

The CU Green Roof Project



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Introduction

Green roofs are a time tested building system dating back to the hanging Gardens of Babylon¹ and serve many aesthetic, cultural, structural, economic, social, and sustainability-related functions. These living systems also function well as a connection between the natural and the built world. In the past 40 years Green roofs have seen a rise in popularity in Britain and more recently in the United States. This rise has

¹ Dunnett, N., Kingsbury, N. (2004). *Planting Green Roofs and Living Walls*. Portland, OR. Timber Press.

been a direct result of an increased focus on the holistic impacts that our buildings have on the rest of the environment, as well as, the numerous benefits that grow from living roofs. Just some of the many benefits that green roof provide include: increased roof system longevity, thermal insulation, air purification (i.e. CO2 mitigation), stormwater management, improved solar efficiency, aesthetics, community-building, mitigation of the urban heat island effect, and food security. As green roofs and various living systems grow in popularity in the West, private businesses, public buildings, and communities at large are demanding the many benefits that green roofs have to offer. As the University of Colorado continues to work towards its strong sustainability goals, living roofs will allow the campus to improve the energy efficiency of current and new buildings, reduce the urban heat island effect, reduce stormwater runoff, increase the efficiency of solar PV panels, improve air quality, achieve LEED points, promote rooftop longevity, create opportunities for urban agriculture, and demonstrate campus leadership in sustainability.

Project Description

As the University of Colorado continues to renovate rooftops under its deferred maintenance plan, more opportunities to install and benefit from green roofs will become available. This proposal seeks to establish a fund (or earmark) that will be specifically used to finance the construction of a green roof system on the CU campus. The proposed budget will cover the net cost difference between a typical roof renovation and a green roof system. When a candidate building is slated for renovation, it will be flagged for review by a committee to deem the feasibility of that structure to hold a green roof. The committee (composed of student, faculty, staff, and Environmental Center representatives) will use the following standards to gauge the feasibility of a project to receive Sustainable CU funding:

Standards for Student Fee Support

In order for a building to receive student fees as part of a green roof project, the building and maintenance plan must include the following elements:

- I. Student and faculty involvement in the planning, design, implementation, and maintenance of the green roof;
- II. Public access for class tours, research, and various education and media events;
- III. Energy, temperature, and stormwater measurements on top of the roof. Preference should be given to buildings that have established baseline utility data;
- IV. Local materials and contractors should be used when feasible;
- V. A wide variety of native plant species are used



Following the installation, maintenance will depend on the type of system installed and plant varieties selected. A team of professionals would be prepared to oversee the 5-month transition period that typically marks the establishment of a green roof. Students should be involved in maintenance, as the iterative experience will facilitate a deeper understanding of the concepts embodied and create space for place-based reflection. The University will need to establish a point of contact for rooftop research and tours, as well as, determine a landscape management team.

Student Involvement

The proposed extensive green roof system would provide many opportunities for synergistic interactions between the student body and faculty from various disciplines. Students would be free to access the rooftop during class tours and for conducting research in conjunction with faculty sponsors. Students would also be involved in the planning, design, implementation, and maintenance phases of the project.

This project would also be a valuable recruitment tool for Environmental Design/Civil Engineering, Environmental Studies, and Ecology and Biology students

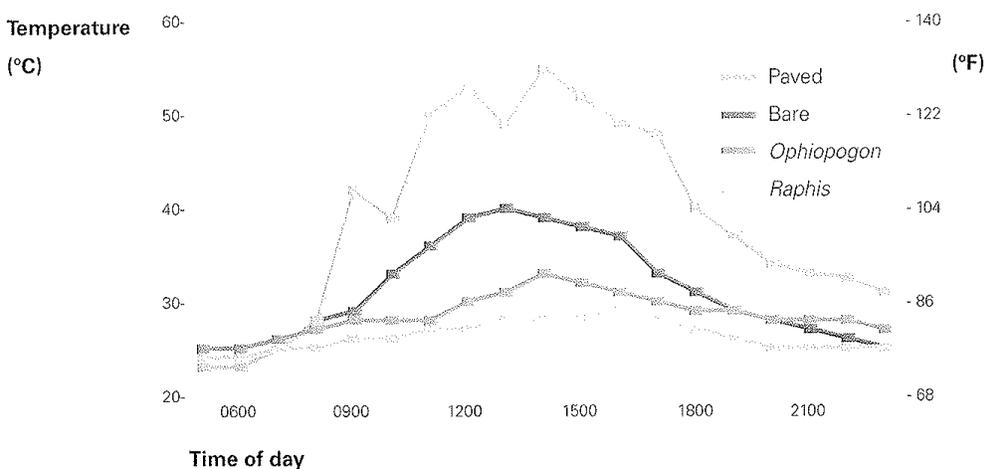


Social Equity

Many of the social benefits that green roofs provide include: offering space for community programs and interaction, local food sourcing, reducing utility bills, and mitigating the urban heat island effect. A high profile living system on the University of Colorado campus would further demonstrate the feasibility of green roofs in Colorado and other arid climates – thereby encouraging their use in urban centers that impact millions of people on a daily basis.

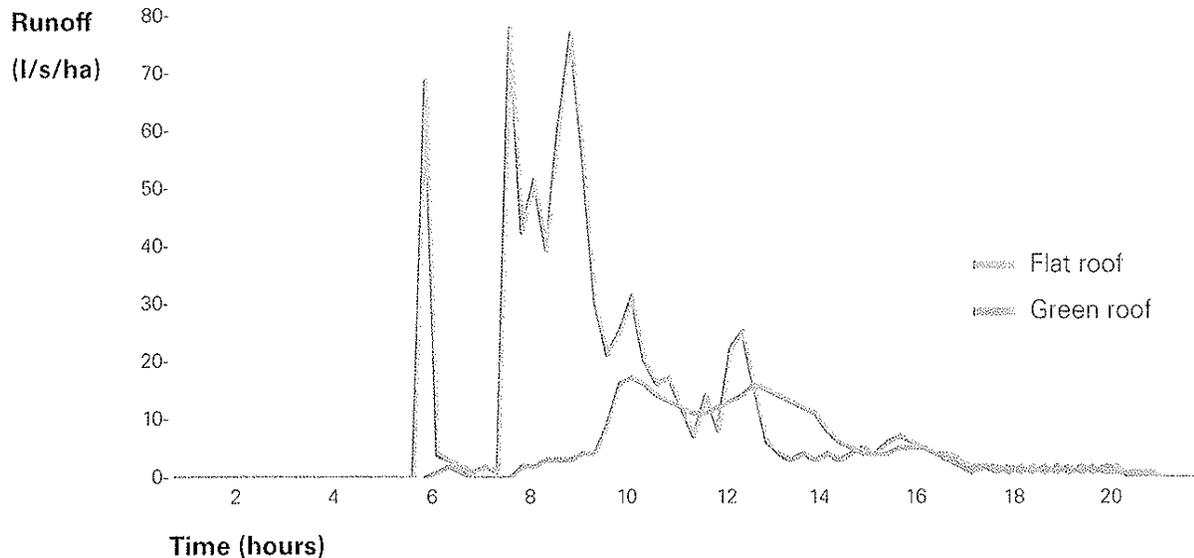
Environmental Impact

A green roof produces many positive environmental impacts. To begin, the living system will increase the building envelope and reduce demand on HVAC systems (thereby reducing electricity use). The green roof will also extend the longevity of the roof materials themselves by significantly reducing the diurnal temperature fluctuations that create thermal stresses on the roof layers. The graphs below demonstrate the temperature fluctuations that occur on a variety of rooftops:



Source: Dunnett, N., Kingsbury, N. (2004). *Planting Green Roofs and Living Walls*. Portland, OR. Timber Press.

Green roofs also aid in the reduction of stormwater runoff and help to purify the water that does reach the storm drains. The graph below demonstrates the mitigation potential of green roofs versus standard rooftops.



Source: Dunnett, N., Kingsbury, N. (2004). *Planting Green Roofs and Living Walls*. Portland, OR. Timber Press.

Living systems also support biodiversity within urban environments. A green roof that incorporates a wide variety of plant species will attract and support a number of insects and birds, while also providing them a migration corridor throughout the built environment.

Green roofs also qualify for LEED building points.

Innovation

This project will become the University of Colorado's first major green roof system and create a precedent for future projects. The project will also maintain the national leadership that the University continues to provide related to environmental sustainability in higher education. A green roof project will also function as a successful model of a living system in the arid West and help to encourage future installations in the community. This project would also serve as a quality example of a successful faculty, staff, and student partnership that leads to a significant sustainability improvement on the campus.

In addition to leadership benefits, this project is an innovative way to purify and mitigate stormwater runoff, improve building efficiency (beyond replacing windows and lights), and mitigate the urban heat island effect that significantly strains the campus environment.

Detailed Budget and Savings

This project requests a \$100,000 dollar earmark to be made in the Sustainable CU account to cover the net difference between a standard roof replacement project and a green roof living system. Although detailed budget estimations cannot be included in this proposal, a list of materials and their respective price ranges are included below. Furthermore, this document includes square footage projections under a variety of cost scenarios.

Major variables that influence the overall project cost are as follows:

- Retrofit versus new construction, potential structural upgrades and/or re-roofing
- Type of green roof - shallow or deeper (extensive versus intensive)
- Accessibility
- Maintenance
- Market maturity

To be cost effective during design and implementation is often necessary and should be done thoughtfully and without compromising the system performance for the life of the roof. Cost factors are generally project scope and building dependent. If the project is new, the significant expense of a structural retrofit may be eliminated. The following cost ranges are generated based on prices in the Denver Metro area. Prices and availability will vary depending on where you are in the region.

Structural Evaluation: \$ 0 (if new) - \$ 3,500 for larger commercial projects.

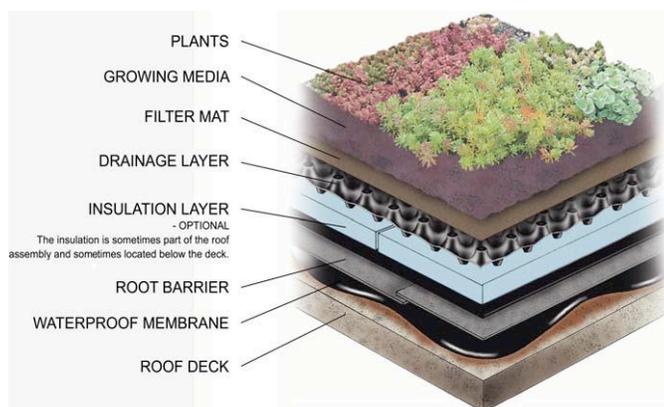
Design: 0 - 15% of the overall project cost.

Administrative Review and Project Approval: 0 - 10% of the overall project cost.

Installation: 0 - 10% of the overall project cost.

Waterproofing Membrane: \$ 7.50-12.50 per square foot. Depends on the size of the project, product availability, number of penetrations, edge conditions and accessibility.

Root Barrier: \$ 0 - 0.75 per square foot. Some membranes function both as the water proofing membranes and root barrier because of material type and thickness. If such a membrane type is used, there is no actual additional cost for the root barrier. If the membrane does not function as both, it is essential to add a root barrier to the system.



Protection Board: \$ 0 - 1.75 per square foot*

Insulation: \$ 0 - 3.00 per square foot*

Drainage and Water Retention: \$ 1.50 - 6.00 per square foot*

Filter Fabric: \$ 0 - 0.35 per square foot*

*Depends on the size of the project, product availability, type of product, access and the number of potential membrane penetrations needed. Some of these layers may not be needed.

Erosion Control: \$ 0 - 0.50 per square foot. Depends on the size of the project, product availability, type of product, access and the number of potential membrane penetrations needed. Some of these layers

may not be needed. For less steep slopes biodegradable straw mat can be found at approximately \$ 0.45 per square foot. For steeper slopes more complex erosion control systems can also be found. Typically the more complex the system the higher the cost.

Growing Medium: \$ 75 - \$ 200 cubic yard. Depends on the size of the project, product availability, type of product (type of specific mix), access and method of conveyance to the roof (crane, blower, truck, manual, etc).

Vegetation:

Modular systems (including plants, growing medium and root repellent): \$ 12 - 25 per square foot.

Shallower (extensive) loose laid systems: \$ 2.00 - 6.00 per square foot.

Deeper (intensive) loose laid systems: \$ 4.00 - \$ 20.00 (or more) per square foot.

Depends on the size of the project, type and the size/maturity of plants, seeds, cuttings, plugs, mats, plant availability, method of conveyance to the roof (crane, blower, truck, manual, etc) and type of container/anchorage for support of larger types of vegetation. Just one plant, shrub or tree can cost several hundred dollars and a field of meadow grasses can be seeded for as little as 2 ¢ per square foot. Landscaping is sometimes calculated as 2.5 - 3 x vegetation purchase price and might include plant warranty for a certain period of time, plant replacement in case something dies within the warranty time given and initial replacement installation.



Chicago City Hall



Denver Botanic Gardens



EPA Region 8 Building, Denver, CO



EPA Region 8 Building Solar Panels

Irrigation: \$ 2.00 - 5.00 per linear foot. Depends on the size of the project, access and the type of irrigation used. Drip irrigation can be installed at approximately \$ 1.50 - \$ 2.00 per square foot (excluding plumbing to the roof) and again depends on the size of project and access.

Walkways, Edges, Borders and Paths: \$ 0 - 20.00 per square foot/linear foot. Depends on the size of the project, product availability, material (pre-cast pavers, pre-cast concrete edges,

metal/wood/aluminum/ gravel/timber edges, natural stone, decking, recycled products), access and number of penetrations to the waterproofing membrane.

Security Railing or Green Screens: \$ 0 - 75.00 per linear foot. Depends on the size of the project, product availability, material used (metal, wood, aluminum, iron, steel, etc), access and number of penetrations to the waterproofing membrane.

Maintenance: \$ 20 - \$ 40 per hour. Depends on the size of the project, types of plants and elements used, access, irrigation, frequency of maintenance visits required and level of expectation. The above mentioned hourly cost most times includes fertilization, pesticides and removal of debris such as clippings and leaves.

Source: Tolderlund, L. (2010). *Design Guidelines and Maintenance Manual for Green Roofs in the Semi-Arid and Arid West*. Available growwest.org.

The savings generated from a green roof include: reduced utility bills and rooftop longevity.

Project Feasibility and Longevity

Feasibility

Green roof systems have been used by a wide variety of cultures over thousands of years in multiple climate – the technology have been proven to be effective. This proposal would earmark student funds to cover the net cost difference between two types of roofs for a project that will be sanctioned by the University of Colorado and ratified by several campus engineers and planning staff.

Longevity

Green roofs significantly improve the longevity of standard roofs. Therefore, this project – if installed properly – will last for a long period of time and be a highly-visible example of the campus' commitment to innovative sustainability.

Capital construction funds are requested for standard renovation to the following roofs on campus:

- Ramaley
- ARC East, 5 roof areas
- Civil Engineering
- Chemistry ENGR
- Admin ENGR
- Aerospace Engineering
- Mechanical Engineering
- Stadium Press Box
- Music
- Denison

When the capital construction funding is allocated to these projects, the stakeholders will assess if the project is a candidate for an upgrade to a green roof. Capital construction dollars are currently unpredictable in their availability so it is not possible to foresee which projects will receive funding and when. If the project is a candidate, the bid will include specs for a green roof system.

It is also important to recognize that the CU Recreation Center will be possibly undergoing a major structural renovation and would be a prime candidate for an intensive green roof system. The University Memorial Center (UMC) will also need to make important rooftop renovations over the next few years –

possibly creating an opportunity for a green roof system. These two locations would be prime candidates since they are operated under student fee dollars.

Outreach has also been done with Housing and Dining Services (HDS) and Athletics to offer a green roof system on their next feasible roof replacement project as well. The overall goal of this proposal is to incentivize the construction of the first rooftop living system on the University of Colorado campus – regardless of the specific department as long as it meets the requirements outlined in this document.



“This is what I think sustainability is all about, and this new facility lays the groundwork for a model of sustainable manufacturing...this is not environmental philanthropy; it is sound business.”

Bill Ford, Ford Manufacturing Company