Greening Campus Landscapes:

A report prepared by:

Matthew Buch, Eileen Divringi, Matthew McCann, Mike Millard, Josh Patten

Project Sponsors:
Andrew Berki, Office of Campus Sustainability
Anthony Cachot, Assistant University Planner

Environment 391, Winter 2011
The University of Michigan
March 28, 2011

EXECUTIVE SUMMARY

Through its comprehensive interdisciplinary report on campus sustainability issues, the Integrated Assessment, the University of Michigan has shown an interest in decreasing the environmental impacts of campus landscaping. The physical campus should promote the University's goals of reducing water use and runoff, utilizing native plants, and shifting to more ecologically aware campus landscaping practices. Much of the current landscape is comprised of vast concrete expanses and highly managed grass areas. These concrete areas reduce water permeability, increase storm water runoff and contribute to the urban heat island effect. At the same time, grass fields are intensively managed to maintain a "pristine" campus image.

Our project seeks to identify feasible alternatives to these current landscaping approaches and proposes a design for an on-campus pilot site that incorporates greater consideration for the ecological impacts of the built campus environment. The benefits of sustainable land use go beyond the environmental perks of reducing paved areas and increasing the use of native plants. The Integrated Assessment also highlighted the economic and social benefits of more sustainable campus landscaping, including lower operating costs resulting from the reduced need for highly managed care, greater community awareness of environmental issues and opportunities for learning.

The site we chose for our project, with guidance from our sponsors' criteria, is a section of Ingalls Mall on central campus. This area is bounded by the Bell Tower to the west, the Michigan League to the east, and two large planters to the north and south. The area experiences heavy pedestrian traffic by students going to and from classes, as well as by large groups holding events in the area. Additionally, it is a tradition for incoming students and outgoing graduates to walk through the fountain in its center, making it both highly visible and symbolically important. Our site selection and proposed design take these factors into consideration, allowing for large numbers of people to quickly and easily pass through the area while reducing the environmental impacts of the site.

The first step in our research was to review case studies of similar initiatives undertaken at other universities and public sites. From these case studies, we were able to drawn design inspiration and knowledge of alternative landscaping strategies. Next, to tailor our recommendations to our users' functional and aesthetic needs, we conducted a web-based survey of students and staff that gauged the relative importance of different site amenities (benches, artwork, etc.). From this initial group of survey respondents, we selected three students to participate in a follow-up focus group session. This session greatly deepened our understanding of the average student's perspective on these issues and has had a significant impact on our proposed design. Of primary concern to the students was maintaining the ability for pedestrian traffic to flow smoothly during times of peak use. Furthermore, the students noted that availability of seating would facilitate public interaction with the space.

Our design seeks to visually highlight environmental, social and economic benefits in an aesthetically pleasing way. To do this, we redesigned the area around the fountain to include two large planters in the shape of leaves. The area inside the planters would be reserved for native plants that would require little managed care. Between the two leaves we be paths of porous pavers to help replenish groundwater. These paths would encircle the fountain, allowing space for incoming and outgoing students to partake in the campus ritual. Informational plaques throughout the site would highlight the environmental benefits of our design, including reduced water runoff and the use of region-appropriate plant species.

Introduction

The University of Michigan's campus is the first physical aspect of the University that incoming students, parents, faculty, staff, and visitors come in contact with. It should therefore project an image and identity that establishes the University as a leader in public education. The campus should inspire the same values the University tries to instill in its current students which, among others, includes moving steadily towards sustainability. Current sustainability efforts on campus are diverse, ranging from student groups advocating for locally-sourced food in the dining halls, to Planet Blue, which is a university-run program seeking to reduce the amount of energy used in campus buildings.

Unfortunately, the University's campus does not currently inspire students and faculty to join sustainability efforts on campus. The conventional approach to landscaping includes concrete expanses with highly managed grass areas interspersed throughout. These concrete areas reduce water permeability, increase spikes of runoff after storms and contribute to the urban heat island effect. Meanwhile, the grass areas are mowed, fertilized, and re-sodded to maintain a "pristine" campus. These practices break down relationships among biota while degrading the ecosystem as a whole, representing a method of landscaping that is out of sync with the area's natural ecology. In contrast, less managed areas require less fertilizers, pesticides and herbicides that contaminate the water supply; less lawn mowers that release carbon dioxide; and less irrigation that contributes to campus water consumption.

In order to demonstrate the benefits of a more environmentally concientous approach to landcaping, our team has been working with Andrew Berki, Director of the Office of Campus Sustainability, and Anthony Catchot, Assisstant University Planner, to design a model site that incorporates greater consideration of local ecological impacts. To achieve this, we have evaluated the benefits of combining native species greenery with various forms of porous pavers and pervious concrete at a site within Ingall's Mall on central campus (pictured in Figure 1 on the next page).

Currently, the only landscaping involving native plant species on central campus is the group of plots outside of the Dana building, which contain plants native to the area that require little to no managed care to grow. The University also utilizes porous pavers around this area, helping to reduce the impact that built areas have on water permeability and runoff. Nearby, the recent redsign of the path leading to the Central Campus Transit Center offers and example of how walkway design can facilitate and direct pedestrian flow in an aesthetically interesting way. Our team is currently evaluating the benefits of synthesizing the ideas behind these two designs to create a space that is visually intriguing, facilliates the flow of pedestrian traffic and lessens the negative environmental impacts of the current landscape

Figure 1: Proposed site for campus greening project

Background

The benefits of natural landscapes are diverse, and include environmental, social and economic factors. Sustainable landscaping practices can have positive impacts on plants, water, and land use, can help reduce stress and improve the general health of people living in urban environments, and can be significantly cheaper to maintain. Meanwhile, the increasing area of urban paved surfaces is increasing storm water runoff. Both the benefits and drawbacks of different landscaping practices can have significant impacts on the campus itself as well as our interaction with it.

There are numerous environmental benefits to natural landscaping, as the reduced use of fertilizers, pesticides, and lawnmowers can have positive impacts on plants, water and land use. These practices break down relationships among biota and can degrade the ecosystem as a whole (Fox, 2010). In a native landscape, plant material should be left as a natural fertilizer, reducing the need for nitrogen-rich synthetics which lead to contamination and eutrophication of fresh surface water (Fox, 2010). Lawn mowing must be switched to a less fossil fuel intensive practice or ceased entirely, which would be accomplished by relying less on managed grass and more on natural flora utilizing native species (Fehrenbacher).

Switching to a more natural campus landscape would also provide many social benefits. The main benefit arising from this switch is reducing stress of those living and working in the area. Stress is much more prevalent in cities than in outlying areas, and this is exacerbated by the lack of natural landscapes. Natural landscapes help people recover from these stresses more than urban environments do, with benefits to physiological indicators such as blood pressure, sweat level and muscle relaxation being seen in as little as 400 milliseconds (Ulrich et al, 1991). People have better general health and immunity to diseases when living in an area with abundant green space, and hospital patients recover faster when a view of a natural environment is available (Ulrich, 1979; Maas et al, 2006; Maller, 2002). Green space also present places for social gatherings and community involvement, and neighborhoods with green space have less crime (Maller, 2002). In addition, students show significantly better ability to focus as well as improved proofreading performance when around natural environments (Tennessen, 1995; Hartig, 1991).

There are also economic benefits to reducing the amount of management the campus landscape requires. For example, reducing the use of pesticides, fertilizers and lawnmowers will be an immediate benefit for the University as it would require less intensive maintenance. In addition, the University may be able to reduce capital costs for lawnmowers and equipment it uses. Protecting the quality of the Huron River Watershed is also an economic priority, as it provides surrounding communities with important ecosystem services.

Moving to more natural landscaping practices would also work to reverse current trends resulting from increasing urbanization. The amount of land used in urban environments is estimated to cover 2.4% of total worldwide land area (Akbari et al, 2008), and this number will only grow as over 5 billion people are expected to live in urban areas by 2050 (Martine 2007). The use of impervious surfaces in urban areas causes storm water runoff, which is water that is prevented from quickly being absorbed into the ground after a rainfall event. Instead, this water is redirected to underground sewage systems and storage areas which can quickly become overwhelmed by the increased volume and can cause flow rates to peak directly after a significant storm, causing flash flooding, accelerated erosion, and disruption of local ecological processes. Impervious surfaces also reduce the ability for rainwater to replenish groundwater

resources and increase the concentration of contaminants from society (Pappas et al, 2007). These contaminants come from transportation and wastes generated by human practices.

Design Case Studies

For design inspiration, we looked at three case studies that modified an existing landscape to improve its ecological and aesthetic qualities. It was important that these projects incorporated environmentally friendly features similar to those desired by our group (i.e. pervious concrete and native plants) to aid us in determining the feasibility of implementing such ideas. Each project offered different design features which we took into consideration and put together to form our group's design. Specifically, the Children's Discovery Museum amphitheater renovation gave us the idea for a tiered concrete bench, the 22nd Street Parklet reenforced the idea to include native plants, and the Auburn University Arboretum renovation demonstrated the potential for porous concrete use in a campus environment at a larger scale than is currently present on UM's campus.

Children's Discovery Museum: San Jose, CA

The Children's Discovery Museum is a family-oriented educational site in San Jose, California that recently renovated the outdoor amphitheater in their courtyard. They contracted this renovation to the HOK architecture and engineering firm, who incorporated a winding, fully-cemented, three-tiered bench area for people to sit and enjoy the events taking place in the amphitheater. Additionally, HOK's bench design incorporates native vegetation lining the top tier of the cement bench. This aspect of their renovation served as the inspiration for the bi-leaf design around the fountain, which incorporates a similar bench form on its edges. The winding nature of the bench not only simulates the shape of a leaf, but also creates a more secluded sitting area in the interior offset pockets. (A picture of the HOK bench design is in Appendix 1)

22nd Street Parklet: San Francisco, CA

In response to excessive amounts of street pavement, the city of San Francisco decided to start the "Pavement to Parks" program, which temporarily converts unused and underutilized spaces into new public plazas and parks. Through this program, the city was able to provide more pedestrian friendly areas by adding large moveable planters alongside tables and chairs within these temporary parks. The 22nd Street Parklet reclaimed three underutilized parking spaces by extending the sidewalk in front of a coffee shop with bamboo decking. The design feature of the parklet most relevant to our proposal is the integration of bamboo planters shaped into benches with low-water demand landscaping lining the street side of the planters. This will be achieved in our design by the use of native Michigan plants, which require less maintenance. Though this idea was also used in the design of the gardens around the enterance of the Dana Building, the 22nd Parklet demonstrated how it can be integrated into a space designed for greater pedestrial interaction. (A concept picture of the parklet is in Appendix 2)

Auburn University Arboretum: Auburn, AL

Previously, Auburn University had a loose woodchip walking trail through its arboretum. This trail traversed a hillside that drops steeply from a parking lot to a nearby pond. Every time it rained the trail would get washed out by the water flowing from the above impervious parking lot. Consequently, the university decided to replace the wood chip trail with a more permanent material that could withstand periodic flooding. Porous concrete was the solution they chose. Not only is porous concrete sturdy, but it also allows water to pass through its open pores, meaning the permeable surface area would not be compromised by the renovation. Since this particular use of porous concrete was for a walking path, it is especially relevant to our project. We have included two main walking paths around the fountain in our design and recomend replacing the existing impervious concrete with porous concrete. This would allow excess water to return to the ground instead and reduce stress on existing storm water infrastructure. In their follow up report (auburn.edu/heinmic/PerviousConcrete/case_studies), Auburn University noted that since the completion of the porous walking path, it has been able to stand up to high densities of traffic. This is of special interest to our team because the site we are working on also receives a high level of foot traffic. (A picture of AU's walking path under construction is in Appendix 4).

Primary Research

In order for the renovated area to be a useful leverage point for for further sustainable landscaping initiatives, it must be accepted by the campus community as a successful and distinctive space. Since students comprise a large and often very critical segment of the university population, we wanted to ensure that the design of the space integrated their feedback and facilitated its use as a common area. Accordingly, we designed a web-based survey to gauge students' current perceptions of the space and desired changes. The survey was followed up by an in-depth focus group in which students reacted to and discussed proposed designs.

Methodology

Survey

The survey consisted of three substantive questions as well as fields for respondents to indicate their year, major, additional comments and whether or not they wanted to participate in the follow-up focus group. The first substantive question asked what type of amenities the student would like to see added to the space, while the second and third measured their opinion on the current landscaping. The survey was designed to be brief in order to maximize the completion rate. As an incentive for completing the survey, respondents were entered in to a random drawing for a $25 gift card. It was disseminated through a Facebook event (each team member invited all of their friends in the "Michigan" network) which included a link to the survey.

At the completion of the survey administration, there was a total of 123 respondents. Our sample mostly included responses from undergraduate students, though a small number of graduate students and staff also participated. The respondents consituted a diverse group representing almost every discipline at the University. Based on our initial analyses, it was clear that they endorsed change to the current area.

Focus Groups

Of the survey respondents who indicated they would be willing to participate in the follow up focus group (approximately half), six were contacted. The six were chosen because they provided helpful or interesting feedback in the optional comments field on the original survey. Three of the six people we contacted were actually available to attend. The focus group was about 50 minutes long and each participant was compensated with a $15 gift card at the business of their choosing.

The participants were asked to react to sketches our first design which incorporated feedback from the survey (see Appendix). To initiate the conversation, questions were asked about how the participants would prefer to interact with the space. Aside from this initial guidance, the conversation proceeded organically and participants were encouraged to discuss and suggest alternate ideas. The focus group was digitally recorded and later reviewed for helpful comments.

Results

Survey

The first question in the survey asked participants which amenities they would like to see added to the site. Respondents were able to select as many items as they wanted. As Figure 2 demonstrates, the most popular option was benches (61.8% selection rate), indicating a desire to make the space more interactive and welcoming. Tied for a close second were green space and landscaping involving native Michigan plants (60.2% selection rate). These findings suggest that there is already support for our desired lanscape modifications among the campus community, even if not explicity motivated by sustainability concerns. None of the other options were elected by more than half of respondents.

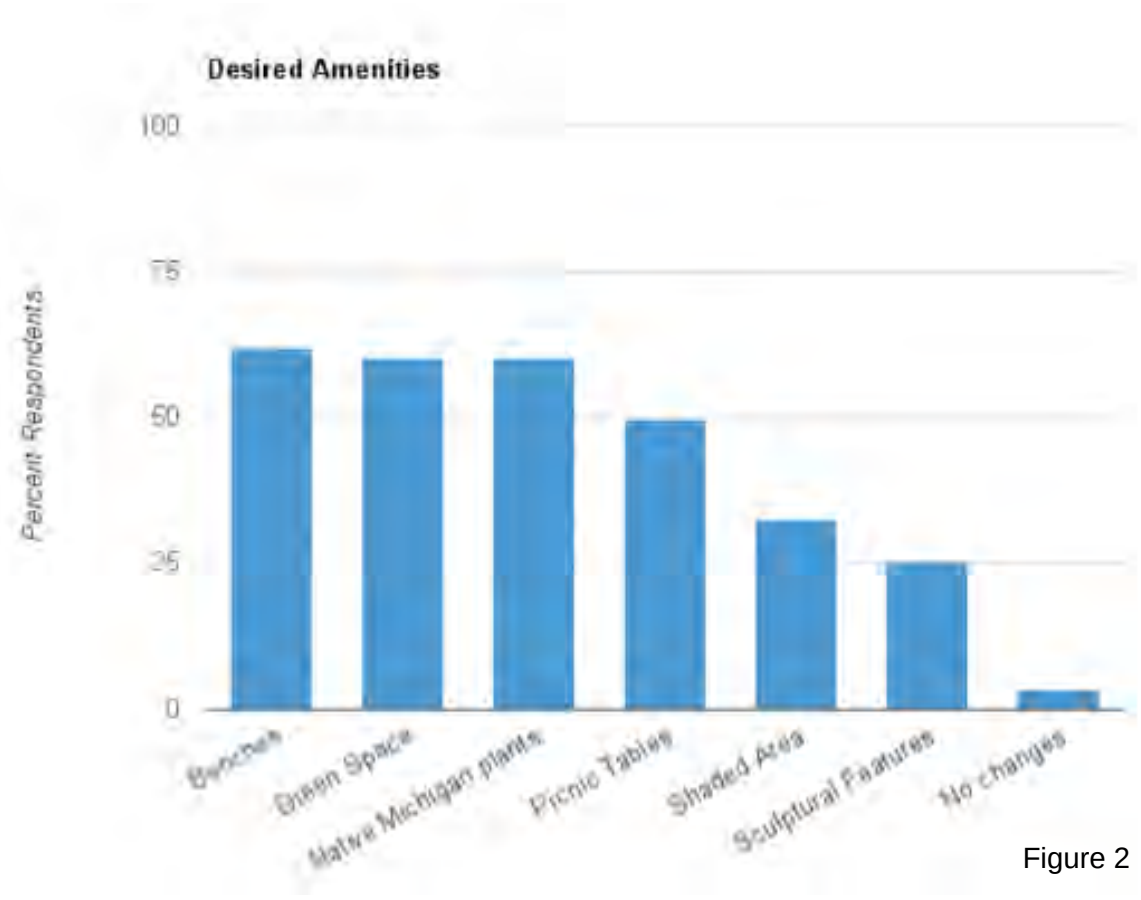


Figure 2

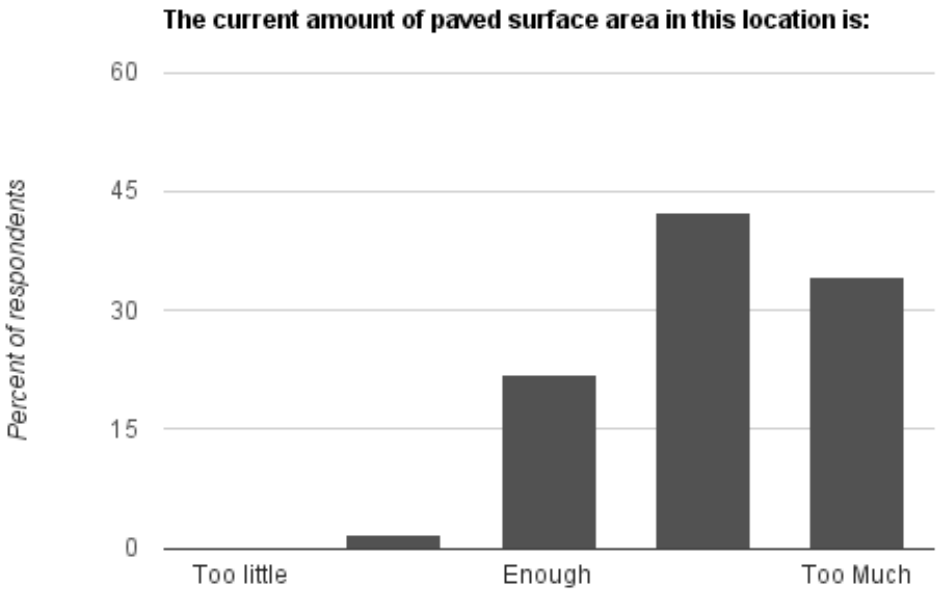


Figure 3

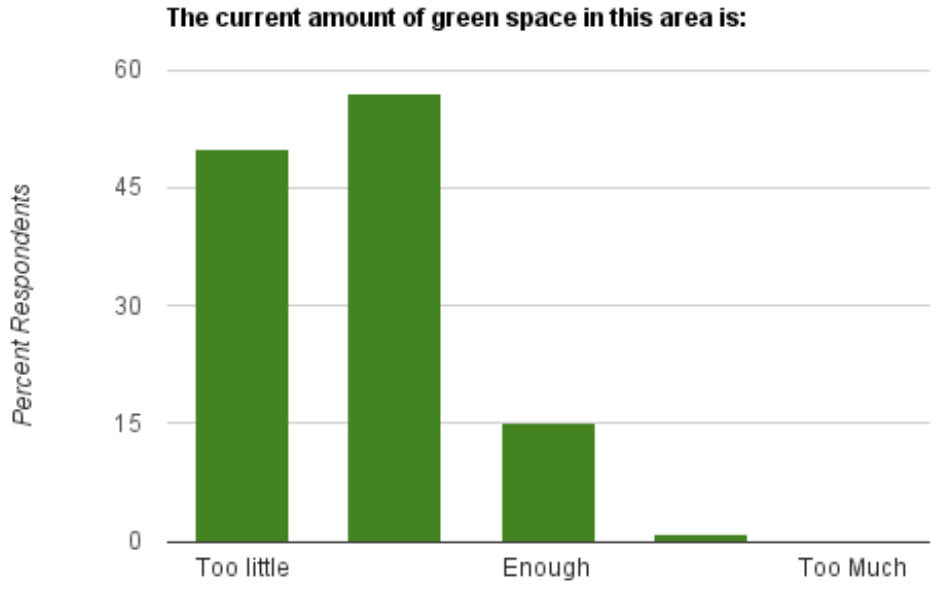


Figure 4

The second set of survey questions shown in Figures 3 and 4 asked participants to evaluate the current amount of green space and paved area at the site. Responses were measure on a scale from 1 to 5, 1 indicating that there was “too little” of the feature and 5 indicating that there was too much. As we suspected, the majority of respondents felt that there was too much

paved surface area in the space, with an average response of 4.09. In contrast, the majority of respondents felt that there was too little green space in the current design (1.73 average). These results suggest that efforts to reduce impervious (essentially, paved) surface area could achieve dual goals by creating a space that is more socially desirable as well as ecological friendly.

Focus Group

Despite the low number of actual participants, the focus group yielded important insights and lasted almost double the time that participants were asked to volunteer, which may highlight students' desire to improve the campus around them. Feedback from the participants generally fell into two broad categories: mobility concerns and space usability and aesthetics.

Initially, all of the participants expressed reservations about how the proposed design (shown in Appendix 4) would affect the walking paths of people moving between the MLB and the Michigan League. To some degree, this was an issue of scale– though the walking spaces on the drawing appeared small, they actually represented fairly wide paths (approximately 5-10ft). However, participants did make valuable suggestions about expanding the sidewalk and minimizing sharp turns around the fountain which will be incorporated into the final design. Participants also recommended shrinking the overall footprint of the planters, opening more walking space around it to accommodate high volume pedestrian traffic in between classes. Though the goal of the design was to funnel pedestrians along the routes which we commonly observed people using, the group felt that our funneling efforts were too aggressive. This feedback was especially important– if students perceive the landscaping as a nuisance, it will not be a useful tool for promoting sustainable landscaping elsewhere on campus. Accordingly, our design needs to accommodate current uses of the space.

Many of the comments the group gave related to how they envisioned students being able to interact with the area. They emphasized the need for seating and space for people to study or read a book. The importance of benches was heavily stressed, one participant even stating that "where there are benches, people will go." Another participant suggested incorporating round inlets into the planters on the fountain side with benches where students could sit. They commented that this would improve space usability because it would provide comfortable seclusion and privacy from passers-by, especially during high-volume use of the space. The inclusion of trees and high hedges around these inlets to further promote privacy was also discussed, though this raised concerns about interfering with traditional uses of the space such as graduation photos.

Aside from these main areas of concern, the group also made some minor comments that we found interesting and helpful. Regarding the educational elements that will be incorporated into the space, participants were very supportive of having plaques describing the native species and the goals of the renovation. They believed that this would deter people from littering in the planters and keep them from thinking that the area was poorly maintained when plants were out of season. Additionally, the group suggested that removable/retractable canopies be added to the design to make the space more comfortable to spend time in during the summer. To assist with project funding, one participant suggested that we ask environmentally-conscious alumni and community members to donate in exchange for their name being carved into a porous brick. This would allow for personal identification with our project as well as an opportunity to express support for environmental efforts on campus.

Environmental Impacts

The current site allows 100% of storm water to run off into sewer systems via on-site drains, contributing to groundwater loss and potentially degreading river water quality in four primary ways: 1) high flow influxes from strom events accelerate the erosion of stream and river banks, 2) storm water runoff at the surface is generally warmer that groundwater and can alter water temperatures and disturb aquatic wildlife, 3) storm water runoff can carry surface pollutants and debris into streams and rivers, 4) surface debris carried into streams and rivers can deplete oxygen during decomposition, lowering the water's overall dissolved oxygen level. (Univeristy of Wisconsin Extension, Huron River Watershed Council 1) For the Huron River Watershed in particular, excessive inputs of phosphorous have become a serious threat. Almost 80% of all phosphorous in the watershed originates from human activities, much of it coming from non-point sources such as impervious paved surfaces. (Huron River Watershed Council 1) Additionally, the difference in intenisty of bank erosion is visible when comparing stream systems near Ann Arbor to those in less developed areas of Washtenaw County. (Huron River Watershed Council 2)

Ann Arbor recieves and average of 52 inches of rain per year, amounting to approximately165,000 gallons of runoff per year of the total area of the site. The primary goal of incorporating more porous surface area into the site would be to mitigate the amount of surface runoff. This will benefit the Huron River Watershed and hopefully provide a model for future projects on campus. According to an EPA report on pervious concrete renovations (US EPA), it is reasonable to estimate that these materials will retain 99.9-100% of stormwater volume, suggesting that almost the entire 110,000 gallons of runoff could be avoided with our design. Pervious pavement also has the potential to mitigate inputs of total suspended solids (TSS), an important pollutant that increases water turbidity and compromises the natural ecology of the watershed. One study found that the use of pervious paving materials removed 90-96% of TSS from influent. (Brown 2009)

Additionally, Michigan native plants will be used inside the terraced planters. These plants will require less watering and less intensive management than species currently used elsewhere on campus. Non-native landscaping practices– like those currently used around campus– release ten times as much phosphorous into the local watershed as landscaping using native plants, contributing to the growth of algae and noxious aquatic plants. Furthermore, using native Michigan plants can provide habitat for local species of butterfly. (Huron River Watershed Council)

Though our proposed site is currently paved and therefore requires minimal management at present, we believe that the community support for incorporating green space (as demonstrated by the survey responses) as well as the environmental benefits of reducing impervious surface area provide enough of an incentive to make the change. Use of native species will reduce or eliminate the need for potentially harmful synthetic chemicals commonly used in managed campus landscaping, including fertilizers and pesticides. We recomend that the species be chosen in consultation with a faculty expert, potentially as part of a future ENVIRON 391 project.

Costs

To determie the overall cost of the materials used in the proposed design, we used a sclae drawing to estimate the total quantites and used prices quoted by local contractors (with the

exception of the price of topsoil, which was taken from the USDA Seeding Fact Sheet). Labor and construction costs can be a difficult estimate to make but should resemble many of the other traditional concrete projects on campus. An estimate of 75% of total construction costs was used to calculate labor costs. We contacted UM landscape aerchitect Keneth Rapp to get an estimate of maintenence and demolition costs.

Material	Cubic ft in proposed design	Cost per cubic ft ($)	Total Cost
Pervious concrete (walkways)	5565	4.6	12799.5
Conventional Concrete (outline of leaf planters, benches)	2665	9.99	8874.45
Topsoil (interior of leaf planters)	4200	0.45	1890
Labor Costs (at 75% of total construction cost)			70691.85
Demolition	5000	5	25000
		Total Construction Cost:	$119,255.80
Activity	**Square ft in proposed design**	**Cost per square ft ($) per year**	**Total Annual Cost**
Maintenance (plants)	1000	0.9	900
Maintenance (paved area)	4000	0.13	520
		Total Annual Maintenance Costs:	$1,420

Recommendations

The initial goal of our project was to identify a common area on campus that could be renovated to lessen its ecological impacts. From this open-ended mandate, we have developed a set of recommendations for the environmental, design and educational aspects of this renovation. Though these recommendations were developed with our specific site in mind, we believe they would be applicable to a wide range of potential landscape greening projects.

Environmental

Water

Our primary environmental recommendation is to convert as much of the site's impervious surface area to pervious surface as possible. Since the main environmental impact of the paved areas is increased storm water runoff– which compromises the Huron River's water quality and prevents the replenishment of ground aquifers. The paved surface alternatives that we considered in our design were porous pavers, porous concrete and planters. The university has successfully implemented these alternatives at other sites, including under many bike racks on central campus, but this would be the first project on campus to incorporate all three in a coordinated manner.

Native Plant Species

Where planters are used a strategy to mitigate water runoff, plant species native to this region of Michigan should be incorporated into the landscaping. As previously mentioned, using native plant species carries a variety of environmental benefits ranging from reduced water use to removal of artificial fertilizers and pesticides from the maintenance regime. Additionally, these plants would require less overall maintenance than the traditionally landscaped areas on campus.

Design

Seating Areas

In both the survey and focus group, students indicated that incorporating seating areas should be a design priority. Over 60% of survey respondents stated that they would like to see benches added to the area, and during the focus group, participants emphasized seating areas as a good way to get students to notice and appreciate the ecological design features of the site. Focus group participants also noted that, in order to provide a comfortable area where community members could sit and read or do work, the seating areas should be at least partially offset from the walking paths so that they are not disturbed during times of high pedestrian traffic.

Accommodating Walking Paths

The primary reservation expressed by the focus group and in the additional comments from survey respondents was a concern over how the renovation would impact pedestrian traffic flows, particularly in between classes. Accordingly, it is important to recognize how the space is currently being used and how that use can be accommodated by the design. In our observations of the site, we noticed that pedestrian traffic tended to flow across the area in two diagonal lines: between the league and the MLB and between the MLB and the North University St access point. We believe our design accommodates both of these flows.

Educational

Informational Plaques

In order for the site to be useful as an educational tool, information about the porous materials, native plants and overall goals of the renovation should be displayed on plaques at the

site. This will help students understand the function of the site in addition to appreciating its aesthetics, hopefully stimulating them to think about how other spaces on campus can incorporate similar concepts. Furthermore, as one focus group participant pointed out, students may be more inclined to take care of the space if they perceive a functional value in it.

Incorporation into Coursework

Like the Dana Building and the Central Campus Power Plant, this site could be used as an on-campus case study for various sustainability and design-oriented classes. Since this would be the first comprehensive sustainable landscaping project, it would complement the other sites nicely. As previously noted, the selection of species to be included in the planters could be incorporated into project-based class such as ENVIRON 391.

Design Proposal

Our proposed design involves approximately five-foot-wide sidewalks made of porous pavers lining the fountain and creating walkways on ground level. On either side of the fountain will be raised planters in the shape of leaves. The innermost edges of the leaves (facing the sidewalks) will be approximately 4 feet tall and have benches molded into their form . As the leaf moves out, it will be terraced down to a final height of 1.5 feet on the outer edge. The planters will be made from molded porous concrete and will contain native Michigan plants. Trees are shown in the image below for shade purposes but may interfere with the design goals overall. With the long-term in mind, trees may eventually disrupt the fountain and sidewalks with root growth. Concept drawings of the proposed site design are included below in Figures 5, 6, 7.

Figure 5: Final Design Proposal

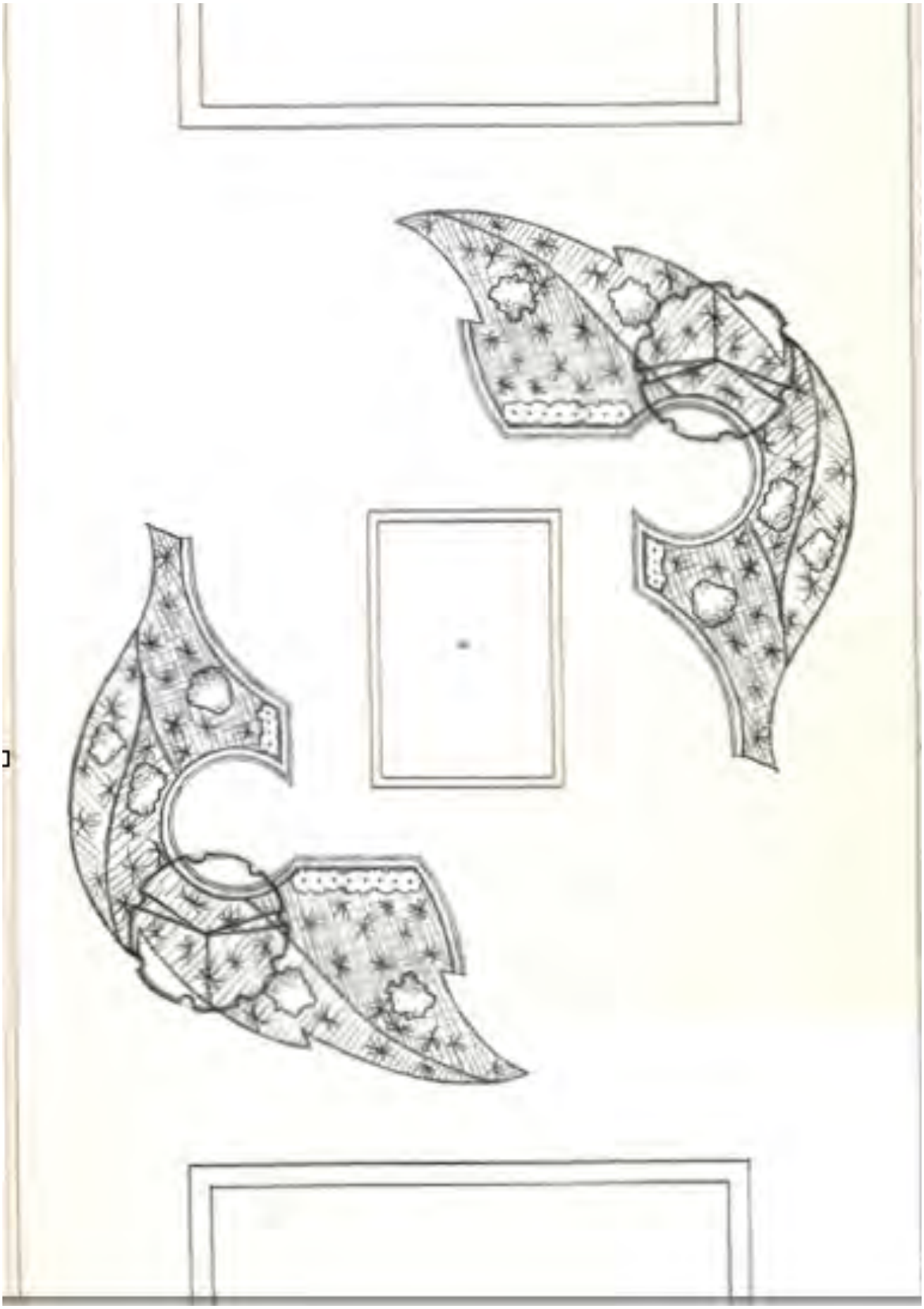
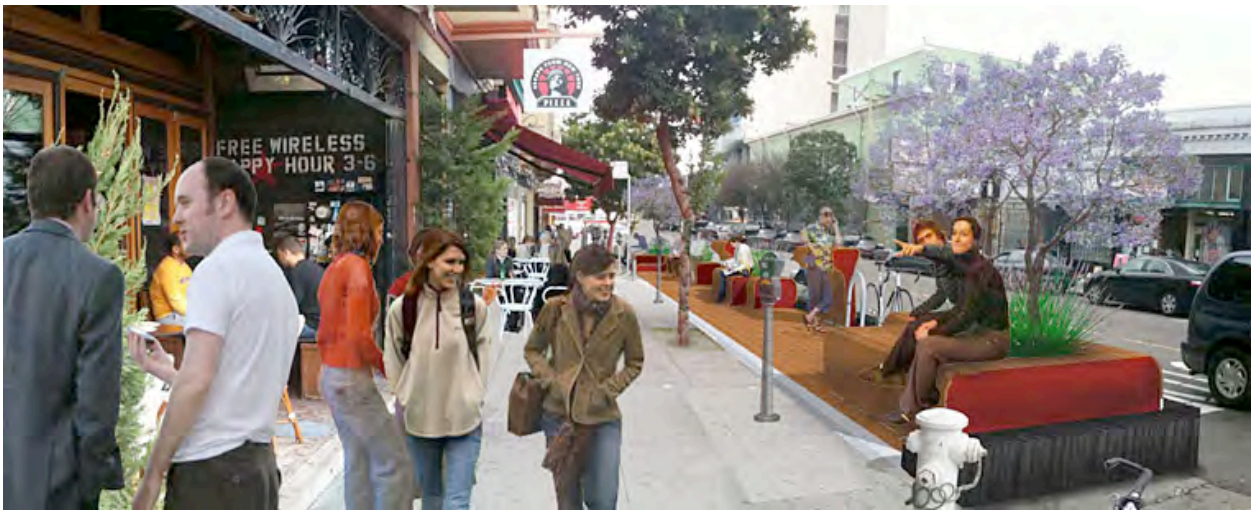


Figure 6: Final Design Proposal

Figure 7: Final Design Proposal

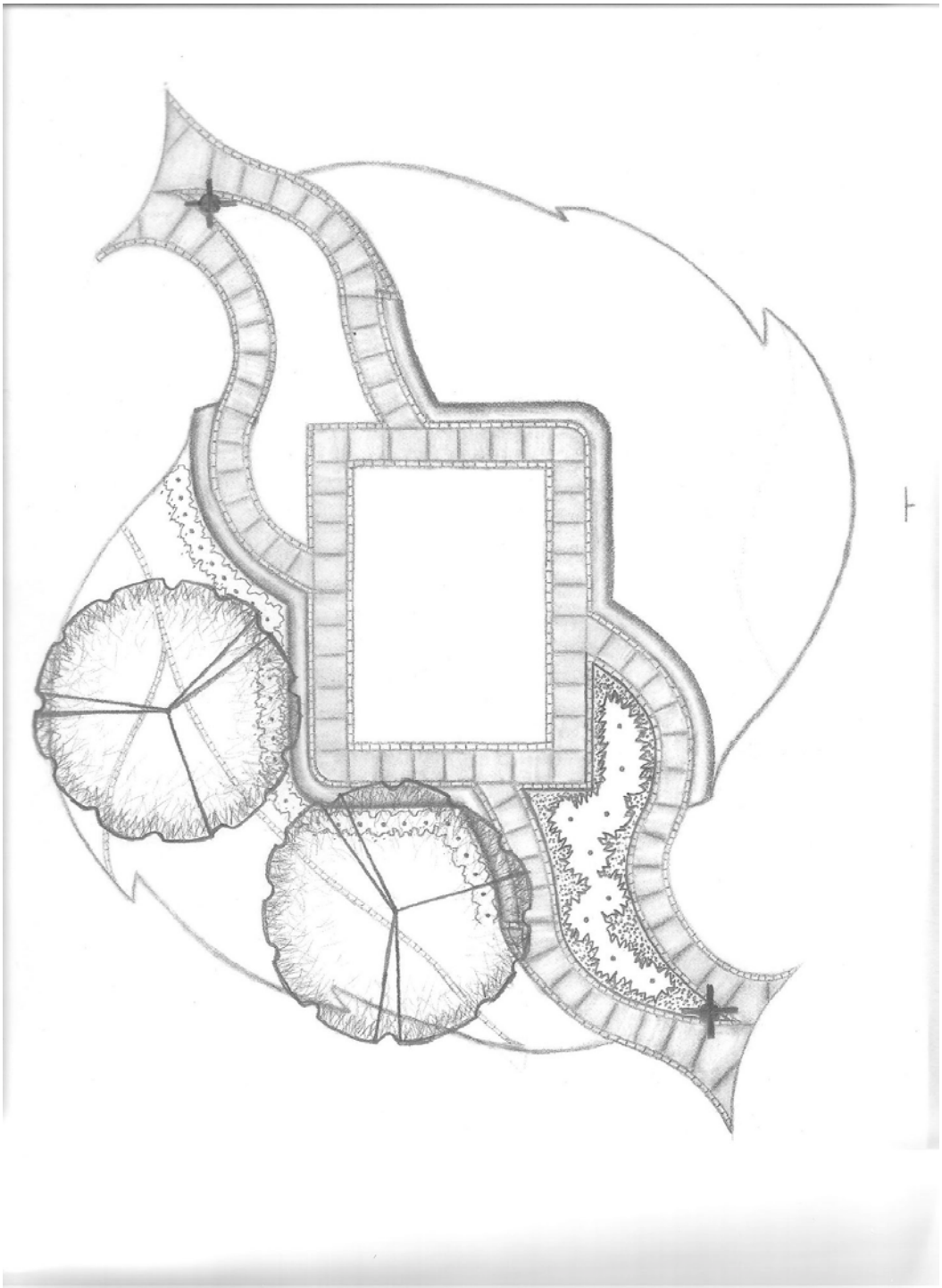
Appendix 1
Children's Discovery Museum Amphitheater in San Jose, CA

Appendix 2
22nd St. Parklet in San Francisco, CA



Appendix 3
Auburn University's Arboretum in Auburn, AL

Appendix 4: Initial design used for focus group



References

Akbari, Hashem; Menon, Surabi; Rosenfeld, Arthur. (2008). Global cooling: increasing world-wide urban albedos to offset CO2. Climatic Change (2009) 94:275–286. DOI 10.1007/s10584-008-9515-9

Almy III, Dean J. "San Francisco's Pavement to Parks Programme." Landscape Urbanism 2010: 13. Print.

Amphitheater Renovation. Children's Discovery Museum of San Jose: Your Children's Museum in Silicon Valley. Cheryl Blumenthal, n.d. Web. 15 Feb. 2011. <http://www.cdm.org>.

Brown, Chris, Angus Chu, Bert Van Duin, and Caterina Valeo. "Characteristics of Sediment Removal in Two Types of Permeable Pavement." Water Quality Research Journal of Canada 44.1 (2009): 59-70.

Children's Discovery Museum Renovation. HOK | Ideas Work. Web. 15 Feb. 2011. <http://www.hok.com/>.

Fehrenbacher, Jill. (2008). United States Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks. Washington, DC: EPA.

Fox, L. (2010). Irrigation Pond Characterization and Analysis: Impact of Weather and Management. Journal of Environmental Horticulture , 224-234.

Hartig, T., Mang, M., & Evans, G. W. (1991). Restorative effects of natural environment experiences. Environment and Behavior, 23, 3–26.

Hein, Michael F.. "Reflections From Pervious Pour Fall 2004."Pervious Concrete Information Center. N.p., n.d. Web. 15 Feb. 2011. <fp.auburn.edu/heinmic/PerviousConcrete>.

Huron River Watershed Council (1) . Runoff as resource: the art of handling water runoff in six easy sections. Retrived from: <http://twp.waterford.mi.us/Departments/Community-Planning-and-Development/PDF/FlyersAndBrochures/Watershed-RunoffasaResource-pdf.aspx>

Huron River Watershed Council (2). The Impact of Development on Fresh Water Resources. Retrieved from <http://www.hrwc.org/the-watershed/threats/development/>

Maller C, Townsend M, Brown P. Healthy parks healthy people: the health benefits of contact with nature in park context. Melbourne: Deakin University and Parks Victoria, 2002.

Mass, J., Robert A Verheij, Peter P Groenewegen, Sjerp de Vries, Peter Spreeuwenberg. (2006). Green space, urbanity, and health: how strong is the relation? Journal of Epidemiological Community Health. 60:587–592. doi: 10.1136/jech.2005.043125

Martine, George. (2007). State of World Population 2007: Unleashing the Potential of Urban Growth. United Nations Population Fund. New York: UNFPA

Pappas, E.A., Smith, D.R., Huang, C. Shuster, E.D., Bonta, J.V. (2008). Impervious surface impacts to runoff and sediment discharge under laboratory rainfall simulation. Catena 72(1), 146-152.

Auburn University. (2006). Department of Building Science. Pervious Concrete Information Center. Accessed from <https://fp.auburn.edu/heinmic/PerviousConcrete/index.htm>

Power, Andres. 22nd Street Parklet. Pavement to Parks. Web. 15 Feb. 2011. <http://sfpavementtoparks.sfplanning.org/22nd_street_parklet.html

Tennessen, Carolyn M., Bernadine Cimprich. (1995). Views to Nature: Effects on Attention. Journal of Environmental Psychology. 15, 77-85

United States Environmental Protection Agency. Pervious Concrete Pavement: Post-Construction Stormwater Management in New Development and Redevelopment. Retrieved from: <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm>. Last updated: September 2009

University of Wisconsin Extension. Total Suspended Solids: The Hows & Whys of Controlling Runoff Pollution. Retrieved From: <http://runoffinfo.uwex.edu/pdf/Runoff-Suspended Solids.pdf>

Ulrich, R. S. (1979). Visual landscapes and psychological well-being. Landscape Research. 4, 17–23.

Ulrich, R. S., Simons, R., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. Journal of Environmental Psychology, 11, 201–230.