RCP–Minnetonka
Green Roofs Report

Prepared by

Patrick Ewing, Nadine Habeel, Chris Swanson, Babina Tuladhar,
Elizabeth Appleby, and Kadence Hampton

AGRO 5321: Ecology of Agricultural Systems
College of Food, Agricultural, and Natural Resource Sciences
Instructor: Nick Jordan
and
PA 5242: Environmental Planning, Policy, and Decision Making
Humphrey School of Public Affairs
Instructor: Carissa Schively Slotterback

Edited by

Chris Swanson

On behalf of

Jo Colleran, Natural Resources Manager, City of Minnetonka

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Resilient Communities Project
University of Minnesota
330 HHHSPA
301—19th Avenue South
Minneapolis, Minnesota 55455
Phone: (612) 625-7501
E-mail: rcp@umn.edu
Web site: http://www.rcp.umn.edu

Introduction

Residents of the City of Minnetonka take pride in the quality of their city, particularly its natural resources, and are becoming ever more conscious of their environmental impacts. As part of its partnership with the University of Minnesota through the Resilient Communities Project (RCP), the City has been exploring various strategies for improving the livability of the city for its residents, responding to changing demographic trends in the area, and developing a more environmentally sustainable that will be able to withstand the future pressures that occur from climate changes such as global warming and increased weather severity. Green roofs – defined as any roofing system that includes vegetation – have been identified as one such strategy to help Minnetonka in achieving these objectives.

The City of Minnetonka would benefit in several ways from encouraging and facilitating widespread adoption of green roofs on its buildings. Developing a green roof – whether through retrofitting of an existing building or incorporating it into designs for new buildings – can be expensive, with estimates varying from $10 for simpler green roofs to more than $25 per square foot for more complex installations (EPA, 2013). However, the potential benefits of green roofs are many and, over the long-term, justify the substantial initial investment. These benefits are realized both privately and publicly, and include:

- *Decreased stormwater runoff* – The costs of water management are substantial for any city, and include costs associated with both treating stormwater runoff, and building and maintaining drainage infrastructure. The high costs of these activities is especially applicable to a city such as Minnetonka, which has the Minnehaha Creek Watershed running right through it on its way from Lake Minnetonka to the Mississippi River.
- *Increased building energy efficiency* – A green roof improves the insulation efficiency of a building, thus reducing the building's energy demand for space conditioning (both heating in the winter and cooling in the summer). A study by Liu & Baskaran (2003) found that energy demand for air conditioning could be reduced by as much as 75%. For large businesses and residential complexes in Minnetonka, such energy demand reductions would amount to substantial cost savings.
- *Aesthetic benefits* –Green roofs contribute to beautifying developed areas and can increase the value of buildings. A study by Abbott et al (unpublished as of July, 2013) found that green roofs could increase rental value of office space in Washington, D.C. by 17%.
- *Public relations benefits* – Green roofs can result in positive PR for businesses when they are seen by consumers as making an effort to be 'green'. For a city such as Minnetonka with an aging demographic, green roofs could be an effective strategy to attract younger, more progressive families to the city.
- *Increased lifespan of building roofs* – Green roofs provide protection from harmful elements such as hail and ultraviolet rays that can damage a building's roofing components and lead to the need for roof replacement. Green roofs can more than double the expected lifespan of building roofs (Gottfried, 2010).

The following report is intended to inform the City of Minnetonka about green roofs and best practices associated with them, as well as identify important considerations the City should weigh in planning and implementing green roof policies in Minnetonka. Section I discusses the various potential impacts of green roof development for a community. Section II lays out a vision of how just one area – that around the Ridgedale Shopping Center – could be transformed and the potential impacts of such a transformation. Section III presents a collection of 25 best practices regarding green roof policy, design, and maintenance, complimented by various case studies of green roof programs around the world. Section IV discusses the various challenges and opportunities present in achieving the desired green roof development transformation in Minnetonka. These were identified through a number of interviews conducted with local business owners, government officials, green roof experts, and other stakeholders during the spring of 2013. Analysis of these challenges and opportunities suggests that education is the essential first step in moving this initiative forward, and this is the focus of Section V. The report concludes with recommended actions the City can take to achieve the essential first step of educating the community about green roofs.

I. The Economic, Environmental, and Social Impacts of Green Roofs

Key decision makers such as the City of Minnetonka, residents, building owners, building users, and others have diverse concerns about the future of Minnetonka. Businesses, for example, are concerned with utility costs that hurt their profitability. The high costs associated with heating and cooling commercial and residential buildings are just one negative attribute that could be addressed by green roofs. Large climate-controlled buildings such as those around the Ridgedale Shopping Center – including the mall itself, as well as the nearby YMCA, Hennepin County Library, hotel, and other commercial buildings – spend significant amounts of money to heat their buildings in the winter and cool them in the summer. Inefficiencies in the architecture, design, and insulation of these buildings increase the heating and cooling costs for building owners and tenants. These factors are impacted by drivers such as increasing extremes in temperatures that have been recently occurring in Minnesota, as well as the desire to minimize development and maintenance costs, which often results in insufficiently insulated buildings and reluctance to upgrade the energy efficiency of older buildings.

Incorporating green roofs into large commercial and residential buildings can have a significant impact on the insulation of the building, thus decreasing the energy costs required to heat and cool the building and mitigating the impact of extreme temperatures outside. As we learned from our interview with Sustology, a local design firm that specialized in sustainability, the greatest improvements by far come in reducing cooling costs during the summer, which can be reduced significantly depending on the size and type of green roof installed. Such energy cost savings would go a long ways in helping to justify the costs of installing and maintaining a green roof.

Further affecting buildings is the wear and tear that sun and precipitation cause to a building's roof over time. Extreme temperatures and weather are drivers that combine to deteriorate the quality and integrity of a roof, eventually resulting in the need for roof replacement. Green roofs, particularly intensive ones with added layers of waterproof membranes and soil, provide extra protection to a roof, keeping water out and blocking UV rays from reaching the roof. According to EPA, green roofs have a longer lifespan than conventional roofs. This affirms some findings from our interviews that the upfront costs of installing green roofs can be well worth the investment in the long run.

Managing storm water runoff is a major cost to both cities and businesses. This cost comes both from treatment - water management accounts for around 30% of the average city's energy costs (US EPA) - but also from maintaining drainage infrastructure. While Minnetonka has eased some of this burden from the public sector by requiring structures larger than 5,000 square feet to pre-treat their runoff, this only increases building and maintenance costs that are already high in Minnetonka. Since green roofs convert impermeable, high-runoff surfaces like roofs to water sponges, they are an excellent way to manage runoff. While they do require irrigation, this irrigation water can come from cisterns or retention ponds that large buildings already must have in place - effectively increasing their capacity to store storm water. Therefore, placing green roofs on large

buildings can help manage Minnetonka's natural resources and environmental footprint while reducing the costs of climate stresses.

Minnesota's climate is wet and the Minnehaha Creek Watershed District (MCWD) encompasses Minnetonka, hence managing runoff is imperative for the City. This need, and the associated costs, will only grow regardless of Minnetonka's added development: Average rainfall in Minnesota is expected to grow over the next fifty years due to climate change. Yet a more important trend we are currently seeing is greater variability in rainfall - a trend toward shorter, more concentrated rain events like thunderstorms rather than drawn-out drizzles (Seeley, 2012). This type of rainfall increases the need for storm water management because rain-accompanying runoff will also come in shorter, but much higher volume events. Having the capacity to effectively manage greater amounts of water will increase storm water management costs for both building owners and the City.

Beyond financial considerations, another primary concern for the City of Minnetonka is maintaining its livability and its diverse and vibrant population. Currently, the population in Minnetonka is aging and the city could face several financial and structural challenges to cope with this trend. A growing elderly population increases dependency on government programs such as accessible housing and social services. In order to reduce this dependency, an increased labor force participation of a younger population needs to contribute to the economy. Minnetonka is thus trying to meet the needs of its increasingly aging population and attract young residents.

Open green spaces are one of the key attractions for young families. Green roofs can provide green spaces even in the most developed areas by increasing the opportunities for recreation while improving environmental quality. They augment the appeal and beauty of their setting, as well. Younger generations are attracted to these benefits. Attracting these younger residents can help improve the city's long-term economic vitality and equip it with resources to provide the needed services for its aging population. While Minnetonka has numerous and large parks, at least as important is ensuring public space is located where people work and live. Green roofs provide an added value to the city as they create more green and open space that can be utilized by citizens for recreational purposes, which generally enhance the quality of life. Because these spaces are where people work and shop, and access is easy and convenient. Open spaces provide further benefits such as investment, where tax-paying residents and businesses are more attracted to the community through the aesthetic beauty and quality of life that open space can afford.

Since Minnetonka is highly developed, existing buildings are the most likely candidates for installing green roofs. However, many buildings lack the physical infrastructure to support the weight of a green roof. This could add significant costs to installation, both upfront in terms of building redesign, and in some cases, in terms of lost interior space to make room for extra roof support.

Such physical constraint means taking advantage of the various designs green roofs can utilize, which come with their own tradeoffs. The major weight of a green roof is soil. This can be minimized in a few ways: choosing a synthetic soil, making the soil thinner, or

installing tray-type ‘extensive’ green roofs rather than ‘intensive’ green roofs. With these choices comes, of course, a tradeoff between performance, long-term maintenance costs, and weight-related installation costs. In order to increase green roof installation, building owners and Minnetonka will need to collaborate to determine site-specific optimum choices.

II. The Vision

In thinking about an ideal model for transformation, we envision a greener Minnetonka; a city that is appealing to young families, better able to manage its gray water, and less of a burden on the environment. To illustrate how this finished product might look in Minnetonka, we have developed a vision of the Ridgedale Shopping Center commercial area of the city (Figure 1). Of course, there are countless ways to re-develop this area to include more green roofs, and this vision is just one potential way of achieving this.

Starting with the Ridgedale Shopping Center property itself, we envision intensive green public spaces incorporated into covered parking lots, and extensive green roofs dominating the roof of the shopping mall. Transforming at least two of the shopping center's four major parking lots into dual-level ramps covered by intensive public green space allows mall visitors the opportunity enjoy the green roofs throughout the year except for winter. These rooftop green spaces could be easily linked through pedestrian bridge to the 2nd floor of the mall, allowing for easy access. By enabling pleasant breaks for shoppers to get away from the stress of shopping, the green spaces could increase mall revenues by making it easier for shoppers – particularly those shopping with children – to lengthen their stay at the mall.

Figure 1 – Development of green roofs around Ridgedale Shopping Center

Figure 1: Vision of green roof adoption in the area around the Ridgedale Shopping Center. Lighter green rectangles represent extensive green roofs on existing buildings' roofs, while darker green shapes signify intensive roofs that could be accessible to the public. Image source: Google Maps.

Two levels of parking for visitors would also create secondary benefits for the shopping center. Shoppers would also appreciate access to covered parking at the mall, allowing them avoid rain and hot sun in the summer, as well as snow in the winter. It would increase parking capacity of the mall while decreasing the land area required, potentially creating

space for future expansion of the mall. This of course would result in increased retail space and business revenues, which also means increased tax revenues for the City and state.

The roof of the mall is also an ideal location to incorporate an extensive green roof consisting of low-maintenance weather-resistant plants. This space would not need to be accessible to the public and the growing medium need not be as deep as the intensive green roofs on top of the parking garages, likely eliminating the need for expensive structural renovations to the roof. The Target Center's extensive green roof, covered exclusively in sedum plants, would provide a great model design for this green roof. The primary benefits of Ridgedale's green roof would be to reduce energy costs of heating and cooling the mall, as well as increasing the lifetime of the building's roof by protecting it from the sun's damaging UV rays.

In addition to the shopping center, there are numerous large businesses – many of which are locally owned – that would be prime locations for green roof development. Just south of the mall are the YMCA and the Hennepin County Library and Government Services Center, both of which have large flat roofs, ideal for green roofs. An intensive green roof on the Library and Government Services Center accessible to library-goers could serve as a great model green roof for the community. To the west of the shopping center, both Target and Best Buy have large buildings that would be ideal for green roofs. Target shares its complex with a Byerly's supermarket, a business that could grow its own herbs and various vegetables in its green roof, providing a direct source for increased profits. Also in the area are several higher end restaurants, including Redstone, Champp's Americana, and Bacio. Green roofs on these restaurants could also provide homegrown herbs and vegetables in addition to the storm water and other benefits they would bring.

If the shopping center and a handful of the surrounding major businesses were to develop green roofs, the area's storm water runoff would be greatly improved – every thousand square feet of impermeable surface would save 2500 cubic feet of water runoff for each 30 inches of rainfall. Additionally, energy costs would be reduced by 10-20% for these business and building owners, and the area's businesses would benefit from increased revenues due to a more pleasant experience for visitors. Finally, in addition to these tangible benefits to the area businesses, the area's new green roofs – some accessible to the public and some merely visible – will contribute to the City's efforts of educating the public about the need for and benefits of green roofs. This could result in a snowball effect of sorts, encouraging more residents and local businesses to incorporate green roofs into their properties.

III. Best Practices

Given the great benefits that can be realized by green roofs, it is important for the City to be aware of best practices for green roof policy, design, and maintenance. Doing so will allow them to effectively inform the city's residents and businesses about green roofs, and encourage them to adopt green roofs for their homes and buildings. The following is a comprehensive list of 25 best practices, categorized into policy, design, maintenance, and additional practices, to help guide the City's efforts in increasing the development of green roofs in Minnetonka.

Best Policy Practices

Best Practice #1: Integrate Green Roofs into Comprehensive Plans
Case Study Location: St. Paul, MN and Los Angeles, CA

Description
To ensure that green roof projects are thoughtfully implemented, they should be integrated into a combination of different plans like a climate action plan, water quality/stormwater management plan, or a comprehensive plan. Integrating green roofs into broader government plans indicates that they have identified benefits and are part of a long-term strategy. The City of Saint Paul has integrated green roofs into its Water Resources Management Plan, which is a chapter of its comprehensive plan. Green roofs in Saint Paul are part of an overall strategy to reduce pollutant loads to water bodies (City of Saint Paul, p. 19). Green roofs are part of a more specific strategy to reduce the negative impacts of rooftop runoff on water quality and water resources.

While the comprehensive plan doesn't necessarily have enforced zoning, having it in the plan makes it more likely to become enforceable in the future through an ordinance. As a demonstration of the benefits of green roofs, the City installed a green roof on its West 7th Street fire station in 2010. Installing a municipal green roof showed the City's commitment to the benefits of green roofs.

The City of Los Angeles has integrated green roof projects into its implementation program called ClimateLA released in 2008, which was the result of the Climate Action Plan released in 2007 (City of Los Angeles, 2008). The ClimateLA action plan outlines specific project goals for green roofs including installing 50 green roofs on new or remodeled city buildings. The plan identifies the Department of General Services, Bureau of Engineering and Public works as the lead agencies on the projects. The document also outlines opportunities and challenges. The opportunities are the fact that there are 800 existing city council controlled rooftop spaces that could be converted into green roofs and provide the city with all of the benefits of green roofs that have been aforementioned. Yet, the City faces challenges of a limited budget and competing green building project funding, as well as feasibility of retrofitting green roofs onto existing buildings.

Context
Saint Paul's Water Resources Management plan is based upon a large city within a metropolitan area within an upper-midwestern climate. It is very similar to Minnetonka in terms of climate, but is larger and has more impervious surfaces.

Los Angeles will likely experience more severe climate change impacts due to its climate, large population size, and amount of urban/impervious surfaces. It is not surprising that the City has adopted a Climate Action Plan as well as a Climate Action Implementation plan to mitigate these projected consequences.

Relevance
Integrating green roof projects into an existing stormwater management plan is probably the easiest way to promote green roofs at a planning level. While Minnetonka has different stormwater management strategies and probably more water and wetlands than Saint Paul, Saint Paul's case study is a great model for Minnetonka to follow. While a climate action plan and subsequent implementation like Los Angeles would be a great goal to set for the City, in the near future Minnetonka should focus more on amending existing plans as a starting point to integrating green roofs.

Best Practice #2: Incorporate Green Roofs into Stormwater Management Plan
Case Study Location: Los Angeles, CA

Description
Integrating stormwater management design elements into a green roof can have many benefits in reducing stormwater runoff, which is typically heavily polluted from contact with impervious surfaces (Environmental Affairs Department, 2007, p. 3). When there is rainfall, the plants on the green roof can absorb and filter more water than a conventional roof, therefore reducing the volume of runoff and pollution. Green roofs act as a filter for stormwater once the runoff hits impervious surface because the roofs do not contain nitrogen and phosphorus particles that are common on dust laden conventional roofs (ibid, p. 4). *Intensive* green roofs have greater stormwater retention ability than *extensive* green roofs because they have more growing medium (EPA). Although, the EPA does report that *extensive* green roofs can capture between 50% and 100% of incoming rain, depending on growing medium, density of vegetation, the intensity of the rainstorm, and frequency of rainstorms.

The City of Los Angeles discusses the direct benefits of employing stormwater management techniques in their Green Roof Resource Guide, released in 2007. By reducing and slowing down the amount of runoff onto impervious surfaces, there is less pollution getting picked up by the decreased force of the water (Environmental Affairs Department, 2007, p. 4). The water is also a significantly lower temperature than runoff from conventional roofs. Therefore, when less polluted and cooler water makes its way to the coastal areas, it is less of a threat to coastal ecosystems.

While the type of vegetation and depth of growing medium are important design elements in reducing stormwater runoff, a cistern can also be useful in further capturing stormwater. The City of Los Angeles, in its Green Roof Resource Guide, discusses cisterns as a measure to retain excess water for future use in irrigation during prolonged dry periods (ibid). This measure is particularly important in drier climates, like California and the arid West, where water scarcity is a much larger issue than in the Midwest.

Context

Los Angeles has experienced significant consequences from the urban heat island effect, which has raised temperatures from 97 degrees in 1937 to 105 degrees in the 1990's (ibid). As a coastal area, Los Angeles also faces many issues with maintaining water quality in these ecosystems. The Green Roof Resource Guide was developed for the purpose of developing and implementing a process, program, or procedure to incorporate green roof projects into city facilities in 2007. The main outcome is to provide more energy efficiency to buildings. The resource guide focuses mainly on extensive roofs due to their minimal maintenance requirements and fact that most roofs are not designed for daily occupancy.

Relevance

This best practice to consider the various stormwater management techniques through design is essential for any green roof project in Minnetonka. Some roofs may not allow for intensive green roofs because of structural issues or preferences, but extensive green roofs can also provide great stormwater runoff benefits when attention is given to choosing the proper plants for the roof. Additionally, while cisterns may not be essential to green roofs in the Midwest, they could be employed in areas near large riverine or lake areas, where the risks of damaging stormwater runoff to habitats are higher than in other areas. The cistern would act as another stopgap measure to slow down the water from entering at an unsafe temperature or with higher pollutants.

Best Practice #3: Mandate green roofs on new buildings

Case Study Locations: Toronto, Canada and Copenhagen, Denmark

Description

Requiring green roofs on new buildings may be the most direct way to increase green roof adoption in a city. In 2010, Toronto, Canada became the first city in North America to implement a bylaw requiring green roofs to be incorporated into new building development with a Gross Floor Area of 2,000m^2 or greater. The bylaw requires such developments to incorporate a green roof covering 20-60% of the building's roof area depending on the size of the building (Torrance et al, 2013. p. 5). The City does allow exemptions to the law conditional upon approval by City Council and a cash-in-lieu payment of $200 per square meter (Toronto, 2013).

By the year 2025 Copenhagen, Denmark is seeking to be the world's first carbon neutral city. A goal this lofty is obviously going to require some steep measures on the part of the city. One of the measures the City is taking is requiring all roofs with a pitch of less than 30° to incorporate some form of soil and vegetation. In the case of roofs that are aged or

dilapidated, the City says that it will provide funds for the retrofitting of these structures. The rooftop gardens must meet at least 2 requirements out of the following: absorb 50-80% of precipitation that falls on the roof, provide a cooling effect to the building, reduce the urban heat island effect, be aesthetically pleasing, and protect the roof against structurally damaging UV rays.

Context
Toronto is a major city that presumably is not experiencing a significant amount of new building development, although older buildings eventually need to be replaced, making the green roof bylaw relevant for other developed cities and suburbs considering green roof initiatives.

Both cities are situated in a northern climate, so other northern cities could learn from the types of plants and the outcomes of green roof projects implemented in Toronto and Copenhagen. Government-business relationships and power dynamics may be different in these two cities than in other countries or communities, so the receptiveness or potential backlash to potential regulations should be considered within the local context.

Relevance
Although Minnetonka is already nearly fully developed, the City should consider mandating green roofs on all new development. This would help ensure that the city doesn't significantly increase its impervious surface area, and thus its stormwater runoff, moving forward. Toronto's approach seems to have been well planned, and the City made considerable efforts to educate and guide the public on how to follow the new policy. Any new green roof regulations on new development could be complemented by government incentives to encourage green roof development (see Best Practices 4-6), particularly for retrofitting existing buildings with green roofs.

Best Practice #4: Incentivize green roof development via green roof subsidization
Case Study Location: Milwaukee, WI

Description
An alternative to the 'stick' approach of mandating green roofs on new buildings would be a 'carrot' approach of incentivizing voluntary adoption of green roofs by directly subsidizing their construction costs. While many people and businesses may resent being forced to incorporate expensive green roofs into new building investments, incentives would likely result in less negative reactions.

Milwaukee is one of several cities that have pursued greater green roof development through direct subsidization of green roofs. Their program, the Regional Green Roof Initiative, is funded by the Milwaukee Metropolitan Sewerage District and offers $5 per square foot (psf) for approved green roof projects. It began this year and is open to public agencies, private property owners, and nonprofits (H2O Capture, 2013).

The City of Portland offers a similar $5 psf subsidy as part of its Grey to Green Initiative, started in 2008 with the goal of adding 43 acres of new green roof area to the city over five years (Plant Connection, 2013). No update was available on the progress that has been made towards this goal. Chicago also had a green roof subsidy program that subsidized up to 50% of installation costs, but this program has recently been suspended due to budgetary issues (ibid).

Context

Milwaukee is a metropolitan city of nearly 600,000 people (U.S. Census Data, 2011) with climate similar to that of the Twin Cities region. The Regional Green Roof Initiative is intended to "increase more natural stormwater management practices that capture, store, or filter rainwater" (H2O Capture, 2013). In addition to encouraging green roof adoption within the city, the Initiative also aims to inform the city about green roof costs, maintenance, and effectiveness. Such data could be very valuable if shared with other cities considering green roof initiatives.

Relevance

Milwaukee's Regional Green Roof Initiative is new and its outcomes and effectiveness are still unknown, but Minnetonka should monitor the progress of the program to assess whether a similar green roof subsidy program could be effective in Minnetonka. Considering Minnetonka's status as a relatively wealthy community, it would be feasible for the City to offer a green roof subsidy for businesses and residents. If such a program were successful at increasing green roof development and achieving its goals of reducing stormwater control costs and attracting young families, the investment would be well worth the costs.

Best Practice #5: Incentivize green roof development via project grants

Case Study Location: Chicago, IL

Description

The City of Chicago, in order to meet its goals for increased urban sustainability through green roofs, has provided many financial incentives for businesses and larger scale developments to implement their own rooftop systems. These financial incentives are in the form of grant funding for applicable projects.

Grants may be appropriate for smaller business owners who need additional funding to bridge the gap between the cost of a green roof project and the amount of own-source funding that can be raised by a business owner. Or, in the instance where cost savings in the form of energy conservation and reduced stormwater utility abatement fees might not be high enough or realized in an appropriate timeframe, grants may be able to provide the extra incentive to push more property owners into developing their own green rooftops.

Context

The grant program in Chicago was able to cover up to 50% of the cost of a green rooftop project if the project covered at least 50% or more of the rooftop space. Or, if the cost of

the project exceeded $200,000, the City was able to offer up to $100,000 in grant funding for projects as long as 50% of the rooftop space was utilized in the green roof project design and implementation.

Relevance

A grant program may be appropriate for Minnetonka since there are many smaller buildings and property owners in the area aside from big box retailers. These business owners may not be able to afford the cost of green roof projects nor implement projects that are as spatially extensive to cover at least half of the available rooftop space on their buildings. The City may decide to offer a smaller percentage of funding with a smaller cap on total funding per project. Or, the City may decide to require a smaller percentage of rooftop space to be covered in particular green rooftop projects depending on the load capacity of older buildings.

The grant program could also be funded with the tax revenue saved from a reduced reliance on stormwater management infrastructure maintained by the City since other green rooftop projects would account for greater stormwater management. The grant program could also be funded by other monies earmarked for conservation if the green roof design incorporated a high mix of native plant species that created additional habitat areas to be preserved.

Best Practice #6: Incentivize green roof development via tax abatement or utility fee credits for buildings with green roofs

Case Study Location: Minneapolis, MN and Nashville, TN

Description

A second alternative to mandating green roofs is to incentivize private development of green roofs through the offering of credits off of utility fees or taxes. Similarly to green roof subsidization, such incentive programs may be received more positively by the private sector than mandating green roofs on buildings. It would also likely be easy to oversee than building regulations, as the onus to seek approval of green roofs would be on those who want to install green roofs for fee credits, rather than the local government having to enforce green roof regulations on all new building developments. Nashville, TN is just one of several U.S. cities that has taken this approach to incentivizing green roof development. Minneapolis also offers credit for green roofs stormwater runoff fees that are incorporated into the water utility bills for a property.

Developed by a Minneapolis council member, the tax abatement program was adopted in the mid-2000s and offers a 100% abatement of the stormwater fee if "a development project has a best management practice with both a quality and quantity reduction in stormwater runoff" (GRIM, 2007). Although this program could easily be extended to residential property owners, the program was intended for new development projects and commercial areas. Through the stormwater utility fee abatement program, the Target Center green roof saved more than $11,000 in stormwater fees in the first year while it is expected that the arena will save an estimated $379,000 in fees over its first twenty years.

Nashville's Green Roof Rebate program provides credit of up to $10 per square foot of green roof towards the sewer fees for any private property connected to Metro Nashville's combined sewer system (Nashville, 2013). Properties must have at least 50% of their roof area covered by green roof, and may receive this credit for up to five years. The maximum credit allowed is based on the type of green roof installed; intensive green roofs are eligible for greater credits than intensive green roofs.

Context

While the Minneapolis model has not spurred the increase in green projects as anticipated, this case study is an important lesson in how to implement better policies. First, the program has not been widely successful to date partly because the stormwater fees are not high enough for smaller properties to stimulate more transitions to green roofs and other water management policies. Second, where fees have been raised, property owners have complained to the point where the City retroactively adjusted and lowered their costs.

Nashville's Green Roof Rebate program is part of a larger strategy to reward residents and businesses that employ Green Infrastructure Practices (of which green roofs is one). It's clear that Nashville has a long-term vision to make the city a greener place, and in that sense would be a useful case study for other cities that are considering green roof incentive programs as part of a larger 'green' strategy.

Relevance

This practice is quite relevant for Minnetonka, a city that's home to several large commercial, office, and residential buildings. Such buildings are prime locations for green roofs, and offering credits towards their presumably substantial stormwater fees could be effective strategies to entice them to build green roofs. Alternatively, instead of stormwater fee credits offered on an ongoing basis, Minnetonka could offer credits toward the one-time Park Dedication Fees that are required for new building developments of a certain size. Decreases on such substantial costs for businesses would likely be an enticing offer.

Best Practice #7: Require adherence to proven standards such as FLL guidelines in green roof design, construction, and maintenance.

Case Study Location: Wiesbaden, Germany

Description

While green roofs are a relatively new phenomenon in the United States, they have been commonplace in many parts of Europe for decades. The Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL) is a German non-profit organization that has been working on green roof standards for more than 30 years (Green Roof Technology, 2013). FLL has published guidelines for green roof design, installation, and maintenance that have served as the sole source internationally for comprehensive information on green roof development.

Image 1 – Cover of FLL Green Roofing Guidebook

Image Source: http://www.greenroofguide.co.uk/

The green roof built in 2003 atop the new headquarters of the Soka-Bau, which administers pension funds for the German construction industry, provides a perfect example of why green roof designs should follow guidelines for effective green roofs such as those offered by the FLL. One of the FLL green roof design guidelines advises that the waterproofing membrane of the green roof should extend up at the roof's parapets at least four inches above the finished grade or planting level. This provides additional flood control by allowing the parapets to protect water from flowing over and onto the side of the building should the designed drainage inlets fail, potentially damaging the building as water drains down the building's façade. The planting level of the extensive green roof on the Soka-Bau building was built flush with the top of the roof's parapets. Despite the drainage mechanisms built into the green roof, the rooftop eventually flooded, causing water to drain over the parapets and causing damage to wooden components below. To resolve the problem, the parapet was rebuilt to extend four inches above the green roof's planting level.

<u>Context</u>

The Soka-Bau building is located in Wiesbaden, the capital city of the southern German state of Hesse, and has a population of about 271,000 (Wiesbaden, 2003 est.). It is a public building, serving as a model for other cities considering implementing green roofs in public buildings. The building's green roof incorporated both intensive and extensive green roof

design elements, providing a great context to compare the two types of green roofs in a single environment.

Relevance
This best practice is quite relevant to Minnetonka planners and policy makers. The City would be well advised to implement policies requiring green roof installations to adhere to strict guidelines such as those published by the FLL. Doing so will ensure that green roofs are installed properly and have the best possible chance for success. In addition to policies requiring standards and guidelines to be met, Minnetonka could hire a design firm on retainer to consult on green roof projects, ensuring consistency of quality and standards across all green roof installations in the city.

Best Practice #8: Use building zoning amendments to encourage green roof development
Case Study Location: Cambridge, Massachusetts

Description
In 2008, Cambridge's city manager appointed a green building/zoning task force. The task force, included "architects, residential owners, developers, solar installers, and representatives of advocacy groups, local universities, and the Cambridge Planning Board" (City of Cambridge, 2013). The task force met monthly with city staff in various departments. In 2010, Cambridge's City Council adopted a green building zoning amendment based upon the recommendations of the task force (Cambridge Green Building/Zoning Task Force, 2009).

According to the green building zoning ordinance, all new or significant rehabilitation projects must meet LEED standards (City of Cambridge, 2009). Green roofs can help a building meet LEED specifications.

In addition, green roofs are excluded from gross floor area (GFA) calculations (City of Cambridge, 2009), even if the green roof is accessible. Furthermore, deck or patios that compose less than 15% of a green roof may also be excluded from the GFA with the new ordinance. Under the old zoning guidelines, accessible rooftops located above a third floor caused the roof area to be added to the GFA total. A reduction in total GFA is essentially a stormwater fee reduction as stormwater control permits cost $0.01 per GFA in Cambridge (City of Cambridge, 2013).

Context
Cambridge is located just north of Boston, and is home to Harvard University and the Massachusetts Institute of Technology. Cambridge's green roof policies are similar to Boston. Both town have demonstration roofs of public buildings, and have LEED building standards.

Relevance

Cambridge is an example of a small city that is just starting out with green roof development. Since Minnetonka is in a similar position, Cambridge makes for a very applicable case study. The green building/zoning task force established in Cambridge could be replicated in Minnetonka. The task force could be charged with supplying recommendations for green building and green roofs in Minnetonka, and represents an opportunity to engage citizens and developers in low impact development strategies. In addition, green roofs for public buildings are a good starting place for Minnetonka to target green roof development.

Best Practice #9: Develop resources for public education about green roofs
Case Study Location: Portland, OR

Description
Green roofs can increase throughout an area when a city makes an effort to inform the public about the benefits of green roofs. This can be through a number of different formats including meetings, brochures, charrettes, and websites. By providing resources in an easily digestible format, people are able to absorb the information in a way that works for them. Metrics and evaluation can also be integrated into these resources (see Best Practice 13).

The City of Portland has an extensive website that includes many different resources for the public about green roofs (City of Portland, 2013). First, they have information about green roof programs, policies and research, for a more academic look at green roofs. Second, they have information about Portland specific policies and incentives. Third, they have a listing of professionals who specialize in building green roofs. Finally, they have information about how to build a green roof and various checklists for moving through the process of building and maintaining a green roof. Portland also has a green roof seminar for professionals.

Context
Portland is known for being progressive and cutting edge when it comes to green building techniques and planning. The demographic makeup of Portland likely has many civically engaged and environmentally conscious citizens who demand these types of resources from their city government. The green roof program in Portland also has a focus on monitoring bird species and tracking wildlife, which is included in their website resources.

Relevance
Minnetonka should start thinking about utilizing this best practice early on while they are developing a green roof program. Getting citizens engaged and informed early on will be the key to success and longevity of the program. While Minnetonka's webpage of resources doesn't need to be as extensive as Portland's, including academic information, technical information, and procedural information is essential to inform the public. Using a variety of sources will ensure that a broad audience can utilize the information. The City may also use a demonstration rooftop to hold meetings at for the public or utilize metrics in presentations to disseminate information that is local and pertinent to Minnetonka.

Best Practice #10: Conduct cost-benefit analysis to inform stakeholders of green roof benefits
Case Study Location: Washington, D.C.

Description
Green roofs have myriad potential benefits, including stormwater, energy, biodiversity, heat island, agriculture, acoustical, clean air, aesthetics and quality-of-life, and roof longevity. Stormwater benefits include reduced quantity of a higher quality runoff that is cleaner than traditional sources of runoff. Energy benefits include resource conservation and reduced heating and cooling costs and needs. Biodiversity benefits include additional habitat for plants and animal species such as birds, bees, and other species capable of flight that provide agricultural benefits. Green roofs also reduce the heat island effect by lowering temperatures, further supporting energy conservation efforts. Agriculture benefits include the potential to grow sources of food and fuel. Clean air benefits include reduced pollution and the offsetting green house gases such as carbon dioxide. Although not explicitly confirmed, some studies suggest that there is a correlation between reduced employee absenteeism and improved productivity. Lastly, green roofs can double the life expectancy of traditional roofs by reducing exposure to UV light.

Despite all of these potential benefits, each with their own cost-reducing qualities, some business owners are still unconvinced that high upfront capital costs justify the implementation of green roofs. However, educating business owners about the benefits of green roofs using cost-benefit analyses may provide the extra push toward implementation

Context
A cost-benefit analysis was conducted for a typical municipal building in Washington, D.C. to evaluate the financial advantages of constructing green roofs. The analysis included "inflation, growth rates for labor and materials, energy, stormwater, community benefits, and diminishing returns based on increases in market supply and experience, a discount rate evaluation and a 50-year timeline" (Friedberg and O'Brien, 2013).

For a 12,000 square foot green roof, the initial cost of nearly $115,000 would be paid back in 6.5 years with a nearly 200% return on the investment. Although implementation and maintenance of the roof may cost up to $300,000 over 50 years, the stormwater, energy, air quality, real estate, and community benefits total approximately $680,000 during the same time frame.

Relevance
Although most green roofs in Minnetonka may be to the same scale as that of the case study, there are still financial benefits to be realized. A more detailed assessment of existing green roofs in Minnesota would provide costs-savings data relevant to the city.

Best Practice #11: Facilitate community empowerment

Case Study Location: Johannesburg, South Africa

Description
In Johannesburg, South Africa the Tlhago Primary Agriculture Cooperative has been providing individuals with the skills and resources to build green roofs since 2010. Within this time they have constructed 2 rooftop gardens in downtown Johannesburg and educated over 100 people on how to do so. The gardens are mostly comprised of edible foods, which are sold to local patrons. Additionally, urban medicines are being produced from these gardens, which are also being sold to local patrons.

The residents being educated are not only being presented the physical skills necessary to build a rooftop garden, but are also being educated about climate change, its potential effects, and the methods to mitigate it. Johannesburg is seeing the in-migration of more and more people from rural areas of the country. Many of these migrants traditionally made their living as farmers, making them extremely good candidates for this type of program, which allows them to use some skill sets they may already possess.

Context
Rural farmers in South Africa are already seeing the negative effects of climate change. Many of them are seeing their crops dry up or worry that their seeds may not sprout at all because of increasing temperatures. These individuals are able to use prior skills to mitigate the effects of something they are witnessing first hand. The construction of rooftop edible gardens allows their caretakers to become entrepreneurs by selling their crops and medicinal plants to local residents, and at the same time creating a local food market.

Relevance
Minnetonka has the desire to introduce mixed-income and high-density housing into its cityscape. With the implementation of these types of developments the City has the opportunity to provide residents with the opportunity to be semi self-sustainable by being able to produce their own food. This example in Johannesburg is an excellent example to follow if a city is seeking to empower and educate it residents along with creating a local food market.

Best Practice #12: Foster community engagement
Case Study Location: New York City, NY

Description
It is a best practice to integrate community development strategies into green roof projects. Local food production is one way of engaging the community in planting and maintaining a rooftop garden. While not all green roofs are feasible or preferred to produce food, green roofs can still be a great way to bring communities together. Whether it is for maintenance activities, leisure, or initial planning of the green roof, there are many ways that people can be engaged. This is most easily done with multifamily housing units, non-profits, and public buildings, where there is already a sense of shared space.

In New York City, the NYC Green Infrastructure Plan was updated in 2011. This plan outlines several strategies for reducing rain-related pollution (New York City, 2011). Through this plan, the City has developed a green infrastructure grant program where applicants can apply if their project will manage 1-inch of stormwater from impervious surface area on private property. The grant program also encourages education and community involvement and job creation (Department of Environmental Protection, 2013, p. 6). In 2011, the Brooklyn Navy Yard and Brooklyn Grange received a $592,730 grant to build a rooftop garden as part of the Green Infrastructure Grand Program (Office of Mayor Bloomberg, 2012). The rooftop is anticipated to divert more than 1-million gallons of stormwater, while creating jobs and growing 20,000 pounds of local food. The Brooklyn Grange has a community center where they educate the public about urban farming. They also invite school groups and the public to volunteer at the rooftop garden.

Context

The Green Infrastructure Plan is the result of a huge push to improve water quality in the largest city in the U.S. With a large amount of impervious surfaces and located in a coastal area, New York City faces monumental challenges in becoming more environmentally sustainable.

Relevance

Using a grant program was a success for New York City in encouraging community engagement for rooftop gardens with the Brooklyn Grange project. While the scale of the grant program wouldn't be as large in Minnetonka, it could be one method to encourage community engagement as a second priority to stormwater management. Minnetonka could also potentially work with food shelves to grow food and provide more access to local food. With public rooftop gardens or extensive green roofs, the City could set up a volunteer program to help with maintenance of the green roofs. This could potentially save money for the maintenance costs.

Best Practice #13: Implement systems to track metrics

Case Study Location: Boston, MA

Description

Installing measuring devices to track various benefits can all be useful tools in evaluating the success of a green roof project. These metrics are also essential in planning for the future or changing aspects of the green roof for improvement. These metrics can also be powerful tools in engaging the public in the benefits of green roofs through tangible results that can be understood on a local level and likely from a familiar landmark.

The City of Boston has adopted several measuring criteria to evaluate green roof projects including energy monitoring, stormwater runoff volume, and interior noise (Arrowstreet, 2009, p. 38). It is recommended to begin these metrics one year prior to the construction of the green roof in order to gain baseline data. Energy can be monitored either through energy costs/bills or through a more sophisticated monitoring device. Stormwater runoff

can be measured through weather stations and flow devices installed in roof leaders and downspouts that track precipitation and flow. The report also notes that stormwater should also be tested for water quality. Finally, the report for the City of Boston also recommends installing interior noise monitors.

Unfortunately, the report only analyzed overall cost analyses, but did not get into the specifics of cost for each of the monitoring devices. The high cost of some of these specialized devices could be prohibitive.

Context

The Green Roof Planning Study conducted in 2009 had the goal of assessing the feasibility of retrofitting municipal buildings with green roofs. The study assessed design and construction techniques, developed guidelines, and prepared overall cost estimates (Arrowstreet, 2009, p. 7). The study also identified potential candidates for retrofits. The study was funded by a Municipal Technical Assistance Grant from the Massachusetts Department of Environmental Protection.

Relevance

The biggest challenge for Minnetonka in implementing this best practice would be funding several tracking devices. This best practice could be implemented first in a demonstration green roof and then expand as the importance of metrics become more widely understood. By just doing metrics on one public building, the City could use this information and share it with the public in unique ways. This could be through seminars or meetings, or through an interactive website.

Best Practice #14: Develop ecological measurements and targets

Case Study Location: Berlin, Germany

Description

In the 1980s, Berlin created the Biotope Area Factor (BAF). The use of the BAF started in West Berlin, and spread to the entire city upon reunification. The BAF is a ratio between an ecologically sensitive area and the total land area (Connery, 2009). Surfaces on a site are given a weighting factor. Green roofs have a high weighting factor, which in turn increases the BAF. Planners set requirements for the BAF, such as a BAF of 0.30 for new commercial buildings.

The BAF does not specify design requirements or standards. This results in lots of flexibility for developers. Planners or developers can choose to employ other best management practices (BMPs) instead or combine them with green roofs, as long as the target BAF is reached. The BAF is a way to use regulation instead of financial incentives, but still give developers lots of design freedom. In addition, if a building is connected to a stormwater drain, green roof areas were not counted into the impervious area used to calculate stormwater fees (Ngan, 2004). This incentive did not directly fund green roofs, but provided a form of compensation for the runoff input reduction to the sewer system.

Context

Berlin is Germany's largest city. Green roof construction was borne out of concerns for diminishing green space and wildlife habitat (Lawlor et al, 2006). Stormwater management was a secondary concern. Germany is an international leader in green roof construction. Berlin benefited from strong federal support for green roofs. The reunification of Berlin also provided an opportunity to test innovative low impact development policies.

Relevance

Berlin's BAF is somewhat unique among green roof policies. It has been included as a case study example because it differs from many other green roof policy strategies. It is useful to consider options other than financial incentives and stormwater fee reductions. However, since the BAF is so unique, its feasibility for Minnetonka as an initial green roof policy is unclear. The BAF case study can serve as a reminder that innovative policies can have good results, but the exact specification of the BAF may be out of reach at this time.

Best Design Practices

Best Practice #15: Consider carefully the decision between Extensive vs. Intensive green roofs systems

Case Study Locations: St. Paul Fire Headquarters vs. Minneapolis' Target Center

Description

There are three general types of green roofs: extensive, intensive, and semi-intensive. Extensive green roofs have a growing medium depth of generally 2-6 inches, are lighter in weight, and tend to allow for fewer species of plants. Intensive green roofs generally have 6+ inches of growing medium, are heavier and costlier to install, and can often be used as amenity or general recreation space. Semi-intensive green roofs are a hybrid of the other two types (EPA, 2013). An example of both ends of the green roof spectrum is available within the Twin Cities; the Target Center in Minneapolis is fully covered by a giant extensive green roof covering more than 100,000 square feet (Maynard, 2011), while the St. Paul Fire Department (SPFD) headquarters building holds an 8,000 square foot intensive green roof (Xiong, 2010). Both green roofs cost significantly more than EPA estimates published more recently, but both seem to be successful.

Image 2 – Target Center's green roof

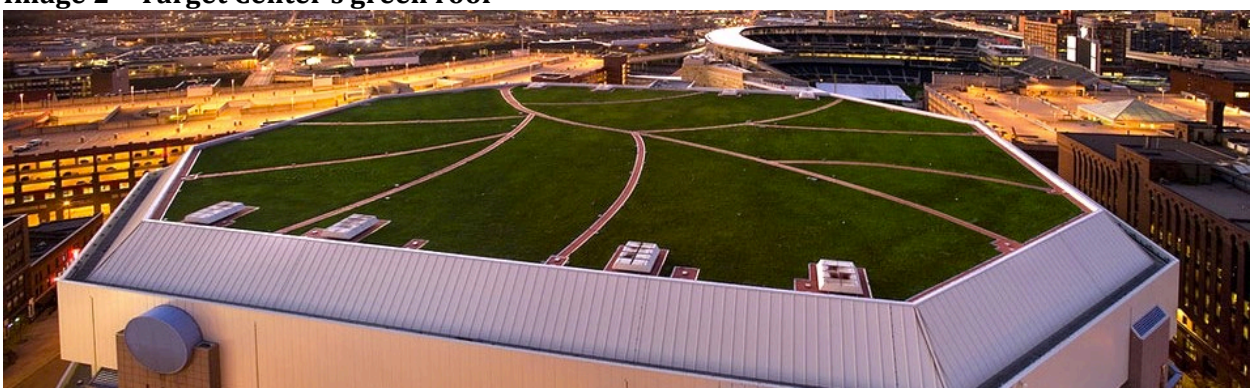


Image Source: http://www.mngreenroofs.org/

The Target Center's green roof (pictured above) was the fifth largest green roof in the country when it was built in 2008, and cost about $5.3 million, or roughly $49 per square foot. The roof is covered in low-maintenance, weather- and pest-resistant sedum species that are native to the region, planted in soil only 1.75-2.5 inches deep (Maynard, 2011). The green roof is estimated to reduce the stormwater runoff from the facility by more than 1 million gallons annually (ibid). In contrast, the SPFD headquarters green roof (pictured below) cost around $500,000 (or roughly $55 per square foot) to build in 2009 – about five times the cost of a traditional roof (Gottfried, 2010) – but serves multiple purposes. The roof holds roughly 100 different species of plants, all native to the state, with soil as deep as 15 inches. In addition to improving the energy efficiency and stormwater runoff of the building, the roof is a public space used for SPFD events and as a classroom for school groups that come on field trips. The City signed a $10,000 three-year maintenance contract

with the company that installed the green roof, after which costs are estimated to be $1,500-2,000 per year (Xiong, 2010).

Image 3 – St. Paul Fire Department Headquarters green roof

Image Source: http://www.mngreenroofs.org/2011/06/big-red-trucks-and-bigger-green-roofs/

Context

These two green roofs were installed in urban areas of the Twin Cities, so would be ideal cases to inform other urban projects weighing the costs and benefits of extensive vs. intensive green roofs. Weather and state regulation considerations would also allow projects in suburban areas of the Twin Cities to draw on as they develop plans and policies for green roofs.

Relevance

While EPA estimates indicate that installation costs for green roofs have decreased in the years since these two were built, Minnetonka should continue to monitor the progress of these relatively new green roof projects, as they mature and longer-term savings are realized. This information could be used to educate businesses and residents as they consider which type of green roof to install.

Best Practice #16: Determine existing and required structural capacity of roof for retrofits

Case Study Location: New York City, NY

Description

It is essential to determine the structural integrity and load capacity of a roof before deciding to install a green roof atop a building. The structural loading capacity of a building

is a “combination of dead loads (all permanently placed parts of the roof above and below, including hardscape, plants, growing medium, features, etc.) and live loads (inconsistent weight such as snow, people, temporary components and equipment)” (Tolderlund, 2010, p. 15). Typical dead load weights of fully saturated green roofs range from 15-55 lb. per square foot (psf) for extensive green roofs to 75-150 lb. psf for deeper intensive green roofs (ibid).

A study of two green roof retrofit projects in New York City (see image below) found that Symphony House, a 43-story mixed-use office and residential building, was structurally sound enough for the planned green roof, while the structural capacity at the second building, a 16-story office building at 215 Hudson St., was deemed insufficient to support a green roof (Melching, 2012). Typical building roofs in New York are designed to meet building code minimum loads of 40 lb. psf (for snow loads), far less than the 100 lb. psf minimum required for public amenity space (ibid, p. 5) or the previously mentioned required loads for intensive green roofs. Load capacity of buildings is typically assessed by structural engineers or architects, often simply by reviewing as-built drawings or certificates of occupancy. Alternatives to this include contacting a building’s original architects or the last resort method of probing the roof’s structure. The roof issue at 215 Hudson was ultimately resolved by installing an additional concrete slab on top of the existing concrete roof, increasing the strength of the structure.

Image 4 – New York City buildings before and after green roof development

Before and after images of 250 Hudson (top), Symphony House (bottom). (FXFOWLE)

Image Source: Melching et al, 2012. Retrieved from: http://www.plazaconstruction.com/pdf/news/Cities_Alive_2012_-_Green_Roof_Retrofit.pdf

Context

New York is a very large, densely populated city in which green space is rare and likely carries a much higher value than in most places around te United States. Thus, while the costs of adding additional support to the 215 Hudson building may have been worth the investment in this case, such costs may not be justified in locations where green space is considered less of a rarity. However, the information provided in the case study on estimated weight requirements and methods for assessing building load capacities could be very relevant for other locations and contexts.

Relevance

Minnetonka's buildings were most likely built in a different era than those profiled in this case study. Older buildings often have been "over-built", so the buildings in this case study may actually have roofs that are stronger than many of those built in Minnetonka more recently, when construction techniques focused more on efficiency. However, the weight requirements for green roofs will be roughly similar in both environments, so the challenge

will be for Minnetonka building owners to determine – presumably with advice from engineers or architects –if buildings meet those requirements, and if not, how best to retrofit them.

Best Practice #17: Incorporate designs that increase plant and wildlife biodiversity
Case Study Document: Toronto Guidelines for Biodiverse Green Roofs

Description
There are many design and maintenance approaches that can nurture biodiversity of both the flora and fauna of green roofs. For example, various plant species require different soil depths and moisture levels to survive and grow. Many grasses and sedum species require only shallow soil depths of less than 6 inches and have minimal moisture requirements, while woody plants and other taller and denser vegetation requires deeper soils with more organic content and moisture content (Torrance et al, 2013, p. 17-19). Varying the soil depths and topography across a green roof – for example, installing deeper soil depths over structural areas with a stronger load capacity, as discussed in Best Practice 6 – will allow green roofs to attract and support a wider range of plants and wildlife.

Improved diversity of a green roof is a self-perpetuating benefit; diverse plant species can support a diverse range of pollinators, birds, and nutrient-cycling insects, which can then nurture and maintain a wider range of plant species on a green roof (ibid, p. 20-22). Other design strategies that can complement this include installing logs, large stones, and pavers to a green roof to increase the volume and quality of potential habitat for such plant and wildlife species. A well-functioning biodiverse green roof will require less maintenance than one that requires constant attention to maintain moisture and nutrient levels in the soil.

Context
Toronto's climate would be somewhat comparable to other northern climate cities, so would likely have some similarities in terms of plant and wildlife that green roofs would potentially support. However, communities should take into consideration the plants and wildlife native to their area, as well as potential invasive species that could negatively impact the biodiversity of green roofs in their area.

Relevance
Minnetonka should encourage businesses and residents to use strategies outlined above to nurture biodiversity within their green roofs. Such strategies would also likely increase the success rate of green roof installations, thus encouraging other businesses and residents to get on board and develop green roofs of their own. Increased biodiversity of green roofs would increase the biodiversity of the city in general and contribute to its image as having wonderful natural resources. This would help to attract younger families to the area looking for greener alternatives to the concrete jungle of more urban locales.

Best Practice #18: Employ the use of native species to increase preservation areas

Case Study Location: St. Paul, MN

Description

When designing green rooftops, it is important to consider which plant species are included in the final project design. While hardy, drought resistant plants and seedum are typically used in general for green roofs across the nation and even in other countries, project designers should highly consider using native plant species. Seedum simply refers to a flowering plant, which belongs to a large genus that includes about 400 different species.

The use of native plant species creates additional habitat for other local species, such as birds, bats, and insects. This addition habitat can also be considered as the expansion of preservation areas since these mini-ecosystems would resemble the larger swaths of surrounding natural environment.

The Fire Headquarters in St. Paul is an example that incorporates a mix of more than 100 native and ornamental plant species, including seedums and succulents. The rooftop also does not require mowing, features a small pond, and also produces vegetables, which are used by the firefighters to prepare their own meals.

Context

The St. Paul Fire Headquarters green roof, known as the R. C. Knox Memorial Garden Green Roof, mixes both native and ornamental species to enhance the success of the rooftop garden. Native species are suited to the climate but may be sensitive to seasonal changes and instances of drought while seedum is generally more hardy and drought resistant. However, the rooftop garden does use rainwater collected in 6,000-gallon cisterns to drip irrigate the garden in times of drought.

Relevance

Using a mix of native and ornamental plants species is relevant to the City of Minnetonka because it can be used to create additional areas of habitat that can be preserved. These native plants are also better suited to the climate of Minnesota and also respect the natural, native beauty of Minnetonka that is so highly valued by the city and its residents. The collection of rainwater also enhances the stormwater best management practices discussed previously because this water is used to irrigate the garden instead of flowing into storm sewers and may be a better water provision system for buildings that do not generate enough greywater to sustain a particularly drought sensitive mix of plant species.

Best Practice #19: Encourage development of living walls to complement green roofs

Case Study Location: Minneapolis, MN

Description

Living walls are similar to green roofs in that they are designed to offer many of the benefits that green roofs do, such as stormwater retention and mitigation, the reduction of the urban heat island effect, purifying the air, and reducing energy costs. The main

difference is that living walls are vertical instead of horizontal and face more structural and design challenges than extensive rooftop gardens.

However, living walls can be used to complement existing or proposed green roofs. Living walls can provide extra stormwater management services by absorbing excess water in times of increased rainfall when a green roof has been completely saturated. Living walls also have greater visibility and have the potential to generate more awareness and support while complementing the natural, open "feel" of places.

Additionally, living walls may be more appropriate for buildings that cannot support the load of a rooftop system and provides a viable alternative in these situations. Living walls are also cheaper to construct, which might be ideal for businesses that may not be able to financially support the cost of constructing a green roof.

Image 5 – Seward Child Care Center living wall

Image Source: The full story – Seward Child Care VGM living wall in Minneapolis
http://tournesolsiteworks.com/wordpress/

Context

The Seward Child Care Center in Minneapolis wanted to better manage its stormwater, but did not have adequate funds to justify the construction of a rooftop system. Although the center received a grant from the Mississippi Water Management Organization, the funds were still insufficient and the designers moved toward a living wall model.

Since Minnesota winters are harsh, the living wall requires a deeper layer of soil to insulate plant roots, which created an extra weight burden on the outside wall of the facility. However, the plants in the living wall have thrived since the wall was reinforced to support the weight of the garden. Additionally, a greater mix of ornamental plants compared to native plants had to be employed to ensure a greater rate of plant survival.

Relevance

The living wall model may be suitable for Minnetonka's older structures that may not be able to support the weight of a green roof or for businesses that have insufficient funding and cost incentives to implement such a project. Living walls could also contribute to the natural, open feel that the City has strived hard to create and maintain. Lastly, living walls could be implemented as a stand-alone project for business owners or in conjunction with larger green roof projects to absorb excess stormwater in times of rainfall.

Best Maintenance Practices

Best Practice #20: Develop comprehensive maintenance plans

Case Study Location: Indianapolis, IN and Denver, CO

Description:

Green roofs cannot just be built and left alone since they are constructed on buildings and are affected by the change of the seasons, storms, and general aging over time. Prior to constructing a green roof, it is a best practice to outline a maintenance plan with detailed tasks and agreement of delegation of tasks. Leila Tolderlund, a professor at UC Denver, outlined several strategies for Colorado and the West in her 2010 report. The maintenance tasks should be specific, like for example tasks after floods and storms, versus tasks changing with the seasons (Tolderlund, 2010). Some of the other tasks Tolderlund highlights are membrane maintenance, drain inspection, and irrigation system maintenance. Tolderlund also mentions the parties that maintain the green roofs in a few case studies. For example, Denver Public Library employees maintain the roof on the Denver Public Library, while Weston Solutions, a subcontractor, maintains the EPA Regional Headquarters Building in Denver.

The City of Indianapolis has also instituted detailed maintenance plans and maintenance delegation early in the process of green roof projects in its Stormwater Design and Specification Manual. The City provides a detailed checklist form that includes structural inspections, vegetation inspection, growing medium inspection, and an "other" category (City of Indianapolis). The checklist has a signature line at the bottom with both the inspector and engineer/consent holder's names in order to ensure multiple levels of review. The manual also recommends "early communication between the design team (developer, civil engineer, architect, landscape architect, planner, roofer, etc)," (City of Indianapolis). All parties shall agree on the feasibility of the green roof and maintenance plan before moving forward.

Context

Denver is located within a semi-arid to arid climate, which presents different maintenance issues. Since it is drier and sunnier than the Midwest, the roofs will likely need to have more maintenance procedures that can occur from those unique climatic conditions.

Indianapolis is somewhat comparable to Minnesota in terms of climate. Therefore, the maintenance procedures outlined in the manual would be directly applicable to any green roof project in Minnesota. The manual is also very general, so it could also be applied to a variety of contexts.

Relevance

Developing a maintenance plan and delegating maintenance tasks prior to building the green roof is essential to the success of a green roof project. Minnetonka should use both of the case studies from Denver and Indianapolis to develop specific tasks, as well as open a dialogue about what parties should design the green roof and who should maintain the

green roof. By delegating maintenance tasks early on, planners can get a better sense of the long-term costs to owning a green roof. Developing a maintenance plan will also bring about discussions of the feasibility of the green roof in the long term. It is possible that developers or the City could afford to construct the green roof, but could not afford to hire an outside maintenance team for many years out. Or, the maintenance could be afforded if an extensive roof was built instead of an intensive roof.

Best Practice #21: Design irrigation systems appropriate for chosen plants and soil depth

Case Study Location: King County, WA

Description

Although a green roof with varied soil depth, topography, and plant species can bring the benefit of increasing biodiversity – as described in Best Practice 7 – these strategies also make maintenance of a green roof somewhat more complex. Various plant species will require different amounts of water, making irrigation of the green roof more challenging, particularly during the critical first year. Several green roof projects in King County, Washington illustrate why anyone considering developing a green roof should give careful consideration to the irrigation system they plan to put in place (Paladino, 2006). Furthermore, while irrigation is most important during the initial 'establishment period' when plants are rooting themselves in the soil, many plants often need continued irrigation, especially during extremely dry periods of weather.

The Justice Center of Seattle, WA incorporated a green roof into their new building in 2004. The roof's design specified irrigation of the roof vegetation during the establishment period only, with temporary hose bibs installed to irrigate from below. However, inadequate irrigation during a dry summer in 2005 resulted in the need for replanting about one-third of the green roof's plants. The Center moved afterwards to watering the roof from a pop-up irrigation system twice a week for 20-30 minutes (ibid, p. 17). On the other hand, the Seminar II building at Evergreen State College in nearby Olympia, WA had better success with their green roof thanks to a well-designed irrigation system. This green roof, built in 2003, was designed with a soaker hose system to irrigate the roof regularly during the establishment period, and for extremely dry conditions beyond that. After watering for 30 minutes twice a day for the first 3 months, they found that watering every day during the summer months, as well as every other day in September and October, was an effective strategy for success of the green roof (ibid, p. 22-23).

Context

King County, WA is home to Seattle and several suburbs surrounding it, and several of the green roofs profiled in this case study were located in suburban ideas, making them good examples to inform other potential suburban green roof projects. The climate of this area, with precipitation extremes of both dry and wet periods, also makes these green roof profiles relevant for other green roof projects to look to for guidance.

Relevance

This case study of several green roofs in the Pacific Northwest – some successful and some not – clearly illustrate the need to have a well-designed irrigation system incorporated into any green roof project. Because Minnetonka experiences extreme temperature and precipitation extremes, the City should research what levels of irrigation would be required for various plant species that might be considered for projects in the city. This information should be published to inform residents and building developers as they design green roofs.

Best Practice #22: Recycle graywater from commercial buildings
Case Study Location: United Kingdom

Description
Rooftop environments can be harsh to plant life with exposure to high winds, dry conditions, solar radiation, temperature fluctuations, and often time shallow soils. Although water is a limiting resource for the viability of some green roofs vegetation, the use of potable water in such applications is considered undesirable and unwise. As such, traditional green roofs tend to rely heavily on hardy, drought resistant plant species for planting.

However, commercial buildings can provide potential sources of water for less drought resistant plants and are capable of producing thousands of gallons of greywater daily, depending on their scale. Less polluted and cleaner sources of greywater, such as that from hand basins and sinks, may be used directly in more traditional green roofs that employ the use of soil-based vegetation.

The Green Roof Water Recycling System, or GROW, was developed in the United Kingdom and uses semi-aquatic plants to filter and treat sources of greywater produced in a building. Greywater from sinks is pumped up to the roof where it is taken up by the roots of these plants to be cleansed. Then, the cleansed water is sent back down into the building to be used for other activities that do not require potable water, such as the flushing of toilets.

Context
The GROW system was developed in the United Kingdom to help meet sustainable water goals and is currently being adapted for smaller scale developments, such as individual households. The GROW system relies on a variety of semi-aquatic plants so that if one species is less tolerant perishes from an overly dirty source of greywater, there will be other plant species to make the system resilient until the dead plants can be replaced. The system does not require lots of maintenance and is intended to be a low-tech design.

Relevance
The GROW system could be adapted to Minnetonka using native species from Minnesota that are semi-aquatic. In this way, the city would be supporting native habitat creation that also serves as preservation areas in such a way that will recycle sources of greywater produced in commercial buildings. This system also helps to enhance water quality

because overall, fewer water resources are being utilized to support the daily uses of these particular commercial developments. Maintaining water quality is an important policy outlined in the City's comprehensive plan and an adapted GROW system certainly helps meet this designated guideline.

Additional Best Practices

Best Practice #23: Develop and maintain a green roof inventory

Case Study Location: Seattle, WA

Description

A green roof inventory is an important planning tool in developing green roof projects around a city. Green roof inventories identify existing green roofs and potential candidates for green roof projects. An inventory can help guide an ordinance document or where tax incentives or other rebates could go, based upon their potential and feasibility. A green roof inventory is also a useful tool in sharing information with the public about where green roofs are located.

The City of Seattle released a green roof inventory in 2010, which was aimed at providing a context for the further development of green roofs in Seattle and beyond (McIntosh, 2010). This baseline information will inform future data about who has built green roofs, what is the annual rate of green roof building in the city, and how Seattle compares to other cities (ibid). To complete the inventory, data was collected through online research, phone interviews and site visits. The inventory included locational information, size of the green roof, type, plants, accessibility, motivation for building, parties involved in construction, etc. (ibid, p. 3). The largest proportion of green roofs from the 2010 inventory was on residential buildings, followed by commercial, and public buildings.

Context

As a large city with ambitious goals to keep up with the latest in green building techniques, Seattle saw an inventory as an essential tool to help compare themselves with other cities. As a progressive city, this is not surprising that they made the inventory a priority. Getting a baseline of data about green roofs will be helpful for Seattle to understand what motivates green roof building and how it will change over time. The City has assumed that green roofs will continue to grow and expand throughout the city, making a baseline of information a useful tool. Green roofs likely have a greater impact in the Pacific-Northwest due to the volume of annual precipitation and frequency of precipitation. Green roofs also can be utilized year-round in Seattle due to mild winter conditions.

Relevance

Since Minnetonka is in the beginning stages of pushing for green roof projects, completing an inventory as soon as possible would be the best way to begin a baseline of green roof information. That way, over time, the City can see its progress in how its policies,

incentives, etc. have impacted green roof projects. This information could be persuasive in making the projects more of a priority for the City. Completing an *existing* green roof inventory in Minnetonka would be less expensive and have a shorter timeline than the inventory completed in Seattle. However, completing an inventory of *potential* green roofs would require more City resources and experts in determining potential feasibility of green roofs in the city.

Best Practice #24: Utilize rooftop gardens for commercial farming of produce
Case Study Location: Whole Foods – Brooklyn, NY

Description
The grocery chain Whole Foods has plans to construct a new store in Brooklyn, New York. Unlike other Whole Foods grocery stores the store will feature a 20,000 square foot garden on its roof. In fact, this is the first grocery store in the U.S. that has an attached rooftop garden. This creates a local food experience unlike any other. Even grocery stores that get much of their produce locally still must rely on some sort of automobile to have the food transported to their shelves. The produce in this store will literally travel mere yards before a consumer purchases it.

Presently, Whole Foods in New York had relied on rooftop farmers in Greenpoint, Brooklyn for its local produce. These same farmers were some of the few local food producers that were able to keep producing and selling in the aftermath of Hurricane Sandy. Whole Foods is now commissioning this same company to construct its rooftop garden, enabling this location to do the same following a potential natural disaster. Whole Foods hopes that this will act as a model for other businesses in the city that rely on fresh produce.

Image 6 – Artist's rendering of Whole Foods' proposed rooftop greenhouse

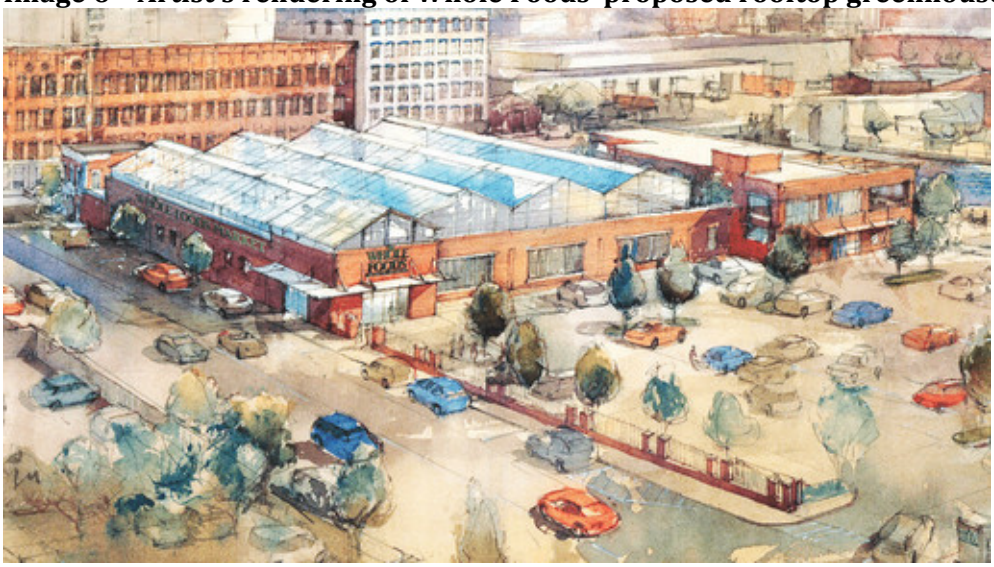


Image Source: http://www.cityfarmer.info/2013/04/08/local-brooklyn-whole-foods-will-have-a-20000-square-foot-rooftop-greenhouse/

Context
In a city like New York where open green space is sparse and the ease of transporting can be cumbersome and expensive, access is everything. Not only is it nearly impossible to get produce that is truly local in New York, any produce purchased from anywhere within close proximity of the city is going to have a high price tag as a result of transportation costs and scarcity. By bypassing the middleman and growing produce themselves Whole Foods is increasing the freshness of foods purchased, decreasing carbon emissions by doing away with the need for motorized transport, and reducing the store's carbon footprint by keeping the building cooler. This appears to be a no loose situation.

Relevance
A city doesn't need the density or demographics of New York to realize that this is a good model for any grocery store. The store reduces the amount of time it takes to get from the farm to the store while at the same time drastically reducing the energy costs that the building produces. Not only could Minnetonka's grocery stores benefit from this model, but also any of its big box retail stores that possess an abundance of unused roof space could adapt to a similar practice. Even if retail stores couldn't use the products of the food garden directly a local grocer or farmer's market would surely make use of it.

Best Practice #25: Utilize green roofs to pretreat wastewater from industrial buildings
Case Study Location: Mannheim, Germany

Description
In addition to utilizing greywater sources from commercial buildings, wastewater from industrial uses can be pretreated using a specific green rooftop design. Wetlands green roofs present an exciting new range of possibilities, particularly their ability to treat contaminated water used in industrial applications through their unique characteristics.

The John Deere Works building in Mannheim, Germany defies traditional green roofs thinking with its wetlands green roof. The building, which houses a factory that produces tractors for the company, innovatively uses its own wastewater to maintain its wetlands green roof. The wetland grasses and plants contain microorganisms in their roots, which actually purify the wastewater to a certain degree before it is sent to the municipal wastewater treatment facility for further treatment.

Context
Leaders at the John Deere Works facility in Mannheim, Germany had already envisioned using wetlands to treat industrial wastewater when they decided to place the wetlands atop the building due to limited land availability. The wetlands green roof, which efficiently utilizes space and resources, pretreats more than 2,500 gallons of wastewater daily. The biological oxygen demand of this pretreated water has been reduced by approximately 65%, which has further reduced the facility's wastewater treatment costs by 60%. However, due to the limited load capacity of the rooftop, this hardy wetland system is entirely hydroponic, unlike traditional wetlands, which rely on gravel, sand, or soil bases.

Relevance

The City of Minnetonka prides itself on the preservation of its natural environment, which includes wetlands, and the management of its water quality. The utilization of wetlands green roofs will serve as additional preservation areas for native species of grasses as plants that could also serve as habitats for various other animal communities. Paired with phytoremediation techniques, these wetland systems could have the potential to treat more harmful pollutants, including airborne sources of mercury, which affects Lake Minnetonka. Phytoremediation is the process by which plants or other microorganisms filter harmful pollutants and chemicals from contaminated water or soils.

Summary of Best Practices:

1. Integrate Green Roofs into Comprehensive Plans
2. Incorporate green roofs into Stormwater Management Plan
3. Mandate green roofs on new buildings
4. Incentivize green roof development via green roof subsidization
5. Incentivize green roof development via project grants
6. Incentivize green roof development via tax abatement or utility fee credits for buildings with green roofs
7. Require adherence to proven standards such as FLL guidelines in green roof design, construction, and maintenance
8. Use building zoning amendments to encourage green roof development
9. Develop resources for public education about green roofs
10. Conduct cost-benefit analysis to inform stakeholders of green roof benefits
11. Facilitate community empowerment
12. Foster community engagement
13. Implement systems to track metrics
14. Develop ecological measurements and targets
15. Consider carefully whether to develop Extensive or Intensive green roofs systems
16. Determine existing and required structural capacity of roof for retrofits.
17. Incorporate designs that increase plant and wildlife biodiversity
18. Employ the use of native species to increase preservation areas
19. Encourage development of living walls to complement green roofs
20. Develop comprehensive maintenance plans
21. Design irrigation systems appropriate for chosen plants and soil depth
22. Recycle graywater from commercial buildings
23. Develop and maintain a green roof inventory
24. Utilize rooftop gardens for commercial farming of produce
25. Utilize green roofs to pretreat wastewater from industrial buildings

Discussion:

While various case studies were used to illustrate individual best practices, many cities mentioned employed a combination of several of these best practices. Some of the best practices focused on technical issues, while others were more planning and community oriented. Stormwater management is the main priority in building a green roof, with secondary priorities of energy efficiency and social benefits. Therefore all of the case studies presented discussed extensively how to design a green roof to maximize stormwater retention.

Besides the best practice for designing a green roof for stormwater management, other technical best practices included a maintenance plan and systems to track metrics. These three best practices work well together because they all help enforce and inform each other. Using metrics helps inform maintenance decisions as well as evaluation of the original design of the roof. Developing a maintenance plan pre-construction can assist with the development of the design due to physical feasibility or cost issues.

The green roof inventory and integration of green roof projects into comprehensive plans are useful citywide best practices for the development of a green roof program. Having green roof projects in a comprehensive plan necessitates the need for a green roof inventory to evaluate how to move forward with the strategy.

Incentives for projects, fostering community engagement, and developing materials for the public are all about getting the community on board with developing a green roof program. Developing materials to the public should be the first step and then developing appropriate incentives for projects should follow. The City should lead the way in fostering community engagement through public green roof projects.

IV. Achieving Transformation – Challenges and Opportunities

To facilitate the City's goal of increasing green roof development, research was conducted to assess the understanding and perceptions of green roofs among potential green roof adopters in Minnetonka. Additionally, the research identified groups and relationships that would be ideal targets of green roof promotion efforts.

Data collection for this research was conducted through primary sources that included interviews with property owners, school district officials, green roof experts, and developers regarding their perceptions and thoughts about green roofs. We also referred to secondary sources such as existing literature on green roofs and sustainable building practices. Initial contacts provided by Jo Colleran, Natural Resources Manager for the City, included diverse stakeholders from the public sector, such as the park board, planning commission members, and school districts. The list also included individuals from the Minnetonka business community such as business managers, developers, engineers, facilities personnel, and operations and development managers. We also interviewed academics and green roof experts from our University connections. Approximately 70% of contacts accepted interview requests, indicating a general interest in green roofs by diverse stakeholders.

For the business owners and managers of buildings, our questions were framed to gauge their understanding of green roofs in general and assess their perceptions about the benefits of and potential obstacles to adopting green roofs. We were also interested to learn if the business community would be more likely to consider a green roof if they received financial incentives or technical assistance from the City government. The interviews with technical experts were more focused on the key considerations required to build a green roof. We wanted to learn if these engineers or developers encourage their clients to build green roofs and why. Additionally, we wanted to identify the key incentives and obstacles to constructing and maintaining green roofs.

Through our research and interviews, a model was developed depicting the complex nature of the issue, including the numerous stakeholders involved and the varying relationships present among them (see Figure 2 below). Stakeholders identified include Minnetonka residents, schools, technical experts, tenants and building users, building owners, and of course the City of Minnetonka itself.

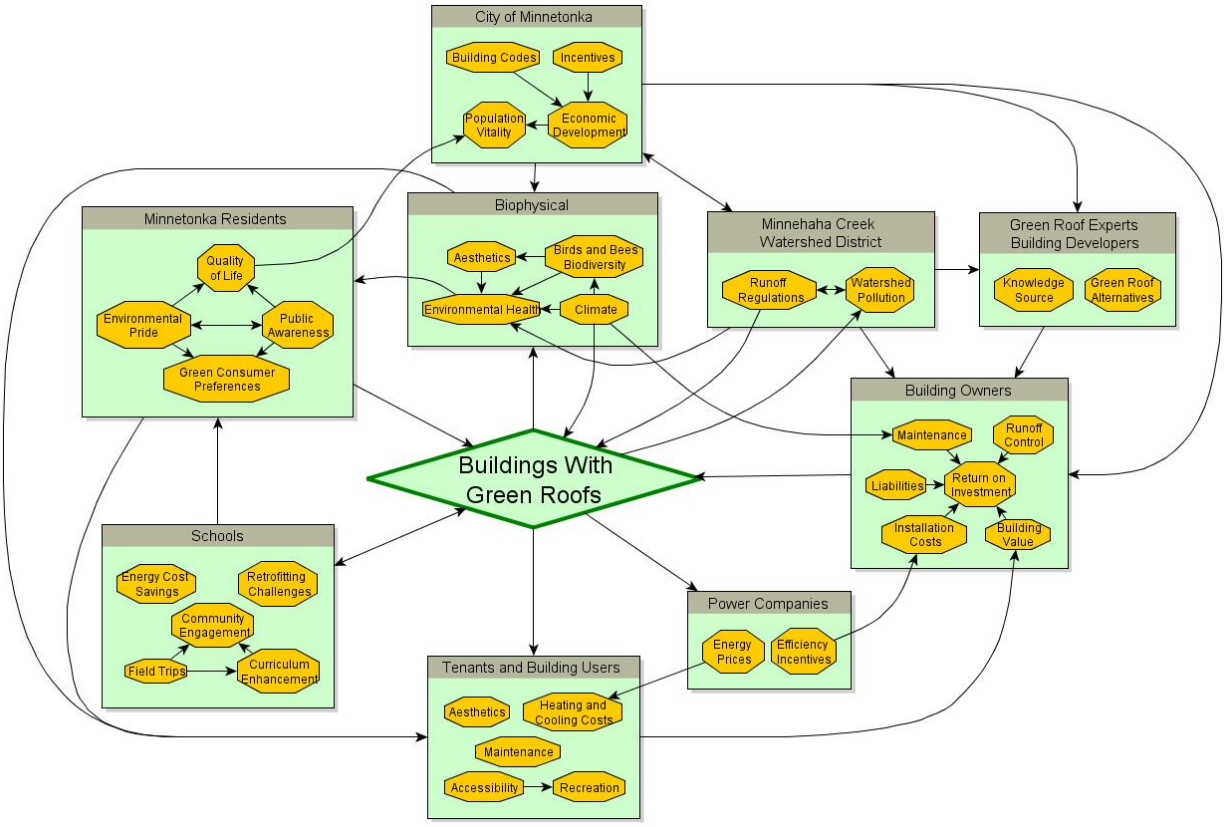


FIGURE 2: *Interactions and players surrounding the challenge of green roofs in Minnetonka. Players are grouped by category in green boxes. Within each category are major concerns or pieces (yellow hexagons) that determine how each category functions. Arrows indicate the dominant direction of effects between entities or concerns. For simplicity, arrows between categories usually show generalized interactions; in some cases, arrows link directly to concerns within categories indicating that these concerns are specific points of interaction for a category.*

Businesses and Citizens

We identified a disconnect between the priorities of building owners and building users - either business or residential tenants - who would receive most of the immediate benefit from green roofs. These benefits center on reduced heating and cooling costs and recreational space if the green roof is accessible. However, because building owners do not receive these benefits directly, they do not consider them while calculating green roof investment returns. Yet, building users' benefits might result in residual benefits for building owners through increased demand for office or apartment buildings with green roofs. A study by a green roofs researcher we interviewed found that office buildings in Washington D.C. with green roofs could charge 17% higher rent prices (Abbott et al, unpublished). However, this potential benefit was not identified by our interviewees in Minnetonka. Thus, one question that should be explored moving forward is whether this benefit would be transferrable to a more spacious suburban setting such as Minnetonka?

Regardless, creating an installation- and maintenance-cost sharing mechanism between building owners and long-term users could facilitate green roof adoption.

Our analysis suggests that building owners are more aware of the public benefits of green roofs – environmental health and storm water control – than the potential internal benefits of greater property values and reduced heating and cooling costs. Installation costs are perceived as being prohibitively high while not actually being understood. Additionally, green roofs are perceived to be hard to maintain with harsh Minnesota winters, while water management and irrigation are actually the more significant challenges. Therefore, any green roof-promoting policy should be accompanied by an education campaign to highlight the facts that (1) green roofs can be a good investment; and (2) green roofs can work in Minnesota. The 2.5 acre, 5-year old green roof on the Minneapolis Target Center provides an important example of both of these points.

Citizens and the City

One of the biggest attributes of concern for the City of Minnetonka is its ageing population. As the baby boomers age, the city faces several financial and structural challenges. A growing elderly population increases dependency on, and costs of, social services provided by the local government. In order to counter the substantial costs of this increased service demand, the City should seek to attract younger families to the city in order to maintain a large tax base and a healthy, diverse population.

Open green spaces are one of the key attractions for young families. Green roofs can provide green spaces even in the most developed areas. They increase the opportunities for recreation and also are great for the environment, adding to the appeal and beauty of the city. Increased numbers of young families and young people in the city can help improve the city's economic vitality and equip it with resources to provide the needed services for its ageing population.

The United States EPA has highlighted the myriad benefits of green roofs such as improved air quality, reduced pollution and greenhouse gas emissions, improvement of building performance, and storm water management (EPA). However, there are no active green roofs in Minnetonka. Through primary and secondary resources we have learned that there is ample interest in green roofs amongst stakeholders such as academics, city officials, and business owners in Minnetonka. Fear of high upfront costs, maintenance costs, inclement weather condition, and general lack of understanding about the operations of green roofs are some of the challenges identified for adopting green roofs in buildings.

Improving the city's aesthetics, recreational opportunities, and environment will also help attract younger populations into the city's predominantly ageing demographic. Citizens of Minnetonka take pride in maintaining their city's environmental and natural resources. Green roofs can play a role in this maintenance directly by providing habitat for biodiversity and aesthetic beauty. Those plants that survive best on green roofs in Minnesota while demanding the lowest maintenance tend to be drought-resistant, native prairie species that are adapted to Minnesota's climate. As seen with the Minneapolis

Target Center green roof, these species can provide prairie-like habitat to insects and birds that, in turn, might improve plant pollination, reduce landscaping pests, and enrich local sonic landscape through song (Maynard, 2009). Flowering species also can add color to the landscape, especially if green roofs are accessible as recreation areas. All of these elements would improve the biophysical environment of Minnetonka, increasing its attractiveness to potential new residents and maintaining or even increasing the values of its properties.

Considerations for Stakeholder Engagement

One of the central aspects of the green roofs project is the potential implication of green roofs for building owners who would incur the costs - as well as certain benefits of developing green roofs on their buildings. Some building owners and managers interviewed expressed limited knowledge of various potential benefits that green roofs could bring, both for them as building owners and for other stakeholders in the community. While certain benefits such as runoff control, environmental health, and improved aesthetics were cited by some interviewees, other important benefits that might have even more significant impacts for buildings owners, such as improved insulation, went unmentioned. Green roof experts interviewed indicated that improved insulation, which increases with the thickness of the soil cover, could result in significant costs savings related to heating and cooling costs for building owners or tenants.

Green roofs also contribute to the quality and quantity of Minnetonka's natural resources and biophysical environment. The extent of this contribution depends on how the green roof is designed, which will require collaboration between building and green roof designers, regulators in the MCWD and the City of Minnetonka, and building owners. The MCWD is a major governing body that manages the watershed and works with the Minnetonka Planning Commission to develop runoff control regulations for new and existing buildings. Since green roofs reduce the impermeable surface area of a building and therefore reduce runoff, they can help building owners comply with runoff regulations, especially for larger buildings. However, alternative runoff management strategies such as rain gardens or retention ponds are more cost-effective in suburban settings where open space is available in the absence of subsidies or building mandates. Any policy on behalf of Minnetonka to promote green roofs should address this fact.

Local businesses are perhaps the most important stakeholders regarding this issue, as they would likely be the first to install green roofs in Minnetonka. Education about green roofs will help them learn more about the costs and benefits of green roof development, and assess the long-term return on such a significant investment. Although upfront costs of green roofs tend to be high, over time they pay for themselves through energy bill savings from increased thermal efficiency in buildings and other benefits. Local government can also provide storm water-related or other tax credits to help offset costs sooner.

For building owners, the decision whether or not to install a green roof simply often boils down to a question of return on investment. To determine if the future benefits of a green roof outweigh the initial and ongoing costs, our interview findings have suggested that stakeholders need to be better informed about the estimated costs that would be incurred

by installing a green roof, as well as the benefits they can directly realize. Architectural design firms and green roof specialists could play an important role in promoting green roofs tailored to Minnetonka's built and natural environment. However, design firms and project managers do not necessarily have adequate knowledge of the tradeoffs associated with green roofs to allow building owners to choose between higher upfront costs and lower long-term expenses, largely because upfront costs are unknown. Therefore, we see a need for a link to be facilitated between green roof experts, building developers, and building owners. The experts may function as an important knowledge source for building owners and design firms considering whether or not to install a green roof on a building.

Other major concerns of building owners include ongoing maintenance costs. Another individual expressed concern over the fact that some buildings were not designed for green roofs and would require large costs to redesign the layout of rooftops or even floor plans. In the case of a school, this could possibly lead to the loss of classrooms, making it difficult for decision makers to be attracted to the idea of green roofs. Moreover, concern over liability for building owners who allow access for people to green roofs was also mentioned. The City of Minnetonka will have to work with the technical experts and the academic community to educate the people on the benefits of green roofs. Widespread adoption of green roofs by businesses will help them save money in the long run and also help the city's environmental health and economy.

V. Education is Essential

Education, regulatory policies, and incentives are likely avenues to achieve the transformation described above and encouraging the adoption of green roofs in Minnetonka. These inter-related, complimentary transformations will address the current lack of education and motivation to adopt green roofs among businesses and building owners. Interviews with various stakeholders revealed that education is the first and primary challenge that needs to be addressed.

Education can be treated as a system to develop green roof policies and adoption by increasing awareness of their costs, benefits, and building limitations in order to increase the number of green roofs in Minnetonka. Education can effectively inform all stakeholders about the costs and benefits of green roofs to the city, it's businesses, and the environment. Education on green roof should inform stakeholders by addressing the following questions:

- What are green roofs?
- What are the benefits of green roofs (both public and private)?
- What are the costs to develop and maintain a green roof?
- How can the City of Minnetonka help building owners adopt green roofs?

Very few stakeholders had extensive knowledge of what could be gained from green roofs, with the only common belief being that green roofs are expensive to install. One local design firm interviewed reinforced this finding by noting that the biggest factor they experience in customers shying away from green roofs is the upfront cost of installation. What many potential adopters overlook, however, is that these costs are often recovered within the first few years through energy savings. Green roofs improve roof insulation, which can result in substantial energy cost savings, particularly during hot summer months: Green roofs can reduce energy demand for air conditioning by as much as 75% (Liu and Baskaran, 2003). Consequently, education about the benefits of green roofs should focus on helping businesses and the general public expand their investment horizon beyond initial capital costs by providing information about the medium to long-term benefits of green roofs, which in most cases will more than offset the substantial upfront costs of installation.

The targeted education of key Minnetonka regulatory agencies would also be fruitful for improving green roof adoption. One Minnetonka park board member mentioned that although the City has very open-minded staff, Minnetonka already has a lot of green space, implying that this is not a priority issue for the city. Therefore, focusing on the public benefits of green roofs, which can impart significant cost savings to the City, is imperative. Reduced storm water management will allow significant energy savings, and climate change is expected to increase these potential savings by causing increasingly extreme rainfall events that can cause flash flooding such as Duluth, MN as experienced in 2012 (Seeley, 2012). Savings to the city will also grow in the longer term by improving the appeal of Minnetonka to young families.

Key City agencies to target include the Department of Public Works (DPW). As the caretaker and manager of Minnetonka's sewer systems, the DPW could be an important ally by pushing for the runoff management savings that green roofs can provide. The

Planning Commission, meanwhile, will be important for helping develop incentives to encourage green roofs. This power comes from their role of "guiding development and protecting the environment", including the stipulation that buildings over 5000 square feet pre-treat their runoff. The Minnetonka Park Board plays a similar role through the maintenance of park dedication fees to new buildings and its task of developing adequate green space and environmental resources for Minnetonka.

Educating businesses on how to make green roofs a reality is also an important aim of the transformation. Our scoping identified that businesses and other entities were unsure what the laws and regulations were to set up green roofs, especially in situations where remodeling a building's infrastructure was required to accommodate green roofs. For example, even if building owners were interested in building a green roof, they were unsure if the building codes would allow them. The remodeling issue is especially important in Minnetonka, where more than 95% of available space is already developed. Issues such as how to legally pursue green roofs and what governmental entity would be the contact and regulatory point for moving forward were frequent concerns in interviews. Consequently, education about laws and procedures is necessary. Because they are ultimately responsible for obtaining proper permitting, potential adopters should be the primary targets of this education.

The education material should be disseminated keeping in mind each group of stakeholders. A general brochure about the basics of green roofs, its benefits, costs, and contact information for further customized details can be very useful. Also, the City can set up town hall meetings, presentations with business-like groups including Rotary International or the Chamber of Commerce to educate businesses and general public on the benefits of green roofs. Framing for these groups should focus on cost savings to building owners, especially through utilities, with secondary attention given to improved public relations. For business-activist groups like Rotary, an emphasis on promoting the long-term vitality of Minnetonka could also be a persuasive component.

Choosing education agents is also important. The City can employ experts such as green roof design firms or University researchers to talk to contractors about green roof development in both new and existing buildings. The City could also provide grants for research on green roofs within Minnetonka, including cost-benefit analyses and best practices for green roof projects of various sizes.

There are several means to educate people on green roofs. Free classes, online information, presentations to business or community groups, and published reports are some of the ways information could be disseminated. However, to ensure the credibility and validity of the information, the City should work with researchers and experts to accumulate context-specific and accurate data.

VI. Recommendations

The graphic below maps potential interventions aimed at achieving our goal of educating businesses and other key stakeholders to encourage green roof development in Minnetonka.

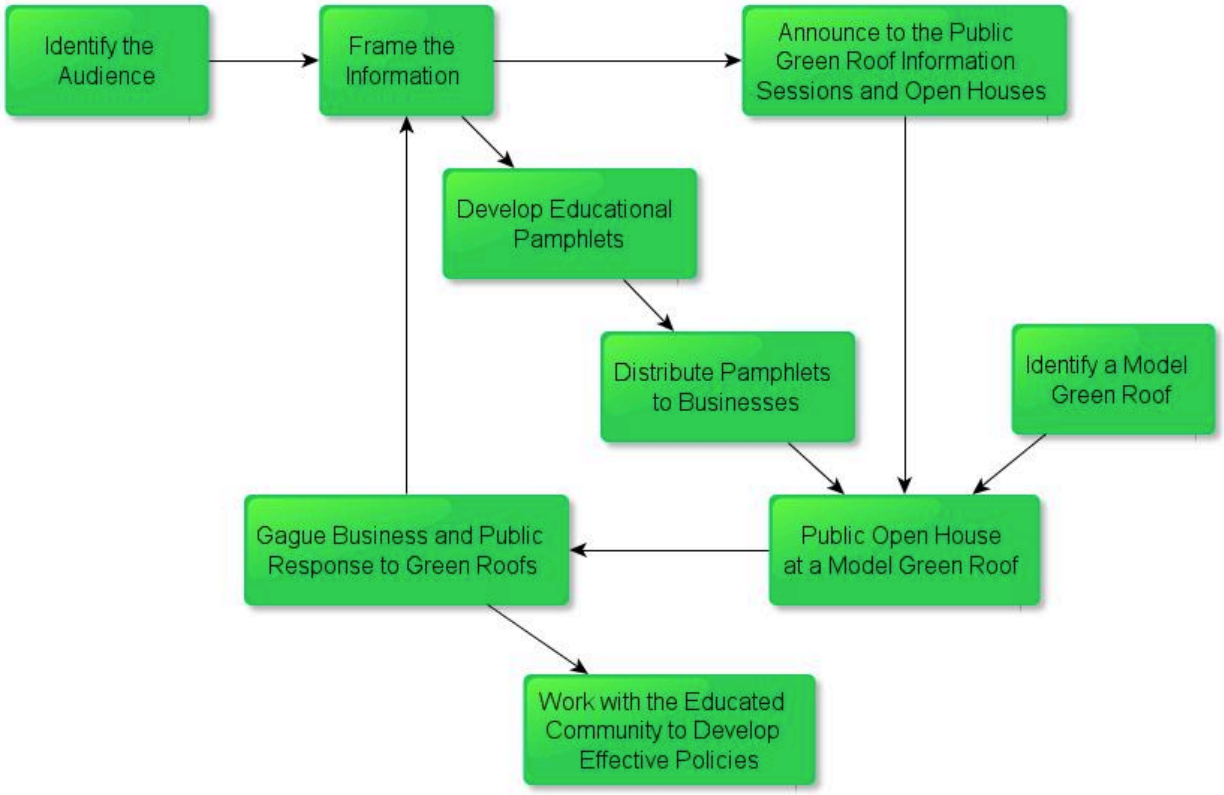


Figure 3: Workflow of Proposed Transformation. Steps begin with identifying an audience from the City government or business community. The goal is to be able to work with educated businesses and City officials to develop sound green-roof promoting policies.

The diagram starts with the City of Minnetonka, specifically the Natural Resources department, assessing exactly who the key audiences for green roof education are. Our scoping work showed that the businesses and building owners have a superficial level of knowledge but are interested in learning more about green roof implementation, benefits, costs, and potential policy incentives. Our team also identified the significant role that technical experts could play as key partners in this endeavor. Firms such as Sustology, a local firm focused on sustainability that specializes in green roof design, could provide data outlining the projected costs and benefits of various green roof projects in Minnetonka.

It will be important to work with all partners to identify appropriate materials for education such as pamphlets, newsletters, workshops, free courses, customized technical advice, or networking opportunities. For example, a presentation at the Chamber of Commerce for local business owners could be effective for local business owners, while an

informational pamphlet (see Appendix A for sample pamphlet template) or newsletter article might be sufficient to increase knowledge among the general public, thus raising the interest of potential green roof adopters. The aim is that the education provided will increase knowledge and awareness of green roofs among stakeholders. They will consider and prioritize green roofs when thinking of sustainable building practices in both old and new buildings.

It's also important to identify potential feedback loops and ensure a continuous means of monitoring, evaluating, and responding to the efficacy of the model. This will help inform the City about its performance and manage its activities to achieve the desired results. Feedback loops within Figure 3 highlight where education materials and techniques can be improved to ensure they are inclusive and effective in order to maximize their utility.

Appendix

Appendix A - Template for educational pamphlet about green roofs

What are green roofs?

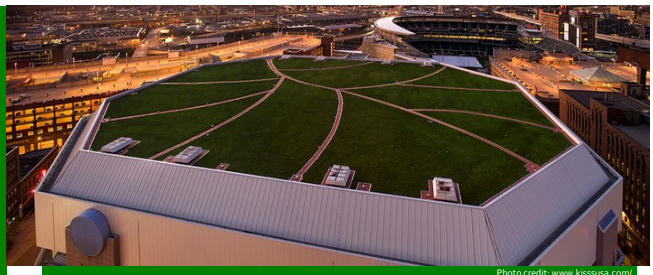


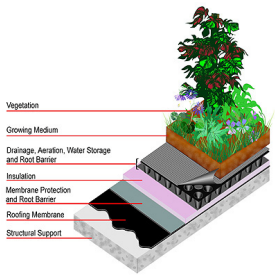
Photo credit: www.kisssusa.com/

Present some key fact here about green roofs (or data about realized benefits/savings from green roof projects that have been implemented)

The benefits of green roofs

The costs of green roofs

Photo credit: greeningthecity.wordpress.com/



How the City can help

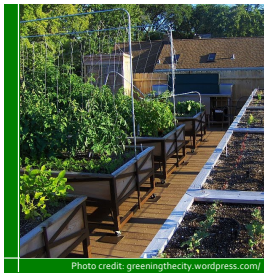


Photo credit: greeningthecity.wordpress.com/

How you can learn more

GREEN ROOFS

For a Vibrant Minnetonka

Insert an artist's rendering here of a Minnetonka building with a large green roof.

City of Minnetonka

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