Sprouting Roots At Sarah Lawrence College

Prospects of Adding A Green Roof or Biowall to Campus

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Building a Green Roof

- Two types: extensive and intensive
  - Extensive roofs: Minimal upkeep
  - Shallow soil → good home for short rooted plants
    - Herbs, grasses, mosses, succulents
  - Intensive roofs can sustain bigger plants such as trees and large shrubs

Energy

- Provided Insulation → lowers AC costs 8% for every decrease of .5℃ in internal temperature
- If temperature is between 25 - 30℃, temperature can decrease 4℃ → yields 64% decrease in AC costs
- The floor immediately below green roofs experience greatest decrease in temperature but changes can reach up to 4 floors below
  - Aside from Hill House, SLC has no building exceeding 4 floors

Runoff

- Large cities have more impervious surfaces which increases movement of pollutants reaching waterways
- 95% of runoff is absorbed in forests while only 25% is absorbed in cities
- In New York, ~50% of rainfall events cause CSOs (combined sewage overflows) → ~40 billion gallons of untreated water
- Between 60-100% of runoff can be reduced and recycled

(TOP) Green roof on Dormitory A of Butler College Section of Princeton
(BOTTOM) Research at by student and faculty mentor on Princeton greenroof

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Building a Biowall

-built on panels with plants growing over 6-12 months
-made of plastics, geotextiles, vegetation and irrigation
-built to simulate nature using hydroponics or aeroponics

Drexel Biowall, located in the new Papadakis Integrated Science Building. Microbial communities living on plant roots help filter the air within the building, producing enough fresh air per minute to sustain two thirds of the fresh air requirements for 300 to 600 individuals. Designed by Nedlaw Living Walls and maintained by Parker Plants.

Psychological Impact

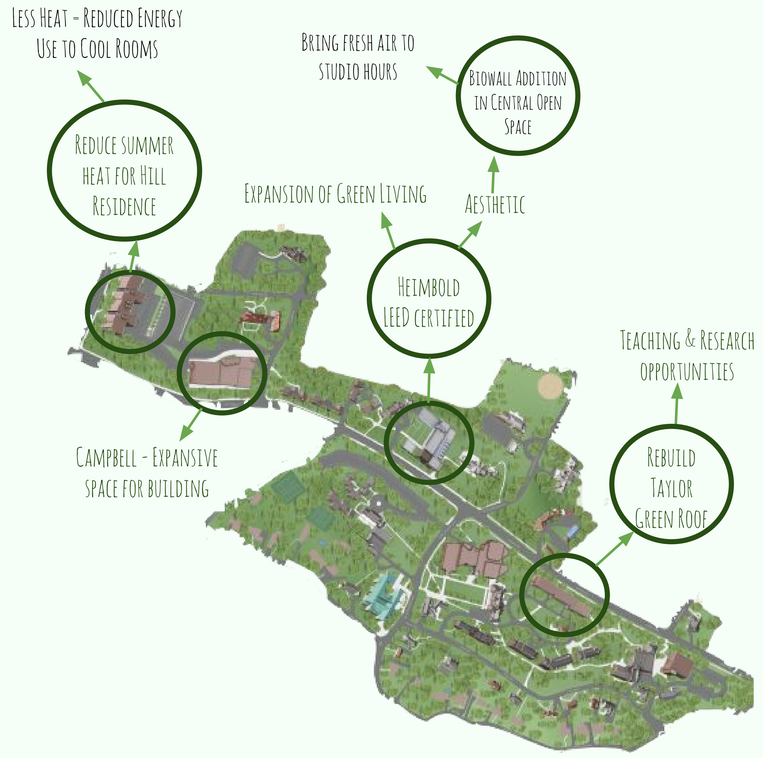
- Exposure to natural environment can result in mental health benefits
- Green color = sense of ease and pleasure
- Green and blue color has low intensity light wave, which cause less strain to process color.
- Help people concentrate under stressful/negative environment

Indoor Air Quality

- Indoor air quality is a huge issue in college buildings
  - air pollution is 25% higher in college settings than non-academic environments
    - Especially in older buildings such as the Performing Arts building
- Bio wall and green roof can remove harmful toxic pollutants such as: nitrogen dioxide, formaldehyde, and twenty other prevalent air toxins
- Removal of toxins reduce change of respiratory illness
- Increase in indoor air quality from bio wall and rooftop garden can increase academic and work performances
- Clean air = increase in brain's neurological activities

Potential at Sarah Lawrence College

- Modifications to rehabilitate the Taylor green roof eliminates cost of rebuilding
  - Rebuilding could happen on a volunteer basis or used as course framework
- Some institutes combine green roofs and solar roofs
- The new Barbara Walters campus building could have plans for the inclusion of a biowall
- Examples to refer to: Drexel Biowall, UPenn green roofs, Colombia, HighLine, among other NYC green movements



Current state of Taylor Green Roof - March 2016

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Global Change Biology
13 March 2016

The installation of green spaces can be an economically and environmentally productive investment. Pollutions, heat-island effects, and energy waste are all issues Sarah Lawrence College faces simply from its location near a major city. With the implementation of green roofs or installation of an indoor Biowall there would be an opportunity to decrease the environmental impacts the college creates and help sustain the dorms and buildings in a more fiscally responsible manner.

Green roofs and biowalls have been found to have positive impacts on the environment and mental health. Green roofs provide insulation that reduce energy costs for buildings annually, both in cooling and heating. They help prevent runoff of pollutants into river ways and water systems. Increased air flow due to recycled oxygen via plants can clean the air, resulting in reduced carbon and other excess gasses in the air outdoors or by cleansing the air indoors, which, according to the EPA, can lead to better mental states for students and teachers. Below, we've outlined in more detail the positive impacts of green roofs and biowalls and examples from other institutions to help inspire a stronger green movement at Sarah Lawrence College.

Energy

High temperatures caused by the heat island effect in cities can increase energy costs to keep buildings at reasonable temperatures during heat waves. For buildings on campus using air conditioning, energy costs could be reduced up to 8% by every decrease in internal temperature of .5℃ from green roof insulation (Getter & Rowe 2006). Green roofs have been found to reduce indoor temperatures by up to 4℃ if temperatures are between 25℃ and 30℃, resulting in a potential 64% decrease in air conditioning costs (Getter & Rowe 2006). In many studies, it has

been shown that cooling of entire buildings have increased due to green roofs, with the floor immediately below the roof receiving the most significant change in heat loss (Orberndorfer et al. 2007). In a a peak demand situation, heat loss was seen down to the fourth floor below the green roof (Orberndorfer et al. 2007). Evapotranspiration that occurs on green roofs is potentially the leading cause of reduced heat in buildings during the summer months, as well as increased insulation and physically shading the roof (Orberndorfer et al. 2007).

Runoff Prevention

Green roofs provide soil mass to take up rainwater and prevent increased runoff. City runoff is especially harmful, relocating pollutants from sidewalks, streets, and other impervious surfaces to water ways. Residential developments of the U.S. are estimated to have only 10% of impervious surface coverage while industrial areas reach between 71 and 95% (Getter & Rowe 2006). Roughly 25% of water from storm runoff is absorbed in these cities opposed to the 95% absorbed in forests (Getter & Rowe 2006). Excess runoff can increase property damages as well as chance of human harm. In many cases, runoff will surpass channel capacities, overwhelming sewer systems and causing raw waste to be dumped in rivers. About half of all rainfall events that occur in New York lead to CSO (combined sewage overflow) leading to ~40 billion gallons of untreated wastewater to be dumped in New York's waterways annually. Adding green roofs can reduce stormwater flow between 60 and 100% and allow for the harvesting of rainwater to be recycled for other purposed by rain gardens or other hydraulic systems (Getter & Rowe 2006, Orberndorfer et al. 2007).

Indoor Air Quality and Health

Indoor air quality can have a significant impact on learning environments. Adding green spaces, like biowalls, can help institutions improve indoor air quality and manage air quaility maintenance.Colleges and other large body institutions have ~25% higher air pollution than non-academic environments due to the large concentrations of people. Lack of proper ventilation systems hinder concentration abilities of students and staff. High- density facilities, especially in older buildings and buildings utilized for craftsmanship and performances (such as the PAC at Sarah Lawrence, among most art buildings), have a higher rate of passing respiratory illness to students and staff through toxin and bacterial particles in the air (EPA, 2007). The bio-wall can remove harmful toxic pollutants such as nitrogen dioxide, formaldehyde (the primary cause of asthma found in furniture and walls), Carbon Monoxide, and twenty other prevalent toxins in the air depending on the plant utilized (Green, 2015). The removal of toxins and air purification can reduce chances of respiratory illness such as lung cancer, asthma, pulmonary disease, excessive dizziness and skin diseases such as atopic dermatitis (EPA, 2007).

Biowalls are well known for their ability to filter and circulate fresh air, which increases academic and work performances. Microbial communities situated on plant roots aid in the biowall's ability to perform air filtration. Harmful airborne pollutants, referred to as volatile organic compounds (VOCs) are broken down by bacteria and fungi and used as food. These compounds are drawn directly through the wall, dissolving into recirculating water and proving carbon to the microbial root communities. The compounds can be broken down even further into carbon dioxide and water and help circulate cleaner air back into the space (Drexel). Higher air quality correlates with higher academic performance (EPA, 2007). The cleaner the air is, the

fewer toxins entering the brain, which increases the brain's neurological activities and facilitates the brain nerve's information relay (Lee, 2014). Fast informational connection between the body and the brain contributes to higher academic performances (Myhrvold, 1996).

Psychological Impact of Green Wall and Green Roof

From a psychological perspective, exposure to the natural environment can be associated with mental health benefits. It has been found that in working environments, especially stressful ones, plants, and green colors provide a sense of ease and pleasure to people (Gromicko, 2014). The way the human eye and brain interpret colors like green and blue requires less dynamicity as other color spectra (Kuehni, 2005). Colors are received as light waves. Green and blue color light waves enter our eye in a low wave intensity, reducing the amount of eye movement required to process the color. The color information itself is calm and stress-free for the eye and cranial nerves, creating a healing effect for people who see colors in the blue/green sphere (Kuehni, 2005). Adding greenery, especially in a the form of a biowall, would help destress individuals and reduce eye and nerve straining.

Biowalls and/or green rooftops help divert attention and provide an escape from the oppressive urban environment and academic intensive surroundings. The stressful academic and urban environment forces people to heavily focus on problems and issues around them in a negative way, which over-stimulates the brain (hard fascination). Biowalls and rooftop gardens bring relief from hard fascination by triggering soft fascination (Kaplan, 2010). Soft fascination has the same attentive component as hard fascination but also triggers pleasure. Green spaces can

create a positive environment where students and staff can concentrate on tasks with reduced stress levels (Kaplan, 2010).

Building A Biowall

There are many ways to build and customize a biowall for different needs. Biowalls are constructed by using pre-vegetated panels. Prior planning is essential for the installation process. It takes six to twelve months for plants to grow and fill the panels (Sharp 2007). Biowall panels can be made up of plastic, geotextiles (fabric in the soil that has the ability to separate, filter, reinforce, or drain), irrigation, and vegetation (Afrin 2009). More so than green façades (plants growing on the side of buildings), biowalls require intensive maintenance such as regular water, nutrients, and fertilizer (Afrin 2009).

To build a biowall, there are three basic designs. One option is to replicate what naturally occurs on the ground- roots embedded into the soil on a vertical surface (Hampton 2012). Another option is hydroponics. This is a system in which plants are grown in water without soil (Hampton 2012). A third option is aeroponics, in which plants grow in misted air. (Hampton 2012). No soil is involved with aeroponic plants. Nutrients are dissolved into the water and used as a concentrate when watering the plants. These granulated nutrients are natural minerals which would normally be found in the soil (Aeroponics Growing, 2015). Biowalls are completely customizable in the sense that they can cover as much as or as little area as one chooses

(Hampton 2012). For instance, larger biowalls, such ah the one located at Drexel, can be up to 80 feet tall, yet the size is adjustable based on the space and materials available. It all comes down to the same infrastructure design, and maintaining access to the plant-root zone (Hampton 2012).

Plants & Installation

Common green roofs come in two forms: extensive and intensive. Extensive green roofs have soil depths between three and six inches where intensive green roofs have soil depths exceeding six inches. Extensive green roofs cannot support larger plant species due to limited soil space and usually have ~10-20% organic matter (Plant Connection 2016), but can be built on sloped surfaces as plants are relatively small (Getter and Rowe 2006). They require minimal maintenance as plant species are limited to herbs, grasses, mosses, and drought-tolerant succulents, like Sedum, which require little water (Getter and Rowe 2006). Intensive green roofs provide a more sustainable environment for larger shrubs, bushes, and trees due to greater soil depths (Plant Connection 2016). Intensive green roofs can only be added to flat roof tops as the complexity and depth of soil and root systems cannot be supported at an incline and require maintenance.

Both extensive and intensive green roofs have similar construction elements. The design of these components depends heavily on the purpose of the green roof and the building load capabilities upon which the green roof is built. First, a root barrier is installed above normal

roofing to avoid root damage to the roof. Next there is a drainage layer that allows excess water flow off the roof. Here, there is an option to add a water retention fabric which can hold extra water for plant benefit. A filter fabric keeps silt and particulate matter in the media from clogging the drainage layer below. Finally, there is the growing substrate, such as soil, which is used to support plant growth (Getter and Rowe 2006).

Biowalls are made up of smaller individual panels, grown with plants, that are then placed side by side to fill a desire space. Biowall panels support a variety of plants, such as ground covers, ferns, low shrubs, perennial flowers, and edible plants. (Sharp 2007). Species are typically selected based on their tolerance of a growing system, site-specific environmental conditions, color and texture, rates of propagation, and root systems (Sharp 2007). Ultimately, the final choice of plant species are based on what works with the elements of the specific setting, including the space's light and its desired aesthetic (Hampton 2012). Prior to the date of delivery to the site, panels are grown horizontally, and then installed vertically (Sharp 2007). Biowalls are able to perform well in full sun, shade and for interior applications they can be used in both tropical and temperate locations (Sharpe 2007).

Sarah Lawrence College Green Space

Currently, Sarah Lawrence as two green roofs, however only one is maintained. One, situated outside Heimbold Visual Arts Center, is covered entirely in grass and is atop an

underground classroom outside the front doors. The second is on the Taylor Dorm roof. Having the groundwork for an already functioning green roof would prove beneficial to the school. Though unkempt, the Taylor green roof could be revamped and then maintained. This could be done by volunteer students on campus who are interested in the environment or in addition to a pre-existing class in the environmental/ecological sector of education. Other possible places for green roof installation include: LEED-certified Heimbold, Hill House, other New Dorm roofs, Campbell Sports Center, or the Performing Arts Center. Each of these places have some form of flat roofing that would be ideal for a green roof. Heimbold is already on its way to a green building and the addition of another green roof as well as its pre-existing solar panels would only further this movement. Hill House, which is inhabited by residents and students year round, would benefit from the addition of a green roof by helping reduce energy costs for cooling in summer and heating in the winter via increased insulation. New Dorms, Campbell, and the PAC are all areas with large, flat roofs that could be potential building areas depending on the feasibility of access for installation and study.

The biowall would, at present, be easiest to install in the new Barabara Walter Campus Center as it could be easily incorporated into design plans ahead of time. The space, time, energy, and money could be adjusted for preemptively rather than attempting to fit a biowall into a pre-existing building. However, another viable place for a biowall would be inside Heimbold.

There's a large open space in the center of Heimbold that a two-story biowall could be fitted to. The insertion of a biowall in Heimbold would be beneficial due to its ability to cleanse the air. Though most building have students in and out all day, Heimbold has students who spend hours in art rooms where they are unable to move their studying and working space due to the equipment needed. A biowall would help circulate air and provide fresh, "outside" air to students who are stuck indoors, ingesting chemical fumes from the art supplies they work with. It would be a good opportunity to provide students with the same health opportunities as a student who is able to study outside or at the very least, change their study location.

The green roof or biowall could provide an opportunity for students and staff alike to join together for a project and provide research opportunities to students who are unable to do so. As campus is filled with activists, many of which are concerned about the environment, there would be an opportunity to open construction up to volunteers. It would also open doors to conference topics students are normally limited by. One consideration would be for students to merge the sciences and arts and use plants grown from either the green roof or biowall for projects for multimedia works. At other institutions, students and faculty have also used green roofs and biowalls as a place to study microbial activity and well as plant growth and hydrology systems. Incorporation of either a green roof or biowall to Sarah Lawrence campus would provide

opportunities previously limited to students and faculty and ensure a greater space for an integrated education.

Current Inspiration via Other Institutions

The green roof initiative has definitely been picking up speed in recent years. Many cities have started implementing the use of green roofs; some even having green area requirements dependent on cubic building surface. Colleges in particular have been taking the opportunity to both help the environment, make financial investments, and use green roofs as a learning curve for students. Princeton's vegetated roof allows students to collect data on heat flux, stormwater runoff, soil moisture and temperature.

One student is using infrared technology to compare conventional roofs to Princeton's green roofs (MacPherson 2009). They are using this research to determine how energy efficient each of their green roofs are. They log building measurements and weather readings continuously and, although only faculty and facilities trained to use such technology are allowed to do so, the data is accessible for student research and teaching (MacPherson 2009). With Princeton's green roof, they also took into account the changes in climate based on solar radiation to ensure max efficiency of their green roofs. As each city has specific climate conditions, it is important to conduct research to ensure increased longevity and effect of each green roof (Thean 2013).

The University of Pennsylvania is using its green roofs to curb CSO events in the city. Their gardens are filled with more self-sustainable perennials in a thin soil expanse (Roofmeadow). One green rooftop, located atop King's Court College House, has been

flourishing nicely. Senior facilities planner, Dan Garofalo, discussed how the green roof is helping the environment and college. Aside from slowing rainwater runoff, the green roof also cools the building up to 20℃ on the top floors in the summer months and protect from icy winds in the winter (Davis 2008). The green roofs also provided homes and resources for many native birds species, increasing biodiversity of the area. Replacing the rubber roof membrane also meant longevity for the roof. Green roofs absorb UV radiation unlike rubber membrane which become degraded over time and must be replaced. According to Mariette Buchman, director of design and construction for Facilities and Real Estate Services, UPenn's green roof could last up to 40 or 50 years (Davis 2008).

Even New York City's High Line promotes biodiversity and sustainable practices. Plant designer Piet Odoulf looked to the area's existing landscape when making plans so as to fill the space with drought resistant, low maintenance, and, most importantly, native species. Such plants means a significant cutback on resources needed to maintain the High Line. The High Line is also landscaped to mirror its natural progression prior to construction. Each microclimate, whether those facing winds from the Hudson or sheltered by adjacent buildings, was taken into consideration and adapted along the High Line to ensure natural growth and sustainability (Friends of the High Line). Friends of the High Line work to use locally sourced materials that ensure successful growth and increased biodiversity, shelter and food for wildlife species. The High Line uses drip irrigation and hand watering when needed to ensure correct water distribution for each species and to account for weather changes (Friends of the High Line).

Drexel University boasts North America's largest living biofilter and the only structure of its kind in any American University - a 22-foot wide, 80-foot tall biowall in the new Papadakis

Integrated Sciences Building, built in collaboration with Nedlaw Living Walls and Parker Plants. Water is recirculated through the walls porous layers that substitute soil for the twelve distinct, tropical plant species that inhabit the biowall. The microbial communities living at the plants roots work to filter the air in the building, providing 1600 to 3000 cubic feet of clean "outside" air per minute which is sustainable for up to 600 people (Drexel). Estimates state that systems similar to Drexel's biowall can reduce airborne pollutants by up to 25% (Drexel). Drexel is using the biowall for studying as well. Both students and faculty are researching the microbes present in the root systems to better understand the impact the biofilter has on the building (Drexel).

The inclusion of a green roof or biowall on campus would significantly impact Sarah Lawrence College's carbon footprint. The potential to save money on heating and cooling costs is a main driver as well as the potential to decrease urban heat island effects and hinder runoff pollution. By installing, or even resurrecting the Taylor green roof, the college has the ability to make an ecological impact while also encouraging community work and research in its students. The drive for students and faculty to be able to continue their research could also curb monetary costs of managing and preserving a green roof. Considering final construction plans have most likely not been reached at this time for the Barbara Walter Campus Center, it would be a viable to option to consider adopting a more green approach to construction by including a green roof or biowall into the plans. Either or both efforts could help move Sarah Lawrence forward, taking the green initiate and encouraging the preservation and importance of such a relevant environmental issues.

At present, we were unable to get in contact with companies to get estimates on the prices involved in the construction of a green roof or biowall on campus. However, here we have provided some links and information about companies as a reference:

http://www.nedlawlivingwalls.com
http://parkerplants.com

NedLaw Living Walls and Parker Plants joined forces to build and maintain the Drexel Biowall. Nedlaw provided the panels and building, while Parker Plants handles more of the maintenance.

https://www.youtube.com/watch?v=Oh7vxlYtM38

A video on the properties and functions of the Drexel Biowall.

http://www.xeroflora.com

XeroFlora is a company, started in 2002, that specializes in building green roofs. Though many of their products are exported to Europe, all of the plants are locally sourced in the U.S.

http://furbishco.com/ecocline-green-roof/

Furbish specializes in EcoLine green roofs which help mimic environmental conditions of drought-resistant plants for extended sustainability and low maintenance. Furbish also designs Biowall that are fully vegetated by installation, which is heavily supervised and commissioned, however, contacting for information on biowalls would be preferable.

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