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A Sustainable Campus for the Future: Proposals for Sarah Lawrence College

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A Sustainable Campus for the Future: Proposals for Sarah Lawrence College

Work from Economics of the Ecological Crisis & Global Change Biology

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In the last century, the rise of the globalized economy has come at a tremendously high ecological cost. The global economy's dependency on the burning of fossil fuels has caused potentially cataclysmic and irreversible climate change. Renewable energy technologies have the ability to dramatically reduce greenhouse gas emissions. In order to better protect the planet from impending climate chaos, it is necessary to utilize and encourage increased installation of available renewable energy technologies. Institutions of higher education have a unique opportunity to become leaders in sustainable development. This project proposes the implementation of solar technology, radiator covers, and power-producing exercise machines on the Sarah Lawrence College campus to increase energy efficiency, campus sustainability, and environmental awareness. Sustainability on college campuses is crucial to educate and prepare the future leaders of a world fraught with the effects of anthropogenic climate change. It is critical that university and college campuses are at the forefront of the transition to renewable energy sources. Sarah Lawrence College has a responsibility to its students, community members, and the planet to adopt environmentally conscious practices to address the reality of climate change in the 21st century. As SLC graduates disperse into the world, their communities will continue to be affected by the devastating impacts of the climate crisis. Thus, it is of equal importance for SLC to inspire and challenge students environmentally as it is to do so intellectually. By receiving a solid basis of environmental education and participating in widespread campus sustainability practices, graduates will have the tools needed to thrive in the world.

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This paper discusses the importance of general sustainability practices on college and university campuses, specifically the importance of environmentally sustainable and efficient campus transportation services. The paper looks at how promoting bicycle programs, creating fixed shuttle routes and improving schedules, increasing education on campus sustainability, and investing in more sustainable vehicles can reduce emissions on college campuses. These sustainability efforts are analyzed looking at Sarah Lawrence College to determine how these practices can aid the institution's environmental efforts.

<u>Sprouting Roots at Sarah Lawrence College: Prospects of Adding a Green Roof or Biowall to Campus</u>
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As a campus that has great concern for environmental issues, it is important to find ways in which to engage both students and faculty in working towards a greener campus. The addition of a green roof or biowall to Sarah Lawrence College would be an amazing opportunity to begin building a more eco-friendly community. Green roofs alleviate environmental stressors while a biowall will increase indoor air quality and productivity. Not only do green roofs and biowalls help curb effects of pollution both indoors and out, but either would be an opportunity for continued research into the effects of green technology. With ample flat roof space across campus as well as having the LEED certified Heimbold Visual Arts Center, building a green roof and/or biowall would both guide Sarah Lawrence into a green movement while providing an opportunity for the community to work together towards a greener goal.

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Jocelyn Zorn and Allyson Panton

Sarah Lawrence College is an institution that inspires innovation within its students and teaches them how to understand and act upon the challenges that our ever-changing society raises. Currently, society is presented with some of the largest ecological crises that humans have ever faced, the consequences of which are widespread, affecting everyone on the planet. In order to address environmental devastation, all institutions must re-evaluate their current practices and implement significant changes. No college is better equipped for creating such change than Sarah Lawrence; founded on innovative educational techniques, we possess the knowledge and creativity that can be harnessed to create environmentally sustainable and economically viable policies on campus. One of the most simple and cost-effective ways to reduce the college's ecological footprint lies within our landscaping practices. The college currently uses an unnecessary amount of water and fossil fuels on maintaining plant species and grassy areas. In order to cut back on water and fossil fuel use, the college can implement basic changes including planting native species, establishing a rain garden, and incorporating Xeriscaping techniques. Replacing the excess of non-native species on campus with native plantings will provide ecological and economic benefits by dramatically reducing the need for watering, fertilizer use, and maintenance. Establishing a rain garden is an aesthetically pleasing solution to improving water quality and mitigating flooding. Xeriscaping is a landscaping alternative that will conserve resources, save money, beautify our campus and provide a central source for community. All of these changes will increase the aesthetic value of campus and improve the quality of student life.

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Joseph Sterling, Lily Frenette, and Jackson Langland

Excessive water use and poor water management has done great harm to the environment through the introduction of pollutants into freshwater supplies as well as increase the risk of extreme weather phenomena such as droughts and storms. To help lessen the environmental footprint of Sarah Lawrence College, we researched a number of strategies to reduce water usage across the campus. Technologies such as dual-flush toilets and low-flow showerheads would not only save the school money, but drastically reduce the amount of water used by across the board. The implementation of rainwater collection systems to provide an additional source for plumbing and landscaping was also discussed. For costs and figures, some comparative studies looked at other institutions with similar plans around the country.

Potential Energy Savings as a Result of Sustainable Lighting, Computer, and Appliance Installation

Elena Sinagra, Zoezra Feldman, and Jocelyn Zorn

Energy consumption accounts for thousands of metric tons of carbon dioxide emissions and trillions of dollars spent annually. Due to economically inefficient and environmentally unsustainable practices, much of the energy consumed that is contributing to these statistics is wasted. Sarah Lawrence College has the potential to drastically reduce its energy consumption through simple and effective measures including implementing energy saving lighting practices, installing energy efficient electronic appliances, and installing power saving software on computers. These changes hold the potential to significantly reduce the institution’s carbon emissions while saving costs by lowering energy bills.

A Brighter Future: Generating Renewable Energy on the Sarah Lawrence College Campus

Arianna Cooper, Iva Johnson, and Kiana Michaan

Introduction

Sustainability on college campuses is crucial to educate and prepare the future leaders of a world fraught with the effects of anthropogenic climate change. In the last century, the rise of the globalized economy has come at a tremendously high ecological cost. The global economy's dependency on the burning of fossil fuels has caused potentially cataclysmic and irreversible climate change. Clear policy solutions to combat the urgent problem of climate change currently exist. Renewable energy technologies have the ability to dramatically reduce greenhouse gas (GHG) emissions. The usage of renewable energy technologies has increased significantly in recent years. These climate change mitigation policies are important on both the global and local level. Institutions of higher education have a unique opportunity to become leaders in sustainable development. It is critical that university and college campuses are at the forefront of the transition to renewable energy sources. Sarah Lawrence College (SLC) has a responsibility to its students, community members, and the planet to adopt environmentally conscious practices to address the reality of climate change in the 21st century. As SLC graduates disperse into the world, their communities will continue to be affected by the devastating impacts of the climate crisis. Thus, it is of equal importance for SLC to inspire and challenge students environmentally as it is to do so intellectually. By receiving a solid basis of environmental education and participating in widespread campus sustainability practices, graduates will have the tools needed to thrive in the world. Increasing energy efficiency on campus presents a challenge as a result of an outdated heating system, and financial limitations, among other institutional barriers. Increasing energy efficiency through innovative cost effective solutions will promote campus sustainability, lower long-term energy costs, and produce a variety of other positive externalities. This paper proposes the implementation of solar technology, radiator covers, and power-producing exercise machines on the Sarah Lawrence College campus to increase energy efficiency, campus sustainability, and environmental awareness.

Background

The economic development and growth of the last century has come at a tremendously high cost. The global economy is currently dependent on the extraction and burning of nonrenewable resources in the form of fossil fuels: oil, gas, and coal. For several decades, the human population's demand for natural capital has been exceeding the biosphere's capacity. The growing demand for nonrenewable fossil fuels within the market for natural capital is of significant environmental concern (Wackernagel et al. 2002). Fossil fuels are living organisms, such as plants, from millions of years ago that have fossilized in the earth's crust (Thorpe 2011). These organisms once captured carbon through photosynthesis. Burning these resources releases that carbon back into the atmosphere. Fossil fuels are able to be produced and sold at an artificially low cost as the result of government subsidies and externalized environmental and social costs (Thorpe 2011). The dramatic effects of human behavior on the climate system are clear given the extensive scientific understanding and consensus. Climate change occurs through higher concentrations of atmospheric GHG, positive radiative forcing, and observed planetary warming. The majority of global anthropogenic GHG emissions are a direct result of the consumption of fossil fuels. Since pre-industrial times, atmospheric carbon dioxide concentrations have increased by 40%, primarily from fossil fuel emissions (IPCC 2013). The effects of the emissions of carbon dioxide (CO2) are cumulative, thus aspects of climate change will persist for centuries regardless of a potential stop in emissions. Past CO2 emissions have already committed the planet to significant amounts of multi-century climate change. These global impacts coupled with the growing world population have severe social and economic implications. The future of the planet and humanity is threatened by anthropogenic climate change.

The continuation of burning fossil fuels is a direct result of economics. Despite the widespread understanding and acknowledgement of problematic global impacts of climate change, the burning of fossil fuels continues to be increasing at an alarming pace. This is due to economic policy and the fossil fuel industry's power. Fossil fuels are the blood of the industrial globalized economy. The global economy is extremely dependent on burning of fossil fuels, especially for the generation of electricity, which is crucial to modern societies. Government policies subsidize and protect these energy industries. The burning of these nonrenewable resources fuels continued economic growth and expansion in the capitalist economic system. Thus current economic function is entirely dependent on externalizing the widespread negative environmental and social impacts from the continued exploitation of the earth's resources. In order to better protect the planet from impending climate chaos, it is necessary to utilize and encourage increased installation of available renewable energy technologies.

Policy Solutions

There exists a variety of policy solutions, some controversial, others widely accepted, to combat climate change. Transitioning to the widespread use of renewable energy sources is a fundamental policy solution, as opposed to non renewable energy such as fossil fuels. Renewable energy sources include bioenergy, solar, geothermal, hydropower, wave power, and wind energy, among others. Renewable energy will be vital to future energy supply systems with greater usage in future global electricity. Economic development has been historically correlated with increased energy usage and greenhouse gas emissions. Renewable energy technologies offer "the opportunity to contribute to social and economic development, energy access, secure energy supply, climate change mitigation, and the reduction of negative environmental and health impacts" (IPCC 2011). Intergovernmental Panel on Climate Change calculated scenarios that include the lowering and stabilization of atmospheric GHG concentrations based off of global growth in the utilization of renewable energy sources. With renewable energy technology readily available, the rate of integration is dependent on several factors, including cost, local government policy, and international policy. Government and economic policy is perhaps the most crucial factor in the instatement of renewable energy technologies.

In order to transition to a low GHG economy, there will need to be a significant increase in investments in renewable energy technologies and infrastructure. This initial economic investment will pay for itself over time in electricity savings and positive externalities, including no additional fuel costs. In addition to aiding in climate change mitigation, this investment in renewable energy will lead to a plethora of positive externalities including the social development, economic development, a secure energy supply, and a reduction in negative impacts on environment and health. Unfortunately, the cost of development and installation for many renewable energy technologies currently remains higher than non-renewable energy prices in most energy markets. Some renewable energy technologies are currently economically competitive with market energy prices in different geographic regions.

Government policy is crucial in helping to make renewable energy economically competitive and viable. Further cost reductions in renewable energy technology are expected over time. The widespread use of renewable energy is technologically feasible. The integration of renewables into the energy grid presents a number of challenges specific to each geographic region. For the integration of renewable energy technologies, "there is no one-size-fits-all policy" (IPCC 2011). Policy can address climate change mitigation with renewable energy sources through several different methods. These policies include subsidizing renewable energy technology, taxing fossil fuels, economically incentivizing the usage of renewable energy sources, and creating infrastructure for accessible renewable energy technology installation. On a local level, community institutions such as schools and hospitals, that use significant amounts of energy and resources, have the power to become leaders in sustainable development through adopting renewable energy technologies (Coote 2014). Additionally, it is very likely that an international binding climate change mitigation agreement will further incentivize the usage of renewable energy sources globally.

Sustainability at SLC

In 2007, several passionate faculty members, staff, and students came together and founded the Sustainability Committee. The Committee was originally created with designated representatives in mind, such as five faculty members, seven administrators (one representing each office, two from Facilities), seven undergraduate students, and two graduate students (Sarah Lawrence College Archives 2007). Since its creation, the Sustainability Committee has been responsible for the majority of campus sustainability initiatives. In 2008, the Committee launched "Footprint Forward February," a campus-wide competition to conserve energy. Houses and apartments were paired off to compete against each other. This challenge was issued via email, which included an extensive list of energy saving and carbon footprint reduction tips. Some of these suggestions included: turning off lights, unplugging chargers and unnecessary appliances, using natural window light whenever possible, taking shorter showers with cold water, refraining from opening windows in dorms and turning down controllable thermostats, as well as exchanging incandescent light bulbs from Facilities for LEDs or CFLs to use in dorm rooms. The effectiveness of this practice is currently unknown. Another successful environmental project was in 2008, through a student-led initiative, a green roof was installed on the Taylor dormitory roof, which reduces heating costs by providing insulation and absorbs runoff.

The construction of the Heimbold Visual Arts Center in 2004 marks the college's first LEED-certified building (Leadership and Energy and Environmental Design). Additionally, it was the first LEED-certified college visual arts building to be built in the country. Heimbold's 61,000 square feet were constructed with a majority of natural and recycled materials. The building's primary materials are fieldstone, cedar, channel glass, and zinc; the stone was sourced from a nearby quarry, utilizing local fieldstone. Materials were selected to reduce contaminants that impact indoor air quality and to lessen the environmental impacts of material manufacture and procurement. More than 60% of the wood materials used on the project were certified as sustainably harvested by the Forest Stewardship Council. Low-VOC adhesives, sealants, paints, and carpeting were installed and composite wood or agrifiber products containing added urea formaldehyde were prohibited. In addition, the stepped, grass-covered roof controls stormwater runoff. Native plants and low-flow fixtures reduce potable water. The geothermal heat-pump system reduces water because it does not require a cooling tower (HPB Case Study 2005). The building was designed to both be aesthetically appealing and to minimize impact on the environment. In 2005, SLC was awarded the Cote Green Project Award from the American Institute of Architects Committee on the Environment. This award was given for Heimbold as an exemplary project that benefited the built and natural environment through sustainable design.

In 2010-2011, Sarah Lawrence was featured in Princeton Review's "Guide to 286 Green Colleges." The Princeton Review highlighted the then-newly renovated resident hall Warren Green, complete with energy-efficient kitchen appliances, a rain catchment tank, a solar hot water heating system, and a vegetable garden. Furthermore, the Princeton Review included statistics of overall campus sustainability efforts. This highlighted the following: 10 % of food budget spent on local/organic food, 22% waste diversion rate, 2% of school energy from renewable resources, 80% of school cleaning products green-certified, and 60% of school grounds maintained organically.

Attention was drawn to the absence of an SLC sustainability office and/or coordinator. In the future, Sarah Lawrence could greatly benefit from considering improvements in the college's sustainability measures such as hiring a sustainability coordinator. Their role would be to centralize the management of green action within the College, publicizing a greenhouse gas inventory plan, and requiring an environmental literacy program for freshman orientation.

Looking to other colleges and peer institutions, SLC has significant potential to increase sustainability efforts. In order to successfully integrate large amounts of renewable energy sources, existing energy systems will need to adapt. That said, renewable energy can be integrated into all kinds of electricity systems, from large to small scale (IPCC 2011). For the successful implementation of greater sources of renewable energy, SLC has a number of institution-specific obstacles to overcome such as school size, minimal funds, and the campus terrain.

Grant Opportunities

Applying to grants offers SLC the unique opportunity to further realize the potential for campus sustainability initiatives without the concern of cost. Recently, in October 2015, Governor Cuomo announced the Energy to Lead Competition. The New York State Energy Research and Development Authority (NYSERDA) and the New York Power Authority are currently teaming up to offer the Energy to Lead Competition as a part of their Reforming the Energy Vision (REV) Campus Challenge. This competition is open to NYS colleges and universities “to develop innovative plans for clean energy projects” (NYSERDA 2016). This competition challenges institutions to devise and implement “plans that advance clean energy on their campuses and local communities in new ways” (NYSERDA 2016). The REV Campus Challenge aims to encourage clean energy in institutions of higher education, “identify gaps and barriers to clean energy implementation, and provide the targeted resources and professional connections institutions need to succeed” (NYSERDA 2016). Three colleges will each be awarded $1 million to implement their clean energy proposal on their campus. This ability to submit a proposal to this competition offers an example of opportunity for SLC to significantly advance current sustainability efforts.

Solar Technology

Solar power is an exciting source of renewable energy. Every hour, the earth receives enough solar energy to the power modern civilization for an entire year. Solar energy is a reliable source of renewable energy. It produces no air pollution, no noise pollution, and little negative ecological effects. The earth receives 174 petawatts of incoming solar radiation in the upper atmosphere. The earth receives about 1,366 watts of direct solar radiation per square meter (Thorpe 2011). Thirty percent of that solar radiation is reflected back to space and the oceans, clouds, and land absorb the rest. The kilowatt-hour is the unit used to measured solar energy where 1 kilowatt-hour equals 1000 watts (Thorpe 2011). The use of solar photovoltaic (PV) energy has increased tremendously over the last decade. Within the primary energy supply, renewable energy sources accounted for 12.9 % increase of global energy from 2000 to 2010, with 0.1% coming from direct solar (Thorpe 2011).

Solar power is converted into electricity through two methods: photovoltaic power or concentrated solar power (CSP). Solar panels come in four different types of technologies: PV, which utilizes solar light, and CSP, including solar towers, and thermoelectrics, which utilizes solar heat (Chow 2010). Direct solar energy is obtained by harnessing energy from solar irradiance in order to produce electricity, heating, cooling, lighting, and fuels. This energy can be captured through several different technologies. PV, solar thermal, and CSP are sources of active solar energy. Due to the variable and unpredictable nature of solar energy, the use of thermal energy storage provides some energy output control for systems such as CSP and direct solar heating (Chow 2010).

The first PV cells developed in the late 1800s were coated in selenium with a thin layer of gold and less than one percent efficient (Thorpe 2011). Today solar PV panels are made with silicon cells. A common type of solar cell is silicon crystalline, which is easily found within the earth's resources. There are three kinds of silicon cells: monocrystalline, polycrystalline, and amorphous (Thorpe 2011). Monocrystalline is a high quality silicon cell, up to 24% efficient. Polycrystalline represents about 85% of the market. Solar cells function by having two layers of silicon placed parallel to one another allowing for the atoms of silicon to transmit electrons to higher bands. The structure is able to capture the electron with minimum energy loss and thus create a circuit or flow of energy. Many solar panel makers inject the layers with phosphorous to create more of a positive potential for energy to be captured. The average home in the United States uses around 1000-1500 kWh per person per year for its appliances and lighting (Thorpe 2011). The voltage recorded is created from a reverse electric field around the junction between the layers. Temperatures beyond 77 degrees Fahrenheit causes a drop of around 0.5-0.6 percent power output. At above 100 degrees Fahrenheit, the crystalline module will produce 6 percent less power than under the standard temperature (Thorpe 2011). In terms of cost efficiency, solar panels can vary depending on the materials used; thin films have an efficiency of 4-12% and the crystalline are under 22%, as of 2012 (Timilsinaa et al. 2012). Limits to solar panels include costs and limited installation training. Solar panels come at a high initial cost and currently have few financial options for funding. There are also a limited number of technicians that are apart of the new solar energy infrastructure (Timilsinaa et al. 2012).

Power-Producing Exercise Machines

A localized renewable energy source, which can act as an education tool for college campuses, is power producing exercise machines. Stationary exercise machines can use this renewable energy technology to convert calories to kilowatts. This technology converts currents from human energy to produce renewable energy. The kinetic energy generated by a workout is converted first to direct current

(DC) and then to alternating current (AC), at which point it can be directed as electricity power to the building (ReRev 2011). Existing exercise machines in gyms can be retrofitted to include this technology. Company ReRev states, “The gym environment is an ideal setting to capture a large amount of consistent kinetics with little upfront cost by utilizing existing infrastructure” (ReRev 2011). These stationary exercise machines produce energy which charges a battery and flows through a current to provide electricity to the gym facility (Gibson 2011). ReRev took this concept and started applying it to college athletic centers. The company has installed over 150 machines in use in more than a dozen colleges and universities across the country, including Drexel University, James Madison University, Oregon State University, Texas State University, and the University of Florida (Gibson 2011).

The science behind these bikes is grounded in the conversion of watts to horsepower. Watts are a basic measurement for power outputs. The conversion between one horsepower is equivalent to 746 watts. To provide some perspective, a laptop uses 60-80 watts, a small tv uses 60-100 watts, and a large tv uses 400-600 watts. The average person produces around a rate of 60 to 120 watts during an hour of strenuous exercise. An elite cyclist can produce around 300-400 watts. In a standard gym the typical person would produce 75 watts for an hour, about one-tenth of a horsepower (Human Dynamo 2016).

The average gym has about 5 hours a day of active time spent on the equipment, at 365 days a year. If each person generates 100 watts, the machine will produce 183 kilowatt-hours of electricity a year. In the United States, commercial power costs around 10 cents per kilowatt-hour. This would mean that the electricity produced in a year by one machine is worth around $18 (Gibson 2011). Generating electricity through exercise machines can be beneficial for institutions of higher education to save costs, increase sustainable development, and provide interactive sustainability education.

Peer Institutions

A number of institutions of higher education have successfully implemented a variety of renewable energy projects. This follows a sweeping push in higher education to empower and protect its students by striving to be at the forefront of the environmental movement and sustainable development initiatives. The scope of sustainable projects on college campuses range from extensive multi-million dollar budgets to small, grant-funded projects. No matter the scope, all of these projects provide significant environmental and economic benefits.

PV systems have been incorporated into many educational programs at universities. An example of a successful solar energy project can be seen at Ithaca College. The school partnered with EcoVillage, a local nonprofit organization that specializes in sustainability education. This curriculum-integrated project resulted in a successful PV array and community solar energy education program. Students were able to design and implement construction plans, create manuals, and speak at public lectures on the creation of mobile solar PV systems on standard utility trailers. The solar trailers have been advantageous as interactive demonstrations both off and on campus. Some advantages include powering music for student hot spots, and providing educational opportunities for environmental science, chemistry, and physics courses (Haji et al. 2010).

Many institutions of higher education have started experimenting with solar photovoltaics campus projects. Some financially feasible projects have included installations for safety phones, irrigation pumps, parking lights, and rooftop installations. In Wales at the University of Glamorgan, streetlights was installed on the campus that integrated solar photovoltaic and wind technology. These streetlights provided lighting near student accommodation buildings. In Houston at the University of Texas, a 20 kW photovoltaic system was installed. This provided daytime lighting to a parking garage. At the time, it was the largest installation in the Gulf Coast area. Annually, Georgetown University, located in Washington, D.C., saves $45,000 in energy costs from photovoltaic panels on roof installations (Haji et al. 2010).

Bard College, a peer institution to SLC, located in Red Hook, New York, has pledged to strive for carbon neutrality by 2035. In recent years, Bard has initiated several solar energy projects on its campus. These include dormitories equipped with a solar thermal hot water system, a 9kW solar electric system, and solar photovoltaic array at a 280kW (Bard College 2016). Additionally, Bard College utilizes geothermal energy for heating and cooling in about 40% of the total space in its buildings. The college completed its 9kW solar electric system in 2014, as the direct result of a $35,000 donation from Green Mountain Energy Sun Club. The college also aims to offset the energy it consumes from nonrenewable sources through the purchase of Renewable Energy Credits/ Carbon Offset Credits. This is an example of a successfully and rapidly expanding renewable energy project at a small NYS liberal arts college.

Bucknell University, a liberal arts college in Lewisburg, Pennsylvania, has extensive successful renewable energy projects. In 2006, Bucknell installed a 2.5 kilowatt solar array. In 2007, two more solar arrays were completed with a total capacity of 3.2 kilowatts. In 2008, the campus installed a solar thermal system. In 2013, the campus installed a 900 watt wind turbine. These solar energy systems feature an accompanying webpage, which provides real-time solar data on the wattage of energy generated for the campus. The university also runs a successful green fund, which provides start-up money for campus sustainability initiatives proposed by members of the community to be implemented (Bucknell 2011). All of these projects can aid in developing a dialogue on their campus about sustainability.

Drexel University in Pennsylvania is among many schools to install power generating exercise machines. The recreation center features stationary bicycles and ellipticals that generate electricity, which is fed directly into the building's power grid. This is part of a growing movement among university athletic centers and membership gyms to bring sustainable practices, renewable energy, and economic innovation to exercise. Similarly, Williams College in Massachusetts also utilizes power-generating ellipticals in their athletic center. The school has 18 energy-providing ellipticals with each machine producing around 45 kW per each hour of usages. Thus with 6 elliptical machines simultaneously in use the energy generated falls between 230-270 kWh. Williams College is able to demonstrate the advances of power generating exercise machines as an innovative tool to generate local, interactive, and educational sources of renewable energy.

SLC Renewable Energy Project Proposal

The college can take a number of steps to increase energy efficiency and save costs on campus:

Solar PV panels can be installed on the SLC campus to generate electricity. The placement of PV panels is dependent of several factors. These include architecturally visible roofs, tree cover, the clearness index for the atmosphere, whether they track the path of the sun or not, the diffuse and direct (beam) radiation amount, the time of sunrise and sunset, and the angle of these relative to the modules. Despite a lack of space, the campus is a good candidate for PV panels in several locations. Significant PV panel placements could be made on the roofs of the Performing Arts Center, the Campbell Sports Center, and a free standing solar garage in Kober parking lot. A variety of potential local solar companies were considered including Safari Energy, Borrego Solar, Solar Street, Sunrun, D and M Alternative Energy, Solar Merchant Inc., and Bunn Merchant Inc. Borrego Solar was selected to work with the college. An estimate of installation costs and energy savings was determined by Borrego Solar for the installation of panels on the Campbell Sports Center and in the Kober parking lot. The cost of installation of these solar panels would be $1.96 million. The lifespan of these panels is 25 years. The energy savings from this installation are as follows:

Table 1 “Installation energy savings” (Borrego Solar 2015).

Month	Energy Savings in kWh
January	32,475.1
February	40,735.1
March	57,548.5
April	73,703.5
May	88,817.8
June	83,333.4
July	82,887.5
August	83,677.4
September	63,581.5
October	57,234.8
November	31,048.1
December	29,443.7

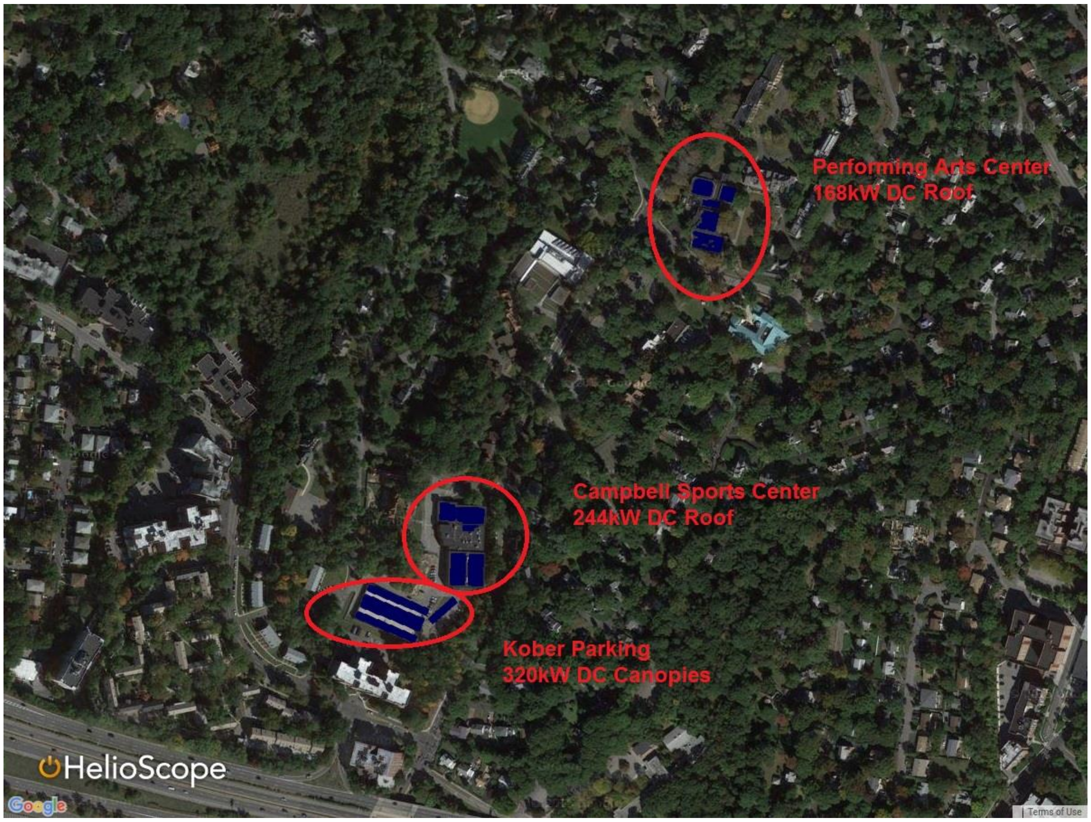

Figure 1 “SLC campus overview of potential solar roof space” (Borrego 2016).

The energy efficiency of the campus heating systems can be significantly increased by employing the services of the company Radiator Lab. This company customizes radiator covers to be placed over the existing radiators in old buildings. Installing these radiator covers would be particularly feasible and beneficial for Hill House, at a price point of $495 per cover. They would allow for each individual student to regulate the temperature within their room. The excess heat would be pumped back into the system and go towards rooms that are less insulated. This system would generate significant cost savings with a 1 year warranty and an average of savings of 34% per year on heating costs.

The college can also take a number of steps to increase environmental education initiatives and awareness on campus:

Replacing the stationary cardio machines in the sports center with power generating exercise machines will have a significant impact in increasing campus sustainability awareness. Many college campuses have installed this technology in their gyms working with companies such as the Green Microgym and Human Dynamo. With these exercise machines, around 200 watts per hour per person can be generated which is about enough to power 1 light bulb. From working with the sports center and speaking with the Green Microgym the following was determined. The Campbell Sports Center could install the following power generating exercise machines: 8 indoor cycles, 8 ellipticals, 8 recumbent bikes, and 8 upright cycles. The Green Microgym offers these machines at the following prices $2,795 per indoor cycle, $7,395 per elliptical, $4,795 per recumbent bike, and $3,995 per upright bike. The average lifespan of a machine is 15 years and lifetime warranties are available for almost all of the parts. The company offers a discount for purchases of over 5 bikes. The interactive sustainability education provides by power generating exercise machines will communicate the value of having an active role in sustainability to the college community.

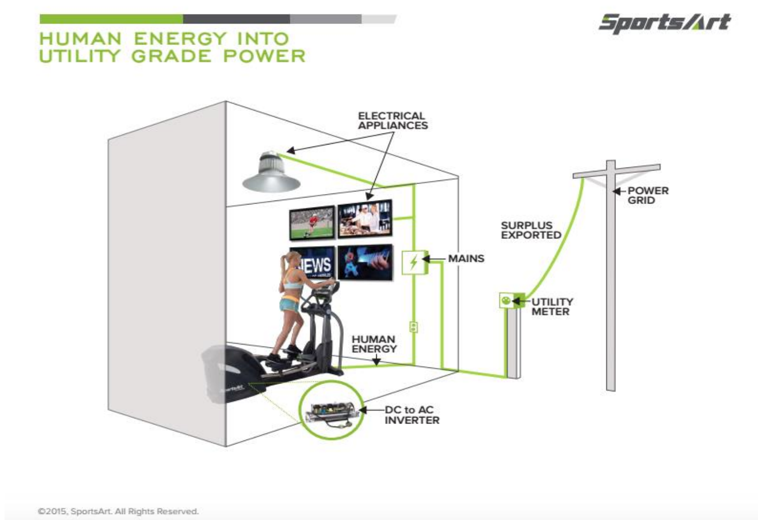

Figure 2 “Human energy into utility grade power” (SportsArt 2015)

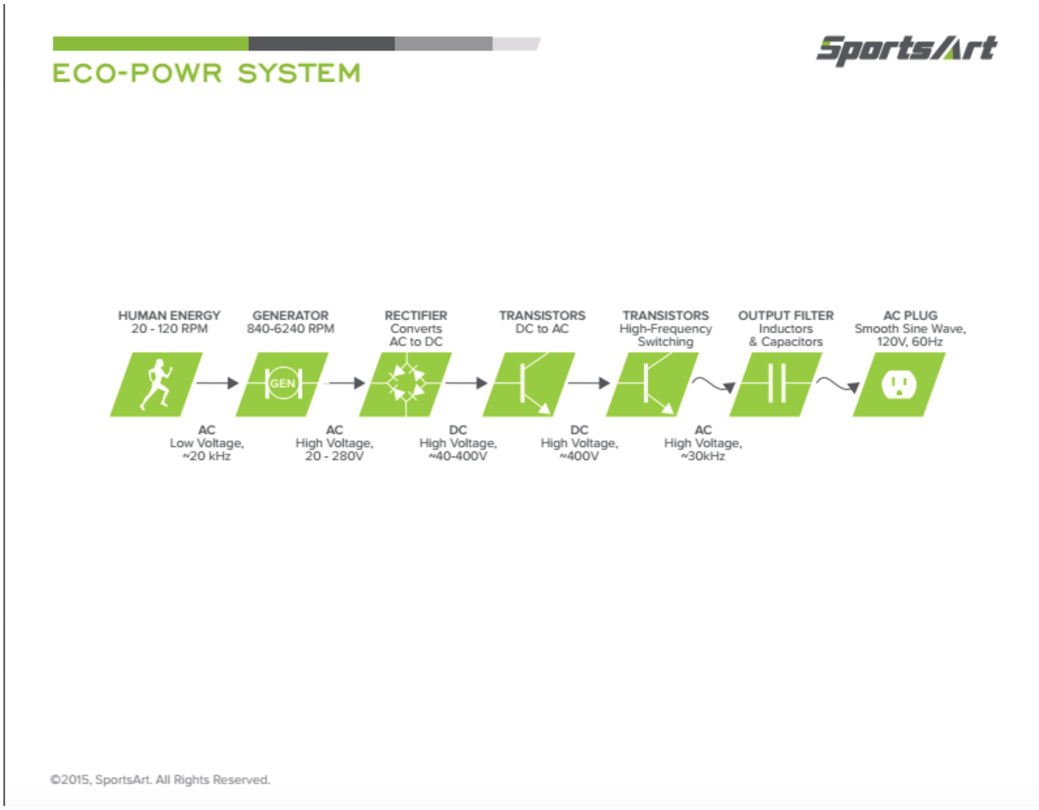

Figure 3 “Human to outlet power” (SportsArt 2015)

The orientation and first year studies classes provides the structure to implement and integrate environmental and sustainability education into the school’s curriculum. This would entail mandatory basic education on the social impacts of climate change, sustainable living practices, sustainability initiatives on campus, as well as online and local environmental education resources.

In order to effectively oversee the proposed cost saving energy efficiency and sustainability education initiatives, a campus office of sustainability is imperative. Establishing a permanent office of sustainability that would provide the institutional structure and support to oversee and maintain sustainability on campus. This would aid in integrating the energy efficiency and sustainability education initiatives into the campus culture overtime. The office would serve the campus and hold similar importance as bodies such as Community Partnerships and Diversity and Activism Programming Subcommittee in serving, protecting, and equipping the community for the realities of climate change.

The college can aim to accomplish these plans as detailed above through funds obtained by grants. Thus, in order to realize these important goals the school continuously and assertively apply to accessible sustainability grants.

Conclusion

The implementation of solar technology, radiator covers, and power-producing exercise machines at Sarah Lawrence College will increase campus energy efficiency, sustainability, and environmental awareness. Campus impact will be strengthened in conjunction with curriculum integrated environmental education. Sustainability on college campuses is crucial to educate and prepare future global citizens and leaders for a world fraught with the effects of anthropogenic climate change. The rise of the globalized economy in the last century has come at a tremendously high ecological cost. It is crucial for institutions of higher education, including SLC, to implement policy solutions to aid in mitigating climate change to the best its abilities. SLC has the opportunity to join the environmental movement and reduce the institution's GHG emissions through the usage of renewable energy technologies. Institutions of higher education have moral responsibility to their students and the broader local community to spearhead the transition to renewable energy sources and sustainable living practices. SLC's mission and value statements stress the importance of providing innovation and exploration of academic and creative ideas throughout the pedagogy and overall campus. The implementation of solar technology, power-producing exercise machines, radiator covers, and an environmental education plan at SLC will increase energy efficiency, campus sustainability, and environmental awareness thus allowing the college to help pave the path to a brighter future for its graduates.

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SARAH LAWRENCE COLLEGE

Sustainability Proposal: Composting Initiative

By: Zoe Berg, Leyana Dessauer and Jesenia Fuentes

Introduction:

Humans are avid consumers. According to Duke University's Center for Sustainability and Commerce, the average person generates an estimated 4.3 pounds of waste per day - an amount 1.6 times greater than we produced in 1960 (Center for Sustainability and Commerce). The majority of pre and post-consumer waste finds its way into landfills or incinerators, which results in leachate production and elevated methane emissions which contribute to global warming (Center for Sustainability and Commerce). Leachate is produced when water filters downward through a landfill, picking up dissolved materials from decomposing waste. Leachate moves slowly and continuously through open spaces in soil and rock, contaminating groundwater supplies. Methane, an incredibly potent heat-trapping gas, is emitted by methane-producing bacteria which decompose organic material in landfills. Therefore, we believe that the implementation of compost management programs at Sarah Lawrence would help to reduce waste in landfills and, thus, mitigate the effects of global warming.

Composting is a biological method of recycling organic matter into nutrient-rich soil. Mesophilic bacteria begin the process by breaking down organic material in the compost pile. As the bacteria use more energy to consume compost materials, they emit heat, causing the temperature of the composting pile to rise. With this increase in temperature, heat-loving thermophilic bacteria take over the decomposition process, and the temperature becomes high enough to kill many common strains of pathogenic bacteria. (Jenkins). Larger organisms such as worms also digest the decomposing matter, excreting nutrient-rich feces and helping both to improve the quality of the compost and to bind small particles into larger crumbly pieces (Compost Fundamentals).

Using compost as mulch or as a potting additive is beneficial in many ways. Compost contains macronutrients, the elements which plants require in relatively large amounts (i.e. nitrogen, phosphorous, potassium) and micronutrients (i.e. boron, iron, zinc) often absent in synthetic fertilizers (Macronutrients and Micronutrients). The release of such nutrients over a period of months or years allows for the soil to remain healthy for prolonged periods of time (Compost Fundamentals). Compost also acts as a buffer in soil in that it contributes to the neutralization of both acid and alkaline compounds, bringing pH levels to the optimum range for nutrient availability to plants, which is between 5.5-7.0 (Compost Fundamentals). In addition, compost helps to bind clusters of soil particles, called aggregates, which supports strong and healthy soil structure, altering it in a way that makes it less likely to erode. Furthermore, compost serves as a vital source of food for bacteria, fungi, insects, worms and other organisms in soil, allowing for fruitful plant growth. Lastly, healthy soil is an important factor in protecting waterways and groundwater supplies, by acting as a natural filter for toxins in surface water. Compost increases the soil's ability to retain water, thus decreasing runoff, which pollutes water via the transportation of soil, fertilizers, and pesticides to nearby water supplies (Compost Fundamentals).

Large-scale sustainability initiatives, such as composting programs, have been implemented at college and university campuses across the United States, helping to spread environmental awareness and offset the detrimental impacts of global warming. We have analyzed successful composting programs at neighboring institutions including Dickinson College, Middlebury College and Cornell University, for insight as to the most effective way to initiate a composting program.We believe Sarah Lawrence College, a small, liberal-arts institution dedicated to civic engagement, could greatly benefit from a well-designed composting program, as it dovetails well with our commitment to promoting sustainability. Composting at Sarah Lawrence would transform pre and post-consumer food waste produced in dining facilities and in dorm rooms into nutrient-rich soils as well as reduce campus-wide trash collection expenses. Based on the research we have conducted, there are three main approaches to composting programs on college and university campuses that would be appropriate at Sarah Lawrence: on-campus composting in hand-made vessels, composting in specially designed containers, and composting using worms.

Traditional Composting:

Composting involves encouraging the natural decomposition of large amounts of organic material into smaller quantities of material which continue to break down slowly, releasing nutrients into the soil as it does so (Raabe 1). It begins when food waste and either wood chips or other dry organic matter are mixed together in a receptacle. Introducing plant material reduces odor and improves the composting process (EPA). It is important that whatever source the plant material comes from (ideally leftover material from campus landscaping) has not been sprayed with toxic chemicals such as pesticides if the resulting soil is going to be used to grow food, because these chemicals could become concentrated in the soil and it is difficult to measure their levels for safety.

Optimal decomposition occurs when the carbon to nitrogen ratio is thirty to one. In order to approximate this ratio without expensive testing, a good rule is to include about half wet or green material, including fresh grass clipping, food waste, and recently pulled weeds, and half dry material, including dry grass clippings, dead leaves, and dry branches pruned from trees or shrubs. If these materials are scarce, non-laminated cardboard and soy-based newspaper make good alternatives (Raabe 1). The bin should maintain a temperature of between 140°F and 160°F for optimal function of the microorganisms which process the waste. If the temperature rises too much, beneficial microorganisms will be killed and the waste will stop composting. This can be prevented by weekly monitoring of the temperature and turning the contents of the bin with a shovel if too hot, or addition of more food waste to spark continued microorganism activity if too cool. Closed wooden bins with removable slats for easy access offer the most inexpensive and easy to maintain system. They also keep harmful bacteria, raccoons and rodents away from the compost, encourage heat retention and prevent odors from spreading (EPA).

On-campus composting has the potential to be the most inexpensive option, and it provides opportunities for campus engagement. In order to succeed, students and the administration would both need to be involved. For on-campus compost processing, a pilot program could be initiated using one aerated free-standing bin. Goshen College, with its small student run program, provides an example of this kind of program (Lopienski). If successful, more bins could be added as compostable waste accumulates. This could be achieved for a low cost by building simple wooden bins on site. In a non-electric composting system, the heat from decomposing food scraps triggers a chain reaction in which the waste breaks down into compost faster than it would in the open air. Compost can self-heat to over 140°F without the use of electricity (Lopienski). Specially designed aerated bins can aid this process and keep rodents out of the compost. Composting can be achieved either with or without the application of additional heat generated by electricity. Non-electric systems, although slower, are more affordable and environmentally friendly. A pilot program could use a single bin capable of handling 75 to 100 of food waste per week for three weeks, before being rotated out for another bin. Each bin costs approximately $150 to build. (Lopienski). This project could then be expanded to handle all the food waste produced on campus.

In-Vessel Composting System:

An easier alternative to building wooden composting bins is purchasing a pre-made in-vessel composter, which is a closed system and requires less maintenance. Some of these systems use electricity to bring the waste up to a high temperature faster, thus increasing the speed of the composting process. How, other models are available which do not need electrical input. They are designed so that it is easy to put waste and wood chips in one end, turn the handle to mix the contents, and remove processed compost in the form of soil from the other end of the machine.

The average amount of back of house waste (BOH, usually consisting mainly of fruit and vegetable scraps) produced in a typical week during the spring semester at SLC is 400 pounds per week, and the average front of house (FOH) waste output in the same time period is 259 pounds per week (information provided by AVI). FOH waste includes all kinds of food scraps and uneaten food, from fruits and vegetables to meat and dairy.

We propose that Sarah Lawrence College invest in one large-sized in-vessel composting bin, called the Ridan Composter, for Bates Dining Hall kitchen. Bates Dining Hall produces between 35 and 50 pounds of pre and post-consumer food waste everyday. However, the Ridan Composter, an $8500 investment, would reduce food waste production dramatically. The Ridan, a closed system, is able to store up to 105 pounds of pre and post consumer food waste and produces compost in 14-21 days. With continual addition of waste and removal of compost, it can recycle up to 440 pounds of food waste per week. Therefore a large size model could handle all of the BOH food scraps produced in Bates, and during the summer it may be able to handle all waste. Due to it’s design as a closed system, the Ridan Composter can safely handle meat and dairy products, which traditional composters cannot do. We have pinpointed this particular composting technology as the most appropriate for our College’s needs because it is simple to operate and after the initial investment it is an inexpensive way to maintain an efficient and successful composting system.

Vermicomposting (Worm Composting):

Vermicomposting is another method of composting which can be done on a small scale and has some benefits not offered by traditional composting. It is less labor intensive because worms are the ones doing a great part of the work in consuming the organic material and breaking it down. The rapid decomposition also means there is less chance for odors to escape. The worms produce something called worm castings. These are worm excrement, which are full of nutrients, making them a natural fertilizer that unlike industrial fertilizer, does not contribute to methane production. The success of plant growth with worm castings is so great that businesses are opening up and selling it as an organic alternative. Worm compost does not contain any toxic chemicals and can protect plants from disease, because antibiotics and actinomycetes found in vermicompost promote plant resilience.

Caution must be taken in choosing an appropriate type of worm for this process. The genus *Amyntha,* also known as the Asian earthworm, has been noted to actually be invasive species which can disrupt an ecosystem with catastrophic consequences. There are a few options which are appropriate, including the *Eisenia fetida,* or "red wiggler", most commonly used for its high reproductive and growth rates. *Lumbricus rebellus*, or "redworm" is another good option. The worms can be attained by going to suppliers who specialize in farming worms for this purpose.

It would take about a pound to start a compost bin. Setting up a vermicompost bins can be done on a small scale, a good example being the worm bins that are set up on campus at the Early Childhood Center. They were created with the goal for the children there to become involved and play a role in trying to help the environment. Worm bins can be acquired by searching for them online and set up in places around campus such as outside of Bates, near the Pub, and outside library. Poultry which contains ammonia is not recommended to be put in the bins for the worms to feed on nor waste containing inorganic salt because they are very sensitive and will die. Not only that but meats can attract flies and other pests. Things with high acidity should also be avoided. It is important that the appropriate food waste goes into the compost bins for this method to be successful and that those that are adding to the compost bins are well informed of what would not be put into a bins by having a sign. Fruits, vegetables, and other organic waste would be ideal. Lastly, worms should be provided with some kind of grit to grind their food because they have no teeth. Rock dust is a form of grit they can use. Despite these restrictions, this method of composting is convenient because the worms do not need to be fed on a schedule. They can be fed with organic waste every so often and can go up to a month without food.

Conclusion:

Composting has biological, environmental and social benefits. It rejuvenates soil that has been leached of nutrients, supports the production of healthy fungi and bacteria, both of which create humus, an organic matter high in nitrogen content, and promotes moisture retention in soil. Composting also reduces waste in landfills, resulting in a decrease in methane emissions (when organic matter decomposes in a landfill, it is not exposed to oxygen, resulting in the anaerobic decomposition of organic matter, a process that produces methane). It acts as an organic fertilizer, reducing the need for synthetic fertilizers on campus. Composting programs also offer opportunities for civic engagement and environmental education.

Sarah Lawrence College has the capacity to explore a variety of campus-wide composting programs. We recommend that the institution explore the off-campus composting avenue because of the College's lack of financial resources to construct the necessary infrastructure to organize an effective, campus-wide composting movement. Therefore, by utilizing an off-campus processing facility, we would partner with one of the aforementioned waste management companies, have the company treat our compost, and transport it to a location in which the compost will assist the growth of organic foods on select organic farms throughout New Jersey. Overall, a composting program would bring sustainability initiatives at Sarah Lawrence to the forefront, build a sense of community among participating students, and mitigate the harmful effects of landfill waste and bi-products of waste incineration.

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Environmentally Sustainable Transportation Practices on College and University Campuses: Transportation Solutions for Sarah Lawrence College

Katherine Labadie and Yuci Zhou

Introduction

Transportation is a key component of campus sustainability. Transportation is responsible for about 32 percent of U.S. carbon dioxide emissions, and toxic tailpipe emissions, such as benzene, butadiene, and diesel can potentially lead to elevated risks of cancer (American Lung Association 2003). Not to mention the potential for environmental damages upstream with oil drilling, risks of oil spills, and nonpoint source water pollution (Toor and Havlick 2004, 1).

The negative effects of transportation on the environment can be ameliorated at Sarah Lawrence College with sustainability practices that increase transportation efficiency in the short term, as well as long-term investments in sustainable vehicles. Stronger bicycle programs, fixed routes for the campus shuttle system, and education on sustainable transportation in general could help Sarah Lawrence in reducing emissions from transportation in the short run. Stronger bicycle programs will reduce the college's impact on the environment, and improve the health and wellness of the staff and students through physical activity. If fixed shuttle schedules are introduced, the annual milage on the Sarah Lawrence College vehicles could be reduced.

Education on sustainable transportation has the potential to ensure that the New York's idling law is followed on campus, as well as the potential to get more students using the campus' environmentally sustainable transit programs, such as the bike share or Zipcar programs.

Then, over time, investment in more energy efficient vehicles on campus can drastically reduce Sarah Lawrence's carbon footprint. By switching to more energy efficient vehicles, such as the Nissan LEAF SUV or the seven passenger Nissan e-NV200, the college can drastically reduce its greenhouse gas emissions, improving air quality on campus, and save approximately $0.5 million over 20 years. Overall, efforts to create a more sustainable campus transportation system can reduce greenhouse gas emissions, improve air quality, and promote health and well-being at Sarah Lawrence College, as well as help lessen environmental damages on a broader scale.

Sustainability and Higher Education

Colleges and Universities play crucial roles in fostering a culture or social norm of sustainability. These institutions of higher education consist of and connect many acres of buildings and land. Colleges and Universities, like any other campus space, can have a huge impact on the degradation or sustainability of the earth depending on their methods of waste disposal, buying practices, and energy consumption.

In addition to all of this land and all of these buildings, college and university campuses are full of young minds. In the United States alone, 14.5 million students attend institutions of higher education (Barlett 2004, 5). These students lifestyle choices and habits are heavily influenced by their education and their university's or college's practices. Furthermore, colleges and universities often have influence in the outside communities. College campuses are often the largest employers in the surrounding area (Balsas 2003, 36). Programs and commitments to environmental sustainability on college and university campuses can have large impacts on environmental health on a broader scale.

The power of higher education in environmental sustainability is reflected in the first Earth Day in 1970, which was facilitated by college students. Then in 1990 with the Talloires Declaration, the first official statement made by university administrators recognizing the importance of a commitment to environmental sustainability. However, there are many obstacles in developing more sustainable practices in the world of higher education. Major obstacles that colleges and universities face are financial limitations and lack of interest and commitment from stakeholders (Barlett 2004, 6). In order for a university or college to change towards a more sustainable future the college needs to be united in their sustainability efforts: there needs to be strong personal relationships across campus, strong leaders to head these programs, and a high level of support from administration and board members.

Helpful measures to get universities and colleges running sustainably include ecological missions, policy measures, and investment in the best available technology for environmental sustainability. A written statement of goals or mission for campus sustainability clearly defines what the university strives to achieve to aid the health of the environment. Once a mission is in place, policy measures can be crafted by administration, staff, and students to meet these goals. In addition to policy regulations, it is helpful for colleges and universities to invest in the best available technology for environmental sustainability that is affordable to the college so the infrastructure for the campuses energy use, waste disposal, etc. has the least environmental impact possible.

Transportation and Sustainability

Transportation is a key component of overall campus sustainability. Many students and staff at colleges and universities commute to campus and travel around campus in personal vehicles. The personal automobile has become the dominant mode of travel in the United States, more than 95 percent of personal trips are taken by car (Toor and Havlick 2004, 1). In addition to commuters, college and university campuses often own their own vehicles for campus maintenance, security, and student transit.

According to the American Lung Association's 2003 State of the Air Report, more than 142 million people living in the U.S. breath in unhealthy amounts of ozone pollution, which is linked to heart and lung diseases (2003). Transportation is responsible for a large proportion of greenhouse gas (GHG) emissions, about 32 percent of U.S. carbon dioxide emissions is from transportation (American Lung Association 2003). Furthermore toxic tailpipe emissions, such as benzene, butadiene, and diesel can potentially lead to elevated levels of cancer for people that live near major roads and highways (American Lung Association 2003). Not to mention the potential for environmental damages upstream in the process with oil drilling, risks of oil spills, and nonpoint source water pollution (Toor and Havlick 2004, 1).

The negative effects of transportation on the environment can be ameliorated with short sustainability and energy efficiency practices and long term investments in zero-emissions vehicles. Promoting bike programs, establishing fixed schedules and routes for the shuttle system, and developing education programs on the importance of on campus sustainable living in general are ways in which Sarah Lawrence College can reduce emissions from transportation.

Bike Programs and Active Transit

One of the easiest short term solutions to make campus transportation more sustainable is to promote bike programs and other modes of active transit for students traveling within and around campus. Active transit encompasses any form of transportation that involves physical activity, walking and cycling are both good examples. Active transit is beneficial on college campuses not only because it reduces demand for parking and reduces the college's impact on the environment, but also because it improves the health and wellness of the staff and students. Studies of adolescents show that increased physical activity has the potential to reduce depression and increase academic performance (Field et al., 2001, 105). Additionally, reducing exposure to traffic, with increased active transport, is likely to create more positive perceptions of the area for students and staff, as well as for residents living near the campus (Bull 2006, 241).

Sarah Lawrence College has a small bike share program already established on campus; however, the program is not heavily utilized by the students. Creating designated bike paths on and around campus would promote use of this program and cycling in general around campus. According to a study of 18 U.S. cities, there is a correlation between the miles of bike paths and the percentage of commuters who cycle (Bull 2006, 245). Putting bike paths around campus will make it easier for students to get from class to class on bike, and less reliant on shuttle systems or personal vehicles. Then if colleges and universities partner with local government to increase the number of bike paths around the campus and throughout the local community, it will be easier for commuter students and staff to bike to campus rather than drive.

In addition to providing cycling and walking pathways for students, colleges and universities can support students who prefer modes of active transit by providing bicycle repair and education services on campus. Reducing the barriers that keep students from using active modes of transport is more effective than simply promoting the benefits of active modes (Bull 2006, 249). In order to successfully promote active transit, campuses must reduce the barriers and increase the convenience of active modes and reduce the convenience and cost-effectiveness of driving (Bull 2006, 249).

Changes to Student Shuttle System

Establishing fixed routes for the campus student shuttle system would also help to reduce the campus' carbon footprint. If the shuttles had direct, fixed routes, such as from the library to Hill House, and designated pick up and drop off stops for students, then the annual milage of these vehicles could be reduced. For the dispatching of the vehicles, a combination system of ad hoc and scheduled pickups could help avoid repeated pickups at a single location. If the shuttles were, on occasion, dispatched in set intervals, for example every ten to fifteen minutes minutes on cold, late nights, repeated pickups could be avoided and each shuttle would be more likely to fill up with students, further reducing the campus' ecological footprint.

Education on Campus Sustainability

Education on campus sustainability in general could help Sarah Lawrence College run with less of a carbon footprint. Even with sustainable transport programs in place, if students and staff are not informed on these programs, they will not be very effective in helping the campus become more environmentally sustainable. Education on how to use the campus' bicycle programs, the fixed schedule and routes of the student shuttle system, and the on-campus rideshare program, Zipcar can help the campus collectively run more sustainably. Students

should also be educated on the parking permit system already at Sarah Lawrence. If more students were aware of the costs of the permits, they would be less likely to bring personal vehicles on campus in the first place. These sustainability measures incentivize alternatives to using personal vehicles on campus. If students and staff are more knowledgeable on these programs, if the barriers surrounding the use of these programs are reduced, they will be more likely to utilize them (Bull 2006, 249).

Education on state idling laws, could help reduce the number of idling vehicles on campus, subsequently reducing the college's carbon footprint. While student shuttles are not in transit and when public safety vehicles are stationed on Kimball Avenue, the car's engine is usually left running. New York State Environmental Conservation Law (ECL) prohibits heavy duty vehicles from idling for more than five minutes at a time (Department of Environmental Conservation). Education on state idling laws for student van drivers and public safety officers could help reduce the number of idling vehicles on campus.

In order for sustainability plans to be implemented, the college should identify potential partnerships for funding and administrations (Toor and Havlick 2004). Federal funding and collaborative administration with local government are all possible options, while private fundings could provide more flexibility. At Sarah Lawrence, an Office of Campus Sustainability could be in charge of searching for federal funding, grants, and loans for the college's sustainability efforts. Offices around campuses collaborating with the already established Sarah Lawrence Sustainability Committee could also aid the school's environmental goals. Implementing all of these plans in a multi-tiered transportation management program can reduce Sarah Lawrence College's carbon footprint and improve the environmental health of the broader community.

Long Term Solutions - Vehicle Efficiency

Besides student and faculty-owned commuting vehicles, "the campus fleet", vehicles that are owned and operated by college and university campuses, have huge impacts on campuses ecological footprints. These vehicles, are typically either used for student transportation or for college administration departments, such as the public safety department. Regardless of their functions, these vehicles are centrally administered by the college and generally operate within the territory of the campus or nearby communities.

One way to improve vehicle efficiency is by using alternative fuels. Most motor vehicles use gasoline, which is not only nonrenewable, but also an emitter of significantly more greenhouse gases than most alternative fuels. The main strategies for implementing alternative fuel technologies are integrating the use of electricity into vehicles and implementing other hydrocarbon alternatives to fossil fuels.

Battery electric vehicles, fuel cell vehicles, plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs) are vehicles that rely on fuels other than hydrocarbons. Fuel cell vehicles use hydrogen fuels along with oxygen from the air to produce electricity (U.S. Environmental Protection Agency and U.S. Department of Energy). PHEVs and HEVs recycle energy from the wheels of the vehicle, using them to turn a motor, which generates electricity PHEVs also have batteries that can be charged from an outside electric power source; however, HEVs can only make use of the energy from engine combustions to generate electricity (U.S. Environmental Protection Agency and U.S. Department of Energy).

Battery electric vehicles have the lowest GHG emission throughout the lifetime of the vehicle, followed by fuel cell vehicles, plug-in hybrid electric vehicles, and hybrid electric vehicles (Nigro 2013, 2). The sustainability of electricity in vehicles that require plug-in charges is not related to the production process of electricity itself. Although electricity is mainly produced by fossil fuel combustion in the United States, electric motor engines are far more efficient than conventional gasoline vehicles (U.S. Environmental Protection Agency and U.S. Department of Energy). The GHG emissions from vehicles that incorporate electricity usage are lower than the GHG emissions for conventional vehicles over time.

Other usages of hydrocarbons as alternative fuels to gasoline and diesel include biodiesel, liquefied petroleum gas (LPG), natural gas, and biologically-generated alcohols. For alcohols, methanol is mostly manufactured from carbon-based feedstock and natural gas, and ethanol by sugar and starch crops, mainly corn in the United States (Toor, Havlick 2004, 224-6). Biodiesel is mostly produced from agricultural feedstock. While the GHG emissions of burning these hydrocarbons are not necessarily lower than gasoline and diesel (U.S. Energy Information Administration), the ecological footprint is, in fact, reduced because the net GHG emission is close to zero (Toor and Havlick 2004, 224-6), since the process of carbon fixation is provided by photosynthesis.

The suitability of alternative fuel technologies for colleges and universities is highly dependent on the cost of infrastructure and availability of resources on the college or university campuses. Infrastructure improvements for a transition to alternative fuels normally include new models of vehicles, charging stations for electric or hybrid cars, and the cost of purchasing alternative hydrocarbon fuels due to their low availability compared to gasoline and diesel. Biodiesel and natural gas are hard to obtain from public fueling stations since they are not popular in most of the states in the U.S. Thus, campuses would need to establish their own network to obtain these fuels (U.S. Department of Energy). For campuses with a huge amount of vehicles, this option may be viable, but it is certainly not an option for small-sized campuses.

The cost of electric or hybrid vehicles mainly comes from replacing old vehicles with new models, which cost range from around $20,000 for HEVs to $40,000 for battery electric vehicles. However, there are one-time tax credits for purchasing these vehicles, which could be as high as $7,500 (International Revenue Service 2009). While the costs of battery replacement could be as high as $8,000 per vehicle for every three to six years, electric and hybrid vehicles offer substantial fuel savings over lifetime (Toor and Havlick 2004, 224-6). Implementing electric or hybrid vehicles is a practical solution for campuses of various sizes but is more likely to be favored by small campuses. Even if fuel cells emit zero greenhouse gasses, the infrastructures are too expensive so that this technology is not a good choice for colleges and universities (Toor and Havlick 2004, 224-6).

Despite the challenges discussed above, it is possible for college campuses to implement alternative fuel technologies. First of all, since campus vehicles are often centrally administered, it is easy for them to be replaced in bulk and to be centrally fueled, thus reducing the cost. For alternative fuel vehicles, the travel distance of a single fuel refill or energy recharge is less than that of traditional gasoline vehicles. While this is often seen as a hindrance for alternative fuel vehicles to be popularized, it does not significantly impact campus vehicles because they do not need to make long-distance travels (Toor and Havlick 2004, 222), campus vehicles typically only travel within the campus or to nearby communities.Thus, campus-owned vehicles could be a frontier to demonstrate the positive influence of alternative fuel technologies.

Universities that are successful in implementing alternative fuel technologies often use natural gas to replace gasoline or diesel. The University of British Columbia, Emory University, University of California–Davis, James Madison University, and University of New Hampshire have all replaced gasoline and diesel with natural gas to fuel their vehicles. Another alternative is using biodiesel to replace gasoline and diesel. The University of Montana and University of Colorado–Boulder replaced fossil fuels with biodiesel. However, among these choices, natural gas is the most convenient, as using biodiesel depends entirely on supply (Toor and Havlick 2004). The University of Montana relies on a local biodiesel producer for supply, and University of Colorado–Boulder constructed a processor of biodiesel.

Natural gas is an easier alternative fuel to implement because it is more readily available than biodiesel.

According to the cost-benefit analysis (CBA) below, investment in electric vehicles for student transportation not only reduces the college's carbon footprint, but also can be more cost effective. The CBA below looks at the costs of doing business-as-usual (not replacing any vehicles), replacing all the vehicles in ten years, replacing the vehicles in five years, and replacing the vehicles all at once. As seen in Table 2, a ten year replacement plan costs the least for the college, followed by a five year replacement plan, and a one-time replacement. According to the CBA carrying on with current transportation practice, business-as-usual, is the most costly for the college. The CBA looks at the costs of doing business-as-usual (not replacing any vehicles), replacing all the vehicles in ten years, five years, and all at once. As one can see infig. 2, replacement plans are far less costly for the college, regardless of the plan's time span. Among the plans, a one-time replacement costs the least and could save about $0.5 million over 10 years, followed by a 10-year replacement plan and a 5-year one.

Cost-Benefit Analysis for an Alternative Campus Fleet

A cost-benefit analysis is made to find out the best alternative to our college's current campus fleet. Since the key is to reduce the ecological footprints of Sarah Lawrence community, the proposed alternative plans all focus on replacing our campus vehicles with electric ones.

Table 1 provides an overview of the annual cost of campus fleet at Sarah Lawrence, excluding maintenance vehicles. Due to our limited knowledge of our campus fleet and the unusual operation manner, maintenance vehicles are excluded from the analysis.

The alternative plan is based on how the vehicles currently are operated in and around the campus. Vehicles the college currently owns have distinct functions and serve different purposes. According to the perceptions of public safety, the fleet functions to expand the student body's opportunity to not only utilize the space of the college equally, but also to explore the area around the college, especially the culturally diverse and dynamic New York City. Thus, as shown in Table 2, the alternative plans make sure that the number of vehicles that could fulfill these functions do not change. In the CBA, we choose to substitute the SUVs the college owns with Nissan Leaf SV, a plug-in electric SUV; besides, the minivans and vans are substituted with Nissan e-NV200, a plug-in electric 7-passenger minivan.

In analyzing the costs of changing into a new, more sustainable fleet, the investment for infrastructure is considered first and foremost. The vehicles can be charged easily with existing electricity supply and the chargers come with purchases. Hence, the only investment involved in the transition is the purchase of new models of vehicles. Although the vehicles are usually priced higher than similar-functioned vehicles that rely on fossil fuels, all electric vehicles can receive federal tax credits as high as $7,500. Besides lower fuel costs compared to traditional gasoline vehicles, electric vehicles also have lower maintenance costs.

A very important factor to take into consideration is how the costs are valued over time. In other words, there is a discount rate involved in the analysis, and it determines the present value of the costs and benefits. Besides, the fuel prices are also expected to change over time: gasoline price will rise, and electricity price will fall slightly. Thus, how the investment allocates over time changes the present value of the alternative plan. In the cost-benefit analysis, three different ways to eliminate fossil fuels are considered – purchasing all the electric vehicles at once, purchasing the electric vehicles over five years, or purchasing them over ten years.

Although the business-as-usual situation does not involve investment on new vehicle models, there are still replacements made annually. In the analysis, the replacement plan derives from the limited information that the college public safety department provided to the research team. The college public safety official provided us with the information regarding the annual replacement plan of vans; however, we could only estimate the replacement plan of SUVs and minivans based on the number of these types of vehicles. This investment constitutes a significant amount in the total cost of the business-as-usual situation.

A summarize of the cost-benefit analysis is available in Table 3, and the full data is available in Table 4. Comparing the costs of four different situations, it is clear that the alternatives can reduce the cost over the 20 years. Among the three alternative plans, replacing all the vehicles at once costs the least, following by replacing all of them in five years, and then in ten years. The plan that costs the least also reduces emission the fastest, since only the electric vehicles that are put into place could effectively reduce carbon emission of the fleet. The upstream externalities of electricity generation are not accounted for in the analysis, because the production of electricity is a convoluted process that involves many different types of externalities.

The possibility of using a loan to finance the investment is not considered in this cost-benefit analysis. There are many possibilities for the college to obtain finance for such a program, including donations, which do not require the college to pay the money back with interests. The interest rates and other costs for obtaining different loans could also be different. Besides, the loan could provoke other side effects for the college administrations. Thus, the possibility of obtaining a loan should be put into a holistic view of the college's big picture.

Undoubtedly, it is worthwhile for the college to transition from regular gasoline vehicles to electric ones. However, how the college decides between cost-effectiveness and increased emissions reduction depends on the consideration of the college administration. This analysis is only to provide an overview of the different possibilities to reduce the ecological footprints of the campus fleet.

Conclusion

The negative effects of transportation on the environment can be ameliorated at Sarah Lawrence College with increased transportation efficiency in the short term and investment in zero-emissions vehicles in the long run. Stronger bicycle programs, fixed routes for the student shuttle system, and education on sustainable transportation in general can help Sarah Lawrence to reduce emissions. Then, over time, investment in more energy efficient vehicles on campus can drastically reduce Sarah Lawrence's carbon footprint. By switching the campus fleet to Nissan Leaf SVs and seven-passenger Nissan e-NV200s, the college can drastically reduce its greenhouse gas emissions, improving air quality on campus, as well as saving approximately $0.5 million over 20 years. Transportation plays a large role in overall campus sustainability as vehicles emit a high level of greenhouse gases, as well as toxic tailpipe emissions. Improving the sustainability of campus transit is not only cost effective, but it also reduces Sarah Lawrence’s impact on the environment, and improve the health and wellness of students, faculty, and staff.

Table 1

Overview of Sarah Lawrence Campus Fleet (Excluding Maintenance Vehicles)

Model	No. of the Model We Own	Fuel Cost per Vehicle ($/year)	CO_2 Emissions (tons/year)	Maintenance Cost ($/year)
Honda Pilot	5	1,250	6.075	4,035
Chrysler Town and Country	3	1,300	6.66	2,421
Ford Transit	4	1,100	5.61	3,228
Ford E350	11	2,150	10.26	8,877
Total	23	5,800	28.605	18,561

Sources: U.S. Environmental Protection Agency and U.S. Department of Energy.

Notes: Calculation based on 45% highway, 55% city driving, 15,000 annual miles and current fuel prices. Carbon emissions are priced $20 per ton. Maintenance cost is ¢5.38/mile for gasoline vehicles.

Table 2

Overview of the Proposed Alternative Fleet

New Suggested Model	Market Price ($)	Quantity	Adjusted Price based on Tax Credit ($)	Total Investment ($)	Fuel Cost per Vehicle ($/year)	Maintenance Cost ($/year)
Nissan Leaf SV	34,200	8	26,700	213,600	274	4920
Nissan e-NV200	20,870	30	13,370	401,100	336	18,450

Sources: American Automobile Association, Nick Bunkley, and U.S. Environmental Protection Agency and U.S. Department of Energy.

Notes: Calculation based on 45% highway, 55% city driving, 15,000 annual miles and current fuel prices. Maintenance cost is ¢4.1/mile for electric vehicle

Table 3

Overview of the Cost-Benefit Analysis

Plan	Present Value of the Total Cost over 20 Years ($)	Total Savings compared to Business-as-Usual ($)
Business as usual	1,676,744.25	0
Replacing all the vehicles at once	1,175,481.33	501,262.92
Replacing the vehicles in five years	1,184,235.16	492,509.09
Replacing the vehicles in ten years	1,199,222.98	477,521.27

Table 4.1

Complete Cost-Benefit Analysis: Business-as-Usual Situation in 20 Years

Year	Fuel and Carbon Emission Cost ($)	Maintenance Cost ($)	Annual Vehicle Replacement Cost ($)	Total Annual Cost ($)
0	38,772.00	18,561.00	72,630.00	129,963.00
1	38,320.29	18,020.39	30,543.69	86,884.37
2	37,873.84	17,495.52	29,654.07	85,023.43
3	37,432.59	16,985.94	28,790.36	83,208.89
4	36,996.48	16,491.21	27,951.80	81,439.49
5	36,565.45	16,010.88	62,651.28	115,227.61
6	36,139.45	15,544.55	26,347.25	78,031.25

Year	Fuel and Carbon Emission Cost ($)	Maintenance Cost ($)	Annual Vehicle Replacement Cost ($)	Total Annual Cost ($)
7	35,718.41	15,091.79	25,579.86	76,390.06
8	35,302.27	14,652.22	24,834.81	74,789.31
9	34,890.98	14,225.46	24,111.47	73,227.91
10	34,484.48	13,811.13	54,043.54	102,339.15
11	34,082.72	13,408.86	22,727.37	70,218.96
12	33,685.64	13,018.31	22,065.41	68,769.37
13	33,293.19	12,639.14	21,422.73	67,355.06
14	32,905.31	12,271.01	20,798.77	65,975.08
15	32,521.94	11,913.60	46,618.43	91,053.98
16	32,143.05	11,566.60	19,604.83	63,314.48
17	31,768.57	11,229.71	19,033.82	62,032.09
18	31,398.45	10,902.63	18,479.43	60,780.51
19	31,032.64	10,585.08	17,941.20	59,558.92
20	30,671.09	10,276.78	40,213.47	81,161.34

Present Value of the Total Cost over 20 Years ($) 1,676,744.25

Notes: The discount rate is 3%. The annual vehicle replacement is calculated based on an annual purchase of a Ford E350 and a purchase of a Honda Pilot ev

Calculation of the annual fuel cost takes into account of a 1.8% gasoline price escalation rate (EIA, U.S. 2011).

Table 4.2

Complete Cost-Benefit Analysis: One-Time Replacement of All Vehicles

Year	Investment on Vehicle Purchases	Escalated Annual Fuel Cost ($)	Maintenance Cost ($)	Total Annual Cost ($)
0	614700	12,272.00	23,370.00	35,642.00
1	0	11,878.82	22,689.32	34,568.14
2	0	11,498.24	22,028.47	33,526.70
3	0	11,129.85	21,386.86	32,516.71
4	0	10,773.26	20,763.94	31,537.20
5	0	10,428.10	20,159.17	30,587.26
6	0	10,093.99	19,572.01	29,666.00
7	0	9,770.59	19,001.95	28,772.54
8	0	9,457.55	18,448.49	27,906.05
9	0	9,154.54	17,911.16	27,065.70
10	0	8,861.24	17,389.47	26,250.72
11	0	8,577.34	16,882.99	25,460.33
12	0	8,302.53	16,391.25	24,693.78
13	0	8,036.53	15,913.83	23,950.36
14	0	7,779.05	15,450.32	23,229.37
15	0	7,529.82	15,000.31	22,530.13
16	0	7,288.57	14,563.41	21,851.98
17	0	7,055.05	14,139.23	21,194.29
18	0	6,829.02	13,727.41	20,556.43
19	0	6,610.22	13,327.58	19,937.81

Year	Investment on Vehicle Purchases	Escalated Annual Fuel Cost ($)	Maintenance Cost ($)	Total Annual Cost ($)
20	0	6,398.44	12,939.40	19,337.84
Present Value of the Total Cost over 20 Years ($)		1,175,481.33		

Notes: The discount rate is 3%. Calculation of the annual fuel cost takes into account of a -0.3% electricity price escalation rate (EIA, U.S. 2011).

Table 4.3

Complete Cost-Benefit Analysis: Greening the Campus Fleet over Five Years

Year	Investment on Vehicle Purchases	Escalated Annual Fuel Cost ($)	Maintenance Cost ($)	Total Annual Cost ($)
0	122,940.00	33,472.00	19,522.80	52,994.80
1	119,359.22	27,743.70	19,887.96	47,631.66
2	115,882.74	22,048.48	20,215.29	42,263.77
3	112,507.52	16,390.39	20,506.68	36,897.07
4	109,230.60	10,773.26	20,763.94	31,537.20
5	0	10,428.10	20,159.17	30,587.26
6	0	10,093.99	19,572.01	29,666.00
7	0	9,770.59	19,001.95	28,772.54
8	0	9,457.55	18,448.49	27,906.05
9	0	9,154.54	17,911.16	27,065.70
10	0	8,861.24	17,389.47	26,250.72
11	0	8,577.34	16,882.99	25,460.33
12	0	8,302.53	16,391.25	24,693.78
13	0	8,036.53	15,913.83	23,950.36
14	0	7,779.05	15,450.32	23,229.37

Year	Investment on Vehicle Purchases	Escalated Annual Fuel Cost ($)	Maintenance Cost ($)	Total Annual Cost ($)
15	0	7,529.82	15,000.31	22,530.13
16	0	7,288.57	14,563.41	21,851.98
17	0	7,055.05	14,139.23	21,194.29
18	0	6,829.02	13,727.41	20,556.43
19	0	6,610.22	13,327.58	19,937.81
20	0	6,398.44	12,939.40	19,337.84
Present Value of the Total Cost over 20 Years ($)		1,184,235.16		

Notes: The discount rate is 3%. The calculation assumes that the investment is distributed evenly throughout the five years. Calculation of the annual fuel cost takes into account of a -0.3% electricity price escalation rate (EIA, U.S. 2011).

Table 4.4

Complete Cost-Benefit Analysis: Greening the Campus Fleet over Ten Years

Year	Investment on Vehicle Purchases	Escalated Annual Fuel Cost ($)	Maintenance Cost ($)	Total Annual Cost ($)
0	61,470.00	36,122.00	19,041.90	55,163.90
1	59,679.61	33,031.99	18,954.17	51,986.17
2	57,941.37	29,961.16	18,855.41	48,816.56
3	56,253.76	26,911.49	18,746.31	45,657.80
4	54,615.30	23,884.87	18,627.58	42,512.44
5	53,024.56	20,883.04	18,499.85	39,382.89
6	51,480.16	17,907.63	18,363.77	36,271.40
7	49,980.74	14,960.15	18,219.92	33,180.07
8	48,524.99	12,042.03	18,068.87	30,110.89

Year	Investment on Vehicle Purchases	Escalated Annual Fuel Cost ($)	Maintenance Cost ($)	Total Annual Cost ($)
9	47,111.64	9,154.54	17,911.16	27,065.70
10	0	8,861.24	17,389.47	26,250.72
11	0	8,577.34	16,882.99	25,460.33
12	0	8,302.53	16,391.25	24,693.78
13	0	8,036.53	15,913.83	23,950.36
14	0	7,779.05	15,450.32	23,229.37
15	0	7,529.82	15,000.31	22,530.13
16	0	7,288.57	14,563.41	21,851.98
17	0	7,055.05	14,139.23	21,194.29
18	0	6,829.02	13,727.41	20,556.43
19	0	6,610.22	13,327.58	19,937.81
20	0	6,398.44	12,939.40	19,337.84
Present Value of the Total Cost over 20 Years ($)		1,199,222.98		

Notes: The discount rate is 3%. The calculation assumes that the investment is distributed evenly throughout the ten years. Calculation of the annual fuel cost takes into account of a -0.3% electricity price escalation rate (EIA, U.S. 2011)

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Sprouting Roots at Sarah Lawrence College

Prospects of Adding a Green Roof or Biowall to Campus

Iva Johnson, Yun Mi Koh, Anna Rossi

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°Cfrom green roof insulation (Getter & Rowe 2006). Green roofs have been found to reduce indoor temperatures by up to 4°Cif temperatures are between 25°Cand 30°C, 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 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 cancreate 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 as 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°Con 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 bird 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=Oh7vxlYt38

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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Reducing Sarah Lawrence's Use of Plastics

Marisa Acosta, Victoria Brown, & Hannah Lawson

In the United States in 2008, 34 million tons of plastic were thrown away, 86% of which was placed in landfills (North and Halden 2013). Sarah Lawrence College uses 50,000 plastic containers per school year, contributing 1.5 tons of plastic per approximately thousand people. If everyone in New York City discarded plastic takeout containers at the same rate, they would produce 126,000 tons of plastic waste yearly. This discarded plastic is not only incredibly wasteful, but poses significant environmental and human health risks. This paper seeks to evaluate the damages and costs of plastic waste and to formulate a plan to reduce this waste on the Sarah Lawrence campus. In the first section, the paper addresses the hazards of plastic. In the second, it explores waste-reduction programs at other schools. Thirdly, it evaluates Sarah Lawrence's current policies on plastic. In the final section, the paper explores potential waste-reduction solutions for Sarah Lawrence. After evaluating the aspects of plastic, it concludes that the most salient policy response is to institute a reusable container system.

Plastic compounds can be found in everyday products such as medical devices, cosmetics, computers, children's toys, and food packaging (Oehlmann et al. 2009). However, despite the usefulness of plastics, they pose severe negative effects on both human health and the natural environment. Many of the chemicals in plastic are toxic (Thompson et al. 2009); phthalates and bisphenol A (BPA), two of the most common plastic chemicals, are produced worldwide in quantities exceeding 1 million tons each year (Koch and Calafat 2009). Detected in the air, dust, and aquatic environments, (Thompson et al. 2009) these chemicals directly enter environmental cycles and the human body (Koch and Calafat 2009). Phthalates and BPA have serious impacts on humans and other animals, including alteration of the endocrine system, anti-androgen action, disruption of thyroid hormone homeostasis, the alteration of gene expression cells, and testicular dysgenesis syndrome. Concentrations of these chemicals far exceed healthy levels in young children and have been proven to alter the development of their brains (Talsness et al. 2009). Strikingly, the chemicals in plastic affect children most. Polybrominated biphenyl ethers (PBDE) have been found in breast milk and fat tissue, leading to a higher exposure in young children (Talsness et al. 2009). Oehlmann et al. (2009) demonstrated that phthalates and BPA can affect reproduction, cause genetic aberrations, and impair development. It has also been found that endocrine disruptor chemicals (EDCs), could contribute to the development of cancer, reduced sperm count in humans, and precocious puberty in females (Talsness et al. 2009).

Exposure in humans and animals is a direct result of exorbitant waste. Chemicals leach out of discarded plastic and contaminate the surrounding environment (Talsness et al. 2009). There are several concerns about disposal: one of the most pressing problems involved in plastic products is the mass accumulation of waste in natural habitats and landfills. Landfills are quickly reaching or have reached capacity (Thompson et al. 2009). Discarding plastics in landfills is unsustainable because as the products break down, they leach chemicals, generating greenhouse gases and other air pollutants, which are very harmful to the environment and contribute to global warming (North and Halden 2013).

Another hazard of plastics is their danger to wildlife. Improperly discarded plastics are often discovered by animals who may consume or become entangled in the plastics. When animals ingest plastic products, the toxins are cumulative and can snowball up the food chain, only multiplying the negative effects. Our current plastic disposable practices contaminate freshwater, marine, and natural terrestrial habitats (Thompson et al. 2009). Bisphenol A is often released through landfill discharge, sewage treatment plants, and water systems and is found regularly in aquatic ecosystems, (Oehlmann et al. 2009).

Initiatives on other college campuses provide us with models for implementation on the Sarah Lawrence campus. This section aims to draw ideas for a program structure at Sarah Lawrence from the programs at other schools.

There were three schools in our study sample who instituted programs that, although they targeted different sources of waste, utilized models that can be applied to a program at the college. State University of New York at New Paltz eliminated plastic bag waste at their school bookstore in two simple steps: removal of waste products and presentation of alternative. They ceased to offer plastic bags with purchases at the school store and began selling reusable canvas bags for $1 each. These bags could be used by the students for other purposes or redeemed for their $1 back at any time. The upfront cost of the program is relatively low and requires only the purchase of canvas bags. It is a self sustaining program that will very quickly begin to pay for itself: the cost of canvas bags is a one time investment while the continued purchase of plastic bags is no longer necessary. The system is self sustaining because canvas bags are returned or reused by students without the need for continual repurchase. An additional potential benefit is that the lack of plastic bags on campus may condition students to use reusable bags for other purchases off campus.

The other two schools, Dartmouth College and Mt. Holyoke, both instituted programs to eliminate disposable cups on campus. At Dartmouth, reusable water bottles were sold for $5 to student from a table in the main dining hall. The table also provided information on the financial, environmental, and health benefits of a reusable water bottle. Mt. Holyoke gave all students reusable bottles at freshmen orientation (for use all four years of school) and removed disposable cups from their dining services. Annually, the college saves over 81,650 cups from the landfill (about $5,000). Dartmouth College placed the price of waste reduction on the students, making the program optional while Mt. Holyoke internalized the cost of the program by providing the water bottles for free. By removing disposable cups, the college made all students participants—if they forgot their bottle, they would have to go thirsty—but, in doing so, created change on a larger scale.

One college, Emerson College, began offering reusable food containers for a one-time fee of $5. Contemporaneously, students were charged 50 cents for every non-reusable takeout container they used. A table was set up in the dining hall where students could return their used container in exchange for a new container or a token to pick up a new container the next time they purchase takeout. Emerson's model incentives reusable container use by adding a considerable cost to disposable containers: even if a student got take out as infrequently as once per week, with an average school year of 34 weeks, they would spend $17 per year, more than triple the cost of the $5 fee.

The downsides of a reusable takeout container system are, most prevalently, the issue of compliance and the infrastructure to clean and redistribute new containers. The token system—which ensures that students only receive one container at a time—prevents a loss of containers while the 50 cent cost incentivizes compliance. Additionally, there are companies that provide services to make the transition and compliance easier. OZZI provides a ready-made system for recycling reusable containers. Large black machines placed around the campus provide an easy, automated return system, allowing students to return their containers for a token, which can be used for another container later on. In lieu of a token, a card reader can be used to return credit to student ID cards, putting meal payment and the reusable container system on the same card. A number of campuses including University of Maryland College Park and the University of California use the OZZI system.

Our current use of plastic is not sustainable (Thompson et al. 2009). Studies show that using a reuse-recycle program for plastic based products can significantly decrease negative environmental impacts (Ross and Evans 2002). However, recycling plastic creates problems such as effective sorting (North and Halden 2013), as we often see at Sarah Lawrence College. The use of biodegradable plastics is sometimes used as an alternative, however this “solution” only creates competition for food supply, as these plastics use resources such as corn and molasses (North and harden 2013). Integrating the use of paper- based and reusable containers at Sarah Lawrence College could be one of the first steps towards a more sustainable and healthy future.

Efforts to reduce plastic on campus have been on the back burner for a while now. Lacking specific data, this section reviews current systems in place at the college and brainstorms methods of raising money for a transition to less wasteful containers in the future. Students could be given the opportunity to “round up” when they make a purchase at the Pub and the extra money could be used to offset the increase in price for the eco-friendly containers. This would be optional so students would have no reason to feel gouged or forced to comply with something they did not agree in. This could be implemented for a set period of time with a specific fundraising goal. This could prove to be a successful method of raising the money, which would also prove that this is something the students are truly passionate about.

The Pub does give discounts to students who bring their own travel mugs when purchasing a beverage. This discount is not something that is particularly known by the students. Similarly, Bates dining hall has a to-go system at Sarah Lawrence. Most students know that you can ask for a to-go container (the same clear-hinged plastic ones available at the Pub), fill it, and leave. Many students do not know that there is another to-go option. For an upfront fee of one dollar, students can borrow a reusable to go container that can be returned for a full refund after they are finished. This program is, in effect, a much smaller scale of the larger reusable container program. Because most students are unaware of these programs, they are rarely used, if the program was more widely publicized, it could be more successful. Additionally, if students disposable drinking cups were only kept behind the counter, where students need to ask for them, students may become more mindful about their cup usage and may decide to transition to a reusable mug as an easier option.

Alternatively, students are less likely to buy into the reusable container system when a free option is available, regardless of the environmental costs. The system would be most beneficial if it was the only option offered. Fortunately, the staff at Sarah Lawrence is willing to commit to make the transition to the reusable container program if enough students demonstrate support. Assuming that the support for this system exists, Sarah Lawrence would solely offer a reusable to-go container at Bates. The student could pay the $1 fee with meal money, 1card, or cash.

There are several environmental benefits to implementing the use of reusable and paper based containers. By eliminating the use of plastic containers, Sarah Lawrence will be doing its part in protecting the environment. By doing so it will reduce plastic in landfills, create a more sustainable system, and safeguard the health of the students and the surrounding environment. Especially with hot foods, chemicals in the plastic tubs can leach into the food in the container and directly enter the student's body. This is very dangerous and can lead to the numerous health problems that are covered in more depth in the first section. Other chemicals can actually release into the air and dust around us, further affecting the environment and other students. By eliminating the use of plastic containers, Sarah Lawrence College would ultimately be benefitting in the form of a healthy student body and a healthy environment.

While there would be many environmental benefits, eliminating plastic from the campus could have financial benefits as well and the transition to a more eco-friendly campus could incentivize possible donors. Many college campuses, like those mentioned earlier in this paper, have begun enacting green initiatives and receiving positive feedback. Sarah Lawrence could highlight these initiatives in press releases, lead to an increase in donations.

While a reusable container program may be financially beneficial in the long run, facilitating the transition to a reusable system can be financially daunting. By using the economic model of Pigouvian taxes, fundraising tactics, and/or eliminating other options, the school and AVI can make the transition smoother and ensure students are invested in the program.

Foremost, AVI has expressed concern about the additional costs of a reusable or compostable container program. Thus, creating a system that does not require additional investment on the part of either the college or AVI is the most surefire way to be successful. There are a number of options to achieve this goal. First, students could be given the option to donate their excess meal swipes and meal money at the end of the semester to a Greener Campus fund. This fund could be invested in financing green projects around campus included, but no limited to, the reusable container program. Alternatively, in the checkout line, students could be asked in the checkout line whether they would be willing to donate $1, $5, or $10 amounts to the reusable container fund and the money could be easily transferred from their 1Card or Meal Money to the fund. Another alternative is to solicit an alumni supporter to supply the upfront costs of containers. For any of these options, a Pigouvian tax of fifty cents (or similar) could be implemented on all non-reusable containers used by students once the program is running. Combining the tax with promotional literature and information on the ongoing monetary and environmental costs of the disposable containers can not only finance the program but also increase students' likelihood of compliance.

Implementing a reusable container program would be very beneficial both financially and sustainably for Sarah Lawrence College. The issue of how to distribute, clean, and redistribute the containers is easily solved with simple planning. Students could have the option of turning in their containers to be cleaned either in the Pub or at Bates Dining Hall. When they are turned in to the Pub, a bin could be designated for the containers that would be taken down to Bates once or twice a day, depending on the frequency of returns. Likewise, bins would be set up at Bates, where the containers could then be washed once a day. The cost of transporting these bins can be easily rationalized. Assuming that most cafeteria employees receive near minimum wage, about $9/hour, the twenty minutes required to transport the containers would cost the college about $3, if this task is performed once a day, seven times of week for the average 12 weeks in a semester, is would cost approximately $250 to pay an employee to transport the used containers each semester. This cost is but a fraction of the $3,750 spent on disposable plastic containers each semester. Employees could transport the used containers to Bates Dining Hall 15 times a day (or for five hours!) before the cost of transporting containers was equivalent to the cost of disposable ones. Even with the time required to clean the containers, reusable containers would undoubtedly be less expensive in the long run.

The containers would be redistributed by way of a token or a credit on the 1Card. This credit or token would be given when a container is returned and taken off when a cleaned container is picked up. Sarah Lawrence College has the resources and ability to become more sustainable and environmentally conscious by making small moves such as switching over to reusable containers.

A reusable system would be most beneficial if it was the only option offered. Fortunately, the staff at Sarah Lawrence is willing to commit to make the transition to the reusable container program if enough students demonstrate support. Assuming that the support for this system exists, Sarah Lawrence would solely offer a reusable to-go container.

Due to the fact that using compostable containers is not a viable option for Sarah Lawrence's campus, this paper concludes that a reusable container program is the best *modus operandi* for reducing plastic waste on the college's campus. Not only will the program reduce the amount of plastic being discarded, but will actually save the college money. With a single overhead cost, minor employee upkeep costs, and a positive impact on the environment, instituting a reusable container system at Sarah Lawrence is a low-cost and relatively easy step that benefits both the environment and the college.

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Jocelyn Zorn and Allyson Panton

Sustainable Landscaping at Sarah Lawrence College

I. Introduction

Sarah Lawrence College is an institution that inspires innovation within its students and teaches them how to understand and act upon the challenges that our ever-changing society raises. Currently, society is presented with some of the largest ecological crises that humans have ever faced, the consequences of which are widespread, affecting everyone on the planet. In order to address environmental devastation, all institutions must re-evaluate their current practices and implement significant changes. No college is better equipped for creating such change than Sarah Lawrence; founded on innovative educational techniques, we possess the knowledge and creativity that can be harnessed to create environmentally sustainable and economically viable policies on campus. One of the most simple and cost-effective ways to reduce the college's ecological footprint lies within our landscaping practices. The college currently uses an unnecessary amount of water and fossil fuels on maintaining plant species and grassy areas. In order to cut back on water and fossil fuel use, the college can implement basic changes including planting native species, establishing a rain garden, and incorporating Xeriscaping techniques. Not only will these changes provide ecosystem services and reduce the college's carbon footprint, they will also lower the cost of landscaping maintenance.

II. Native Species Plantings

Currently, the college has an excess of non-native species planted throughout the campus that could be replaced with native species to provide ecological and economic benefits by dramatically reducing the need for watering, fertilizer use, and maintenance. The potential alternatives for non-native plants are abundant. Native species can be aesthetically pleasing and even visually similar to non-native species currently on campus, and are available in a wide range of light and water requirements as well as flowering period. Hydrangeas (*Hydrangea* L.), for instance, are a flowering shrub ubiquitous on campus that have an extensive underground root system, requiring water to penetrate deep into the soil, which is accomplished through hours of soaking. Two of the many potential native alternatives for flowering shrubs are New Jersey Tea (*Ceanothus americanus* L.), which improves soil quality by fixing nitrogen into the soil, and attracts butterflies, and Mountain Laurel (*Kalmia latifolia* L.), an evergreen that displays beautiful pink inflorescences. Both of these species are able to thrive with little water inputs and no fertilizer (Westchester Community College). Meanwhile, Chokeberry (*Aronia* Medik.) can replace the invasive Porcelain Berry (*Ampelopsis glandulosa* Wall. Momiy) found around campus, as it fruits beautiful dark berries and can thrive in multiple sunlight and watering conditions (Westchester Community College). There are also non flowering bushes planted around buildings that workers are required to spend hours watering with a hose; replacement potentials include Northern Bayberry (Myrica pensylvanica Mirbel) and Dwarf Sumac (Rhus copallinum L.), which both require little water to thrive and change from deep greens in the summer to beautiful reds in the fall (Westchester Community College).

The benefits of planting native species across campus can be measured not only in terms of the direct benefits that the college will receive, but also in terms of ecological services that will benefit the environment. Cultivating native species will provide habitats for insects and small mammals that are native to New York, as opposed to species that are potentially invasive or harmful to the natural habitats in Yonkers (California Native Plant Society). Encouraging the successful establishment and growth of native populations makes for a more biologically sound, functioning local ecosystem and minimizes the risks brought on by introducing non-native species. Non-native plants can alter soil processes and soil biota by changing potential nitrogen mineralization rates as well as soil microbial community structure and function; these changes can lead to long-term effects including changes in soil pH levels and nitrification rates, and consequently promote invasion of other exotic species and damage native species (Kourtev 2003). Some introduced plant species even have the potential to escape cultivated areas and become pests in natural areas, potentially leading to problems including but not limited to competition for resources, changes in nitrogen fixation rates, changes in hydrologic cycles, and increased sedimentation in natural areas (Reichard 2001). The economic costs of invasive plants in natural areas, agriculture, and gardens has been estimated at 35 billion dollars per year (Reichard 2001).

In terms of inputs, native species require significantly less water and fertilizer than the species currently planted on campus because they are acclimated to grow in this environment and therefore do not need additional supports in order to thrive (USDA). When planted in proper locations, native species can get the majority of their water supply from rainfall, which saves freshwater that would otherwise be provided by sprinklers and hoses. Although freshwater is a renewable resource, it is currently being used at a nonrenewable pace; a transition to native species will benefit the environment by alleviating the depletion of freshwater. Eliminating the need for fertilizer also provides environmental benefits. Fertilizer is used because it improves soil quality and provides nutrients to plants by increasing nitrogen and phosphorus levels; however, during rainfall nitrogen and phosphorus are washed away and carried into aquatic ecosystems through runoff (Murray 2004). Once in aquatic environments, nitrogen and phosphorus encourage the growth of algae, leading to excessive algal blooms, which deplete oxygen, sometimes to the point where no fish or sea life can survive (Biello 2008). Since native plants are already acclimated to grow in the soils found in New York, switching to native plantings will indirectly help to improve the quality of aquatic ecosystems in the area by reducing the need for fertilizer. Finally, planting ground covers, which are plants that spread across the ground without growing tall, would eliminate the need for lawn watering and mowing in areas on campus where students do not use lawns or where lawns do not provide aesthetic purposes. This would save water as well as fossil fuels from gas powered equipment, therefore lowering the college's carbon footprint.

While the environmental benefits to ecosystems are reason enough to make the switch to native plantings, there are also economic and social gains to be had from changing. The money that the college will save from making the switch is perhaps the biggest incentive to make the switch. The costs would mainly entail purchasing new plantings and the labor of digging out old plantings and establishing new ones. Meanwhile, since the new native plantings will require little to no inputs once established, the college will save money on water bills, fertilizer costs, and labor and maintenance costs. The cost of purchasing fossil fuels for lawn maintenance equipment would also be lowered. Establishing a campus full of native plantings also has the opportunities to improve student life. Experiencing the beauty of New York's ecology will improve the ties that students have to the surrounding community and environment and allow students to fully experience living in New York.

Some schools across the United States have already begun to enact such a change. The University of New England, for example, has a native prairie garden as well as a blueberry garden on campus, both comprised of entirely native plants (University of New England). The native prairie garden was planted by students in an ecological restoration class; this kind of process helps to improve students' ties to their peers and the college community while reducing the cost of labor. The University of New England has described on their website the benefits they have received from planting native species:

> "Our perennial native wildflowers and grasses reduce the energy and resources needed to maintain landscaping. Well-adapted to Maine's climate, these plants are deep-rooted, hardy and non-invasive, and they serve as host-plants required by native butterflies and other vital insect species. They demonstrate how human-modified landscapes can be beautiful while contributing to biodiversity and a healthier ecosystem." (University of New England)

The experiences of other universities provide examples of how planting native wildlife can be beneficial. In addition, Westchester Community College, which has its own native plant center, has described native plants as "provid[ing] a regional identity, [and] sense of place" to its students, while providing practical and ecological benefits by "provid[ing] valuable sources of food and shelter for wildlife and help[ing to] protect water quality by filtering stormwater pollutants and reducing soil erosion” (Westchester Community College).

III. Rain Garden

Rain gardens are a an aesthetically pleasing solution to improving water quality for our community and protecting it against water pollution. A rain garden is a shallow depression that is planted with native plants that are able to tolerate both dry and wet conditions (NRCS 2005). The purpose of these gardens is when placed near a source of runoff water, for example a gutter after a storm, it allows the water to seep into the soil at a much slower rate than normal instead of veering directly to a storm drain or natural body of water. This process is immensely important, because runoff water can be a source or a catalyst for water pollution. It has been shown that, “Stormwater runoff from residential areas often contains excess lawn and garden fertilizers, pesticides and herbicides, oil, yard wastes, sediment and animal wastes which cause water pollution.”, and this water finds its way to our lakes and streams, which in turn has harmful effects on the various species that need that water to survive (Mass Audubon). Polluted runoff affects not only aquatic life, but also makes the water unsuitable for leisure activities, such as fishing and swimming (University of Connecticut NEMO). Rain gardens are a way to reduce peak storm flows, which helps to prevent stream bank erosion (Mass Audubon). It also helps to reduce the risk of flooding, since any excess water will slowly seep and be absorbed into the soil.

When deciding to develop a rain garden, it is best to choose native plants and flowering perennials with light exposure, moisture retention and quality of soil in deep consideration. Plantings that don’t require chemical fertilizers and pesticides are best when making a rain garden due to the high risk of such chemicals running off. When gardening one can also make sure to plant beautiful flowering species that will attract butterflies, songbirds, and other wildlife. This will provide food and a habitat for more native species that may be have lost theirs over time (EPA). Butterfly gardening is a popular, and easy way to achieve this,”. It can be as simple as providing the appropriate variety of host plants for larval growth and adult feeding." That will encourage the annual return of butterfly populations (Krischik). There have been over 100 butterfly sighting in Westchester County. The beautiful Baltimore Checkerspot (*Euphydryas phaeton)* most common host plant is a flowering perennial, Turtlehead *(Chelone),* which is native to our area (Kim Eierman 2014). Milk weed (*Asclepias L.*) is another important plant to consider, because it is a host plant for the Monarch butterfly (*Danaus plexippus*), as well as other insects. The Monarch butterfly has been threatened greatly in past decades due to global warming (which affects the timing of migration), habitat loss, and pesticides used to kill the milkweed which is an important source of food for them. Monarchs aren't the only butterflies that are in trouble in the United States, and if we garden with them in mind, we can not only help restore their habitat, but improve our waters as well.

The rain garden will provide the ecological benefits discussed as well as practical uses that the college will directly benefit from. The flood mitigation services that rain gardens provide will save the college money and prevent the inconvenience of cleaning up a flooded building, a situation that the school recently had to deal with in the science center after snowmelt flooded the lobby. In addition, campus beautification is a large incentive for making a change; flowering plants, butterflies and songbirds brought on by the garden will improve student life and impress prospective students. A rain garden also offers the opportunity for hands-on learning in biology classes and community building activities for students.

Taking into account the environmental and practical benefits that a rain garden will provide, the college can't afford not to invest in the implementation of one. In general, institutional rain garden costs can range between 10 to 40 dollars per square foot; these costs occur in the planning phase, design phase, construction phase and closeout phase, and take into account the need for control structures, curbing, storm drains, underdrains, plants, and soil amendments (Low Impact Development Center, Inc. [LID] 2007). However, many of the costs that involve establishing and planting the rain garden can be done by student volunteers who are interested in environmental sustainability, gardening, or horticulture, which would lower the cost of implementation and improve student life by providing outdoor activities and increasing the bond between students. The college's cost savings will increase after the rain garden is established and the use of traditional structural stormwater conveyance systems is reduced. For example, a medical office building in Maryland reduced the amount needed of storm drain pipe from 800 feet to 230 feet by establishing a rain garden, saving the office 24,000 dollars (LID 2007). Similarly, a new residential development spent about 100,000 dollars using rain gardens on each lot instead of 400,000 for the traditional stormwater systems that were originally in use (LID 2007).

Other universities have already caught on to the benefits of rain gardens. The University of New England has an established rain garden situated at the source of stormwater runoff, slowing the flow of water and absorbing excess nutrients while filtering pollutants (University of New England). Their rain garden was funded by a grant from the EPA and involved the work of five faculty members and 49 students from conception to completion; students in environmental classes collected information about rain gardens; developed the garden design, installation and maintenance plans; grew the majority of the garden's plants from seeds, planted the garden, and prepared educational materials for the garden (University of New England). Not only does the garden provide an opportunity for hands on learning to the students, but it also provides a botanical haven with over 150 individual plants representing over 17 native species and includes a stone walking path, bridge, and seating for the students' enjoyment (University of New England). More locally, Westchester Community College has already established a rain garden on campus, making use of its practical components and providing aesthetic value to its campus (Westchester Community College). With neighboring colleges embracing this change, it is time for Sarah Lawrence to step up and follow in its peers' example.

IV. Xeriscaping

Xeriscaping is a creative way of landscaping that can help conserve water on campus. This area is meant to not only be a space where little landscaping is required but also a student space as well. Xeriscaping calls for planting drought tolerant plants, appropriate landscape design and horticultural techniques that minimize water use and is defined as "quality landscaping that conserves water and protects the environment" (EPA). There is a small landscape opposite of student housing on Mead Way that is underutilized and maintained for appearances. Students enjoy spending their free time on top of the hill, but the rest of the area is rarely occupied. That is why it is a perfect space for a xeriscaped student area.

There are seven principles of Xeriscaping:

1. Water Conservation
2. Soil Improvement
3. Limited Turf Area
4. Appropriate Plants
5. Mulch
6. Irrigate
7. Maintain your landscape

And these principles are all necessary in creating the most efficient landscape (Earth Easy). How the area is designed is of utmost importance when it comes to conserving water. Certain plants should be zoned based on the amount of water they require in order to get the most efficient water use. By denoting anything that might limit water flow, such as, trees, fences, walkways, and structures, as well as note areas of shade and sun, we can get the most optimal space for water conservation and sun exposure, due to a well thought out design plan..

Xeriscaping is a way to not only promote soil that drains quickly but also store water at the same time (Earth Easy). By increasing the amount of organic material, such as compost, in the soil and also keeping it aerated will improve the quality of soil tremendously. Limiting turf area will reduce landscaping maintenance which will assist in conserving more water. Planting native species is another way to conserving water, since these plants are most suitable for this environment and implement them in zones based on their water needs will make the space work more efficiently. Mulch helps to prevent erosion, eliminate weeds, retain soil moisture and temperature. Irrigation systems are an important component to xeriscaping, because they conserve water by only providing water to the root of plants instead of all over the maintained area; this helps to reduce water loss from evaporation, and if delivered at a slow rate, helps promote root absorption. If all seven principles are followed, we can reap the biological benefits and practical benefits that xeriscaping has to offer.

It is also important to note that by using native plants in this capacity will eliminate the need for chemicals from fertilizers or pesticides. The use of native plants, shrubs or trees, will also help establish more habitats for Westchester's local wildlife. Xeriscaping will also reduce pollution. Gas mowers consume fossil fuels, and with this type of landscaping, that can be minimized. Any turf, which should be small, can be maintained with a reel mower. Xeriscaping is very popular and has been shown to increase property value for homeowners (East Larimer County Water District). Xeriscaping is also popular amongst colleges and universities as well, as part of their own sustainability initiatives. In the midst of an extreme drought California State University, Fullerton has spent over $250,000 on drought-tolerant landscaping (Picazo 2014). In an article from the Daily Titan, their school newspaper reported that, "Kathy Ramos, associate resource specialist of Metropolitan Water District, said a water saving analysis showed that commercial sites who removed turf reduced their water usage on average by 23.9 percent.", showing how low maintenance landscaping can reduce water usage. By reducing water use, we in turn reduce spending, both on water, and lawn supplies, like lush greenery and rolls of sod for example. University of Texas is saving 233,000 gallons of water annually by xeriscaping (The Daily Texan 2012). Two of their rock gardens alone are saving the university 72,000 gallons of water annually. Because there is limited greenery, it would be easy to design a space that could be a meeting space for students on campus. This space could have benches, tables, and other seating areas that would encourage and invite students to congregate in. Xeriscaping is a great landscaping alternative that will conserve resources, save money, beautify our campus and be a central source for community.

V. Conclusion

Landscaping practices, when done sustainably, are sure ways to reduce our ecological footprint. If more native species were planted on campus, in new rain gardens or added to a xeriscape landscape, more water would be conserved, we would use less fossil fuels, and curb the level of maintenance needed at Sarah Lawrence College. By making changes to the landscape, money can be saved, due to low maintenance solutions like native plantings, rain gardens, and xeriscaping. These solutions will also beautify our campus with flowering perennials, providing a once lost habitat for local wildlife, and be a source of food for other life forms as well. If one thoroughly thinks about and designs public spaces with the environment in mind and consider what's native to the region, one can reap the biological, ecological, and practical benefits of a more sustainable practice. By doing this, the community can help in reducing the consequences of its environmental degradation. Sustainable landscaping is an exemplary practice for reducing ecological footprints, beautifying public spaces, and being a catalyst for a greater sense of community.

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Water Sustainability at Sarah Lawrence College

Joseph Sterling, Jackson Langland, and Lily Frenette

Why Save Water?

Water use has a large impact on an institution, both in terms of its ecological footprint and financial cost. Water is a necessity in daily life and as such our use of it should be fully understood. Misuse of water can have environmental and economic impacts on an institution and its surrounding area. As climate change worsens many environmental issues will become apparent and those already affecting the world will be exasperated. One of the most important effects of climate change, and an issue of global scale that is currently occurring that is expected to worsen over time, is water and water use. Fresh water is a limited resources and must be conserved and use curbed as much as possible.

Water and Climate Change

As the climate changes, the availability of water around the world will lessen and accessibility to water will likely become more and more volatile. A study by Alcamo et al. (2010) predicted, “water stress will be increasing over most developing regions,” based on models that look at population and industry growth. Climate change will affect the frequency and severity of both droughts and storms (Hirabayashi et al 2010). These changes are a result of the intensification of existing weather patterns around the world. The circulation of air, and the interactions between hot and cold masses of air largely drive weather and climate. Global warming will cause warm air to get even warmer leading to more intense movement and circulation of air. As a result of these dramatic changes water availability, even in well-developed areas, will be very hard to predict accurately due to the change in global weather patterns and climate. Water use is already a large concern both economically and environmentally for a large portion of the world, and these concerns will only be increased as climate change takes effect. According to The US National Assessment, which is an assessment of probable climate change impacts in the US, the Northeast region of the US will experience longer, more frequent, and more severe heat waves, along with more flooding from both rivers and sea level rises. It is also possible that the number of powerful storms, including hurricanes, will rise over time.

Environmentally, more storms and floods will create a variety of problems including erosion, soil degradation, runoff, and pollution. These issues are all problematic although runoff and pollution are two of the most important issues. Runoff is the water that passes over roofs, roads, and other materials and carries with it pollutants and other harmful characteristics (Gnecco et al 2005). Runoff can enter rivers, lakes, oceans, and even soil causing harm to those environments. With an increase in the amount of storms and floods, runoff will become a more and more prevalent source of pollutants. Once pollutants have entered an ecosystem they can have a myriad of effects that range from individual level to population level events. Pollutants are harmful to life in many places and can have effects on many aspects of an organism including size, health, and general fitness and survival rates. This can lead to a loss in biodiversity, and therefore a loss in the amount of life on the planet. We must make changes going forward that lessen these harmful impacts and lower our need for water in anticipation of volatile future water availability levels.

How Sarah Lawrence Can Save Water

More efficient toilet use would lessen environmental impact by reducing the amount of water used, and therefore reducing the amount of water released into the environment as sewage. Sewage can be extremely harmful to ecosystems and our own population. Sewage carries with it many harmful pathogens that can do a large amount of damage to a population. These pathogens carried in sewage work their way into our drinking water if not properly addressed and managed. Any reduction in the amount of sewage created is helpful in reducing the human impact on the planet and surrounding ecosystems. Both rainwater collection and more efficient bathroom appliances can have very helpful environmental effects, which benefit both environment and the general populous.

In order to lessen these impacts and reduce our water footprint we propose two main strategies, rainwater collection and more efficient toilet use. Rainwater collection has many positive effects. These effects include a reduction in water use, and a reduction in runoff produced and therefore smaller amount of water pollution. Rainwater collection can take many forms but the most popular are collection through systems like gutters, or collection into large rain barrels. Rain barrels collect the rain and storm water, not allowing it to become harmful runoff. A study by Steffen et al (2013) found that a system of rain barrels in Salt Lake City could reduce the amount stormwater runoff by 12%, a system on a smaller scale could have an even larger effect. This reduction in runoff and pollution would lead to a healthier ecosystem, and in fact a healthier community of people (Gaffield et al 2003).

Sarah Lawrence Bathroom Facilities

With the number of old building on campus, replacing outdated water fixtures, such as sinks, showers, toilets, and urinals, with new ones could save water and money. The existing sinks and showers could have certain parts swapped out for low-flow versions, which will use less water and save SLC money in the long run. Current toilets could be replaced with low-flow models or dual-flush models. Water-free urinals could replace any currently in use.

Proposal: Showers

Sarah Lawrence has an estimated 325 showers on campus. This number was approximated by looking at floor plans and knowledge of the buildings. If the shower heads currently installed were made after 1992, they use 5.5 gallons of water per minute (gpm), if after 1992, they use 2.5 gpm. By replacing old 5.5 gpm heads with newer 2.5 gpm ones, the school could save 27,000 gallons per year and $260 per head per year (Beach, n.d.). If 2.5 gpm shower heads are replaced with low flow 2.0 gpm heads, 2,900 gallons per year could be saved. Replacement heads can cost between $10 - $50. Sarah Lawrence would not be the first college to replace their shower heads. Duke University installed over 500 low-flow shower heads during a drought in 2007 (Duke, n.d.). William Peace University worked with the city of Raleigh to get free low-flow heads in exchange for replacing their old ones (William Peace University 2012). Boston College has also replaced 750 shower heads with low-flow options (Office of News & Public Affairs 2014). Installing new shower heads is incredibly easy and this could be an easy way for Sarah Lawrence to conserve water.

Proposal: Faucets

Changing out faucet aerators is another easy way for SLC to conserve water. An aerator mixes air in with the water, allowing the faucet to achieve the same level of wetness, while consuming less water. If the faucets use more than 1.5 gpm they should be replaced with low-flow aerators (Samuleson 2012). These aerators can save almost 50% of water usage in faucets, cost only between $5 - $10 each, and would save $110/year per 0.5 gpm less is being used (Eatheasy 2012). William Peace, Boston College, and Duke University have all replaced their faucet aerators with low-flow options – Duke switched out over 3,000. Vanderbilt University has switched out their faucets for motion sensing faucets using low-flow aerators, which cuts the cost even more (SEMO 2016). This would be an inexpensive and money saving way of conserving water.

Proposal: Toilets

Toilets might be harder to replace than faucets or shower heads, but they will save a lot of money in the long run. With an estimated 436 toilets, SLC flushes a lot of water down the drain. There are two options for more sustainable toilets: low-flow or dual flush. For a low-flow toilet, a valve could be installed inside the toilet, or the toilet could be replaced. This would cut down significantly on the water usage. Older toilets typically use 3-5 gallons of water per flush (Moloney 2014). If replaced with a 1.28 gpf model, it would save 10,000 gallons per year on average. With dual flush, the toilet must be completely replaced with a different model, which could cost anywhere from $120 - $200 plus the cost of installation, but would give both a low-flow option for liquid waste and a slightly more powerful option for solid waste. Another, even easier, option to conserve water with toilets would be to displace water in the tank. By placing a large object in the tank, such as a brick or plastic bottle filled with rocks, in the tank, there is less water available for a flush. William Peace University received rebates from the city of Raleigh when replacing their 3 gpf models with 1.2 gpf toilets. Duke placed low-flush valves into more than 3,000 toilets and urinals. Vanderbilt replaced their toilets with dual flush models with a .8 gpf setting and a 1.3-1.6 one . All of these options would be valid paths for Sarah Lawrence to take in attempting to conserve water.

One intriguing option in conserving water would be to replace current public urinals with water-free options. A water free urinal can has a trap filled with a chemical that causes the urine to flow down the drain. This can save up to 40,000 gallons of water per year per toilet (Heimberg 2014). Vanderbilt University made all their non-residential urinals water-free in 2013. Sierra College also installed 33 waterless urinals, with plans to install more than 100 new urinals in the future. Waterless urinals have an assumed cost of $550 including the price of installation and also require $180 worth of maintenance per year (AHLA 2016). This means that the waterless urinal would pay for itself in eleven months. Because there is no current estimate on how many public urinals Sarah Lawrence has, it is hard to know how much water or money SLC would be able to save, but it is clear that waterless urinals would be a good way to save both.

Proposal: Rainwater Collection

One of the best ways for Sarah Lawrence to become more efficient with its water usage would be through the implementation of a rainwater collection system. In most cases, rainwater is collected directly via either a tank or a system of drains, often on the roof of a building, where it is later cleaned and recycled. While not safe for human consumption, the water would be clean enough to be utilized for plumbing, drastically reducing the amount of clean water which would have to be wasted for toilets; the recycled water can also be used for greenskeeping purposes should the need arise.

Several American schools utilize a similar system. Yale University has an extensive water collection system designed by Nitsch Engineering for one of their science centers, Kroon Hall. Designed with aesthetics in mind, the system channels water from the building's roof where it is filtered in a collection pond, which doubles as a water feature, before being passed on and stored in an underground cistern. The system can store up to 20,000 gallons, and according to Nitsch Engineering's website, helps save Yale approximately 634,000 gallons of water per year (Nitsch Engineering, n.d.). While Yale is considerably larger than Sarah Lawrence, the school itself putting the figure at around 5,500 enrolled undergraduates (Yale University 2015), the school is still smaller in scale than other universities which implement similar systems and, thus, more comparable to Sarah Lawrence.

Valencia College in Orlando has also put a similar system in place. They maintain two cisterns, one capable of storing 9,000 gallons of collected rainwater on their West Campus, while the other, based on their Osceola Campus, has a 10,000 gallon capacity. According to their site on the subject, the water stored is used both for irrigation and for plumbing (in tandem with low-volume toilets) (Valencia College, n.d.).

The best model for Sarah Lawrence to look to as an example is Cochise College in Arizona. On their Sierra Vista campus, which is comparable in size to SLC with a student body of approximately 2,000 undergraduates (Cochise College, n.d.), two cisterns were installed in 2015; both can hold 10,000 gallons of collected rainwater. Much like the previous two examples, rainwater is collected from the rooftops of the surrounding buildings and fed into the tanks via gravity, and the water is then primarily used for irrigation and landscaping. Furthermore, the school raised the funding for the project by receiving a grant from a local organization, the Cochise Water Project (Cochise College, n.d.), something that Sarah Lawrence could investigate to cover some of the costs.

It should be stated that rainwater collection is not without its drawbacks. If the system were to be used for landscaping and irrigation, as the majority of the provided examples did, then the water would have to be moved from the storage tanks to places it may be needed around campus by the greenskeeping staff, which could prove to be difficult logistically. The issue of space would have to be resolved as well, as the campus currently lacks a convenient location for one to be constructed. With that said however, very little work would have to be done in order to convert existing buildings into being capable of collecting water, as the system itself is not much more complicated than rerouting the existing gutters into storage tanks. A consultation with a local contractor would be useful in determining the needs of Sarah Lawrence and thus the size of cistern necessary.

Water Sustainability Is the Way Forward

Water is our most important resource, and as such we should take every available step to conserve water and reduce our own use. Water is not as infinite as it may seem and it is clear that the availability of usable water will diminish over time as the effects of global warming and climate change take place. Our proposal would have Sarah Lawrence College be at the forefront of water saving efforts, efforts which would save money and would aid the beautiful nature that surrounds our campus. Our ideas for water conservation would not require the college to change drastically, but rather have the college make manageable changes and additions that would have a large impact on both economic and environmental factors. Additionally, these changes would show that the school is forward looking and would make the school an example of how other institutions could help the environment in these changing times.

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Potential Energy Savings as a Result of Sustainable Lighting, Computer, and Appliance Installation

Introduction

It has become apparent the rate at what we use energy needs to drastically decrease. The United States is one of the leaders of energy consumption; therefore it should be our job to be the leaders in changing our behavior towards energy and the way we consume it. There has never been a more important time to make these changes than now. Global warming is real, and we are seeing the very serious affects of it today. Oceans are rising, storms are becoming more intense, years are becoming warming, while ecosystems and resources are becoming destroyed. Although a large cause of global warming is because unsustainable practices are institutionalized by our economy and culture, individuals can do a surprising amount to make our planet more sustainable and cut down on carbon emissions. Implementing sustainable light bulbs, sleep smart computer software and buying energy efficient appliances, are all changes that we are able to make which also cut down our energy consumption drastically.

Lighting

Being able to turn on the lights is something that many people take for granted. You simply flip a switch or pull a string and the room is illuminated. However, much more actually goes into being able to light up a room than we often think about. It first starts by the need to mine finite resources such as coal, oil; there are some power plants that are beginning to use solar and wind to to generate the power needed for electricity (Energy and Environmental News,2011). Most of the electricity that is generated in the united states is produced in thermal power plants. Here what happens is that the resources are burned to produce steam which then is used as power to turn a turbines which then turns the mechanical energy into electric energy (Energy and Environmental News, 2011). This energy is then carried through a transmitter along a grid and into the building where the electricity is needed.

The leading cause of global warming is the combustion of Co2 into the atmosphere, which creates the greenhouse effect which traps the heat within the atmosphere. Although people normally do not think that ,lighting and the choices they make when it comes to lighting their home has a large impact on the environment and status of the world but it does. The U.S. Energy Information Administration has estimated that in 2014, about 412 billion kilowatt hours of electricity were used in the residential and commercial sector, which i is nearly 12% of total electricity consumption (U.S. Energy Information Administration, 2015). In U.S. homes lighting accounts for 10% to 25% of total energy consumption (U.S. Energy Information Administration, 2015). The manufacturing sector in the us also spent and used a considerable amount of electricity of 52 billion KWh which is 1.3% of the US total electricity consumption (U.S. Energy Information Administration, 2015).

A significant amount of carbon dioxide is emitted into the atmosphere due to the lighting industry, but there are some ways in which we can reduce these emissions through government intervention and policy. For example, there could be policies directing the stop to the production of the highly inefficient incandescent light bulbs. In continuation of this, there could be subsidies placed on the LED and CFLs light which have traditionally been more expensive but much, much more efficient. This subsidy would help allow lower income people to not be burdened with the loss of the the cheap incandescent light bulbs. Another policy that would help lower the emissions from lighting would be to expand and invest in solar and wind energy (Harris, Roach 2013). What makes lighting unsustainable is that to produce the electricity to light homes and buildings, fossil fuels are burned, which emits co2. However, if we could generate the power needed to make electricity, without burning fossil fuels, through wind or solar, it would decrease emissions.

One way to reduce the amount of energy needed to light the residential and commercial sectors is to install compact fluorescent bulbs or light emitting diodes. These lights produce light differently than the generally used incandescent light bulb where electric current runs through a wire filament in order to heat up the filament until it begins to glow (Energy Star 2014). What makes incandescent lights so inefficient is that to produce light, it first must produce heat. The heat is a wastes a lot of electricity and requires a greater input of power than in other types of light bulbs. In compact fluorescent bulbs electricity is shot through a tube within the light bulb which contains argon and a little mercury vapor. This produces ultraviolet light which reacts with the fluorescent coating to generate light (Energy Star 2014). A light emitting diode, or LED for short is another strategy that will more drastically cut down on energy use. The LED is a two lead semiconductor and works by supply electricity to the bulb, electrons react with electron holes; in the midst of this process, light is produced (EarthLed 2007). This light bulbs last longer and are quite a bit more efficient than CFLs.

Although compact fluorescent bulbs are more expensive than incandescent light bulbs; they are about 8-12 each, they are an incredibly worthy and smart investment. They use 75% less electricity than incandescent light bulbs and lasts ten times longer (Tufts Climate Initiative, 2015). CFLs use less watts, A watt, on the other hand, is the amount of electricity a light bulb uses to produce light - it's not an indication of brightness (Consumer

Energy Center 2016). Meaning that a 13 watt CFls produce as much light as a traditional 60 watt incandescent light bulb (Consumer Energy Center 2016). This results in massive savings and in the energy bill and in the amount of energy needed to produce electricity. On average it costs 8 cents per kilowatt hour, with an incandescent light bulb, it would cost 35.04 whereas if you had a compact fluorescent bulb, it would cost 8.06 whereas a Compact fluorescent bulb would save around 550 kilowatt hours over the course of its lifetime (Consumer Energy Center 2016). Also, if the electricity that is pr when coal is the generator of the electricity , that savings translates to 500 pounds of coal not burned which then translates to 1300 pounds of carbon dioxide and 20 pounds of sulfur dioxide will not get into the atmosphere, just by switching one bulbs with a CFLs can save 25-70. Over a CFLs lifetime is prevents 1,000-2,000 pounds of carbon dioxide from emitting into the atmosphere as well as 8-16 pounds of sulfur dioxide (Consumer Energy Center 2016). This is crucial to making the transition into a green lifestyle. To light the united states, it takes a considerable amount of energy and power is needed. These create emissions which contribute to the greenhouse effect and the warming planet. It takes a small investment and little effort to take a step that would vastly improve the status of light.

Compact fluorescent lights are great in cutting emissions, LEDs are even more energy efficient. Although a bulb is more expensive, around $15-20, they use a considerably less energy. a LED light only uses 44 KWh a year where a CFL use 55 KWh a year (EarthLed 2007). Since it uses so much less energy, it therefore emits a lot less carbon as well. One bulb emits 45 pounds a year whereas to a CFL which emits 56 pounds a year, compared to an incandescent light bulb which emits 225 pounds of carbon a year (Boston University Sustainability 2016). a LED light, although more expensive also has a significantly high life span, one of 25,000 hours, than that of the other types (Boston University Sustainability 2016).

Although transitioning to LEDs is the most impactful thing to do in terms of reducing emissions generated by lighting, there are also other things individuals and institutions can do to lower unnecessary light use. This includes the implementation of motion/thermal sensors and lighting timers in public spaces. Thermal sensors, also called occupancy sensors is a light switch which has both an infrared sensor with a timer, which automatically turns off the lights after the timer if there is no bodily heat or motion (University of Oregon Environmental Leadership Program 2016). The lights will go back on if the sensor detects any sort of motion, such as walking into the room. It is also convenient these controls can also be canceled by simply switching the switch as well. These sensors have the most potential to save energy and money when installed in institutions or public buildings. Sensors are an extremely worthy investment because they have the potential to lower the lighting bill and consumption up to 50% and only cost between 20- 60 dollars (University of Oregon Environmental Leadership Program 2016).

Thermal/motion sensors work well in places such as Universities/colleges because they have so many common places and public buildings. Other schools have made the investment of implementing lighting sensors and have seen drastic results. For example, Saint John's university in Queens, New York installed thermal/occupancy sensors in their lighting fixtures and saw immediate positive results. Saint John's has 33 buildings which take up 2.2 million cubic feet (Leviton Manufacturing CO. 2012). They had a goal to make their campus more holistic and energy efficient. They therefore contacted Leviton and Energy Conservation and Supply, Inc, and installed sensors in classrooms, labs, offices and other rooms. These sensors have saved the universities $13,293 and cut kWh usage by 73,848 a year (Leviton Manufacturing CO. 2012). The sensors implementation cost $10,442 and saw a full return on that investment in only nine months (Leviton Manufacturing CO. 2012).

Another example of an educational institution to making successful changes that benefited both financially and environmentally is Boston University. B.U. took an initiative to make the campus more sustainable back and part of this initiative was to improve lighting efficiency. Therefore, the school replaced all of incandescent light bulbs in many of the buildings with LED or CFLs (Boston University Sustainability 2016). These projects have resulted in a savings of 5,794,883 kWh/year and 2,706 metric tons of CO2e/year, which equals 497 cars or 69,385 trees (Boston University Sustainability 2016). Boston University has also upgraded the lighting systems for the new buildings. This has helped them reduce energy consumption by 53% than if they were not changed (Boston University Sustainability 2016). The university has also found perks in the fact that since LED and CFls last much longer than incandescent light bulbs, there has been a significant reduction in maintenance and costs because the bulbs do not have to be replaced not really as frequently. This has allowed for the maintenance crew to focus their attention on other areas.

From looking at the success stories from other schools, we can see that motion sensors and LED are an extremely smart and worthy investment to make here at Sarah Lawrence College. Not only will it reduce the school's energy bill, but will also decrease the school's carbon footprint and ensure that the institution is committed to a sustainable and green future. To ensure the maximum benefits from these investments and transitions, it is important that the school replaces all non LED light bulbs in every building and fixture. This includes hall lights, library desk lamps, decorative lights and more. The school should also make effort in encouraging students to buy these for dorm room desk lamp. Sarah Lawrence College should also take action on installing motion sensors in hallways, classrooms, study rooms, bathrooms and laundry rooms. The college's administration should also take steps to ensure that lights in student's dorms are the most sustainable option as well. They can do this by encouraging students to bring LED lights on packings lists and only selling LEDs in the bookstore or Hill2Go. Making these types of appliances will definitely cost something, but compared to the rate of return and the amount of money that will be saved in the future, it is a very small amount.

Computers

Computer monitors use more energy than all other office equipment combined, and from universities alone, contribute to about 1.5 billion dollars worth of wasted energy every year (Clark 2003). This energy gets wasted because on average across universities, more about 60 percent of computers are left on overnight, and more than 40 percent of computers not equipped for power management (EPA). At Sarah Lawrence, computers exist in faculty offices, staff offices, student spaces, and the library. When turned on, computer monitors use energy even when not actively in use. In order to curtail the amount of energy that the college puts into running computers, the college could apply software like the EPA's Energy Star Computer Monitor Power Management Program, "Sleep is Good!," which sets monitors to sleep mode automatically after 10 minutes, or the EPA's Energy Star EZ Save Software Program, which enables IT departments to manage power settings across entire networks of computer monitors from a central location, allowing for IT to put network computers into a low power sleep mode when not in use and to turn computers off at the end of the day. These government sanctioned programs can be downloaded for free from the energy star website and has the potential to save up to 200,000 kWh per year for every 1,000 computer monitors (EPA). The EZ Save Software Program will reduce energy consumption by computers and monitors during operating hours and overnight; the reduction in energy costs has the potential to save the college thousands of dollars a year while reducing carbon emissions and consequently the college's ecological footprint.

Several institutions have benefitted financially from establishing computer sleep and power protocols. Harvard University, for example, has taken advantage of Energy Star's EZ Save Software Program by installing it on 1,000 faculty and staff computers, resulting in 15,000 dollars worth of savings annually (Potier 2003). The school was able to accomplish this by enabling all networked computer monitors to manage power through the network itself through EZ save. Harvard was consequently honored by the EPA for its power saving initiative. The entire process of switching 800 network computer monitors to incorporate Energy Star's EZ save program took Harvard only four hours. Meanwhile, Penn State's Energy Program Engineer Doug Donovan used the EZ Save software to analyze almost 300 computer monitors' power management status before enabling them for power management, saving the university 740,000 kWh a year, about 17,000 dollars in energy costs a year, and 780 tons of carbon dioxide emissions a year (Brink 2002). Other universities have benefited from similar practices; power management systems on computer monitors at University of Ohio has saved 15,150,000 kWh and 15,000 tons of carbon dioxide emissions and Mount Holyoke 574,000 kWh and 411 tons of carbon dioxide emissions (Patrick 2008). As climate change continues to grow as a threat to the planet, the college cannot afford to not make such a simple change to reduce emissions.

Conclusion

More efficient lighting and computer use holds the potential to reduce the college's energy consumption significantly; continuing on this path, the college can benefit further by applying sustainability to larger appliances such as refrigerators, air conditioners, dishwashers, stoves, and ovens. In fact, some peer institutions have already begun to implement such changes. In the past few years, Ithaca College has moved towards sustainably developing their campus. To begin this transition the school has invested 1.3 million dollars in purchasing Energy Star appliances (New York Times, 2010). Energy star appliances, labeled through the Federal Trade Commission, are appliances that are more energy efficient than minimum guidelines (Environmental Protection Agency). With an estimated energy reduction of between 10 percent and 50 percent per appliances, it's not surprising that Ithaca has saved half a million dollars annually on heating and electricity costs (New York Times, 2010). The purchase of energy star appliances has essentially paid for itself in thirty-one months.

This transition has earned Ithaca College the government's energy star label, which is based on their utility bill and accounts for factors such as building size, computer use, local climate and occupancy (New York Times, 2010). The energy star label achieved by Ithaca College has attracted them the attention of the New York Times who praise Ithaca "for its embrace of all things sustainable"1. And, within the past few years, Ithaca's environmental and sustainability programs have thrived. Ithaca College is recognized as "one of the nation's leading education institutions in environmental and sustainability education and action" (Energy Star, 2010).

Following Ithaca College's lead, Sarah Lawrence can take similar measures to reduce energy consumption. If Sarah Lawrence invests in purchasing energy star appliances, the school would not only see massive costs savings, but a government sanctioned label and a guaranteed space on the map of environmentally sustainable universities. Thus far two colleges in New York, Ithaca and Hamilton, have earned energy star labels, helping to bolster their environmental and sustainability programs (New York Times, 2010).

Beyond substantial savings and school promotion, the energy star appliances have the potential to make a big difference in reducing waste and power usage. For instance, energy star washers and dryers have been installed at Tufts University, saving the school 17,000 gallons of water per year and cutting carbon emissions by more than 30 tons annually since their installation (State of Massachusetts, 2008). Additionally energy star vending machines installed at Tufts have cut consumption in half (State of Massachusetts, 2008). In the 90 machines installed 100 tons of carbon dioxide were saved annually (State of Massachusetts, 2008). When the University of Maryland replaced 50 old refrigerators with Energy Star refrigerators the university cut carbon emissions by 45 tons annually (University of Maryland, 2016).

With a relatively low startup cost and a very quick payoff, it is in Sarah Lawrence's best interest to purchase energy star appliances; such a purchase would allow the college to continue to grow in a sustainable manner.

Maura Beard, spokeswoman for the Energy Star program, explains that every year "colleges and universities spend almost 2 billion dollars on energy" (New York Times, 2010). She goes on say that a lot of people believe the solution to the running of a environmentally sustainable university lies in the "latest gizmo or newest technology" (New York Times, 2010). But there are things universities can do that are relatively simple. It could be as easy as swapping out light fixtures and monitoring computer power usage or a small upfront investment in the purchase of more efficient appliances. The idea is extricating waste into our atmosphere and within this report we've described ways for Sarah Lawrence to do so without overrunning the current system. The adoption and implementation of these programs will both save money and help towards creating a better, more environmentally sustainable university.

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