Green Roofs in the Saratoga Lake Watershed: Sedums of Change

Capstone in Environmental Studies
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Introduction

There are more than 6.8 billion people across the world (U.S. Census Bureau, 2010) and to accommodate this constantly growing number, human built environments are on the rise. In 1950, 30% of the world's population lived in cities. Today, it's 50% and by 2050, 70% of the population will be living in cities (Cedare, 2007). In the United States, almost 80% of people lived in urban areas in 2000 and the buildings that support our population account for 40% of our total energy consumption (EPA, 2010). As these figures grow, urbanites suffer the consequences of environmental, social, and economic issues associated with urban areas. Thus, improving existing and future development of urban areas is imperative to global public health.

Urbanization

The development and infrastructure required to support human populations frequently includes the addition of impermeable surfaces, 66% of which come in the form of parking lots, driveways, roads, and highways (Getter et al., 2007). Rooftops, concrete, asphalt, pavement, and other similar materials also fall under the category of impervious surfaces, meaning they restrict water permeability. Impermeable surfaces are directly related to reduced air and water quality, increased noise pollution, loss of biodiversity, and increased air temperatures, or urban heat islands (Getter et al., 2007). These impacts are a direct result of replacing natural areas with human-built structures. Urban areas contain high concentrations of impervious surfaces, and often result in environmental issues of water quality and quantity, the effects of which are social and economic. (EPA, 2010).

Impermeable surfaces enable and come with large-scale development, but at the cost of the environment. When precipitation cannot infiltrate the ground because of impermeable surfaces, or absorption of water by permeable surfaces reaches a maximum, the water remaining is known as runoff. The USEPA has stated that an average city block produces five times more runoff than a woodlot of equal size (VanWoert et al., 2005). This is due to the alteration of natural settings. Under natural conditions, precipitation infiltrates the ground and becomes ground water, which provides a variety of services to vegetation and ground water aquifers. The soil and root systems found underground also act as a type of filtration system for infiltrating water, removing excess nutrients and pollution. When natural areas are modified by the addition of impervious surfaces, precipitation is prevented from infiltrating the ground, thus becoming runoff. Due to the lack of filtration through soiled, rooted areas, runoff often acquires pollution and excess nutrients as it moves across impermeable surfaces (VanWoert et al., 2005). With its rapid rate of movement, runoff can accumulate in large amounts in a short period of time. Flooding and water quality issues often take place as a result (VanWoert et al., 2005).

All runoff has an ending point. In urbanized areas, most runoff is directed to a drain, which pipes the water to a larger water body or sewage treatment plant. This is a form of stormwater management, or a means for dealing with the physical, environmental, and economic aspects of stormwater. If runoff from developed areas is piped directly into a water body such as a lake, stream, river, or pond, the results can be ecologically damaging. Plants and animals living in these areas are especially vulnerable to poor quality runoff (VanWoert at al., 2005). Pollution and excess nutrients contained within runoff often alter the natural order of the water body, the consequences of which can be cultural eutrophication and loss of biodiversity (EPA, 2008). Non-native species of plants and animals can thrive in polluted waters, leading to the displacement of native species, which play vital roles in ecosystem services and should not be overlooked.

The high concentration of impermeable surfaces associated with urban areas counteracts ecosystem services provided by natural habitats. With a decreased density of plant life, urban areas experience the direct effects of air and water pollution and increased air temperature. Traditionally, solar radiation is either absorbed and converted into usable energy by plant life or absorbed within surface soils. When plants and other ground cover are replaced by darkly colored impervious surfaces, large amounts of heat are absorbed and re-radiated into the surrounding environment, creating urban heat islands. This aspect of urban areas is cause for concern as high temperature episodes have led to more deaths in the United States than lightening, hurricanes, floods, tornadoes, and earthquakes combined (Getter and Rowe, 2006). Although past and current development has created these issues, they don't have to be permanent. Policy makers and advances in technology have the power to bring nature back into urban areas through approaches such as low impact design. Green roofs are an example of low impact design, and are gaining ground as a tool for reducing stormwater runoff, improving air quality, and reducing energy use.

Why Green Roofs?

There are two kinds of vegetative roofs—intensive systems, or rooftop gardens and extensive systems, or green roofs. Roof top gardens (intensive) consist of a thick media depth and wide variety of plants, making the roof top more of a park-type setting (Wark and Wark, 2003). Green roofs (extensive) have a shallower media depth and usually contain one to two plant species (Wark and Wark, 2003). Due to these characteristics, extensive green roofs are more commonly used as an application for thermal and hydrological benefits rather than as a garden type environment, seen with intensive systems (Wark and Wark, 2003). As of June 2008, approximately 8.5 million square feet of green roofs had been or were in the process of being installed in the United States (EPA, 2010). For these reasons, we will focus primarily on extensive green roof systems.

Extensive green roofs have a variety of ecological, environmental, economic, and aesthetic benefits. The most beneficial aspect of green roofs is commonly regarded as the ability to reduce storm water runoff by 60 to 100 percent (Getter et al., 2007). In Toronto, it was estimated that if 6% of all buildings had green roofs, the amount of stormwater retention would be equal to that of building a $60 million storage tunnel (Getter et al., 2007). Across the nation, tens of billions of dollars are spent on treating wet weather flow pollution annually (EPA, 2009). Considering these costs, substantial savings could be achieved by adopting green roofs. Yet, the benefits of green roofs are not limited to runoff reduction.

Green roofs add a significant layer of insulation to the buildings upon which they are installed. In warm climates, green roofs aid in cooling, while in cold climates green roofs act in warming, so temperate regions receive both heating and cooling benefits from green roofs (Sonne, 2006). Heating and cooling assistance by green roofs is reflected in reduced costs of heating and cooling large buildings and decreased emissions of carbon dioxide (Getter et al., 2009). Green roof installation is only about $10 to $25 per square foot or more (Rosenzweig et al., 2006). With less than $1.50 in annual maintenance (per square foot), a 21,000 square foot green roof would save $200,000 in thermal insulation (EPA, 2010). Buildings that integrate solar panels receive greater efficiency of energy production due to the reduced surface temperature of building roofs (The World Green Roof Infrastructure Project, 2008).

Related to heating and cooling benefits, green roofs reduce a phenomenon known as “the heat island effect” (The World Green Roof Infrastructure Network, 2008). Again, due to high concentrations of darkly colored impervious surfaces, and loss of soil and vegetation, urban areas are often much warmer than rural areas, a potential difference of up to 42 degrees Fahrenheit (Getter and Rowe, 2006). Warm urban surfaces raise the temperature of runoff, increasing its impact on the water body to which it flows (EPA, 2009). Additionally, increased temperatures result in higher energy consumption for cooling, which leads to higher emissions and reduced air quality, further compromising human health (EPA, 2009).

Due to the energy intensity and high emissions of urban settings, air quality is a common issue. Carbon dioxide emissions are the primary cause for concern due to the impending threat of climate change. Burning fossil fuels releases carbon dioxide. Plants require carbon dioxide during the process of photosynthesis. If extensive and intensive roof systems were to be adopted on a large scale in urban areas, they could significantly reduce the concentration of carbon dioxide in the surrounding atmosphere (Getter at al., 2009). For example, Getter et al. estimated that if the city of Detroit converted its commercial and industrial roof tops to vegetated systems, the benefits would be equal to that of removing 10,000 mid-sized SUV's from the road for one year (Getter et al., 2009). In addition, these green roofs would be able to sequester the "carbon cost" of the materials from which they were constructed within roughly nine years of being established (Getter et al., 2009).

Carbon sequestration is not directly experienced by urbanites, but green roofs offer a variety of other advantages to city-living. Many studies show that green roofs increase the longevity of the average rooftop, reducing overall maintenance costs (VanWoert et al., 2005). Additionally, green roofs have demonstrated greater resistance to fire than that of the typical roof (Oberndorfer et al., 2007). Similar to the way in which green roofs provide thermal insulation, they can also reduce issues of noise pollution, which is especially common in cities (Oberndorfer et al., 2007). Finally, the habitats provided by green roofs increase urban biodiversity by creating wildlife refuges (Oberndorfer et al., 2007). This aspect of green roofs in particular offers people more aesthetically pleasing working and living environments. In fact, studies have shown that views incorporating nature lead to lowered blood pressure, reduced stress, released muscle tension, and increased positivity, all directly improving health and productivity (Getter and Rowe, 2006). Even with the exceeding and multidimensional benefits of green roofs, wide-scale implementation is largely determined by regional characteristics and feasibility to existing infrastructure and regulations.

The Saratoga Lake Watershed

There may be great potential for green roofs throughout the Saratoga Lake Watershed, which covers an area of 244 square miles that includes part or portions of 12 municipalities, including Saratoga Springs (US Census Bureau, 2010). Over the past 20 years, Saratoga County has been the fastest growing county in Upstate New York with a total population growth of 30.5% (US Census Bureau, 2010). Saratoga County is expected to grow by an additional 58,000 people by 2040 (Saratoga County Board of Supervisors, 2006).

Population growth has caused a large increase in the amount of impervious surfaces (built environment) throughout the watershed. At and around Skidmore College, this issue is magnified because its surficial geology is primarily composed of impermeable bedrock (Gibson, 2009). As a result, surface water, especially runoff, has become the primary source of inflowing water to the lake, meaning higher levels of pollution. The same case might be true for the Wilton Business District area if it were not located on highly permeable sands, meaning runoff becomes integrated into groundwater aquifers (Gibson, 2009). Past studies of impermeable surfaces have found water quality degradation can occur with as little as 7-15% impervious surface cover, corresponding to 20-30% urban land use (Barbec et al., 2002). A 2002 surface mapping of the watershed found the average percent of imperious surface cover throughout the watershed to be 6.1% (www.sara-lake.org, 2010).

All direct sources of pollution into waterways began to be regulated on a federal, state, and local basis since the Clean Water Act (CWA), passed in 1972 (EPA, 2009). In response to requirements of the CWA, the EPA mandated that large cities develop a storm water management program. These programs were called Municipal Separate Storm Sewer Systems (MS4s) and were comprised of a system of grates, pipes, and drainage ditches. These systems were constructed to carry runoff away from roads and ultimately back into waterways, usually without treatment (EPA, 2009). The EPA approved a more in-depth statewide program for New York State known as the State Pollutant Discharge Elimination System (SPDES), which controls point source discharges to groundwater as well as surface waters.

In 2003, Saratoga Springs became regulated under the first stages of Phase II of the SPDES program and was required to purchase MS4 permits (www.dec.ny.gov, 2010). Along with the permits, Saratoga County was required to develop a Storm Water Management Program. The Saratoga County Inter-Municipal Storm Water Management Program (SCIMSMP) was created to educate the public on how to take care of the watershed. The proposed strategy by the SCIMSMP is a Best Management Practice (BMP) strategy that includes a permitting process, post construction standards, illicit discharge monitoring and a public education and awareness campaign. While the proposed BMP strategy supports the implementation of green roofs, the individual municipalities within the watershed are still developing the official implementation programs that will regulate storm water pollution within the watershed (www.saratogastormwater.org, 2010).

While the current major incentives for green roof installation are limited to larger cities, municipalities within the Saratoga Lake Watershed may be regulated to include green roofs, or other low impact design in the near future. An increasing number of studies are emerging that list the many cost-effect aspects of green roofs that have previously been overlooked. This combined with the many ecosystem services green roofs have to offer, make them the emerging solution to negating the detrimental impacts of urbanization.

This project will investigate the perceived major obstacles to implementing green roofs in the watershed and evaluate the numerous ecosystem services green roofs have to offer. By creating a model for green roofs in the Wilton Business District and Skidmore College and by conducting a series of interviews, this study aims to encourage stakeholders to both consider retrofitting current structures and incorporate green roofs into future development practices within the watershed. Skidmore, as an institute of higher education, and the Wilton Business District, as a representative of commercial suburban America, both have potential in furthering the growth and awareness of green roofs, regionally and nationally.

Methods

The methods of this project are based on the methods from a previous capstone, "The Current Stormwater Management Infrastructure in Saratoga Springs, New York and the Challenges of Implementing Low Impact Alternatives" (Ruschp et al., 2009). We researched the current policies developed to manage stormwater in Saratoga Springs, specifically how these policies are formed and enforced. We conducted a series of semi-structured, open-ended interviews with various stakeholders within the watershed. These interviews were performed: to gain a more complete understanding of current stormwater management in the watershed; to identify the perceived physical, political, and economic obstacles and benefits to applying green roofs on the Skidmore College campus and in the Wilton Business District; and to learn more about the benefits of green roofs (Ruschp et al., 2009). These interviews were carried out with the following people and organizations:

- Blue Neils, Saratoga County Intermunicipal Stormwater Coordinator
- Keith Manz, Director of Engineering and Planning for Wilton
- Kate Maynard, Principle Planner for Saratoga Springs City Planning
- Charles Ferguson, Macerich Design, Wilton Mall Property Manager
- James A. Edgar Company, Wilton Mall Roof Company
- Paul Lundberg, Project manager, Facilities Services, Skidmore College

The questions for each interview can be found in Appendix I.

In addition to interviews, we created two theoretical case studies of applying green roofs to the Wilton Business District and Skidmore College. We measured the spatial area of commercial roofs using GIS (geographic information systems) and estimated the potential for: carbon sequestration, economic savings in heating and cooling, and stormwater retention. Using a common industry procedure, we took 65% of the total flat roof area collected in the GIS mapping. This was done to account for the fact that green roofs cannot take up 100% of each roof because of space required for vents, skylights, drains, etc. We then applied the methods from (Getter et al. 2009) to calculate carbon sequestration, (Getter et al. 2007) to calculate stormwater retention, and (Lui et al. 2003) to calculate energy and heating savings.

Carbon Sequestration

Getter et al. 2009, found that an extensive green roof with a growing substrate depth of 6 cm could sequester 6.6 kg of Carbon per square meter. To calculate total potential carbon sequestration, we multiplied our 65% area by 6.6 kg. We then converted kilograms to pounds. Getter et al. 2009 collected this data over a two year period, so we divided the total pounds by two in order to get an annual value for carbon sequestration. We then converted total pounds of sequestered carbon into cars worth of carbon. Based on an Environmental Protection Agency (EPA) study, the average American car drives 15,000 miles a year and gets 25 miles to the gallon (EPA/DOE, 2010). We also found that a gallon of unleaded gas produces 19.8 pounds of carbon dioxide, when burned by the average combustion of light trucks and passenger cars combined (EPA/DOE, 2010). To calculate how much carbon the average car produces per year, we took average mileage and divided it by the average miles per gallon, then multiplied that by 19.8 pounds of carbon dioxide. We then divided the total amount of sequestered carbon by the annual emission of an average car to determine how many cars worth of carbon the two models could sequester.

Stormwater Retention

Getter et al. 2007, found that an extensive green roof with a growing substrate depth of 6 cm and a 2% slope would retain 85.2% of all liquid precipitation events. Using data collected from the U.S. Geological Survey website, we found the average annual precipitation levels for our two models (USGS, 2011). Using a United States Geological Survey study, we found that an acre of land receives 27,154 gallons of water from an inch of rain (USGS, 2011). We calculated total gallons per acre by multiplying 85.2% of the annual precipitation by 27,154 gallons. We then converted the 65% of roof area from square meters to acres. We calculated the total gallons of water retained by multiplying the value for gallons per acre by total acres. We then converted total gallons of water retained into number of Olympic sized swimming pools retained. We found that there are 660,430 gallons of water in an Olympic sized swimming pool (www.dimensionsguide.com). We then divided total gallons of water by 660,430 to convert the total volume of retained water into Olympic swimming pools.

Energy Savings

The original objective of this section of our methods was to determine the energy savings of our green roof models, using examples from Lui et al. 2003. Through extensive researching for examples of energy savings and communication with architect firms, we realized that if we could calculate any kind of energy and financial savings, they would likely be inaccurate. This was realized due to the lack of uniformity among limited examples of energy reductions. Instead, we used our research to highlight exactly why determining energy savings is so difficult.

Results

Interviews

The primary perceived obstacles to implementing green roofs at Skidmore College and the Wilton Business District include high installation costs, lack of awareness and education, long term maintenance concerns, and comparability with existing structures. None of the interviewees view green roofs as cost-effective applications. As a roofing company representative explained, "We'd all like to do it if we had endless amounts of money. The reality of it is, this black stuff over here [conventional roof], it works. It's one-third the cost." In addition to installation fees being too high, they believe there is a significant void in the availability of information regarding the payback period and long term benefits of green roofs. A project manager described, "I don't think anybody understands enough about it to feel comfortable even giving it a lot of consideration." In regards to maintenance, most interviewees were unsure about the upkeep associated with green roofs. They discussed that maintenance could be demanding and costly, especially regarding leak repair. There was also wide spread apprehension about green roofs being established on pre-existing buildings. They believe that older buildings might not be able to support the weight of a green roof, especially with added rain and snow loads.

Limited knowledge of green roofs was also seen to be an obstacle. Although most of the interviewees had a general idea of what green roofs are, no one had a complete understanding of their benefits. A few subjects explained that their training neglected the topic entirely, while a few others were supplied only minimal understanding of green roofs in their training. Those who exhibited the greatest knowledge of green roofs did not attribute their comprehension to their education, training, or any other particular source. Exposure to information about green roofs appeared to correlate with the relevance of green roofs to the interviewees' particular professions.

All interviewees agreed that green roofs are good for the environment, at some level. A national development firm property manager and a commercial roofing company were confident that green roofs are environmentally advantageous, but did not delve into further detail. A city engineer perceived green roofs to be especially useful as a tool for stormwater management, the urban heat island effect, and improving urban aesthetics. A project manager expressed the same perceptions in addition to aiding building cooling and the use of green roofs as an example for higher education. A town director of planning and engineering viewed green roofs as a means for reducing runoff volume and temperature, relieving nutrient loading in water bodies, and especially effective for large commercial structures. A city stormwater coordinator explained a variety of benefits including stormwater management, urban heat island effect, aesthetics, and energy savings through building cooling. All subjects believe that green roofs will become more widely used when there are more examples of successful green roofs for people to look to. Once this happens, they explained, people will be able to develop a better understanding of exactly why green roofs are beneficial.

Models

At Skidmore College, the total area of flat roofs is 46,439 square meters (Table 1) (Figure 2). With a conservative estimate of 65% of this area available for installing green roofs, the total area becomes 30,185 square meters (Table 1). With a roof slope of 2% and 85.2% of total annual precipitation retained (Getter et al., 2007), Skidmore's green roofs would hold 7,495,047 gallons of water annually, or 11 Olympic sized pools (Table 1). The carbon sequestration potential of our green roof models is 6.6 kg of carbon per square meter, every two years (Getter et al., 2009). Total carbon sequestration for the Skidmore model is therefore 219,143 pounds annually, the equivalent to taking 18 cars off the road (Green University, 2011) (Table 1). At $45 per square meter, the fee of green roofs for Skidmore College totals $1,358,325 (Table 1).

In the Wilton Business District, the total area of flat roofs in 227,995 square meters, with 148,197 square meters available for green roofs (Table 1) (Figure 2). Again, with a slope of 2% and 85.2% of annual precipitation retained (Getter et al., 2007), Wilton's green roofs would take up 38,997,970 gallons of water annually, or 59 Olympic sized swimming pools (Table 1). Carbon sequestration of the roofs would total 1,075,910 pounds annually, the equivalent to taking 90 cars off the road (Table 1). To reap the benefits of this model, the Wilton Business District would have to pay $6,668,865 in installation costs, at $45 per square meter (Table 1).

In attempt to resolve energy and financial savings of our green roof models, we found that installation costs, maintenance, and building characteristics all vary considerably, creating inconsistencies in energy and economic savings. Green roof websites list installation costs ranging from $9 to $25 per square foot, $15 when averaged from three different sources (Great

Lakes Water Institute, Greenroofs.com, Green-Buildings.com). This range is attributable to differences in fees established by green roof installation companies, area of the green roof system, and characteristics of the roof (plant composition, soil depth, etc.). The cost of maintenance fluctuates on both a short term and long term basis. Being most demanding within the first year of installation, maintenance is initially focused on general inspections and ensuring proper functioning of the green roof (Great Lakes water Institute). Yet, over the remainder of the green roof's life, maintenance can be relatively minimal and is primarily concerned with the roof membrane. Adding an additional layer of protection, green roofs actually extend the life of the roof membrane by two or even three times that of the conventional roof by reducing UV ray deterioration and frequency of leaks (Roofscapes Inc, 2011). Realizing these benefits, some roofing companies have even decided to extend warranties for buildings which utilize green roofs. The third complicating factor in determining savings involves energy use, which is further explained in the discussion.

	Skidmore College	Wilton Business District
Total Flat Roof Area (square meters)	46,439	227,995
Green Roof Area (square meters)	30,185	148,197
Stormwater Retention (gallons annually)	7, 495,047	38,997,970
Olympic sized pools annually	11	59
Carbon Sequestration (pounds annually)	219,143	1,075,910
Cars off the road	18	90
Total Installation Cost	$1,358,325	$6,668,865

Table 1: Summary of Skidmore and Wilton green roof models. Total roof area, potential area for green roofs and resulting stormwater and carbon savings, with included installation cost.

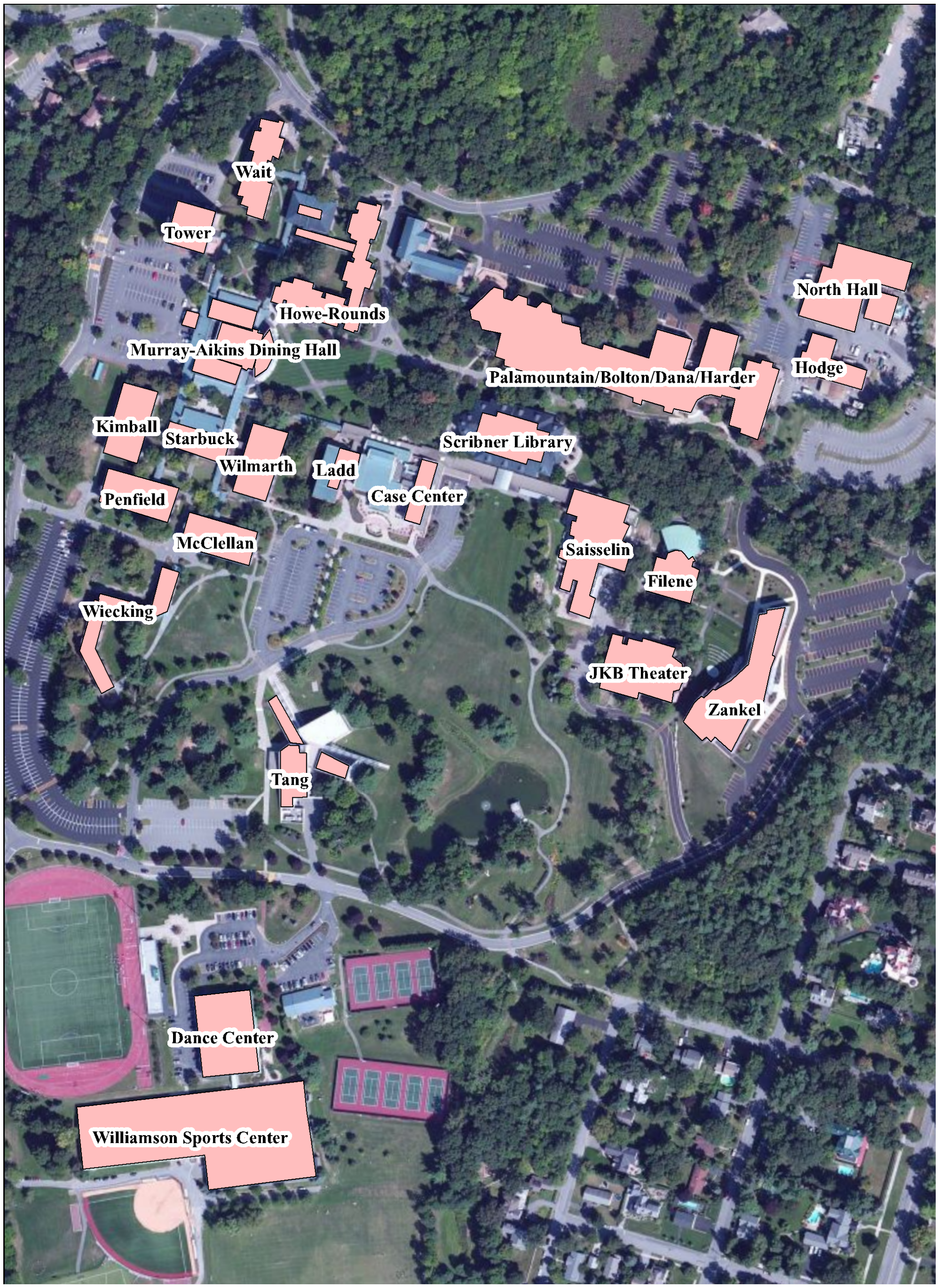

Figure 1: Skidmore College and 100% of flat roof area.

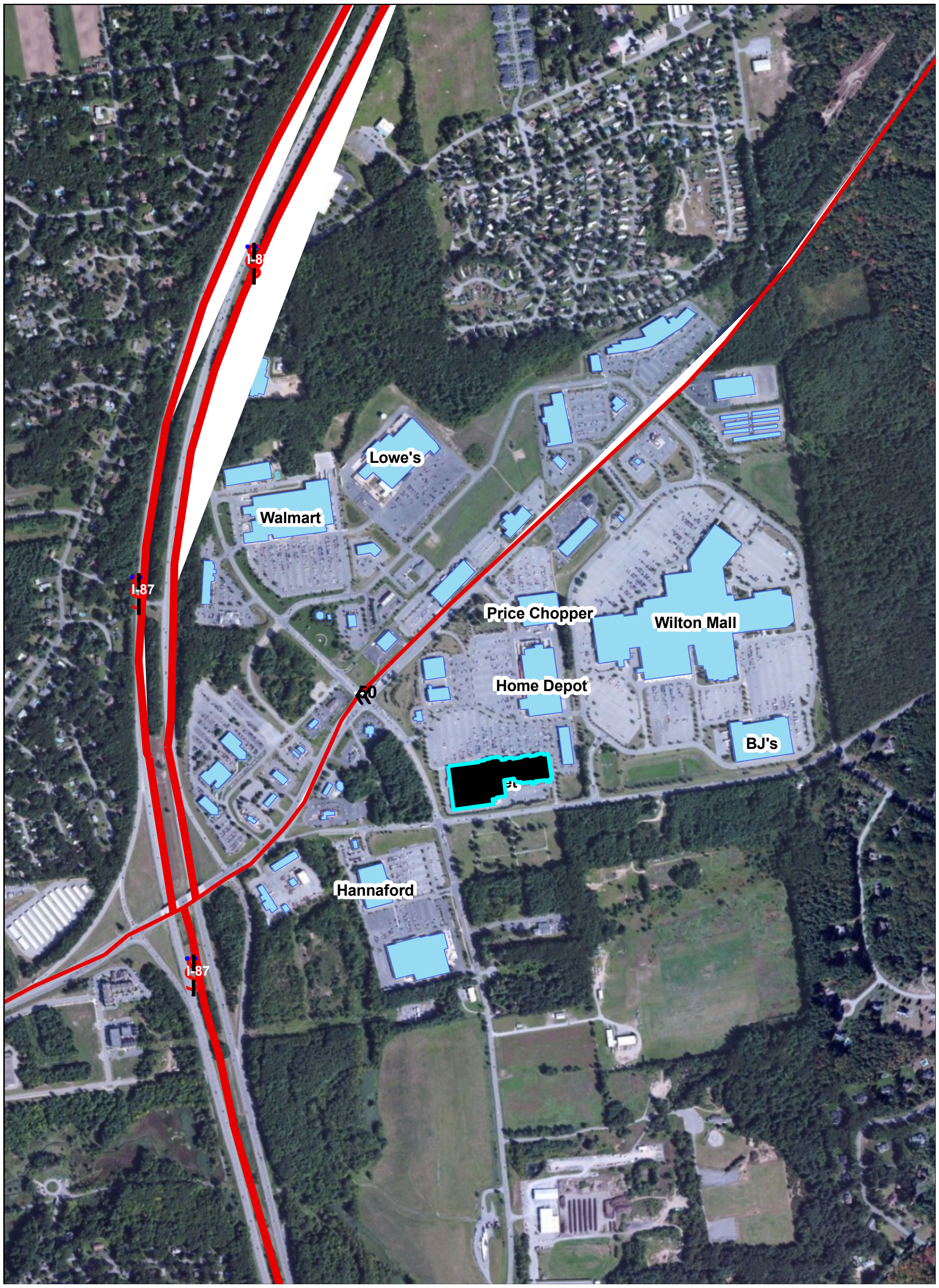

Figure 2: Wilton Business District and 100% of roof area.

Discussion

The current industry stigma pertaining to green roofs can currently be explained by a lack of education and a misunderstanding of initial costs and economic benefits. When asked about the perceived benefits of green roofs, all of the interviewees acknowledged that green roofs carry the reputation of being good for the environment. However, when requested to further elaborate on specific benefits, a few interviewees were unable to do so. The interviewees were individuals whose vocations could be related to green roofs and even they experienced a lack of information and education surrounding green roofs. This discrepancy is not a reflection of the intelligence or environmental concern of the interviewees, but instead represents the current lack of information regarding green roofs on a national scale.

Almost all interviewees agreed that green roofs are simply not understood on a large scale. In the United States, there are few examples of green roofs for people to look to. The most successful areas of green roofs include Chicago, New York City, and Detroit, but these cases are dwarfed by applications in places like Toronto and Germany. For Skidmore College and the Wilton Business District, there is little comparability or opportunity for such areas to relate to. As the Saratoga City Engineer pointed out, people don't see green roofs unless they have a pent house apartment or happen to take a helicopter ride over a city. Potentially, this is a major point of disengagement and reason for the limited amount of knowledge and awareness of green roofs.

Although there was a lack of overall knowledge surrounding green roofs, all of the interviewees stated that they expect to see a growth in green roofs as an industry. Some believed this growth will come from increased education, increased environmental consciousness and others believe it will come from enforced regulations. Before this growth can occur on a large scale, the most prominent obstruction surrounding green roofs must be overcome.

When asked about the current perceived obstacles that hinder green roof implementation, all of the interviewees responded with cost and maintenance. There is a current misunderstanding regarding initial overheads and the economic benefits of green roofs. Concerns for installation costs are somewhat validated, initially, but over the long-term, green roofs pay back and begin to accumulate energy and financial savings. The estimated cost of installing a standard industrial roof is $9 per square foot whereas an estimate from green roof manufactures range from $10 to $25 per square foot or more (Rosenzweig et al., 2006). If investors were willing to look beyond the initial costs, they would see that the net present value (NPV) analysis, comparing a conventional roof to an extensive green roof system over 40 years, actually demonstrates a 20.3% to 25.2% decrease in costs (Clark et al., 2008). The initial upfront cost is recovered when the conventional roof is replaced.

According to data from the Means Construction Cost Data, a traditional roof has an effective 20-year life before replacement, whereas green roofs are projected to last for 40 years (Carter et al., 2008). Green roofs last longer than traditional roofs because the vegetation protects the roof membrane from direct ultraviolet exposure and reduces the daily heat fluctuations experienced by roofs during the summer months. Heat aging at 70°C is commonly used in the roofing industry as an accelerated aging test (Sidwell et al, 2008). In a study conducted by Liu (2003), the membrane of the reference (traditional) roof exceeded 70°C (158°F) during the summer, while the membrane under the green roof only reached around 30°C (86°F). Despite the seemingly high cost of installation, green roofs reduce energy demands, which translate into economic savings, both of which reach full potential within six years of establishment (Getter et al, 2009).

There is a common misconception that green roofs must be maintenance intensive because they contain soil, living plants, and with precipitation could result in substantial leaks. Contrary to these beliefs, the most intensive maintenance is required within 6 to 12 months of the installation period and is provided by the installers (Urban Design Tools, 2007). Frequently perceived as a major issue, the maintenance of extensive green roofs is actually associated with minimal requirements and can even prolong the conventional roof by at least 20 years (Urban Design Tools, 2007). Beyond this time, weeding and watering on a seasonal basis and an annual roof inspection is enough to sustain the system (Great Lakes Water Institute) (Getter and Rowe, 2006). Additionally, because extensive green roofs are composed of only a few sedum species, which are able to withstand inclement weather and drought, and soils are contained to the roof barriers, there are few maintenance concerns related to the living areas of the roofs (Getter and Rowe, 2006).

Already existing buildings may have been constructed differently than newer buildings, but in a temperate climate, both old and new buildings should be able to withstand the weight of extensive green roofs. As Blue Neils, stormwater coordinator of Saratoga Springs explained, roofs of all buildings in temperate regions are designed to hold significant snow loads, especially newer structures. With an additional 30 pounds per square meter of fully saturated green roof, the design of the roof should not be under jeopardy (Alive Structures, 2011). In the unlikely chance of leakage, Blue Neils explained, the leak would be traced to its source in the same manner as a conventional roof. The difficulty is going underneath the green roof to repair the leak, which is an annoyance for roofers, James Edgar Roofing explained.

Due to the seemingly expensive initial costs of green roofs, there are only a few cities that are trying to implement large-scale green roof programs. The three largest proponents of green roof implementation in the United States are Washington D.C., New York City, and Chicago. A 2010 study in Washington D.C. found that while the individual building roof replacement determines the output of NPV, at the city scale, the infrastructure and emission benefits augment the NPV. When implemented on a citywide scale, the break-even point for green roof instillation in Washington D.C. would be seven years (Hao, Niu, et al., 2010). Inspired by Chicago, New York City implemented a project in June of 2008 to help with the installation costs of green roofs. The New York program offsets $4.50 in property taxes for each square foot of green roof installed for a year, and is also capped at $100,000 per project (Environmental Building News, 2008).

The City of Chicago is currently leading the US in green roof policies. In 2001, the city passed the Energy Conservation Code, which required all new and retrofit roofs to meet a minimum standard of 0.25 reflectance for solar reflectivity (Lawlor et al., 2006). In 2003, the city implemented the Building Green/Green Roof policy. In this policy, the city offered tax bonuses to new building projects that had a minimum of 185.8 m2 (2,000 sq. ft.), or at least 50% of the roof surface area covered in vegetation. As a result of these programs, Chicago currently has more than 92,903 m2 (one million sq. ft.) of green roofs within the city limits (Lawlor et al., 2006). In June of 2006, the city of Chicago established the Green Roof Improvement Fund. This fund matches the investments, up to $100,000 per project, made by building owners to retrofit downtown buildings with green roofs (Environmental Building News, 2006).

While these programs encourage large corporations to install green roofs, the residential sector is currently left out of the policy. Residents of Munster Germany are currently charged a storm water fee of 0.44 Euros per meter squared/year, based on the amount of impervious surface area on their property. However, if the resident installs a green roof on a majority of their impervious surface area, the fee is reduced by 80% to 0.09 per meter squared/year (Lawlor et al., 2006). Presently, the largest deterrent for people to install green roofs is the initial installation costs. If a residential policy, like the one found in Munster, was implemented in the United States, the market for green roofs would increase and the initial installation cost would decline. This could open the door for more wide spread residential installations.

On March 1, 2011, the standards set in the New York State Stormwater Management Design manual went into effect. This manual is a key component of the Phase II State Pollution Discharge Elimination System (SPDES) general permit for stormwater from construction activities from all sizes of disturbance (www.dec.ny.gov 2010). The manual claims it has three purposes:

1. To protect the waters of the State of New York from the adverse impacts of urban stormwater runoff

2. To provide design standards on the most effective stormwater management approaches including:

- Incorporation of green infrastructure achieved by infiltration, groundwater recharge, reuse, recycle, evaporation/evapotranspiration through the use of green infrastructure techniques as a standard practice
- Design and implementation of standard stormwater management practices (SMPs)
- Implementation of a good operation, inspection, and maintenance program

3. To improve the quality of green infrastructure and SMPs constructed in the State, specifically in regard to their performance, longevity, safety, ease of maintenance, community acceptance and environmental benefit (www.dec.ny.gov, 2010).

The second bullet point is especially important because it transforms the best management practices (BMPs) from the 2003 regulations to standard stormwater management practices (SMPs). Unlike BMPs, which were often very vague and loosely regulated, SMPs are very specific and require permits. SMPs are much more structured than BMPs and will hopefully decrease the negative environmental impacts of new development. Green roofs are included in this manual as an SMP for reducing the amount of impervious cover. Chapter 5, subsection 3.8 is the section of the manual concerning Green Roofs. This subchapter gives background information about what a green roof is and how it works. It also lists the environmental, economic, and social benefits of green roofs and gives sizing and design criteria for implementing green roof SMPs.

Although the inclusion of green roofs in this guide will greatly spread the credibility of green roofs as a stormwater management tool, the energy savings of green roofs should become a significant force in the expansion of the industry. In 2008, New York State passed an incentive which agrees to cover 25% of the costs of labor, materials, and installation of a green roof. Although this is only applicable for buildings in cities of one million or more people, it also offers eligibility for up to $100,000 in property tax credits if the roof includes at least two inches of soil and covers at least 50% of the roof (Green Roofs for Healthy Cities, 2008). As building owners decide to take advantage of incentives such as this one, the energy savings of green roofs will supplement and perhaps even take over their regards as being useful for storm water management. With more installations and examples of their many benefits, green roofs should be expected to become a more widely used technology in the United States and globally.

The following links provide information about green roofs, including a general explanation up to details for those interested in installing a green roof:

http://www.roofmeadow.com/faqs/faqs.php

http://www.greenroofs.com/

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Appendix I, Interviews:

Blue Neils (Saratoga County Intermunicipal Stormwater Coordinator)

1. Current storm water techniques are not solving storm water issues within the watershed. Are efforts moving forward to adopt additional techniques, or are solutions at a standstill?
2. What are your views on green roofs in general and as an approach to storm water management?
3. Do you believe that green roofs could be a successful technique to managing storm water and other environmental issues in the Saratoga Lake watershed?
4. Where are the current "hot spots" within the Saratoga Lake Watershed that discharge the most stormwater?
5. How big of a threat is stormwater to the overall health of the water bodies within the Saratoga Lake Watershed?

6. How realistic is the idea of a residential and commercial impervious surface tax within the Saratoga Lake Watershed?

Keith Manz (Director of Engineering and Planning for Wilton):
1. What are your perceptions of green roofs?
2. What do you see as the potential benefits of green roofs?
3. Are green roofs a possibility for the businesses of the Wilton Mall and the surrounding development?
4. If not, or if so, what do you see as the major obstacles to implementing green roofs?
5. Do you think these obstacles will be overcome?
6. Who is responsible for deciding whether or not green roofs will be utilized?
7. Do you know of any incentive and/ or education programs to encourage green roof installation?
8. What are some of the standard energy outputs of commercial buildings in the Wilton mall area?

Kate Maynard (Principle Planner for Saratoga Springs City Planning)
1. What are your perceptions of green roofs?
2. What do you see as the potential benefits of green roofs?
3. Are green roofs a possibility for the businesses within Saratoga Springs?
4. If not, or if so, what do you see as the major obstacles to implementing green roofs?
5. Do you think these obstacles will be overcome?
6. Who is responsible for deciding whether or not green roofs will be utilized?
7. Do you know of any incentive and/ or education programs to encourage green roof installation?

Charles Ferguson (Macerich Design)
1. What are your perceptions of green roofs?
2. What do you see as the primary obstacles to implementing green roofs on a commercial scale?
3. What do you see as the potential benefits of green roofs?
4. Do you think other developers share your views and are there discussion of green roofs at the various conferences and gatherings you attend?
5. Do you know of other developers who are employing green roof technology? If so, what do you hear from them?
6. Who is responsible for deciding whether or not green roofs will be utilized?
7. Do you know of any incentive and/or education programs to encourage green roof installation?
8. Do you have any leaseholders who ask you about green roofs or other low impact design features?

James Edgar (Wilton Mall roofing)
1. What are your perceptions of green roofs?
2. What do you see as the potential benefits of green roofs?
3. Are green roofs a possibility for the roof of the Wilton Mall?
4. Why or why not?
5. Who is responsible for deciding whether or not green roofs will be utilized?

6. In your opinion, do these issues constitute the major obstacles to implementing green roofs on commercial buildings in Wilton?

Paul Lundberg (Project Manager, Skidmore College)
1. What is limiting Skidmore from installing green roofs?
2. Beyond the recently added rain garden, what are Skidmore's current approaches to managing storm water and reducing the energy consumption of heating and cooling?
3. Do you believe that Skidmore's campus influences projects throughout Saratoga? For example, if Skidmore were to install a green roof, do you think this would encourage others to consider green roofs?
4. What is the story behind the small patch of gravel on the small roof on the loading dock next to the library?
5. Are there any plans to incorporate green roofs in the proposed 50-year development plan?
6. Green roofs act as excellent thermal insulators, has Skidmore ever considered green roofs as a tool for reducing their carbon footprint?
6. Mild flooding is already an issue within Scribner Village and will only get worse with the new development plans. Are there any proposed ideas to help regulate storm water within the new development?
7. When the rain garden was installed in 2008, two green roofs were constructed on either side of the library. How was this project achieved and how realistic would it be to build off of this project in the future?

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