The Ohio State University
Campus as a Living Laboratory

North Residential District Transformation Green Roof Proposal

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Executive Summary

The Ohio State University's North Residential District Transformation presents a perfect opportunity for the addition of a green roof to north campus. Amanda Waples, the Program Manager for Student Life Facility Planning and Design, suggested further research be done on green roofs in order to create a flexible plan. Due to the uncertain nature of the North Residential District Transformation, the flexibility of these green roof plans is crucial in order to give the highest probability of implementation.

While green roofs require a more complicated roof structure, they allow for a range of plants to grow on the rooftop. There are three general types of green roofs: intensive, semi-intensive, and extensive – all of which vary in the levels of human involvement they are capable of sustaining and the amount maintenance that they required. These designs also provide varying levels of benefits which include increased durability, energy savings, storm water management, and aesthetic appeal. Intensive and semi-intensive designs also hold the added benefits of the potential for student involvement. Three general plans, each representing one of the three styles of green roofs, are presented, along with a recommendation from the authors as to which plan they think would be best suited for OSU.

Green roofs present several drawbacks that can prevent them from being constructed. These drawbacks include higher initial costs, increased maintenance, and increased safety concerns. However, these drawbacks can be easily mitigated as green roofs can easily pay for themselves with energy savings and increased lifespan, and safety concerns can be addressed by keeping to strict building codes.

Green roofs have been successful, not only in large cities but in universities as well. Universities that have welcomed green roofs onto their campuses include Evergreen State College, which has an award-winning green roof on one of its seminar buildings; Tufts University, which focuses on developing and researching green roofs through its Office of Sustainability; and Pennsylvania State University, which was the first school in the nation to create a course centered on green roof technology.

Introduction

The Ohio State University's (OSU) framework plan for residential life sets a goal for an increase in green space to promote student and environmental health. We are proposing that a green roof be added to the current North Residential District Transformation (NRDT) plans as an extension of these goals.

A green roof will not only extend the life of the roof and reduce energy needs, but also provide green space for students to utilize and enjoy. In addition, green roofs can contribute up to 15 points towards OSU's commitment to Leadership in Energy and Environmental Design (LEED) certification. Through our proposal, we hope to convince decision makers involved with the NRDT that a green roof will easily pay for itself from roof replacement costs, energy savings, and LEED certification benefits.

This paper will examine green roofs and their possible application in the North Residential District Transformation. The NRDT budget allows for one green roof, however the budget and the amount of space provided for the green roof project is currently unknown. This ambiguity could affect the type and design of the green roof plan chosen by the university. To address this aspect of uncertainty, we hope to create a range of proposed designs for the university to review.

This paper will also discuss the purpose behind adding a green roof to the current NRDT plans. The first section will cover background information on the NRDT, followed by a section on the basic information on green roofs. The third section will introduce the three proposed plans for the NRDT green roof. The fourth and final section will present cases where green roof systems have been successfully enacted by other universities, not only on their campus but also in their curriculum.

1.0.0 North Residential District Transformation

Location is a key factor in the planning and success of a green roof project. Ohio State's NRDT offers the best opportunity for the construction of a green roof on one of the new buildings. The NRDT is a plan to create a better place for students to live and learn on north campus, while encouraging environmental stewardship (OSU Finance Committee, 2012, p. 166). Although the NRDT plans include more buildings than are currently on north campus, the plans allow for more green space by removing Curl Drive (Waples, personal communication, February 5, 2013). Along with this green space, installing a green roof on one of the new buildings on north campus would be an ideal example of new developments in sustainable design for The Ohio State University.

The idea for a green roof addition was first proposed by Amanda Waples, the Program Manager for Student Life Facility Planning and Design. Ms. Waples suggested further research on green roofs was needed in order to create a flexible plan for the addition of a green roof. According to Ms. Waples, the most likely location of a green roof in the NRDT plans would be on one of the two new dining facilities.

Throughout this project, the NRDT and its building specifications have been constantly changing; the designs for the first two buildings that our team was directed towards were both scrapped during our design process. Due to the constant evolution of the NRDT plans, our team and Ms. Waples decided that refocusing on a flexible framework would be best since it could be applied to essentially any of the buildings proposed for the NRDT.

2.0.0 Green Roofs

Over the last 30 years, green roofs have become a staple in the majority of large urban cities for the benefits and green space that they provide. A green roof has a more complicated structure than a conventional roof (Figure 1), but it allows for the growth of a range of plants from grasses to small trees. The basic structure of a green roof includes a number of different layers that play vital roles in the function of the system.

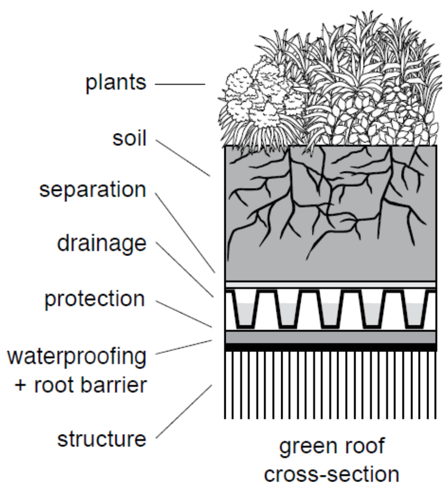


Figure 1. Layers of a green roof (City of Indianapolis Department of Public Works, 2008)

The first component of a green roof is the roof structure itself. Since additional materials, and often people, will be on the roof, the load capacity of the roof needs to be enough to handle the increased weight. A waterproof membrane and root barrier is also placed over the roof structure to help offset any loss in structural integrity by keeping out moisture and roots that would otherwise damage the structure. The third layer is a drainage layer comprised of a plastic, egg carton-esque material and/or lightweight granular medium. The purpose of the drainage layer is to help maintain the water content and aeration necessary for plant growth. Next is a section of an engineered, non-woven filter fabric that acts to keep fine soil particles from getting down into the drainage layer. A layer of growing medium is then added to the roof, the depth of which is dependent on the type of green roof being utilized, but generally varies from 60 millimeters in depth with low organic content to more than 350 millimeters in depth with more organic matter or sand. Finally, the visible top layer of the system is comprised of the plant material. This layer is even more variable in its composition than the growing medium, ranging from grasses to shrubs to even small trees. All plants chosen for a green roof, however, should be drought tolerant, self-sustaining, perennial, require low maintenance, fire resistant, and heat, cold, and high wind resistant (City of Indianapolis Department of Public Works, 2008).

2.1.0 Types of Green Roofs

There are three general types of green roofs, with varying levels of accommodation for human and maintenance. These types include extensive, semi-intensive, and intensive styles, with each type of green roof holding its own set of advantages and disadvantages.

2.1.1 Extensive

An extensive style green roof is the most basic of the three options, and is generally associated with plants such as mosses, sedums, herbs, and grasses. These plants require around 60 to 200 millimeters of growing medium, which is the shallowest of the three types of green roofs. The small amount of growing medium and vegetation used in extensive roofs make it the least expensive of the three. There is also very little maintenance associated with extensive roofs, and they do not require any type of irrigation system (International Green Roof Association, 2013).

The advantages of an extensive type green roof are their low maintenance requirements and low cost. However, these are offset by the reduced energy savings and lack of accessibility to the roof. Generally, extensive type green roofs are only accessed for maintenance and as needed for weeding.

Overall, the main purpose of an extensive type roof is for an ecological protection layer. This protective layer extends the roof life and reduces storm water runoff. It acts as an insulator for the roof, reducing energy costs and environmental impacts.

2.1.2 Semi-Intensive

A semi-intensive green roof is the intermediate option between extensive and intensive roof styles. With a growing medium range of 120 to 250 millimeters, this roof style can support grasses, sedums, and herbs, as well as small shrubs. The semi-intensive roof comes at a higher cost than the extensive roof, because it requires both periodic maintenance and in some instances irrigation to keep the plants healthy (International Green Roof Association, 2013).

Although the semi-intensive roof is more expensive, it increases energy savings by increasing insulation (Niachou, Papakonstantinou, Santamouris, Tsangrassoulis & Mihalakakou, 2001, p. 727) and has the important advantage of recreational access to the roof. Although allowing people to use this green space is a major benefit, there are disadvantages when allowing access to non-maintenance personnel. Once people have general access to the area, extra maintenance is usually required due to increased foot traffic. Safety also becomes a concern once people have access to the roof space. Railings have to be added to the perimeter of the roof in order to prevent people from accidentally falling over the edge.

Overall, semi-intensive green roofs are the recreational green roofs. In addition to providing a thicker and therefore more protective barrier, semi-intensive green roofs also provide an aesthetically appealing space accessible to the people.

2.1.3 Intensive

An intensive style green roof is the most elaborate and expensive type of green roof. The layer growing medium ranges from about 150 to 400 millimeters deep, and supports everything from sedum and grasses to larger shrubs and small trees. Similar to semi-intensive roofs, the more intensive the plants and the style, the higher the construction cost. This design also requires more maintenance than either the extensive or semi-intensive styles, and usually requires irrigation systems to maintain healthy growth in most designs (International Green Roof Association, 2013).

Intensive style green roofs are similar to parks, incorporating pathways, benches, gazebos, and even water features into their designs (Welsh, personal communication, March 22, 2013). These additions are the main cause of the increased price of intensive designs, because the cost includes the features and the necessary structural support.

Overall, intensive green roofs go far beyond the other designs in providing a fully-functional space for people to enjoy.

2.2.0 Benefits from Green Roofs

The addition of a green roof can provide a building with a number of significant benefits, and it is a practical and efficient way of returning nature to the urban environment. Green roofs provide increased durability, an opportunity for student involvement, energy savings, and even storm water management. Rather than being localized to the building on which they are constructed, the benefits of green roofs can extend to the surrounding community as well.

2.2.1 Durability

One of the most important economic benefits of green roofs is the increased longevity of the roof. The waterproofing membranes on traditional black roofs deteriorate quickly when exposed to ultraviolet (UV) light, which causes the membranes to become weak. The membrane is therefore at a greater risk for damage when the roof expands and contracts in widely fluctuating temperatures. The growing media and plant material of a green roof shield and protect the roof from UV light, while also preventing drastic changes in temperature on the rooftop. A green roof can dramatically extend the life of a roof by upwards of 20 years; some green roofs in Berlin, Germany have lasted 90 years without needing major repairs (Oberndorfer et. al., 2007, p. 827). These increased lifespans would be the primary economic incentive behind the addition of a green roof, as it drastically reduces the amount of money needed to not only repair damaged roofs, but also to replace old roofs.

2.2.2 Student Involvement

The addition of a green roof to a building on north campus will give students another way to be involved in the community. Students from a wide range of disciplines would be able to work with faculty to use the green roof for research, internships, and community service. Such projects could include analyzing the most effective plants for decreasing pollution, or pollinator experiments.

The green roof will also be a great opportunity for students involved with the Second-year Transformational Experience Project (STEP). The STEP program was designed by Ohio State administrators to increase sophomore involvement on-campus, and all second-year students living on-campus are eligible to apply. The program will pair accepted students with a faculty member who shares similar interests. The student will then work with their faculty advisor to design their “transformational experience”, which could include internships, service learning, research, or other projects. Students will receive funding (a stipend of $2,000) for their experience, allowing them to access unique and exciting opportunities. A green roof would be an excellent place for sophomores to complete their STEP experience with a hands-on approach (STEP, n.d.).

2.2.3 Energy Savings

In addition to lasting longer than traditional roofs, green roofs also provide further savings by lowering energy demands. For traditional buildings, the roof is where the majority of the heat is lost in the winter and where the highest temperatures are in the summer. A green roof can regulate these changes and prevent energy loss by reducing heat transfer. The growing medium and plant material provide natural insulation that prevents heat loss in colder months and prevents roof heating in warmer months (Green Roof Benefits, n.d.).

While buildings lacking adequate insulation benefit most from green roofs, heating and cooling costs are reduced for all types of buildings (Niachou, Papakonstantinou, Santamouris, Tsangrassoulis & Mihalakakou, 2001, p. 727). Studies show that green roofs have reduced indoor temperatures by 3 to 4°C when outdoor temperatures were between 25 °C and 30°C (Getter & Rowe, 2006, p. 1281), and research conducted at the University of Florida suggests that energy savings can reach 15% to 30% per year (Clark, Acomb, Lang & Ren, 2008, p. 3).

2.2.4 Storm Water

A main environmental benefit of a green roof is in their storm water management capabilities. Precipitation that falls on the roof is stored by the growing medium, taken up by the plants, and then returned to the atmosphere through transpiration and evaporation (Green Roof

Benefits, n.d.). Green roofs may reduce runoff by 60% to 100% depending on the type of green roof system and vegetation used (Getter & Rowe, 2006, p. 1278). Green roofs can delay storm water runoff by holding the water in the growing medium, even when they are unable to fully reduce the runoff. This delay can reduce the stress on sewer systems during peak flow periods, and lead to lowered chances of toxins and pollutants entering bodies of water (Green Roof Benefits, n.d.).

2.2.5 Aesthetic Appeal

Some key incentives of a green roof are social benefits, which includes their aesthetic appeal. The natural elements of the green roof can provide a respite from the predominately hard surfaces and build structures of the urban environment. In addition to a visual escape, green roofs provide psychological benefits as well. Health benefits of green roofs can include reducing stress, lowering blood pressure, releasing muscle tension, and increasing positive feelings (Ulrich & Simmons, 1986 in Getter & Rowe, 2006, p. 1279). These health benefits are related to the concept of biophilia, the idea that humans have an inherent need to interact with nature (Kellert, January, 2013). Adding a green roof to campus would be an outward symbol of OSU's commitment to the environment and sustainability, as well as a selling point to prospective students. The beauty of the green roof would benefit the university's mission and goals, and improve student wellbeing.

2.2.6 LEED Certification

Adding to Ohio State's image as a green university and providing another social benefit to green roofs is the potential for credit towards Leadership in Energy and Environmental Design (LEED) certification. LEED certification is administered by the US Green Building Council to establish standards and guidelines for designing and constructing environmentally friendly buildings that reduce negative impacts. There are many benefits to having LEED certified buildings, including increasing a property's value and promoting an image of sustainability. Part of OSU's plan for the NRDT and continued commitment to sustainability is to construct only LEED Silver certified buildings or higher. A well-planned green roof can gain a building up to 15 LEED credits in the categories of water efficiency, sustainable sites, and energy and atmosphere (Getter & Rowe, 2006, p. 1284). Adding a green roof to one of the new buildings on north campus will support Ohio State's LEED initiative.

2.3.0 Drawbacks of Green Roofs

Despite the benefits of green roofs, they do present some drawbacks that can discourage their construction. The main drawbacks of a green roof are their higher initial costs, increased maintenance requirements, and an increased safety risk associated with the semi-intensive and intensive types. However, each of these drawbacks can be easily mitigated through careful planning and realistic expectations.

2.3.1 Cost

The structure of a green roof is much more complex than a conventional roof. Additional measures are needed, such as waterproofing, root barriers, and additional structural support – each of which increases the cost of construction. Not only do the materials themselves have a higher cost, but the number of green roof contractors is very limited. With the small amount of experienced contractors there is little room for negotiation and competition. Many builders often decide that a green roof is not worth the cost and opt for a traditional black top roof due to these issues.

The benefits of green roofs, however, save more money than the cost of construction and maintenance of a green roof. Studies done at OSU and other universities have shown that the longevity and energy benefits from green roofs save more money than the cost of installation. For example, OSU's Hitchcock Hall has had its traditional black top roof replaced twice in the past 45 years, costing the university approximately $760,000. If an extensive green roof were installed on Hitchcock Hall, it would only need to be replaced once in a 45 year period, and would only cost $533,000 (Cooke, Higbie, Holton, McGraw & Laver, 2012, p. 13). The economic potential of green roofs comes from their long term savings despite their short term initial costs.

2.3.2 Maintenance

Green roofs require additional maintenance compared to a traditional hard top roof, with even more maintenance the more intensive the design. This increased maintenance does not necessarily have to be a downside. On the contrary, it can become a way for Ohio State to increase student involvement. Most green roof contractors provide the maintenance requirements for the first few years, and even offer training to those who will maintain the green roof in the future (Welsh, personal communication, March 22, 2013). After the contractors stop maintenance, the university can either hire someone to oversee further maintenance or find a faculty member who would be willing to work with students to maintain the roof. Students can help maintain the roof by either forming a student organization or create a related internship through the STEP program. If students are able to get more involved in the green roof's maintenance, Ohio State would not need to hire more employees, further saving the university's money.

2.3.3 Safety

The most significant drawback of green roofs is safety. If people access the roof, then there is an increased chance of injury or possible death due to falling. A main reason for constructing a green roof at Ohio State is so students can utilize the space to its fullest potential. In order to keep visitors safe, building codes state that a railing must be installed. This railing must be gridded with the openings being no larger than 4 inches in diameter (Welsh, personal communication, February 25, 2013). Another more expensive option would be a Plexiglass sheet which would eliminate the risk of falling and also allow for a less obstructed view of the surrounding area.

To reduce the risk of students accidentally falling off of the roof, the times at which the roof is accessible could be restricted. We suggest the green roof could only be accessed with a BuckID from 8:00 am to 8:00 pm on weekdays, and to have more restricted times on weekends, in order to promote healthy decisions.

3.0.0 Proposed Plans

Ohio State has the opportunity to take advantage of the many benefits that green roofs can provide. The following three sections will present three different plans, each representing one of the three green roof styles that could be included into the current NRDT plans.

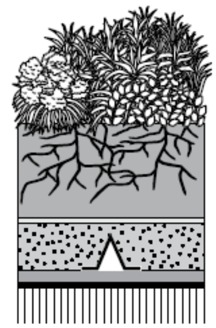
Since no concrete building constraints have been determined, the three plans are modeled after the Market Place currently on south campus for square footage, as the most likely location for the green roof would be on a similar building. Also, given the lack of specifications, each of the proposed plans will act as more of a rough framework rather than detailed designs.

3.1.0 Plan One

The first plan will feature an extensive style green roof that will not allow for any student access to the green roof. This plan will feature basic extensive ground cover comprised of simple sedums and perennials. There is, however, enough flexibility in the types of plants available for this cover to potentially tailor the selection of species to those that attract butterflies and/or birds for increased biological diversity benefits.

This plan would utilize a granular drainage system, and between 2 to 8 inches of growth medium, and would require structural support that could withstand 23 to 36 pounds per square foot of saturated weight (Table 1).

This type of design would provide several benefits such as increased durability, energy savings, storm water retention (between 50 and 60%), and LEED certification (Green Roof Handbook, 2008).



system designation	G2
typical plants	sedum herbs perennials
extensive soil mix	4"
intensive soil mix	-
separation fabric	1/8"
granular drainage	2"
protection mat	1/4"
nominal thickness	6"
dry weight	24 lbs/ft²
saturated weight	36 lbs/ft²
minimum slope	0:12
maximum slope	1:12
water retention	60%

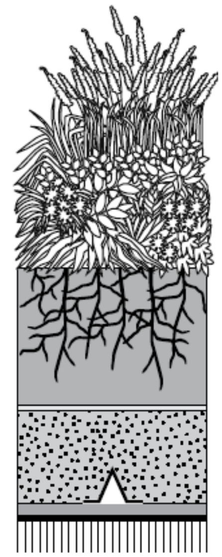
Table 1. Plan One (City of Indianapolis Department of Public Works, 2008)

3.2.0 Plan Two

The second plan will feature a semi-intensive green roof and would allow for some students to access the area. This plan will feature more aesthetically pleasing ground cover than what might be found in the extensive plan, as well as perennial flowers and possibly small shrubs.

This plan would utilize a granular drainage system, and between 4 to 10 inches of growth medium. The semi-intensive plan would require the structural support that could withstand not only the roughly 60 pounds per square foot for the green roof layers, but also the additional 15 to 45 pounds per square foot for the pathway materials (Table 2).

This type of design would provide all of the benefits included in the extensive plan, with an additional amount of storm water retention (roughly 70%), increased aesthetic appeal, and the possibility for student involvement with the green roof (Green Roof Handbook, 2008).



system designation	G3
typical plants	perennials grasses shrubs
extensive soil mix	-
intensive soil mix	6”
separation fabric	1/8”
granular drainage	4”
protection mat	1/4”
nominal thickness	10”
dry weight	40 lbs/ft²
saturated weight	58 lbs/ft²
minimum slope	0:12
maximum slope	1:12
water retention	70%

Table 2. Plan Two (City of Indianapolis Department of Public Works, 2008)

3.3.0 Plan Three

The third and final plan will feature an intensive green roof that will allow more students to access the roof than the semi-intensive plan. This plan will feature the most aesthetically pleasing ground cover, accent flowers and shrubs. The intensive design will also include more people-friendly accents, such as benches and tables.

This plan would utilize a granular drainage system and between 6 to 16 plus inches of growth medium. The intensive plan would require the structural support that could withstand not only the roughly 85 pounds per square foot for the green roof layers, but also the additional 15 to 45 pounds per square foot for the pathway materials (Table 3).

This type of design would gain all of the benefits seen in the semi-intensive plan, with even more storm water retention capabilities (roughly 80%), the maximum aesthetic appeal, and the a very high possibility for student involvement with the green roof (Green Roof Handbook, 2008).

3.4.0 Recommendation

We recommend that the university construct a semi-intensive green roof, which was illustrated in the second plan. This option is the most practical as it still allows students access the roof, while somewhat minimizing the cost to the university. It would be in Ohio State's best interest to have the roof be accessible to students, in order to experience the full range of benefits that green roofs have to offer. We propose that the green roof be available only to students that live on campus and hold sophomore standing or higher. This somewhat limited access would reduce the amount of foot traffic and encourage upperclassmen to continue living on campus.

system designation	G4
typical plants	grasses shrubs trees
extensive soil mix	-
intensive soil mix	9"
separation fabric	1/8"
granular drainage	5"
protection mat	1/4"
nominal thickness	14"
dry weight	56 lbs/ft^2
saturated weight	82 lbs/ft^2
minimum slope	0:12
maximum slope	1:12
water retention	80%

Table 3. Plan Three (City of Indianapolis Department of Public Works, 2008)

4.0.0 Success at Other Universities

Universities across the country have found green roofs to be greatly successful. Many universities already have several green roofs in place on their campuses, as some started developing designs for green roofs over ten years ago. Ohio State is behind in green roof technology when compared to other universities. Universities that are leading the way with green roofs include Evergreen State College, Tufts University, and Pennsylvania State University.

4.1.0 Evergreen College

Evergreen State College has an award-winning green roof on its Seminar II Building ("Sem II"). The sustainable roof is expected to last over 30 years - a remarkably long time when compared to traditional roofs. Evergreen State College designed their green roof to focus on environmental sustainability, one of the school's core values. "Sem II" boasts that it has 33 flowering perennials on its green roof, along with other sedums. The green roof also collects rainwater, which is filtered through the green roof system. The water is slowly released into the local environment after overflowing into a 20,000-gallon reservoir. The process is designed to reduce the need for storm water retention ponds around the building (Evergreen's..., 2005).

4.2.0 Tufts University

Another university that has found success with green roofs is Tufts University. Tufts has established a Green Roof Collaborative through the Office of Sustainability, focused on developing and researching green roofs. Tufts has a green roof located on top of Tisch Library, which holds 20,000 pounds of plant and soil material. Researchers at the university have found that the shade provided by green roof plant material and growing medium can greatly extend the life of the roof. Research showed that the shade kept the roof at a consistent temperature and provided UV protection which in some cases tripled the roof's lifespan. Similar to other universities, those involved with the green roof collaborative at Tufts found that the early costs of a green roof tend to be higher than those of a traditional roof. The researchers are quick to state that the benefits of a green roof pay for these initial costs relatively quickly (Carter, T. & Butler, C.M., 2008).

4.3.0 Pennsylvania State University

Pennsylvania State University is a university that is making remarkable advances in the field of green roof technology. Penn State has established the Center for Green Roof Research, which is an initiative focused on examining the benefits of green roofs. The Center is valuable and unique, as it is "the only location in North America with small test green roofs on replicated buildings." Penn State currently has four different green roofs, located on the Forest Resources Building, The Root Cellar, The Student Health Center and The Dickinson School of Law. The green roofs at Penn State range in size from 4,500 ft^2 to 22,000 ft^2, and vary in benefits, public access and maintenance. The Center for Green Roof Research has released several reports and publications focusing on the green roofs and research being done at Penn State. Penn State continues to promote awareness of green roof technologies, both to students and the public.

Penn State is also the first school in the nation to establish a green roof technologies course: Horticulture 497B. The class was created in 2005 and is taught every Spring semester. Students from many disciplines participate in the course, with experiences such as field trips, guest lecturers, and hands-on projects. The objectives of the course are “to examine the fundamentals of green roofs, living walls, constructed wetlands, and selected other green technologies.” Penn State is one of the most innovative universities in the nation with green roof technologies, and hopefully OSU can look to them in the future as a role model as it furthers its own green roof program (Center for Green Roof Research..., n.d.).

Conclusion

This paper has looked at the costs of green roofs, the benefits they provide, and all the steps necessary in designing a green roof. There are, however, more than just economic and environmental benefits to green roofs. Beyond just their functional benefits, green roofs can provide a relaxing environment for students to wind down after a midterm, a natural sanctuary in an increasingly urbanized world, and a hands-on, “living laboratory” for student use. These benefits have the greatest effect on the students and the surrounding ecosystems, proving to be a huge asset to any community.

The Ohio State University is recognized as one of the top colleges in the country. The university offers over 175 majors, and hundreds of specializations and minors, with competitive standards and students coming from all over the world. In many cases, The Ohio State University is finds itself at the forefront of new and innovative programs and ideas. As one of the most prestigious universities in the nation, Ohio State should join other leading universities in its application of green roof technologies to become a more environmentally friendly and sustainable university.

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