Proposal for a Green Roof

Brittany A. Heyman, Team Captain

Michael Weinstein, Benjamin Veilleux, and Michael Collins

Southern New Hampshire University

Abstract

This paper proposes the installation of a green roof system on the new residence halls to be constructed on the Southern New Hampshire University Manchester campus. Green roofs have been shown to benefit sustainable initiatives by reducing carbon dioxide in the atmosphere both onsite and offsite, mitigating storm water runoff volume and pollutants, lessening airborne and noise pollutants, and creating wildlife corridors. Economically, the long-term savings they promote quickly offset the initial short-term costs that come from installation of green roofs. Green roofs are projected to have double the service life of traditional roofs, and lower electricity costs substantially by insulating and cooling buildings, thus reducing energy loads. Based on these effects--in addition to engendering positive publicity, increased recruitment, and possibilities for local agriculture--this study recommends strongly considering the inclusion of an intensive green roof system on the new residence halls.

Proposal for a Green Roof

Green roofs, also referred to as a rooftop gardens, are essentially rooftops that are covered or semi-covered in vegetation. They can range from simple structures that support rugged, self sustaining flora, such as sedums, to rooftop parks that are capable of supporting vegetable gardens and shrubbery, and in some cases even trees (EPA, 2008; She & Pang, 2010). Green roofs are becoming increasingly popular in urban areas as a means of retaining green space for biodiversity and aestetic appeal. Roofs represent approximately 21 to 26 percent of urban areas (Wong, 2005 as cited in Rowe, 2011, p. 2108). These typically unused spaces can be utilized to effectively address pollution concerns, protect the environement through more sustainable practices, and create a more cost-effective use of space to the owner over time (Rowe, 2011, p. 2108).

The two main types of green roofs are extensive green roofs and intensive green roofs. Extensive green roofs are lighter, require little maintenance, and are able to be planted on sloped roofs; however, they only allow for a restricted variety of hardy flora (EPA, 2008, p. 4). Intensive green roofs allow flexibility in vegetation choices, are able to sustain size-appropriate gardens, and are more cost effective in the long run; however, intensive green roofs require a larger initial investment than extensive green roofs (EPA, 2008, p. 4).

Both extensive and intensive green roofs are constructed with four main components: a layer of vegetation planted over a growing medium above a drainage layer and a waterproof membrane (She & Pang, 2010, p. 459). This basic model of a green roof construction differs slightly between the two main types of green roofs. Extensive green roofs require little more structural support than is already necessary for a hard roof (EPA, 2008, p. 4). Intensive green roofs compel the need for more structural support than extensive green roofs and growing mediums will differ among elected vegetation for the green roof of choice (EPA, 2008, p. 4).

Green roofs are beneficial additions to buildings, particularly in urban areas for many reasons. They reduce cooling loads to the building by inhibiting excess heat from entering a building via shading and evapotranspiration (EPA, 2008, p. 3), retain precipitation thus reducing storm water runoff (Bliss, Neufeld, & Ries, 2009, p. 413), improve urban air quality by increasing uptake of carbon dioxide and pollutants via biomass (Li, Wai, Zhan, Ho, Li, & Lam, 2010, p. 2644), aid in reducing noise pollution and soundproofing the building (Van Renterghem & Botteldooren, 2011, p. 734), and improve aesthetic appeal of urban buildings.

In addition to the benefits to the environment and quality of life of the occupants, green roofs are also cost-effective to the building owner. Green roofs have a longer service life than hard roofs (She & Pang, 2010, p. 458); a hard roof has an average service life of 20 years while green roofs have an estimated 45 year lifespan (Rowe, 2011, p. 2104). They offer additional insulation value (Castleton, Stovin, Beck, & Davison, 2010, p. 1583), and reduce annual heating and cooling costs (Susca, Gaffin, & Dell'Osso, 2011, p. 2125). Having a green roof installed on 50 percent or more of a roof structure guarantees two points towards LEED (Leadership in Energy and Environmental Design) Certification, while aiding up to seven additional points being awarded based on design, resulting in almost 20 percent earned of the total points required for a building to earn LEED certification (Green Roof Service, LLC., 2015).

Proposed Structure

The proposed living roof structure will have an access port on a far side of the building where stairs accessible from the top floor of the building will lead to the roof. This access port will have a door exiting to the roof facing toward the remainder of the narrower side of the roof.

A green wall will also be implemented on the side of the access port that will host an herb garden, made available to culinary students, or the student population in general. In addition, this roof access port will include solar panels on top of it to reduce overall energy costs and increase the environmental friendliness of the building.

A path leading from the exit onto the roof will encircle the roof and lead to a vegetable garden on the far side of the roof with a benched seating area. In the center of the green roof will be wildflowers, chosen over grass because they are more rugged and require less maintenance (Benvenuti, 2014, p. 159). A fence approximately four feet in height will surround the area of the roof and will be similarly designed to that of the new library window barriers, and a perimeter of shrubbery will sit just inside the fence for added safety and security.

Environmental Concerns

Recently, green roof technology has started to emerge as a promising type of storm water runoff control device for retaining rainfall volume and attenuating storm runoff peak flows from urban areas (She & Pang, 2010, p. 458). Numerous studies indicate that green roofs are effective for reduction of runoff volume and peak flow, and delay of peak flow in rain and storm water events, as opposed to conventional roofs (Li & Babcock Jr., 2014, p. 727). The growth media in the green roof system typically retains and detains rainwater (Lee, Lee, & Han, 2015, p. 171).

Studies have shown that extensive roofs will typically capture between 50 and nearly 100 percent of incoming rain, depending on the amount of growing medium used, the density of vegetation, the intensity of an individual rainstorm, and the frequency of local rain events (EPA, 2009, p. 8). In addition to simply controlling runoff volumes, studies have shown that green roofs produce runoff that demonstrates neutralization of slightly acidic rainfall (Bliss, Neufeld, & Ries, 2009, p. 415)

Green roofs also have the intrinsic ability to remediate various types of pollutants, both directly and indirectly. Plants take up gaseous pollutants, including greenhouse gases, through their stomata (Rowe, 2011, p. 2100). They are also capable of intercepting particulate matter with their leaves, and are capable of breaking down certain organic compounds, like hydrocarbons in their tissues (Rowe, 2011, p. 2102). Green roofs also serve naturally as a carbon sink. Carbon is a major component of plant structures, and is naturally sequestered in plant tissues through photosynthesis (Rowe, 2011, p. 2103). On a sunny day, a green roof may lower the carbon dioxide concentration in the nearby region as much as two percent (Li, Wai, Zhan, Ho, Li, & Lam, 2010, p. 2651). This, in addition to their ability to lower energy expenditures and thus reduce offsite carbon dioxide emissions, means that green roofs function to reduce carbon dioxide in the atmosphere in two distinct ways (Li, Wai, Zhan, Ho, Li, & Lam, 2010, p. 2651). Of additional note is the potential for green roofs to mitigate noise pollution as well. As opposed to the hard surfaces of a traditional roof, green roofs provide mitigation for noise pollution due to absorption of certain frequencies (Van Renterghem & Botteldooren, 2011, p. 737). Vegetation in combination with the growing substrate will absorb sound waves to a greater degree than a hard surface (Rowe, 2011, p. 2105). Finally, lifecycle pollution may also be reduced with the use of a green roof. While a typical traditional roof lasts 20 years, green roofs are estimated to have a 45-year lifespan, thus reducing roofing materials in landfills (Rowe, 2011, p. 2104).

While traditionally viewed as unused spaces, roofs may represent up to 26% of the landscape of urban areas (Rowe, 2011, p. 2108). This is important for Southern New Hampshire University, as the school's campus is located just outside of New Hampshire's largest city. The inclusion of a green roof on the new residence halls can address pollution concerns while also protecting of our environment through more sustainable practices (Rowe, 2011, p. 2108). A long-term strategy focusing on the adoption of green roofs can provide better storm water management, improvement of air quality and increase in biodiversity here on campus and for our local community (Susca, Gaffin, & Dell'Osso, 2011, p. 2126).

Economic Concerns

There are many economic values and advantages in regards to the installation of a green roof on the new campus residence halls. The increase in initial, short-term costs that come from the installation of a green roof are quickly offset by the long-term savings that it can supports. The underlying roof itself will require less upkeep and maintenance due to the green material on top of it (EPA, 2009, p. 14) making less work for the maintenance personnel on campus. Reduced stresses on roofing materials typically double the service life, typically prolonging the practical life by 20 to 25 years (Rowe, 2011, p. 2104); therefore, the costs for rehabilitation or replacement of roofs can be delayed. Added insulation from having vegetation on 50 percent of the roof or more will keep excess heat out of the building during the warmer months, and trap warm air inside the building during the colder months, effectively reducing heating and cooling costs year round (Susca, Gaffin, & Dell'Osso, 2011, p. 2125).

The addition of a green roof to the new residence halls will be cost effective to the campus as a whole. The installation, debut and upkeep of a green roof will attract positive attention. An aesthetically pleasing environment that marries form with function will be an added selling feature in recruiting new students. Rooftop agriculture, by way of the proposed vegetable garden and green wall attached to the roof access, is becoming a hot button topic in urban areas with locally grown vegetables being increasingly desired (Whittinghill & Rowe, 2011, p. 315). In addition, rooftop agriculture will reduce food costs to the culinary department and increase freshness and quality of the food practices and educational experiences that are available to culinary students. This will further increase attention from potential incoming students. With the simple addition of the propose solar panels on the roof, more energy would be harnessed, reducing the energy costs for the building overall.

Conclusion

Based on all of the combined environmental, economic, and social benefits, this study recommends strongly considering the inclusion of an intensive green roof system on the new residence halls. The proposed green roof supports the University's sustainable initiatives via intrinsic performance; and as a highly visible aesthetic symbol, promotes those same initiatives to the community. Additionally, such an undertaking has the potential to create long-term cost savings to the school, by way of decreased energy expenditures and increased lifetime versus a traditional roof. Lastly, with its ability to create a unique and attractive space for local agriculture and recreation, the green roof has enormous potential to foster favorable public perception and goodwill for years to come.

References

Benvenuti, S. (2014). Wildflower green roofs for urban landscaping, ecological sustainability and biodiversity. *Landscape and Urban Planning, 124*, 151-161. doi:10.1016/j.landurbplan.2014.01.004

Blackhurst, M., Hendrickson, C., & Matthews, H. S. (2010, December). Cost-effectiveness of green roofs. *Journal of Architectural Engineering*, 136-143. doi:10.1061/ASCEAE.19435568.0000022

Bliss, D. J., Neufeld, R. D., & Ries, R. J. (2009). Storm water runoff mitigation using a green roof. *Environmental Engineering Science, 26* (2), 407-417. doi:10.1089/ees.2007.0186

Castleton, H. F., Stovin, V., Beck, S. B. M., & Davison, J. B. (2010). Green roofs: Building energy savings and the potential for retrofit. *Energy and Buildings, 42*, 1582-1591. doi:10.1016/j.enbuild.2010.05.004

EPA. (2008). *Reducing urban heat islands: Compendium of strategies.* Environmental Protection Agency. http://www.epa.gov/heatislands/resources/pdf/GreenRoofsCompendium.pdf

Green Roof Service, LLC. (2015). *Green Roofs and LEED Certification.* Retrieved March 18, 2015, from Green Roof Technology: Form and Function: http://www.greenrooftechnology.com/leed/leed_Greenroofs

Kadhim-Abid, A. L. (2014). Comfort management in changing climate conditions with the use of green roofs. *Management & Marketing. Challenges for the Knowledge Society, 9* (1), 3-12. http://www.managementmarketing.ro/pdf/articole/338.pdf

Lee, J. Y., Lee, M. J., & Han, M. (2015). A pilot study to evaluate runoff quantity from green roofs. *Journal of Environmental Management, 152*, 171-176. doi:10.1016/j.jenvman.2015.01.028

Li, J., Wai, O. W. H., Li, Y. S., Zhan, J., Ho, Y. A., Li, J., & Lam, E. (2010). Effect of green roof on ambient carbondioxide concentration. *Building and Environment, 45*, 2644-2651. doi:10.1016/j.buildenv.2010.05.025

Rowe, D. B. (2011). Green roofs as a means of pollution abatement. *Environmental Pollution, 159*, 2100-2110. doi:10.1016/j.envpol.2010.10.029

She, N., & Pang, J. (2010, June). Physically based green roof model. *Journal of Hydrolic Engineering*, 458-464. doi:10.1061/ASCEHE.1943-5584.0000138

Susca, T., Gaffin, S. R., & Dell'Osso, G. R. (2011). Positive effects of vegetation: Urban heat island and green roofs. *Environmental Pollution, 159*, 2119-2126. doi:10.1016/j.envpol.2011.03.007

Van Renterghem, T., & Botteldooren, D. (2011). In-situ measurements of sound propagating over extensive green roofs. *Building and Environment, 46*, 729-738. doi:10.1016/j.buildenv.2010.10.006

Whittinghill, L. J., & Rowe, D. B. (2011). The role of green roof technology in urban agriculture. *Renewable Agriculture and Food Systems, 27* (4), 314-322. doi:10.1017/S174217051100038X

Whittinghill, L. J., Rowe, D. B., & Cregg, B. M. (2013). Evaluation of vegetable production on extensive green roofs. *Agroecology and Sustainable Food Systems, 37*, 465-484. doi:10.1080/21683565.2012.756847

Yanling, L., & Babcock Jr., R. W. (2014). Green roof hydrolic performance and modeling: a review. *Water Science & Technology, 69* (4), 727-738. doi:10.2166/wst.2013.770