temperatures of 158 ºF/ 70ºC and as a result have an enormous effect on building and ground level temperatures. A green roof can reduce that temperature in half. An Environment Canada study, Mitigating the Urban Heat Island with Green Roof Infrastructure, found that 25% green roof coverage can reduce the UHI by up to 33.8ºF/1ºCover approximately ¼ of the city. With green roof coverage of 50%, maximum UHI cooling was increased up to35.6ºF/2ºC.[6]

A green roof will have a noticeable impact on the heat gain and loss of a building, as well as the humidity, air quality and reflected heat in the surrounding neighborhood. In conjunction with other green installations, green roofs can play a role in altering the climate of the city as a whole.

On a summer day, the temperature of a gravel roof can increase up to 140 to 176°F. Covered with grass, the temperature of that roof would not rise above 77°F, likely resulting in energy cost savings.[7]

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[3]Stovin, V., Dunnett, N., & Hallam, A. "Green roofs—getting sustainable drainage off the ground," 2007.
[4]Moran A., Hunt B. and Jennings G., 2004, A North Carolina field study to evaluate green roof quantity, runoff quality, and plant growth, *2nd Greening Rooftops for Sustainable Communities Conference,* Portland, 2-4 June, 446-460.
[5]Liptan T, 2003, Planning, zoning and financial incentives for eco roofs in Portland, Oregon, *Greening Rooftops for Sustainable Communities*, Chicago, 29-30 May, 113-120.
[6]Bass, B., Krayenhoff, S., &Martilli, A. (2002). Mitigating the Urban Heat Island with Green Roof Infrastructure," Urban Heat Island Summit: Toronto.
[7]Reducing Urban Heat Islands: Compendium of Strategies, Environmental Protection Agency, USA.

Plants do this through evapotranspiration – as they grow, they give off water vapor and that helps cool the building, just as our bodies sweating cool us down. It is very hard to determine the R value of a green roof so they are typically not known as an insulator.

Every building is different in size, height, age of HVAC system, and age of the building itself. Although it is not quantifiable in a percentage, a green roof can provide energy efficiency within a building. Most commercial buildings have their AC intake on the roof – and if it is drawing in cooler air it operates more efficiently. Good design from the beginning of a project can increase the energy savings through systems integration.

Improved Air Quality

A green roof will not only absorb heat, decreasing the tendency towards thermal air movement, but will also filter the air moving across it. Researchers estimate that a 1,000-square foot (93 m^2) green roof can remove about 40 pounds of Particulate Matter (PM) from the air in a year, while also producing oxygen and removing carbon dioxide (CO_2) from the atmosphere.[8]Forty pounds of PM is roughly how much 15 passenger cars will emit in a year of typical driving.[9]

New Amenity Spaces

Green Roofs create amenity spaces for the tenants of a building. These amenity spaces can be used for relaxation, dining, entertainment and so on. They can provide a reprieve from the day and an opportunity to reconnect with nature. They also create a more favorable view from surrounding buildings where people overlook a roof that has been transformed into a green roof.

Local Job Creation

A study done in 2002 by the City of Toronto projecting 6% green roof coverage over 10 years conservatively estimated direct and indirect job creation of 1350 full time jobs per year. Although no exact figures exist, it is estimated that the roofing industry in Germany employs approximately 12,000 people, and if all low slope roofs were to be greened, this figure would increase to approximately 100,000 full-time jobs.[10]

Fire Retardation and Potential Insurance Savings

In areas where wildfires and roof fires are a concern the flame retarding qualities of a green roof may be important. The Germans looked at green roofs as a way to reduce wild fires beginning about 50 years ago. Stuttgart, Germany is the leading green roof city in Germany and has undertaken studies to determine if green roofs provide enough fuel to sustain or even propagate fires. During the dry season (August through October), researchers tried to start fires on green roofs with a defined set-up which was installed on the roofs and ignited. They expected the organic material in the growing medium to ignite, and the dry plants to spread the fire across the roof.

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[8]Peck, S. and M. Kuhn. 2003. Design Guidelines for Green Roofs. Canada Mortgage and Housing Corporation, Ottawa, and the Ontario Association of Architects, Toronto.

[9] U.S. Department of Transportation Federal Highway Administration. "Annual Vehicle Distance Traveled in Miles and Related Data-2004."

[10]City of Toronto and Ontario Centres of Excellence-Earth and Environmental Technologies, 2005. Report on the Environmental Benefits and the Costs of Green Roof Technology for the City of Toronto.

Instead, they found it nearly impossible to set a healthy extensive green roof on fire. In fact, the risk of fires on fully adhered bituminous waterproofing membranes is 15 – 20 times higher!

Today in Germany, there are at least 2 billion square feet of extensive green roofs built and there is no fire recorded related to a green roof. This is probably why they offer a 10–20% discount on fire insurance when a seamless extensive green roof is installed.

Marketability and Increased Sense of Community

Green roofs can provide access to green space and recreational opportunities. They can directly impact a user's physical well-being and increase their sense of community.

Parks and community gardens provide mechanisms for social interaction and allow for community building activities. These vegetative spaces have been correlated to creating a sense of pride and place; increasing levels of trust; reducing violence, aggression, and vandalism; and reducing quantities of litter.[11]

Benefits to Nature and Wildlife

Rooftop habitats can play one of two roles: a 'stepping stone' habitat connecting larger natural isolated habitat pockets with each other; or an 'island' habitat (with its own microclimate) remaining isolated from other habitats at grade. They provide food and homes to all kinds of wildlife, particularly insects and birds. Both roles are important in protecting wildlife and increasing wildlife diversity, particularly in growing urban areas.

Educational Opportunities

Green Roofs present educational opportunities about horticulture, wildlife, microclimates and ecosystems to schools, particularly those in urban areas where access to nature is limited or nonexistent. Green roofs can also be used for research and other educational purposes at schools and universities, such as the green roof at the University of Alabama at Birmingham.

Health Benefits

As with indoor plants, many studies have found positive correlations between physical and mental health and a natural view. For example, a 1988 study by Dr. Roger S. Ulrich concluded that the availability of a natural view decreased job stress, ailments, headaches, and the number of sick days taken by employees and increased job satisfaction and productivity. Dr. Ulrich also compared post-operative surgery in patients with a natural view and those without. Those patients with a natural view made quicker recoveries with fewer negative evaluations from nurses and lower rates of medication.[12]

Local Food Production and Urban Agriculture

Although very few green roofs are designed for food production in a commercial context, some green roofs cater to a niche market specializing in the production of gourmet fruits and vegetables.

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[11]Winter, Leslie, 1999.Designing a Sense of Community: Use of Neo-traditional Design Elements in Public Housing, master's thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginian.

[12]Ulrich, Roger S., Ph.D., "Healthy Benefits of Gardens in Hospitals", presented at the Plants for People conference, International Exhibition Floriade 2002.

In addition, many groups utilize the roof growing space as community gardens. For example, Foodshare, a Non-Governmental Organization (NGO) based in Toronto, Ontario, uses its green roof and food production programs to cultivate an appreciation for food among volunteers, fostering community development, and providing job training for at-risk youth.

Similarly, Earth Pledge, a non-profit based in New York, uses its green roof to cultivate vegetables and herbs for their Sustainable Cuisine courses, which are designed to reinvigorate participants' enthusiasm for cooking.

These programs not only educate users about food production but also help change their relationship with food. Involvement in food production allows participants to reconnect with food sources, dismantling the prevalent notion that food is endlessly available in containerized format on supermarket shelves.

Types of Green Roof Systems

Intensive Roofs

Intensive green roofs can be thought of as a rooftop garden where anything is possible if you have the weight bearing capacity. Trees, shrubs and water features may be added and they will need to be engineered to conform to the load requirement.

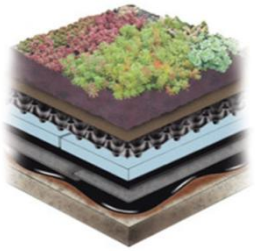
Intensive green roof

Intensive green roofs tend to be more elaborately designed roof landscapes, such as roof gardens and gardens on the roofs of underground parking garages, intended for human interaction. Intensive green roofs provide access to people for enjoyment and interaction with nature.

Intensive green roofs can be distinguished from the popular roof garden of container-filled plants by the continuous underlying green roofing layer system. Ideally, these green roofs have relatively low slope roof surfaces (1 - 1.5%) or mild roof slope percentages of up to 3%.

Different growth media types and depths allow for a larger selection of plants, including flowering shrubs and trees. Typical soil depths start at 6 - 8 inches and go up from there - the limiting factors here are the roof loads and perhaps the client's budget. Intensive green roofs tend to weigh more due to the deeper level of substrate. They also allow for more plant choices, require more maintenance and tend to cost more than other systems.

Intensive green roofs may cost anywhere from US $20/sq. ft. to US $200/sq. ft. installed, depending on the system, plant material and other design and engineering factors



Extensive green roof

Extensive Green Roofs

Extensive green roofs are lightweight veneer systems composed of thin layers. Drought tolerant self-seeding green roof covers may use colorful sedums, grasses, mosses and meadow flowers requiring little or no irrigation (dependent on the regional climate) , and less maintenance after establishment. These roofs are not intended for recreation, or to accommodate the weight of people, larger shrubs or trees.

Soil depth is generally 3 to 6 inches and they weigh approximately 8 to 17 lbs. /sq. ft. /inch deep, fully saturated, including all layers above the membrane. This weight is comparable to the weight of gravel ballast placed on many conventional roofs.

The ideal slope is between 1/4" and 1/8" per foot in length and can be built on roofs with slopes up to 33%. They can also be retrofitted onto existing structures. An extensive green roof will need to be irrigated for the first two years of establishment. Depending upon the climate, they may need irrigation continuously.

Extensive green roofs are less costly due to single or double layer construction, costing anywhere from US $15/sq. ft. to US $50/sq. ft. installed.

Modular Roofs

With a modular system, the drainage, soil substrate or media, and the plants are self-contained within a lightweight high-density polyethylene (HDPE) module, of varying dimensions. In effect, the three main components of a green roof are replaced by a fully planted module. With a modular system, the client can get the "instant green" affect.

Modular roof

Any roof that has 90% plant coverage at the beginning is more costly on the front end; however, maintenance costs will be lower due to better plant coverage and the lack of weed growth.

Modular roofs vary in depth and weight depending on the system. For example, one modular system can be purchased in 5" or 8" depths and generally weighs 33 pounds for a 4 ft. sq. module when planted. Costs vary greatly depending on system, size, media and plant material.

Modular roof systems provide the following installation and maintenance benefits:

- Simplicity of design by incorporating drainage, the soil substrate and plant material into one unit
- Ease and time savings during installation
- Ability to be planted prior to the installation, at any time of year
- Instant effect with pre-planted materials
- Use of different substrates and planting depths within the green roof for increased plant diversity
- Increased air and water flow in the root zone for healthier plants
- Option to incorporate irrigation in the system.[13]

Loose laid roof

Loose Laid Roof

With a loose laid system or built up green roof, the green roof components are installed in layers above the waterproofing membrane. The system includes, but is not limited to a root barrier, drainage layer, growth media and the plants. A loose laid system allows for the entire area covered with a green roof to be one working organism. An intensive roof will likely be a loose laid roof.

[13] Velazquez Linda S., ASLA Associate, Modular green roof technology: an overview of two systems, *First Annual Greening Rooftops for Sustainable Communities Conference 2003,* Chicago, IL.

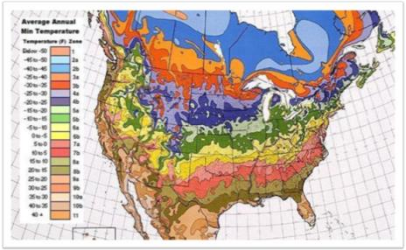
Considerations for Green Roofs

Design and Usage Intent

It is very important for the building owner to discuss their expectations and the intentional use of the space during the design phase. Weight load capacity, structural engineering and local building codes are the first items that must be considered when planning a green roof. Depending upon budget and weight-bearing capacity the possibilities are endless. A roof can be used simply to manage storm water, create an urban garden or used as a space for healing.

Regional Considerations

While there are many suggestions for plant types and species, consult with your professional horticulturist about the best plant selections for your region and for your particular project. North America has a vast range of climate differences. Each region must be considered carefully to ensure a successful and surviving living roof. Some frequently-used plants include sedums, grasses and wildflowers native to the area.



Installation

Green roofs should be installed by a professional horticulturist in collaboration with a building's architect and engineer. There are several considerations. The weight load capacity of the roof should be determined by a structural engineer before moving forward with construction. Another weight consideration is the fully saturated, fully grown weight of the roof. There are now a number of different media specifically designed for green roofs, some of which are lighter in weight than others. The system chosen and substrate will have a large impact on the weight of the green roof and weight issues must be considered when deciding on a system.

The international Green Roofs for Healthy Cities association is an excellent source for information and recommendations. They are also responsible for certifying green roof specialists under their Green Roof Professional (GRP) certification program. Requirements for this certification are strict and include a very thorough educational program and experience. Many of the manufacturers of green roof systems certify their installation contractors as well.

An experienced team will understand the best methods of conveying materials to the roof, point load restrictions, protecting the waterproof membrane from penetrations and of most concern – safety.

Maintenance

Maintenance costs are often not considered during the design phase. While some designs can be lower maintenance, no green roof is maintenance free. Specifications should include a maintenance plan and these services should be a part of the original contract. Ask that a minimum of three months and ideally one year of maintenance be included with the installation contract. Green roof maintenance should include:

- Weed control
- Pest and disease control
- Checking and adjusting irrigation, with supplemental watering during dry periods
- Checking the drainage system
- Periodic roof inspections for possible leaks and other issues

- Planting for special occasions, seasonal blooming plants or replacement of poor-quality plant material.
- Documentation of any changes or issues.

And these all need to be done safely! A properly designed, installed and maintained green roof should last for decades.

Conclusion

There are many benefits to using living green roofs, and many different and unique ways to incorporate them into your workplace and living space. Green roofs connect us with nature, clean the air, modify temperatures, control noise, divert storm water, improve aesthetics and improve our lives. We encourage you to contact your local horticultural experts to assist you with the design, installation and care of your green roof. See how green roofs can improve your built environment—and your life!

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