

Implications

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Benefits of Green Roofs

L. Peter MacDonagh, RLA

Green Roofs

Though it has thousand-year-old origins in Icelandic sod roofs, the technology for present-day green roofs was developed in Germany about 30 years ago. At present, green roofs are prevalent throughout Europe, but not common in the United States. However, green roofs are gaining in popularity in the US by merit of their many advantages over conventional roofs. The advantages of green roofs include:

- Stormwater management
- Air quality and thermal benefits
- Noise insulation
- Social and psychological benefits
- Economic benefits

Green roofs can be installed on new or existing buildings and are not limited to flat roofs. While commercial, conventional roofs are relatively simple (including a membrane topped with four inches of gravel ballast) the components of green roofs, from the top down, include:

- The plants
- An engineered growing medium
- A landscape or filter cloth to contain roots and the growing medium
- A drainage layer
- The waterproofing/roofing membrane
- The roof structure

Stormwater Management

When comparing green and conventional roofs, stormwater management emerges as an important differentiating factor. While conventional roofs merely shed water, green roofs use most incident water and slowly release the remainder. For example, in a typical year in the Midwestern United States, 75% of the water is retained on a green roof, stored in plants and the soil layer, and 25% becomes runoff. Green roofs control runoff even in areas with cold, snowy seasons. Again in the Midwest, the average summer water absorption rate is 70-100%, with winter absorption averaging 40-50%.

It works this way: when a green roof reaches saturation, excess water slowly percolates through the vegetation layer. The soil layer traps sediments, leaves, heavy metals and other particles, treating runoff before it reaches the drainage outlet. Besides improving water quality by cleaning runoff, green roofs also decrease flooding in local watersheds by maximizing plant uptake of rainfall and minimizing costs of stormwater management. A system of green roofs could be the single most effective approach to stormwater management in urban centers.



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Section diagram of a green roof

Air Quality Benefits

The vertical building massing of downtown areas often inhibits ventilation, reducing wind speed and trapping pockets of heat. Pollutants can remain suspended for long periods of time. Green roofs absorb carbon dioxide, a major automobile emission, through foliage, naturally cleansing the air. The air-cleansing capacity of green roofs has direct benefits for people who suffer from asthma and other respiratory ailments.

Thermal Benefits

Green roofs impact both humidity and temperature. High temperatures are responsible for urban heat islands. Average summer temperatures in major North American cities have been on the rise over the past decade. High temperatures necessitate more electricity for air conditioners and increase pollutants, such as ground-level ozone. Such conditions can result in heat exhaustion, heatstroke, and even death. Green roofs can dramatically lower temperature. For example, on a recent hot day in Minneapolis, Minnesota (90 degrees Fahrenheit), a reading on the green roof of the Minneapolis Central Library building registered 92 degrees Fahrenheit, while a neighboring conventional roof registered a temperature of 170 degrees Fahrenheit.

Even when the air is clean, dry air can put a strain on a person's breathing during periods of high temperatures. Green roofs capture and hold precipitation in the plants, thereby increasing humidity and easing breathing difficulties.

A simulation conducted by the City of Chicago of its City Hall green roof showed that every one degree Fahrenheit decrease in air temperature resulted in a 1.2% drop in cooling energy use. The study suggested that retrofitting all of the buildings in the Chicago metropolitan area with green roofs over a 10-year period would result in an annual savings of \$100 million by reducing cooling costs.

Noise Insulation

Controlling noise is another reason to choose green roofs. Soil, plants, and the air layer trapped between the green roof assembly and the building surface provide sound insulation. The substrate blocks lower frequencies, while the plants block higher frequencies. This can mean a reduction in indoor sound levels of as much as 40 decibels, an important difference to those who live near airports, major highways, or other forms of industrial-related noise pollution. Additionally, wind moving through the stems and leaves on green roofs can provide masking noise or create a beneficial soundscape.



Roof of the Minneapolis Central Library, Minnesota



The roof of The Green Institute in Minneapolis, Minnesota

Social and Psychological Benefits of Nature

Well-being is widely acknowledged to be enhanced by green spaces and interaction with nature. As Frederick Law Olmsted put it, “Humans have physiological reactions to natural beauty and diversity, to the shapes and colors of nature, especially to green, and to the motions and sounds of other animals.” In urban settings, green roof views offer a welcome respite from the urban material palette of gravel, asphalt, and concrete. As for other animals, studies in the US indicate that butterflies visit green roofs up to 20 stories high and birds up to 19 stories.

To foster social interaction, many green roofs are designed with seating areas situated into conversational groupings, providing opportunities for socialization and restoration. At the Gap Headquarters in San Bruno, California, absenteeism decreased and productivity increased a year after installing a green roof. A sense of community can also be fostered through green roof gardens. Fifteen inches of soil is sufficient to cultivate tomatoes and other vegetables.

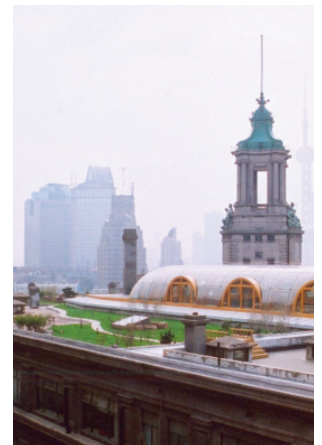
Economic Benefits

Reclaiming Waste

Green roofs have the capacity to capture waste and convert it to useful product. A Belgian factory that manufactures biodegradable laundry products has two acres of native grasses and wildflowers on its roof. By-products of their manufacturing process are treated in an on-site sewage pond and then filtered through the green roof, simultaneously acting as irrigation and a nutrient source for the plants.

First Costs versus Life-Cycle Costs

Despite the many benefits of green roofs, their limited use is attributable to their higher first costs. Typically, a conventional roof costs \$10-\$12 per square foot; the initial cost for a green roof can be up to twice that much. A life-cycle perspective, however, reveals the economic benefits of green roofs. Because they protect the roofing membrane against ultra violet radiation, extreme temperature fluctuations, and puncture or physical damage from recreation or maintenance, the green roof prolongs the life expectancy of the roof up to three times longer than a conventional roof.



Roof in Shanghai

As an example, a London department store that installed a roof membrane under a planting in 1938 found the membrane still in excellent condition fifty years later. In England’s rain-soaked climate, most conventional flat roofs have an average lifespan of only 10-15 years.

Energy Savings

Additional cost-savings come from the insulating properties of green roofs. By trapping an air layer within the plant mass, the building surface is kept

cool in summer and warm in winter. By covering the roof with vegetation, the summer heat is prevented from reaching the building's skin; in the winter, the internal heat is reflected or absorbed. This translates into year-round lower energy consumption and lower corresponding costs.

Clearly, green roofs make sense, both in ecological and economic terms. As former Vice President Al Gore said, "In the future, livable communities will be the basis for our competitiveness and economic strength. Our efforts to make communities more livable today must emphasize the right kind of growth—sustainable growth. Promoting a better quality of life for our families need never come at the expense of economic growth."

Teaching Design Process

Roger B. Martin, FASLA

Good designers are those who can visualize their ideas and translate verbal concepts into visual communication. Design thinking skills, crucial to the practice of landscape architecture and other design professions, should be taught. Though there is extensive literature on creativity, the creative skills needed by designers are unique, and require adapting what we know about creativity.

In terms of the design process itself, Benjamin S. Bloom identifies the following stages:

- Accepting the problem
- Analyzing the relevant facts
- Defining significant criteria (identifying what is not important)
- Creating alternative solutions
- Synthesis: selecting the most satisfactory alternative
- Design refinement
- Evaluation and critique

Though some students move through this process smoothly and unselfconsciously, design thinking can also be taught. Beyond a focus on analyzing the facts, design education often has not enriched those key subprocesses that are part of idea generation. Yet directed creative devices—techniques that support the design process—can be used to teach the subprocesses. Below are directive creative processes that help define significant criteria:

- List the attributes and activities that are part of the problem
- Identify discrepancies, paradoxes, and questions raised by the problem
- Identify issues of habit and change in the problem
- Postulate unfamiliarity and redefine the problem in new terms

Creating alternative solutions can also be fostered using directed creative devices:

- Translate information from verbal to diagram form
- Diagram relationships and alternate solutions
- Use analogy, inductive reasoning, role-playing, and brainstorming
- Explore logical but extreme solutions



Teaching design skills: from verbal to visual form

Options for Engagement

In one successful use of a creative device, role playing, students wrote narratives about a place. They used rush-writing—writing constantly about anything that came to mind in a 10-minute period. They then circled keywords in their texts. In another use, students wrote narratives about the place they would design; one student wrote and illustrated a postcard to her children. Whatever the creative device, the essential design step was translating verbal ideas into visual representations.



An exercise in translating verbal ideas into visual form

Design education should develop each student's design process skills as fully as possible during the years of formal education. The ability to call on these process skills effortlessly is essential to future, creative design professionals. Teaching design process sooner frees up the designer to deal with the complexity of built projects later. To repeat a favorite Zen saying, "Develop an infallible technique, then place yourself at the mercy of inspiration."

References—Green Roofs

- Dramstad, W., Olson, J., & Forman, R. (1996) *Landscape ecology principles in landscape architecture and land-use planning*. Island Press: Washington, DC.
- Green Roofs for Healthy Cities* www.greenroofs.org
- Peck, S., Callaghan, C., Bass, B., & Kuhn, M. (1998). *Greenbacks from green roofs: Forging a new industry in Canada*. Canada Mortgage and Housing Association: Ottawa, Canada.
- Scholz-Barth, K. (2001). Green roofs: Stormwater management from the top down. *Environmental Design & Construction* 4, 1.
- Zinco www.zinco.de

References—Design Process

- Bloom, B. (1956). *Taxonomy of educational objectives: Handbook 1: Cognitive domain*. New York: David McKay.
- Burriss, R. (1976). *Human learning: Handbook of inductive organizational psychology*. Rand McNally College Publishing: Chicago, IL.
- Gordon, W. (1961). *Synectics: The development of creative capacity*. Collier MacMillan: London.
- Johnson, D. (1975). *Learning together and alone: Cooperation, competition, and individualization*. Prentice Hall: Englewood Cliffs, NJ.
- Koberg, D., & Bagnall, J. (1970). *The universal traveler; A soft systems guide to creativity, problem solving, and the process of reaching goals*. William Kaufman: Los Altos, CA.
- Frank, W. (1969, December). Models for encouraging creativity in the classroom by integrating cognitive-affective behaviors. *Educational Technology*, 7-13.

About the Authors

In 1990, L. Peter MacDonagh, RLA, co-founded The Kestrel Design Group, Inc. It has won numerous awards, including the 2006 national Green Roof Award of Excellence. Additionally, MacDonagh is part of the Landscape Architecture faculty at the University of Minnesota's College of Design. He is a Registered Landscape Architect, Certified Horticulturist, and Certified Arborist. Peter graduated in Landscape Architecture from the University of Minnesota.



Roger B. Martin, FASLA, has emphasized design process and thinking throughout 20 years of teaching at the University of Minnesota and University of California, Berkeley. He was a founder of the interdisciplinary firm InterDesign and of Martin and Pitz Associates, Landscape Architects. He has worked on plans for the Minnesota Zoological Garden, renovation of the Minneapolis parkway system, and development of the central riverfront in Minneapolis. Martin holds a degree in Horticulture from the University of Minnesota and Master of Landscape Architecture degree from Harvard University.



Related Research Summaries

InformeDesign has many Research Summaries about green design, design processes, and other, pertinent, related topics. This knowledge will be valuable to you as you consider your next design solution and is worth sharing with your clients and collaborators.

“Rooftop Gardens in Singapore”
— *Landscape and Urban Planning*

“Green Zones Improve Human Comfort in Cities”
— *Journal of Urban Planning and Development*

“Evaluating Urban Green Spaces”
— *Landscape and Urban Planning*

“Naturalistic and Formal Urban Parks”
— *Landscape and Urban Planning*

“How Natural and Urban Environments Affect Stress”
— *Journal of Environmental Psychology*

“Images Aid Design Process”
— *Journal of Architectural and Planning Research*

“Incorporating Acoustics into the Design Process”
— *Journal of Architectural Education*

“Using Plans to Analyze Visibility in Buildings”
— *Environment and Planning B: Planning and Design*

“Narrative Theory as a Tool for Identifying Meaning”
— *Journal of Interior Design*

Photos Courtesy of:

Emily Durand, University of Minnesota (Shanghai green roof, p. 3)

Roger Martin (design process images, pp. 4-5)

College of Design, University of Minnesota (p. 6)

The Kestrel Design Group (remainder)



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