August
2011

GREEN ROOFS

WESTMINSTER COLLEGE

Introduction

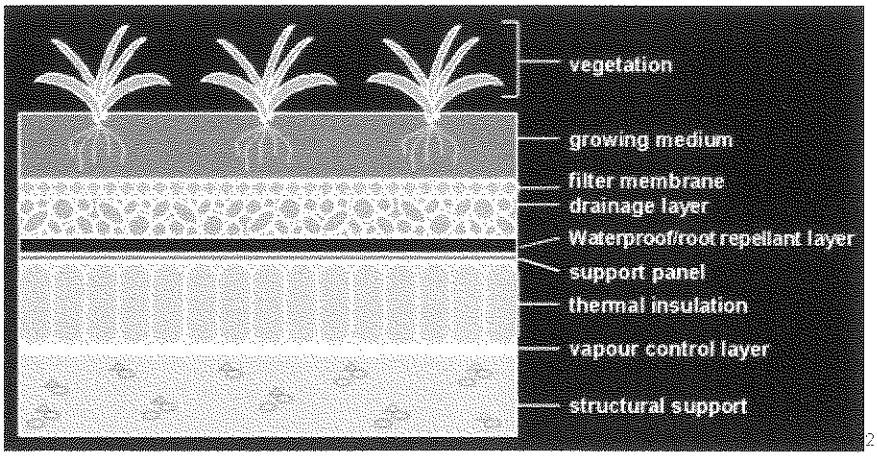
If one were to look at the area surrounding Westminster College, one would find a typical urban setting. The college is directly surrounded by houses, and further out there are local and international businesses. However, more people living in a more condensed area have changed the natural environment. Salt Lake City is like many cities across the world that is experiencing urbanization. Urbanization is defined as the state of taking on city characteristics[1], and essentially more people being in an urban verses rural setting. The term has come to be associated with more grey space, or constructed space, and less green natural space. Westminster College has succeeded in installing various campus gardens to restore part of the natural environment, however more can be done. Other collegiate campuses, like Columbia University and Michigan State University, have studied live roofs or green roofs and their relation to offsetting carbon dioxide and providing a natural irrigation system. Their results, along with other research, have shown that green roofs can help offset the environmental degradation that is caused from urbanization.

The Environmental Studies Department has awarded me with the opportunity to do such research with direct relationship to the Westminster Campus. My goal is that one day a student, staff member, or professor will be able to take my research and install a green roof on Westminster College's campus.

Green Roof Basics

Green roofs, also termed live roofs, eco- roofs or garden roofs, use live vegetation to improve the traditional man made roof. These roofs remove the necessity of the outer layers of a traditional roof system, like the bare membrane, the gravel ballast, or the shingles and tiles and instead require new exterior layers such as a drainage system, a medium that plants can grow in, and the plants. A typical green roof will have the components outlined in the diagram below.

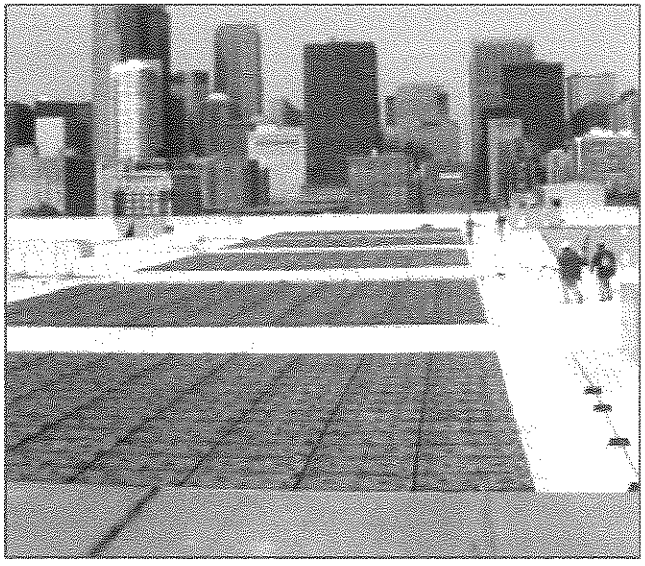
[1] "Urbanization - Definition and More from the Free Merriam-Webster Dictionary." *Dictionary and Thesaurus - Merriam-Webster Online*. Merriam-Webster, Incorporated, 2011. Web. 10 Aug. 2011. <http://www.merriam-webster.com/dictionary/urbanization>



[2]

Types of Green Roofs

There are two overarching types of green roofs: extensive and intensive. An extensive roof is more of an 'eco-roof'. It contains less and thinner layers making it lighter and less expensive, and it requires less maintenance. These roofs do best with limited human access and only increase the weight tolerance by 10- 50 lbs/square feet. The typical plants on an extensive roof include sedums, flowering herbs, and grasses. An intensive roof looks more like a garden, as the multiple and thicker media layers can support traditional plants. These roofs can become costly and maintenance intensive depending on the design of the plants. These roofs generally are accessible to humans and the structure should be able to hold between 80-120 lbs/ square feet of additional weight.


[3]

Extensive Green Roof

[2] "Principal Green Roof Technology Components." *Green Roofs for Healthy Cities*. Ed. National Research Council, Institute for Research in Construction. 8 Dec. 2009. Web. 10 Aug. 2011. <http://greenroofs.org/index.php/about-green-roofs>.

[3] School of Fresh Water Sciences. "Great Lakes WATER Institute Green Roof Project." *School of Fresh Water Sciences*. University of Wisconsin-Milwaukee. Web. 11 Aug. 2011. <http://www.glwi.freshwater.uwm.edu/research/genomics/ecoli/greenroof/roofinstall.php>

Additionally, the two types of roofs can be installed with live trays, which range in size and depth to allow the choice of either an extensive or an intensive roof. The trays are a modular design that allow for simple installation, precise architectural design and simple removal if any roof or ceiling damage happens in the future. The trays range from one-inch to eight-inch depth, typically, and require a roof with enough structural integrity to hold 44 lbs/ square feet. Plants are typically grown in the trays at nurseries and then sold to buyers for installation. Many green roofs require a new waterproof layer on the existing roof, and although this step and the installation of the green roof can more than double a roof's life, it may be an expensive step that can be skipped if using the installation trays.

Intensive Green Roof [4]

Students Installing Modular Trays for a Green Roof At University of Connecticut

Based on my research on green roof basics, it first needs to be determined where a green roof is to be installed, what is the load capacity for the roof, what type of plants are suitable for the load capacity and the natural environment, and what benefits are expected of the roof prior to determining which installation method is best.

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[4] School of Fresh Water Sciences. "Great Lakes WATER Institute Green Roof Project." *School of Fresh Water Sciences*. University of Wisconsin-Milwaukee. Web. 11 Aug. 2011. <http://www.glwi.freshwater.uwm.edu/research/genomics/ecoli/greenroof/roofinstall.php>

[5] "University of Connecticut Rooftop Plaza Green Roof." *Green Roofs - GreenGrid® Modular Green Roof, Rooftop Garden, Living Roofs, Sustainable Roofs, Vegetated Roofs*. Sept. 2009. Web. 10 Aug. 2011. <http://www.greengridroofs.com/projects/institutional/projects_uconn-plaza.htm>

Benefits of Greens Roofs

The benefits of a green roof vary based on the type of green roof that is installed. These include extending the life expectancy of the roof, energy savings, natural irrigation, and creating a habitat for migratory birds and insects. Michigan State University has green roof platforms to research plants species, collect water irrigation data, determine green roofs potential to sequester carbon, study the public relations effect of green roofs and to evaluate the difference in heat collection on a normal roof and a green roof[6]. Penn State University has established a green roof test facility to determine the effectiveness of a green roof in cleaning rainwater runoff[7]. Columbia University has installed seven green roofs after studying how green roofs prevent the overflow of untreated sewage, reduce energy costs in heating and cooling the building and purify the air quality[8]..

The purpose of a green roof varies with each location. For instance, in New York, the installation of green roofs focuses on natural storm water management and filtration for water. Other cities that do not have access to natural open spaces are using green roofs for community gardens or park like areas. Germany is using green roof to buffer the sound of air traffic. Although these benefits are all important, Westminster would reap different benefits. With the installation of a green roof, Westminster could begin to offset the transportation carbon dioxide foot print, double the life of a standard roof, mediate the temperatures of a desert environment by breaking up the heat island effect, allow students the opportunity to commit to a more sustainable future, and provide those involved with Westminster and the Sugarhouse areas an aesthetic roof top to admire.

The Environmental Protection Agency describes the heat island effect in the following way:

> The term "heat island" describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C). Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water quality.[9]

The increased temperatures in urban settings have, over 25 years, lead to over 8,000 premature deaths in the United States cities.[10] Additionally, heat island effect can lead to increased energy consumption

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[6] Rowe, Bradley, Jeff Andresen, Rique Campa, Milind Khire, Joanne Westphal, Indrek Wichman, Kristin Getter, Leigh Whittinghill, Erik Cronk, Carly Eakin, Jeremiah Johnson, Kevin Krogulecki, Theresa Miller, and Jeremy Monsma. " Green Roof Research Program." *Michigan State University - Department of Horticulture*. 30 Aug. 2006. Web. 10 Aug. 2011. <http://www.hrt.msu.edu/greenroof/>.

[7] "About the Center." *Center for Green Roof Research at Penn State University*. The College of Agricultural Sciences, 25 July 2006. Web. 10 Aug. 2011. <http://horticulture.psu.edu/cms/greenroofcenter/>

[8] "National Science Foundation Grant Supports Research on Columbia University Green Roofs." *The Earth Institute - Columbia University*. Columbia University, 14 Aug. 2009. Web. 10 Aug. 2011. <http://www.earthinstitute.columbia.edu/articles/view/2522>

[9] "Heat Island Effect." *US Environmental Protection Agency*. Web. 12 Aug. 2011. <http://www.epa.gov/heatisland/>

[10] Center for Disease Control and Prevention. 2006. Extreme Heat: A Prevention Guide to Promote Your Personal Health and Safety

during peak periods of the summer, which leads to increased levels of air pollutants and greenhouse gases and eventually formation of ground level ozone. Concrete pavement and man made roof tops absorb heat and then transfer that heat to storm water. This raises water temperatures, which can stress delicate water ecosystems. Many of these problems are present in Salt Lake City during the summer months.[11]

The following universities have gathered data on the benefits of green roofs.

Michigan State University has complied a list of plants and how to select various species based on the type of medium used to grow the plants, the state in which the plants were studied, and which regions of the United States is recommended for specific species.[12] This information is valuable to companies, universities, and other individuals who are interested in which plants they should install for maximum green roof survival and minimum maintenance.

Columbia University has installed seven green roofs on its campus in New York City and is using two of the roofs to provide data about energy use and storm water run off. They have found that the use of green roofs can decrease exterior building temperatures by 40 degrees in the summer heat and can help insulate the buildings to hold in the heat in the winter. The research also shows that green roof installation on the majority of roofs in New York City can mitigate 40 percent of the city's combined sewage overflows.[13]

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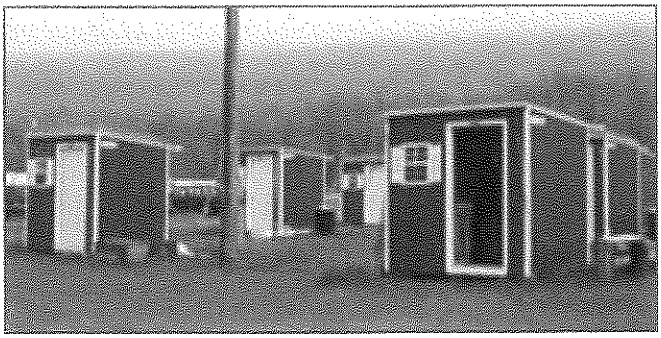
[11] "Heat Island Effect." *US Environmental Protection Agency*. Web. 12 Aug. 2011. <http://www.epa.gov/heatisland/>

[12] Getter, K.L. and D.B. Rowe. 2008. Selecting plants for extensive green roofs in the U.S. Extension Bulletin E-3047, Michigan State University.

[13] Green Roofs Help Keep It Cool « LI-COR Environmental NewsLine." *LI-COR Biosciences*. 5 July 2009. Web. 18 Aug. 2011. <http://www.licor.com/env/newsline/2009/07/green-roofs-help-keep-it-cool-2/>

Penn State University research found that green roofs reduce peak runoff rates acting as a roof top detention basin[14]. Additionally, the research showed that energy used to cool the building at peak summer temperatures reduced 15 units of Kilowatt-hours used per day.[15]



At the onset of researching green roofs, I was hoping to formulate an entire proposal on the size, plants, and type of green roof to off set Westminster College's commuter footprint. Green roofs do have the potential to sequester carbon from non-renewable energy sources. Penn State University and Michigan State University have ongoing research on their simulated green roofs to account for the amount of carbon that is sequestered from various sizes of green roofs and from various species of plants that are grown on green roofs. Westminster College in the fiscal year of '09-'10 contributed 1,694 metric tons of CO2 equivalent from commuters[16]. It would be ideal that adding more green space to the college could compensate this. However, at the sequestration rates established by these universities, it would take over 31,284,714 square feet of intensive green roof area, with trees, to offset all the commuter emissions[17].

Building Criteria for Green Roofs

Westminster College needs to account for the following when installing a green roof. The roof needs to be safely accessible or can easily renovated to be safely accessible. This requirement is for the most obvious reason that people will need to be able to get on the roof to install the green roof and to maintain it in the future. Once a building has been decided on, the next step is to determine how much additional weight the structural integrity of the building can support. Buildings in Utah need to be able to support snow in the winter, and any roof that is proposed to house a green roof needs to be structurally sound for the snow and green roof weight. If no building possesses such qualities, it will need to be determined how much it would cost to retro fit the building and if the price is effective for the potential benefits for the roof.

Additionally, the building that fits into the first two categories needs to be scheduled to remain on campus and not be slated for major renovations or demolitions. However, since green roofs are retro

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[14] Center for Green Roof Research. "Storm Water Quantity." *Department of Horticulture*. Penn State, 2005. Web. 10 Aug. 2011. <http://horticulture.psu.edu/cms/greenroof/?q=node/50>

[15] Beattie, David, Robert Berghage, Albert Jarett, Harvey Manbeck, Jelena Srebric, and Julie DeNardo. "Center for Green Roof Research at Penn State- Slide 30." *Department of Horticulture*. Penn State - Center for Green Roof Research. Web. 10 Aug. 2011. <http://horticulture.psu.edu/cms/greenroofcenter/presentations/epa/psuheatisland.htm>.

[16] Case, Kerry. 10 Aug. 2011 STARS information Interview.

[17] "Tree Benefits Page." *CTC Web Page*. Web. 15 Aug. 2011. <http://www.coloradotrees.org/benefits.htm>

fitted to existing roofs, there is not a specific roof that is required to become a green roof. Any roof base will work because the outer layers are removed and a new waterproof membrane is installed.

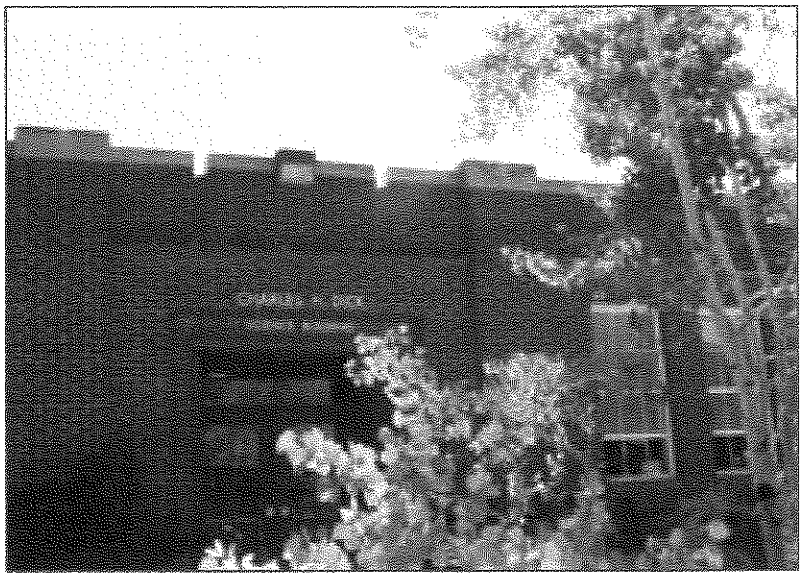
The final proposed criteria is that the roof is visible to the Westminster campus and to its neighbors. One large benefit of a green roof is the aesthetic factor and it would be a shame to waste such benefits. An irrigation system needs to be chosen. An extensive roof will only require a irrigation system for the first two years, and a back up incase of a drought or other issues, while an intensive roof will require more permanent irrigation systems. The type of irrigation system should also be chosen based on the plants desired for the installation.

Proposed Buildings and Roofs on the Westminster Campus

After looking at the building criteria and Westminster Campus' Master Plan, I propose the following buildings for installation of green roof.

Dick

The most prominent feature that the Dick Building has to offer is it is centrally located on campus and people in other buildings on campus see its rooftop. If the aesthetic benefit is one that Westminster College is seeking, then Dick is one of the only options. Dick fits into the criteria explained previously. Dick has rooftop access through a custodial closet, which would need to be secured and expanded if Dick's structural integrity could withhold the additional weight from a green roof. Additionally, Dick is schedule to remain on Westminster Campus without any major renovations in the next 15 years. However, it is slated for a new roof in the next five years. If the college is already being forced to reroof the building, why not pay more of the upfront costs and reroof with a green roof?



Jewett

Although Jewett's roof is not as visible as the other roofs on campus, it is already promoting clean energy with the recent installation of solar panels. Using the roof that is not dedicated to solar panels and filling it with a green roof would make a large statement for Westminster College. Additionally, Jewett has decent roof access via a custodial closet. This hatch would need to be made safe and expanded as well. Like Dick, Jewett will soon need to be reroofed where solar panels are not present. The bid for project is estimated around $52,000. Although there may be weight issues due to the installation of solar panels, a green roof could be installed in the remaining area for the amount of money that it would cost to reroof.

The Garfield School

Although installing a green roof off the main Westminster campus would not provide the campus with aesthetic benefits of the green roof, it would increase the aesthetic appeal of the Garfield School to its neighbors in the Sugarhouse community. The Garfield School has the best roof top access compared to the buildings listed above and it is not on main campus, allowing construction and installation to be done at any time regardless of students needing to get to classes. The Garfield School, since it was recently added to the campus plan, will likely be schedule for drastic remodels or renovations, however this would not be a problem if the green roof was installed after the renovations or after any plans concerning the roof were complete.[18]

Green Roof Process and Budget

The initial costs of a green roof can be more expensive than leaving a traditional roof, however green roofs can increase the lifetime of a roof by double. The initial cost will be hiring a structural engineer to determine which buildings have the structural weight load capacity to support the snow in the winter and the green roof year round. From there, the structural engineer will be able to provide an assessment

[18] Brockmyer, Richard. Interview on 18 July 2011.

that will provide Westminster College with choices of where green roofs could be retro fitted to existing roofs and what type of repairs or structural strengthening needs to be done before the installation. The analysis should provide Westminster College with the choice of the building, the size, and potentially the type of roof that the college can install on its campus.

Next, the college will need to obtain permits for installing and housing a green roof. Most cities are offering incentives for installing green roofs and could be beneficial to the college to seek the permit. However, permits can also limit the type of green roof that is installed. Before Westminster obtains permits, it may be wise that if it is choosing to have companies design, manage and install a green roof that it select the company prior to permit process. However, students can head this venture and they can have a formulated proposal and plan at the time of submitting the request for a permit.

The college at this stage has to determine, if structural analysis and permit does not suggest otherwise, which type of green roof to use. The plants and medium will also need to be determined at this stage. At this point some design, either by an architectural designer or a student collaboration, will need to be formulated to map out the amount of space, how the space will be used, and, if accessible to people, how will they walk through the space.

The following people and processes will need to be accounted for when installing a green roof:

- Structural Analyst's Consultation fee
- Design Consultation fee
- Contractor fees for repairs or improvements prior to installation
- Landscape Design Consultation fee
- Irrigation/ Drainage System
- Permit Fee (or reimbursements)
- Garden material, like plants, growing medium, fertilizers, pavers, etc.
- Initial and ongoing maintenance costs (minimal after two years)
- Contracted assistance growing plants, transporting materials, and installing materials

Costs for an extensive green roof range from an overall cost of 8 to 20 dollars per square foot and intensive range from 15 to 25 per square foot (with more costs of maintenance in the future).[19] If the roof needs to be re-roofed, this can hike prices up to 50 dollars per square foot. [20]

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[19] School of Fresh Water Sciences. "Great Lakes WATER Institute Green Roof Project." *School of Fresh Water Sciences*. University of Wisconsin-Milwaukee. Web. 11 Aug. 2011. <http://www.glwi.freshwater.uwm.edu/research/genomics/ecoli/greenroof/roofinstall.php>

[20] Cutlip, Jamie. *Green Roofs: A Sustainable Technology. Sustainability and the Built Environment*. University of California Davis, Oct. 2006. Web. 10 Aug. 2011. <http://extension.ucdavis.edu/unit/green_building_and_sustainability/pdf/resources/green_roof.pdf>

Student Learning Opportunities

As an environmental senior, I took part in the Environmental Studies senior seminar this past spring. There were 13 students and two professors in the class. The senior project aims at giving students experience in their field since the major does not require an internship. The class went through the process of choosing a topic, researching ideas, presenting projects to the class, determining a project, and then working together, students, faculty and staff, to accomplish the projected goals. Although I gathered valuable information about gardens, their benefits, and different restoration techniques, the truly valuable experience was the interaction between the students, the faculty and the staff. The process of installing and maintaining a green roof would provide students, faculty, and staff with an opportunity to work together and to learn from each other.

The College Wide Learning Goals for Westminster College are as stated:

- Critical, analytical and integrative thinking
- Creative and reflective capacities
- Leadership, collaboration, and teamwork
- Writing and other communication skills
- Global consciousness, social responsibility, and ethical awareness

Installing and maintaining a green roof would achieve all the learning goals, however I believe that the installation and the upkeep of a green roof can establish a permanent collaboration among the students, faculty, and staff. The students and faculty could follow the example of Penn State and Michigan State University to establish a class focused on researching and maintaining the roofs installed on campus. Additionally, with the blessing of funding and cooperation from the college and Environmental Center, leadership roles could be established among the student body to coordinate maintenance plans, ongoing research and lecture series for sustainable buildings and practices. The Environmental Center has established a team to head sustainable transportation, through the campus bike coordinator, and sustainable food, through the garden coordinator. A sustainable building coordinator does not seem out of context.

The second learning goal that would be highlighted is global consciousness and social responsibility. Any step in the sustainable direction and off the path of over consumption is a direction to a well-rounded future. By installing a green roof, Westminster College would be acknowledging some of the real problems of the globe, like climate change, air and water pollution, and the limitations of non-renewable energy. The installation of a green roof will make Westminster College's students, staff, faculty, and neighbors feel as though they have become socially responsible by choosing to be part of a college that cares about the condition of the world in the future. By utilizing the green roof, students and faculty can create roles of collaboration in the installation process, maintenance process, and education process. The green roof will create awareness that the traditions that Americans and many more are becoming accustomed with are not sustainable and at some point, drastic changes will need to be changed.

Recommendations

After reviewing the research from other universities and the buildings at Westminster College I am making the following recommendations. If the building is found to be structurally sound or not too costly to make sound, I recommend installing a green roof on Jewett. The idea of a roof housing both a green roof and solar panels makes such a bold statement to the public. I think that it is important for the first green roof to be installed on Westminster Campus so that students, faculty and staff can help install and maintain the roof. Based on what the building can support, I would recommend installing an extensive green roof so that maintenance in the future would be reduced. I think that it would be wonderful to eventually install an intensive roof on campus that mimics a garden, but the first green roof should grow sedums and native grasses. Another step that I would suggest is installing the green roofs via trays. The trays allow for easy removal if there are ever reasons to access the base layer of the roof and it can create different designs that can help add to the aesthetic factor. All and all any of the buildings suggested could successfully house a green roof, however with the added benefits of solar panels and the estimated cost to re roof the building, I think that Jewett could make the most impact showing the Sugarhouse community of Westminster's efforts to become sustainable.

Initially, I intended to find a way to wholly offset the commuter carbon dioxide emissions through green roofs. As a fellow commuter, I understand that personal transportation is a way of life for American's and it will be a long process to change this custom. However, as an Environmental Studies major, I have found that shrugging our shoulders and saying "oh well" is not the only option. Other options are to take steps to make our impact less, so that when big changes come there is an infrastructure there to support the progress. Why would we, as professional academics, not look into helping the problem instead of just staring at the signs driving down the I-80 canyon about driving less due to poor air conditions? The installation of a green roof will by no means solve all the woes of the world, however it will provide steps forward in becoming a sustainable campus. In addition, other universities have provided the foundation for all other academic institutions with research, data collection, and proving the tangible benefits that green roofs provide to urban areas. I would like to see Westminster College pick up where these colleges have left off and research the carbon sequestration that green roofs can accomplish and then put those roofs into action. I want to see Westminster College lead Salt Lake City to a cleaner, less polluted future.