AN EVALUATION OF THE RESTORATION OF THE EAST PRESERVE, UW-MADISON LAKESHORE NATURE PRESERVE

by

Rebecca Kagle

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

(Land Resources)

at the

UNIVERSITY OF WISCONSIN-MADISON

2007

Executive Summary

From June 2005 until July of 2007, I was appointed the first student manager of the East Preserve portion of the UW-Madison Lakeshore Nature Preserve, part of the University of Wisconsin Madison. In this capacity, I had multiple responsibilities including restoration planning and implementation as well as evaluating the work that had been accomplished.

This thesis records the results of the ecological assessment that occurred, describes various implementation techniques that were used, and evaluates the decision making process that was utilized, the use of other students (non-managers) throughout the process, and the restoration projects that were undertaken. The hope is that this process can serve as a model and jumping off point for other restoration projects in the Preserve.

Initial Site Analysis and Restoration Implementation

I conducted a site inventory and analysis to determine which of the restoration objectives for Muir Woods had been met prior to commencement of the project and to aid in guiding what aspects and areas of restoration should be of highest priority. The restoration objectives are measurable benchmarks by which we can determine how well the restoration is proceeding. They cover biological and user experience aspects of the restoration, as well as the condition of the infrastructure. The biological objectives address such features as the composition, structure and diversity of the canopy, midstory and understory, the presence of representative species and guilds, and the extent of tree reproduction. The human use and experience objectives concern the number and condition of trails, the presence and extent of erosion channels and gullies, and the nature of volunteer participation in the project.

The inventory and analysis revealed that only two of 15 objectives had been met prior to the initiation of restoration activities. Based on these results, my restoration recommendations are:

- Plant additional species in order add diversity (especially in the tree and ground layers), increase canopy cover and tree density, better represent the species composition and guild structure of mesic/dry-mesic forests (the model ecosystem for the site),and increase overall ground cover
- Control both exotic invasive species and opportunistic native species.
- Stabilize the slope and control erosion
- Facilitate the use of these spaces as laboratories for UW-Madison classrooms

Given the types of actions needed, I present detailed recommendations regarding a number of restoration procedures:

- Selection of plant communities
- Restoration site preparation
- Invasive plant management
- Planting Techniques
- Basic hillside stabilization techniques
- Trail maintenance
- Design and maintenance guidelines for physical infrastructure (signage, benches, and fencing)
- Guidelines for the management infrastructure (how to recruit and manage volunteers, supervise staff, and create partnerships with academic classes)

Ongoing Maintenance, Monitoring and Experimentation

One of the most important aspects of a restoration project is developing a system to keep track of what is done, where, when, and by whom. Detailed record keeping enables us to better understand what actions have or have not worked, and allow us to keep track of progress towards the restoration goals. In order to facilitate our ability to track changes over time, as well as pinpoint locations for restoration and management activities we established an x by y grid in Muir Woods, marking the locations of the grid cells, by installing permanent pipes. I also created a procedure by which field workers record their observations and enter data into a digital storage location, if appropriate, in order to track activities and observations over time.

In addition, I established a field experiment to help determine optimal planting densities for herbaceous groundlayer species and field trials to test different hillside stabilization techniques and erosion control methods. The idea is to use the results of these investigations to choose which of a variety of available options work best on this site.

Evaluation of the Restoration Process

From careful evaluation of a research online log that I kept, and notes from meetings, I was able to generate three key themes:

1. How decisions were made, and how the process changed through time
2. How different visions for the Lakeshore Nature Preserve affect the restoration
3. Impacts of the decision to use student managers

My observations include:

- It is important to have weekly meetings during which the field manager can communicate with representatives from all groups with oversight responsibilities for a restoration site, and with a set of experts who are familiar with the site and have experience in implementing restorations. In the case of the Lakeshore Preserve, this was accomplished by creating a subcommittee of the University committee with policy authority over the Preserve. The subcommittee contained representatives from the University's Physical plant, the unit responsible for all of the grounds of the campus, as well as representatives from funding groups, the parent committee, and university restoration experts.

- It is critical to the success of a restoration project to have a Master Plan that sets overall policies for the project, and a Restoration Plan that establishes restoration targets and expectations. At the start of my involvement with the Preserve, the Master Plan had not yet been written. As a result, permission to take any action in Muir Woods or along the Lakeshore Path had to be granted on a case-by-case basis, often only after considerable debate. After the adoption of a plan, we could proceed with more independence, needing to consult with the oversight committee and university departments only in exceptional cases.
- Conflicting visions as to process or outcomes need to be openly acknowledged and resolved. During this project, it became clear that there was an underlying tension regarding a desire to achieve quick and particular results, sometimes without thinking about long-term management implications, and a desire to collect information and plan for contingencies before acting, and in the process training students. Failure to resolve these conflicts led in some cases to a need to divert resources causing a delay in completing a task in order to accomplish damage control.
- One of the biggest obstacles in the way of the restoration has been the lack of a reliable source of funding.
- Students, working in close collaboration with FPM staff and expert faculty and academic staff, have the potential to achieve high quality restoration planning and implementation.

- Collaboration, communication, and transparency are necessary components of any restoration project that occurs in the Preserve.

Student Outreach Logic Model

This thesis also investigates the student outreach portion of the work that was accomplished. This was a major focus of the project because the Lakeshore Preserve Master Plan has a mission statement about education, and because Muir Woods in particular was originally protected as a student laboratory. Students have been involved with the woods as volunteers, interns, paid staff, and student researchers.

I used a logic model, a tool for program planning and evaluation, to determine how the project has done in terms of meeting its goals in this regard. Over the last two and half years, the following short term goals have been met:

- Development of a standard tour that can be modified and given to a wide variety of students
- Existence of a student group
- Regular volunteer opportunities are widely publicized to the campus community
- A list of faculty, courses, student groups, online calendars, bulletin boards that are appropriate for finding volunteers, staff, and student researchers has been generated.

The following short terms goals have yet to be achieved:

- Development of criteria for what types of projects are conducted by which types of volunteers
- Development of a go-to list of volunteer and research projects that are appropriate for students

The following medium terms goals have been met:

- Ability to give tours with minimal planning
- Interested and appropriate students are found for tasks.
- Planned activities are a good fit for students
- Opportunities are posted to the appropriate places to find students

The following medium terms goals have yet to be achieved:

- The student group is not yet self sustaining
- A wide variety of faculty are not yet aware of the work occurring in the East Preserve and therefore are not referring students to these projects or generating labs/activities that are conducted there.

The following long terms goals have been met:

- Students want to return as volunteers/student workers and/or researchers.
- Muir Woods is used as a laboratory
- Students are assisting in getting critical work done in the East Preserve.

The following long term goals have yet to be met:

- All incoming students do not know about Muir Woods and what goes on there
- A framework is not in place for keeping students involved in the Preserve overtime

The logic model should continue to be used as a method for planning future activities and for evaluating the continued impacts of this project on students at the University.

Overall conclusions

The restoration model that includes site inventory and analysis, setting and testing of goals and objectives, and long term monitoring and maintenance has been successful and in the long run should not take longer than restoration without these steps. It has the advantage of providing information about restoration that will be useful in other sites throughout the Preserve and elsewhere.

Managing restoration in the Preserve must have a focus that is broader than simply the ecology of the site. How people use it, what educational opportunities should be offered, and what aspects of physical infrastructure should be in place all need to be considered. Furthermore, a manager must be able to run all aspects of a project from managing the budget and the staff to determining an appropriate plant palate and setting up long term monitoring protocols.

What is clear from this thesis is that students, both the managers and other students who become involved, have been critical to this project. By having students serve in the roles of both leaders and participants, goals of both the University and the Preserve are being met. Students, working in close collaboration with FPM staff and expert faculty and academic staff, have the potential to achieve high quality restoration planning and implementation

While this project advocates for using student managers in the future, what is even more important is conducting restoration in a systematic way that involves creating plans and testable objectives so that it can be determined the extent to which implemented projects are aiding the restoration of the site.

Acknowlegements

I could not have completed this project without the faculty and staff mentorship that I received over the course of my three years as a student in Madison. Most importantly, my advisor and sub-committee member, Dr. Evelyn Howell provided steadfast support, was a sounding board, and a fabulous editor, even when I moved 1000 miles away.

The weekly meetings with the sub-committee were what made this document and all of the work that I was able to accomplish over the past few years possible. Thank you Ann Burgess, Susan Will-Wolf, and Cathie Bruner for eating lunch with me once a week and being so passionate about the East Preserve and providing such valuable guidance. I learned so much from all of you. Thank you to my masters committee members, John Harrington, William Cronon, and Sam Dennis for helping to guide my research. I have also been fortunate to have great co-workers whose knowledge about restoration and dedication to the Preserve helped shape this document and the work that was accomplished in the field. University staff from the grounds department, the Arboretum, and Extension all provided resources and information when I most needed them.

And of course, I absolutely could not have completed this process without the support of my friends and family. Even when they had no idea what I was doing or why it was taking so long, they remained supportive and interested in the work and the place about which I had become so passionate and would even occasionally come out and build trails or pull invasives with me. I am forever indebted to Molly who saw our evenings, weekends, and even vacations disappear while I worked on this project. I was fortunate to have her guidance, encouragement and understanding during this process.

Table of Contents

List of Figures

List of Tables

List of Appendices

Chapter 1. Introduction

Genesis and Purpose of this Project

This project came about as part of a Project Assistantship that was paid for by donors to the UW-Madison Lakeshore Nature Preserve. The idea was to build upon a plan that had been written as part of a class and hire a student who could both refine this plan and begin the implementation. I was hired as the student manager of the East Preserve in June of 2005 to begin this process. A second project assistant, Lars Higdon, was hired in September 2006 to assist in the East Preserve and help manage other areas of the Preserve. The thesis is a document that builds upon the work that has come out of my assistantship.

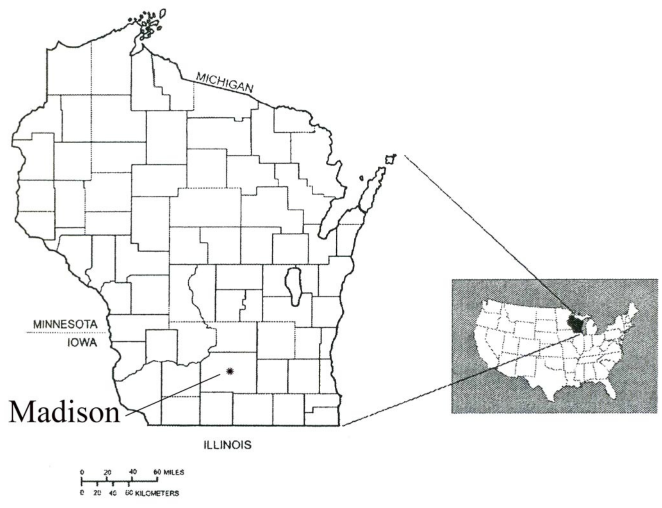
The purpose of this research was to participate in, document, and critique the steps involved in creating and implementing restoration and management plans for Muir Woods and the vegetated portions of the Howard Temin Lakeshore Path. This project not only sets the ground work for ecological monitoring, but looks at the process of restoration of an urban preserve holistically and evaluates the critical components of management efficacy, the role of volunteers, and other practical day to day aspects of planning and implementing a restoration program. By setting up a framework and evaluating its various aspects, the hope is that the entire system can respond to future drivers or events and be adaptively managed, which should therefore increase the chances of a responsive and successful restoration (Zedler, 2005).

Furthermore, this project attempts to provide recommendations and techniques for restoration for the major problems facing urban forests, including invasive exotic plants, lack of recruitment of native plants, excessive stormwater and the effects of "use, misuse, and mismanagement", while remaining pragmatic about the resources (time, money, expertise) that this and similar projects can expect to receive over time (Sauer, 1998, p.ix).The idea is to provide a general framework for how to have students design and implement restoration for this site that can be modified for other similar sites and to provide a model that will be useful to both restoration practitioners and restoration ecologists.

Location of Study Site

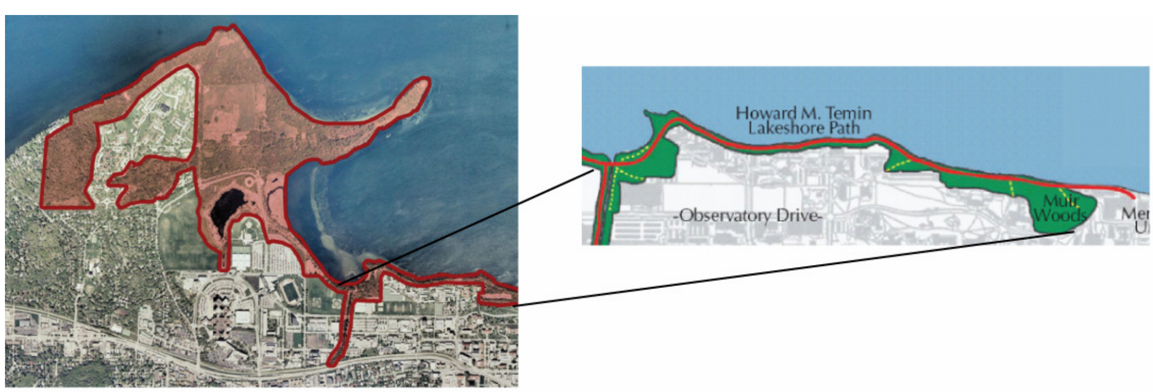
The study site for this project is located in Madison, Wisconsin (Figure 1) in a portion of the University of Wisconsin-Madison Lakeshore Nature Preserve ("The Preserve").

Figure 1. The Location of the State of Wisconsin within the United States and the Location of the City of Madison within Wisconsin (Ortwine-Boes, 2003)**.**



This protected area is located at the northern and western edges of the UW-Madison campus and contains approximately 300 acres of open space that stretches for almost four miles along the Lake Mendota shoreline (Figure 2). This array of woods, open fields, marsh habitats, and restored prairie and savanna includes several miles of trails, two swimming beaches, picnicking and observation spots, and various areas for learning and recreation.

Figure 2. The location of the East Preserve within the UW-Madison Lakeshore Nature Preserve (Maps from UW-Lakeshore Nature Preserve Website).



This project focuses on an area, collectively called the East Preserve, that includes both Muir Woods, a seven acre woodland, and the eastern portion of the Howard Temin Lakeshore Path from the Center for Limnology to Willow Creek (referred to as the Lakeshore Path). This project does not focus on the path itself, but rather on the restoration and management of the vegetation around the path.

These sites were appropriate for this project because not only were they in need of a restoration and management plan, there were donors who were willing to fund a graduate student to be the land manager for this area. Furthermore, the East Preserve is the area that is closest to the heart of the UW campus and, therefore, is a place that is heavily visited by students. It is used as a circulation route, for nature study, for jogging or walking, or for socializing, and as a laboratory for teaching for multiple classes. The East preserve has been heavily affected by these uses, and by its urban surroundings.

Urban Forest Restoration Ecology

There are many challenges facing urban greenspaces, and urban forests in particular, which make their management and restoration different from that of sites that are more removed from direct human influences. Leslie Sauer describes an urban woodland as a place where "trash is ubiquitous", the soil includes broken glass, construction rubble, and cigarette butts, and there may be large patches of bare soil due to "trampling, stormwater runoff, or filling", various pollutants are present, they may be providing shelter to the homeless, and due to the chronic disturbance, exotic vegetation plays a major role as the native species often fail to naturally regenerate (1998, pg 1). Urban greenspaces are typically degraded and surrounded by "pavement, infrastructure, alien species, and many physical stresses" (Handel, 2002). The differences are almost all due to human impact. As cities become denser and their natural areas shrink, the pressure on these systems increases and the potential damages to their functioning as habitat decreases.

Urban forest patches are found in protected areas within cities. They can be state or city parks, private land, arboreta, parts of botanic gardens or university campuses. The urban forest is often defined as any and all trees that are found within cities whether they are found within a forest fragment, along a street or planted in a backyard (McPherson, Nowak, & Rowntree, 1994). However, urban forest restoration is generally referring to areas that include a plant community that is dominated by woody plants, on the order of more than a single tree or two and that can provide at least some of the functions typically found in larger less fragmented forests such as nutrient cycling, erosion prevention, and wildlife habitat. These forested spaces play important social and ecological roles in the urban environment. Studies have shown that trees in cities absorb pollutants and reduce the effects of the urban heat island (Bonsignore, 2003). The presence of urban greenspaces has been claimed to "improve the appearance and the environmental quality of an area, they can sometimes have an impact on critical social issues such as health care, education, crime and safety, economic development, and social disenfranchisement"(Westphal, 2003).Other research has shown that trees in the urban environment can improve healing and mood, improve worker productivity, help organize communities, improve mental health, increase feelings of safety and reduce domestic violence (Hull, 1992; Kuo, 1992; Kuo & Sullivan, 2001). Although the research on this subject has focused on a variety of impacts, it is clear that urban greenspaces have the opportunity to enhance the quality of urban life and provide a valuable ecological role (Chiesura, 2004).

Since many urban forests are heavily degraded and under stress from the surrounding urbanization their "natural systems are so compromised we cannot expect them to recover if they are simply left on their own" (Sauer, 1998, p.xvii). Urban forest restoration and on-going management are critical to these sites retaining their ecological and social functions.

These fragmented spaces cannot be expected to meet the typical goal of ecological restoration of creating a self-supporting community since they are often too small for a natural disturbance regime to occur or too altered to be able provide ecosystem functions and processes, or prevent erosion or provide habitat for diverse native species (Lesica & Allendorf, 1999; White & Walker, 1997). That is not to say that some of these characteristics cannot occur as the result of a restoration project, but the likelihood that the community can be self supporting is low when the city, with its impervious surfaces and invasive plant seed sources, surrounds these small areas (Society for Ecological Restoration International Science & Policy Working Group, 2004). This reality is an important one to keep in mind when planning for the long term management of urban forests.

Constant vigilance and awareness of how the surrounding areas are changing will be necessary to achieve restoration goals. Also, these sites tend to have been so heavily altered that compelling them to a state that may have existed historically may not be possible when alterations to a system are not or cannot be addressed. Trying to direct projects to end points that are incompatible with current environmental conditions can lead to failure of restoration projects (Hilderbrand, Watts, & Randle, 2005). This results in pragmatism being an important component in urban forest restoration planning. Before reintroducing conditions based on historical records it is important to investigate if the drivers of that system still exist and are possible to reintroduce and maintain. For example, if fire cannot feasibly be reintroduced to a site, either a secondary way of mimicking that disturbance must be selected or perhaps allowing the site to transition to forest is more appropriate. Keeping systems trapped at a point in time may not be possible under current conditions and allowing a system to succeed to another appropriate native system that can provide ecological and social benefits may make more sense.

Campus Preserves

College and university campuses can provide a unique opportunity for management and increasing knowledge about urban forest restoration. Large universities can be thought of as small cities themselves and are often found in urban and metropolitan areas. Fortunately, many universities across the country have portions of the campus that are protected from further development to serve as “a place for wildlife enthusiasts and for those seeking a quiet place to recharge themselves"(Brock, 2005). The size of these protected areas range from just a few acres to over 700 acres (*Michigan State Campus Natural Areas.*).

These preserved areas are often protected as living laboratories that are used for classes and research, but tend to be more than just laboratories; they are educational and recreational resources for the academic communities and the communities in which the Universities reside (Dye, 2002) These areas also have the unique situation of being able to utilize the current students who can form a skilled and dedicated part time staff and cadre of volunteers who can work on restoration projects in a variety of capacities. Since most of these areas have been protected for the university community and as a learning environment, using students to plan and implement restoration can be a great way to give students hands on experience while improving the quality of these protected areas.

Model for Restoration

The implementation plan that is the heart of this study relies heavily on the goals and objectives which are laid out in the restoration plan for the East Preserve. The restoration plan follows the broad outline that is taught by Drs. Evelyn Howell and John Harrington as part of their Restoration Ecology Course (personal communication, Fall Semester 2004). According to this model, a restoration plan includes:

- Conduct Preliminary Research (Site and Landscape Inventory and Analysis: Site History, Review of Precedents)
- Develop a Purpose for the Project, a Use-Policy, and a Research Plan
- Determine Restoration Goals and Objectives based on Conceptual Design Model
- Prepare Site
- Implement Restoration
- Monitor to see if Objectives are being met.

Goals are the description of what the site will be like in physical, biological, and cultural terms at the completion of the restoration. They are written in general terms. Objectives are measurable statements, qualitative or quantitative, that serve as indicators of success. They can be thought of as the performance standards for a site.

There is no cook-book set of goals and objectives or of implementation techniques that can be directly translated from one project to another. However, there are certain types of goals and objectives that should be consider for every project. They can be broken down into a few category types: biological, physical infrastructure, and user experience. The biological objectives should include performance standards for levels of diversity, canopy cover, invasive species cover, and other important factors that affect community structure and function. The targets should express our current understanding of what the desired communities are like and are based on prior investigation of reference communities, and on our current understanding of ecological theory and on how human interactions might changes them (exotic plants, change in fire, flood regimes, fragmentation etc.) as well as on our understanding of the site at hand. Physical infrastructure objectives should describe desired conditions of trail systems, erosion control measures, and any other aspects of the built environment that might be needed for a site. Finally, objectives about the user experience should outline targets for who will use the site, how they will use it, and what, if anything, will be provided to enhance their experience. These should complement the user policy that is also part of this restoration model.

The restoration plan for the East Preserve follows this general outline and contains descriptions of the reasoning behind all of the recommendations contained therein. I was a member of the team that created the plan. This thesis focuses in particular on developing the site inventory; establishing and applying several research components; and determining whether the initial site conditions meet reasoning behind each of these components is included in this document; for details regarding the other components, please see the separate restoration plan.

The particular goals and objectives for this project were generated as part of a collaborative process between myself, the Preserve Field Manager, and a variety of restoration professionals.

Apart from using the model from the restoration ecology course taught at the UW-Madison, the plans for restoration in Muir Woods also follow an adaptive restoration approach. Even as the field of ecological restoration has grown, and knowledge about it has increased, our understanding is limited and makes it difficult to know which conditions, structures and functions should be restored. Adaptive restoration allows a synthesis of current knowledge to be paired with selection of actions, then monitoring the results and using them to adjust future actions (Zedler & Callaway, 2003). Adaptive restoration allows for there to be "decision points along the way" which "allow for critical assessment and possible intervention with contingency plans" (Hilderbrand et al., 2005, p.18). This allows projects to have resilience and provide increased knowledge about restoration in general. The East Preserve project includes multiple experiments and trials. These will be evaluated and modified over time to increase the likelihood that actions taken are making reaching the restoration objectives possible.

Project Overview

This thesis has 3 distinct parts.

1. An implementation plan for Muir Woods and the eastern portion of Lakeshore Path (Chapters 2, 3, and 4)

2. Evaluation of the current governance structure, decision making process, and volunteer program of the East Preserve using both case study methodology and logic models. (Chapters 5 and 6)

3. Discussion of the adaptive restoration experiments and field trials occurring in the East Preserve. (Chapter 7)

The first part of the thesis serves to guide future managers of this land and similar sites on the hands-on aspects of restoration. The implementation plan creates a framework as to how to achieve the goals and objectives that are stated in the restoration plan and then provides guidelines for the long term monitoring and maintenance of this site. In this section, I describe an inventory process to determine the current state of the vegetation in Muir

Woods, summarize the results, and make recommendations regarding how to take the vegetation from where it is today to what the restoration objectives specify.

The second part of the thesis serves to critically evaluate the process used to implement the restoration. Even this early in the project, it is possible to look with a critical eye at the social and managerial aspects of this project and evaluate their strengths and weaknesses as a way to judge the efficacy of the model which has been set up. Careful evaluation of this process will allow me to create a framework for managers of other portions of the Preserve. Furthermore, this research provides insight for others responsible for the Preserve on how best to facilitate successful student partnerships, how decisions were made throughout the course of the project, and what the role of student managers should be.

The third part of the thesis evaluates what has been learned from the adaptive restoration and experimental trials that have been set up as part of this progress. In order to learn how best to restore this site and others like it, I have set up a variety of comparative studies of various detail that attempt to answer questions that will help to achieve the restoration objectives.

Specifically, this thesis addresses the following questions:

1. What is the current state of the East Preserve and what implementation techniques are necessary to achieve restoration goals and objectives?

2. How are decisions about the restoration actually made, and how effective is this process (Case Study)?

3. How effective is the volunteer program in meeting the goals that were created for it? (Logic Model)

4. How effective are the restoration techniques in meeting the project goals and objectives? (Long-term Monitoring and Experiments)

Chapter 2. Initial Conditions Prior to Restoration: Determination of Restoration Needs

One of the first steps in a restoration project is to conduct an assessment of the current conditions of the site—the vegetation, hydrological features, soils, human use, etc. This information can then be compared with the restoration goals, used to lay the foundation for the creation of realistic objectives and to set the stage for beginning the implementation of restoration projects.

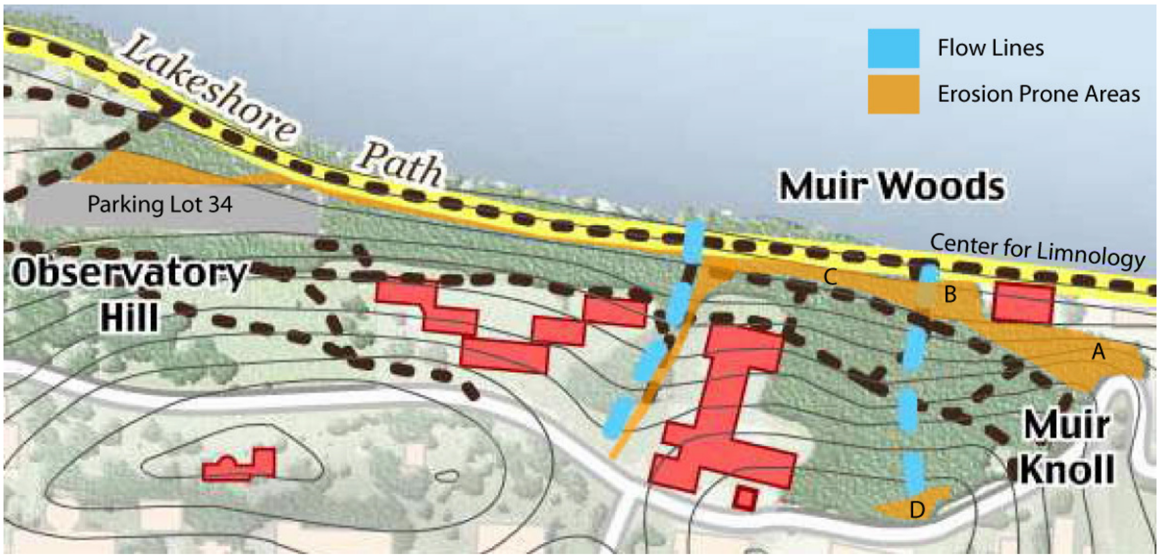
In the East Preserve, I conducted research about the topography and drainage patterns on the site, conducted intensive plant inventories in Muir Woods, made observations about the vegetation along Lakeshore Path, and noted erosion along the slopes of both sites.

Initial Conditions

Topography, Drainage, and Erosion in Muir Woods

Muir Woods is a north facing slope with varied topography (Figure 3). The area directly behind the Center for Limnology is the steepest portion and it will require a large investment to stabilize and re-vegetate this slope (A on Figure 3). Water also flows along an erosion cutout just east of the steps that lead down Muir Knoll to the Lakeshore Path (B on Figure 3).

Figure 3. Map of Muir Woods showing 10' contour lines, flow lines and erosion prone areas (modified by Rebecca Kagle from Preserve Interactive Map).



A – Steep slope behind the Center for Limnology
B – Erosion cutout just east of the steps that lead down Muir Knoll to the Lakeshore Path
C – Areas with multiple gullies and little or no vegetative cover
D – Erosion prone area off of Observatory Drive

Farther west, at the junction with the steps that come down to Lakeshore Path and westward, there are multiple gullies and areas that have little or no vegetative cover due to stormwater runoff and/or trampling by humans (C on Figure 3, Figure 4). Gully erosion is caused by concentrated overland flow of stormwater in depressions and drainage ways. The erosive force of the runoff removes topsoil while increasing energy as it moves down-slope. Once a gully begins to form, lateral erosion takes place, widening the gully and undercutting the sides, which causes additional soil to be removed (Gray & Leiser, 1982).

Figure 4. Non-restored gully in Muir Woods (photo by Rebecca Kagle).

Since the majority of stormwater was routed off the site in the late 1990s, the rate of gully degradation and creation has slowed (see site history in the restoration plan for more information about this project). This decrease in overland flow improves the chances of repairing the gullies.

A number of undesirable trails follow natural depression lines down the slope, essentially creating opportunity for new gully formation. Trampling removes the protective vegetation and compacts the soil, opening a path for runoff water to easily flow downhill.

Other areas where erosion is a problem include the rocky slope that runs off of the sidewalk on Observatory Drive (D on Figure 3) and along the flow lines in Muir Woods and in the areas below Parking Lot 34.

Shoreline Erosion along Lakeshore Path

The shoreline is steeply sloped from The Center for Limnology to Willow Drive and there are a number of heavily eroded areas. The Master Plan lists the eastern portion of Lakeshore Path as an area of concern due to eroded footpaths to the shoreline and stormwater that accumulates on the path itself (Ken Saiki Design, 2006). The vegetated areas of Lakeshore Path also have to contend with wave and ice action from the Lake. Lakeshore Path and the shoreline are comprised largely of fill. This material erodes easily. The problem is compounded by the steep banks and frequent trampling by people who want water access from the path. Wave action on Lake Mendota is caused by both wind and watercraft and is, according to the DNR Wave Energy calculator classified as moderate (Bauman et al, 2004). Constant waves and swells created by winds can loosen soil particles on shorelines and cause erosion, especially along points and other areas exposed to wind (Tennessee Valley Authority, 2006). Lake ice pushed by wind or wave action into the shoreline can cause major damage. However, most of the shoreline in the East Preserve has some sort of riprap (placed stones) along the water's edge which dissipates these forces. Even with the riprap, the forces of ice and wave action are likely to limit the types of bioengineering techniques that will successfully stabilize this shoreline (see section on "Hillside and Lakeshore Stabilization" for the techniques that have been tried thus far).

Human Use

One of the major distinctions between restoring and managing urban greenspaces and rural spaces is the impacts of the heavy human use that many of these spaces experience. It is important to understand how a site is being used before commencing restoration and to determine a clear use policy.

Human Use in Muir Woods

The Master Plan lists Muir Woods as being an area of moderate intensity use (Ken Saiki Design, 2006). Apart from its use as a laboratory and classroom, the site is used by students, faculty, and staff as a place of respite during the day. Its trails are used as an alternate way to get to University buildings, or by joggers. After having interacted with many undergraduate courses as part of this project, it is clear to me that many students are unaware of this woodland, or, if they have heard of it, are unsure of if they are welcome. Many students only enter it as part of a class assignment.

Not all of the use is positive. We often found beer cans littered along any area where a natural seating area has formed or in secluded areas in the woods. Occasionally we found evidence that (presumably homeless) people have set up camp in the woods during the summer. Unapproved art installations and structures made of downed wood have been installed both as part of classes and independently. And, while it appears that most people stick to the trails, there are many redundant and renegade trails throughout the woods. This situation both creates additional understory disturbance and makes the trail system confusing to visitors.

Human use in Eastern Portion of Lakeshore Path

The Lakeshore Path gets heavy use from walkers, bikers, and runners and therefore it has been defined in the Master Plan as an area that gets high intensity use (Ken Saiki Design, 2006). People use it for both commuting and recreation. People desire both physical and visual access from the path to the lake in all seasons. Due to the current lack of designated and designed access areas, there are many unauthorized access points down to the water. Until the summer of 2007, there were areas along the East Lakeshore Path that had been used as boat storage. Even though the boats have all been moved to Willow Creek Beach, the heavily eroded pathways that they left behind still exist. All of these access points are heavily compacted and devoid of vegetation which increases soil erosion into the lake.

There is currently one wooden observation deck at the base of the paved path that comes off of Charter Street. However, this does not provide the experience that people want because of encroaching shrubs and more problematically, the locking of bikes to its posts and rails when the adjacent bike rack is full, making the deck unusable for its designed purpose.

Infrastructure

At the start of this project, it was clear that little attention had been placed on the infrastructure of Muir Woods for many years. A path system was present, but it was difficult to determine what official trails were and what had been created by users over the years. There was no signage present anywhere on the site. There were pieces of fence and stairs that did not link to current trails. The only infrastructure that was present was a mostly broken wire fence that ran along the ridge directly south of Lakeshore Path and a staircase that brings users from the top of Muir Knoll down to the path. These stairs, while still functional, were eroding away from the stormwater that came off of the knoll.

Vegetation

Vegetation Inventory of Muir Woods

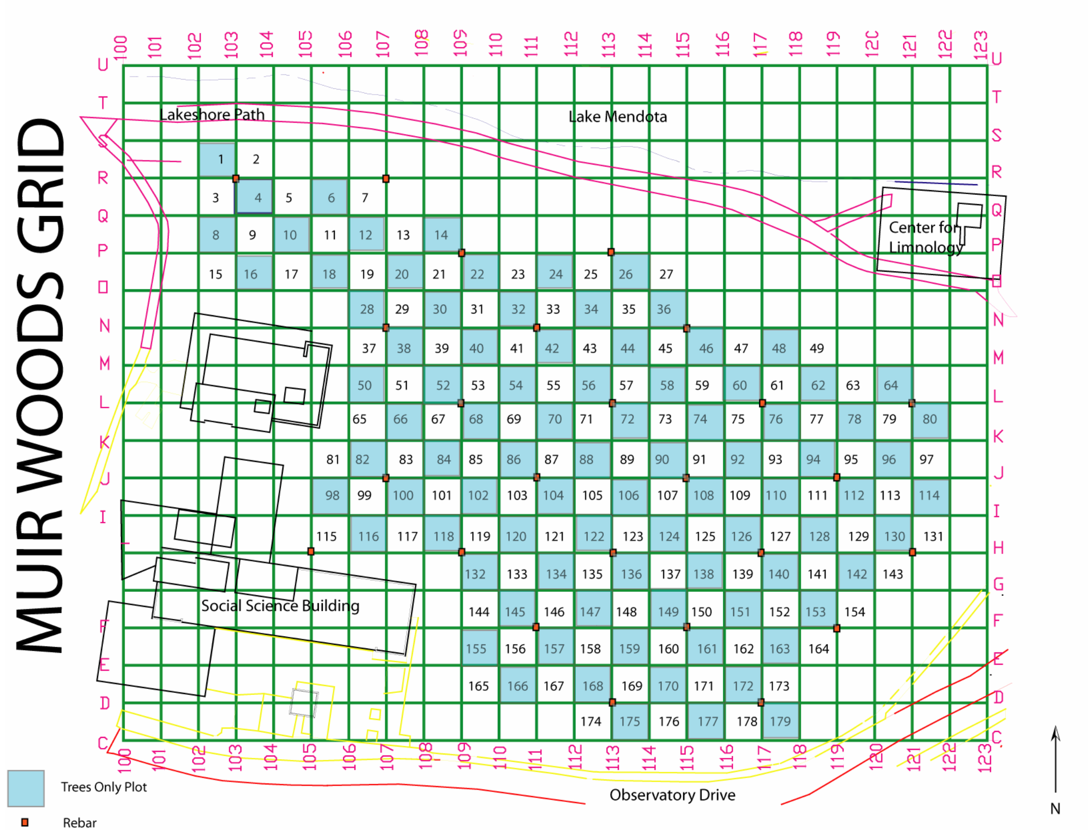
A vegetation inventory was completed in the summer of 2006. We used a set of nested quadrats to collect quantitative information on the canopy (10m x 10m quadrats), midstory (5m x 5m quadrats for shrubs and saplings), and understory (1m x 1m quadrats). The quadrats were part of a grid containing 179 10m x 10m cells.

In 91 of the plots (Figure 5) we collected the following information, using the protocol described in Appendix B:

- Species and diameter at breast height (dbh) of all trees
- Species and heights of tree saplings and seedlings
- Species and percent cover of shrubs
- Species and cover of understory herbs and vines
- Light levels
- Digital photograph

In addition, we made qualitative descriptions of each plot. In the remaining 88 plots, we inventoried trees with dbh >30cm only.

Figure 5. Sampling Grid in Muir Woods.



In all of the grid cells, using triangulation from known points, we recorded the locations of all trees with dbh >30cm, recorded their species, and marked each individual with a numbered metal tag. We then generated a map of the trees using a computer-aided design program, Autocad (manufacturer: Autodesk) (Figure 6). Using this program not only allows visual representation of the tree cover in the woods, its various layers allow a user to see where certain species are clumped or to see where the woods are the most diverse (Figure 7). As trees die or are removed, they can be put on a different layer in Autocad, creating a documentation of change in the canopy over time.

Figure 6. Tree Map showing ID Numbers and all Tree Species

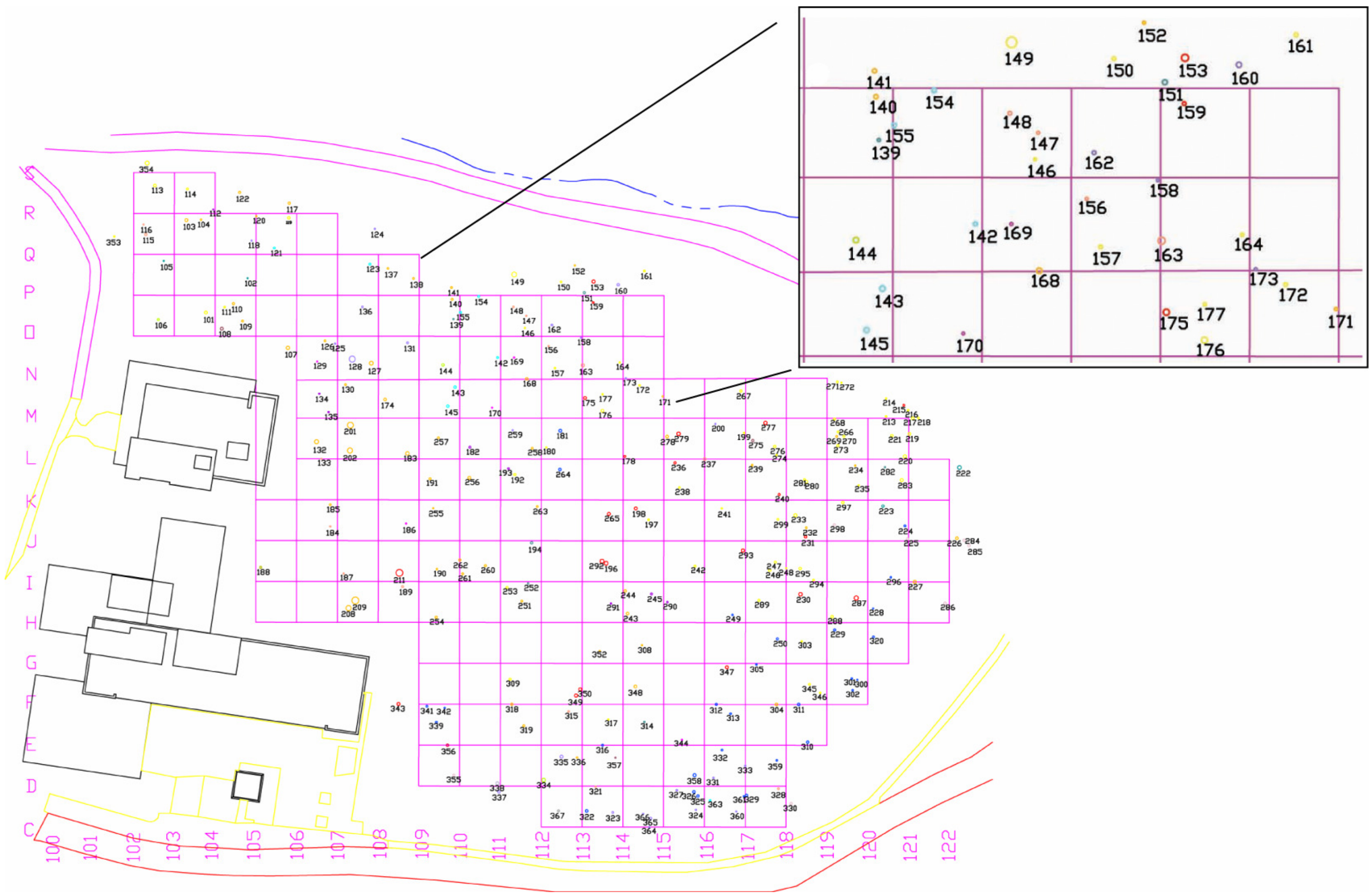


Figure 7. Tree Map showing locations and relative sizes of White Oaks (*Quercus alba*)

Determination of Physical Infrastructure Needs for Muir Woods and Lakeshore Path

Based on the observations made about the conditions of the physical infrastructure, it was clear that work to improve and repair this aspect of the woods was important. The trail system needed to be clarified and the selected trails enhanced through edging and resurfacing. Redundant and unnecessary trails would have to be decommissioned to prevent further use. Since many of the gullies present were formed prior to the re-routing of stormwater under Muir Woods, they will simply need to be stabilized and revegetated.

Signs were determined to be needed to provide way finding for those unfamiliar with the woods and benches should be added to provide more formal places of respite for users.

Other problems that were determined to need addressing included renegade art projects that were being installed either as part of art classes or independently without consultation with any Preserve staff. Trash buildup and the occasional person camping in the woods also needed to be considered.

Determination of Vegetation Restoration Needs for Muir Woods

By comparing information on the current condition of the vegetation of Muir Woods with the restoration goals and objectives, we can determine what, if any, actions need to be taken. The Draft Muir Woods Restoration Plan presents a list of 10 objectives (I refer to the plan as being a draft, because, as of this writing, it has not yet been officially adopted by the Lakeshore Preserve Committee. I went through each draft biological objective and analyzed the data that had been collected to determine if the objective had been met prior to the commencement of this restoration project.

In this section, I will first explain the rationale for and origin of each objective, and then present my evaluation as to whether or not it has been met. In most cases, the objectives are based on data summaries compiled by UW-Madison Botany Professor John Curtis and his students during an extensive inventory conducted in the 1940s and 1950s of high quality Wisconsin remnants (Curtis, 1959). The Curtis Team used quantitative sampling techniques to collect information on the presence and abundance of species in stands located throughout Wisconsin.

Objective 1. Overall number of native species is greater than 75 (At least 10 tree, 5 shrub, and 30 herb species).
Objective 2 Overall more than 80% of species present come from list of desired species (Appendix A).

Rationale for Objective 1

One of the classic measures of the structure and composition of plant communities is a list of the species present. Because communities are often also defined by the presence of particular life forms—for example, trees in a forest--it is also helpful to specify the expected number and composition of these.

I specified a minimum total number of 75 native species, because when this objective is met approximately half of the total species from the list will be present in Muir Woods.

Forests are often described as having at least three layers, each of which has one or more major life forms. These layers include the canopy, made up of trees; the midstory, made up of trees and shrubs; and the groundlayer, made up of largely of herbs (and also seedlings of trees and shrubs, as well as vines, ferns, and grasses.) I specified the minimum numbers of trees, shrubs and herbs using the list of desired species found in Appendix A. The overall species numbers on this list is 14 tree species, 13 shrub species, and 107 herbaceous species. I used these relative numbers to come up with a conservative minimum number (due to disturbed urban conditions of Muir Woods) of each forest layer that was desired. In retrospect, I should have been more methodical with my choices. The best method would have been to choose a percentage of the species from the total list of desired species since this list is based on Curtis's data that is specifically relevant to this community type (perhaps 50%, resulting in 7 tree species, 6 species of shrubs, and 53 herbaceous species needed).

This objective is meant to move the forest towards the overall diversity that was found in Curtis's statewide samples while still being realistic about what can be purchased commercially or transplanted locally.

Rationale for Objective 2

Curtis found 230 species in his samples of high quality Southern Wisconsin Mesic Forests (25 trees, 33 shrubs, and 172 herbs) and 275 in Southern Wisconsin Dry Forests (26 trees, 48 shrubs, and 201 herbs) (1959). Since not all of the species that Curtis found are appropriate for this part of the state, I decided to only use the data for the four sites studied by Curtis in Dane County that were dominated by sugar maple and basswood (they had a 1800 or higher on the Curtis Continuum Index).

I then calculated the average frequency of each species found on these four sites. I included those species having an average frequency of greater then four percent in the list of desired plants.

Evaluation: Objectives 1 and 2, Met or Not Met?

Neither one has been met

These two objectives are linked since they look at the overall number of species present in Muir Woods at the time of the vegetation inventory. Muir Woods had 71 species, of which 45 were native (Table 1 and see Appendix C for total species list).

Table 1. Number of species in Muir Woods in the summer of 2006.

Total Species in Muir Woods:	71
Total Native Species	45
Native Tree Species	15
Native Shrub Species	5
Native Herb Species	25
Total Species on the List	26
Percentage of Native Species on the List	57%

In terms of the objectives, 45 native species is too low, but the number of tree and shrub species both are satisfactory. Only 57% of the native species present in Muir Woods are the list of desired species. Planting of additional species from the list of desired species has already started as part of the restoration project.

Objective 3. Evidence of Natural Regeneration of at Least 5 Desired Native Woody Plant Species

Rationale for Objective 3

This objective was selected because one of the primary tasks of ecological restoration is to have a site that "may no longer require external assistance to ensure its future health and integrity," and in order for this to occur, desired species must be regenerating on their own (Society for Ecological Restoration International Science & Policy Working Group, 2004, pg. 3). We chose a target minimum of 5 because there were 12 woody species from the list found as part of the vegetation inventory and it seemed appropriate to have almost half of these already established species to be regenerating with the hope that newly added species will eventually become established enough to reproduce on their own.

Evaluation: Objective 3, Met or not Met?

Met

In Muir Woods, there are 8 tree species that are present in the seedling or sapling phase that are found on the list of desired species (Appendix A and Table 2).

Table 2. Seedling and Sapling Numbers of Desired Species in Muir Woods.

Celtis occidentalis	Common Hackberry	21
Tilia Americana	American Basswood	19
Acer saccharum	Sugar Maple	5
Ulmus sp.	Elm species	3
Fraxinus americana	White Ash	3
Prunus serotina	Black Cherry	2
Quercus rubra	Red Oak	1
Cornus alternifolia	Pagoda Dogwood	1

Saplings and seedlings of these species are all present in small numbers especially when compared to green ash (333 seedling/saplings) and box elder (257 seedling/saplings). This objective has been met, but increased regeneration of desired species should still be a focus of the restoration plans.

Objective 4. More than 60% of all trees (dbh greater than 30 Cm) in the forest are sugar maple (*Acer saccharum*), basswood (*Tilia americana*), and red oak (*Quercus rubra*).

Rationale for Objective 4

This objective was selected by using data from Curtis that showed that these three species would be expected to dominate a southern mesic/dry mesic forest in Dane County (1959). Both sugar maple and basswood have a Presence Value (the number of stands that contain a certain species as a percentage of the total number of the stands of a community type studied) of over 95 in mesic forests and Red Oak was shown to dominate southern dry mesic forests in Wisconsin (Curtis, 1959).

Evaluation: Objective 4, Met or Not Met?

Not Met

These tree species are present in Muir Woods, but, with a collective density of 34%, these species are not present in the numbers that are stated in the objective (Table 3).

Table 3. Trees in Muir Woods that are sugar maple, American basswood and red oak.

Acer saccharum	Sugar Maple	2
Tilia americana	American Basswood	66
Quercus rubra	Red Oak	25
	Total	93
	Total Trees in Muir Woods	268
	Percentage that are ACSA, TIAM, QURU	34%

The overall numbers of sugar maple and red oak in particular needs to be increased so that the composition of the canopy can, over time, change to meet the objective. (Currently the canopy is dominated by green ash, white oak, box elder, and basswood.)

Objective 5. Total density of at least 80 trees per acre. (Tree = 30cm dbh or greater)

Rationale for Objective 5

According to Curtis's research in Dane County, the southern mesic forests that were sampled had 80 trees per acre (1959). The southern dry mesic forests that were sampled (in Green County) had 86 trees per acre (1959). The objective was generated from these findings.

Evaluation: Objective 5, Met or Not Met?

Not met

The area of Muir Woods was that was within the grid was 4.42 acres. There were 237 trees measured resulted in 57 trees per acre. Additional planting will be necessary to meet the objective.

Objective 6: Desired species cover 75% of the ground layer in early summer

Rationale for Objective 6

This objective is based on data collected from a study conducted by the Minnesota Department of Natural Resources, which surveyed southern forests. The data showed a ground layer cover of between 50 -100% in mesic and dry mesic plots (Minnesota Department of Natural Resources, 2007). The cover value of 75% was selected since this value would allow for the bare areas that will be required to have trails and seating areas while still having a dense groundcover layer that can serve as a barrier to invasive species establishment.

Evaluation: Objective 6, Met or Not Met?

Not Met

The average percent cover of herbaceous plants (vines included in this study) is 50.30%, much lower than the desired objective. This includes all species, including non-natives and native species that are not typically found in mesic/dry mesic forests.

Objective 7: Percentage of species found in each photosynthetic guild is within 1 standard deviation of average proportion of a typical* mesic/dry-mesic forest.

Rationale for Objective 7

This objective was generated from Brian Bader's thesis about the distribution of forest herb photosynthetic guilds in Wisconsin Forests (Bader, 1995). Bader's analysis, in turn, was based on the data collected by Curtis. Photosynthetic guilds classify herbaceous species on the basis of their phenology. The criteria include such things as the seasonal timing of leaf and stem emergence, active growth and senescence; flowering and fruiting times; and the dates of seed set. Guilds are a useful consideration because they provide models to determine the proportion of species types to use when creating species lists for restoration projects.

I took the percentages that Bader generated through his research and determined that Muir Woods should resemble (within one standard deviation) the "typical" southern mesic/dry mesic forest.

Table 4. Guild information for "Typical" Southern WI forest communities vs. Muir Woods

	Spring Ephemeral	Early Summer	Late Summer	Shrub/Vine	Winter Annual	Winter-green	Di-morphic	Myco-trophic	Ever-green
Mesic	5%	54%	21%	13%	2%	0%	1%	1%	3%
Standard Deviation	*5%*	*11%*	*8%*	*6%*	*2%*	*1%*	*1%*	*1%*	*3%*
Dry-Mesic	1%	44%	31%	20%	1%	0%	1%	0%	3%
Standard Deviation	*2%*	*6%*	*6%*	*5%*	*1%*	*0%*	*1%*	*1%*	*3%*
Average Proportion	3%	49%	26%	17%	2%	0%	1%	1%	3%
Avg. Standard Deviation	4%	9%	7%	6%	2%	1%	1%	1%	3%
Muir Woods (natives)	**7%**	**48%**	**17%**	**24%**	**0%**	**0%**	**3%**	**0%**	**0%**
Acceptable Low	0%	41%	19%	11%	0%	0%	0%	0%	0%
Acceptable High	7%	58%	33%	22%	3%	1%	2%	2%	6%
Muir Woods in Range?	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes
			Low	High			High		

Information from: (Bader, 1995)

Evaluation: Objective 7, Met or Not Met?

Partially Met

Overall, the following guilds are present in the desired percentage: spring ephemerals, early summer, winter annuals, wintergreens, mycotrophic and evergreen species. The latter four guilds do and should make up a very small portion of the total species found in the woods. Of greatest concern for the restoration of Muir Woods is the low number of late summer species and the high percentage of shrub/vine species in comparison to what should be present in a typical dry-mesic/mesic forest.

Restoration efforts should concentrate on adding late summer species and possibly reducing the numbers of some shrubs and vines (See also Objective # 1).

Objective 8: Overall Canopy Cover Between 75-85%.

Rationale for Objective 8

This objective came from the Minnesota DNR study which found that both mesic and dry forests have a canopy cover between 50-100% (interrupted to continuous) (Minnesota Department of Natural Resources, 2007). Muir Woods should have a canopy cover that falls right in the middle of this range because any sparser would put it at too great a risk for further invasion by sun loving invasive species and denser would make it less hospitable to the late summer guild of herbaceous plants.

Evaluation: Objective 8, Met or Not Met?

Not Met

None of the vegetation studies that have been completed in Muir Woods to date measure canopy cover directly. Instead, a measurement of photosynthetically active radiation (PAR) was taken in each intensively surveyed plot. This method measures if there is adequate light in the spectral that is useful for terrestrial plants (400 to 700 nm). It is basically a measurement of how much of the visible light is useful. This reading cannot be translated directly into canopy cover, but can be used to calculate the percentage of available light that is being intercepted by plants at 2m and lower in Muir Woods. In Muir Woods, 28.8% of available light is being intercepted by plants which means that roughly 61.2% of the light is being blocked by the canopy (David Bart, Personal Communication, 7/5/07). In other words, canopy cover is approximately 62%. This means that the canopy objective had not been met at the start of the project.

Objective 9: Less Than 10% of Cover Is Classified As That of Non-native Invasive Species.

Rationale for Objective 9

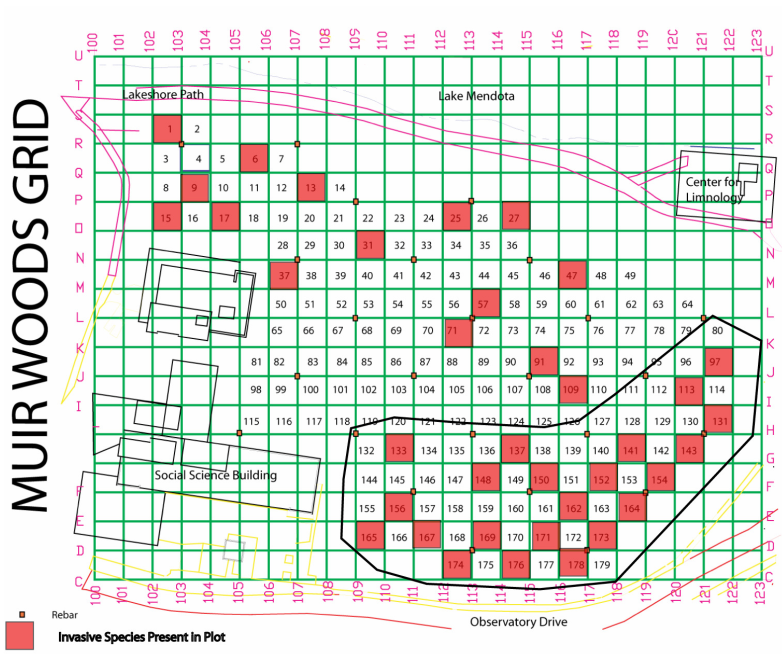
It is clear that exotic invasive species is not a major component of the ecosystem model upon which the restoration goals and objectives were based. The native remnant stands studied by Curtis (1959) had few, if any, exotic species present at the time of his surveys conducted in the late 1940's and early 1950's. Based on these data, a target of less than 5% cover would be justified. However, in an urban landscape in which Muir Woods is located, suffers from a heavy invasion pressure due to seed sources brought in by Preserve users from nearby plantings, furthermore these sites tend to be heavily disturbed and highly fragmented which also increase the likelihood of invasion. It is not realistic to eradicate invasive species, but having a cover of 10% or less should not affect the overall structure and function of the forest.

Evaluation: Objective 9, Met or Not Met?

Not Determined

This objective cannot be evaluated quantitatively using any of the data that was collected prior to commencing this restoration project. We did not measure percent cover of invasive species as a separate category and only obtained percent cover data for herbaceous species (from which invasive species was excluded) and for shrub species that fell in the midstory of the woods. It is unlikely that 10% of less than the overall cover is invasive species. The data that was collected about invasive species demonstrates that they are concentrated around the edges of the woods (Figure 8).

Figure 8. Plots that contain invasive plant species.



Objective 10: Less Than 10% Cover of each of the Following Opportunistic Natives: Box Elder (*Acer negundo*), Virginia Creeper (*Parthenocissus cinquefolia*), and Chokecherry (*Prunus virginiana*).

Rationale for Objective 10

There is a threat of having the woods dominated by species that are native, but whose presence has increased due to their hardiness and tolerance of the types of disturbance that have occurred in Muir Woods. These species need to be watched due to their frequent dominance in heavily disturbed settings (Uva, et al, 1997). These species do have a presence in either dry mesic or mesic forests in Wisconsin, but they are minor, rather than dominant, species. These species should be controlled in Muir Woods to allow the opportunity for other native species to become established. Their overall frequency and density should match less disturbed sites. 10% cover of each was selected to match imprecise observations of other communities in this part of the state pared with a sense of pragmatism about the conditions of this site.

Evaluation: Objective 10, Met or Not Met?

Probably not met

Once again, our inventory methodology did not give us data that can be directly translated into whether or not this objective was met at the start of the project. The survey did show that Virginia creeper had an average cover of 24.86%, far exceeding the desired cover for this species. No percent cover was collected for box elder, but it did have an importance value of .16 once its dbh reaches 30cm and .39 for all seedlings and saplings. These high numbers relative to Curtis demonstrate its impact on the woods. Choke cherry was a species that had a lot of confusion associated with it during the inventory – it was classified as both a tree and a shrub so that the data is unclear. However, in the 57 plots where the shrub intercept method was used, there was 6.12% cover from individuals that fell in the midstory. This excluded 13 choke cherry that were counted as trees, 138 that were counted as seedlings, and 50 classified as shrubs that were shorter than .5m or taller than 1.25m, leading the inference that there is more than 10% cover of this species.

Overall Assessment of Initial Condition of Muir Woods Vegetation

In summary, 8 of the 10 biological objectives were either not met or could not be assesses with the data at hand at the start of this project. Of the remaining 2 objectives, only the one pertaining to natural regeneration was met completely. The objectives about guilds and about the total number of invasive species were partially met. Having this knowledge greatly affected the restoration activities that have been undertaken thus far.

Apart from using the data from the vegetation inventory to evaluate the biological objectives, it is also useful to use it to look at the trajectory of the forest. The trees (dbh greater than 30cm) with the highest Importance Values (IV) were green ash (*Fraxinus pennsylvanica*), white oak (*Quercus alba*), and box elder (*Acer negundo*) (Figure 9). In contrast, the trees with the highest Importance Values in good quality mesic or dry mesic southern Wisconsin forests are sugar maple (*Acer saccharum*), basswood (*Tilia americana*), and in fewer numbers, red oak (*Quercus borealis*). Basswood does have a relatively high IV in Muir Woods (8.6), but the IVs of red oak and sugar maple are quite low (2.6 and 1.7, respectively).

The IVs of the seedlings and saplings (Figure 10) follows the same pattern as as the trees, with the biggest difference being that the oaks (white, red, and bur) that are found in the tree layer are absent from the seedling and sapling layer with the exception of the presence of one red oak. This would indicate that the desired tree species (sugar maple and red oak for example) are not present in abundance on site, and will have to be planted.

The hope for this forest is that red oak and sugar maple would be reproducing on its own. However, as the amount of light at the ground layer increases, as restoration proceeds, the likelihood of red oaks germinating and surviving are low. Since it is desired that red oak is present in the woods, it will be important to plant it in areas that are open either due to edge or tree falls. In contrast, sugar maple should be able to reproduce on its own in low light. The issue at present seems to be a lack of seed source.

The top three species that are reproducing in the woods are box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), and hackberry (*Celtis occidentalis*), all species that are typically found in southern wet or southern wet mesic forests in Wisconsin (Curtis, 1971). This indicates the high level of disturbance that is found in Muir Woods. Species found in wetter habitats can handle low oxygenated soils (since there is periodic flooding) which are also found in urban soils as a result of erosion and compaction.

Figure 9. Importance Values of Trees in Muir Woods.

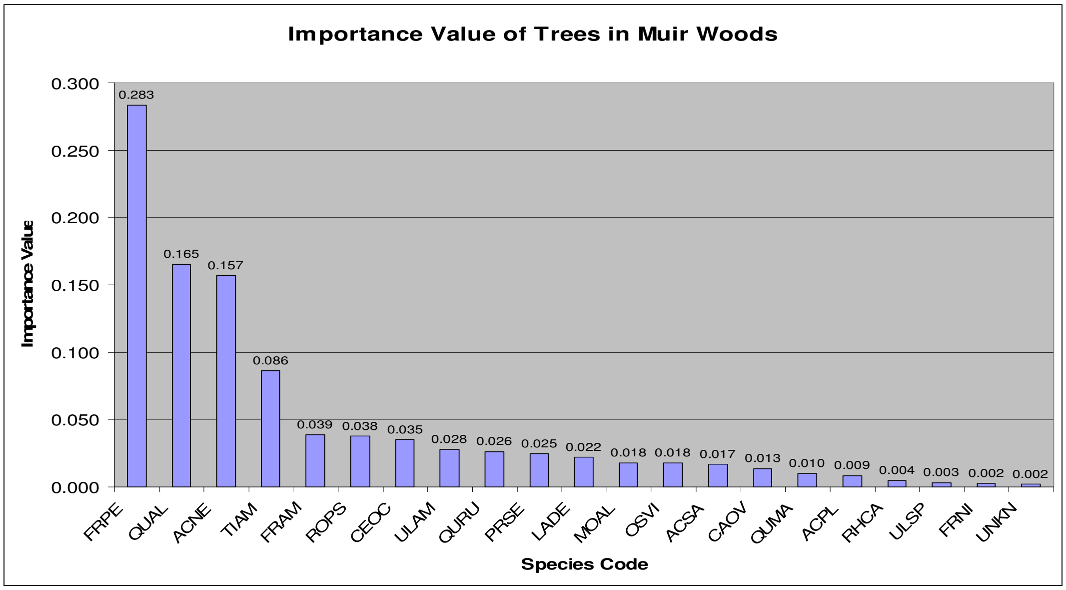
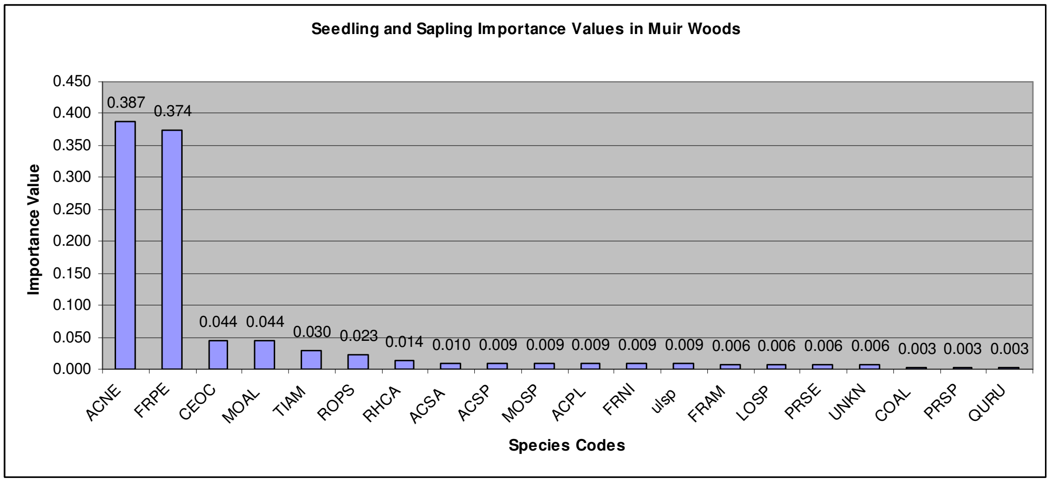


Figure 10. Importance Value of Seedlings and Saplings in Muir Woods.



ACSA	*Acer saccharum*	Sugar Maple
CAOV	*Carya ovata*	Shagbark Hickory
CEOC	*Celtis occidentalis*	Common Hackberry
COAL	*Cornus alternifolia*	Pagoda Dogwood
FRAM	*Fraxinus americana*	White Ash
OSVI	*Ostrya virginiana*	American Hophornbeam
PRSE	*Prunus serotina*	Black Cherry
QUAL	*Quercus alba*	White Oak
QURU	*Quercus rubra*	Red Oak
TIAM	*Tilia americana*	American Basswood
ULAM	*Ulmus americana*	American elm
ACNE	*Acer negundo*	Box elder
ACSA	*Acer saccharinum*	Silver Maple
FRNI	*Fraxinus nigra*	Black Ash
FRPE	*Fraxinus pennslyvanica*	Green Ash
QUMA	*Quercus macrocarpa*	Bur Oak
ACGI	*Acer ginnala*	Amur Maple
ACPL	*Acer platanoides*	Norway Maple
AESP	*Aesculus* sp.	Buckeye sp.
LADE	*Larix decidua*	Eurpean Larch
LITU	*Liriodendron tulip*	Tulip Tree
MOAL	*Morus alba*	White Mulberry
PRSP	*Prunus sp.*	Ornamental Cherry Species
ROPS	*Robinia psuedoacacia*	Black Locust

While there is a tremendous additional amount of information that can be mined from the data collected through the vegetation inventory, what was analyzed suggested that this forest should be maintained as a dry mesic to southern mesic forest as defined by Curtis (see ecosystem model in the Restoration Plan). However, this does not mean that the entire woods is uniform or should be managed in the same way.

Chapter 3. Implementation Protocols for Lakeshore Preserve with Examples from the Restorations of Muir Woods and Lakeshore Path

Introduction

The long term protection and stability of preserved areas can often hinge on the production and follow through of a plan. The planning process is often critical to the obtainment of goals. If there is no plan, preservation, development, and use- activities will occur haphazardly, often in response to political pressure with little consideration to the implications for the future. The result is likely to be “lost opportunities and irreversible damage to resources and values” (Young & Young B., 1993, p.12). A plan should help provide a continuity of management, help to “identify and define management effectiveness” over time, and provide a long term vision for the East Preserve to help guide the day to day restoration and management (Thomas & Middleton, 2003, p.2).

The hope is that this document will provide a way for future managers to easily continue the restoration so that its goals will be met and the site can therefore transition to the long-term management stage (where work can be carried out by either students or Preserve staff). This implementation plan should be considered a living document that is changed as more is learned about restoration, this site in particular, and in response to changes in the surrounding environment.

As has been previously stated, the overall Preserve Master Plan and the site-specific restoration plans are blue prints that will provide guidance for how to restore and manage the

Preserve. In order for the East Preserve project to have any chance of successfully being carried on by subsequent managers, there needs to be some implementation protocols and careful documentation addressing what we have done and why. This chapter presents protocols for the types of restoration tools and activities required for a successful restoration project, using the requirements of the Muir Woods and East Lakeshore Path restorations as examples. At the start of this project the areas had the following issues: fewer than desired native species, greater than desired exotic invasive species, the presence of erosion gullies, too many trails, and a general feeling of neglect, as evidenced by poorly surfaced and edged trails, and trash scattered on the ground. Based on these requirements of the East Preserve, the following protocols are included:

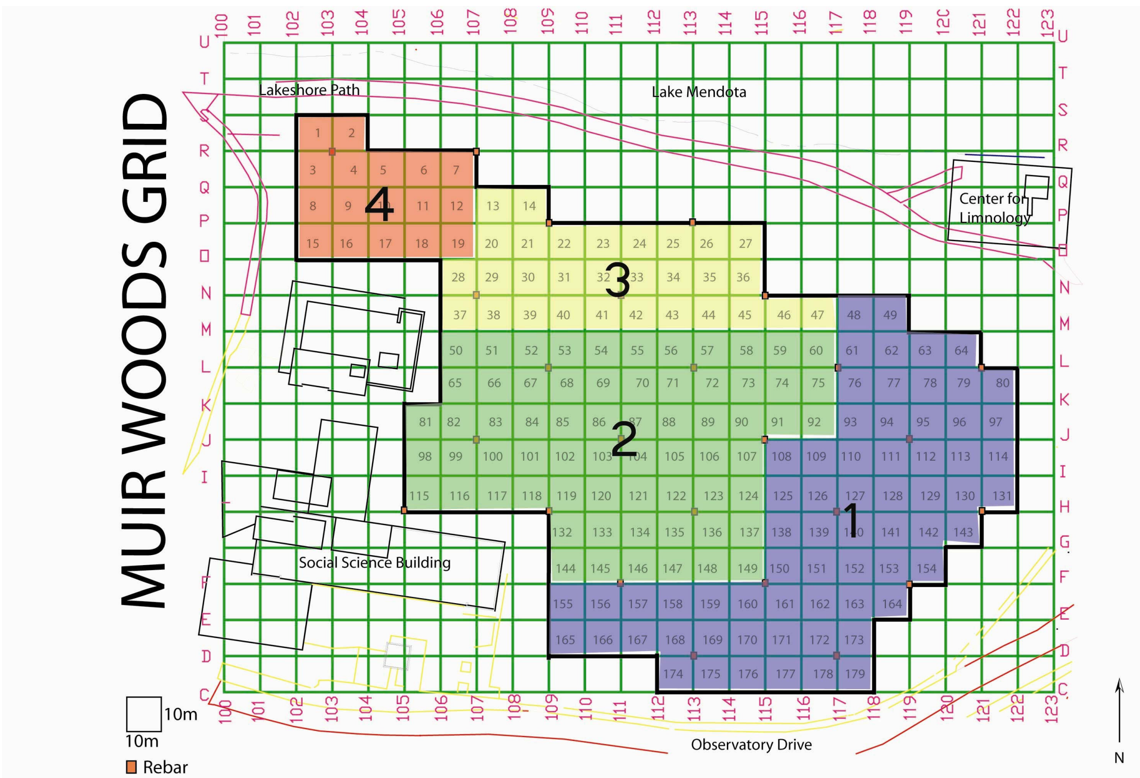
- Creating Restoration Units
- Establishing a Reference Grid
- Trail Establishment and Management
- Hillside and Lakeshore Stabilization
- Signage
- Fencing
- Seating
- Control of Invasive Exotic and Opportunistic Native Plants
- Planting Techniques
- Establishing and Maintaining Human Infrastructure

This chapter lays out the "how" of the restoration of the East Preserve and should serve as a tool for both maintaining the current projects as well as expanding the restoration over time.

Establishment of Management Units

It is often helpful to divide a site into units that are relatively homogeneous with regard to use history and current vegetation structure and composition.. In this way, restoration activities can be tailored to fit the conditions of each unit. I used the patterns of distribution of trees and the presence and extent of exotics and opportunistic natives to create four restoration units within Muir Woods (See Appendix C for the data analysis and Figure 11).

Figure 11. Muir Woods Management Units



All of the units should be restored to southern mesic/dry mesic forest with plants selected from the lists found in Appendix A. In all of the stands, units, the Importance Value (IV) of box elder (*Acer negundo*), and green ash (*Fraxinus pennsylvanica*) are too high for the target community. Both are urban tolerant species that can handle soil compaction, drought, and a variety of pollutants so it follows that they are reproducing so readily in Muir Woods. The process of reaching the target community is going to be different in these four different areas based on their current conditions.

Description of the Vegetation in Unit 1

This vegetation in Unit 1has the most evidence of management of all 4 and yet has the least native canopy cover. The black locust (*Robinia psuedoacacia*) that was planted in Muir Woods for erosion control is almost all located within this unit. Sixteen of the 22 black locusts in the eastern part of Muir Woods are here, with an average diameter at breast height (dbh) of 43.73 cm. However, there are only 4 black locust saplings present. This may be due to removals as part of a prior invasive removal project, or this species may not be invading this forest. Other planted species that are only found in this area are mock orange (*Philadelphus sp.*), European larches (*Larix decidua*), and a species of ornamental cherry (*Prunus sp.*). The sapling layer is dominated by box elder (28% of the total saplings) and green ash (55% of the total saplings). The shrub layer is heavily dominated with choke cherry. There were 24 herbaceous species found, with Virginia creeper having the highest importance value by far.

In spite of past control efforts, this unit is still invaded by a variety of exotic species. There is a population of exotic white mulberry along the southern and eastern edges and a very large Norway maple (*Acer platanoides*) in Plot 165. There is a dense stand of common buckthorn in Plots 155, 165, 166, and 167 (the southwest corner of the unit).

The area directly south of Observatory Drive (most of is outside the grid) is more open and has been planted prior to beginning of this project with native species that need high levels of sunlight to survive (the planting was developed as part of a course in

Landscape Architecture, but the planting list is not available), however it has been heavily infested with weeds including motherwort (*Leonurus cardiaca*), catchweed (*Galium aparine*) and Canada thistle (*Cirsium arvense*).

Description of the Vegetation in Unit 2

Unit 2 has the highest density of chokecherry (*Prunus virginiana*) and highest importance value for white oak (*Quercus alba*) of any of the other units. The white oaks are forest grown, not open grown. The sapling layer is made up almost entirely of box elder and green ash. This is the only stand that has black cherry (*Prunus serotina*) saplings present, even though all but one of the 6 black cherry trees in the woods are located in Unit 1.

Except for an invasion of honeysuckle (*Lonicera sp.*) and white mulberry (*Morus alba*) along the edge of the Social Science Building (outside of the grid), and small patches of garlic mustard (*Allaria petiolata*) in the interior of the unit, invasion by exotic species is not a major threat.

The understory is fairly diverse with 19 species. It is dominated by Virginia creeper, which has an importance value of 0.38. The second most important herb is Jack-in the Pulpit (*Arisaema atrorubens*) with an importance value of 0 .16.

The shrub layer is dominated by chokecherry, but there are 34 elderberries (*Sambucus sp.*) found in this unit and only 2 buckthorn shrubs. This is the only unit that has gooseberry species (*Ribes sp.*) found within it (6 individuals).

Description of the Vegetation in Unit 3

Our data shows that this site is does not have nearly the presence of Virginia creeper as the other units, however this is likely due to the fact that these plots were sampled in mid-

May when the spring ephemerals like cut-leaf toothwort (*Dentaria lacinata* were present and before Virginia creeper was fully expanded. Based on observations later in the summer, Virginia creeper is not as common in this part of the woods as in Units 1 and 2, but when this area is re-inventoried as part of the monitoring of this woods, surveying should occur later in the summer and these values recalculated. Shrubs and trees found in this unit are fairly typical for Muir Woods with green ash, basswood and box elder having the highest Importance Values for trees and the greatest density in seedlings and saplings. No data about shrub density or cover can be calculated due to chokecherry having been counted as both a tree and a shrub for the plots within this unit.

Description of the Vegetation in Unit 4

Unit 4 is distinct because it the only part of the woods that is adjacent to the heavily invaded corridor leading down from Charter Street as well as the western part of Muir Woods. It is also bordered by an area that is still experiencing heavy stormwater flows on a regular basis (Figure 3), which is a likely dispersal agent for weedy and invasive plant seeds. This area is currently heavily invaded by honeysuckle (*Lonicera sp.*), with multiple large individuals present in the stand. It is also the only unit where box elder is the most dominant tree. Even with its surrounding conditions, it does have a diverse herbaceous palate, with multiple native wildflowers (cutleaf toothwort, Virginia waterleaf (*Hydrophyllum virginianum),* early meadow rue (*Thalictrum dioicum*) and false solomon's seal (*Smilacina racemosa*) having high Importance Values in this area.

Recommendations for the Restoration of the Four Muir Woods

Unit 1

Unit 1 will require a number of steps in order to reach the desired restoration goals and objectives. This area has the highest concentration of black locusts in the woods. They are in decline (2 large ones have fallen in the last year) and are barely regenerating. They should not be removed due to the amount of sunlight that this would create, a situation that could result in a heavy growth of undesirable species (In areas where black locusts have fallen, we are observing more Virginia creeper (*Parthenocissus quinquefolia*) and motherwort rather than a diversity of native mesic species volunteering in.). However, as they fall they should be replaced with appropriate mesic tree species. Even though the large Norway maple is not seeding very much, this tree should be removed due to the threat that this species holds for the Preserve. Norway maples are heavily invading the areas around Bill's Woods and should therefore not be allowed to remain. This large tree should be cut, and the area opened up by its removal should be planted densely with native trees, shrubs, and herbs which should be maintained carefully (weeded and watered until establishment).

The open area directly north of Observatory Drive is being overtaken by weeds and should be planted with species more appropriate for a mesic or dry mesic forest (See Appendix A). Woody plants should be added to increase the shade in this area which should prevent many of the weeds from persisting on the site.

All of the area of Unit 1 that borders lawn should be replanted. These borders are the last remaining patches of invasive species in the eastern portion of Muir Woods, most notably in Plots 155, 165, 166, and 167 where buckthorn has been allowed to remain until plants have been purchased for this site. The fear is that opening this up without planting heavily will invite people to enter the woods from the Social Science Building and create a web of trails in an area that should be trail free. These areas should be planted with a higher emphasis on shrubs than would be found in other areas of Muir Woods to provide an effective barrier initially. They can eventually be thinned to create a more open view into the woods.

This unit includes an area that is designated as a bench site by the master plan. If benches are going to be installed in Muir Woods (there are none there now), criteria for selecting their location and strict design criteria are needed as part of the implementation plan.

Unit 1 includes a large portion of the stairs that take users between Lakeshore Path and Muir Knoll. These stairs are eroding away under the forces of the water that come off of the Knoll. There are long term plans to remove these stairs and replace them as part of project to enhance Muir Knoll, but this will not happen for many years (Cathie Bruner, personal communication, 6/05/07). Until then, the stairs need to be maintained after large storm events (gravel added, large holes filled with quickcrete etc.) and stop-gap measures of building water bars off of the edges of the current steps should be undertaken.

Unit 2

In order for this unit to meet the goals and objectives for Muir Woods, chokecherry, box elder, and Virginia creeper are going to have to be controlled so that their dominance and frequency decreases. Future managers will have to keep a handle on the invasive exotic species that have been found in Plots 115, 98, 81, 65, and 50. Compaction should be minimized through careful trail maintenance. Spot plantings can be added after disturbance events and in areas that are cleared of exotic invasives and opportunistic native plants. Erosion is not a problem in this area since it is fairly flat. Even the major flow line that goes through this unit has recovered its vegetation.

Unit 2 has one of the designated seating areas within it. Currently this is just a large area of compacted soil and a large rock that people sit on. This area needs to be maintained so that it does not get any larger and the soil further compacted. A rustic bench or downed log should be placed here and the area covered with mulch.

Unit 3

Much of the vegetation management for Unit 3 can be similar to what is recommended for Unit 2 with the exception of the steep slope that runs from Lakeshore Path up to the lower trail in Muir Woods. This area has experienced a high level of erosion that is resulting in patches of bare soil and gullies of difference severities. The erosion comes from two sources: surface runoff from the upland and heavily compacted soil due to heavy human use. Both of these factors need to be taken into account when designing restoration projects. Plants that have traits that aid in hillside stabilization should be planted here (deep rooted, can handle low oxygen content in the soil etc.). Also since this area is a transition between the woods and Lakeshore Path, there should be an overlap of species between the two – species like wild columbine (*Aqueligia canadensis*), woodland sunflower (*Helianthus divaricatus*), big leaf aster (*Aster macrophyllus*), elm leaf goldenrod (*Solidago ulmifolia*), and American hazelnut (*Corylus americana*) should be planted in the sunnier spots of this unit, since these species will also be found in the restored areas of Lakeshore Path.

Strategies for reducing soil compaction and for restoring areas affected by stormwater are necessary for meeting the objectives of having no gullies deeper than 6" and infiltrating stormwater before it reaches the lake. Trail management has been and will continue to be a major focus of the management of this unit.

Unit 4

Unit 4 will need to be cleared of invasive species if the woods is expected to obtain the goal of having less than 10% cover of invasive exotic species. This work should be done in the late fall or winter as not to disturb the diverse herbaceous layer that exists in this site. This site will need additional plants to prevent re-invasion of exotic species or high levels of colonization by plants that are just meant to be small component of a mesic/dry mesic forest (chokecherry, box elder and Virginia creeper). The unit has no trails running through it and no seating areas. This site is adjacent to a paved path that is currently a non-porous channel for stormwater in heavy rain events. A culvert has been added and modified (last enlarged in the summer of 2005) and the curb on the path built up to prevent water from entering the woods. Currently, neither of these alterations is successfully protecting this part of the woods from the effects of the water. This area may need some water bars and other such structures to help mitigate the effects.

Establishment of a Reference Grid in Muir Woods

As stated above, many parts of the Preserve, and Muir Woods in particular, were originally preserved as a laboratory which means that our goal is to make the conducting of ecological experiments and monitoring as seamless as possible and to integrate these types of activities into the overall management regime of the woodlands. All of these facts made it clear that a system that permanently marks points in the restoration sites would be critical to providing a way for future managers and student scientists to track work already completed, understand changes in the woods that were impacted by management, and conduct and track experiments over time.

It seemed that the best way to achieve this was to set up a permanent grid in Muir Woods, similar to the one set up in Noe Woods in the UW-Madison Arboretum (McCune & Cottam, 1985). A grid marked at regular intervals with the points permanently marked would allow managers and researchers the ability to describe their work spatially in a way that was previously impossible.

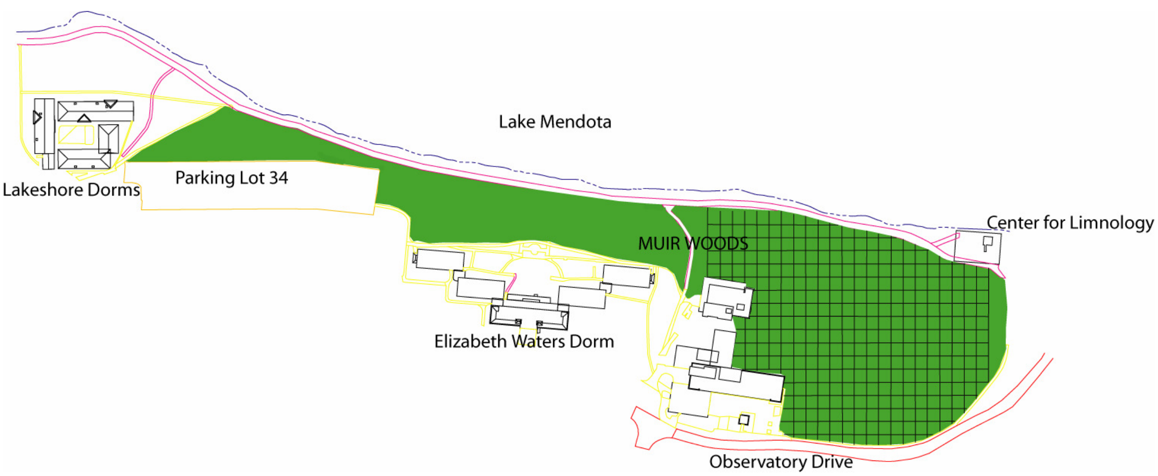
A 10m x 10m grid was selected as appropriate for the inventory and long term tracking of this project. Grid squares of this size can be combined into larger blocks if needed, but are small enough that small scale experiments can be conducted easily and the points are easy to find in reference to one another.

While there are many methods for installing a permanent grid within a wooded area, we chose to use land surveying techniques, since they provide a high level of accuracy and are one of the fastest and easiest methods for placing a grid of this size. We used a total station, an optical device that can be used to measure distance and angles, to locate the points that been generated based on control points (points that have known ground locations that can be accurately located). A geographic positioning system (GPS) was used only to determine locations of control points placed along the sidewalk since in the rest of the woods the dense tree cover would cause too much interference in receiving an accurate satellite signal (Figure 12).

Figure 12. Map of Initial Seven Control Point Loop in Muir Woods.

The grid was set up in the eastern portion of Muir Woods and goes from the road to the crest of the slope that leads to Lakeshore Path (Figure 13). The steep hill portion of the woods was excluded as well as the area of the woods behind the Elizabeth Waters dormitory and Parking Lot 34. The idea was for this portion of the woods (17,900 square meters/4.42 acres) to serve as a test area for the process of grid installation and for the usefulness of this endeavor. The goal is that the grid will be expanded as the restoration project begins to tackle other areas.

Figure 13. Grid Location within Muir Woods as of 2007 (Campus Autocad map modified by Rebecca Kagle).



Initially, four control points (CPs) were set on the north sidewalk of Observatory Drive and three more within the woods using GPS surveying equipment (Figure 13). These were selected so that they were all possible to be viewed from multiple points, could be tied into a permanent control point on Bascom Hill and that at least a few could be checked through the use of GPS.

Later, four more control points (CP8-CP11) were set using a total station to survey a traverse loop starting at CP8 and closing the loop at CP7. These CPs were further north into the woods towards the lake, but south of the Lakeshore Path. From these eleven control points (CP1-CP11) all grid line intersection points were calculated in terms of distance and angle of rotation from each of the control points. This allowed us to set up the total station on any control point and locate and mark ("shoot") as many points as were visible from that point. As many intersections as possible were shot when set up on established control points to optimize accuracy. When physical terrain, distances or objects prevented shooting intersection points, the total station was set up on a point that had already been marked and then the remaining intersection points were shot. These intersection points were always in a cardinal direction (North, South, East, or West) for angle of rotation and were multiples of 10 meters away depending on how many rows or columns they were from the point the total station is occupying.

The grid system consisted of numbered vertical columns running nearly north-south, spaced 10 meters apart, and lettered horizontal rows running nearly east-west also spaced 10 m apart, thereby marking each point on the 10mX10m grid (Figure 14). Each point became part of multiple grid squares, which were numbered sequentially from 1 – 179. The boundaries of the grid were the edge of the woods to the east, west and south and the steep ridge leading down to Lakeshore Path to the north (Figure 13).

When an intersection point was initially shot it was marked with a blue or yellow pin flag with the location coordinates written on it (for example D-18, the number in the one hundreds digit was dropped as is the standard in surveying). Later, when a number of points were shot, pipes and rebar were set (Figure 14). The flags were left in place after the pipes and rebar were set to expedite the location process in the future.

Figure 14. Intersection Points and Numbered Grids

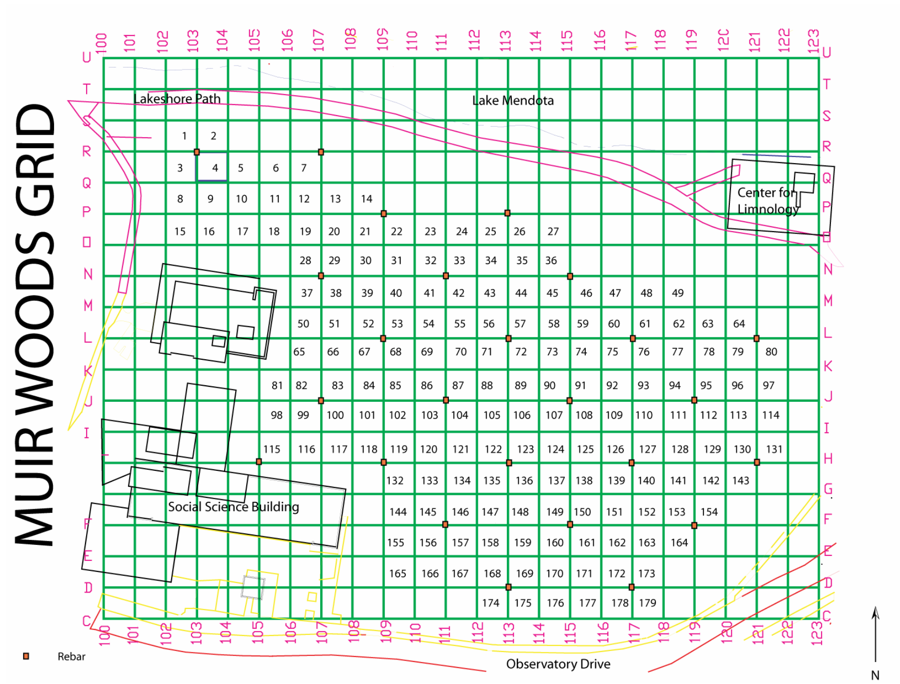


Figure 15. Rebar and Pipe in Muir Woods (photos by Rebecca Kagle).

Initially, 24 inch x 1inch diameter galvanized pipes were set at every grid intersection point except where 0.5 x 24 inch rebar pieces were set. Later, 24-inch pieces of galvanized pipe were replaced by 18 inch pieces as this length was deemed deep enough to ensure the pieces would not heave or be easily removed and required less labor to install. All pipes were threaded at one end and were capped with a 1-inch metal plumbing cap, also galvanized to prevent rust. Each cap had its pipe's grid location stamped onto it (example; K09 for K 109, L21 for L 121). Stamping the pipe caps was done using a stamp kit and sledge hammer and done prior to fixing the cap to the pipe. The pipe tops were left 2 inches out of the ground to aid in finding them again. They were only hammered flush if they were located directly on a trail where they could present a tripping hazard.

Rebar pieces were set every fourth column, and every fourth row, in a staggered, or offset, manner (Figure 14). They were installed only at 24 of the intersection points so that they could provide an easy way of finding some of the points without providing too much of a visual distraction to the average user of the woods. The rebar had a hole drilled 3/8" from the top the a tag was laced through. This was labeled with its grid location. The rebar was left 6 inches out of the ground and were spray painted a florescent orange color to facilitate locating them in the future.

Installation of the grid took approximately 90 hours. The total cost of both labor and materials was over $1500.00.

Current Uses

The grid installation was completed in early May of 2006. It was immediately put into use. Thus far, it has been used extensively. Example projects that have utilized the permanent grid:

- The vegetation inventory that was conducted in the summer of 2006,
- Spring ephemeral survey
- Planting density study conducted by the Muir Woods staff
- Footbridge area restoration project (to calculate area and evaluate current vegetation)
- Garlic mustard mapping

While the grid is a great resource, work in the field needs to reference it in order for it to be useful. Every project that starts in Muir Woods should be described in terms of the grid and even projects that exist outside of the grid (for example the lower slope) can reference the nearest points.

Potential Uses

The grid should be kept up (missing points replaced etc.) for future use. The hope is that more student researchers and professors will want to set up and monitor projects using the grid. Also, as more restoration work gets completed, the grid should be used in note taking to describe where actions were taken and plants installed.

Recommendations for Grid Installation in other sites of the Preserve

- The Department of Biological Systems Engineering purchased a survey quality total station in the summer of 2007. This will be a good tool for setting the control points now that Dan Rodman can no longer provide support.

- Many engineering students do surveying as part of their summer jobs. Post job the job opportunity in these departments.

- Install rebar at every other point rather than at every fourth point so that they can serve their purpose and aid users in finding the grid squares.

- The rebar and pipe can be fabricated by the UW FPM Machine Shop. The cost of labor is $60 per hour.

- If erosion is a concern in the area, make sure that caps are at least 1" off the current ground level or they will be buried fairly rapidly and a metal detector will be needed to locate them again.

- Small plastic caps should be put on the top of the rebar to prevent injury to Preserve users and workers.

Important Pointers for Grid Installation

- Survey as much as possible when leaves are not present on trees as sight lines are maximum at this time

- Maximize using control points to set up on to shoot points, minimize using set pipes to set up on to shoot points

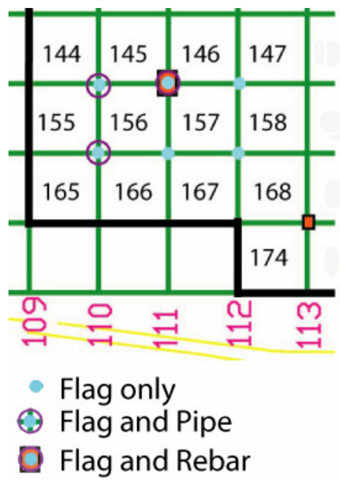
- Minimize time between setting flags and setting pipe/rebar to reduce chance of flag tampering or removal

- Periodically check into set points to detect errors

- It is important when shooting intersection points to check into already set pipes after backlighting to make sure everything checks out. Also, sighting down rows or columns periodically is another quick way to check for errors or problems. All flags/pipes should be in line.

- When surveying and setting pipes and rebar, a careful process should be used to reduce confusion and work redundancy. For example: A dot could be placed at the intersection point when it was surveyed and a labeled flag only was set. Circle this dot when the actual pipe with labeled cap or rebar piece with labeled tag were set at the intersection point (Figure 16).

Figure 16. Field Marking System for Grid Installation.



Physical Infrastructure: Trail System: Muir Woods Example

The restoration goal for all of the trails in the Preserve is to have a well-maintained and clearly marked trail system that is used by visitors. The restoration objectives for Muir Woods in particular include having no unauthorized trails, and that all the main trials are edged. Other goals for Muir Woods include:

- Minimize soil compaction and vegetation loss.
- Preserve large parts of forest as habitat for wildlife and vegetation without limiting access to major routes
- Provide access to major destinations (Buildings, Lakeshore Path, Scenic Overlooks)
- Serve the educational activities that occur in Muir Woods (laboratories, discussion sections, art classes etc.)
- Create access points that are logical and safe
- Use as many existing trails as possible

- Enhance designated sitting areas

When this project first started, one of the most glaring issues in Muir Woods was the lack of a coherent trail system. The trail system was poorly maintained and undefined which had resulted in the trampling of vegetation and also the compaction of soil. There were many "desire lines" (trails created by users) linking paths at many places (Figure 17). These unauthorized paths are detrimental to heavily used woodlands since they "create large areas devoid of vegetation and loss of organic soil and vegetation" (Cole, 1993 p. 18).

Figure 17. Trail System in Muir Woods at beginning of project (August 2005).

One of the first priorities in this project was to redesign the trail system. The tangle of redundant trails was leading to both ecological and human use issues. Preserving the trails is "an act of…conservation, one that is designed to preserve soils, water quality, and vegetation" (Demrow & Salisbury, 1998, p. viii) and it is therefore critical to the restoration of Muir Woods.

According to the Appalachian Mountain Club Trail Manual (Demrow & Salisbury, 1998) a good trail protects the region it passes through from damage by use and is built and maintained to protect the environment, not to make passage through the woods easier However, due to the fact that this woods is supposed to serve as a laboratory and classroom for the UW, this trail system should not only protect the woods, it should also provide access to and through it. Once these goals were set, I conducted historical research and interviews with staff who use the woods in their classes, and made on-site observations, and then used this information to create the current trail system.

The UW-Cultural Landscape Survey had an original trail map from John Muir Park design by William A. Longenecker in 1959 (Longenecker, 1959).

Figure 18. Historic Map of Muir Woods Trail System (Longenecker, 1959).

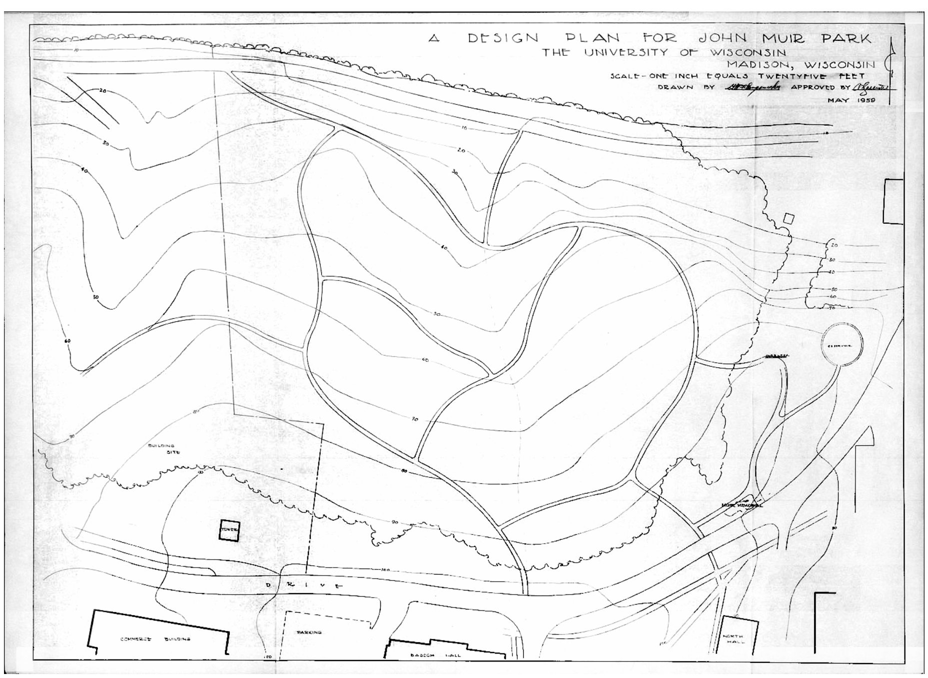
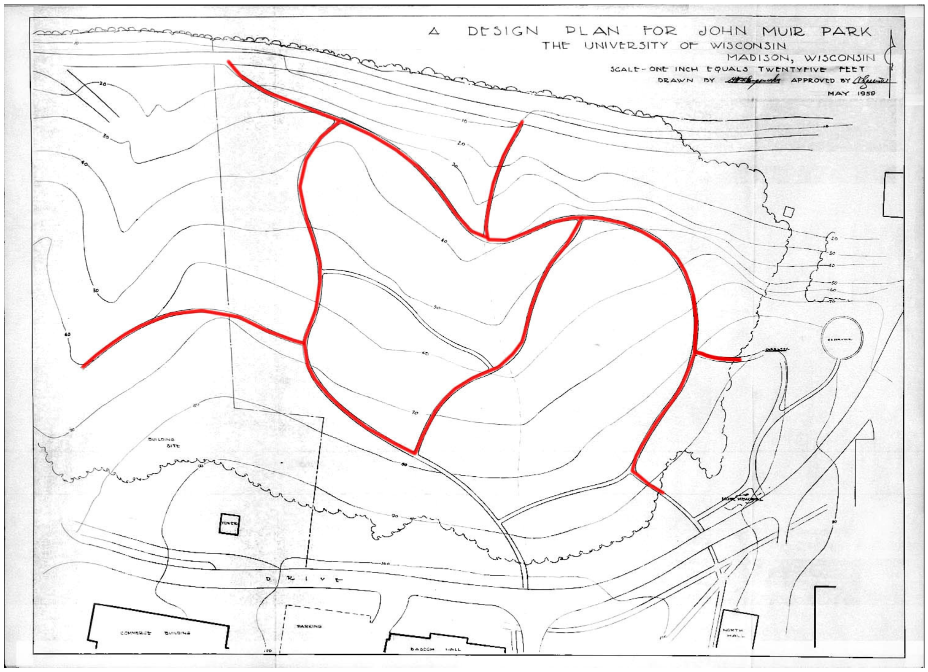


Figure 19. Trails Present in August 2005 in Muir Woods that match the Longenecker Map (map modified by Rebecca Kagle).



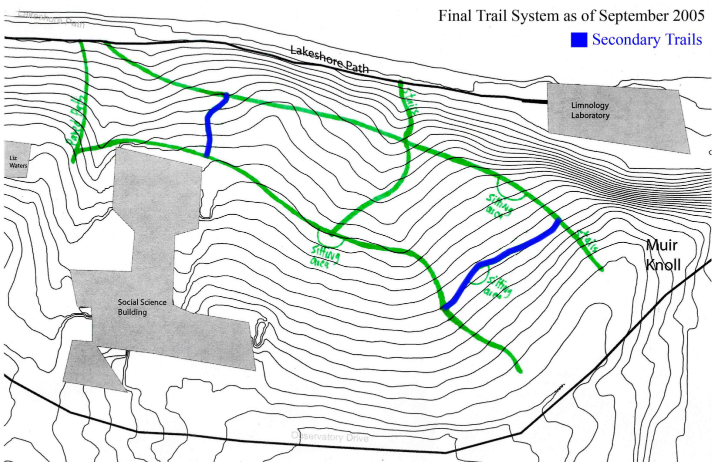
Since many of these original trails were still in operation almost fifty years after this map was constructed (Figure 19) it seems logical that either trails were constructed based on this map or that this map was drawn based on trails that were already in place. Even though the Longenecker plan provided interesting historical insight into this space, it does not make sense to follow it to the letter when modifying and restoring the trail system because the situation in and around the woods has changed since its design.

Most importantly, this map was created before the construction of the Social Science Building. The building site is noted on the map, but its impact could not be known at the time. Also, the number of students enrolled at the UW has increased greatly since the late 1950s and the people pressure on the woods has therefore increased, potentially making additional trails necessary. Furthermore, since many new trails have been created by users it is important to take into account how people are currently moving around in the woods, in order to try to accommodate this movement while still meeting the ecological goals of the woodlands. Too much of a radical change in trails may cause people to at best ignore them and at worst destroy anything meant to block access to old trails (John Clasby, personal communication, 3/7/2006).

Final Trail Design

After careful analysis, the following trail system was proposed and brought to the Preserve Committee in early fall of 2005. It consists of two trails that run from east to west, and one that runs from north to south that links with the other two. There are also two narrower secondary trails that run north south and connect the two east-west primary trails. It consists of two trails that run from east to west, and one that runs from north to south that links with the other two. There are also two narrower secondary trails that run north south and connect the two east-west primary trails.

Figure 20. Approved trail system.



Primary Trails (green) – they are between 24 – 48" wide and will get the most regular use of trails in the woods. These trails are designed to be able to handle heavy foot traffic.

Secondary Trails (blue) – they are between 12" – 18" and will get less frequent use than primary trails. They are designed to have a more rustic feeling than primary trails.

This trail system is a step towards meeting the trail goals stated earlier. It does not create any new trail segments and removes all redundant trails which will minimize soil compaction and vegetation loss, keeps intact all of the trails that are most heavily used, and allows people to access the Social Science Building and reach the Lakeshore Path and Muir Knoll easily. The modified trail system calls for the closing of 16 trail segments with brush and/or signs. It leaves three small gathering areas that can be used for educations and social purposes. Access points that are unsafe or in areas that we have decided will be trail free have been removed and the plan is to enhance those entry points that will be kept. The new trail system calls for five entrance points to the woods, two from Lakeshore Path, two from Muir Knoll, and one from the northwest corner of the Social Science Building. The southernmost portion of the woods is left as a large area of forested habitat without trails going through it. This section was selected because the trails in it either led to the unsafe stone slope along Observatory Drive or were redundant to other paths that already existed in the woods without offering any novel experiences.

The committee accepted this trail system unanimously in the Fall of 2005. There was some concern that the southernmost portion of the woods might need some trails, but it was stressed that this map could be altered if additional trails were needed, but that at this point in time trails in this area were deemed unnecessary and could not be made safe for access.

Muir Woods Trail Construction and Maintenance Specifications

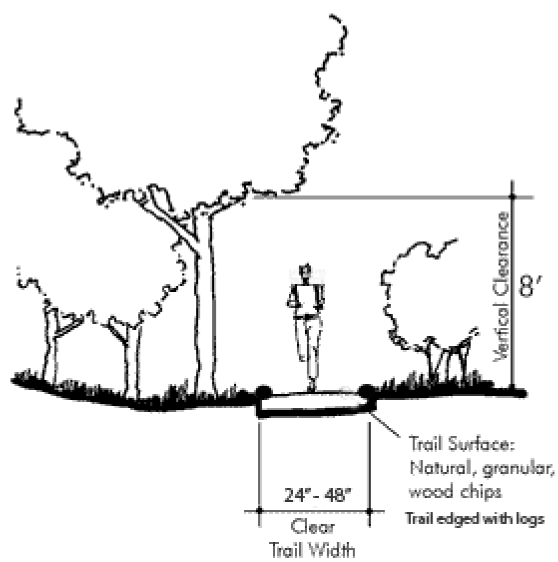
Once the routes of the trails were set, it was important to create standards for trail construction and maintenance. The trails should blend into the woods visually, but also be clearly defined so that users know where to travel. We decided to use natural materials to edge and cover our trails as a way to achieve the goals of making the trails user friendly and reduce the compaction that human foot traffic can cause. The two different trail types, primary and secondary, have different construction specifications. These trails do not have to be ADA accessible (which would require a 7ft width minimum and make woodchips an unacceptable trail surface) due to the overall slope of the woods (Michele Chalice, personal communication, 1/27/2006).

Trail Specifications

Primary Trails

All primary trails in Muir Woods (Figure 21) should be edged with logs as a way to maintain trail width and provide a clear demarcation between trail and protected area. Primary trails should be approximately 24”-48” wide and covered with woodchips which will reduce compaction, increase water infiltration and provide a pleasing walking experience for the user (Iowa Department of Transportation, 2000), (National Park Service, 2003). Vertical clearance should be approximately 8 feet which means that all underbrush that extends into the trail zone and would impede pedestrian crossing should be removed. However, unlike many trail systems, a “clear zone” off the side of the trail is not needed. Vegetation can and should grow right to the trail edge.

Figure 21. Vertical Clearance of Primary Trails (Figure 4-6 of Iowa Trails 2000, modified by Rebecca Kagle).

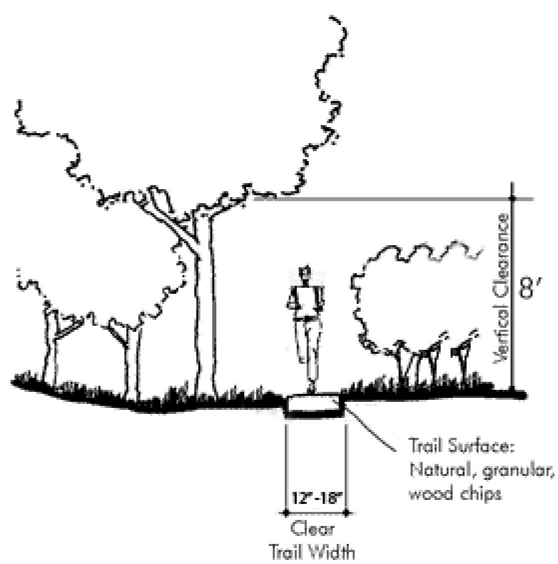


Secondary Trails

Secondary trails (Figure 22) should be between 12" and 18" across (Iowa Department of Transportation, 2000; National Park Service, 2003). They should not be edged, but should be covered with woodchips. Edging is unnecessary on these narrow, minimally used trails. They tend not get wider over time due to their minimal use so there is no need to install edging logs.

The width of the secondary trails was determined based on the fact that these trails are most often used by people walking single file and occasionally two abreast. It is rare that people cross going in opposite direction and the advantage of smaller trails (less damage to surrounding environment, more rustic experience for the user) seemed worth the rare occasion when someone might have to turn sideways to let another person pass (Figure 22).

Figure 22. Vertical Clearance of Secondary Trails (Modification of Figure 4-6 from Iowa Trails 2000, modified by Rebecca Kagle).



Edging Trails

To properly edge a trail, logs should be found or cut to follow the contour of the trail. Logs were used because they are readily available and have a natural look to them.

Logs can be procured through the Grounds Department and other Preserve projects. The most commonly available tree is box elder since these are often removed as part of restoration projects. It is beneficial to store logs in the woods as they become available until the project is complete. Even once the primary trails have been edged it is recommended to keep a small log pile to replace logs as they rot or are tampered with.

Edging Log Specifications

- Preferable species are long lasting (hickory, oak etc.), but any non disease-ridden species can be used (avoid American elm and oaks from oak wilt areas. Ash may have to be avoided once the Emerald Ash Borer is confirmed in Wisconsin). Some species may sprout (black locust, mulberry), but these are fine to use as long as they are maintained.

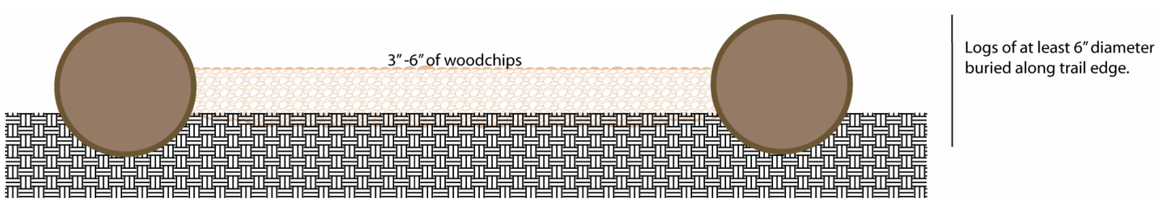
- Lengths and widths of logs can be variable, but lengths between 3 and 7 feet are preferable. Too many small logs will result in labor intensive and sloppy trail edging. Long logs are useful for long straight stretches of path. Diameter of logs should be between 5" and 12". If they are too small it is impossible to make them secure in the ground and still have them serve as a visual barrier. If logs are too large they can be unwieldy to move throughout the woods and may act as unofficial benches.

Log Placement

Once the path has been chosen, logs should be buried in the soil (Figure 23). The depth of burial is dependent on the thickness of the log, but approximately ½ of the log should be buried so that they will be stable. Soil disturbance should be minimized by not working when the ground is extremely wet and by collecting the loose soil on the trail itself to be used to bury the log.

After logs are set, the tread of the path in between the logs should be covered with a 3" -6" layer of woodchips to increase hiking comfort and reduce soil compaction. Woodchips are plentiful on campus and can be dropped off by the truck load at entrances to Muir Woods by the Grounds Department with at least two days advance notice. Woodchips should not come from chipped buckthorn or honeysuckle due to fear of new invasion from viable seeds although research has not been conclusive as to whether seeds are viable after being run through the chipper, at this point, there are enough woodchips made from non-invasive species to be found on campus that the risk is unnecessary. Woodchips tend to decay quickly in a shaded environment and must be replaced at least every two years, but due to their availability, the fact that woodchips add organic materials to the site, and their natural look they are the perfect choice for a woodland that has large amount of volunteer labor able to keep the trails well maintained (Rathke & Baughman, 2007).

Figure 23. Cross section of Completed Primary Trail.



Trail Decommissioning

In order to get rid of the redundant and unnecessary trails in Muir Woods it was important to decommission them. The assumption is that, by ending the trampling caused by users of these renegade trails, the area will beginning to recover on its own with leaf litter aiding in the creation of a new organic layer and some of the more aggressive native species

(Virginia creeper, white snakeroot (*Eupatorium rugosum*) etc.) recolonizing the areas (Leonard, McMahon, & Kehoe, 1985). Depending on the level of use of the trail that needs to be taken out of use, there are multiple strategies for decommissioning.

1. If the trail seems to be used rarely, simply drag available brush to its entrances. Pile it up in a way that will be annoying to cross. Make sure the pile is wide enough that people do not simply go around it and then re-enter the trail.

2. Signage may also be necessary to let people know that an area is not a trail. Since we want minimal use of signs through out the woods, only install a sign if blocking the trail is not working.

Newly decommissioned trails should be monitored to see if attempts at re-routing people is working and to see if they are naturally revegetating. If they remain bare even after people have stopped using them, additional restoration work may be needed (planting, soil amendments etc.). Currently, we have decommissioned 11 segments of trail in Muir Woods. All of them have had brush dragged in front of the entrances and 5 of them have had signs that state “this is not a trail” installed. Throughout the course of the project, two new desire lines have appeared due to newly fallen trees opening up seating areas. These were all blocked off and the sitting logs cut up to prevent further trampling of the areas.

Creation of New Trails

The only compelling reason to add new trails to the current plan would be if a new approved use of the woods had been designed (a new seating area etc.) or if a desire line was being so heavily used even after decommissioning that it was determined to be better management to keep that length of trail open and maintained.

Trail Maintenance

The trails should be constantly maintained.

- Underbrush should be trimmed so that it does not hang over the trail edge or obstruct the traveled way. Any branches that would come into contact with a 6" person should be cleared.
- As logs edging primary trails rot or are tampered with they should be replaced.
- Woodchips at minimum depth of 3" on all primary trails. As they rot they should be replaced.
- Large trees that fall and block the trail should be removed immediately. Depending on their size and the manager's comfort with a chainsaw, removal can be conducted by Preserve staff or by the Grounds Department.
- If there are any areas of water pooling or constant muddiness on the trail, water bars and other drainage techniques should be used to alleviate this problem (A good source for how to install water bars can be found in *The Appalachian Mountain Club's Complete Guide to Trail Building and Maintenance Manual* (Demrow & Salisbury, 1998)).
- Signs should be maintained and replaced as needed (see Physical Infrastructure: Signs section for design criteria).

Trail work is an excellent project for volunteers. Edging is great work for skilled volunteers while spreading woodchips and trail decommissioning can be completed by almost anyone.

Major Trail Projects

Apart from trail edging, chipping, and rerouting we have completed two additional major trail projects, a footbridge and a cribbing wall. Both of these projects were labor and cost intensive, but necessary for the sites where they were installed (Appendix E). Trail projects were selected for areas that would help us meet the restoration goals of minimizing compaction and erosion while providing a well maintained and usable trail system for visitors.

Footbridge

The footbridge was installed in August and September of 2006 (see Appendix E for the location).

Figure 24. Muir Woods Footbridge (photo by Lars Higdon).

The idea to build a structure to bring pedestrians up and over a heavily compacted area of the lower trail was conceived as part of the original trail restructuring that occurred in the summer of 2005. The trail at this point could not be moved away from the extremely disturbed area since it hugs the ridge that provides lake access and the areas both above and below it were also heavily disturbed.

The footbridge was designed and installed by an Eagle Scout and his troop mates and family. The goals for the footbridge aligned with the goals for built structures in the Preserve laid out in the Master Plan. We had determined that a structure was needed, but wanted to make sure that its form and color blended in with the natural setting, that it was sustainable and environmentally friendly, and that its construction and presence minimized adverse physical, biological, and aesthetic impact (Ken Saiki Design, 2006). These goals led us to choose to build the bridge from a saddle colored composite plastic and wood recycled lumber product. We felt that this was a more sustainable choice than using virgin wood, most of which is not harvested sustainably, and that the color would blend into the setting. The campus landscape architects were involved in the design process of the bridge, providing approval of material and color choices as well as determining that the bridge was going to be safe for users.

At this point, there are no other sites in Muir Woods or along Lakeshore Path that should need a footbridge installed. These types of built structures should be avoided whenever possible so that the woods does not begin to feel too much like the campus areas that surround it. However, the design of this bridge and the materials used should be monitored to see if it might be appropriate for other sites in the Preserve. There are some concerns about the longevity of composite lumber products and the footbridge in Muir Woods can provide information about the appropriateness of this material for other sites in the Preserve, especially in heavily shaded areas where there is concern about the material growing mold (Taylor, 2006).

Retaining Wall

In the summer of 2006, a wooden retaining wall was installed as part of a trail re-routing project. Its purpose is to stabilize sloping ground and to prevent the erosion and the movement of soil where there are vertical or near vertical grade changes. Unlike the location for the footbridge, this was a site where we could move the trail from a heavily compacted area to an area further away from the steep slope and with less potential for compaction without moving pedestrians too far from the most direct route and the best views of the lake. We did this by moving the trail approximately 10 feet north of where it had previously been. Once the trail was moved, the area where the trail had been for many years (this portion of the trail is part of the Longenecker Map from the 1950s) was severely compacted and was in danger of collapsing since it was on a heavily eroded slope that had been further damaged by regular foot traffic (Longenecker, 1959). In order to prevent this, it was determined by the 2006 summer crew that a retaining wall in concert with plantings and erosion control fabrics was the best way to stabilize this site and prevent increased erosion over time (Figure 25).

Figure 25. Log Retaining Wall (photo by Rebecca Kagle).

This project will need to be maintained for it to succeed in holding back the slope until plants can do the job. The wall was built with wood which will rot over time. The plants and materials used should be monitored over time to make sure that water and soil are still being retained by the structure. Plants were added twice to this project. The first time was right after the wall was completed. Plants were a combination of nursery purchased plugs and pots and plants that had been donated to the project from the native plants that had been in one of the Agriculture Hall courtyards. The red oaks planted as part of this project were heavily browsed and had to be removed due to the fear of oak wilt (see section on Oak).

A second retaining wall was installed to replace a pre-existing one that had rotted away and as a result of this stormwater was not only causing problems in Muir Woods, but also eroding away a portion of the shoreline. The installation of this new wall was greatly helped by having the specifications already laid out from the prior project.

At this time there are no sites additional sites in the eastern portion of Muir Woods that will need the addition of a retaining wall. The installation of these structures requires large amount of soil disturbance and therefore retaining walls should only be installed where the erosion process is severe and the land manager determines that a retaining wall is the most effective erosion control option. The only other area where they may be needed is in the area of Muir Woods behind the Elizabeth Waters Dormitory where there is a short, but steep drop (45% and greater slope) between the edge of the woods and Lakeshore Path. In many of these areas, simply installing erosion control fabric and plants may be enough to prevent problems, but in particularly steep areas, the construction of short retaining walls may be needed. However, other methods such as using single biologs should be tried before installing these on such a highly visible section of the Preserve.

Physical Infrastructure: Hillside and Lakeshore Stabilization

Stabilizing the slopes of the East Preserve has to be a major priority as this project continues since this is one of the restoration goals for both Lakeshore Path and Muir Woods.

Both sites should have no gullies deeper than 6” and minimal erosion and compaction occurring on site.

The slopes in Muir Woods are eroding due to overland flow, lack of vegetation and soil compaction. All of these factors are negatively affecting the Lakeshore Path which also has to handle ice and wave action (see section on Shoreline Erosion along Lakeshore Path for more about these erosive forces). There are various ways that slopes can be stabilized ranging from hard armoring techniques like tall concrete walls or the addition of gabions, large metal cages filled with stones, to soft armoring techniques like log jams or brush layering. All of the recommendations in this document are bioengineering strategies, a specific type of soft armoring. Bioengineering uses “inorganic and organic materials combined with plants to create a living barrier of protection” (C. L. Henderson et al., 1999, p. 73). Using bioengineering techniques is recommended because it emphasizes habitat creation/replacement, looks natural rather than part of the built environment, generally does not require heavy equipment for installation, and its non-plant components should degrade over time leaving no remnant of what was added, just the desired plant community and a stable slope.

Several projects in the East Preserve are an attempt to control erosion through the stabilization of hillsides and shorelines. Six such projects have been completed with two more planned for the summer of 2007. These types of projects will be a major part of the ongoing work that needs to occur in the East Preserve.

There have been various attempts at controlling erosion in the Preserve with notable projects occurring at Raymers Cove and along the paved path that cuts through Muir Woods from the end of Charter Street down to Lakeshore Path. However, both of these projects were designed and implemented by the Campus Planning Department and installed by outside contractors. We wanted, where appropriate, to design projects that could be easily installed by student employees and volunteers. This goal along with the overarching goals of the project and the Preserve guided our selection of stabilization techniques. We tried a variety of techniques so that their feasibility and success rates could be assessed and to guide future projects.

Stabilization Projects in Muir Woods

As of early summer 2007, 3 projects to control erosion and stabilize the hillside have been installed in Muir Woods. One is the retaining wall project which was described in the trail section of this document. The other two involved installing an erosion control fabric and plants.

Erosion control fabrics are a useful tool in slope stabilization because these materials have an open weave which can "act as tiny check dams, which inhibit the flow velocity of water keeping soil in place allowing plant material to grow", and "naturally absorb and retain water while retaining its integrity providing an ideal microclimate for the growth of vegetation" (Nedia Enterprises, 2007). While there are many different biodegradable erosion control mats on the market, coir should be installed on all of slopes that are going to be revegetated as part of the restoration of Muir Woods (see Chapter 7 Adaptive Restoration Trials and Experiments for an investigation of different erosion control materials). Any of the completely biodegradable gauges could be used, but the most widely available is the BioD-70 and this will almost always be appropriate (it the product numbers range from 40 to 90, with 90 being the most tightly woven).

Installation is a fairly simple process:

1. Clear any invasive or non-desirable species from the site. If the slope is steeper than 3:1, invasive woody plants should be cut and treated and their roots left in place to minimize soil disturbance. If a chemical is used, do not re-enter site to begin the fabric installation for as long as the herbicide label recommends.

2. Clear any major debris from the site. This includes anything that will affect the ability of the fabric to make contact with the soil.

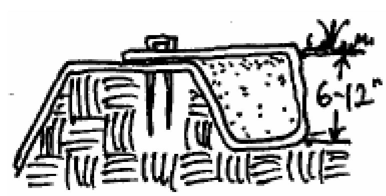
3. If the site is to be seeded, the soil should be scarified and the seed thrown down before the installation of the fabric. The student team has had success with seeding after coir is in place, but due to the decreased amount of soil contact this is not the preferred technique. If the site is going to be planted with trees or shrubs that are in pots that are larger than 3 gallons, they should be installed at this point, although it is possible to do it after installation. Waiting to install them means that large holes will need to be cut into the coir therefore reducing its efficacy. If they are planted first, the hole just needs to be of a size that can go around the above ground part of the plant rather than its entire root ball.

4. We have been using metal sod staples (11-gauge minimum, 6" to 12" long) to anchor the fabric. They can be installed with a rubber mallet or a hammer. There are some biodegradable options available on the market, but we found them somewhat hazardous to work with due to the frequency that the tops flew off and do not recommend them at this point. However, new products are introduced frequently and this avenue should be explored again.

5. At the top of the slope, a trench that is at least 6"deep x 6" wide should be dug and the fabric laid into this, attached and rolled down slope (Figure 26).

6. This process of "keying in" will make sure that water and debris cannot get under the fabric and that it is attached securely to the slope.

Figure 26. Keying In Diagram from The Capay Valley Conservation and Restoration Manual (Howard et al., 2002).



7. Unroll blanket down slope in the direction of the water flow. The blanket should not be stretched but should have full contact with the soil. Install staples every 12" – 18".

8. If the slope is wider than 8' the typical width of a roll of coir, add additional widths as needed. Overlap edges of adjacent parallel rolls by approximately 6" and anchor with staples.

9. Since soil contact is critical to the fabric aiding in reducing erosion, any place that the coir has to go over a rock, tree stump, a planted or pre-existing tree or shrub, it should be spliced so that it goes around it rather than over it.

10. The fabric should also be keyed in at the bottom of the slope using the same process as listed in step 4.

11. Once the fabric has been installed, native plugs can be added to the site. Coir is stiff enough that it will need to be cut to plant into it. Generally, for plugs a small "X" can be cut into the fabric which is spread apart wide enough to dig a hole to install the plant.

12. The slope must be watered and weeded regularly. Weeding can be difficult with the coir since it can be hard to remove the roots of a plant through the fabric. For this reason, weeding should happen often to prevent plants reaching a large size. If they do, they should be cut before they go to seed.

Channels and Gullies

Many of the remaining eroded areas in Muir Woods will need more than simple fabric covered slopes due to the level of erosion that has already occurred. Some of the gullies in Muir Woods will need a combination of structures and vegetation in order to restore them. The goal of all of these projects is to get a site covered with appropriate vegetation, and minimize the amount of stormwater and soil entering Lake Mendota. In channels where simply planting native species (areas that have eroded into channels that are more than 1' lower than the surrounding ground level) will not hold back the slope, I recommend the use of check dams and logs.

Check dams "consist of rigid supports, such as boards or logs…that are anchored in place like stair risers along the slope's contours to slow the flow of water. They reduce the erosive force of runoff and encourage deposition and the gradual buildup of the slope" (Sauer, 1998, p. 255).

When a check dam is installed as a permanent structure it creates a relatively level surface over which water flows at a non-eroding gradient. The water then cascades over the dam through a spillway. By constructing a series of check dams along the gully, a stream channel of comparatively steep slope or gradient is replaced by a stair-stepped channel consisting of a succession of gentle slopes with "cushioned" cascades in between. Check dams can be thought of as very short retaining walls that are filled with soil behind them. They trap water behind them and slow it down so that it can be infiltrated and silt and debris are deposited in the gully rather than having more material removed from the site (Gray & Leiser, 1982). The construction of these structures is an important tool in stabilizing eroded slopes.

There are multiple types of check dams that may be appropriate for Muir Woods. They include ones built from trees branches or brush, posts (either live (willow, dogwood etc.) or dead), rock, coir rolls or boards. Since none of them have been installed at this point, it makes sense to try out a few different methods to see what works best in different situations and what is the most cost effective and easiest for the student mangers to install with the use of student hourly staff and volunteers (See Chapter 7 for the logic behind this recommendation).

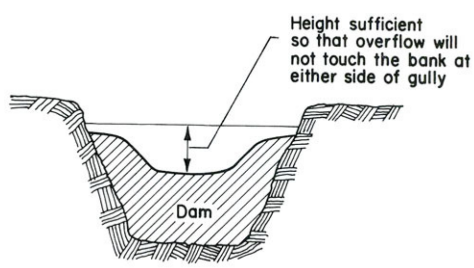
Regardless of what type of check dam is selected for installation, there are some guidelines that should be followed to increase the likelihood of these structures serving their purpose.

General design criteria for check dams

1. Numerous low dams (shorter than 4' in height) are preferable to a few higher dams (Gray & Leiser, 1982).

2. All check damns should have a "spillway", a notch or a lower center along the top of the structure so that water can pour over the dam rather than pool behind it. This also makes sure that water does not travel along the top of the dam and cause erosion around it (Figure 27).

Figure 27. Elevation View of Gully showing low center in a check dam (From Gray & Leiser, 1982).



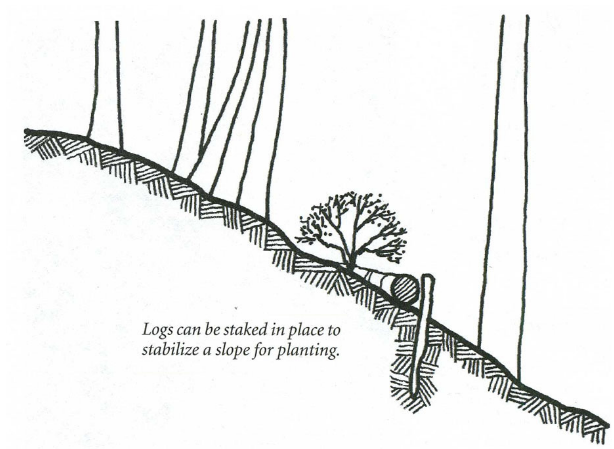
3. If there is concern that the strength of the water coming over the spillway may be erosive, then a hardened apron made of small stones should be constructed down slope of each check dam. The length of the apron should be approximately half the height of the check dam (Gray & Leiser, 1982). Since most of the storm water has been rerouted, at this point the construction of aprons should not be necessary in any of the gullies in Muir Woods.

4. Since sediment build up is important to fill these gullies, debris should not be removed unless it is clogging the spillway or if it is building up higher than the dam itself.

5. Check dams should be anchored with stakes that are 1/2 to 1/3 the height of the dam itself and the stakes should be placed at approximately 3' intervals along the dam.

6. In small gullies, all that may be necessary is a "check log" – just one log anchored to the ground without any spillway which retains rainwater behind it to slow erosion (
7. Figure 28).

Figure 28. Diagram of a check log installation (Sauer, 1998).



8. Construction should be started at the bottom of the slope so that sediment that is loosened during construction is caught by the already installed dams.

9. The height of the dam should not be flush with the existing level of the gully so that peak water flow does not spill over the edges of the gully and create additional channels (Sauer, 1998).

10. The space between check or log dams should be small (2-6') so that natural deposition can fill them and therefore prevent erosion between the dams (Gray & Leiser, 1982). If it seems that not enough soil is being brought through the gully to ever form natural looking terrain then it may make sense to bring in a low nutrient soil mix (such as a shredded topsoil) to partially fill in between the dams. If soil is added, coir should be installed over it.

11. Once the dams have been anchored to the site and the soil, if needed, brought in, the site should be planted with the native species listed in Appendix A. It can be beneficial to have plants with deep tap roots (i.e. young oaks (if there is enough sunlight)) mixed with plants with more shallow fibrous roots (*Corylus americana*). Since vegetative cover is a long term way of preventing further erosion on these sites, plants should be planted as densely as the project budget allows, and following the results of the planting density experiment described

in Chapter 7 (Currently, the literature recommends planting densities of 12" - 24" on center (o.c.) for herbs, 5 ft o.c. for shrubs, and 10 ft o.c. for trees) and should be watered to aid in initial establishment. If the site is sunny enough, a cover crop could be considered to help hold back the slope temporarily.

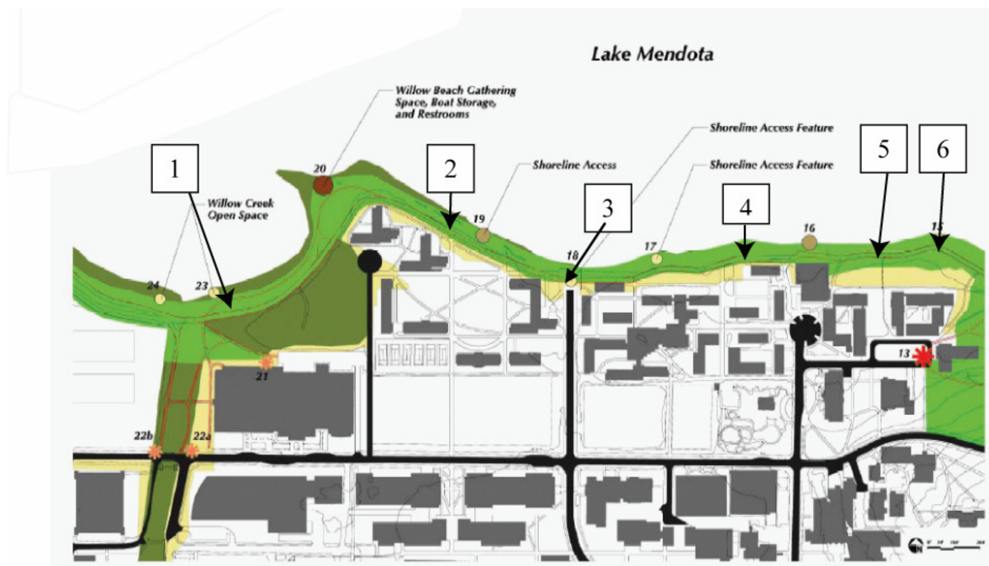
12. Brush should be laid across the slope in line with the contours to move water off to the vegetated edges, catch debris and make the area less inviting to people. Signs and/or fencing should be added to protect the site during establishment.

Other techniques that might work for gullies in Muir Woods are contour brush layering, contour wattles, brush mattressing and/or live staking (see *Lakescaping for Wildlife and Water Quality* by Carol Henderson for descriptions of these techniques (C. L. Henderson et al., 1999)). All of these require the use of stakes that have the potential to sprout which may be difficult given both the dryness and shade found in Muir Woods. However, experimentation of these alone or in concert with check or log dams is recommended. There are some plans to install check dams below the footbridge in the summer of 2007. This project should be monitored to guide the restoration of the other gullies along that ridge.

Lakeshore Path Shoreline Restoration

The area between Lakeshore Path and Lake Mendota has been heavily affected by erosive forces, both from surface runoff and wave and ice action (see section on Shoreline Erosion along Lakeshore Path for definitions of these terms). A variety of bioengineering techniques have been tried as part of this project and should be monitored over time for their overall success to determine the process of continuing and expanding the restoration of this shoreline (See Chapter 7 for a description of them). At this point, each of the sites has been restored with a different technique or series of techniques in an attempt to investigate which strategies may be effective. Three of the sites that have been restored were cleared by the Grounds Department in the December of 2005. These are referred to by numbers that they were given as part of that project (Figure 29). The 2007 summer crew cleared and seeded one additional site in the very eastern portion of the path just adjacent to the Howard Temin Memorial Plaque that is embedded in a large rock.

Figure 29. Locations of openings along Lakeshore Path as of December 2006 (Map modified from Master Plan by Rebecca Kagle)



All shoreline restoration projects occurring in the East Preserve should attempt to achieve a slope of 30% or less (Jeremy Balosek, personal communication, 3/16/06). The more gentle the slope, the less harmful the effects of overland flow and ice and wave action. This will not always be possible since it is not legal to extend the slope into the water and on all but a few of the sites the slope extends right up to Lakeshore Path so it cannot be cut to decrease the steepness. However, the restoration target is to have 50% of the path have slopes of less than 30%.

The first step in any shoreline restoration project is a site assessment which should include a measurement of the average slope of a given site (can be taken with a clinometer, a compass, or a transit). If the slope is already at a steepness of 30% or less, the strategies should include removing unwanted vegetation replacing them with desired species, and perhaps using an erosion control mat to help stabilize the soil while waiting for the new vegetation to become established. For slopes that are initially steeper than 30%, more intensive bioengineering techniques will be needed. Examples of the different shoreline restoration trials we set up can be found in Chapter 7, Adaptive Restoration Trials and Experiments.

Physical Infrastructure: Signs

Signage can be an important aspect of reaching the restoration goals of the East Preserve as well as of the quality of the human experience on the site (Ken Saiki Design, 2006). It is important, however, not to allow signage to intrude upon, rather than to enhance the site. The Lakeshore Preserve Master Plan states why limited signage is important:

> Visitors need carefully designed signage to help them know when they are entering the Preserve, to help them navigate the trail system, and to help them better understand the natural and cultural resources that the Preserve protects. Too much signage, though, can detract from the natural beauty of the place, so a careful balance must be struck to make sure visitors have just the right amount of information to enhance their experience and understanding (Ken Saiki Design, 2006, p.21).

Furthermore, signs can be used to alert users to new restoration projects and recent alterations to the trail system, as well as provide information about how a site can be used. If the goal is to change human behavior or protect a newly restored site, signs can be used alone or in concert with fencing.

The goals of the East Preserve project include the installation of minimal signage with information about the goals of the Preserve, the on-going restoration projects visible from the paths, the ecology of the natural systems found there, and the cultural history of the site. There are two different types of signs that are used in the Preserve. The first are that are meant to be temporary to last for the duration of an experiment or treatment. The second type is meant to be permanent and should last for five years or more. Permanent signs would include those that provide maps or directions, describe a more permanent structure (the footbridge for example), or are educational in content. The Preserve Master Plan lays out the following design standards for the permanent signs in the Preserve:

- Signs should be located to minimize the visual impact while maintaining visibility.
- Heavy wood treated timbers (6” x 6”) should be used for posts, and use recycled composites as materials for sign graphics base plates.
- Locate freestanding signs off of walk edges and outside of pedestrian spaces.
- Use directional signs to guide visitors to the Preserve and offer clear direction to navigate easily within the Preserve, though avoid overuse of signs.

(Ken Saiki Designs Consultants, 2006)

The temporary signs should also follow these guidelines, with the exception of that which specifies the materials.

Current Signage in East Preserve

We used several kinds of temporary signs in this project. Most of them are informational or regulatory signs that either alert users to the fact that an area has been restored and is fragile or to the fact that a desire line is no longer a trail, or that an established trail has been blocked off. In Muir Woods we also have a series of directional signs that point people towards the major landmarks (The Knoll, Social Science, Lakeshore Path) that can be reached from this woods. The signs are laminated, and attached to fences, metal posts, or wooden stakes. These materials are readily available such that the signs can be easily designed and fabricated.

The text on all of the signs include the Preserve Logo and the contact information of a point person, usually Field Manager, Cathie Bruner or myself, the lead Project Assistant. This system personalizes the contact for the visitor and may be inviting, but as staff comes and goes the signs need to be changed. A more appropriate procedure might be to create a separate email address for this purpose so that the signs stay up to date even with staff turnover.

Currently, Ann Burgess, a retired Academic Staff member who is very involved in the Preserve, designs and creates the temporary signs. She has a series of signs written and all that I needed to do was contact her with a request or with text for a new sign and she dropped them off for installation.

During the course of the project, several signs have been stolen or tampered with (set on fire or bent), and others have been lost through fading with age or falling off of their posts. It is likely that such losses will continue in the future, given the urban nature of the site. It is therefore important that the locations of signs are mapped and checked on a regular basis so that they can be replaced as needed. If are consistently being vandalized and do not accomplish their purpose, for example, they are not effectively blocking people from trails or restored areas, either the wording needs to be changed or another system (create a trail, add additional plants etc.) needs to be implemented.

Physical Infrastructure: Fencing

Fencing serves two purposes; protecting young plants from trampling and modifying the behavior of users (Andropogon Associates & Prospect Park Landscape Management Office, 1994). When a new restoration project forces a change in the path system or blocks people from places that were formally accessible, such as particular shoreline locations, fences can create effective barriers. It is helpful to use signage to explain the reason for the installation of the fencing.

Current Fencing in East Preserve

At this point, two types of fencing have been installed in projects in Muir Woods and along Lakeshore Path. The majority of the fencing is 4-foot tall red wooden snow fence. At one site along Lakeshore Path (Site 3 on Figure 29. Locations of openings along Lakeshore Path as of December 2006 (Map modified from Master Plan by Rebecca Kagle), a post and chain fence has been used. However, the tradeoff is that the snow fence is much more visible than the chain fence and detracts more from the naturalness of the landscape. Also, it rots and is can be broken by those who want to enter a site.

For the most part, The UW- Madison Grounds Department has been responsible for installing fences for our projects. The advantage of this is that allows us to use our limited hours to focus on other restoration activities and it allows a skilled crew to install it. The disadvantage is that the fence crew is extremely busy and there is often a gap between when we are ready for a fence and when they can schedule the installation. To overcome this, we have used other barriers temporarily until a fence can be installed or have started to install the fence on our own. For a given project timeline, either strategy may be appropriate.

At this point, we have not been aware of any negative reaction to fencing that has been installed. No one has provided feedback one way or the other. However, as fencing becomes a more common and prominent aspect of restoration projects, there may be a stronger reaction. In order to choose materials and select which projects truly need fencing conducting a survey of Preserve users could prove useful. Also, thus far, none of the fences have been tampered with, but it is important that these fences are well maintained and look cared for in order for them remain effective and increase the sense that this is a place that cared for.

Based on my experience in the East Preserve, I drafted the following policy for consideration for adoption by the Preserve Committee. Final approval is pending, but it has been used to guide decisions throughout the Preserve thus far.

Fencing Policy

Temporary Fencing

Definition: Fencing that will remain up for the life of a project, with the end goal being a site that is not fenced. The duration of the project can be anywhere from a few weeks to a few years depending on the level of establishment that is necessary for the outlined goals of a project.

Materials: Appropriate materials for temporary fencing include wooden snow fence (preferably 'natural' in color), black weld wire fence, or black plastic snow fence. Rebar or cedar stakes can be used to support these fences. Non-flared stakes should be used for easy removal.

Criteria for installation:

- Site needs to be protected from trampling by humans and dogs
- Plants already present or recently installed need time to establish before being accessible to users
- A trail or area that was previously used is to be given time to "recover" from this use and allow plants to reestablish (either through planting or volunteering).
- Area is temporarily unsafe due to alterations made in the course of management or change in the landscape. (i.e. blow down of a large tree)

Permanent Fencing

Definition: Fencing that will be installed with the goal that will remain and be maintained in place as long as conditions of the site do not radically change.

Materials: Appropriate materials for this kind of fencing include chain link, split rail, aluminum etc. Type of fence should be congruent with aesthetic and functional goals for the site.

Note: Any permanent fence that is installed should have locked gates as part of the design.

Criteria for Installation:

- Site is extremely delicate or has features that are critical to protect (i.e. Burial Mounds).
- Protects users from an area that is dangerous (i.e. A very steep slope)

Before any fencing is installed, a plan for its long-term maintenance must be created.

Physical Infrastructure: Seating Areas

Designated seating areas in natural settings come in a variety of forms, ranging from cleared spots on the ground, to carefully arranged rocks or boulders, to fallen logs, to chairs or benches. The Master Plan provides recommendations both for bench design and for locations. It states that benches should be "sensitively designed" and "allow access to desired views and features within the Preserve" (Ken Saiki Design, 2006, p.26). In terms of design the Plan specifies three types of benches that are appropriate for the Preserve: Custom, Wood, and Log (See page 56 of the Master Plan for detailed information about them).

Current and Proposed Seating in East Preserve

Current Conditions

Lakeshore Path has two benches and one wooden overlook. One of the benches is right beside the Limnology Garden and the other is in the not yet restored part of Slope 6 (Site 6 on Figure 29. Locations of openings along Lakeshore Path as of December 2006 (Map modified from Master Plan by Rebecca Kagle) These benches are not of consistent style or materials. The wooden bench beside the limnology garden gets heavy use and the stone one at site 6 gets much more minimal use even with increasing the view to the Lake. Muir Woods does not have any benches but has three informal seating areas that are used by at least some visitors (Figure 30). Two of them are fallen logs and the other is a large rock and cleared area. They have become gathering areas for both positive activities (classes, reading, talking) as well as negative ones (drinking, doing drugs, camping out).

Figure 30. Seating Areas in Muir Woods (Current and Recommended). Modified by Rebecca Kagle from (Ken Saiki Design, 2006, p. 36).

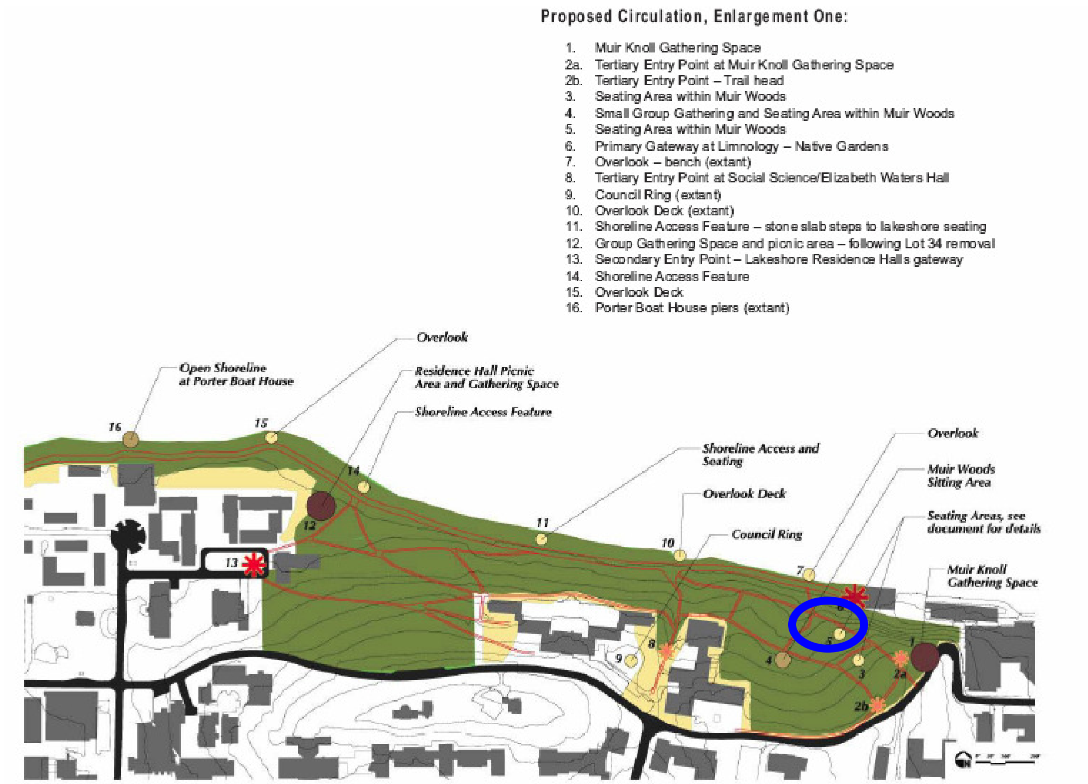
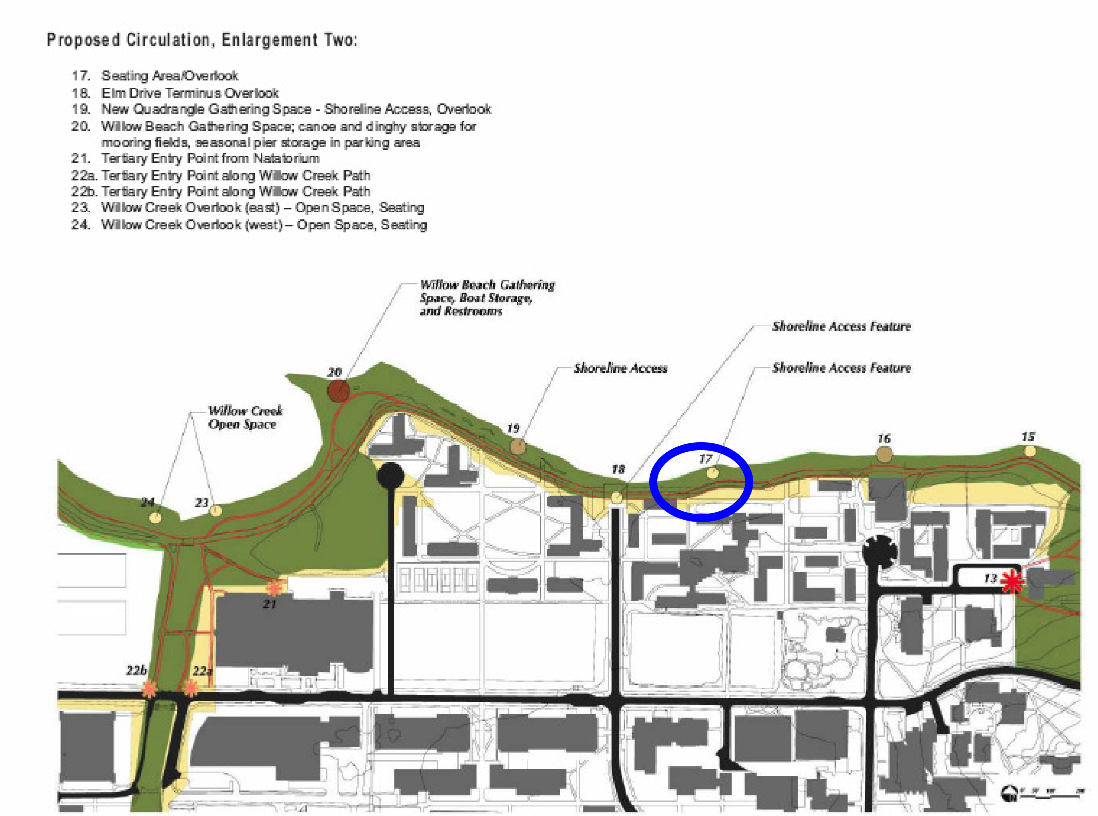


Figure 31. Seating Areas along the eastern portion of Lakeshore Path (Current and Recommended) Modified by Rebecca Kagle from (Ken Saiki Design, 2006, p. 36).



Recommendations for Seating Areas: Muir Woods

The addition of any structures in the East Preserve should not be taken lightly. This is a natural area that should provide contrast to the built environment and "offer access to wild, non-human nature for the campus community" (Ken Saiki Design Consultants, 2006, p.4). According to the guiding principles of the Preserve, all built structures should minimize adverse physical, biological, and aesthetic impacts. When recommending benches it is important to keep these things in mind and select locations that do not detract from the wildness of the space. The risk of installing a bench is that it can increase human use to levels that create problems including soil compaction, litter, and increased damage to the areas surrounding the bench. Any structure that is installed in the Preserve must be maintained to prevent these issues.

Since there are already locations for small gathering sites in use in Muir Woods, these should be enhanced and maintained. These locations are also endorsed by the Master Plan. At this point, only one bench should be added in the boundaries of Muir Woods. The bench should be placed at Location 5 on Figure 30. This site was selected since it will provide a respite for people walking up the stairs; it provides a view of Lake Mendota; the area has already been disturbed since a fallen tree has been serving as a seating area; and the location is right on the edge of major path so it will not bring people into an area of contiguous forest. The money to purchase this bench has been donated by the academic staff members who work in Bascom Hall and this location is close enough to their offices to be a space that they would (or already) utilize. Other benches should be placed on Muir Knoll once that is redesigned (outside the scope of this project).

Design Recommendations for a Bench in Muir Woods

- Bench should be constructed of black locust that has been milled on site (three trees were felled in the Summer of 2006 for this purpose).
- It should have a back to make seating more comfortable.
- It should not seat more than 3 people – this site is meant for individuals or very small groups to sit and observe the Preserve, eat lunch or talk with friends.

- The small pathway leading to the bench and the area immediately around it should be mulched with woodchips to protect the site from increased soil compaction.

In addition, simple logs placed along the trail can also serve as seating.

Lakeshore Path

At this point, there is no reason not to accept the locations of seating areas as designated by the Master Plan (Figure 31). These areas should provide easy and safe access to Lake Mendota. Only location 17, which is circled on Figure 31, calls for seating. This is the location of the stone bench currently at Slope 6. While this flat area remains appropriate for seating, this particular bench should be torn out during the completion of restoration of this site since due to its design it is not heavily used. It should be replaced with wooden bench that has a back which meets the design standards set in the Master Plan.

Biological Aspects of Implementation: Invasive Plants

The Problem

Like most, if not all, urban forests, Muir Woods and Lakeshore Path have been invaded by plants that are not native to the area. Many plants that are introduced (transported across a major geographical barrier) become invasive (produce offspring in areas distant from site of introduction) (Richardson et al., 2000). Species that invade can have tremendous effects on ecosystems, both ecological and economic. It is critical to remember that these species can change ecosystem processes by forming monocultures, excluding native plants, and changing ecosystem functions (D'Antonio & Vitousek, 1992). According the UW-Preserve Master Plan, invasive plants are a threat to the Preserve because they:

• Compete with native vegetation for sunlight and water;
• Interfere with regeneration of native plants;
• Compete for pollinators;
• Have shallow root systems that exacerbate soil erosion;
• Displace rare plant species;
• Replace diverse plant communities with monocultures;
• Encourage dense thickets that obstruct prime views; and
• Increase soil exposure and further encourage erosion.

(Ken Saiki Design, 2006)

For these reasons, one of the guiding principles of the Preserve is to control invasive species, and one of our restoration objectives for the East Preserve is to have less than 10% of overall cover consist of non-native invasive species.

In this section, I will describe the current extent and past control efforts of invasive exotics in the East Preserve, describe the life history characteristics and current potential control strategies of the species that are presently of most concern (buckthorn, bush honeysuckles and garlic mustard), and finally, based on my experience in the Preserve, recommend how these species should be controlled on this site in the future

Current Conditions

Muir Woods and Lakeshore Path have been heavily invaded by various exotic species. The “big three” that have most heavily invaded this area (and this pattern is true for most of the Preserve) are common buckthorn (*Rhamnus cathartica*), various bush honeysuckles (*Lonicera tatarica, morrowii, and x- bella).* and garlic mustard (*Alliaria petiolata*). The invasions of these plants are not uniform throughout the management area.

The easternmost portion of Muir Woods has been managed the longest and most intensively and so while it has populations of the three most common invasives, the populations are fairly small and localized (Figure 32). The western portion of Muir Woods, has had minimal management and the invasions of the three species are still very problematic, although garlic mustard invasion is minimal. It is unclear whether this is due to site conditions or to past management.

Figure 32. Invasion Levels of Project Site.

Buckthorn was found in 14 of the 79 plots surveyed. In the portion of the woods in the area behind the Elizabeth Waters Dormitory, buckthorn has not been surveyed, but it is extremely dense with many large, seed bearing plants present in this area.

The conditions along the edges of Muir Woods are perfect for honeysuckle invasion and establishment; however, most of the inner portions of the woods appear to have too much shade to allow establishment and spread. Honeysuckle was found in 8 of the 71 plots that were surveyed, mostly concentrated along wide pathways and the edges of lawn areas.

Along Lakeshore Path, there are large populations of both of the woody invasive species, but no garlic mustard. This may be due to vigilance on the part of people who walk the path, or due to the number of times that the edges of the path (the most likely site of invasion) has been torn up for construction projects. Buckthorn is found on lakeshore path mostly in areas where there is a wide strip of land between the path and the lake. Honeysuckle is found along the entirety of Lakeshore Path.

There are other potentially problematic species that are currently present in low numbers. In addition to buckthorn, honeysuckle and garlic mustard, the following non-native invasive species were found:

Table 5. Additional non-native species found in Muir Woods

Scientific Name	Common Name
Acer ginnala	Amur Maple
Acer platanoides	Norway Maple
Euonymus alata	Winged Euonymous
Euonymus fortunei	Creeping Euonymous
Morus alba	White Mulberry
Robinia psuedoacacia	Black Locust
Viburnum opulus	European Crannyberry Bush Viburnum

There are other non-native species that are found in the woods that were most likely planted or escaped from nearby plantings and have not been found to be invasive and therefore their removal seems unnecessary. These include mock orange (*Philadelphus sp.),* tulip tree (*Liriodendron tulipifera*), Ohio buckeye (*Aesculus glabra*) and European Larch (*Larix decidua*). These species should be monitored in case their spread begins to cause concern. Currently only tulip tree and the mock orange are regenerating. While these species do not fit into the target plant community, removing them should be of low priority since their current impact is minimal, and removal, could create large light gaps in the forest along the Knoll, inviting further invasion by more undesirable species that can utilize that resource.

Along Lakeshore Path, Oriental bittersweet (*Celastrus orbiculatus*) is a problem that should be managed.

There are other non-native species that are found in the woods that were most likely planted or escaped from nearby plantings and have not been found to be invasive and therefore their removal seems unnecessary. These include mock orange (*Philadelphus sp.),* tulip tree (*Liriodendron tulipifera*), Ohio buckeye (*Aesculus glabra*) and European Larch (*Larix decidua*). These species should be monitored in case their spread begins to cause concern. Currently only tulip tree and the mock orange are regenerating. While these species do not fit into the target plant community, removing them should be of low priority since their current impact in minimal, and removal, could create large light gaps in the forest along the Knoll, inviting further invasion by species that can utilize that resource. Along Lakeshore Path, Oriental Bittersweet (*Celastrus orbiculatus*) is a problem that should be managed.

Control Efforts in the East Preserve

With the help of volunteers, we removed any buckthorn and honeysuckle that we found in the eastern portion of the woods, with the exception of the buckthorn plants in one area in the northwest corner of the woods. We used both hand pulling, weed wrenches, and herbicide in our efforts. We decided not to remove the buckthorn in the northwest corner because we were concerned that total removal of the buckthorn in this area would open the woods to increased desire lines due to its proximity to the Social Science building and distance from official entry paths to the woods. In the western portion of the woods, some honeysuckle removal has been done with the help of volunteers, most often by mechanical removal followed by herbicide treatment at a later time.

Garlic mustard has been hand pulled for over 15 years in Muir Woods by University employees (most notably Dave Eagan) and their hard work has kept the population small. There has been almost no removal of invasives along Lakeshore Path except in the areas that were completely cleared for restoration (See Chapter 7).

Life Histories and Recommended Control Techniques

Best management practices dictate that managers use the most effective techniques that cause the least damage to non-target species. In order to accomplish this, it is important to understand the characteristics of the invasion and the significant features of the organism's life cycle, with particular focus on strategies influencing survival and reproduction. There are ongoing studies about the life histories of the three primary invaders—buckthorn, honeysuckle and garlic mustard--species found in the East Preserve, but for the purposes of this document, those found in the UW-Madison Arboretum's Pest Control Handbook provide an excellent synopsis of what is known (Glass, Leach, & Farrior, 2006).

Common Buckthorn (*Rhamnus cathartica*)

Life History

Common buckthorn is "characterized by long distance dispersal ability, prolific reproduction by seed, wide habitat tolerance, and high levels of phenotypic plasticity (adjusting physical appearance to maximize environmental conditions)" (Glass et al., 2006).

Seed:

- Under full sun conditions, they can begin to produce seed a few years after establishment. Fruit production may be delayed for 10 to 20 years in shaded habitats.

Flowering and Fruiting:

- Common buckthorn flowers from May through June and fruit ripens August through September.

Dispersal:

- Plants produce copious amounts of fruit which are eaten by birds. This allows for long distance dispersal of seeds. Even though the seeds and fruits are somewhat toxic to animals, they are eaten and due to their cathartic effect, spread throughout the landscape (Richburg, Dibble, & Patterson, 2000).

- Initial establishment in a natural area is often the result of spread by birds. Once initial plant is established and begins to produce seed, an area can often become dense with buckthorn.

Establishment:

- Plants establish best in areas with large amounts of light, but can also germinate and grow in shady areas.

- Buckthorn grows quickly and resprouts profusely after being cut.

- "The vigor of buckthorns is positively correlated to light availability" (Glass et al., 2006).

Effects on Plant Community

- Like many invasive exotic plants, buckthorns leaf out early in the spring and hold their leaves longer than most native plants, thereby making growth for native wildflowers difficult, since light availability is limited which effects germination and growth.

Bush Honeysuckle (*Lonicera Sp.)*

There are multiple bush honeysuckle species that are invasive in Southeastern Wisconsin. Tartarian honeysuckle (*Lonicera tatarica*) has smooth, hairless, bluish-green leaves and pink to crimson colored flowers. It invades dry areas. Morrow's honeysuckle (*Lonicera morrowii*) has downy leaves and is found in moister areas than Tartarian Honeysuckle. Bell's honeysuckle (*Lonicera X bella*) is a hybrid between the Tartarian and Morrow's varieties (Glass et al., 2006). Both of these species have white flowers that become yellow with age. Since the control methods are the same regardless of which species is present and these species will be treated as one for the purposes of this report.

Life History

An excellent life history of the invasive bush honeysuckles can be found on the Wisconsin Department of Natural Resources website. A synopsis of the critical parts of their information follows: (Wisconsin DNR, 2003).

Seed:

- The seeds appear to require a cold stratification period to break dormancy.
- Individual plants begin to produce seeds between 3-5 years of age.
- They are profuse seeders, with plants of 6m in height having been found to produce 96,512 seeds in a single growing season (Klawinski & Jewell, 2005).
- Seeds have high germination rates, with 50-80% success rates having been documented.
- They do not form a persistent seed bank.

Flowering and Fruiting:

- Flowering generally occurs from early to late spring, but varies for each species and cultivar.

Dispersal:

- Most commonly dispersed by birds. They ingest the fruits and disperse them over long distances.

Establishment:

- Seedlings establish in sparse vegetation, and are usually found growing under tall shrubs or trees.
- Seedlings establish in areas of sparse herbaceous vegetation and can tolerate moderate shade (Nyboer, 1990).
- The plants also sprout from cut stems or the root crown. This response is especially vigorous if the plants are cut back in the winter.

Effects on Native Plant Community:

- Due to their rapid growth and expansion once in an area, bush honeysuckles negatively affect shrub and ground layer species. It is not uncommon for areas that are heavily invaded by this shrub to have it entirely replace natives species due to the layer of shade they create and the depletion of soil moisture and nutrients.
- Since this species tends to leaf out early, they may prove to be particularly damaging to spring ephemerals.
- They tend to hold their leaves until late November (Wisconsin DNR, 2003).

Garlic Mustard (*Alliaria petiolata*)

Life History

Garlic mustard grows in upland and floodplain forests, savannas, yards, and along roadsides, occasionally in full sun. It is shade-tolerant, and generally requires some shade; it is not commonly found in sunny habitats. It cannot tolerate highly acidic soils like peat (Glass et al., 2006).

Seed

- Biennial so only produces seeds in the second year.
- Profuse seeder, each plant can produce hundreds of seeds.
- Reports of how long seeds remain viable in the soil vary, but estimates range from three to seven years.
- Germination often occurs in early April and early growth can be seen at this point.
- Seeds are viable mere days after plant flowers.

Fruiting and Flowering

- Blooms in southern Wisconsin from May through early June.
- Fruits begin to ripen in mid-July.

Dispersal

- Seeds are commonly dispersed by animal fur, flowing water, and human activities.

- Garlic mustard tends to spread in two patterns. One is the expansion of already existing patches ("an advancing front" according to the Pest Control Handbook) and the other involves the establishment of populations on new sites.

- Forest invasions often start at the edge and move inward along trails.

Effects on Native Plant Community

- Spreads quickly and displaces native wildflowers [although the claim that it displaces natives has recently been thrown into contention] (Blossey, Nuzzo, Maerz, & Davalos, 2005).

- Considered a major threat to Wisconsin's wildflowers and the wildlife that depends on these species.

- Of special concern, because it spreads into high quality forests. Many other invasive species are commonly found only in disturbed areas.

Recommended Control Methods

Background

The best ways to manage invasive species are always evolving and the most current research should always be utilized when it comes to choosing management techniques (A good source for this information is the Wisconsin Department of Natural Resources Invasive Plants Website: http://dnr.wi.gov/invasives/). Everything should be done to prevent introduction from occurring, but once invasive species are present, there generally are three options for control: mechanical removal, chemical control, or biological control. These three tools can be used alone or in concert.

Biological control, in theory, has the advantage of begin able to control populations of invasive plants in areas that are difficult for humans to reach. Also, the control can proceed without further efforts from managers (since the control agent population adjusts to weed densities). The controls can be specific to the target exotics, such that there is a lack of damage to non-target plants and to other parts of the environment. Finally, biological control can be less expensive than the other techniques. (Culliney, 2005). However, the introduction of additional exotic species to control invasive species carries with it risks and truly predicting the outcome of such an introduction is extremely complex (Louda & Stiling, 2004). There can “be unexpected levels of non-target feeding and impact.” In fact, only 20% of weed control projects that have used biological agents have successfully controlled the target species (Louda & Stiling, 2004). At this point, we do not know enough to truly predict the outcomes of these releases, so, although it may be a promising option in the future, the use of exotic species to control current invasives has not been used in the Preserve to date.

Currently, the Preserve uses both mechanical and chemical removal to control invasives. According to the Master Plan, site managers should be encouraged “to use sustainable natural landscaping and landscape management techniques that minimize the need for irrigation water, chemical fertilizers, pesticides, herbicides, and vehicular traffic” (Ken Saiki Design, 2006).

Control Methods for Buckthorn and Honeysuckle

At this point, the recommended control methods for buckthorn and honeysuckle are very similar so they will be dealt with together. Although fire has been shown to be effective in controlling buckthorn and honeysuckle, it is not recommended for use in the East preserve because this disturbance regime is not appropriate for southern mesic forests. Therefore it is not described here.

Mechanical Removal

Honeysuckle and buckthorn can be pulled by hand or uprooted with the aid of weed wrench. The best time for removal is early spring or late fall, times when most native shrubs and herbs are dormant. The green growth of honeysuckle and buckthorn is easy to spot in the otherwise brown and gray woods, allowing for minimal collateral damage to non-target species, and helping to ensure that all of the buckthorn and honeysuckle plants will be treated. The shrubs are easiest to remove mechanically if the soil is moist, but care must be taken to avoid soil disturbance in these conditions. If any type of mechanical pulling is utilized, care must be taken to remove the entire root system, a proposition that gets more difficult as the stems get larger. Stems that are too large to pull can be cut with hand or power tools (only to be used by trained Preserve staff). Mechanical removal will have to be repeated multiple times due to the high likelihood or resprouting. Girdling is another mechanical technique which has been shown to be effective in controlling buckthorn, but has been shown to be more effective if paired with herbicide treatment (Missouri Department of Conservation, 2004). It also does not work well on small stems.

Chemical Removal

Herbicide use has been shown to be effective, but should be applied carefully and at the lowest concentration shown to be effective, in order to minimize risk to both the applicator and non-target species. Both triclopyr and glyphosate can successfully kill buckthorn and honeysuckle. Glyphosate has been shown to have less severe environmental and human impacts (eye fatigue, volitization etc.) than many other herbicides (Plant Conservation Alliance, Alien Plant Working Group, 2006).

The standard method is to cut the stems of the shrubs and dab the herbicide on the stump immediately after cutting. A 25% solution of glyphosate seems to be the most effective dilution.

Treatment should be avoided during sap flow since this greatly reduces efficacy.. For buckthorn, this technique has found to be most effective when temperatures are near 32 degrees Fahrenheit (Glass et al., 2006). A water soluble dye added to the mixture can prevent either dabbing twice or skipping a cut stump inadvertently.

Recommend Treatment for Buckthorn and Honeysuckle in Muir Woods and Lakeshore Path

I recommend controlling these woody species using the cut stump/herbicide application approach. The stems should be cut with hand tools and dabbed with a 25% glyphosate mixture mixed with a water soluble dye. Even though the use of herbicides poses some risk, the use of mechanical techniques alone requires repeated interventions over a number of years due to the ease with which both buckthorn and honeysuckle can resprout. At this point, I do not recommend hand pulling anything other than very small first year growth due to potential soil disturbance and the likelihood of leaving parts of the roots to continue to grow in the soil. A study currently being conducted in Tent Colony Woods may provide information about the effectiveness of mechanical removal and the recommended treatment should change if this is proven to successfully reduce populations of these noxious species with reduced use of chemicals.

Control Methods for Garlic Mustard

Mechanical Removal

Hand pulling has been shown to be effective, if careful technique is utilized. Focus should be placed on removing all second year plants before they set seed (before or right after flowering). Plants should be bagged and immediately removed from the site. Pulling first year rosettes can be done, but emphasis should be placed on getting to plants that will set seed in the current growing season. There has been some success found with mowing or cutting close to ground level before seeding, but this method is not appropriate for the small patches.

Chemical Removal

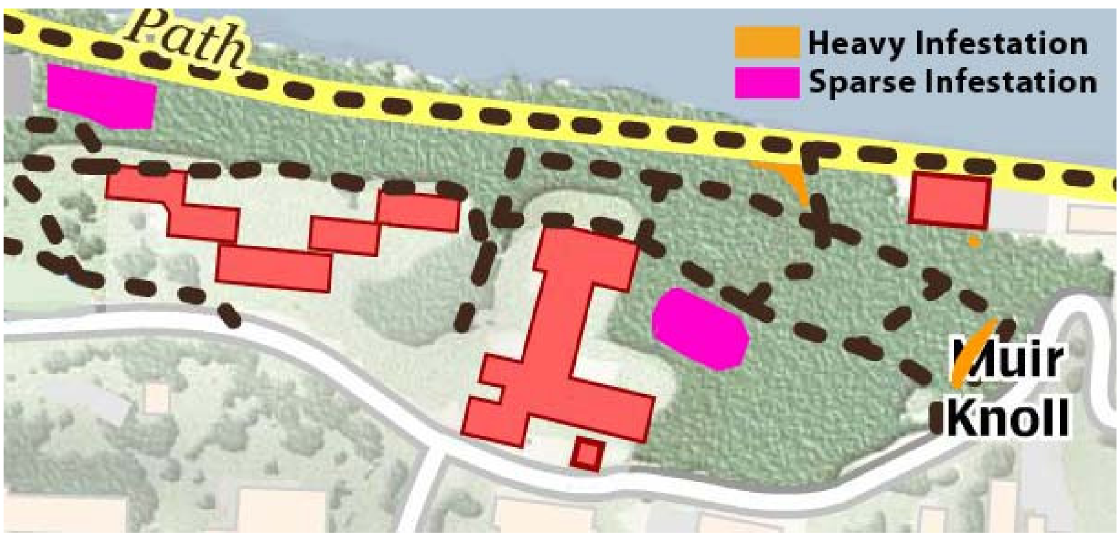
Foliar spray with either garlon 3-A or glyphosate at a 3% solution has been shown to be effective before seed set, but should only be utilized where the spray will not effect desired species.

Recommended Treatment for Garlic Mustard in Muir Woods and Lakeshore Path

The most important part of managing garlic mustard in the eastern portion of the Preserve is constant monitoring to keep existing populations under control and to prevent the success of new populations. The woods should be constantly monitored especially along trails where the seeds could be brought in by humans and their pets. Stormwater entry points and the bases of large trees are common sites for invasion and should be checked with vigilance (Glass et al., 2006).

Therefore, garlic mustard should be monitored every spring. Areas where it has been found in the past should be marked with a green pin flag and mapped roughly. Currently there are a few patches in Muir Woods that should be monitored (Figure 33). These areas should also have green pin flags or marking tape added to the sites and their grid locations noted. Any new sites that appear should be added to the map and flagged on the site.

Figure 33. Garlic Mustard Locations in the East Preserve (Map Modified by Rebecca Kagle from Preserve Interactive Map)



Known areas of invasion should be checked soon after snow melt and repeatedly after that. Casual walking surveys should be conducted to find new infestations. Once individuals have been found they should be pulled by hand at the roots and bagged for removal. Since first year plants remain green through the winter, it is possible to check for the presence of this plant in the woods throughout the year.

The Friends of the Lakeshore Nature Preserve have an intensive garlic mustard pulling and monitoring effort underway. Efforts to collect data that is useful to the Field Manager should be made. Currently, the volunteers keep a record of how much time is spent pulling in each area and a total number of garbage bags filled (regular household bags, not contractor bags). They mark patches with green flags or pink or red flagging tape.

Recommended Treatment for Additional Exotics in Muir Woods and Lakeshore Path

The species of concern shown in Table 5 should be closely watched and removed as soon as possible, since these populations are currently small enough that they may actually be able to be eradicated.

Biological Aspects of Implementation: Opportunistic Natives

Apart from species that are brought in from other places and are able to become established, there are many species that are native, but historically present in small numbers in relatively undisturbed communities and now have become much more dominant due to changes in the disturbance regime. In Muir Woods and along Lakeshore Path the species that are opportunists and natives in the East Preserve are box elder (*Acer negundo*), Virginia creeper (*Parthenocissus cinquefolia*), and chokecherry (*Prunus virginiana*). These species are more abundant than other plants that typically make-up a larger part of the plant communities that we are attempting to restore. Eradication of these species not only may be impossible, but is inappropriate since these species would have been part of the communities before European settlement. For this reason the restoration objective is less than 10% cover of each of the following three species: box elder (*Acer negundo*), Virginia creeper (*Parthenocissus cinquefolia*), and chokecherry (*Prunus virginiana*).

At this point, we remove these species when they are in an area where a restoration project is going to occur, but do not go and clear them the way that we would most of the exotic invasives that are present. More research needs to be done on how to regulate the frequency and density of these species.

Biological Aspects of Implementation: Planting

One of the primary objectives for Muir Woods and Lakeshore Path is to have highly diverse communities present (at least 75 species in each area) (See Chapter 2). At this point, there is no evidence that the seed bank and seed rain from native plants would be enough to re-colonize the site. Without the addition of native plants, the chances of invasive species taking hold again after removal or of the site's experiencing increased erosion due to bare soil is great and the chances of the site meeting our restoration goals of high diversity, provision of habitat and minimal soil disturbance is low.

Planting is often a critical step in the restoration of a site since the addition of native plants can aid in providing food and nesting sites for birds, help reduce the abundance of exotic plants through competition, and assist in restoring biodiversity and ecosystem function (Lesica & Allendorf, 1999). Most of the sites in Muir Woods and Lakeshore Path will need some addition of native plants. There is a history of planting projects in Muir Woods that have occurred at least since the 1960s so there is minimal risk of pollution of native strains of species (see the restoration plan for further information about historical plantings in Muir Woods). As part of this project, we have already completed plantings in Muir Woods and along Lakeshore Path. There are many more sites that will need to be planted as this project continues.

There is currently a study occurring in Tent Colony Woods that are looking in depth at what happens to sites that have invasive species removed and are not planted. If this were to yield data that planting was not necessary, then these recommendations should be modified as appropriate.

Species can be added using seed, nursery-grown seedlings or young plants, cuttings, or transplants from the field. Planting can occur in the spring, fall, or summer. (If seedlings or plants are used, adequate water must be provided to keep the plants hydrated during periods of active growth until their roots become established. Some species do better when transplanted in either fall or spring, but most can be planted at any point. Summer is not the ideal time to plant due to the average daily temperatures, which, together with the relatively frequent dry periods that occur in this climate, lead to high water demand. However, we often plant during this season since we have the most skilled staff working on projects at this point. The potential negative effects of summer planting can be mitigated by careful planning (not planting during periods of very high temperature) and plant after care (regular watering).

All purchased plants should come from nurseries that grow native stock from seeds that have been collected locally. Plants of the same species are often different ecotypes from state to state and seed collected from these sources will share these conditions (Gustafson, Gibson, & Nickrent, 2005). Plants or seed that are "introduced from distant source populations may not be adapted to the local climatic, edaphic, or biotic environment" (Lesica & Allendorf, 1999). While a case can be made for using cultivars selected for high performance or including a mixture of populations form different sites so as to have a diverse gene pool, the fact that plants evolve to be closely adapted to their local environments is reason enough to use plants collected within a 100 mile radius of the restoration site. Even though distance criteria are somewhat arbitrary, it can be assumed that seed collected within this range~~,~~ would share climate and disturbance regime characteristics. Ideally, seed would be collected from a variety of populations within this range to provide appropriate genetic variation and the highest chances for long term viability (Lesica & Allendorf, 1999).

Planning for Planting Projects

The following are some general guidelines, based on my experience in the Preserve and the literature. These should be modified as the results of the adaptive management experiments come in.

Before planting a site, it is important to prepare the site so that plant survival and spread has the greatest potential for success. This step is crucial to any project, since "more restoration failures are due to poor site preparation than any other single factor" (Morgan, 1997). An important first step in this process is conducting a site inventory to assess the current conditions of the site and determine what actions must be taken to get the site ready for planting and in fact to determine if planting is necessary.

The most common site preparation activity is invasive plant removal. This is done to lessen competitive pressure for the desired species. All species of high concern (species that have been shown to spread either on site or in other similar habitats) should be removed. Occasionally, non-native species that have been shown to spread are left on site as a temporary measure to prevent additional problems with bare soil. For example, European cranberrybush viburnum, *Viburnum opulus*, is a non-native shrub that is common in Muir Woods. At this point it does not seem to be an aggressive competitor so rather than remove it and create patches of bare soil, use herbicide or disturb the soil we leave it on the site. It is also sometimes important to remove some native species as part of site preparation, either because the plants are opportunistic and are too highly represented on the site, because the individual is a potential vector for disease, or because the species is no longer appropriate to the plant community that is being restored. It is important to remember that removing plants of any kind is a disturbance and that this can affect the future trajectory of the site. Plants deemed for removal should be removed according to the methods described in the invasive species section of this document.

Once the necessary plants have been removed, it may be necessary to stabilize the site, depending on how much bare soil is present, the percent slope and the expected rate of cover by the newly planted species. This is done, both to prevent soil loss through erosion, and loss of the planting through slippage and erosion. Stabilization can include techniques ranging from the addition of a cover crop to using bioengineering techniques (for specific recommendations see the section on Shoreline Stabilization in Chapter 7).

Another aspect of preparing the site for planting is setting up a method to protect a site from human impact and/or herbivory while it is being restored and while plants are getting established. This can range from small laminated signs to temporarily fencing off the site (see section on Signage).

Planting Techniques

This document will not go into tremendous detail about how to plant trees, shrubs, herbaceous plugs or how to sow seed. Techniques about how to do these can be found in a variety of sources and there appears to be minimal variation between them (One excellent resource is Chapter 24 of Leslie Sauer's book, *The Once and Future Forest* (1998)). The information provides an overview that is a useful refresher and also provides a list of key points that should be conveyed to volunteers, many of whom will be doing their first restoration planting.

Slightly more depth will be placed on how to utilize live stakes, a method for hillside stabilization, since this technique is used less frequently and therefore fewer practitioners have experience with it. In particular, it is appropriate for the shoreline along Lake Mendota.

Plants in Pots

The "rapid establishment of plants with a high survival rate is important to prevent erosion and invasion by exotics" and is critical to many restoration projects (Lesica & Allendorf, 1999). One of the best ways to do this is to use plants that have been grown in pots in a nursery setting, since they should already have an established root system. With all plants that have been grown in pots (trees, shrubs, and herbs), based on my experience, there are some basic steps to getting them in the ground to increase their chances for success. These include:

Digging the Hole:

- Dig the planting hole so that when placed in the hole, the plant is level with the existing ground or slightly higher (since it will settle after planting).

- Clear any existing roots from the dug hole and cut them cleanly.

Preparing the Plant:

- Water the plants before bringing them out to the field for planting. The soil in the pots should be moist.

- Remove the plant from the pot gently. This may require putting pressure on the sides of the pot to release the plant, or trimming away roots that have grown around the pot.

- Once the plant has been liberated from its pot, cut away any thick (greater than ¼") roots that have grown around the root ball. They should be cut cleanly with a sharp pair of hand pruners. Any loose roots that have been cut should be pulled outward so that they do not continue to girdle the plant.

- Fine roots that have encircled the soil should be scored (run the hand pruners down the length of the root mass) on each side and gentle massaged to release the roots somewhat.

Replacing the Soil:

- Use the soil removed while digging to refill the hole around the plant.

- Pack the soil in, leaving minimal air pockets around the plant. Pack it around any roots that you have pulled outward.

- Do not add anything other than soil to the hole. Remove leaves, large rocks, sticks etc. from the soil you are returning to the hole.

- For larger plantings (1 gallon and larger), create a small basin around your planting, by creating a low wall of soil a few inches away from your plant. This will allow water to stay in the area of the new plants root system.

- If possible, use leaf mulch around the new plantings, but take care no to let it pile up around the base of plants themselves in order to prevent rot.

- New plantings should be watered on a fairly regular basis depending on outside temperature, rainfall, and sunlight conditions. A general guideline for watering is that the project site should not have a dry surface at any point until the first winter after planting. This generally means that rain or watering is needed once a week during the spring and fall and between 2 to 4 times during the summer. Watering can stop once plants have been established (generally one full year after planting).

Protecting the Plant:

- Many newly planted sites will need to be fenced to protect them from trampling or tampering. This should be determined based on the recent use of the site and how much people's behaviors may have to change based on the newly restored site.

- Certain species are likely to get eaten by rabbits and these should be caged using either chicken wire or purchasing items designed particularly for this purpose. Oaks (*Quercus spp.*) and hickories (*Carya spp*.) must be caged and all woody species should be monitored for rabbit browse especially during snowy winters. This type of browsing is characterized by clean cuts on a 45 degree angle.

Planting from Seed

Seed mixes are created based on a list of desired species for a site. -Seed can be collected locally or purchased form a nursery with local stock. Seed tends not to have high germination and establishment rates in shady forest sites, so it is not recommended to rely on them for the restorations of the wooded areas of the Preserve. For prairie and savanna restorations, seed can be a good choice. If direct seeding is successful, it can result in establishment of more plants per acre at a comparable or cheaper price than seedlings alone. Seed can be used in concert with live plants. In prairie or savanna situations, forbs will establish from seed much more slowly than grasses which grow more quickly and can displace forbs before they can become established. (Lown, 2001; John Harrington, personal communication, 7/10/07). Therefore a good approach to restoring these grassland communities is to use plugs for the forbs and seed the grasses.

Seeding rates for prairie or savanna should be around 60 seeds/sq. foot for each species (R. A. Henderson, 1995). This number can be altered depending on budget available, desired plant density, grass to forb ratio, and existing conditions. Some nurseries only describe ratios as lbs/acre. If this is the case 6-10 lbs per acre is usually appropriate for our projects.

One additional step is needed for preparing a site for seeding as compared to the preparation necessary for using plants or pots. That is that the site should be raked to break up the surface of the soil somewhat. Once the site has been prepared for seeding, the seed can be broadcasted mechanically. The seed should be mixed in a 1:1 ratio with an inert ingredient (sawdust, perlite etc.). This is recommended because it makes the seed easier to spread, allow you to see where you seeded, and makes the seed heavier and therefore more likely to stay in contact with the soil (Morgan, 1997). Choose a technique that will guarantee total coverage of the desired area. Once the site is covered with seed the seed should be pressed into the soil either by walking over the site or using a roller pack.

Sowing a Cover Crop

Since seeding with perennials often results in slow establishment of native plants, sowing a cover crop makes sense in most applications in the Preserve. A cover crop is recommended since it "shades the soil and helps it retain surface moisture, …outcompete[s] annual weeds, [and] provide[s] quick soil-holding capabilities on slopes…where wind erosion can be a problem" (Morgan, 1997). The potential problem with throwing down an annual is that it may compete with the perennials and slow their establishment even more; however, in highly invaded and erosion prone sites, it is more beneficial to have something growing quickly rather than bare soil (Delany, Roger, Woodliffe, Rhynard, & Morris). We recommend using certified oats (*Avena sativa*) at a rate of approximately 25 pounds per acre.

It is important to purchase oats that have been certified since this means that the seed quality has been checked by a third party and are free from severe weed problems. The cover crop should peter out after a few years and not outcompete the native perennials as they become established (Delany et al.).

Live Staking

This is a technique that is used for stabilizing slopes and gullies. Most simply put, live stakes are "living pieces of stems or branches taken from trees or shrubs with the ability to root vigorously from cuttings that are driven into the soil and eventually root in place" (Sauer, 1998, p. 249). This technique is useful because live stakes can often be collected on site, are easy to install, and are quick to establish. These characteristics make live staking a cost effective method for hillside stabilization. Staking can be used alone and with other planting techniques depending on the budget and needs of the projects.

The specific species that can be used as live cuttings are characterized as being able to sprout and take root from cut branches, stabilizing areas with a dense matrix of roots. Species appropriate to the Preserve's target restoration ecosystems are found in Table 6. These species are also self-healing so that damaged branches and stems readily re-spout or sucker, making this technique especially applicable along Lake Mendota. Dogwoods and willows are the most common species to be used in live staking. Species of willow that are native to this area include peach leaved willow, *Salix amygdaloides*, and black willow, *Salix nigra*. However, I do not recommend using any willow unless its species is certain, as exotic willow may pose problems for native plantings. Many of the willows along the Lakeshore Path have been planted from unknown stock. Although red osier dogwood, *Cornus sericea*, is commonly recommended as being suitable for live-staking, it is known to be aggressive and should not be used in restoration even though it is prevalent on site (Wisconsin DNR, 2004).

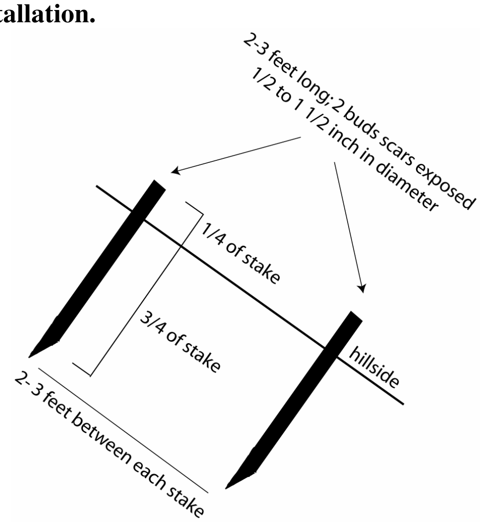
Table 6. Plant Species Appropriate for Live Staking in Muir Woods and Lakeshore Path Adapted from (C. L. Henderson et al., 1999, p. 83) and (Iowa Department of Natural Resources, 2006)

Common Name	Scientific Name	Size/Form	Root Type	Rooting Ability from Cuttings	Available in the Preserve?
Silky Dogwood	*Cornus amomum*	Medium Shrub	Shallow fibrous	Very Good	Yes
American Elderberry	*Sambucus canadensis*	Medium Shrub	Fibrous	Good	Yes
Meadowsweet	*Spirea alba*	Small Dense Tree	Dense Shallow Lateral	Fair to Good	No
Arrowwood	*Viburnum rafinesquianum*	Large Shrub	Shallow fibrous	Fair to Good	No
Nannyberry	*Viburnum lentago*	Large Shrub	Shallow fibrous	Fair to Good	Yes
Common Ninebark	*Physocarpus opulifolius*	Medium Shrub	Deep fibrous	Good	Yes

Live stakes should be installed during the fall or spring when the original plant is dormant (C. L. Henderson et al., 1999). This means that stakes can be collected from late fall until early spring. However, they should be cut immediately before installation which means that the ground must be workable. We recommend installation in November or March.

Stakes should be installed at between two to three feet from one another. Stake rooting will be most effective if the stake is not positioned vertically but positioned at an angle off horizontal so that rooting can occur more effectively along the entire below ground length. Once a site is selected, a pry bar or piece of rebar can be used to create a pilot hole for the stake. Depending on the hardness of the ground, a sledgehammer may need to be used to drive the rod into the ground. Live stakes should be 2 to 3 feet long and ½ to 1 ½ inches in diameter (Figure 34). Stakes should be flat cut on the top and diagonal cut on the bottom to clearly distinguish between the top and bottom of the cutting as well as to increase ease of installation. They should have at least two bud scars near the top of the shoot (Sauer, 1998). I recommend cutting the stakes longer than 3 feet in case they split during installation. Place the stake in the pilot hole and use a dead blow hammer to bury at least ¾ of the stake underground. If the ground is hard, it may be necessary to cut the stake so that a disproportionate amount of it is not above the ground. To prevent the stake from splitting during installation, some sort of cap should be placed over the stake (I used a 1" plumbing cap). If splitting does occur, cleanly cut the stake and remove the damaged area. The soil around the base of the stake should be tamped in so that there is the maximum amount of stem/soil contact (C. L. Henderson et al., 1999).

Figure 34. Detail of Live Stake Installation.



Once the stakes are installed, they should be fenced with chicken wire to prevent rabbit browse (Steve Glass, personal communication, 11/04/07). If they are planted in the late fall, they should covered with leaf mulch to protect them from heaving due to freezing and thawing. This mulch should be removed in early spring to prevent rot from occurring along the stems.

Plantings using plants or seedlings

We have planted trees, shrubs, and herbs in Muir Woods over the past two years, using seedlings or young plants. We obtained the plants from nurseries, as well as from members of the Lakeshore Preserve Friends who obtained them from their near-by properties.

While waiting for the results of our planting density experiment (See Chapter 7) we have relied for guidance on the density of these plantings on a chart that was created by Sound Native Plants, a native plant nursery based in Washington State.

Table 7. General Guidelines for Planting Densities

PLANT TYPE	GOAL FOR SPACING	SPACING	DIVIDE YOUR SQUARE FOOTAGE BY
Trees	Dense	6 ft on center (o.c.)	36 ft^2
	Average	8,9,or 10 ft o.c.	64, 81, or 100 ft^2
	Sparse	15 ft o.c.	225 ft^2
Shrubs*	Dense	3 ft o.c.	9 ft^2
	Average	4 ft o.c.	16 ft^2
	Sparse	5 ft o.c.	25 ft^2
Herbaceous/ground cover (4" pot)	Dense	12 in o.c.	1 ft^2
	Average	18 in o.c.	2.25 ft^2
	Sparse	24 in o.c.	4 ft^2
Live stakes for soil stabilization	Dense	1 ft o.c.	1 ft^2
	Average	2 ft o.c.	4 ft^2
	Sparse	3 ft o.c.	9 ft^2

Most often we planted herbaceous plugs at densities ranging from 1 ft to 2 ft on center, shrubs at between 5 and 7 feet on center, and trees at 10 to 15 feet on center. These numbers were also modified based on current native plant cover on the site. If a site already had good cover of native species and the goal of the project was to increase diversity, we would plant less densely. If a site were bare, we would use a higher density.

Plantings using Seed and/or Plugs

On Lakeshore Path, we have experimented with using seed alone as well as seed along with plugs and pots. Seed is cheap compared to nursery grown stock ($.10 per square foot for seed versus $1.00 - $2.00 per square foot for plugs) and if it proves to be effective along the lake, it could provide an excellent way to stabilize the slope, increase diversity, and provide habitat.

Management Infrastructure

Program Tracking

In order for this restoration to continue over time and to monitor its successes and failures, a detailed system of describing, updating, and tracking the work that has been accomplished is critical. The most effective method we have found for doing this has been the use of a Project Description Sheet which provides a way to tie the site where work is being done to a grid location, site description, a map, lists of plants added, overall description of the restoration process, and to track work as it is done to the site (Appendix F). Ideally, all photos taken will be posted into this document. Every time work is completed on the particular project or something is observed on the site, it can be added to the form (see Appendix G for an example of a form in progress).

This form was introduced in the late spring of 2007. Currently, these forms are stored as separate word processing files. It would be ideal to eventually create a database that would allow users to search for work completed on a particular day or a summary of projects that utilized a particular technique. This template as is or in a database form is something that could easily be used for projects throughout the Preserve.

Other types of project logs (in the form of simple spreadsheets) have been created to track volunteer hours, budgets, and payment of student hourly employees over the course of the projects. A database in Microsoft Access was created so that the student managers could track time spent on different projects. A spreadsheet is used to keep track of all purchases so that the manager can be aware if the budget is being adhered to and if it might need to be adjusted.

This aspect of the project should now be completed as part of the Program Manager's work since he or she will manage expenses for the entire Preserve. A monthly expense report should be sent to both the Field and Student Managers as a way to track total expenses.

Photography

Another important aspect of monitoring and tracking any restoration project is the use of photos. It is a great way to visually see how a site has changed on a regular basis. It is also a quick method that if done right can be replicated quickly by people of various skill levels. However, for photo monitoring to work the following things must occur:

- The photo spot must be clearly marked and/or clearly described so that the photo can be taken at regular intervals. The description should include references to non-moveable landmarks and include a directional bearing from which to take the photo.

- Once taken, the photo must be downloaded from the camera, and stored in a way that makes the location and date of the photo clear (currently photos are labeled with the sitename_date_#).
- The photos must be stored in a place that will accessible over time.
- There should be both a digital and printed copy of the photo.

Once again, the issue of time comes into play. Taking the photo is a simple and quick process. Setting up and describing the photo spot is not. Making sure that the photos are cataloged and stored in a usable way are additional tasks that can take time. While it is easy to make the case that this information is extremely important, it is hard to build in the right number of hours to get this work done when it pulls away from the critical work of actually getting projects completed in the field.

Assessment of Tracking Work

One of the most salient things learned through the course of this project has been the importance and the difficulty of tracking the work that we have done. Various templates were tried to make tracking hours spent on projects and work completed an easy and straightforward process. One key thing learned was that no matter how streamlined, clear, and effective the form was, if we did not build time explicitly into our day to fill it out, it quickly got overlooked. We would log our hours for a few weeks after tweaking the database that we were using, but this soon was disregarded as it seemed more valuable to spend time in the field or doing research for an upcoming project. In the summer of 2007, not only did we introduce the Project Description Sheet Template, we required that summer crew return to the office ½ hour before the end of the day to take notes on what they had accomplished and observed on project sites. By starting this at the very beginning of the field season, it quickly became the norm and we are on the path to having some extremely well documented projects.

Even with these two forms, there are still a few problems with tracking our work. The managers have to make documentation a focus of their work and this is difficult to do. We already get so bogged down in managing the budget, placing orders for supplies and other "office work" that any additional work of this type adds to the sense that not enough is being accomplished in the field. The project description sheets are designed to be filled out quickly, but creating the original form for new projects takes at least an hour and updating them needs to happen regularly since we have found that it is extremely difficult to document work that was completed even a few days before sitting down at the computer.

Project Infrastructure Recommendations

Between June 2005 and the summer of 2007, much headway has been made creating a restoration program that runs smoothly and in which regular business tasks (ordering supplies etc.) have a repeatable and usable system for all aspects of the management infrastructure needed (see Appendix H for additional aspects of the management infrastructure). The first few restoration projects that were completed resulted in a disproportionate amount of time being spent on paper work and struggling with from whom and how to order the needed supplies. The hope is that future managers will not have to struggle with this and can spend more of their time installing restoration projects rather than working on the office work component of this job. Also as projects are tracked clearly, they can be mimicked easily so plant lists for one project can be easily modified to fit the requirements of a new site. However streamlining this process should be a continuing process.

Recommendations:

1. Build in time each work day for organizing photos and tracking work completed.

2. When the output expectations for a Project Assistant are generated, approximately 10% of the time should be expected to be spent on documenting the project, managing the budget and other infrastructure tasks. Field work expectations should be adjusted accordingly.

Management Infrastructure: Volunteer Program

Volunteers have been a huge asset to the program so far. Through regular volunteer work parties and class sections (led by teaching assistants) we have had over 1000 hours of labor completed by volunteers in 2 years. The development of the volunteer program is described in detail in the Logic Model section of this document; however this section lays out the different sources for recruiting volunteers and the types of projects that they have worked on.

We have run four types of volunteer activities. The first and most common is ~~was~~ a two hour work party on Friday afternoons. This program started when the Muir Woods Mentors, a student-led group that “provides university students with the opportunity to mentor 5th grade students from [a] local elementary school by exposing them to outdoor science experiences on and off campus”, was unable to organize trips to the woods for their students (Curti, 2005). As a way to keep the college students who participated in the program involved they chose to volunteer in Muir Woods. This started the Friday volunteer work parties.

Even though the Muir Woods Mentors no longer volunteer in Muir Woods on a regular basis due to increased time commitment at the elementary school at which they volunteer, we still offer a volunteer activity on Fridays from 3:00 – 5:00pm from September to late October and early March to the week before final exams (early May). Attendance is generally from 4 to 15 people per week.

We also hold work parties on Saturdays. These are scheduled when we have work that needs to get accomplished and we need extra help. Generally, these are very well attended by UW students, especially during the fall semester, because there are many classes that have a service learning or volunteer requirement. Saturday work parties also are more accessible to staff members and members of the community who work full time.

We advertise these types of events by posting them on the Environmental Studies Student Listserv (referred to as "essa"), to the Students of the Lakeshore Nature Preserve Student Group (SLNP@googlegroups.com) and on the online UW environmental events calendar (http://www.nelson.wisc.edu/events/eventcal.php). Prior to the formation of the Student Group, we had our own list of interested volunteers that we had generated by attending program orientations. Posting events these three ways seems to be effective in getting us a good number of volunteers for each activity. If a large number of volunteers is desired or if just posting it to those three places is not proving effective, lab managers of courses with an ecology or environmental focus can be another good resource. The methods we use reach out to students directly and also to teaching assistants that may announce these events to their classes. Using this method also means that we do not have to schedule extremely far in advance which tends to work well for our project since depending on the weather or what work we have to get done we can add volunteer dates or cancel them easily. Posting in newspapers of newsletters would cause us to lose this flexibility.

The other types of volunteer programs that we have run are for specific groups ranging from dorms and service sororities to girl scouts and elementary school students (see Appendix I for a complete list). These projects have decreased in frequency because it often seemed as if we were generating work to be done in order to get the group out in Muir Woods rather than having a group help us with a current project. While there are many advantages to getting groups out in Muir Woods, including educating them about the Preserve in general, connecting them to a greenspace right in their "backyard", and cultivating them as future volunteers, too often we were spending a tremendous amount of time planning and coordinating activities that we would not have been working on if the volunteers were not coming. Too often we would unleash 20 or more students on the invasive species behind the Elizabeth Waters dormitory. This is a project that will eventually need to be completed, but since there was no plan for this area the species were removed and the area often left bare. This is exactly the type of restoration work that we do <u>not</u> want to characterize this project and the appeal of having many students involved in the project should not override this.

The activities at these work parties have included trail building, invasive removal, planting, and installing erosion control fabric. All of these are appropriate for a wide range of skill levels. Even trail building, which often includes moving heavy logs and using sharp tools, can be modified to just include spreading woodchips which is an appropriate activity for children, if properly supervised. When planning volunteer activities, it is important to keep in mind the skill level of the group, the amount of time allotted for the work (always build in time for introducing the project and discussing safety), and what work is a priority in the Eastern Preserve. It can be difficult to gauge how many people are coming and therefore how many tools are necessary to bring. For that reason, it is nice to have a large number of the cheaper tools on hand (trowels, mallets, loppers etc.). It is also possible to borrow tools from the Field Manager, Cathie Bruner, or the Arboretum if it known that a particularly large group will be coming out to work.

Logging Volunteer Participation

Currently, volunteer participation is monitored with a very simple spreadsheet that tracks the number of people, the number of total hours volunteered, and a very brief description of the task accomplished. It would be beneficial to track volunteer work in more depth both by tracking hours by individuals and better logs of what work occurred.

Volunteer Liability

When having people volunteer it is important for them to be aware of the risks that doing outdoor work may entail. Not only should there be a safety discussion at every work party, but all adult (18+) volunteers must sign in on a form that outlines their rights and responsibilities as a volunteer. This form is their liability waiver and only needs to be signed once for that purpose, although since it may also serve as a sign-in sheet most volunteers will sign in each time they volunteer. If the participant is under 18 they need an additional waiver to be signed by a parent or guardian. This requires some coordination with the leader of the group to make sure that the forms are signed before the students arrive on site. Any questions about liability waivers should be directed to the UW-Madison Department of Risk Management.

Management Infrastructure: Staff

It would have been impossible to accomplish all that we have without the assistance of the eleven student employees that have worked for this project. Student employees will need to be a major component of this project as it continues on. We have used student employees in four capacities in the East Preserve. They include:

1. Surveying – Two engineering students with experience surveying were hired to plan and install the grid.
2. Volunteer Activity Leadership – Certain of the students hired focused on leading or co-leading volunteer work parties.
3. Inventory and Scientific Study Assistants – These students helped carry out the vegetation inventory, the planting density study, and assisted with data analysis and shoreline monitoring.
4. Field Assistants – These employees helped install and plan a wide variety of projects in the East Preserve. They also help maintain many projects.

In general, during the academic year we have employed one student focus on volunteer projects. At first, the person in this position just assisted the manager in running each activity but as we were able to find more skilled staff we were able to turn the planning and running of these work parties over to him or her. This freed up the student managers to focus on other projects.

During the 2005-6 Academic Year, we hired two students to focus on grid installation. They were responsible for surveying, installing the permanent points, and writing up the project. If future plans include further grid installation, more students with this experience should be hired. Any potential jobs of this type should be posted in the Engineering departments on campus.

Each summer we expanded our summer crew. In the first summer of the project (2005), one student was hired and he just worked a few hours a week assisting in the initial projects. The second summer (2006), three students were hired to each work 16 hours per week on the vegetation inventory, the cribbing wall project, and the restoration of Slope 4. In the summer of 2007, two students were hired for 16 hours per week to focus on the East Preserve. For the summer staff, we have been able to find extremely skilled students and one of the goals is to let each of them have leadership on at least one project through the course of the ten week summer.

Other than the Surveying students, all jobs should be posted a variety of places to reach out to skilled candidates. Generally, jobs are advertised on essa, in the Landscape Architecture Department, and the Botany Department. Occasionally, we will have lab coordinators of specific classes (Biocore, General Ecology) list our jobs in their weekly email bulletins if we do not find a suitable candidate through the avenues listed.

Once a student has been selected for a position, they must be hired by the Facilities Planning and Management Division of the University. This requires filling out paperwork and becoming entered in Kronos, the computerized payroll system utilized by the University. They will use this system to print out biweekly timesheets which must be signed by the Field Manager and returned to the Service Building.

At this point, students are hired for a set number of hours rather than a particular work schedule. For example, we generally hire students on the summer crew for 160 hours. This gives them the flexibility to take days off if needed and still give us the amount of time that we need to get our projects accomplished. The summer crew generally sticks to a schedule of two eight hour days over ten weeks, but this system allows us to get the type of output that we need from a summer crew while being realistic about our staff's summer schedules. We try to budget enough money so that we can offer additional hours if there is work to be done.

Management Infrastructure: Student Interns and Class Projects

Interns can be a valuable way to increase student involvement in the Preserve and to get assistance on projects that might not get completed otherwise. They tend to have a commitment of at least one semester and often have an independent project to complete or a set of expectations from the class they are taking. This program has had interns from a variety of courses (see Chapter 6 for an evaluation of our work with interns). They have worked on a variety of projects from simply participating in invasive plant removals with the crew and other volunteers to conducting vegetation surveys. In order for the internship to be beneficial for both the Preserve and the student, the project must be interesting to the intern and useful for the Preserve. The student manger must have time to supervise and oversee what ever project the intern is completing. For all interns completing independent work, weekly meetings with the student manager should occur to check in about their progress and to fine tune their experience. Even though interns are not getting paid, they should fill out a timesheet every two weeks to help both manger and intern determine if the expectations are reasonable and if the intern is fulfilling his or her responsibilities. Having interns working on monitoring project data collection and analysis should be a major part of this project as the number of hours that managers are focusing on the East Preserve declines.

Class projects can be another excellent way to get both student and faculty support while providing an opportunity for the woods to be a learning environment. The grid installation project started out as part of a summer engineering course (which no longer is offered) and a Landscape Architecture class conducted all of the data collection for the first spring ephemeral survey. As with interns, these partnerships can be fruitful for both the Preserve and the involved students, but the managers should only seek out or agree to working with a class if they can provide the support and planning necessary for the project to go well.

Chapter 4. Monitoring and Management in the East Preserve

Too often restoration projects are ignored soon after installation or if they are managed and/or monitored the process is haphazard and difficult to replicate (Pastorok et al., 1997). Restoration can not be thought of as finished once a site has initially been cleared of invasive species, revegetated or stabilized. There are steps that must be taken for these initial actions to have any long term impacts in changing the character of a site.

Ecological Monitoring

This project has many purposes, but it is clear that learning more about restoration is a driving force. Through both its explicit experiments and through the multiple iterations of shoreline restorations, slope stabilizations, and plantings that have occurred through the course of this project, the East Preserve can provide the opportunity to learn more about how best to restore these sites and others like them. However, this is only possible if the work that we have completed is monitored. There is no other way to determine if we are moving toward our goals and objectives unless data and observations are collected on these sites (Bakker, Grootjans, Hermy, & Psochlod, 2001).

Detailing a monitoring protocol should be part of the initial restoration planning both so that baseline data can be collected and also so that it is clear that the monitoring parameters will aid in evaluating if objectives are being reached (Clewell, Rieger, & Munro, 2005). In some cases, we did not do this and as a result do not have the data that we need to evaluate our objectives. Too often success of restoration projects are judged based on "limited, informal observation over a short period of time" rather than more rigorous protocols which allow the determination of if "the effect of the management action or the effects of other events and processes are linked to observed changes" (Ralph & Poole, 2003, p.230). This is not to say that rigorous hypothesis testing is necessary for all projects, but it is clear that monitoring that is more detailed than informal observation should be a major part of this project as it continues.

Monitoring is important because it can allow the site manger to:

1. Determine whether restoration goals [are being] met;
2. Identify potential threats to the integrity of the communities in order to trigger management responses;
3. Determine whether chosen restoration or management techniques are effective: and
4. Document any ecosystem changes that may occur so that we can better understand these systems.

(Harrington & Howell, 1998)

All four of these points are critical to the sustainability of this piece of land. Questions that can be investigated through monitoring can include those about the trajectories of invasive species and native species populations on a site or the effectiveness of a stormwater management strategy.

Furthermore, this work is designed to be adaptive. These sites are complex and there is uncertainty about how they will respond to our restoration techniques. Therefore, these projects must be tweaked as they change in response to restoration or as new information becomes available (DellaSala et al., 2003). Projects should be fine tuned after initial implementation based on the results of monitoring (Pastorok et al., 1997). In order to determine what is occurring on a site and make appropriate changes, there must be protocols for monitoring and the time to both conduct them and analyze the results. Pragmatism must be a factor in deciding what type of monitoring project to implement at a site. While it would be ideal to collect a tremendous amount of data about every project, this would start to be the only activity occurring in the East Preserve. Since this is not what is desired, monitoring a variety of types of monitoring, with a range in the level of detail needed, should be implemented.

Types of Monitoring

This project should have three types of monitoring occurring simultaneously:

1. This first is a series of monitoring protocols that rigorously investigate what is occurring on sites where restoration has occurred. This type of monitoring can help assess if restoration goals are being met. The information collected from these types of protocols will result in data that can be analyzed statistically to determine if there are any significant changes that may be a result of restoration.
   Example: Shoreline Restoration Monitoring.

2. The second is inventories of specific aspects of the Eastern Preserve that can provide insight into overall trajectories of the area in both areas that have and have not been restored.
   Example: Spring Blooming Plant Sampling. (See Chapter 7)

3. The third category is for monitoring of sites using assessments that can help guide management and maintenance without the inclusion of data analysis. These include taking photos at photo spots, doing seasonal walkthroughs of all the sites, and taking notes of observations of the site throughout the year.
   Example: Planting project above the footbridge in Muir Woods.

Monitoring Recommendations

Muir Woods

Vegetation Inventory

See Chapter 2 and Appendix B for the rationale and protocol for the Vegetation Inventory. One-half of the plots should be inventoried every five years. Since one-half of the plots were inventoried in 2006, the other half should be completed in 2011 (Figure 5). The inventory should occur during the summer, once the Virginia creeper has been completely leafed out (usually early June).

Spring Blooming Plant Survey

See Chapter 7 Adaptive Restoration Trials and Experiments for the rationale and protocol. This survey was completed for the first two years of this project (2006 and 2007). The inventory should continue in the spring of 2008 and then every other spring to coincide with the offering of LA 651, a class which can conduct the monitoring.

Other Types of Monitoring

All other project sites that have already been installed should be monitored through the use of photo spots (to give a visual representation of change over time) and walk-throughs that are logged on the Project Description sheets. These sites include: the entire trail system, the slopes that have had coir or jute installed, above and below the footbridge, and the 2 cribbing walls (See Appendix E for site locations of these projects). The entire woods should be monitored for invasive species through walk-throughs and more intensive surveying. Stems should either be removed as part of the walk-through or flagged and their grid location noted for future removal and future monitoring for potential reinvasion.

Lakeshore Path

Shoreline Monitoring

New projects along Lakeshore Path should be monitored annually for first 3 years after installation and then every 3 years after that. The monitoring protocol should include both a broad scale aspect (transect) and a fine scale aspect (quadrat). If a new project is an expansion of an existing project, the transect can be expanded and additional quadrats selected (Using the protocol found in Appendix K). Shoreline sites are referred to by the numbers shown on Figure 29 (and described in more detail in the Adaptive Restoration and Trials chapter).

Current Shoreline Monitoring Timeline

Slopes 3, 4 and 6	Monitored annually in the fall of 2007 then not again until the fall of 2010
Slope 5 and the Limnology Opening	Monitored in the fall of 2007 and 2008, then not again until the fall of 2011

On both Lakeshore Path and in Muir Woods, projects should be monitored two years in a row for plant survival, overall native plant diversity and presence of invasive species. Then once every three years after that. Protocols already in place can be modified for each site. Lives stakes and other areas where planting densities greater than the desired objective have been used due to high likelihood of mortality should be monitored yearly and plants should be pruned or culled if survival is high and views to the lake are being effected.

Monitoring Timeline for the East Preserve

Fall 2007

1. Monitor Shoreline Projects (3,4,5,6, and the Limnology Opening).
2. Install photo spots at all shoreline sites that capture entire site (use GPS once leaves have dropped).
3. Monitor Planting Density study (See Chapter 7).

Spring/Summer 2008

1. Monitor plantings around the footbridge, the restored slopes, and the cribbing walls (photo, qualitative site descriptions).
2. Monitor white oaks at Slope 4 (photo, qualitative site descriptions).
3. Spring Blooming Plant Survey by LA 651
4. Monitor any live staking projects that have been installed (Slope 6).

Management

In order for the East Preserve to continue to meet the restoration goals which have been set, managing all project sites is important. Management activities may decrease over time as native plant communities become established, but some level of management will be needed in perpetuity on this urban site. Since the projects that have occurred in the East Preserve have had many different components, it is important that all aspects of the project are managed. These include:

- Watering and Weeding sites that have been planted
- Rabbit proof fence removals as trees reach a dbh of 1" of great and shrubs have a spread of greater than 2'.
- Invasive Plant Removal
- Upkeep of signs and fences
- Removal of fences, signs, or stormwater structures that will not biodegrade quickly, when they are no longer needed.
- Repair of permanent or semi-permanent structures like footbridges and cribbing walls.
- Trash removal
- Unauthorized project removal (art installations, camping structures etc.)
- Thinning and pruning any site that has had live stakes installed

Management Projects

Muir Woods and Lakeshore Path

In order to determine when management activities need to occur, it is important that the manager or the appropriate field staff are observing the sites on a regular basis. A regular schedule can be set out for all of these tasks, but this should be altered based on factors that range from rainfall to how people are using the Preserve. Any time management is done on a site it should be logged in the Project Description Sheets (Chapter 3 and Appendix H) as a way to gauge the frequency with which these tasks should be accomplished.

Weeding

For this project a weed is defined as a plant that is in a spot where it is not wanted. This could mean that it is an exotic invasive, an opportunistic native that is too prevalent, or a garden plant that is out of place. Sites that have been restored will most likely have had invasive species removed and been replanted with desirable native species. This restoration process almost always increases the amount of light reaching the ground layer (at least in the short run) and therefore increases the likelihood of undesirable species entering a site. It is important that these species are removed on a regular basis and not allowed to become established. There are various techniques that be used for removing these plants from the site that include hand pulling, weed wrenching, using a weed whip, or applying herbicide. Depending on the impact to the restoration and surrounding areas, the most minimally invasive technique that will prove effective should be selected. The more frequently a site is weeded, the less the likelihood of having apply chemicals or bring in heavy machinery and the higher the likelihood of desirable plants surviving and establishing. The regularity of weeding needed will be affected by rainfall, conditions of surrounding sites, if soil was brought in from off site, and a variety of other factors. Sites that have been opened up should be assessed at least weekly during the peak growing season to determine if weeding is necessary and what the best tool for removal.

Signs

Laminated signs have been placed in Muir Woods and along Lakeshore for a variety of reasons. These should be checked on a regular basis to ascertain if they are still appropriate, if they are still legible and if they have been vandalized. Furthermore, the sites of new signs should be noted in a log and on a map so that they are not forgotten as management transitions from one Project Assistant to another. Currently, signs will be replaced or altered each time a new manager takes over since signs include contact information for the prior project leader. For this reason (among others), I recommend that a general email address be created that can be passed from one student manager to the next or that the Field Manager's contact information be including instead since it is likely this person will be around for longer than each student manager (See Chapter 3).

Fences

For fencing to do its job of protecting new and delicate restoration projects, it must be maintained. Broken or rotting snow fence should be replaced as soon as possible. Fencing should be altered if a current project is extended or if an existing fencing placement is not successfully keeping people off of the site. Fencing should also be removed once it has been determined that the site has been established and can handle the occasionally trampling by humans or their pets. A site is considered established in Muir Woods when there is less than 20% bare soil and at least 5 of the herbaceous species that have been planted are still present. (See the restoration objectives in Chapter 2). A site is considered established along Lakeshore Path when there is less than 10 % bare soil and at least 15 of the herbaceous species that have been planted are present.

Watering

Guidelines for how often a project should be watered can be found in the Plants section of this document (Chapter 3). Depending on the location of the site, the project can be watered from the tank that can be installed on the Gator, from a hose, or with the use of buckets or watering cans. During the summer, it is important that the manager is aware of how current conditions are affecting new plantings. Watering should occur either early in the morning or late in the evening to minimize evaporation and maximize water that is available to the plants. Plants that are being stored for future plantings in a holding area must be watered frequently to prevent dieback. Shade plants should be stored in the shade to minimize their need for water.

Oak Management

Oaks have been and will continue to be planted as part of this project since they are dominant trees in many of the community types that we are trying to achieve in the Preserve as a whole. Muir Woods has suffered from Oak Wilt in the past and is always at risk for re-infection. Although this pathogen is mostly thought of as being spread through root grafts, it can also spread overland if the fungus is carried from an infected tree to a fresh wound on a healthy tree by sap feeding beetles (O'Brien, Mielke, Starkey, & Juzwik, 2000). Since newly injured trees are the most at risk for this, no oaks should be pruned once daytime temperatures reach 50 degrees Fahrenheit (approximately April) until 2 or 3 weeks after leaf development (generally early July) (Wisconsin DNR, 2007). Also all oaks that have been planted as part of the project should be monitored for injury. If they have been browsed by rabbits or have suffered broken branches they should be pulled and removed from the site to prevent becoming a site for infection. Similar protocols may be necessary for other pathogens as they become present in the Preserve.

On-Going Projects in Muir Woods and Lakeshore Path

Projects that should be occurring on a monthly basis year-round:

1. Maintain all fences and signs that have been installed as part of the project. Replace as needed. Fence can be removed once plants are established.
2. Trash removal
3. Replace any sections of trail where the edging has rotted or been removed.
4. Remove invasive species in all areas where restoration has occurred.
5. Make sure trails meet design standards; prune, chipped, edge, and clear as needed.

Fall 2007

1. Water all projects that have had any plants installed since Summer 2006
   - Shoreline Sites 3,4,5,6
   - Juted Slope
   - Above and Below Footbridge
   - Around cribbing wall
2. Spot remove any invasives found in Muir Woods excluding small patches along perimeter that need plants added as a barrier to human traffic.
3. Water all plants that have yet to be planted. Overwinter by covering with leaves by December 1st.

Projects:

1. Restoration of heavily invaded edges of Muir Woods with plants from the mesic plant list
2. Finish edging and chipping lower primary pathway in Muir Woods
3. Add live stakes to Slopes 4 and 5 to help with overall stabilization
4. Oversee Lot 34 Project
5. Finish the project below the footbridge (add plugs, pots, and live stakes).

Spring/Summer 2008

1. Water sites that have been installed since Summer 2007
   - Slope that was covered in Jute
   - Above and Below Footbridge
   - Slope 3,5,6
   - Fall 2007 Muir Woods Plantings

2. Experimental Gully Project (just west of the footbridge)
3. Inventory, Trail Plan, and Planting Plan for area behind Liz Waters
4. Expansion (clear new areas) of Slopes 3 and 6 restorations (including access point by Slope 3)

Priority Projects in Muir Woods and Lakeshore Path

At this point, the funding situation for the East Preserve is unknown. There is money in the budget for some staff in the Fall of 2007 and it is likely that a PA will give at least a few hours a week towards these projects. Obviously this is not ideal since there are many projects that need to be monitored and maintained and a variety of priority projects that still need to be accomplished.

The new projects that are of the utmost priority and for which money should be raised to continue:

Muir Woods

1. Removal of large patches of invasive species still present in Muir Woods along the edges by Social Science and the Knoll. These should be cleared and replanted.
2. Removal of the rusted metal fence that runs along the lower ridge of Muir Woods. Not only is this unsightly and no longer serving any purpose it is a safety hazard. It should not be replaced except in the area from directly below the knoll to the landing of the small wood steps.
3. The remaining gullies should be filled and replanted.
4. Restoration of the area around Lot 34 to Southern Mesic Forest (in progress by another student in the summer of 2007).

Lakeshore Path

1. At least two physical access points to the lake should be designed and established.
2. The remaining sites from the clearing in December 2005 should be restored. These projects will be out of the scope of a student manager.
3. Continue to expand current restoration sites, utilizing the method that has been proven effective in sites with similar conditions and other stabilization techniques

than the ones that have been tried before. Examples: brush layering, vegetated geogrids, pre-made soil lifts etc.

Secondary Projects in Muir Woods and Lakeshore Path

Once the first priority projects have been completed are complete or enough money is available, the following second priority projects should be started:

Muir Woods

1. Planning, grid establishment and restoration of the area below Elizabeth Waters Dormitory. This should include:
    a. Trail system created with consultation with the Department of Housing
    b. Invasive Control and Replanting
    c. Comprehensive Plan to deal with the erosion at the base of the slope.
2. Restoration of the stairs to prevent continued erosion
3. Increase overall diversity in the woods through removal of opportunistic invaders paired with replanting.

Lakeshore Path

1. Restore area just west of Willow Beach.
2. The areas that are extremely compacted due to renegade lakeshore access should be restored
3. Bikes should be removed from wooden overlook at the terminus of the Charter Street Extension and an alternate plan for their storage created.

Chapter 5. Case Study

Question: How effective has the East Preserve restoration structure and process been in guiding the restoration thus far?

Since this project is supposed to serve as a model for the restoration of the Lakeshore Preserve in particular and as a trial run for the use of students managers for restoration sites more generally, it is important to evaluate the process thus far to determine what has been working, what still needs to be tweaked and the limitations of this prototype. There is a clear way to evaluate the biological outcomes of this project using ecological monitoring and experimentation (see Chapter 2); however evaluation of how the more managerial and project management aspects of the project is more difficult. I used a case study approach for this evaluation, since it is a tool that has often been used for the systematic evaluation of the processes behind and the outcomes of design and planning projects with the end goal of informing future practice. It is a methodology that is holistic and descriptive, and includes varied sources of information (Hancock & Algozzine, 2006). Using this framework has allowed me to "illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result."(Yin, 2003, p.12).

This single case study method is appropriate because it will allow a holistic look at the creation of a management plan and its implementation and it will allow this process to serve as a representative case, or precedent, for future projects of this type (Hancock & Algozzine, 2006).

Since a case study is by definition well-documented, an important aspect of this project has been the careful documentation and analysis of the process of managing this land (Francis, 1999). I have employed that documentation to reflect on my experiences in creating and implementing this plan and have used my reflections to guide to my recommendations (Smith, 2005). I have used a limited access web log (blog) to document meetings, describe the process through which management decisions were made; describe effective techniques for recruiting and working with volunteers and interns; and discuss the process of partnering with the Grounds Department, Physical Plant, various academic departments, and the Preserve Committee. I also used the blog to document the challenges of this project. This careful documentation and analysis of the process of working as the manager and creating the management plan has helped me to generate an infrastructure that is helpful for long term management of this and other sites within the Preserve.

Carefully documenting this process has allowed me to create a framework for future student managers in this and other portions of the Preserve. Furthermore, it should provide insight for the Lakeshore Nature Preserve Committee and staff as to how to best facilitate effective student management and to inform them as to what the main challenges have been. Rather than go into detail and investigate all of the "processes, decision~~s~~ making and outcomes" of this project, I will focus on a few of the key themes that have I identified in reading my blog that can provide the most insight into future projects (Francis, 1999, p. 2).

Themes

From analyzing the blog, I identified 3 main themes to investigate:

1. How decisions were made

2. Different visions for the Lakeshore Nature Preserve and how that effects this project
3. Impacts of the decision to use student managers

How Decisions were Made

To implement any restoration, the following types of decisions need to be made:

- Determine the Timeline for Implementation
- Identify the Material and Tools Needed
- Decide on a Budget
- Deide which Student employees to Hire and How to Manage Them
- Set Project Priorities and Determine How to Approach Each One
- Identify Whom to Consult for a Particular Project (affected parties, experts etc.)
- Determine What to Monitor and Document and How to Proceed
- Determine What Projects are Appropriate for Volunteers, Interns, Classes

The identity and roles of the person(s) responsible for making these decisions evolved during the course of the two years I was involved in the project. From the start, there were four types of personnel involved:

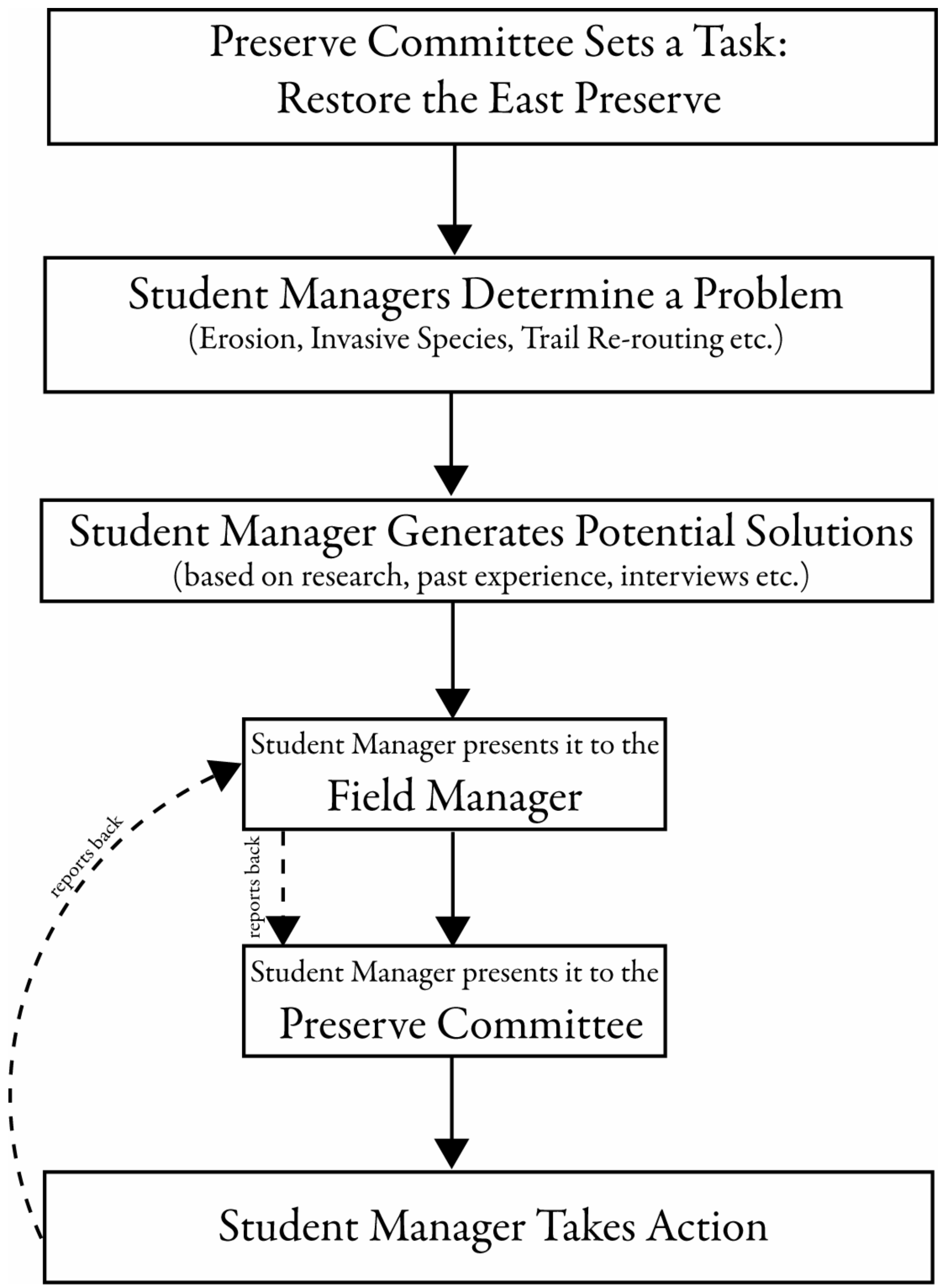
Personnel Type	Role
Field Manager	Guides all aspects of restoration and planning in the Preserve
Student Manager	Conducts both field implementation and long term planning
Student Field Workers	Conduct~~s~~ projects in the field
Policy Makers (Preserve Committee, Student Managers, Field Manager, Grounds Department, Various UW faculty and staff)	Guide~~s~~ long term planning and specific types of implementation decisions

The UW Division of Facilities Planning and Management (FPM) is responsible for the ongoing management of the Preserve and to this end currently employs two full time staff, a field manager and a program manager. There is a University Governance Committee made up of faculty, staff, and students which "recommends to the University of Wisconsin administration policies and practices for the stewardship and management of the Lakeshore Nature Preserve" (Slapnick, 2006). This committee was created in September of 2000 with the charge to "ensure the integrity of these cherished campus resources through the provision of necessary and appropriate oversight, policies, guidelines, stewardship and management…any and all activities proposed for or conducted in the [Lakeshore Nature Preserve] that could affect [it], should be of concern to [this] committee." (Wiley, 2000). Like all university governance committees, the Preserve Committee advises the Chancellor who then generally takes the recommendations and sees that they are implemented.

Initial Decision Making Process (Pre-Master Plan)

At the start of this project, it was somewhat unclear how major decisions about the restoration and management of the East Preserve were supposed to proceed. The original vision of the decision making process was to take the broad parameters that were set out by the Preserve Committee and then have the students managers generate potential solutions, present them to the Field Manager and then to the Preserve Committee prior to implementation. Once an action was taken the results would be reported back to the Field Manager and then to the Preserve Committee (Figure 35).

Figure 35. Decision Making Tree at the beginning of the project (Pre-Master Plan).



Example of a Project that used this decision making process

When the East Preserve Project first began, it was clear that the trail system in Muir Woods had not been maintained for a number of years and that various desire lines had been created by users. It became a priority to have well maintained trails that took users to and from key locations and to remove all of the redundant and unnecessary trails. It was clear that accomplishing these goals certainly met the broad parameters set by the Preserve Committee (this was before the completion of the Master Plan) and so in the summer of 2005, the student manager and one field assistant mapped the current trail system, analyzed human use patterns and consulted faculty and staff who used the woods as to their access needs (Dr. Quentin Carpenter, Dr. Paul Zedler, Dr. Susan Will-Wolf). From this information, I designed a new trail system and temporarily flagged its route in the woods. Before any action was taken to remove or enhance trails, I consulted with the Field Manager and other potentially affected parties (lab managers etc.). I also offered tours of the proposed trail system to committee members (only 1 person participated). I then presented the new map to the Preserve Committee along with the rationale for removing or enhancing trails and the specifications for how work would be completed. The Committee approved the changes unanimously. As progress was made it was reported back to the Preserve Committee at each meeting. This same procedure was used for the first planting project that occurred in Muir Woods.

Pros to this method: Preserve Committee has direct oversight of work being conducted. Their support can be of tremendous use in the student manager’s decision and implementation process.

Cons to this method: Extremely time consuming for the Preserve Committee. It can stall student manager from taking action.

Current Decision Making Process

The decision making process changed over time partially due to the creation of a Preserve Committee Sub-committee consisting of a group of key players to make sure that I understood the directive of my project as conceived by the Preserve Committee. Originally, the group included Dr. Evelyn Howell, PA supervisor, my advisor and an ecological restoration expert, Field Manager, Cathie Bruner,, Preserve Field Manager, and Dr. Ann Burgess, retired Biocore Coordinator, active Preserve and Friends volunteer, and at the time, Preserve Committee Member. We met weekly and the Sub-committee members provided feedback on all aspects the project from starting the volunteer program to determining the initial restoration projects. Eventually, this group became a more formal apparatus of the Preserve Committee with the mandate of making sure that the work being accomplished by the student managers is appropriate for the Preserve. The group expanded to include a second academic staff member, Dr. Susan Will-Wolf, who is also a voting member in the UW-Lakeshore Nature Preserve Committee and therefore acts as the liaison between these two groups.

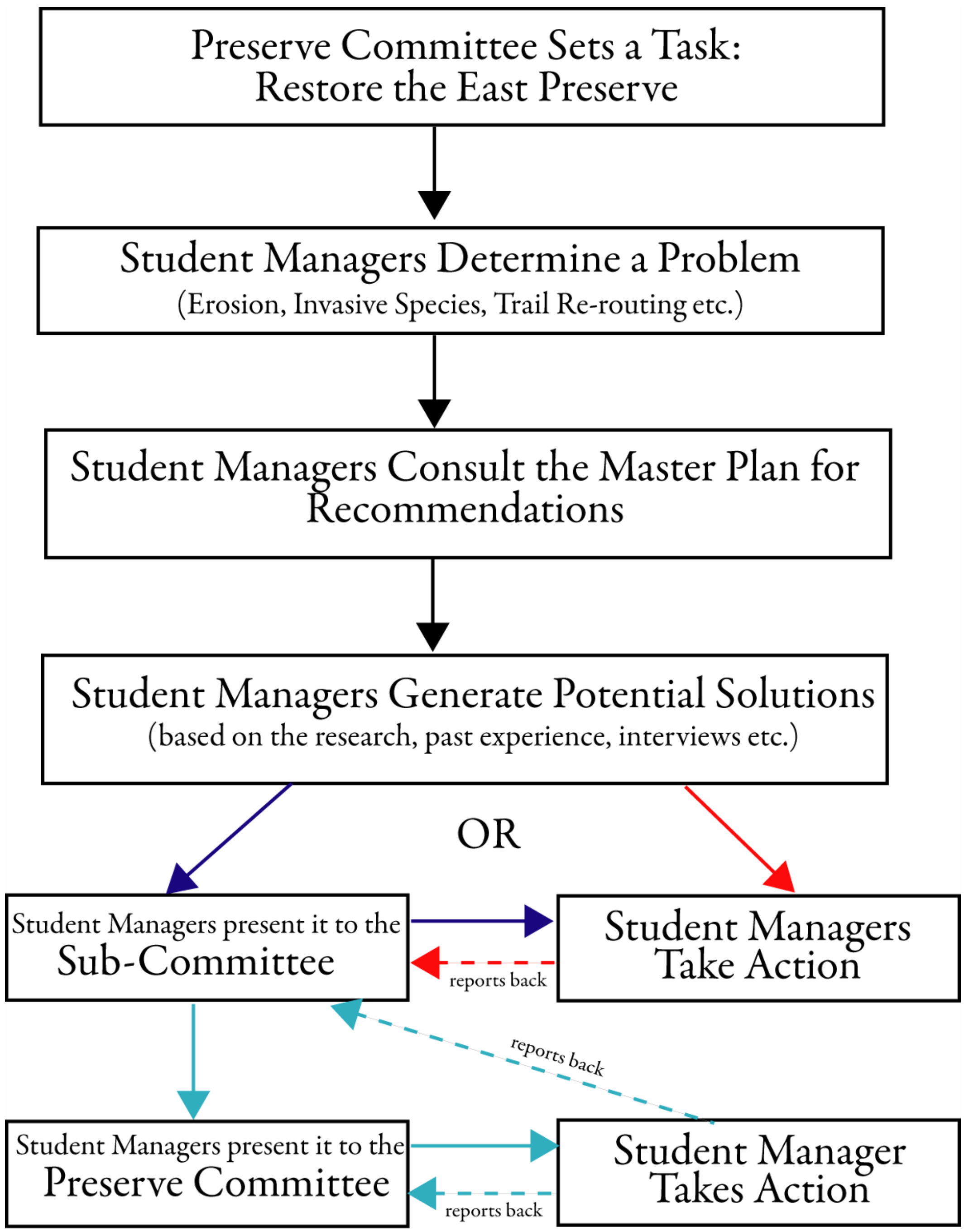
It is important to note how both the structure and knowledge provided by the Sub-committee has been crucial to all aspects of the work completed on this project. The Sub-committee meets on a weekly basis and is made up of faculty and staff with a wide range of expertise and experience all of which is relevant to the science of ecological restoration. It is important to stress that the members of the Preserve Committee, in contrast, are members of the UW-Madison community (students, staff, and faculty) with an interest in the Preserve, who may or may not have any experience with restoration.

The Sub-committee can address all of the issues that the student managers face whether that be how to mentor an intern, where to obtain a piece of equipment needed for sampling, or troubleshooting an experimental protocol. The sub-committee works for the Preserve Committee to make sure that the work being accomplished by the student managers is appropriate for the Preserve. The sub-committee model, which in many ways has been the key to accomplishing innovative projects, supervising staff and interns well, was created as a way to bridge the academic/planning aspects of the project with the on the ground implementation.

Along with the sub-committee, the finalization of the Master Plan has also led to a change in the decision making process. Prior to its existence, determining if a project would be acceptable was a difficult process since there was no “blueprint” to guide the decision making process. Now there is a document that can help the manager make decisions about physical infrastructure, desired plant communities and trail systems. Since the Committee unanimously approved the Master Plan, as long as a project is in harmony with its guidelines, it is not necessary for them to be involved other than the be made aware of projects that have occurred.

The creation and formalization of this group along with the adoption of the Master Plan has led to major decisions being made through the oversight of the Field Manager and a subcommittee with only sporadic reports back to the Preserve Committee after work had been accomplished (Figure 36).

Figure 36. Current Decision Making Tree



In this model, there are more paths to action being taken than in the previous version which may seem like the process has become more complicated than the initial decision making process, however, this system works because it allows the student managers to choose the level of support and guidance that they need. There are three paths that can be taken before action is taken:

1. If a problem has been dealt with before, for example restoring a shoreline slope that is less that 3:1, the managers can simply take action since the desired plant community has already been decided with the help of the Master Plan and the sub-committee (Red on Figure 36). The student managers will report back on any action in the weekly sub-committee meetings.

2. Novel problems are brought to the sub-committee who will then approve or alter a strategy and then the student managers will take action (Dark blue on Figure 36).

3. The sub-committee may also recommend that the project be brought to the Preserve Committee before any action is taken (Light blue on Figure 36). This happens if the student managers are recommending something that might conflict with the recommendations of the master plan or is introducing a new policy that has not been in place before. Once the committee makes a recommendation, the student managers can take action and report back to the both sub-committee and the Preserve Committee.

In all of the scenarios, the Preserve Committee is kept in the loop through regular reports of what has been accomplished at the beginning of each monthly meeting.

In this process, the oversight of the Preserve Committee has decreased because of:

- Completion of the master plan.
- Increased confidence in the decision making and implementation ability of the student mangers
- Increased emphasis on allowing the Field Manager to make day to day decisions.
- Confidence in the guidance of the Sub-Committee.

The decreased involvement in the routine restoration activities by the Preserve Committee is appropriate and leads to more work being accomplished in a timely matter.

It is still important that the Preserve Committee is kept up to date on work and is allowed to make decisions on broad policies that are being created by the student managers (for example about fences or herbicide use). However with the Master Plan, the Field Manager and the Sub-committee to guide the projects, direct oversight become less necessary and frees the Preserve Committee up to make broader Preserve-wide policy decisions.

Example of a Project that used the Current Decision Process

At the beginning of this study, each project was brought to the Preserve Committee to justify what our plans were for the East Preserve. At this point, decisions are most often made with the approval of either the Sub-committee or without any oversight. For example, on a complicated project, like the planting density study, the Sub-committee helped analyze the protocol, design the experimental setup and select the plants used for the project. For a simpler project, like transplanting herbaceous plants from the Limnology Garden to eroded slopes of Muir Woods, we simply checked in with the Field Manager to confirm that the species that we wanted to take did not interfere with her vision for the garden. For projects where we have already set out the general plan we often do not consult with the Sub-committee at all. The Sub-committee spent time on the trail system map and now any work to achieve the goals laid out in that are taken care of. If a new desire line appears, we will simply take the action to cut up some brush to block the path and simply report this back to the Sub-committee. This increased autonomy has greatly sped up the process of getting things done in the field, but could not have been achieved without the steps of receiving guidance as our general policies and restoration philosophies were defined.

Pros to this method: Fairly streamlined and can allow a project to start soon after it is conceived and planned. Faculty and key Preserve staff have the opportunity to guide any large project that is going to occur. This method puts the day to day running of the Preserve in the hands of the Field Manager and the student managers.

Cons to this method: The Preserve Committee is not made aware of potentially major projects until after they have started or are complete.

Breakdowns in the Current Decision Making Process

However, there are many examples of when this decision making process is not utilized. One of the most common and most problematic examples is when action is taken in the East Preserve without alerting the student managers (a tree is taken down, an area cleared, a capital project is planned and/or started) and the managers must respond to that action and often times be responsible for its consequences. Often, after the action is taken by the outside party, the student managers will be responsible for the next steps of the management of the site so they must determine a plan or plans of action and bring them to the Sub-committee before starting. Many times, the action is taken because there is a safety hazard, or a capital project obtains funding. In these cases, action must be taken, but the student managers should be made a part of the process as much as possible.

Pros to this method: None. Often it is necessary for other groups to complete work in the East Preserve, but other than in emergencies (a tree across a path etc.), the student managers should be brought into the loop.

Cons to this method: Decision making is taken out of the hands of Preserve staff and the student managers. This process can result in project of lesser priority being work on.

The issue of major decisions or action being taken without alerting the student managers has been a significant problem throughout this process. One of the most striking examples was the clearing of six openings along Lakeshore Path (see section on differing visions for an outline of this conflict). It happened again recently with the initiation of the bidding process for the stormwater project occurring below Parking Lot 34. Initially, the students were not aware of this occurring and as a result the initial plant list was inappropriate for the site (not all natives, seed provenance unimportant etc.). If they had been brought on board earlier, there would not have been the need for a change order to go out on the bid. This lack of communication continues and can be described as symptomatic of four things:

1. Lack of legitimacy of the student managers – In order for this model to be successful, the Preserve stakeholders have to perceive the student managers having authority over the decisions of the land that they manage.
2. Lack of institutional understanding of the student manager position
3. Lack of confidence that the student managers would take action in the desired time frame and at the desired scale.
4. Lack of legitimacy of the restoration process selected by the student managers – The process of completing a site inventory and analysis and making a plan as part of restoration has not been accepted by all – there is a vocal minority who wants the land cleared and replanted immediately.

Student managers must make decisions that both follow the guiding principles and mission of the Preserve as laid out in the Master Plan and make the decisions that best live up to them and the goals and objectives set out for the restoration. However, if decision and actions are taken by others that are unaware of these priorities, the system does not work. This particular problem is not unique to the student manager, there are times when the Field Manager has not been made aware of an upcoming project and therefore cannot alert the student managers because she herself was unaware of what was going to occur.

While the student managers have had increased autonomy through the course of this project, it cannot and should not be expected that all of the ideas that they generate are welcomed or approved by all of the interested parties. For example, soon after the shoreline areas were cut, the student manager began consulting with the new landscape architect for the Campus Planning Department. At first, we each had different priorities for the site – hers included issues of safety and views whereas the student manager and the Sub-committee were more focused on stormwater management and appropriate plant communities. In many ways, the decision to restore this area to a savanna community was a compromise that encompassed all of these concerns.

However, the process is not always this smooth. When the student mangers wanted a partially fallen willow removed from Slope 6 to allow more light and make the restoration process easier, assistance from the experts in the Grounds Department was needed to remove it. The Grounds Department decided that it was more appropriate to leave the tree since it provided visual interest, and would sprout profusely if cut. We had to accept their decision and could either leave the site as is determining that without the removal that restoration was not possible, or modify our plans and restore around and below the tree. We chose to plant around the willow with the hope that the new plants will survive and become established by the time the tree falls, creating the conditions we would have preferred. This decision was based on wanting to continue our mostly agreeable relationship with the Grounds Department, a deference to their knowledge about tree management, and the fact that compromising was not going to force us to abandon any of our restoration goals.

In general the current decision making process works well, because it is flexible, builds on the Master Plan, allows the student managers to receive regular guidance from a sub-committee made up of restoration experts, and allows actions to be taken quickly as precedent and expertise increases.

Different Visions for the Lakeshore Nature Preserve

Another key theme that I noticed was how often different visions for the Preserve affected our work. There are various stakeholders with opinions about how the Preserve and specifically its eastern portions should be managed. They include:

1. The UW-Lakeshore Nature Preserve Committee
2. The East Preserve Sub-Committee
3. UW Lakeshore Preserve Staff: The Preserve currently has two full time staff members. Cathie Bruner, the Field Manager, and Daniel Einstein, the Program Manager.
4. Grounds Staff: The Grounds Department has its own responsibilities in the Preserve including care of hazard trees and also assisting in the restoration work including removal of large trees, providing vehicles and storage space, fence installation and technical guidance.
5. Department of Facilities Planning and Landscape Architecture: This department is responsible in the implementation of the Campus Master Plan and coordinates site and landscape architecture planning and ADA accessibility issues.

6. Donors: Both directly and indirectly, the people who have given the money to fund projects in the Lakeshore Preserve do play a role in the decision making process.

7. Faculty, Teaching Assistants and Staff who utilize Muir Woods and Lakeshore Path for their classes: Since this land was preserved as a laboratory, those who use it in that capacity have some say in certain decisions that must be made.

8. Friends of the Lakeshore Nature Preserve

9. Preserve Users and Volunteers.

The members of these groups have different opinions; the most vocal opinions can be characterized thusly:

Table 8. Stakeholder Visions

Group	Vision for Preserve
Preserve Committee	Support the vision as laid out in Master Plan, however often individual members have particular projects that are of interest to them (dogs, biking, teaching etc.)
East Preserve Sub-Committee	Emphasize that the Preserve is a place that provides opportunities for teaching and learning and that is managed in an ecologically sound way.
Preserve Staff	Believe that activities must balance all of the other interest groups, focus on education, ecology and user experience.
Grounds Staff	Follow the lead of Preserve staff. Emphasize public safety and, due to how short staffed they are, projects that do not require additional work on their part.
University Depts. of Facilities Planning + Campus Planning	Focus on the user experience, aesthetics, safety, stormwater management
Donors	Vision of donors can vary, but often feel empowered by their donation to demand their vision (see text for examples). Donor visions can be at odds with those of other groups.
Faculty, Teaching Staff	East Preserve as laboratory, space for teaching.

Friends of the Lakeshore Nature Preserve	Mission statement includes goals about biodiversity, education, appropriate use, and financial support. Vision of most members is to help the Preserve financially and through volunteering by following the vision of the staff. However, there is a vocal minority whose vision is that this land must be rescued by any means necessary and that action must be taken quickly to save it from what they believe to be the greatest threat: invasive plant species.
Student Volunteers	Preserve as a place where they can get involved with the environment, do physical work, and connect with others.

Almost of these visions can be implemented by the field staff; however, all cannot be embraced in all projects.

Sometimes these conflicting visions can lead to actions being taken that the manager would not have advocated for or would have completed in a different manner. In December of 2005, the Grounds staff opened up six views of the lake along the path by removing the shrub layer in 6 sites that had been so designated in the Master Plan. Most of the shrubs in questions were invasive exotics (honeysuckle and buckthorn) so this action was consistent with the restoration goals. However, the restoration protocol when shrubs are removed calls for the implementation of erosion control techniques and, usually revegetation. The clearing took place with no prior planning for these actions and took the student manager, who was not made a part of the decision, by surprise (see the Shoreline Stabilization in Chapter 7 for a description of the restoration process for these sites). Grounds staff completed this work under the directive of the Associate Vice Chancellor in charge of Facilities Planning and Management along with input from the head of the Grounds Department and the Preserve Field Manager. The responsibility for restoring these areas fell under the student manager who was not made a part of the decision to clear these areas. There was no plan in place for what to do with these sites once the invasives were removed and the views to the lake open even though clearing them could lead to increased erosion of the shoreline. The end result of this action wound up being positive since it sped up the process of starting the shoreline restorations, however, the locations of the sites, timing, and technique of these removals were not discussed with those expected to restore the newly altered landscape. For those without experience with hands on restoration, the act of creating a view may seem like a simple task. To the managers, the issues are much more complex – how should the site be stabilized, what plants should be placed there and are they available from nurseries, should there be an access point, what type of view should each site have. This is not to say that the other parties are ignorant of these issues, however they may underestimate the amount of planning and work that they take.

Conflict has also arisen between the donors and the student managers/sub-committee due to different visions for the Preserve. In this project, interaction with donors has been minimal and their concerns, if they had any, have not been brought to the student managers. However, the potential for conflict is playing out in Tent Colony Woods, another site managed by the same team of students that currently manages the East Preserve. Here the main donor, along with some vocal members of the Friends of the Lakeshore Nature Preserve would rather see restoration work happen quickly, with less of an emphasis on adaptive restoration than is currently planned.

They want restoration done in a highly visible way that will show other donors that their money is being used in a positive way. Their assumption is that the best way to restore this site is to go in and remove all of the invasive plants, add some additional native plants and then weed and water the site. Furthermore, they seem to feel a sense of urgency and that waiting any longer to start this process is putting these sites in further danger for loss of biodiversity and as habitat. This model has been working for them in the Frautschi Point area of the Preserve, but less well in Bill's Woods where the clearing of invasive species has left room for a carpet of small invasive seedlings. At this point, this model is seen as being in direct conflict with the assumptions of the student managers and the overall mission of the Preserve. We feel that there are many unknowns about how best to restore these areas and that further information is needed prior to starting a project to help guide choices and that information should be collected throughout the process to make appropriate changes. The assumption is that through taking the time to do this, the restorations have a higher chance of reaching their goals in both the short term and in the long run, and of providing information that can help guide other restoration projects.

This type of conflict is understandable and should be dealt with head on with the goal of educating the donors about why we have chosen the methodology we have selected and perhaps reaching somewhat of a middle ground. The Preserve is moving away from allowing people to donate to specific sites for this very reason – the Field Manager, not the people who give money or who are active volunteers, should be making decisions about restoration priorities.

Decision to use Student Managers

Until this project started, most of the management in the Preserve had been conducted by University staff or paid contractors. Several students had been hired as hourly employees, and in certain areas a tremendous amount of labor had been completed by volunteers.

Multiple class projects had been responsible for writing restoration and long term management plans for parts of the Preserve, but little of this had actually been implemented. This project took the novel approach of hiring a student (and eventually a second student as well) to do both long term planning and short term implementation for a particular site, giving them more responsibility and autonomy than previous student hires.

The idea for this project started after a plan for the East Preserve was written as part of a 2004 Restoration Ecology course. This plan, which I co-wrote, included some specific recommendations that could be carried out immediately (trail system upgrades in particular) as well as starting points for many other projects. There was some money that had been donated by the UW-Madison Class of 1963 for the restoration of this area and so the timing was good for taking aspects of this plan and building on it as well as starting some of the restoration work it described. The idea to build this into an education experience for a graduate student was generated by Cathie Bruner with the support of Dr. Evelyn Howell and others.

Hiring a student to do this work made sense when one looks at the mission of the both the University and the Preserve. Having students manage portions of the Preserve is in line with the overall mission of this land since one of the guiding principles states that "management priorities that maximize education[al] benefits" should be established (The UW-Madison Lakeshore Preserve Committee, 2005). Furthermore, the Preserve is part of the University of Wisconsin which has a mission statement that declares that

> "the primary purpose of the University of Wisconsin–Madison is to provide a learning environment in which faculty, staff and students can discover, examine critically, preserve and transmit the knowledge, wisdom and values that will help

> ensure the survival of this and future generations and improve the quality of life for all" (University of Wisconsin, 1988).

Simply put, this land should be a place where members of the University community expand their own knowledge and the body of knowledge about ecological restoration and urban land management. One way to meet these goals is by having students at the helm of these projects. This arrangement is in many respects analogous to hiring a student (or post-doc) research laboratory manager. In this the case, the "lab" is highly visible and shared with many members of the University Community.

The patterns revealed by the case study have made several other advantages to hiring student managers apparent:

- Graduate Students are connected to other students – Although this may seem as though it is a minor point, it has been one of the keys to success of the project thus far. Through being connected to other students, the student managers are able to recruit volunteers, find out which class sections might be interested in volunteering, know a wide variety of students whose research might be of use to the project, and relate well to the students that become involved. This is not to say that a non-student could not accomplish all of these things, but it is a much easier task for a student than for someone who is not directly connected to the student population. In the short run, students provide relatively cheap labor (often free), creative ideas and enthusiasm, in the long run, experience in the Preserve connects the student to the University for life. This connection may lead to both political and financial support for this land in the future.

- Graduate Students have advisors and faculty and academic staff who are directly connected to their project and offer technical assistance.

- It is easier to create a new project assistantship than a new permanent staff position at the University due to the process for allocating funds to fulltime staff (Cathie Bruner, personal communication, 6/19/07).

- Graduate students who are intensively focused on small pieces of the Preserve as part of their educational experience are extremely likely to make recommendations based on detailed site inventory and analysis and design restoration projects that are adaptive and include experimentation that may provide valuable information. This is not to say that a paid academic staff member would take actions that are haphazard or not well researched, but since students will most likely see this work either as their masters research or an extension of it, they are likely to integrate some of the more academic aspects of restoration which is exactly what should be occurring at a university.

However, it was not easy to get the donors and some faculty and staff on board to use the money to not only pay a project assistant salary but to also pay for student labor for the implementation. In many cases, the critics of using students feel as though paying a contractor to complete the work as dictated by the Field Manager and/or Preserve Committee is the ideal path due to the perceptions listed below:

- Short term commitment of students – a Project Assistant (PA) is likely to remain on a project for only two or three years.
- Expense – Employing graduate students as PAs is becoming exceedingly costly.
- Legitimacy – Fulltime staff members may be perceived as more professional, knowledgeable and committed than students. On multiple occasions, it has been made clear to me that certain staff members feel as though students never complete the projects they start and often leave the long term management and maintenance to staff members. There are other assumptions about lack of experience. These perceptions are powerful and it is important that work is done to alter them and not live up to them.
- Pace of Work – If it is decided by the Preserve Committee or staff that clearing invasive plants at a rapid pace without site inventories, experimentations and careful monitoring is a priority, then it is likely that simply hiring consultants who will come in and do rapid brush removal and replacement will conduct this work more quickly and effectively than student teams.

These are valid concerns and there certainly are some projects that will be better served by hiring additional staff or contracting out the work. This project shows that students are effective at getting other students involved, getting projects completed, and providing plans to protect and manage the land over time.

Recommendations based on the Case Study

Over the last two years, much has been learned about the process and types of personnel involved in implementation of restoration in the UW-Lakeshore Nature Preserve. While it seems clear the current structure has been met with success, there are certain conditions which need to be maintained for this model to work well.

The student managers must be given certain legitimacy by the University Divisions with which they must interact, most notably the Grounds Department and Campus Planning. At this point, legitimacy was granted fairly easily from the Preserve staff and Preserve Committee.

One of the easiest ways to gain legitimacy is to earn it, by demonstrating knowledge, follow-through and high quality work. This project has hopefully taken some steps in earning legitimacy for student managers. However, this is precarious because the money is running out for the continuation of the project in the East Preserve. If the work that has been accomplished is allowed to enter into disrepair and the newly restored shorelines become dense weedy thickets again or the trail system becomes a maze of redundant paths, the legacy of student work in the Preserve will be tarnished and the only successful student projects will be thought of ones that are managed by staff (i.e. Biocore Prairie).

Furthermore, the model of having student managers must continue so that they are considered important to the management process and are not excluded from important decision making processes such as capital projects that overlap their work sites. If there are large gaps in between student managers, permanent staff members will be less likely to see student managers as key players in the restoration of the Preserve.

I am not suggesting that all work in the Preserve should be planned and completed by students. Some projects are better suited to be planned by the University Landscape Architects (for example, projects that involve heavy bioengineering, or other major alterations to the physical conditions of a site) and others require a level of skill that is better conducted by the Grounds Department (for example large tree removals). Also, many of the projects that will be planned and implemented by student managers should eventually be turned over to Preserve staff for routine maintenance. This will include occasional weeding, watering during droughts, trash pickup, thinning of shrubs that are blocking views etc. The hope would be that many projects could be turned over after they meet the restoration goals that have been set and the project switches to the management phase.

Another type of legitimacy that has yet to be earned is for the restoration process that has been created. As outlined in the implementation plan, there are important steps that must be taken alongside and before restoration begins. Rather than just stick with the usual paradigm of removing an area of invasives and then either relying on the seed bank or adding native plant stock, this project used the model outlined by Professors Harrington and Howell in their restoration ecology class. The hope is that through a detailed site inventory, historical analysis, setting up experiments, and documenting what we have done, not only will this project have the greatest chance at meeting the goals and objectives laid out, but it will provide valuable information about this type of project as a whole from ideal planting densities, which plant communities have the greatest chance of establishment, and methods for tracking changes in a site over time. At this point, this process has yet to be embraced by some of the more vocal members of the Friends of the Lakeshore Nature Preserve. There is tremendous pressure to just go and make the site look different. The goal must always be for the student managers to value getting work done throughout a restoration project, but not to bow to the pressure of simply taking action to appease critics of the selected restoration process. Hopefully, the restoration of the East Preserve will serve as an excellent advocate for the selected methods and make at least partial converts of its critics.

If these issues of legitimacy can be addressed, the student mangers should be able to continue managing their assigned areas smoothly and help the Preserve and University achieve important aspects of their mission. However, these are not easy aspects to tackle since institutions and departments are slow to change.

Conclusion

The three most explicit patterns that were made clear through my analysis of my blog, have all had great effect on the restoration and planning process in the East Preserve. The process of modifying the decision making process into something at allows work to be accomplished effectively with the proper amount of oversight has demonstrated a model way of setting up future projects in the Preserve regardless of if student managers are used. In particular, the formation of the sub-committee, which meets regularly and is made up of relevant experts, should be considered for all future projects. Not only does having regular meetings with the sub-committee help guide project managers, it frees the Preserve Committee to focus on broad policy decisions (use of herbicide, the dog policy etc.) during their monthly meetings, which is more in keeping with the mission of this group.

Furthermore, the analysis of the decision making process and how it has evolved over time demonstrates that the current system is working well, but more work needs to be done to make sure that it is not bypassed and action taken without consultation with the field and student managers. The current process makes sure that the student managers have appropriate oversight and guidance by faculty and staff, but still allows them the ability to guide the projects. They should have this autonomy since they know the issues facing the land as well as anyone and know what they themselves and their crew and volunteers are capable of. Furthermore, this leadership opportunity greatly increases their learning and skill development, another important aspect of this program.

While at this point, there is no resolution to the fact that there are many groups with conflicting visions for the Preserve, it is key for future project managers to be aware of the political situation that can come into place when undertaking any restoration in the Preserve. Work should be done to better integrate these visions and to educate and collaborate with those who visions are in direct conflict with the Master Plan or current management.

This case study demonstrates that this pilot project of hiring a student to manage a particular area of the Preserve is a viable option that has many benefits and fulfills many of the Preserve and University goals. Certain aspects of this model have been successful because the manager is a student, but other aspects (the sub-committee, having staff members focused one area of the Preserve etc.) could occur if additional staff (limited term or full term employees) are hired for the Preserve.

General Recommendations

1. Students have the potential to make excellent managers of campus protected areas.
2. Have a clear chain of command and decision making processes in place for the student managers.

3. Documentation of the restoration is important and time should be built into the daily schedule so that work can be tracked and continued even as students finish their role in the project. The focus on this will make the transition between student managers easier and increase their productivity and the likelihood that the programs created continue to improve.

4. Student managers are responsible for many types of decisions from budget formulation to determining a planting density. The guidance of a sub-committee that meets weekly and is made up of members with a wide range of knowledge and experience provides the greatest likelihood that the students will be able manage all aspects of these projects.

5. Stakeholders should be included in the formulation of the goals and objectives for a site, both so their input can be integrated, but also so they can get a more holistic sense of what goes into a restoration project.

6. The student manager needs to have clearly defined responsibilities. These should be enumerated clearly to both the manger and to the other parties with which the manager will interact with on a regular basis. This will ease many of the minor conflicts and misunderstandings that have occurred during the course of the project. Long term permanent staff should play a critical role in facilitating this process.

Chapter 6. Logic Model for the Student Outreach Program in Muir Woods

The importance of volunteers in ecological restoration projects has been well documented (Ferguson, 1999, Ostergaard, 1998). Volunteers can play an important role in the regular management and maintenance of a site, participate in monitoring, and aid in the overall stewardship of a piece of land. The use and management of volunteer labor has been a critical component of the restoration of Muir Woods. Two of the initial goals of the project are to increase student awareness and involvement in the Preserve in general, and specifically in Muir Woods. This type of work has value on a deeper level than just providing bodies to complete tasks. It leads to people wanting to protect the sites where they work and to develop an increased land ethic (Light, 2004). The hope of the stakeholders (users, Preserve Committee members etc.) is that a passionate student body involved in Muir Woods will work to continue the restoration of the land and ensure its protection over time. Even though there is tremendous value in using volunteers, for many restoration projects it can be a challenging process to successfully recruit, train, and design suitable activities for those willing to lend a hand (Grese, 1999).

In Muir Woods our challenges have been to determine which projects are a good fit for the overall restoration goals and are appropriate for the interested parties. For a narrative description of all of the volunteer programs we have created, please see Chapter 3. To date we have had few problems recruiting and training volunteers.

It is crucial to make sure that we have a clear set of goals and way of evaluating the extent to which the volunteer program that we have designed is meeting the goals we have set. Too often the desire to get people involved causes managers to forget the important process of questioning whether or not time spent training and managing volunteers serves the overall restoration goals. This is a tricky process – teasing out the delicate balance between successful public involvement and the need to complete projects that advance restoration goals.

As the person in charge of creating and implementing the volunteer program in Muir Woods, I have used logic models, a tool for program planning and evaluation, to guide the use of volunteers within the context of this project and to evaluate the volunteer program that has been developed. Logic models will serve to guide future Preserve managers in both decision-making and evaluation of their work in public outreach.

The restoration planning technique described by Drs. Howell and Harrington, provides a clear method of evaluating our success at reaching our biological restoration goals; however, a parallel method for evaluating the social components of the project is also critical. We needed to select an evaluation method that can assess how well our program is working and allows us to create an iterative process for adaptively managing our volunteer program. Logic models are a tool commonly used by social service agencies and other non-profits that can serve a program in both the planning stages and the evaluation stages. This makes them an ideal choice to use in the creation and evaluation of volunteer programs in Muir Woods (Julian, 1997). While there are many methods of program evaluation, the logic model approach is well suited for this purpose because it creates,

> [a] frame work that organizes a program and shows planned results. It helps programs stay on target and recognize whether they are veering off course. Thus, logic models generally lead to more effective programs…and clearer knowledge about what works as well as what does not (W.K. Kellogg Foundation).

Since the East Preserve Project is still in development, this tool, which is useful for both evaluation and program planning, and will guide the evolving volunteer program toward meeting its goals.

Although there are many different ways of setting up a logic model, I used the framework set up by the University of Wisconsin Extension's Division of Program Development and Evaluation. Other models include those developed by the Kellogg Foundation, the Free Management Library, and the Harvard Family Research Project. (*Family Involvement Project (FIP) Logic Model, Logic Model Development Guide* 2004, McNamara, 1997). I selected the UW Extension model because it is provides templates and tools for creating a model suited for a particular project, includes a tutorial, and the authors of the model are headquartered locally which means they are available for feedback and guidance if needed (Taylor-Powell, Steele, & Douglas, 1996). This model contains five key components:

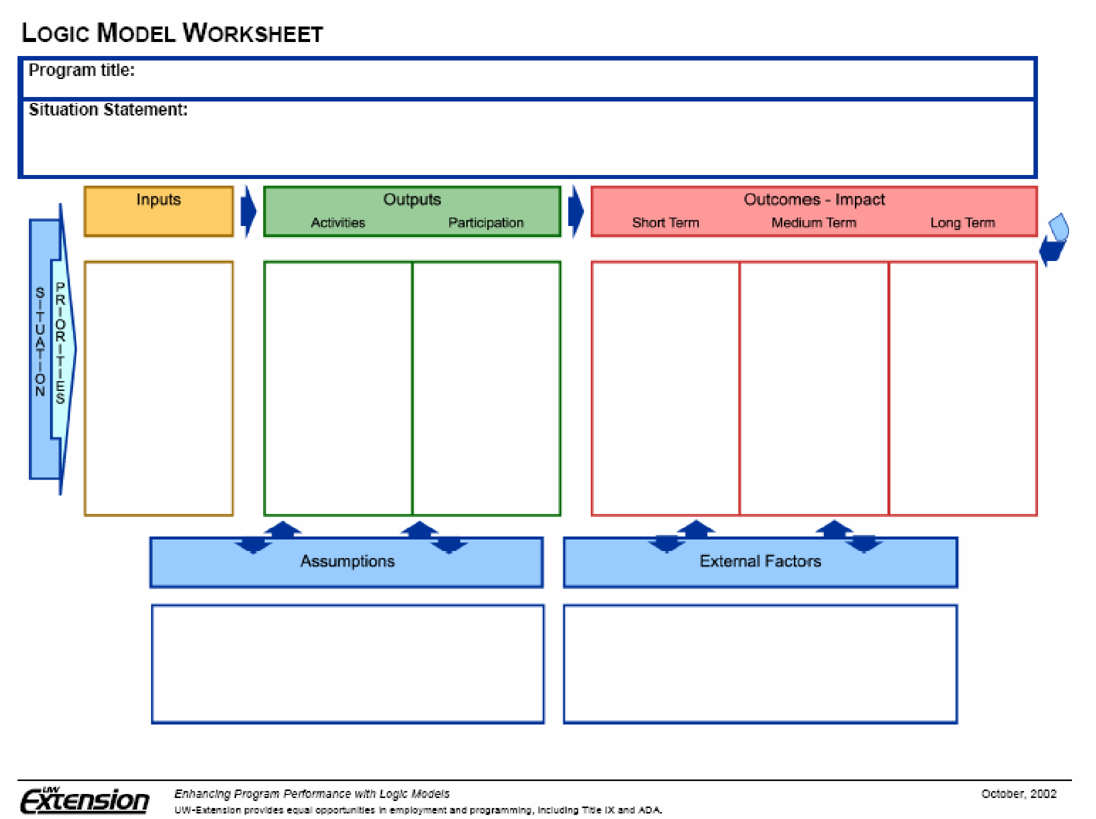
1. Inputs – resources, investments etc. that go into the program
2. Outputs – activities, services, events
3. Outcomes – results
4. Assumptions – prior beliefs we have about the program, people involved and the way we think the program will work
5. External Factors – outside forces that can affect the program

(Taylor-Powell et al., 1996)

Essentially, a logic model is a systematic way to show the relationships between these five components.

I used the following template to design my logic models:

Figure 37. UW-Extension Logic Model Worksheet (from Taylor-Powell et al., 1996)



One of the trickiest aspects of evaluating this project is that my position as the current manager renders my understanding, and my vested interest in this evaluation to not be as detached or as objective as that of the traditional evaluator. My goal is still to be "a seeker of fact and understanding who aims to produce a valid report on the program – its inputs, processes and/or outcomes" and to do so without become biased with "views, hopes, or fears" (Weiss, 1998, p.98).

While there are many different aspects of the East Preserve Volunteer Programs that could be evaluated using this tool, I decided to focus on one in order to outline the process for using this as a tool for evaluation. The study investigates the use of UW-Madison students in Muir Woods.

I selected this aspect because the major emphasis of our volunteer program has been working with current UW students and as a result, we are very interested in evaluating the degree to which we are moving in the right trajectory to achieve our long- term goals.

By generating a series of these models in the graphic format shown above, it will become possible for me and future managers to clarify:

1. That our activities are leading to our desired outcomes,
2. That our program is staying on target,
3. How to make mid-course corrections, if needed.

Student Outreach Logic Model

For the sake of this model, we consider student outreach to include activities with UW students as volunteers, paid positions, unpaid interns, researchers, and students who utilize the Preserve at all, either through classes or independently. The greatest focus to date has been on volunteers, student researchers and hourly staff.

In the next few pages, I provide a brief definition of each of the model compartments, an explanation of the components of the model as I have formulated them, as well as a preliminary assessment of whether or not we are achieving our desired outcomes. The components of the model are based on prior experience leading restoration projects that have a volunteer and/or student component, brainstorming sessions with the East Preserve Sub-

Committee, the body of literature on volunteer management, analysis of the goals of the current Lakeshore Preserve Master Plan and lessons learned in the process of creating this volunteer program.

Muir Woods Student Outreach

Situation Statement: Muir Woods, a seven acre forest in the heart of the UW-Madison Campus, has been degraded due to lack of management, inappropriate use, and urban pressures. Muir Woods has been protected as a laboratory and with restoration and long term management can better serve this end goal. It can also provide respite and interaction with the natural world in an area that is easily accessible to a wide variety of students, staff, faculty and community members. In its current state, many people are unaware of its existence, only a small subset of faculty use it for teaching and it is not inviting for use. Since June 2005, there has been renewed interest in this parcel of land. Graduate students were hired to being planning and implementing the restoration and involving volunteers in this process. There has been money, staff, and time put towards making Muir Woods more ecologically diverse and more useful for teaching, research, outreach, and recreation. It is important that the current activities are evaluated to determine if they acheiving desired outcomes.

Inputs

- Knowledgeable Staff
- Funding
- Institutional Support
- Tools/Equipment
- Research and Best Practices
- Partners/Advocates (Faculty, Community Members, other professionals)

Outputs

Activities

- Volunteer days that are advertised widely to the general student body.
- Tours/Volunteer days aimed at students newly arrived in Madison.
- Tours and Class to relevant courses and student groups.
- Volunteer days that are directed towards students groups that are connected to the Preserve.
- Provide mentorship to the Students of the Lakeshore Nature Preserve
- Internship Supervision to undergraduates as part of Independent study , URS, capstones etc.
- Gather impressions from students about the resources available in MW.

Participation

- Students that are new to Madison
- Students in Classes that utilize Muir Woods
- Members of Students of the Lakeshore Nature Preserve
- Student Researchers
- Casual Users of the Preserve

Outcomes - Impact

Short Term

- Develop standard tour that can be modified and given to a wide variety of students.
- Existence of Student Group
- Develop Criteria for what types of projects are conducted by which types of volunteers.
- Develop a go-to list of volunteer and research projects that are appropriate for students.
- Regular volunteer opportunites widely publised to campus community.
- Identify faculty, courses, student groups, online calenders, bulletin boards etc. that are appropriate for finding volunteers, staff, and student researchers.

Medium Term

- Give tours with minimal planning.
- Self Sustaining Student Group
- Interested and appropriate students are found for tasks. Planned activities are a good fit for students
- Post opportunities on EE calender, to list serv, appropriate classes
- Have wide variety of faculty aware of programs/opportuntites in Muir Woods. Faculty refer students and generate labs/activities that are conducted in Muir Woods.

Long Term

- Have all incoming students know about Muir Woods and what goes on there.
- Framework in place for keeping students involved in the Preserve.
- Students want to return as volunteers/student workers and/or researchers.
- Muir Woods is used a laboratory.
- Students are assisting in getting critical work done in the woods

Assumptions

Donors will continue to be interested in funding students.
Students/Professors will be interested in using Muir Woods as a place of learning/volunteering.
Projects of importance will be able to incorporate volunteers/students.
Staff who are interested in working with students are hired.

External Factors

University Policies on PAships etc.
Funding
Liability Policies

Situation Statement

The first step in creating a logic model is generating the situation statement. This communicates the relevance of the project and provides an overview of the project including a list of the stakeholders and a statement of the problem being tackled. The situation statement can be used in both program creation and evaluation. This tool serves to provides a baseline for determining if a program has reached its intended audience and if it has provided the overall contribution as intended (McCawley). The situation statement for the Muir Woods Student Outreach Logic Model describes the problems facing the land, its current use, and the current management structure:

Muir Woods, a seven acre forest in the heart of the UW-Madison Campus, has been degraded due to lack of management, inappropriate use, and urban pressures. Muir Woods has been protected as a laboratory and with restoration and long term management can better serve this end goal. It can also provide respite and interaction with the natural world in an area that is easily accessible to a wide variety of students, staff, faculty and community members. In its current state, many people are unaware of its existence, only a small subset of faculty use it for teaching and it is not inviting for use. Since June 2005, there has been renewed interest in this parcel of land. Graduate students were hired to being planning and implementing the restoration and involving volunteers in this process. There is has been money, staff, and time put towards making Muir Woods more ecologically diverse and more useful for teaching, research, outreach, and recreation. It is important that the current activities are evaluated to determine if they are moving the project forward.

It is difficult to evaluate the situation statement before we are able to evaluate any of our long term and most of our medium term outcomes. At this point, the situation statement serves the purpose of helping program staff to determine if activities and outcomes will move the project towards the appropriate goals.

Inputs

Inputs are the resources that need to be invested in a program for it to occur. They can range from tangible resources such as staff, funding, and facilities to more intangible resources such as knowledge bases (McCawley). For this Muir Woods project, inputs include:

- Continued funding
- Institutional support,
- Proper tools/equipment,
- Knowledgeable staff
- Program infrastructure.

If any of these resources were to disappear, it would be difficult to run a successful volunteer program.

To evaluate the inputs, we must look at the program since its inception and determine if the necessary resources were directed at the program. For some of the inputs this is a straightforward process. For example, as of November 10, 2006, over $7,000 dollars had been spent on equipment, training, and plant materials for this project with ample money remaining in the budget. Currently, budget constraints have not been a factor in the project. We have been able to obtain all of the tools and supplies that we need to run the current student program. However, much of the current funding stream that supports this program is going to run out within next year. In order for the project to continue, additional funding will have to be allocated to hire staff to run volunteer days, give tours, supervise interns and to provide suitable supplies for these projects. This shift in funding could greatly alter the success of the student outreach program in Muir Woods.

In terms of staff input, students paid by the hour have spent over 657 hours (at a cost of approximately $6,700 dollars) working on a variety of tasks, some of which relate directly to the volunteer program. In June 2005, I was hired as the first Project Assistant (a graduate student who receives tuition remission, benefits, and a stipend for the completion of a specific project, referred to as PAs from here forward) to work twenty hours per week to run the restoration of Muir Woods and Lakeshore Path. In September of 2006, Lars Higdon, was hired as a second PA to work with the current project assistant on projects in Muir Woods as well as expand the scope of management to a separate woodland elsewhere in the Preserve.

It is difficult to remain objective as an evaluator in some categories more than others. For example, as one of the staff people hired it is difficult for me to objectively determine if the staff is knowledgeable, but the record of outcomes will hopefully provide this type of insight. Certainly, both PAs have multiple years of experience conducting restoration projects with the assistance of volunteers and interns and both met the criteria set out in their respective job postings. To confirm that these staff members are a good fit for the program a more formal review structure should be implemented.

Although we have been successful in finding knowledgeable staff and securing funding, we have not focused on seeking out and conducting research on the best management practices of working with student volunteers and researchers. We have used prior personal knowledge and very infrequent meetings with UW-Madison Arboretum staff who also utilize volunteers in ecological restoration. We have used time spent on research and meeting with other practitioners to study restoration techniques and practices, rather than focusing on working with students. While these experiences certainly affect the volunteer experience, there is much to be learned about the best techniques regarding training, recruiting and building a knowledgeable volunteer base. In the future, it would be beneficial to read literature and attend conferences that focus on working with volunteers. Both the Morgridge Center for Public Service and Dane County United Way are local agencies that provide seminars that may be relevant. Also, setting up at least semi-annual meetings with staff at the Arboretum could increase institutional learning about the best ways to work with volunteers.

Outputs

Outputs are what a program does and who it reaches. Outputs are not the same thing as outcomes – inputs produce outputs which lead to outcomes. It is important to describe outputs because they "allow us to establish linkages between the problem (situation) and the impact of the program (intended outcomes)" and also "constitute a bridge between the problem and the impact" (McCawley). In the UW-Extension model, outputs are broken up into two separate categories, activities and participation. Activities include events, experiments, incorporating feedback, or generating feedback (Taylor-Powell, 2005). Participation refers to who will participate in the program and may include the public, key stakeholders, policymakers, and current program users.

Outputs: Activities

In Muir Woods, there are a variety of activities that will enhance the UW student connection to Muir Woods, the Preserve, and greenspaces in general. They range from staff informally collecting impressions from students about the resources available in Muir Woods to running volunteer days and tours for different target groups. Those listed in the logic model are not comprehensive, but are examples of the types of activities that should be offered. To evaluate an activity, we must look at whether they are leading us towards our desired outcomes (Taylor-Powell et al., 1996).

Rather than evaluating each of the seven activities enumerated in the logic model, I will focus on activities that relate to the newly formed student group, Students of the Lakeshore Nature Preserve, and on internship supervision. I selected these because they have been the activities on which we have spent the greatest amount of time and effort. To evaluate our success in this area, I will be looking at how many volunteers we had, how many sessions we offered, how the process of supervising interns went and the quality of these types of experiences. Furthermore, I will be investigating the specific activities and the extent to which they have occurred.

Activity: Supervising Interns

Since June 2005, the program has had four interns each from different programs. Zach was part of the Undergraduate Research Scholars (URS) a program which helps "first- and second-year undergraduates get hands-on experience in research or other creative endeavors by working closely with UW faculty and research staff" (*Undergraduate Research Scholars Homepage.*2007). He worked with us from October of 2005 until May of 2006 for 5-6 hours per week. Emily came to us as part of Professor Stanley Dodson's Ecology Internship Course (Zoology 677) which has the goals of "offer[ing] an applied, service-learning, ecology course that makes a difference for students and for the public [and] give[s] students the opportunity to put their interest in ecology into action" (Dodson, 2002). She completed 72 hours in the Preserve, of which approximately half were spent on Muir Woods related work. Aaron was a student in a capstone course for the Nelson Institute for Environmental Studies certificate program. This course is for students who want to complete an internship over the course of one semester to complete their degree. His internship was split between Muir Woods and other parts of the Preserve.

Since no unpaid intern was found for the Fall of 2006 we paid two students to complete a light meter study for us. We had tried to recruit for an intern to complete this work, but no students selected our project as part of their coursework.

In the spring of 2007, we had one student, Jo, doing research with us as part of the Biology 152 curriculum, which requires an independent project. For this project, Jo was expected to spend approximately six to eight hours a week working on her research project which occurred in both Muir Woods and Tent Colony woods. She received additional supervision from Dr. Evelyn Howell, but Lars and I supervised the field component of her project.

Each of these projects has been extremely different in terms of their programmatic expectations and the academic and maturity level of the students. In terms of evaluating if we did succeed in having interns, the answer is a qualified yes. We have done very little to seek out interns – in each of the above cases they have been referred to us via another faculty or staff member and often have not put enough analysis into if we will accept to work with the student. Perhaps in part due to this haphazard approach to accepting interns, we have had mixed success with these programs, which will be examined more deeply in the outcomes section of the logic model analysis.

Activity: Mentoring the Students of the Lakeshore Nature Preserve Student Group

Two types of activities that involved the Students of the Lakeshore Nature Preserve group were a series of volunteer days that were directed towards this student group and providing mentorship and program support to them. In my original conception of the activities that would be provided, I did not anticipate the creation of this group, but once the idea germinated, it was a natural fit for our programmatic goals. Providing support and volunteer opportunities for a self selected group of students who already had interest in the Preserve would not only provide us labor, but these students could help generate a self-sustaining group of students with interest in protecting and aiding the Preserve. While in the long run we would like to see this group rely on minimal mentorship from program staff, we would like there always to be a strong connection between this group and the restoration occurring in Muir Woods.

Since the group formed in the Fall of 2006, we have provided supervision of over fifteen volunteer work parties, all of which were heavily attended by members of the Student Preserve Group, with occasional participation by those who had to come out for a service learning or volunteer component of a class. Those ten work parties resulted in over 150 volunteer hours in the fall semester alone and over 50 volunteers. As mentors, we have provided support to the leadership of the student group, attended group meetings, and helped guide winter projects conducted by the group.

Currently, we have no way of concretely knowing the value and quality of the mentorship we are providing. It would be valuable to interview the student leaders to gauge the helpfulness of our guidance. Furthermore, our role has sometime been unclear since we want to help the creation of this group, but not become vital to its success since we want the group to be a self sustaining student organization not dependent on project assistants. As the group continues to grow and change, it will be important to clearly define the role of student managers and full time Preserve employees.

Outputs: Participation

The students we wanted to reach as part of this project in Muir Woods included students already involved in groups that are connected to the Preserve, as part of their classes, students new to Madison, students looking for internships or research experience, and students who use Muir Woods casually (runners, birders, walkers etc.).

Of the two student groups currently in existence that relate to the Preserve (Muir Woods Mentors and Students of the Lakeshore Nature Preserve), both participated in volunteer days and tours on a regular basis, although, due to a lack of reliable transportation and a regular habit of last minute communication from student leaders, we had fewer events with the Muir Woods Mentors and the elementary school children that they work with than we would have liked. We did have a strong level of participation from the Students of the Lakeshore Nature Preserve especially by a core group of ten to fifteen students. Although the mailing list for this group numbers over one hundred names, we only saw a small fraction of these students. We should improve our tracking of individual volunteers and should figure out the status of other students on the mailing list. It may be that many of them signed up at a student organization fair without much intention of becoming active in the group (a typical freshman response at their first student organization fair) or that the activities that we are providing are not of interest and if we expanded the scope that more of them would become involved.

We have also been successful in partnering with a variety of classes ranging from introductory English courses to upper level Environmental Studies and Landscape Architecture classes (see section on the Spring Blooming Plant Survey (Chapter 7) for details of one such partnership). Some of these partnerships have been more useful than others. Certainly classes that come into the woods and learn about the critical issues being faced and who often lend a hand to critical work from invasive removal to assisting with vegetation surveys are a good fit since they help us complete necessary tasks. It is harder to quantify the educational impact on classes where students go on a tour and do not contribute directly to the site. The hope is that this brief introduction to the land will alter their awareness for these protected areas and may result in their increased involvement. It would be beneficial to track the changes in perception and action of the students who have used the woods for classes that do not have an environmental or ecological focus.

Outcomes

Most simply put, outcomes are the intended results of a program. They can also be thought of as the overall impact of the program. These impacts can be broken up into short term, medium term, and long term outcomes. Together these can form the "fundamental intended or unintended change occurring in organizations, communities, or systems as a result of program activities within 7-10 years" (*Logic Model Development Guide,* 2004, p.2). Outcomes should be easily measurable and clearly written so that it is possible to evaluate if they have been met. Each activity should link directly to an outcome. Several things should be kept in mind while generating outcomes:

- They should reflect progressive steps that participants can make toward longer-term results

- They should be within the scope of the program's control
- It should be possible to hold the program accountable for the incomes specified
- They should be specific, measurable, action oriented and realistic

(*Logic Model Development Guide,* 2004)

In other words, it should be clarified that each outcome is important, reasonable, and realistic. Also, no outcome should have potential negative effects.

Once outcomes have been determined, they can be used to evaluate the program's effectiveness, determine what still needs to be done, and define what was learned to guide further student outreach in the Preserve.

Short Term Outcomes

Short term outcomes are those can be reached within the first few years of a project. To evaluate them, we need to investigate if we are on the path to achieve these. It is important to remember that this program is only two years old and that explicit program planning did not occur until a few months into the existence of the program. There are five short term outcomes listed in the logic model and of those we have unequivocally reached two. We have a standard tour that can be modified and given to a wide variety of students. This tour has been facilitated by the creation of a map that includes stops in Muir Woods and what can be discussed there. A series of visual aids that are useful for the tours has been collected including historic photos, diagrams of the grid system, and images of sites before restoration. This system has proven effective. I was able to hand over the responsibility of leading a group to Lars by simply handing him this file and he was able to quickly develop a tour that was appropriate for the group at hand. This was an important outcome to achieve since we are so often asked to give tours and they are an excellent way to recruit volunteers and interns and educate a wide variety of students about the Preserve and Muir Woods. Often the tours can be paired with a small amount of field work for students or an alternative way to interact with a group of students when there is not appropriate field work available.

We have been extremely successful in providing regular volunteer opportunities for a wide variety of university students. Since the inception of this project over 1000 volunteer hours have been logged in the eastern portion of the Preserve. These have been mostly in the form of Friday and Saturday volunteer work parties which are open to anyone interested. Other volunteers have been recruited through classes which require students to participate in invasive removal or planting or interns completing their hours.

Another short term outcome that has been reached is the existence of the Students of the Lakeshore Nature Preserve, but its true impact will be evident only if the medium and long term goals associated with this group are achieved.

Many other of the short term outcomes have only been partially achieved – mostly due to lack of emphasis being placed on these tasks. As a staff, we have developed a loose criterion for which types of projects are conducted by which type of volunteers (i.e. large groups vs. small groups, skilled vs. unskilled etc.), and this has been recently documented. A summary of potential volunteer and research projects available in the Preserve has yet to be developed – we still tend to develop projects as opportunities appear. If a student approaches us wanting to do an internship or a research project we will brainstorm with them to determine what might work.

This is not a good system since a) we may agree to a project that is not truly useful for the restoration goals of the project (even if it meets the educational goals of the Preserve) and b) we often do not seek out students for important projects which therefore often remain incomplete. One of the barriers to getting this list accomplished is that this list should be Preserve-wide so that when a class or individual student approaches any Preserve staff member they can be funneled to the appropriate people whether it be Preserve full time staff, a long term volunteer steward, a faculty member, or a student manager. There have been multiple conversations about how the process of generating and organizing the list should occur, but since the old system has been working well enough there does not seem to be much urgency to develop something new, even though it would most likely provide better experiences for staff and the students involved.

We have been successful in identifying some classes, courses, student groups, online calendars and bulletin boards that are appropriate for funding volunteers, staff, and student researchers (Appendix I), but this list certainly is not complete and should constantly be added to and modified so that we can continue to match the right students with the right projects. For example, we know that Horticulture 112, has a service learning requirement of twelve hours whereas Biocore 301 just requires one volunteer experience in the course of the fall semester. Therefore, if we have one weekend when we need to get a lot of plants in the ground (unskilled labor, but much of it needed) we should reach out to Biocore 301 whereas if we have a project that requires regular amount of labor over the course of the semester, we might reach out to Horticulture 112. This knowledge allows us to plan our projects for each semester and pair students with appropriate projects while allowing us to have a large amount of labor to accomplish what we need.

Medium Term Goals

Most medium term goals cannot be evaluated yet due to the newness of the program. However, it is possible to determine what characteristics will indicate if these goals are being met. We have met the first medium term goal of being able to give tours with minimal planning which built on the short term goal of designing a standard tour that could be easily modified for different groups. We have created the infrastructure so that even someone who had only worked in Muir Woods for a small amount of time could give an effective and interesting tour.

At this point it is impossible to determine if the student group, the Students of the Lakeshore Nature Preserve, is self sustaining. The group began in the Spring of 2006 and its leadership and much of its active membership has stayed the same. It is still receiving strong mentorship from the student Preserve Managers. To determine if the group is self sustaining the following questions should be asked:

1. Does the group have a clear mission?
2. Does the student group have leadership that includes a range of students at different points in their academic career? Are the current leaders explicitly training new leaders?
3. Does the student group have a strong connection with Preserve staff?
4. Does the student group have a strong connection with the Friends of the Lakeshore Nature Preserve?
5. Does the group have a clear way of recruiting new student membership?
6. Does the student group understand how ASM and other university services can aid them?

At this point, the preliminary answers to these questions indicate that the student group is not on a path towards lasting once the current student leaders graduate or move on to something else. Since a student group has been determined to be an important part of overall student outreach, it is important for Preserve staff to put energy into guiding this group towards long term existence.

For the most part, we have been successful in finding interested and appropriate students for tasks. We are often able to find interns or student researchers to complete projects that are of interest to them that also helps us complete work that is important to our goals. In the spring of 2007, we had to complete a second year of data on spring blooming plants and through Dr. Evelyn Howell, a professor who has provided tremendous guidance to this project, we were able to find a Biology 152 student to complete and analyze this data for us. The hope is that as the project grows it will be part of the institutional knowledge of students, Teaching Assistants, and faculty members and more students will think of this space as a site for their research and teaching. These projects should all be logged and determined if they move forward the ecological and management goals of the woods as a means of evaluating if we are being successful in our medium term goals.

Long Term Goals

Most long term goals cannot begin to be evaluated for at least four years into the project so at this point we cannot begin to evaluate these impacts (*Logic Model Development Guide* 2004). Our long term goals include having a wide cross section of students aware of the value of the woods, having students constantly involved in its stewardship, and that the woods is being used in a laboratory. At this point, we can only make sure that our short term and medium goals are on track to being fulfilled and that they will provide the ground work for meeting the long term goals. It is the achievement of these goals that will provide the overall program impact.

Assumptions

Assumptions are "the beliefs we have about the program and the people involved and the way we think the program will work" (Taylor-Powell et al., 1996, p.15). They are often the basis of why strategies being selected will work in the particular case. Listing assumptions allows the creator of the logic model to make explicit beliefs that are framing the situation at hand. Examples of common assumptions include:

- People will be motivated to learn
- Information exists on the best ways of accomplishing outcomes
- Existence of funds will be a catalyst for the project

(Taylor-Powell et al., 1996)

In the Muir Woods projects the assumptions include:

- Donors will continue to be interested in funding student workers
- Students/Professors will be interested in using Muir Woods as a place of learning/volunteering
- Projects of importance will be able to incorporate volunteers/students
- Staff who are interested in working with students will be hired

It is important to be aware of assumptions that are being made since these are often the basis for how the program is being designed (*Logic Model Development Guide,* 2004). If at any point in the program, any of these assumptions are proven to be untrue, the student outreach program would need to be re-evaluated under the new conditions.

External Factors

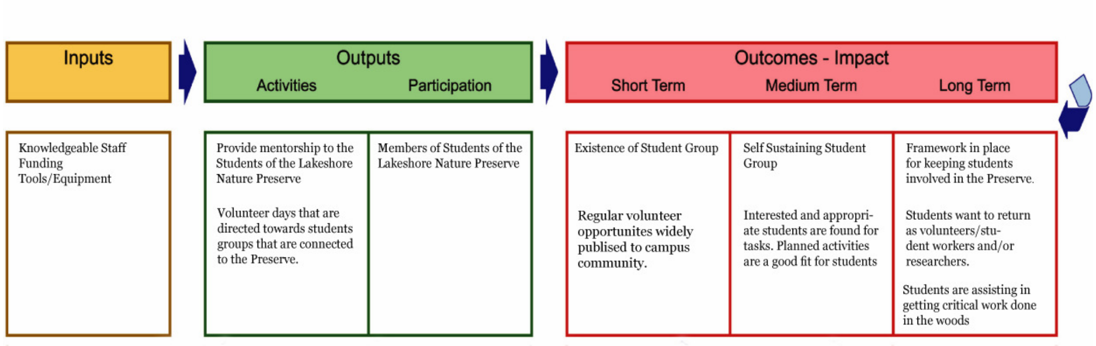
External factors are things that cannot be controlled by the program itself and that can affect the program's success. They include things like political environment, and changing policies and priorities that can greatly alter the likelihood of a program meeting its goals.

The external factors can affect what resources are available, who the participants are and program implementation. It is critical not only to outline the external factors that can come into play, but also to generate potential contingencies if these were to change radically. There are many external factors that could affect the trajectory of the Muir Woods project. For example, if the University makes it even more expensive to hire PAs, it is unlikely that this model of student mangers can continue. The program will then either be abandoned, staffed by student hourly employees, or staffed by non-student staff members. Each of these models could affect the effectiveness of student outreach in Muir Woods. Additional external factors include other dramatic changes in funding which could lead to either an increase in student help (if more money were to become available for student hourly employees) or a decrease (if there is no one to supervise volunteers, interns, and researchers). Another change that could alter the possibility of students doing work in the Preserve would be if an alteration in liability causes the types of work that students are allowed to participate in to change and therefore limits their participation in restoration activities.

Analysis of the Student Group Portion of the Logic Model

It is important to make sure that the logic model works as a cohesive whole if it is to work as useful tool for program development and analysis. Each activity must lead to a series of outcomes and all of the inputs should be linked to specific activities and there must be participants for each activity. Often specific inputs will be necessary for various activities and many of the short terms goals can lead to one medium term goal. For example, I pulled out all components that relate to the Student Group portion of the overall Student Outreach Logic Model:

Figure 38. Portion of the Logic Model that focuses on the Students of the Lakeshore Nature Preserve.

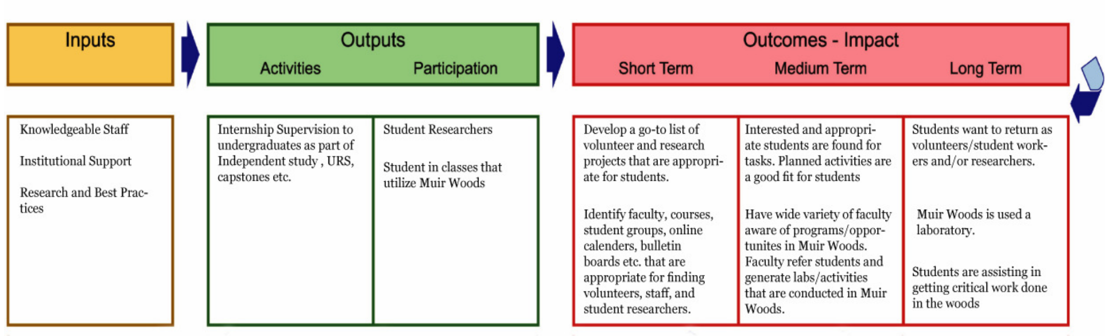


Only a subset of the total input, outputs and outcomes of the entire project are needed to reach the long term goal of having a student group. By looking at all of the components it becomes easier to evaluate the progress of the student group as part of the student outreach provided by the student managers of the eastern portion of the Preserve. Currently, we have all of the inputs needed, are providing the activities that are needed, and have the participation of the group. The short term outcomes are being met, but indicators for the medium term goals are not as positive as I would like. Attendance at work parties has greatly decreased this semester – although this could be due to the fact that the cold, snowy weather continued longer this semester than in previous past semesters, that we did not evaluate the effectiveness of the student we hired to run the volunteer days, and that fewer classes have service learning as part of their curriculum in the spring semester. If this trend continues, activities and modes of advertising will have to be re-evaluated. It also may make sense to interview members of the student group about their experience and vision for the group in order to determine where the group should be headed in order to increase its likelihood of lasting.

Analysis of the Student Intern Portion of the Logic Model

A similar method can be applied to looking at student interns in Muir Woods.

Figure 39. Portion of the Logic Model that just focuses on the student internship program in Muir Woods.



There is very little overlap between and the components necessary for student interns and for the student group. Most of the overlap is in the long term outcomes which is logical since these few goals are what all of the other components are funneling towards. Once again, we currently have all we have all of the inputs needed, are providing supervision to student interns listed, and have participation by student researchers and classes. However, the quality and amount of supervision should be evaluated by current and past interns. As mentioned earlier, there is more work to be done on all outcomes, however we have accomplished the early stages of a “go to” list of classes, student groups, and bulletin boards that can be resources for finding interns (Appendix I). While we do not have a running list of volunteer and research projects, as we are doing planning for the upcoming season, we do note which projects might be good to turn over to an interested student or to for which to seek out a student. This should be made a more formal part of the student manager planning process and the list should list projects that need to be accomplished in more than just the upcoming months.

Conclusion

The process of creating and using the logic model to evaluate the current status and trajectory of student outreach in Muir Woods is valuable to make sure that the choices that we are making are leading us towards the impacts that will make this program successful for the woods and the students involved. For instance, since this logic model has been created, it is has been easier to turn down groups that do not move us towards the outcomes that we have selected. It has also shown where our energy still needs to be placed in order to keep student outreach in Muir Woods as a valuable aspect of the overall management of the land.

While logic models clearly have a place in this project and their use could be expanded, one distinct weakness of this model is how it is distinct in terminology, use and evaluation from the framework we use for the ecological goals for this piece of land. While one can hope that managers will integrate the two, it would be beneficial to use a method that integrates these two very important components of this restoration and management project.

Despite this weakness, even at such an early stage of this project, the student outreach logic model can provide a useful method to evaluate the program that is being created, justify and guide actions, and provide a shared language between stakeholders about the program. The hope is that this model will not be thought of as static, that is will be a dynamic document that will be tweaked, as the program evolves and as external factors change. Also, the evaluation of the current model has just begun. There is more rigorous evaluation of each of the components that can and should be completed. Interviews with volunteers, interns, professors, and staff could all be used to create a data set that would make it easier to evaluate if changes in perception about Muir Woods, knowledge about opportunities, and long term student interest is occurring. Even without this raw data, the logic model provides a powerful framework under which to evaluate the current student outreach component of this interdisciplinary project and provides a model that can be used to evaluate many aspects of the current program.

Chapter 7. Adaptive Restoration Trials and Experiments

Various research projects have been built into the restoration of the East Preserve. They range in rigor from experiments that attempt to control for outside factors and have enough replicates for statistical analysis trials that will provide less generalizable information, but hopefully enough to guide both future projects and experiments. These tools are important, not only because they should increase our knowledge of how best to restore these sites, but also they utilize the East Preserve, and thus fulfill one of the guiding principles for the Preserve (Ken Saiki Design, 2006). They are designed to provide information to help determine which implementation techniques are most effective on this site, and also to provide insight into urban ecology. These experiments and trials will hopefully decrease "the significant disconnect between on-the-ground implementation…and subsequent, explicit attempts[s] to evaluate the outcome[s]" (Ralph & Poole, 2003, p.224). The studies have occurred in both Muir Woods and Lakeshore Path and include:

1. An experiment to evaluate the effects of planting density on the establishment of planted herbaceous understory species in Muir Woods.
2. Trials to test different approaches to hillside and shoreline stabilization in Muir Woods and the Lakeshore Path shoreline.
3. A study in Muir Woods, conducted by members of a UW class, to track populations of spring blooming species over time as restoration activities proceed.

Experiment on Planting Density

In order to successfully implement restoration plans that work for the East Preserve, an adaptive approach is being utilized (Zedler, 2005). There are a variety of questions for which we want answers that can only be determined through experimentation due to either a lack of published information or due to a need to figure out the best protocol for this particular site. In the early stages of this restoration, we were only able to conduct one of the rigorous experiments which we conceived of. Other experiments should be integrated into the future restoration plans for the site.

Research Questions

This study in Muir Woods will begin to answer the question of how densely herbaceous plugs need to be planted to survive and spread in areas that have been heavily disturbed due to urbanization. Planting density can affect plant survival in a variety of ways, in both the short and long terms. The questions include:

1. Does increased planting density lead to faster ground coverage, and thus to lessened soil erosion and invasion by exotics?
2. Does increased planting density lead to amelioration of the microclimate, and/or to a competitive advantage over existing species and thus to better survivorship? Or:
3. Does increased planting density actually decrease survivorship due to interspecific competition?
4. Does increased planting density lead to the demise of other desirable species?

5. What site conditions (composition and abundance of existing vegetation, light levels, soil condition, presence or absence of herbivores, etc.) influence the effects of planting densities? And, more generally:

6. Is planting density reflected in the presence and abundance of the planted species and other desired species 5 and 10 years after installation?

There is very little published literature on planting densities in forest restoration projects, and often that information comes from the nurseries that are selling the plants and therefore may be biased, or the information is very general, or is geared towards garden design rather than ecological restoration (Sound Native Plants, 2003). Planting density should be investigated more fully by scientists studying ecological restoration. Huddleson and Young (2004) noted that “differing planting densit[ies] not only may affect planting success, but are also associated with very different planting costs, and therefore should be of interest to restoration practitioners.”

We designed this experiment in Muir Woods to compare planting densities of native herbaceous plants that we are introducing in order to reach our restoration target of an average groundlayer coverage of 75% desired species (See Chapter 3). The research questions include:

1. Does the planting density of native species affect their overall survival and spread?

My hypothesis is that if native species are planted more densely that they will have higher survival rates and greater spread since they are more likely to outcompete other ground layer plants than to interfere with one another. Even if there is some die-off there will be enough individuals remaining to approach a viable population.

2. Does the density of the plantings of native species affect their performance with regard to various covariants (*Parthenocissus quinquefolia* cover, overall existing herbaceous cover, existing woody plant cover, light availability)?

My hypothesis is that there will be a positive correlation between per cent survival and light availability and a negative correlation between per cent survival and *Parthenocissus quinquefolia* cover, existing woody plant cover and overall existing herbaceous cover.

3. Does planting density affect how close we are to achieving our target of an average cover of 75% of desired species in an area after 3 years?

My hypothesis is that there will be a positive correlation between higher density and closeness to reaching our target percent cover after 3 years.

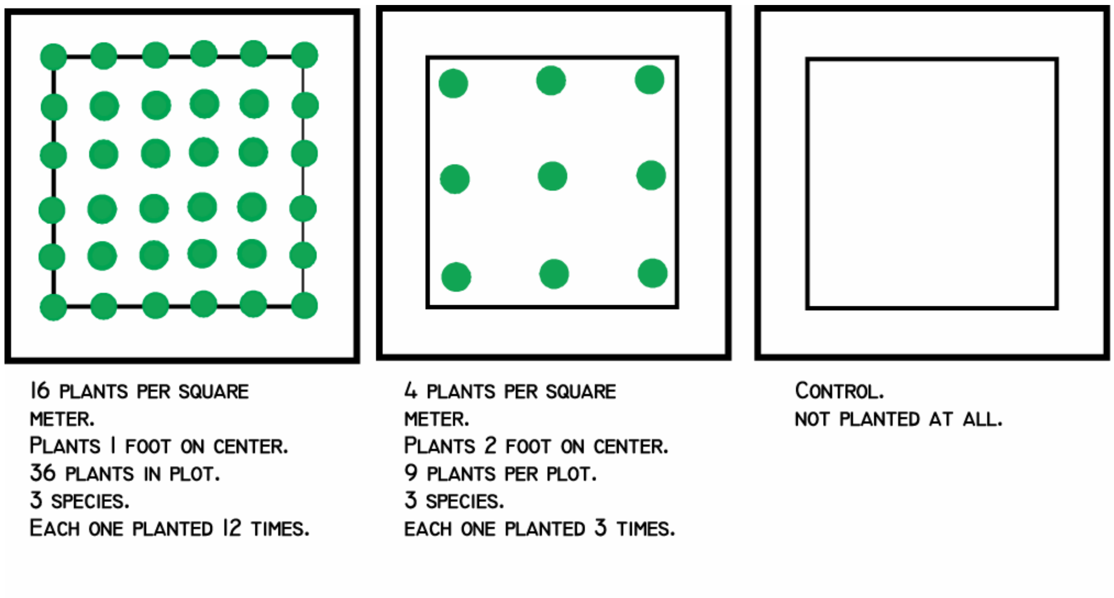
We are testing two planting densities, 4 plants/m^2 and16 plants/m^2. We selected these densities because they are the equivalents of planting "1 foot and 2 feet" on center, two approaches used by restoration practitioners

Experimental Plots

There will be 3 types of plots (Figure 40):

1) 16 plants per square meter (1 foot on center)
2) 4 plants per square meter (2 feet on center)
3) No planting

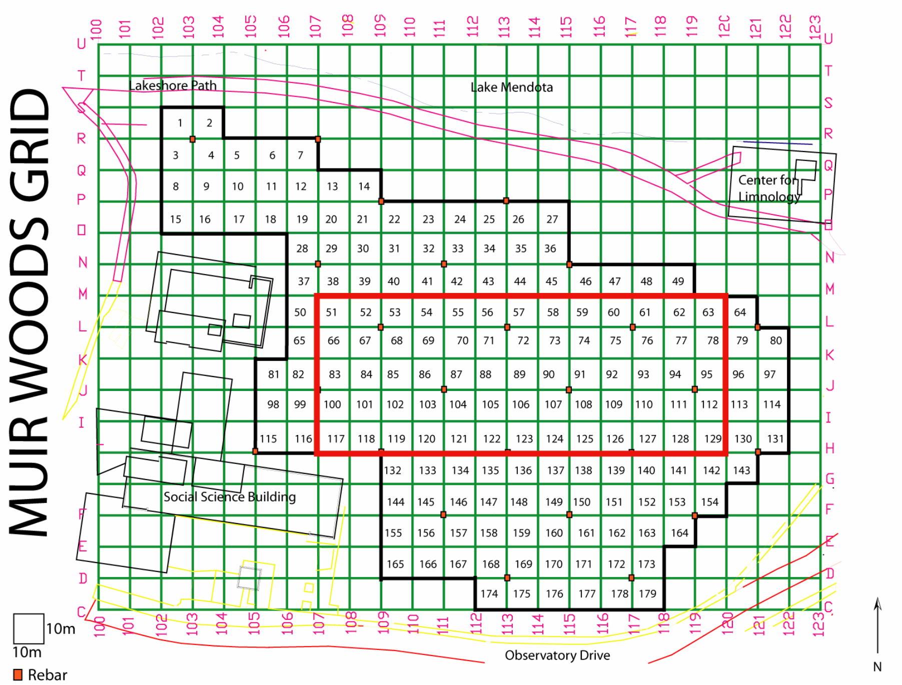
Figure 40. Illustration of the 3 types of plots installed as part of the planting density study.



Each square plot is $25ft^2$ ($2.3\ m^2$) with a one-foot (0.3048 m) buffer around it (This study was measured in feet since many practitioners use this system of measurement). Each plot type has been replicated five times for a total of 15 plots.

We set up the experiment to make use of the reference grid in Muir Woods (See Chapter 3). We wanted to find an area that would be big enough to accommodate 15 experimental plots, was in the middle of the woods to avoid possible "edge effects", for which we had a complete set of "before" vegetation data, and which was relatively homogeneous in terms of the composition and cover of existing ground layer species (Figure 41). We initially identified 27 grid cells that met these criteria. These became potential locations for our plots.

Figure 41. Block from which experimental plots were selected.

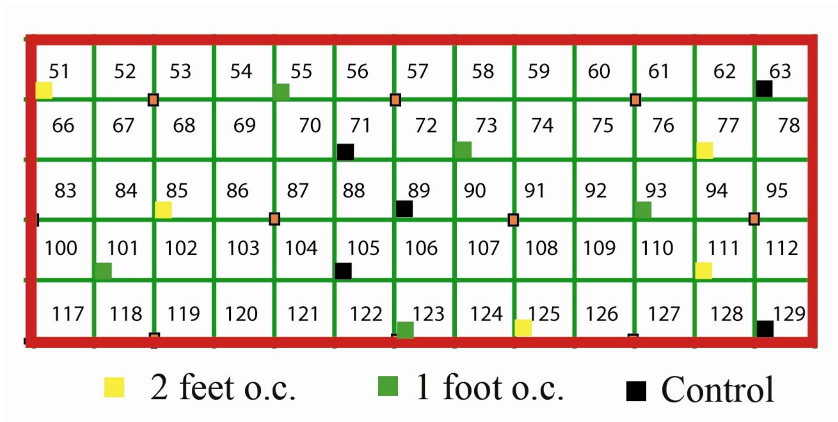


We then calculated average woody plant cover, herbaceous plant cover, and cover of Virginia creeper (*Parthenocissus quinquefolia*) for these areas. We excluded any grid cells that had a woody plant percent cover over 75%. Only grid cells that fell within one standard deviation above or below the average cover of herbaceous plants and Virginia creeper cover were included in the study. Only one location that was elegivle was not used (one row had four cells that met the criteria; see Appendix L for a more detailed description of how the plots were selected). This left 19 potential areas remaining. We excluded one of the 19 because it includes a large tree within it and two other grids because large portions of them are located on current trails within Muir Woods. Of the remaining 16 grid cells, we randomly assigned one from each row to each of the 3 experimental treatments (Figure 42).

Table 9. Data for all eligible plots for Planting Density Study.

	Existing Herbaceous % Cover	% Woody Plant Cover	PAQU % cover
Average	43	26	23
Standard Deviation	24	27	23
Range	18-64	0-70	0-45

Figure 42. Locations of Treated Plots within Muir Woods.



We planted a mix of 3 species: wild geranium *(Geranium maculatum),* Pennsylvania sedge (*Carex pennsylvanica)* and elm leaf goldenrod (*Solidago ulmifolia)*, each representing a different functional guild (see the vegetation section of Chapter 2 for a definition of functional guilds). Plants were all 2.5" nursery grown plugs. The total number of plants per plot was divided equally among the species. Planting location for each plug within each experimental plot was selected randomly (drawing a name out of a "hat" for each planting location) and each plot had a random and distinct planting plan (see Appendix L for a planting diagram).

Prior to planting, we collected the following data: percent cover of herbaceous plants, Virginia creeper, woody species, and woody debris. We wrote a qualitative description of the plot and took a photo before and after planting (see examples in Appendix L).

The experimental setup was installed in Muir Woods on October 15, 2006. A group of five people met and completed the process of locating the plots, taking preliminary data, and installing the plants. We marked the plots using rebar and string to prevent tampering and accidental management which could alter the results. No further maintenance or management of the plots followed installation.

Data Collection

The plan is for each plot to be resurveyed for 3 years (2007, 2008 and 2009) during the times at which ah of the experimental species reach their maximum growth. The inventory protocol is the same as was used in 2006 (Appendix L). The planting diagram for each plot will be used to figure out which of the initial plants are still surviving. Once this has been determined, the diameter of each surviving plant will be taken at its longest spread.

Data could be analyzed a variety of ways, some of which will only be apparent after data collection. At this point, the statistical tests that seem like they will be most revealing include:

- Blocked ANOVA of the dependent variables (density, cover, and rate of spread) for planted plants only between the two planted treatments after 3 years.
- Blocked ANOVA of the dependent variables (density, cover, and rate of spread) of all desired plants for all three treatments after 3 years.
- Blocked ANOVA for the dependent variables adding the covariants (light, PAQU cover, starting plant cover) to see if they explain any of the differences.
- Blocked ANOVA to look at change over time (Year 1, Year 2, Year 3) of the dependent variables with and without covariants.

- Repeated measures analysis may prove to be helpful and should be investigated as data analysis commences.

(Susan Will Wolf, personal communication, 6/29/07).

The hope is that the analysis of the data collected will lead to more clarity as to the effects of various factors in the woods on planting density and will allow recommendations to be made for planting protocols for future restoration projects. The results will also likely lead to additional experiments (testing additional planting densities and/or species, examining the effect of controlling Virginia creeper etc.).

Muir Woods Hillside Stabilization Trials

In addition to the experiment investigating the effects of planting density, we have set up trials (comparative studies) to investigate particular restoration techniques, materials, or management regimes. The trials differ from experiments primarily because they include no replicates or controls. They do include careful and sometimes quantitative observations on the effects of single examples of each applied treatment.

One of the first comparative studies that we set up was to investigate the use of different erosion control fabrics on the eroded slope between the lower footpath in Muir Woods and Lakeshore Path. There are several kinds of erosion control materials available commercially. Before deciding on an approach that could be used in many areas of the Preserve we decided to test two materials, both of which are commonly used in ecological restoration projects that are emphasizing using biodegradable materials. Coir is a semi-permanent mat made from coconut fiber that should last approximately four to six years and is effective on steep slopes (Nedia Enterprises, 2007). It costs approximately $1.50 a square yard. Jute is an original 100% biodegradable brown, open weave, light duty erosion control matting. Under normal conditions, a jute mesh blanket will last approximately one to two years (Nedia Enterprises, 2007). It is a low cost (approximately $.49 a square yard), short-term erosion control product for gentle slopes.

We started with two areas that were devoid of vegetation, but that had not started to form gullies. They had different level of steepness and different disturbance histories (one had been compacted by trampling the other was eroding due to stormwater), but had similar plant communities surrounding them and received similar amounts of light. Our hypothesis was that jute, would not last long enough for plants to establish on these slopes and that coir, would be a necessary investment. Rather than run strict data collection on this project, we simply secured the fabric, planted the two slopes with the same plants (all herbaceous species) at the same densities (approximately 1.5' on center) and observed the differences.

As expected, the jute almost completely disintegrated within two years, which was not enough time for plant establishment at sites in Muir Woods. From photos of the site, it is clear that almost no plants took hold on the slope that had the jute on it, whereas the slope covered in coir has a much denser plant covering. While the slope with the jute did not collapse and it does have more vegetation than it did prior to the restoration project, there is currently no fabric present to hold water, or slow soil and debris movement. The plants that we have added have had low survival rates and have needed more watering than the corresponding slope that had coir added to it.

There were many factors that we did not control for on this study such as light availability, original soil conditions, and level of human disturbance. While this study does not meet most assumptions for statistical testing, it confirms our supposition that that the longer lasting coir seems to aid vegetation establishment making it a worthy investment.

Figure 43. Coir and Juted Slope Over Time (photos by Rebecca Kagle)

A, B – Slopes before addition of fabric
C – Slope two years after addition of coir and plants
D – Slope two years after addition of jute and multiple plantings

The restoration of these slopes is on-going and plants have been transplanted to both slopes to hopefully increase the pace at which roots, rather than erosion control mats are able to prevent further erosion on these slopes.

Shoreline Stabilization Trials

Any area along the eastern portion of Lakeshore Path in which invasive vegetation is removed in large numbers will also need to have a comprehensive plan for dealing with erosion. Currently, even with the vegetation in place, there are many heavily eroded areas along Lakeshore Path. This will only be exacerbated by vegetation clearing as has been called for in the Master Plan in order to open views from Lakeshore Path to the lake. In fact, the opportunity to conduct these trials came about due to actions taken by the University Grounds Department to create such views. As of the summer of 2007, five slopes have had some initial restoration work completed. On each area, a different restoration technique was tried as a means to gain more information about what techniques will be effective for restoring this much degraded shoreline. At this point, we have only installed one trial for each of the five methods we have tried. Based on the results, replicates of the more successful treatments will be put into place.

All of these slopes have permanent quadrats and transects installed that will be monitored on a yearly basis for three years after installation which will help determine if restoration objectives are being met (see the Restoration Plan). Success of each treatment will be measured by overall plant diversity (75+ species) and cover of desirable species paired (graminoid cover is be 60% or greater and forb cover 25% or greater) with low invasive presence (less than 10% of overall cover). Cost per square foot will also be factored into the decision of it a treatment is used again.

Currently the only ways we are monitoring the effectiveness of our erosion control techniques is by examining the vegetation on the slopes, extrapolating that if we have good savanna plant community cover, then the roots are effectively holding the slope. We also do some qualitative monitoring – looking for any signs of soil movement cause by overland flow or ice and wave action. However, some studies should be implemented, perhaps in partnership with the stormwater management class that is offered in the Landscape Architecture Department or with the help of some Water Resources Management students or

Engineering students to design an appropriate protocol to determine are techniques stabilizing the shoreline.

Trial 1: Brush Removal and Seeding: Limnology Slope

This slope was cleared by the Muir Woods summer crew in May of 2007 (Figure 44). Invasive woody plants (buckthorn and honeysuckle) were cut and treated with glyphosate. Some of the smaller box elder and ash were also removed. No woody stems were pulled out in order to minimize soil disturbance. Burdock was removed with a shovel. Other herbaceous weedy species (orchard grass (*Dactylis glomerata*) and a Eurasian grass that was likely brought in with the latest construction along the Path etc.) were left on site with the hope that the will be out-competed by the newly planted species. Once the area was cleared, it was seeded with Seed Mix 2 (Appendix M), and certified oats mixed with sawdust.

Figure 44. Limnology Site just after it had been cleared (May 29, 2007) (photo by Lars Higdon).

This method should be appropriate on slopes that are 3:1 or flatter, and that do not have large patches of bare soil remaining after clearing. This method is cost effective since the only costs are labor, seed, and herbicide and the technique minimizes soil disturbance and requires little initial labor. However, since no plugs or pots are added, the site has the tendency to look bare and may invite people to scramble down to the waters edge which would make the survival of our seed unlikely and increase the instability of this portion of the shoreline. Signs were placed along the slope alerting people to the new restoration project. Fencing may be necessary if the signs are not effective. Since plants from seeds can take a long time to establish, it is likely that the area will be invaded or reinvaded by invasive species so constant monitoring and weeding may be necessary.

Trial 2: Brush Removal, Seeding and Plugs:

Slope 3: Future View/Terminus Overlook

Figure 45. Photo of Slope 3 just prior to planting (October 2006) (photo by Rebecca Kagle).

This cleared area has a slope of approximately 1:3 and had large rocks exposed throughout (Figure 45). For this reason, the plan was to plant it so that the vegetation could work to minimize additional erosion. This site was seeded with a purchased plant mix, some local seed donated by some active volunteers in the Preserve from their land outside of Black Earth, WI, herbaceous plugs and one 3 gallon buttonbush (*Cephalanthus occidentalis*) (See Appendix M for species and amounts). This site is now blanketed by a mix of native “weedy species” (white snakeroot, figworts, jewelweed etc.), the natives we have planted, and exotic species (Figure 46). In order to reach the plant community goals listed in the restoration objectives, additional planting and weeding will need to occur on this site.

Figure 46. Slope 3, Jun 11, 2007 (photo by Rebecca Kagle).

This technique is recommended for sites that do not appear to be heavily prone to damage from surface runoff or ice or wave action. Purchasing plugs can lead to significant cost, but should result in vegetative cover much more quickly than seed alone and will allow for a more diverse planting palette since not all species can be grown from directing sowing. If planting from seeds and container are going to be used in concert (as they were in this site) without any sort of erosion control fabric, the plants should be installed, watered heavily for one to two weeks and then the seed broadcast and the site allowed to rest for a few days so that they are not all washed away once the plugs must be watered.

Trial 3: Brush Removal, Fabric, Seeding, Plants, and Live Stakes

Slope 6 - Promontory North of Tripp Hall

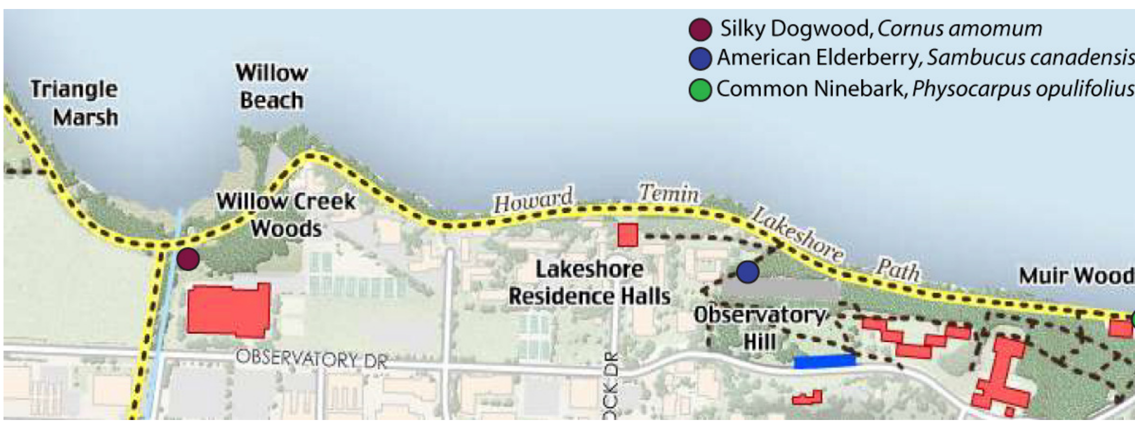
This site has two distinct portions. The eastern most area is extremely steep and will need heavy bioengineering techniques that are outside the scope of this project. The remaining portion of the slope has a much milder slope (Figure 47).

Figure 47. Slope 6 soon after secondary clearing prior to restoration (October 2006) (photo by Rebecca Kagle).

Since Slope 6 does not have the boulders present in Slope 3, it was determined that using coir to hold the slope as plants become established would be a sound choice. Most of site was seeded, the coir installed, and plugs planted in the fall of 2006, with a small extension added in the summer of 2007 (see Appendix M for the planting list). Coir installation techniques should be identical to those listed in the (see section on Live Staking for species and installation techniques) were installed with the hope that once established, they would protect the lower slope from ice and wave action. They should not be a barrier to the views of the lake since they are planted so low on the slope.

Along the bottom of the slope, live stakes were installed with the hope that once established, they would protect the lower slope from ice and wave action. They should not be a barrier to the views of the lake since they are planted so low on the slope. We used 3 shrub species for this technique, Silky Dogwood, *Cornus amomum,* American Elderberry, *Sambucus canadensis,* and Common Ninebark, *Physocarpus opulifolius*, all of which were collected from areas in the east Preserve (Figure 48, See Chapter 3 for installation techniques).

Figure 48. Locations of Species Used in Fall 2006 Live Staking Project (Modified from Preserve Interactive Map by Rebecca Kagle).



- **Silky Dogwood, *Cornus amomum* -** found in a small planted patch in between Lakeshore Path and the Nantatorium
- **American Elderberry, *Sambucus canadensis*-** found in the area in between Lot 34 and paved pathway leading from Tripp Circle to Lakeshore Path. This area is slated for construction in the summer of 2007, so it is unlikely that cuttings can be collected from this site in the future.
- **Common Ninebark, *Physocarpus opulifolius*** – found in area between road and the lake just east of the Center for Limnology. (slight chance this is a cultivar, needs to be watched).

As of early summer 2007, the portion of this slope that had been planted in the fall of 2006, was heavily vegetated with native plants both from plugs and seeds. There were minimal weeds or resprouts from the invasives that had been cut and treated (Figure 49). All of the live stakes that had been planted had sprouted leaves.

Figure 49. Slope 6 on June 11, 2007 (photo by Rebecca Kagle).

This method, while somewhat time and resource consumptive should be a regular technique for restoring slopes along Lakeshore Path with slopes that are 3:1 or slightly steeper. The work is appropriate for volunteers and should be scheduled in the fall which is an appropriate season for this type of work and is when the highest numbers of students typically participate.

Trial 4: Soil Lifts and Plants

Slope 4 - "Future Filtered View"

This site was the most challenging because the lower portion of this slope had been severely undercut by ice and wave action (Figure 50). The upper portion of the slope had closer to a 20 -25% slope. Due to this variation, it was decided to restore the top of the slope with coir and plants (seed, plugs, and pots) and to use a modified a shoreline stabilization technique called "soil lifts" for the lower portion.

Figure 50. Slope 4 just prior to restoration (June 2006) (photo by Rebecca Kagle)..

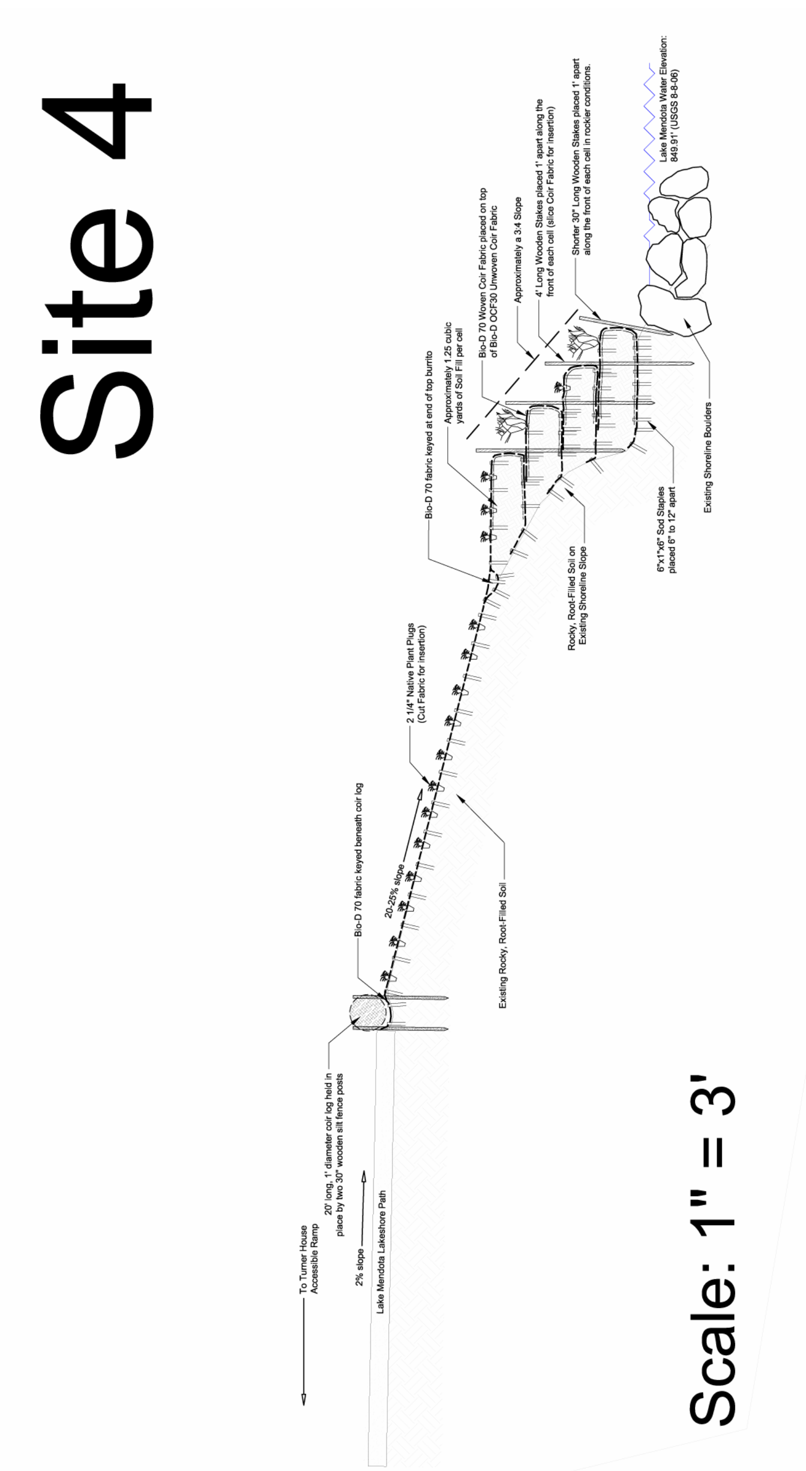
This technique was selected because it been effective on other lakes that have medium to high levels of ice and wave action (Allen & Leech, 1997; Lake County Stormwater Management Commission, Lake County Planning, Building and Development Department, & U.S.D.A. - Natural Resources Conservation Service, 2002). Soil lifts should produce a newly constructed, well-reinforced shoreline, enhance conditions for the colonization of native species, and aid in bank rebuilding. They were needed to provide armoring (fixed structure to reduce shoreline erosion) for the shoreline in a way that blended in with the site and that would revegetate easily. They were constructed by creating an envelope of two different geotextile fabrics each with a different function (Figure 51):

1. BioD 70 Coir which provides a high tensile strength and therefore more reinforcement
2. BioD-OCF 30 which is made up of loose coir stitched between two jute nets. This material secures the soil within the lifts.

These two fabrics are laid on top of one another and then filled with compacted shredded topsoil and the fabrics wrapped up and over this and then the lakeside edge secured with 3' or 4' oak stakes and the tops were secured with metal staples (Figure 51 and Figure 52). Each lift was approximately 18" tall with each one being installed on top of another until they were at grade with the existing slope. The lifts were planted with shrubs and plugs and covered with oats (Species list can be found in Appendix M). If this technique is utilized again, the seed mix and oats should be spread onto each lift before it is closed up to increase the number of roots taking hold.

Figure 51. Photos of Soil Lifts in Progress and Completed (Prior to Planting) (photo by Rebecca Kagle).

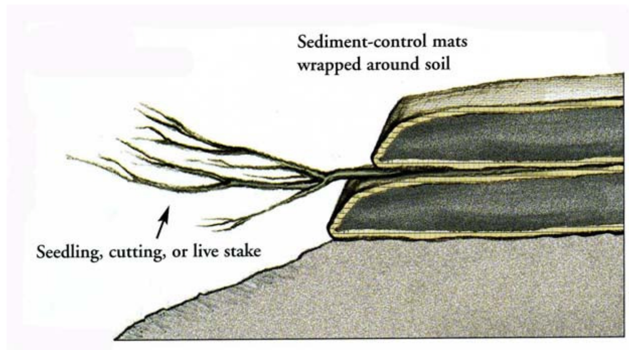
Figure 52. Detail of Slope 4 soil lifts (Autocad work completed by Tristan Porto).



This technique was extremely labor intensive and required a highly skilled crew to install. It requires moving multiple yards of soil by hand, cutting many layers of coir, and pounding in more than 100 stakes, often into areas that were all exposed subsoil. Creating a stable vertical edge for each lift took a mix of brute force and finesse. Rolanka, an provider of jute and coir erosion control supplies has developed a coir block system which provides a soil lift that is already constructed, called a BioD-Block system and just needs the addition of soil to complete (Northcut, 2004). This could speed up the process and should be considered for an additional shoreline treatment.

We will add live stakes (Silky Dogwood, Elderberry, and/or Ninebark) to them in the fall of 2007 to increase the root structures growing within the soil lifts so that as the fabrics break down, the soil is held. On Slope 4, in the fall of 2007, live stakes will be installed vertically in the lowest lift to anchor it further. This step can aid in the process of the structure buffering the slope from wave and ice action, provide wildlife habitat, and anchor the lifts (C. L. Henderson et al., 1999) (see Shoreline Erosion along Lakeshore Path Section in Chapter 2 for an explanation of these terms). We will modify the typical protocol and install the stakes vertically rather than horizontally since are lifts are already installed and we can no longer place the stakes between them. The only disadvantage to this modification is that there will be less surface area that will take the ice and wave action head on.

Figure 53. Soil Lifts with Live Stakes (From (C. L. Henderson et al., 1999))



Based on observation and initial vegetation monitoring, we are happy that the progress this slope has made after one year. The upper slope is covered with native vegetation and most importantly, the lifts have remained stable over the course of their first year and plants are beginning to become established in them (Figure 54).

Figure 54. Slope 4 Photos – Jun 11, 2007 (photos by Rebecca Kagle).

Trial 5: Coir Logs as Water Spreaders

For all of the projects that were deemed to need some sort of coir fabric to help stabilize the upper slope, it was clear that surface runoff from campus was causing at least part of the problem. The ideal solution to this problem would be for more of the storm water to be infiltrated outside of the Preserve, but since this is not currently the case, a spreader was added.

Spreaders are used to disperse concentrated flow thinly over a vegetated buffer or filter strip (Minnesota Pollution Control Agency, 2000). Their purpose is to "spread concentrated water over a wide enough area so that erosion of the …strip does not result." (Van Der Wiele, Cynthia F., Hunt, & Hathaway, 2006). Upon consultation with Shawn Kelley, Registered Landscape Architect and Lecturer in the UW Department of Landscape Architecture, we decided to install a 12" coir log along the very top of Slopes 4 and 6 with the hope that these would serve to spread any water that was coming across the path and therefore limit further erosion from surface runoff (Figure 55). These structures are biodegradable, but will be removed once the sites have an overall cover of native vegetation that graminoid cover is 60% or greater and forb cover is 25% or greater. They should be able to be reused for other sites at that point.

Figure 55. Coir Logs as Spreaders (photo by Rebecca Kagle).

To install, the biologs we dug a small trench directly adjacent to the path side of the coir. They were secured with 3’ oak stakes placed every foot, alternating between the front and back side of the log. The stakes should be woven through the jute rope that surrounds the log. The stakes should be angled toward the log when being pounded into the ground. A log has been installed well if it does not move when kicked.

Spring-Blooming Plant Survey

Another ongoing study in Muir Woods is looking at the populations of spring-blooming plant species to determine if it is changing over time. Muir Woods is noted for its dense covering of spring-blooming wildflowers, although there has not been a study of what species are present and in what amounts. Populations of spring bloomers are decreasing throughout southern Wisconsin due a variety of factors which can include deer browse and competition from invasive plants (Czarapata, 2005). Furthermore, these species are often very difficult to restore and often determined to be highly vulnerable to disturbance

(McLachlan & Bazely, 2001). It is important to gather data about species presence, density, and frequency and to monitor these characteristics over time.

The research questions that will be answered through this study will include:

1. What is the current composition of the understory layer of Muir Woods in early spring?
2. Is the composition constant throughout the woods?
3. Is the composition changing over time

The initial data for this study was collected by students in Landscape Architecture 651. In the spring of 2006, members of the class completed a random survey of twelve $1m^2$ squares throughout Muir Woods to get a sense of presence, density, and frequency of herbaceous species throughout the woods in early spring. Students broke up into four groups and collected three $1m^2$ samples within each of the 10 m^2 grid cells in which they worked. The survey was conducted again in the spring of 2007, this time by a student in a different class, Biology 152. She then compared the results of her survey with those that had been collected in 2006 and found that a decline in spring blooming plant species richness from 2006 to 2007 (This report is part current project archives stored in the Student Manager Office in Agriculture Hall). It is too early to know if these results represent a trend. More years of data collection are needed. The data should continue to be analyzed to monitor changes in the spring-flowering plant populations over time. Not only will the study provide important quantitative data, it also will provide information about classes and interns conducting long term ecological monitoring.

Conclusion

The hope is that the varied types of information-generating observations that are being run as part of this project can serve to further the knowledge of Preserve staff, students and restoration ecology practitioners. As things are learned from each study or trial, the next treatment or study should build upon this information. This should provide future managers the ability to evaluate each technique that we tried, to help ascertain if projects have aided in the path to the restoration goals and objectives.

Chapter 8. Conclusion

This thesis looks at the restoration process that has occurred in the East Preserve over the last two and half years. It evaluates all aspects of the project from how restoration priorities were set and projects implemented to the use of students in the program and the management infrastructure. This holistic analysis was appropriate because any restoration occurring in the urban environment has to include a focus on both the ecology and the human use of the site. In order to evaluate the restoration itself and the process of setting up the restoration, I investigated four questions. Following is a summary of my main findings as well as suggestions for future investigations.

1. What is the current state of the East Preserve and what actions are needed to achieve restoration goals and objectives?

We conducted a quantitative inventory of the vegetation of Muir Woods to determine to what extent the site matched the biological restoration objectives at the start of the study. We used a series of nested quadrats distributed throughout a 10m x 10m grid. The inventory collected information on the species present, the abundance and location of shrubs and herbaceous species, and the numbers, and sizes of trees, saplings, and seedlings. In addition, we noted the condition of the physical (trails, seating) and social (volunteer, field trip opportunities) infrastructures as well s the presence of human impacts, such as erosion gulleys.

Based on the results of the veegetation inventory, I determined that Muir Woods had a greater than desired presence of invasive exotic and opportunistic native species, fewer than desired native species, and a more open canopy and lower tree density than called for in the restoration objectives. Therefore my restoration recommendations are:

- As existing mature trees die, replace with, sugar maple (*Acer saccharum*), basswood (*Tilia americana*), and if there is sufficient light, red oak (*Quercus rubra*). Consider planting saplings or seedlings of maple and basswood underneath the existing canopy. Consider removing exotic tree species such as black locust, but only if this can be done without opening the canopy up too much.

- Continue to remove invasive exotic shrubs such as honeysuckle and buckthorn, and add native herbs and some shrubs. Use this opportunity to replace the material removed with new species that are characteristic of mesic or dry-mesic forests—the target communities for this restoration. Include species that bloom in the late summer, a guild that is not presently well-represented.

- Reduce the cover of each of the following opportunistic natives box elder (*Acer negundo*), Virginia creeper (*Parthenocissus cinquefolia*), and chokecherry (*Prunus virginiana*).

At the start of the project Muir Woods the following Physical Goals and Objectives had <u>not</u> been met:

- Tails edged and/or chipped
- Appropriate seating provided
- Directional and information signage present
- No unauthorized trails
- No gullies that are deeper than 6”
- Stormwater prevented from entering the lake from Muir Woods
- Records being kept of restoration work/practices

My recommendations are:

- Trails have now been edged and wood chips have been applied. Such trail work has been and needs to continue to be priority of the managers. Volunteers have proven to be extremely adept at this task.

- Trails have been simplified and designated and managed as being either primary or secondary. A trail map has been created and approved by the Preserve Committee. Any pre-existing trails that are not part of this new system have been blocked off and replanted. If a trail is still heavily used after it has been blocked, it should be considered as an addition to the trail system if needed. New trails created by users should be blocked,, unless it is determined that they meet a new need.

- The fence should be removed and not be replaced. It has essentially been non-functioning for many years and has therefore proven unnecessary. The stairs will be removed as part of the Gard Foundation Memorial for which funds are currently being replaced. Until that project begins, the stairs should be maintained and additional water bars added to prevent erosion gullies from forming within the treads of the stairs. A rustic bench should be placed along a trail to provide a resting spot for one of two individuals. A site has been selected for one bench and this will be placed once a design has been chosen by the Preserve. This bench should be in place for at least one year and its effect on the user experience as well as ecological conditions in the woods gauged before any additional benches are considered.

- Since the project has started, signs about ongoing projects, the Preserve, and directional signs have been added. The East Preserve Manager should be collaborating with the Program Manager on this project to determine if additional signs are possible. The sub-committee should help to determine content.

- Gully repair has begun and should continue. Filling gullies, diverting stormwater, and replanting the gullies should be a priority in the upcoming months

- The University should continue to re-design its stormwater system to harvest the runoff in the uplands, rather than directing it to flow into the Preserve to the lake

- We have created a reporting system to record work progress at the end of each work day.

Our social/educational experience goals included having at least 3 community volunteer days during the academic year and restoring the Preserve so that it provides UW researchers and classes in the natural sciences an opportunity to observe ecological communities and experiment with restoration models. Currently, weekly volunteer days occur during the fall and the spring. Continued support for the Students of the Lakeshore Nature Preserve group should continue as a way to maintain a body of interested participants. Currently, two courses, Ecology 460 and Botany 130 currently use Muir Woods as part of their curriculum. More partnerships should be sought out and more opportunities for students to do independent research created.

General Reflections

Once the goals and objectives were specified and evaluated, it was possible to use these to begin project implementation. It is important to note that as part of this type of restoration model, not all of the data needs to be collected and analyzed before the project begins since often it is clear which goals and objectives are not met and need attention. However, it is important that goals and objectives have been set prior to any implementation so that all action is part of a larger plan that is guiding restoration choices. As work continues, the objectives can be used as performance standards to determine if the actions being taken are moving the site towards the ecosystem model and use policy that have been selected.

It is still too early to determine if we are moving towards our biological objectives. Implementation thus far has been guided by the information obtained from the initial vegetation inventory. A second, less intensive inventory should be conducted in the summer of 2009 to determine the extent to which we our actions are affecting our desired outcomes.

Future Research

This project opens up many avenues of future research. Most pressing will be using the data collected by future vegetation inventories to evaluate the extent to which our actions have moved us towards our restoration goals and objectives. As monitoring data demonstrate which aspects of the project are working it will be important to try and determine which of these aspects can directly transfer to other sites.

2. How did the East Preserve Project operate? (Case Study)

This project evolved over time and much of what was learned was by comparing initial behaviors or management strategies with ones that developed or by looking back at the challenges of the project over time.

The Decision Making Process

Through evaluating the restoration project over time, there was a clear shift in the efficiency and effectiveness of the entire restoration process as a result of both the adoption of the Master Plan and the use of a small committee of faculty and staff with restoration expertise. The Master Plan provided a level of guidance previously missing, since it is a document that represents the opinions of the Preserve Committee, the community at large, and University staff affiliated with the Preserve. Another aspect of the project that proved invaluable was the creation of the sub-committee. This group of experts met weekly and was able to provide guidance and support for the manager. A key member of this group is the Field Manager, since she is the voice of Facilities Planning and Management and provides a critical link between the restoration activities occurring in the East Preserve and the work that the Grounds Department needs to accomplish. With these two pieces of management infrastructure in place, it was possible for the Preserve Committee to decrease their direct oversight of the student manager. This allowed more work to get accomplished since action did not have to be put on hold until it could be approved in a monthly meeting.

Even with having the Field Manager as part of the weekly sub-committee meetings there is a need for constant communication between full time field staff, policy makers, various university departments, and the student managers. At this point, this does not occur formally and results in miscommunication and an unclear understanding of responsibilities on all sides. If action is not taken to remedy this, it may result in the erosion of the effectiveness and legitimacy of having managers of particular pieces of land within the Preserve. My recommendation is that a bi-weekly meeting of the Field Manager, a Grounds Department representative, and all field staff doing work in the Preserve occurs so that resources can be divided and responsibilities made clear.

Different Visions for the Preserve

The case study also brought to light the effect that the variety of visions that are held for the Preserve is having on its management. An explicit set of guiding principles does not lead to all of those who are involved with the Preserve agreeing on priorities or methods that should be used in its care. There are many players whose opinions can affect a decision in Preserve management. They include Facilities Planning and Management Staff, faculty who use the Preserve for their research or classes, community volunteers, those who donate money, and members of the Preserve Committee. Often all of these groups can feel as though their needs and responsibilities are being met and those who do field work can carry on without the opinions of others playing a role. However, this is not always the case and currently the Preserve does not seem to be set up to handle conflicts between the different vision holders.

While there are many examples of how different visions are coming into play, they can almost always be parsed down to the idea of "process vs. product". What this means is that whenever there is a suggestion for completing a restoration project that utilizes the process outlined in this document (site analysis, creating goals and objectives, long term monitoring etc.) it is viewed as being slow and unnecessary, and detrimental to reaching the final "product". The general feeling from those who oppose this process is that there is already enough known about restoration ecology and work that involves inventories, experimentation, and monitoring is not needed and only slows down reaching the final state that is desired. This is problematic because the assumptions on which this opinion is based are faulty. It is simply not true that enough is known about restoring these sites – more research is needed and performance standards needed to determine if actions taken are beneficial for the site. Furthermore, it is currently unknown if taking all the steps actually slows down the reaching the final "product" that is desired. It is certainly likely that through careful understanding of a site, utilization of an ecosystem model, and monitoring, that problems can be brought under control early on and that choices made are more likely to move the site toward success. It is possible that using a methodical technique can actually bring a site to its target conditions more quickly that simply installing a restoration without this information and infrastructure. Furthermore, the focus on the product rather than the process of restoration negates almost of all the educational value of this type of project, which is inappropriate for areas in need of restoration at a university.

This type of conflict has escalated during my time as manager and very little action has been taken to assuage it. The solution at this point in time seems to be to allow the donors and the Vice Chancellor to make the decisions about how the implementation of the restoration should occur, without first consulting those who have on the ground experience and can make recommendations with the guidance of restoration experts, the Master Plan, and the Preserve Committee. Work is going to need to be done to bring the parties in conflict to the table to discuss their respective visions and see where the commonalities lie. This issue cannot be overlooked with the hope that it will simply fade away.

Using a Student Manager

The final theme that became clear through case study analysis was the advantages and disadvantages of using a graduate student to manage a piece of land within the Preserve. The advantages can most clearly be quantified through looking at the progress made on the ground in the East Preserve – there are trails built, shorelines that have been opened and revegetated, and there has been a tremendous amount of volunteer support. Of course, all of these results could have occurred if the manager was not a student. However, the likelihood that the manager would have been as connected to the general student body is low. Also using an employee does not meet as closely match the strong educational mission of the Preserve or the University. As I wrap up my time as a UW-Madison student, it is clear to me how much I learned and how much my knowledge grew from working on this project. This type of experience is what the educational mission of the Preserve is striving to offer students. This model is becoming less feasible as time goes on and the cost of hiring a Project Assistant rises. In particular, donors and University Grounds Department staff may see this cost as unnecessary when there are many talented potential part time employees that could be hired. While this is true, it decreases the educational experience that the student manager model offers.

Future Research

The case study provided a framework in which evaluation of various aspects of this project could be made. From here, the questions that remain include:

- What are the beliefs held by those who are opposed to this restoration model?
- Does this decision making model transfer to other portions of the Preserve?
- Does this model work if the manager of the area is not a student?

3. Is the student program meeting the goals that were created for it? (Logic Model)

As has been stated previously stated, the emphasis of this project providing educational opportunities for students comes from the mission of the Preserve and the University itself. While using a student manager is one way to reach this mission, it was also important that the student manager provided a way for other students to become involved in this project. The focus on getting a wide variety of students involved was always an implicit goal of the East Preserve project, but as it began to become more of an emphasis, a way to evaluate this portion of the program was needed. Logic models were selected as a way to clearly lay out our goals for working with students and then identify if they were being met.

Based on the logic model, it became clear that the student aspect of this program was moving towards the goals that the manager and sub-committee had set for it.

Short Term Goals we have met include:

- We developed a standard educational tour to students
- The student group exists with guidance of the student managers
- We offer regular volunteer opportunities
- We have identified some faculty, courses, online calendars etc. that help us find volunteers, student employees, interns and researchers

Medium Term Goals we have met include:

- We give educational tours with minimal planning
- We can almost always find interested and appropriate students for a project and generally offer activities that are good fit for the students who work with us
- We post our events widely

Long Term Goals we have met include:

- Some students want to return as volunteers/student workers/researchers
- Muir Woods is being used as a laboratory, by the current student managers and also by additional students and classes
- Students are assisting in getting critical work done in the woods

While the meeting of the goals listed above demonstrates that we are successfully providing opportunities for students, there are certainly some goals that we have yet to achieve. The main goals that we are not meeting have to do with the long-term sustainability of the student group and developing a frame work for keeping students involved in the Preserve. This is something that future managers will have to focus on.

Future Research

The logic model was useful in helping me to evaluate if the opportunities and activities we are offering are moving us towards the goals of the Preserve student volunteer program. However, it also led to some questions that were not answered as part of this document including:

- Are there ways to integrate the evaluation of the volunteer program with the evaluation of restoration goals and objectives?

- What is the best model to create a viable sustainable student group?
- How should we the student experience? Interviews? Focus groups?
- Can/should the volunteer program be replicated in areas of the Preserve that are less centrally located?

4. Are the restoration techniques utilized as part of this project successful?

As part of this project, I set up a variety of restoration trials and experiments to help guide future restoration projects, both in the Preserve and elsewhere. I felt it was important to try different techniques that were likely to be effective and determine their efficacy through monitoring. It is difficult to evaluate this part of the project since it has been at most two and half years since project implementation, which is not long enough to tell if plants have become established or if slopes are being stabilized. Within the next few years, data about our shoreline restoration projects, the changes in the spring ephemeral populations in Muir Woods and ideal planting densities, should become available. The data should be analyzed to determine which of the techniques are moving us towards our objectives. Techniques that are less successful should also be evaluated because the reasons that they are not working may also provide useful information.

Future Research

This project has been effective in moving the restoration of the East Preserve, a previously neglected portion of the Preserve, forward. There are many projects that are now in place that will hopefully move the site towards a less disturbed, more highly functioning state. Also in place are tools of evaluating the various aspects of the project from using logic models to evaluate social components to biological and physical goals and objectives for evaluating the on-the-ground restoration. However, this project is still in its nascent stages and in the course of its implementation it has lead to a variety of new questions the answers to which would provide valuable information for this restoration and other restoration projects in the Preserve. They include:

- What are the best ways to make sure that the work we have accomplished remains transparent for future managers (data, document and knowledge management)?
- Effects of noxious natives on reaching plant community targets
- Studies on other shoreline and gully restoration techniques
- Fencing Study (public perception, reactions and effectiveness to different types of fencing)
- Role of soils in the restoration of Muir Woods/Lakeshore Path (paired with study occurring in Tent Colony Woods and the UW-Madison Arboretum)

Viability of this restoration model

As my time as the manager of this project comes to a close it has been important to reflect on whether this model that we have worked on creating is viable for other parts of the Preserve and other restoration sites.

The model is currently being translated to Tent Colony Woods, another site within the Preserve, although with markedly more donor involvement. The work by student managers in this site should be evaluated and compared to the work in Muir Woods. This will continue to provide information about the efficacy of this model.

The greatest barrier to continue this project is going to be raising money that can be used for the East Preserve. Without additional funds, the focus on these sites will have to decrease, especially if money that is tied to other locations is raised. The importance of finding a way to continue this project is needed since much of what has been put in the ground needs additional management and monitoring, these sites are the most accessible for students interested in interning or volunteering, and there is much that can learned from what has been put in place. Ideally, an endowment would be created that focused on the East Preserve. The money could be used to hire graduate student managers or others to focus on this site.

There is much that can be learned about running restoration projects, about urban restoration ecology, and about how to evaluate projects that can be gleaned from this document. My hope is that this is just the beginning to the Preserve's using this restoration model (with or without the use of student managers). The Preserve could become a place that is looked to for how restoration projects on University properties should be conducted. This can only happen if this project is continued and modified over time.

References

Allen, H. H., & Leech, J. R. (1997). *Bioengineering for Streambank Erosion Control* No. Technical Report EL-97-8). Washington, D.C.: U.S. Army Corps of Engineers. Retrieved 6/29/07, from http://el.erdc.usace.army.mil/elpubs/pdf/trel97-8.pdf

Andropogon Associates, & Prospect Park Landscape Management Office. (1994). *A Landscape Management Pla for the Natural Areas of Prospect Park.* Unpublished manuscript.

Bakker, J. P., Grootjans, A. P., Hermy, M., & Psochlod, P. (2001). How to Define Targets for Ecological Restoration? [Electronic version]. *Applied Vegetation Science, 1*(72), 1-6. Retrieved 4/23/07,

Bader, B. J. (1995). *The distribution of forest herb guilds in wisconsin deciduous forests and the implcations for restoration of the forest understory.* Unpublished Master of Science, University of Wisconsin-Madison.

Bauman, M., Hahn, J., Kagle, R., Tesarik, S., & Waterman, T. (2004). *Restoration Plan for Campus Natural Areas: Muir Woods and Howard Temin Lakeshore Path*. Class Project for LA 666, Restoration Ecology:

Bischoff, A., Vonlanthen, B., Steigner, T., & Muller-Scharer, H. (2006). Seed Provenance Matters — Effects on Germination of Four Plant Species used for Ecological Restoration. [Electronic version]. *Basic and Applied Ecology, 7*(4), 347-359. Retrieved 3/17/07,

Blossey, B., Nuzzo, V., Maerz, J., & Davalos, A. (2005). Ecosystem impacts of *alliaria petiolata* (garlic mustard). *Symposium on the Biology, Ecology and Management of Garlic Mustard (Alliaria Petiolata) and European Buckthron (Rhamnus Cathartica),* St. Paul, Minnesota. 1-3.

Bonsignore, R. (2003). *Urban Greenspace: Effects on Climate and Water*. Minnesota: Design Center for Urban American Landscape. Retrieved 5/27/2006,

Brock, J., Contact. (2005). *ASU Students Install Riparian Preserve at Polytechnic Campus.* Retrieved 10/18, 2006, from http://www.poly.asu.edu/news/2005/07/15/

Chiesura, A. (2004). The Role of Urban Parks in for the Sustainable City. [Electronic version]. *Landscape and Urban Planning, 68*, 129-138. Retrieved 6/20/07,

Clewell, A., Rieger, J. & Munro, J. (2005). *Society for Ecological Restoration Internation: Guidelines for Developing and Managing Ecological Restoration Projects, 2nd Edition.*

Retrieved May 2, 2007, from http://www.ser.org/content/guidelines_ecological_restoration.asp

Cole, D. N. (1993). Minimizing conflict between recreation and nature conservation. In D. S. Smith, & P. C. Hellmund (Eds.), *Ecology or greenways: Designa nd function of linear conservation areas* (pp. 105-122). Minneapolis, Minnesota: University of Minnesota Press. Retrieved 4/2007, from http://www.fs.fed.us/rm/pubs_other/rmrs_1993_cole_d001.pdf

Culliney, T. W. (2005).
Benefits of Classical Biological Control for Managing
Invasive Plants. [Electronic version]. *Critical Reviews in Plant Sciences, 24*, 131-150. Retrieved April 20, 2007,

Curti, J. (2005). *Muir Woods Mentors Homepage.* Retrieved May 27, 2007, from http://muirwoodsmentors.rso.wisc.edu/.

Curtis, J. T. (1971). *The Vegetation of Wisconsin* (2nd Edition ed.). Madison, Wisconsin: The University of Wisconsin Press.

Czarapata, E. J. (2005). *Invasive Plants of the Upper Midwest : An Illustrated Guide to their Identification and Control*. Madison, WI: University of Wisconsin Press.

D'Antonio, C. M., & Vitousek, P. M. (1992). Biological Invasions by Exotic Grasses, the grass/fire Cycle, and Global Change. [Electronic version]. *Annual Review of Ecology and Systematics, 23*, 63-87. Retrieved April 19, 2007,

Delany, K., Roger, L., Woodliffe, P. A., Rhynard, G., & Morris, P. *A Guide to Establishing Prairie and Meadow Communities in Southern Ontario* No. 2007). Ontario, Canada: Environmental Canada. from http://www.on.ec.gc.ca/wildlife/docs/doc-planting-prairie-e.html

DellaSala, D. A., Martin, A., Spivak, R., Schulke, T., Bird, B., Criley, M., et al. (2003). A Citizen's Call for Ecological Forest Restoration; Forest Restoration Principles and Criteria. [Electronic version]. *Ecological Restoration, 21*(1), 14-23. Retrieved 5/15/2007,

Demrow, C., & Salisbury, D. (1998). *Complete Guide to Trail Building and Maintenance* (3rd ed.). Boston, MA: Appalachian Mountain Club Books.

Dodson, S. (2002). *Ecology Internship Course Expectation.* Unpublished manuscript.

Dye, F. J. (2002). *Westside Nature Preserve Homepage.* Retrieved 5/29, 2005, from http://www.wcsu.edu/wnp/

Family Involvement Project (FIP) Logic Model. Retrieved 4/3, 2007, from http://www.gse.harvard.edu/hfrp/content/pubs/onlinepubs/rrb/learning-diagram1.pdf

Ferguson, W. (1999, Fixing a Salt Marsh: Citizens, Shovels, and Sweat. *The Volunteer Monitor, 11*(1) 3-4.

Francis, M. (1999). *A Case Study Method for Landscape Architecture*. Washington D.C.: Landscape Architecture Foundation. Retrieved 11/05/06, from http://www.lafoundation.org/CaseStudyMethod.doc

Glass, S., Leach, M., & Farrior, M. (2006). *Pest Plant Control Strategy Handbook.* Unpublished manuscript.

Gray, D. H., & Leiser, A. T. (1982). *Biotechical Slope Protection and Erosion Control*. Cincinnati: Van Nostrand Reinhold Company.

Grese, R. (1999). Caring for urban wilds: Restoring and managing wildlands in the city. *Research in the Interest of the Public and the Environment Interdisciplinary Problems and Solutions at the University of Michigan,* Ann Arbor, Michican. from http://www.environment.research.umich.edu/downloads/grese.pdf

Gustafson, D. J., Gibson, D. J., & Nickrent, D. L. (2005). Using Local Seeds in Prairie Restoration: Data Support the Paradigm. [Electronic version]. *Native Plants,* (Spring), 25-28. Retrieved 4/16/07,

Hancock, D. R., & Algozzine, B. (2006). *Doing Case Study Research*. New York, NY: Teachers College Press.

Handel, S. (2002). *Determining Limits to Restoration Success: Experiments in Isolated Urban Patches - Conference Abstract.* Unpublished manuscript.

Harrington, J., & Howell, E. A. (19xx). *Natural Ecosystems Monitoring Plan for Carver National Monument.* Unpublished manuscript.

Henderson, C. L., Dindorf, C. J., & Rozumalski, F. J. (1999). *Lakescaping for Wildlife and Water Quality*. Saint Paul, MN: Nongame Wildlife Program, Minnesota Dept. of Natural Resources.

Henderson, R. A. (1995). *Plant Species Composition of Wisconsin Prairies: An Aid to Selecting Species for Plantings and Resotration Based upon University of Wisconsin-Madison Plant Ecology Laboratory Data*. Madison, WI: from http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?id=EcoNatRes.DNRBull188

Hilderbrand, R. H., Watts, A. C., & Randle, A. M. (2005). The Myths of Restoration Ecology. *Ecology and Society, 10*(1), 19-29.

Howard, V., Robins, P., Wrysinski, J., Drewitz, J., Jaouen, S., & Caterson, D. (2002). *Capay Valley Conservation and Restoration Manual*. Woodland, CA: Yolo County Resource

Conservation District. Retrieved 5/29/07, from http://www.yolorcd.org/resources/manuals/Revised%20Manual%20111702.pdf

Huddleson, R. T., & Young, T. P. (2004). Spacing and Competition between Planted Grass Plugs and Preexisting Perennial Grasses in a Restoration Site in Oregon. [Electronic version]. *Restoration Ecology, 12*(4), 546-551. Retrieved 10/24/2006,

Hull, R. B. I. (1992). Brief Encounters with Urban Forests Produce Moods that Matter. *Journal of Arboriculture, 18*(6), 322-324.

Iowa Department of Natural Resources. (2006). *How to Control Streambank Erosion.* Unpublished manuscript. Retrieved April 28,2007, from http://www.ctre.iastate.edu/erosion/manuals/streambank_erosion.pdf

Iowa Department of Transportation. (2000). *Iowa Trails 2000.* Retrieved 3/6, 2007, from http://www.iowabikes.com/trails/

Julian, D. A. (1997). The Utilization of the Logic Model as a System Level Planning and Evaluation Device. [Electronic version]. *Evaluation and Program Planning, 20*(3), 251-257. Retrieved 2/1/07,

Klawinski, P., & Jewell, W. (2005). *Shrub Honeysuckle Seed Dispersal.* Retrieved March 23, 2007, from http://www.kcwildlands.org/naturalenemy17.htm

Kuo, F. E. (1992). Inner cities and chronic mental fatique: Designs for a fighting chance. *Proceedings of the Environmental Design Research Association Conference,* Denver, CO.

Kuo, F. E., & Sullivan, W. C. (2001). Environment and Crime in the Inner City: Does Vegetation Reduce Crime? *Environment and Behavior, 33*(3), 343-365.

Lake County Stormwater Management Commission, Lake County Planning, Building and Development Department, & U.S.D.A. - Natural Resources Conservation Service. (2002). *Streambank and Shoreline Protection Manual*. Lake County, Illinois:

Lakeshore Nature Preserve Committee (Ken Saiki Designs Consultants). (2006). *University of Wisconsin - Madison Lakeshore Nature Preserve Master Plan.* Unpublished manuscript.

Leonard, R. E., McMahon, J. L., & Kehoe, K. M. (1985). *Hiker Trampling Impacts on Eastern Forests* No. Res. Pap. NE-555). Broomall, PA: US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. from http://www.fs.fed.us/ne/newtown_square/publications/research_papers/pdfs/scanned/OCR/ne_rp555.pdf

Lesica, P., & Allendorf, F. W. (1999). Ecological Genetics and the Restoration of Plant Communities: Mix Or Match? [Electronic version]. *Restoration Ecology, 7*(1), 42-50. Retrieved 4/16/07,

Light, A. (2004). Restorative relationships. In R. France (Ed.), *Healing nature, repairing relationships; landscape architecture and the resotration of ecological spaces* (). Cambridge, MA: The MIT Press. Retrieved 2/5/07, from http://faculty.washington.edu/alight/papers/Light.Restorative_Relations.pdf

Logic Model Development Guide(2004). No. 3669). Battle Creek, MI: W.K. Kellogg Foundation. from http://www.wkkf.org/Pubs/Tools/Evaluation/Pub3669.pdf

Longenecker, W. G. (1959). *Plan, John Muir Park.* Retrieved 5/6, 2007, from http://digicoll.library.wisc.edu/WebZ/FETCH?sessionid=01-50562-56985593&recno=2&resultset=2&format=F&next=html/nffull.html&bad=error/badfetch.html&&entitytoprecno=2&entitycurrecno=2&entityreturnTo=brief

Louda, S. M., & Stiling, P. (2004). The Double-Edged Sword of Biological Control in Conservation and Restoration. [Electronic version]. *Conservation Biology, 18*(1), 50-53. Retrieved April 20, 2007,

Lown, L. (2001). *Going Native: A Prairie Planting Guide*. Granger, IA: Polk County Conservation Board.

McCawley, P. F. *The Logic Model for Program PLanning and Evaluation.* Retrieved 3/2, 2007, from http://www.uidaho.edu/extension/LogicModel.pdf

McCune, B., & Cottam, G. (1985). The Successional Status of a Southern Wisconsin Oak Woods. *Ecology, 66*(4), 1270-1278.

McLachlan, S. M., & Bazely, D. R. (2001). Recovery Patterns of Understory Herbs and their use as Indicators of Deciduous Forest Regeneration. *Conservation Biology, 15*(1), 98-110.

McNamara, C. (1997). *Guidelines and FRamework for Designing Basic Logic Model.* Retrieved 4/3, 2007, from http://www.managementhelp.org/np_progs/np_mod/org_frm.htm

McPherson, E. G., Nowak, D. J., & Rowntree, R. A. (1994). *Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project* No. NE-186). Radnor, PA: USDA, Forest Service, Northeastern Forest Experiment Station. Retrieved 2/3/07, from http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/scanned/OCR/ne_gtr186a.pdf

Michigan State Campus Natural Areas. Retrieved 05/15, 2006, from http://www.cpa.msu.edu/nat_area/

Minnesota Department of Natural Resources. (2007). *Southern Mesic Maple-Basswood Forest.* Retrieved 5/4, 2007, from http://files.dnr.state.mn.us/natural_resources/npc/mesic_hardwood/mhs39.pdf

Minnesota Pollution Control Agency. (2000). *Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota*. St. Paul Minnesota:

Missouri Department of Conservation. (2004). *Vegetation Management Guideline: Common Buckthorn (Rhamnus Cathartica L.).* Retrieved 3/23, 2007, from http://www.mdc.mo.gov/nathis/exotic/vegman/eight.htm

Morgan, J. P. (1997). Plowing and seeding. In S. Packard, & C. F. Mutel (Eds.), *The tallgrass restoration handbook* (pp. 193-215). Washington D.C.: Island Press.

National Park Service. (2003). *Point Reyes National Seashore Trail Inventory and Assessment Appendix A: Standards, Guidelines, Ratings*from http://www.nps.gov/pore/parkmgmt/upload/planning_trailinventory_2003_appendixab.pdf

Nedia Enterprises, I. (2007). *Woven Coir Fabrics.* Retrieved 6/4, 2007, from http://www.nedia.com/woven_coir_Koirmat400.html

Northcut, G. (2004). *Project Case Study: Stable Streams*. Retrieved 6/5/07, from http://www.cenews.com/article.asp?id=611

Nyboer, R. (1990). Bush Honeysuckles: Tartarian, Morrow's, Belle, and Amur Honeysuckle (*Lonicera Tatarica* L., *L. Morrowii* Gray, *L. x Bella* Zabel, and *L. Maackii* (Rupr.) Maxim.). *Vegetation Management Guidelines, 1*(6), March 23, 2006 from http://www.inhs.uiuc.edu/chf/outreach/VMG/bhnysckl.html

O'Brien, J. G., Mielke, M. E., Starkey, D., & Juzwik, J. (2000). *How to Identify, Prevent and Control Oak Wilt* No. NA-PR-03-00). Northeast: USDA. from http://www.na.fs.fed.us/spfo/pubs/howtos/ht_oakwilt/toc.htm

Ortwine-Boes, C. M. (2003). *Bumblebee Foraging Dynamics in Northern Wisconsin Cultivated Cranberry Landscapes.* Unpublished M.S., University of Wisconsin-Madison.

Ostergaard, E. (1998, Three Ways to Monitor a Wetland: Minnesota Volunteers Explore Options. *The Volunteer Monitor, 10*(1)

Pastorok, R. A., MacDonald, A., Sampson, J. R., Wilber, P., Yozzo, D. J., & Titre, J. P. (1997). An Ecological Decision Framework for Environemental Restoration Projects. [Electronic version]. *Ecological Engineering, 9*, 89-107. Retrieved 5/4/2007, Plant Conservation Alliance, Alien Plant Working Group. (2006). *Least Wanted: Common Buckthorn.* Retrieved 3/23, 2007, from http://www.nps.gov/plants/alien/fact/rhca1.htm

Ralph, S. C., & Poole, G. C. (2003). Putting monitoring first: Designing accountable ecosystem restoration and management plans. In D. Montogomery, S. Bolton & D. Booth (Eds.), *Restoration of puget sound rivers* (pp. 222-242). Seattle: University of Washington Press.from http://www.krisweb.com/biblio/gen_uofw_ralphetal_ip.pdf

Rathke, D. M., & Baughman, M. J. (2007). *Recreational Trail Design and Construction (University of Minnesota Extension).* Retrieved 4/7, 2007, from http://www.extension.umn.edu/distribution/naturalresources/DD6371.html#step6

Richardson, D. M., Pysek, P., Rejmanek, M., Barbour, M. G., Panetta, D., & West, C. J. (2000). Naturalization and Invasion of Alien Plants: Concepts and Definitions. *Diversity and Distributions, 6*, 93-107.

Richburg, J. A., Dibble, A. C., & Patterson, W. A. (2000). Woody invasive species and their role in altering fire regimes of the northereast and mid-atlantic states. Paper presented at the *Proceedings of the Invasive Species Workshop: The Role of Fire in the Control and Spread of Invsive Species. Fire Conference 2000: The First National Congress on Fire Ecology, Prevention, and Management.* Tallahassee, Florida. *, 11* 104-111. from http://jfsp.nifc.gov/invasive%20publications/ttrs_22pr_09_104_111_c.pdf

Sauer, L. J. (1998). *The Once and Future Forest*. Washington, D.C.: Island Press.

Slapnick, S. (2006). *Lakeshore Nature Preserve Committee.* Retrieved 10/24, 2006, from http://waa.uwalumni.com/lakeshorepreserve/committee.html

Smith, M. K. (2005). David A. Kolb on Experiential Learning. *The Encyclopedia of Informal Education*, 5/15/06

Society for Ecological Restoration International Science & Policy Working Group. (2004). *The SER International Primer on Ecological Restoration* (Version 2 ed.). Tuscon, Arizona: Society for Ecological Restoration International.from http://www.ser.org/pdf/primer3.pdf

Sound Native Plants. (2003). *Planting Density.* Retrieved 10/17, 2006, from http://www.soundnativeplants.com/PDF/Planting%20density.pdf

Taylor, A. M. (2006). *Decking Lumber Options* (http://web.utk.edu/~mtaylo29/files/Decking%20Lumber%20Option.pdf ed.)University of Tennessee Extension. Retrieved 6/28/07, from http://web.utk.edu/~mtaylo29/files/Decking%20Lumber%20Option.pdf

Taylor-Powell, E. (2005). *Logic Models: A Framework for Program Planning and Evaluation.* Retrieved 4/3, 2007, from http://www.uwex.edu/ces/pdande/evaluation/powerpt/nutritionconf05.ppt#256,1,Logic Models: A framework for program planning and evaluation

Taylor-Powell, E., Steele, S. & Douglah, M. (1996). *Program Development and Education from University of Wisconsin-Extension-Cooperative Extension, Program Development and Evaluation Unit Web Site.* Retrieved 1/15/07, 2007, from http://www.uwex.edu/ces/pdande/evaluation/evallogicmodel.html

Tennessee Valley Authority. (2006). *Understanding Erosion.* Retrieved 6/24, 2007, from

The UW-Madison Lakeshore Preserve Committee. (2005). *Lakeshore Nature Preserve Guiding Principles.* Retrieved May 30, 2007, from http://www.lakeshorepreserve.wisc.edu/about/guiding_principles.htm

Thomas, L., & Middleton, J. (2003). In Phillips A. (Ed.), *Guidelines for Management Planning of Protected Areas*The World Conservation Union. Retrieved 4/27/06, from http://www.iucn.org/bookstore/HTML-books/BP10-guidelines_for_management_pas/cover.html

Undergraduate Research Scholars Homepage. (2007). Retrieved 4/5, 2007, from http://www.lssaa.wisc.edu/urs/

University of Wisconsin. (1988). *University of Wisconsin-Madison Mission Statement.* Retrieved May 30, 2007, from http://www.wisc.edu/about/administration/mission.php

Uva, R., Neal, J. C., & Ditomaso, J. M. (1997). *Weeds of the Northeast*. Ithaca, New York: Cornell University Press.

Van Der Wiele, Cynthia F., Hunt, W. F., & Hathaway, J. (2006). *Level Spreader Design Guidelines*North Carolina Division of Water Quality. from http://h2o.enr.state.nc.us/su/Levelspreader

W.K. Kellogg Foundation. *Guiding Program Direction with Logic Models* (Item #1213 ed.). Battle Creek, MI:

Weiss, C. H. (1998). *Evaluation* (Second Edition ed.). Upper Saddle Hill, NJ: Prentice Hall.

Westphal, L. M. (2003). Urban Greening and Social Benefits: A Study of Empowerment Outcomes. *Journal of Arboriculture, 29*(3), 137.

White, P. S., & Walker, J. L. (1997). Approximating Nature's Variation: Selecting and using Reference Information in Restoration Ecology. *Restoration Ecology, 5*(4), 338-349.

Wiley, J. D. (2000). *CNAC Appointment Memo*

Wisconsin DNR. (2003). *Bella Honeysuckle.* Retrieved March 23, 2007, from http://www.dnr.state.wi.us/invasives/fact/honeysuckle_bella.htm

Wisconsin DNR. (2004). *Red Osier Dogwood (Cornus Sericea).* Retrieved 4/28, 2007, from http://www.dnr.state.wi.us/invasives/fact/wetshrubs_red.htm

Wisconsin DNR. (2007). *Oak Wilt in Wisconsin: Biology and Management.* Retrieved 5/29, 2007, from http://www.dnr.state.wi.us/ORG/LAND/Forestry/fh/oakWilt/

Yin, R. K. (2003). *Case Study Research Design and Methods* (3rd ed.). Thousand Oaks, California: Sage Publications.

Young, C., & Young B. (1993). *Park Planning: A Training Manual (Instructors Guide).* Mweka, Tanzania: College of African Wildlife Management.

Zedler, J. B. (2005). Ecological Restoration: Guidance from Theory. [Electronic version]. *San Francisco Estuary & Watershed Science, 3*(2), 1-31.

Zedler, J. B., & Callaway, J. C. (2003). Adaptive restoration: A strategic approahc for intergrating research into restoration projects. In D. J. Rapport, W. L. Lasley, D. E. Rolson, N. O. Nielsen, C. O. Qualset & A. B. Damania (Eds.), *Managing for healthy ecosystems* (pp. 167-174). Boca Raton, Florida: Lewis Publishers.

Appendices

Appendix A: Desired Species Planting Lists

Southern Mesic Forest List

Tree Layer

Species	Common Name
Acer saccharum	Sugar Maple
Tilia americana	Basswood
Ulmus rubra	Slippery elm
Quercus rubra	Red Oak
Ostrya virginiana	Ironwood
Carya cordiformis	Yellow-bud hickory
Gymnocladus dioica	Kentucky Coffee Tree
Fraxinus americana	White Ash
Ulmus americana	American elm
Juglans cinerea	Butternut
Carya ovata	Shagbark Hickory
Celtis occidentalis	Hackberry
Quercus alba	White Oak
Prunus serotina	Black Cherry
Juglans nigra	Black Walnut

Shrub Layer

Ribes cynosbati	Prickly Gooseberry
Euonymus atropurpureus	Eastern wahoo
Staphylea trifolia	Bladdernut
Corylus americana	American Hazlenut
Virbunum lentago	Nannyberry
Cornus rugosa	Round-Leaved dogwood
Sambucus canadensis	American Elderberry

Herbs

Actae alba/pachypoda	Baneberry sp.
Adiantum pedatum	Maidenhair Fern
Allium tricoccum	Wild Leek
Amphicarpa bracteata	Hog Peanut
Anemone quinquefolia	Wood Anemone
Aplectrum hyemale	Adam and Eve Orchid
Aquilegia canadensis	Wild Columbine
Aralia nudicaulis	Wild Sarsaparilla

Arisaema triphyllum	Jack in the Pulpit
Asarum canadense	Wild Ginger
Aster macrophyllus	Big-leaved Aster
Aster sagittifolius	Arrow-leaved aster
Athyrium filix-femina	Lady Fern
Botrychium virginianum	Rattlesnake Fern
Brachyelytrum erectum	Long-Awned Woodgrass
Camptosorus rhizophyllus	Walking Fern
Carex convoluta/rosea	Curly Styled Wood Sedge
Carex davisii	Awned Graceful Sedge
Carex deweyana	Dewey's Sedge
Carex hirtifolia	Hairy Wood Sedge
Carex pennsylvanica	Pennsylvania Sedge
Carex sprengelii	Sprengel's Sedge
Carex tetanica	Stiff Sedge
Caulophyllum thalictroides	Cohosh
Claytonia virginica	Spring Beauty
Cryptotaenia canadensis	Canadian Honewort
Dentaria laciniata	Cut Leaved Toothwort
Dicentra canadensis	Squirrel Corn
Dicentra cucullaria	Dutchman's Breeches
Ellisia nyctelea	Water Pod
Erythronium albidum	White Trout-lily
Galium aparine	Stickwilly, Annual bed straw
Galium concinnum	Shining Bedstraw
Galium triflorum	Fragrant Bedstraw
Geranium maculatum	Wild Geranium
Geum canadense	White Avens
Habenaria viridis	Frog Orchid
Hepatica acutiloba	Sharp Lobed Hepatica
Hydrastis canadensis	Golden Seal
Hydrophyllum appendiculatum	Great Water Leaf
Hyrdrophyllum virginianum	Virgina Water Leaf
Impatiens pallida	Yellow Jewelweed
Isopyrum biternatum	False Rue Anemone
Laportea canadensis	Canadian Wood-nettle
Osmorhiza claytoni	Sweet Cicely
Phlox divaricata	Wood's Phlox
Phryma leptostachya	American Lop-seed
Podophyllum peltatum	Mayapple
Polemonium repetens	Jacob's Ladder
Polygonatum biflorum	Solomon's Seal
Polygonatum pubescens	Downy Solomon's Seal
Prenanthes alba	Rattlesnake Root
Sanguinaria canadensis	Bloodroot
Sanicula gregaria	Black Snakeroot
Smilacina racemosa	False Solomon's Seal

Smilax ecirrhata	Upright Carrion Flower
Solidago flexicaulis	Zig Zag Goldenrod
Thalictrum dioicum	Early Meadow-rue
Trillium gleasoni/flexipes	Bent Trillium
Trillium grandiflorum	Great White Trillium
Uvularia grandiflora	Large Yellow Bellwort
Viola cucullata	Marsh Blue violet
Viola pubescens	Downy Yellow Violet

Southern Dry Mesic Forest List

Species	Common Name
Tree Layer	
Acer saccharum	Sugar Maple
Quercus alba	White Oak
Quercus rubra	Red Oak
Tilia Americana	Basswood
Ulmus rubra	Slippery elm
Shrub Layer	
Cornus alternifolia	Pagoda Dogwood
Cornus racemosa	Gray Dogwood
Cornus rugosa	Round-Leaved dogwood
Corylus Americana	American Hazlenut
Ribes cynosbati	Prickly Gooseberry
Rubus allegheniensis	Blackberry
Rubus occidentalis	Black Raspberry
Rubus strigosus/idaeus	Red Raspberry
Sambucus canadensis	Blue elderberry
Viburnum lentago	Nannyberry
Viburnum rafinesquianum	Arrow-wood

Herbs

Adiantum pedatum	Maidenhair Fern
Agastache scrophulariaefolia	Giant Hissop
Agrimonia gryposepala	Agrimony
Amphicarpa bracteata	Hog Peanut
Anemone quinquefolia	Wood Anemone
Anemone virginiana	Tall Anemone
Thalictrum thalictroides	Rue Anemone
Apocynum androsaemifolium	Spreading Dogbane
Aralia nudicaulis	Wild Sarsaparilla
Aralia racemosa	Spikenard
Arisaema triphyllum	Jack in the Pulpit

Asclepias exaltata	Tall Milkweed
Aster prenanthoides	Crooked Aster
Aster sagittifolius	Arrow Leaved Aster
Aster shortii	Blue Heart Leaved Aster
Athyrium filix-femina	Lady Fern
Botrychium virginianum	Rattlesnake Fern
Brachyelytrum erectum	Long-Awned Woodgrass
Bromus purgans/kalmii	Ear Leaved Brome
Campanula americana	American Bellflower
Carex hitchcockiana	Hairy Wood Sedge
Carex jamesii	Grass Sedge
Carex pennsylvanica	Pennsylvania Sedge
Caulophyllum thalictroides	Cohosh
Cirsium altissimum	Tall Thistle
Corallorhiza odontorhiza	Coralroot
Cryptotaenia canadense	Canadian Honewort
Desmodium glutinosum	Cluster Leaf Tick-trefoil
Desmodium nudiflorum	Bare Stemmed Tick-trefoil
Elymus villosus	Downy Wild Rye
Erigeron pulchellus	Robin's Plantain
Eupatorium purpureum	Purple Joe-Pye Weed
Eupatorium rugosum	White Snakeroot
Fragaria virginiana	Wild Strawberry
Galium aparine	Stickwilly, Annual bed straw
Galium circaezans	Forest Bedstraw
Galium concinnum	Shining Bedstraw
Galium triflorum	Fragrant Bedstraw
Geranium maculatum	Wild Geranium
Geum canadense	White Avens
Goodyera pubescens	Downy Rattlesnake Plantain
Hackelia virginiana	Stickseed
Helianthus strumosus	Pale leaved Woodland Sunflower
Heracleum lanatum	American Cow parsnip
Hieracium scabrum	Rough Hawkweed
Hydrophyllum virginianum	Virgina Water Leaf
Hystrix patula/Elymus hystrix	Bottlebrush Grass
Lactuca spicata/biennis	Tall Blue lettuce
Lathyrus ochroleucus	Cream Pea-Vine
Orchis spectabilis/Galearis spectabilis	Showy Orchis
Oryzopsis racemosa	Black-seeded Rice Grass
Osmorhiza claytoni	Sweet Cicely
Osmorhiza longistylis	Smooth Sweet Cicely
Osmunda claytoniana	Interrupted Fern
Panax quinquefolius	Ginseng
Panicum latifolium/Dichanthelium latifolium	Broad-leaved Panic Grass
Parietaria pensylvanica	Pennsylvanian pellitory

Phryma leptostachya	American Lop Seed
Podophyllum peltatum	Mayapple
Polemonium reptans	Spreading Jacob's-Ladder
Polygonatum pubescens	Downy Solomon's Seal
Prenanthes alba	Rattlesnake Root
Pteridium aquilinum	Bracken fern
Ranunculus abortivus	Little-Leaf Buttercup
Ranunculus recurvatus	Hooked Buttercup
Sanguinaria canadensis	Bloodroot
Sanicula gregaria	Black Snakeroot
Scrophularia marilandica	Eastern Figwort
Smalacina racemosa//Maianthemum racemosum	False Solomon's Seal
Smilax ecirrhata	Upright Carrion Flower
Solidago ulmifolia	Elm-leaved Goldenrod
Thalictrum dioicum	Early Meadow-rue
Trillium gleasoni/flexipes	Bent Trillium
Triosteum perfoliatum	Feverwort
Uvularia grandiflora	Large Flowered Bellwort
Veronicastrum virginicum	Culver's Root
Viola cucullata	Marsh Blue violet
Viola pubescens	Downy Yellow Violet

Shoreline Savanna Planting List

Shrubs	
Ceanothus americanus	New Jersey Tea
Corylus americana	American Hazelnut
Cephalanthus occidentalis	Buttonbush
Trees	
Quercus alba	White oak
Quercus rubra	Red Oak
Quercus macrocarpa	Bur Oak
Quercus bicolor	Swamp White Oak
Herbs	
from Seed:	
Agastache scrophulariaefolia	Purple Hyssop
Agrimonia spp.	Agrimony
Allium cernuum	Nodding Onion
Anemone virginiana	Tall Anemone
Aquilegia canadensis	Wild Columbine
Aster drummondii	Drummond's Aster

Aster laevis	Smooth Blue Aster
Aster sagittifolius	Arrow-leaved Aster
Bouteloua curtipendula	Side Oats Grama
Bromus ciliatus	Fringed Brome
Bromus latiglumis	Ear-leaved Brome
Carex bicknellii	Copper-shouldered Oval Sedge
Carex bromoides	Brome Hummock Sedge
Carex sprengelii	Long-beaked Sedge
Coreopsis palmata	Prairie Coreopsis
Dalea candidum	White Prairie Clover
Dalea purpurea	Purple Prairie Clover
Desmodium canadense	Canada Tick Trefoil
Desmodium glutinosum	Pointed Tick Trefoil
Desmodium illinoense	Illinois Tick Trefoil
Diarrhena americana	Beak Grass
Elymus canadensis	Canada Wild Rye
Elymus patula	Bottlebrush Grass
Elymus riparius	Riverbank Wildrye
Elymus villosus	Silky Wildrye
Elymus virginicus	Virginia Wild Rye
Eupatorium maculatum	Spotted Joe Pye Weed
Helianthus strumosus	Woodland Sunflower
Heuchera richardsonii	Alum Root
Juncus tenuis	Path Rush
Koeleria cristata	June Grass
Kuhnia eupatorioides	False Boneset
Liatris pycnostachya	Prairie Blazing Star
Monarda fistulosa	Wild Bergamot
Napaea dioica	Glade Mallow
Panicum virgatum	Switch Grass
Phryma leptostachya	Lopseed
Polygonatum biflorum	Solomon's Seal
Ratibida pinnata	Yellow Coneflower
Rudbeckia hirta	Black-eyed Susan
Rudbeckia triloba	Brown-eyed Susan
Schizachyrium scoparium	Little Bluestem
Scrophularia lanceolata	Early Figwort
Solidago rigida	Stiff Goldenrod
Solidago speciosa	Showy Goldenrod
Solidago ulmifolia	Elm-leaved Goldenrod
Sporobolus cryptandrus	Sand Dropseed
Tradescantia ohiensis	Spiderwort
Verbena stricta	Hoary Vervain
Veronicastrum virginicum	Culver's Root
from plugs:	

Anemone canadensis	Meadow Anemone
Aquilegia canadensis	Columbine
Asclepias tuberosa	Butterfly Weed
Aster azureus	Sky Blue Aster
Aster ericoides	Heath Aster
Aster laevis	Smooth Blue Aster
Aster macrophyllus	Big-Leaved Aster
Aster novae-angliae	New England Aster
Astragalus canadensis	Canada Milkvetch
Baptisia leucophea	Cream Wild Indigo
Blephilia ciliata	Downy Wood Mint
Bouteloua curtipendula	Side Oats Gramma
Campanula americana	Tall Bellflower
Carex crinita	Fringed Sedge
Carex hystricina	Bottlebrush Sedge
Carex sprengelii	Woodland Sedge
Cinna arundinacea	Wood Reed Grass
Coreopsis palmata	Stiff Coreopsis
Desmodium canadensis	Showy Tick Trefoil
Dodecatheon meadia	Shooting Star
Elymus hystrix	bottlebrush Grass
Elymus riparius	Riverbank Wild Rye
Elymus virginicus	Virginia Wild Rye
Eupatorium maculatum	Joe-Pye Weed
Geranium maculatum	Wild Geranium
Helianthus divaricatus	Woodland Sunflower
Helianthus occidentalis	Western Sunflower
Helianthus strumosus	Woodland Sunflower
Hypericum pyramidatum	Great St. John's wort
Koeleria cristata	June Grass
Liatris pycnostachya	Prairie Blazingstar
Lupinus perennis	Wild Lupine
Monarda fistulosa	Bergamont
Phlox pilosa	Downy Prairie Phlox
Pycnanthemum virginianum	Mountain Mint
Ratibida pinnata	Yellow Coneflower
Rudbeckia hirta	Black-eyed Susan
Rudbeckia subtomentosa	Sweet Black-eyed Susan
Rudbeckia triloba	Brown-eyed Susan
Schizachyrium scoparium	Little Bluestem
Solidago graminifolia	Grass-leaved Goldenrod
Solidago speciosa	Showy Goldenrod
Solidago ulmifolia	Elm-leaved Goldenrod
Spartina pectinata	Prairie Cord Grass
Sporobolis heterolepis	Prairie Dropseed
Thalictrum dasycarpum	Purple Meadow Rue
Tradescantia ohiensis	Spiderwort

Vernonia fasciculata	Ironweed
Veronicastrum virginicum	Culver's Root
Zizia aptera	Heart Leaved Alexander
Zizia aurea	Golden Alexanders

Appendix B: Vegetation Inventory Protocol and Data Sheets

Protocol for Vegetation Inventory in Muir Woods

Prepared by: Rebecca Kagle
Draft: 5/1/2006

I. Rationale

This inventory which will be completed in the Summer of 2006 will serve to generate baseline data about the vegetation in the eastern portion of Muir Woods. This information will guide the management of the woods, provide information for future studies, and be used by classes that currently inventory specific sections of aspects of the woods. The permanent grid that was installed as part of this project will provide a 'language' on the ground to track work and experimentation that has been done so that the work can be continued and altered over time. The grid and the data collected from it will also be crucial to the long term monitoring protocols set up.

This protocol will serve as a guide for implementing other inventories in the Preserve.

II. Goals

Data collected will be used to measure the density, frequency, and importance value of herbaceous and woody plant species within Muir Woods. We will get a sense of species richness, canopy cover, and overall plant diversity. Information about leaf litter, standing snags, and fallen logs will also be collected.

Much of the data collected will be quantitative, but qualitative data about the human use patterns and overall conditions of the plots will be noted. This will help guide future management and understanding of the current conditions. Photographs taken of each plot will provide a visual image of the conditions of each site.

Information about the current dominant species will be gained as well as a picture of the dominant vegetation of the future.

The data collected, along with the maps that are generated by the inventory, will provide a clear picture of if there are zones within the woods that should be managed differently from one another.

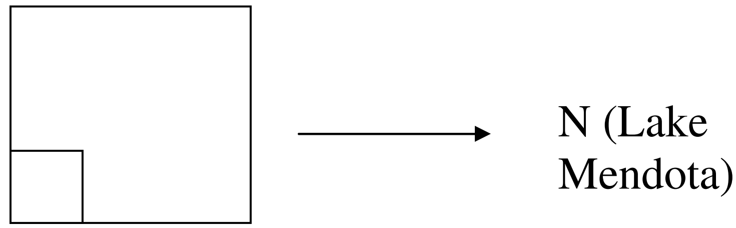
III. Data collection within the plots

Materials Needed:

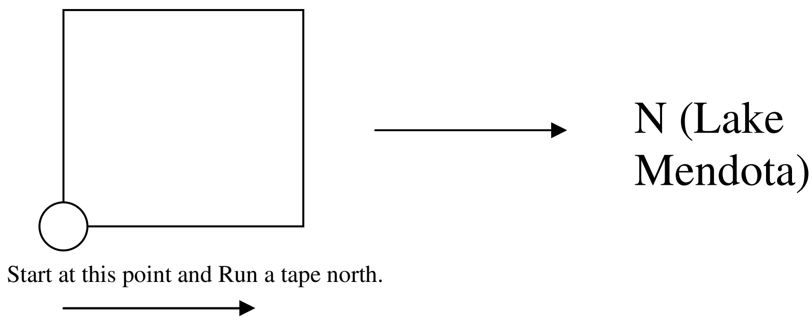
- **Chaining Pins**
- **3-5 measuring chains (at least 30m)**
- **DBH tape (metric)**
- **7.6 foot leveling rod**
- **Compass**
- **Light Meter**
- **Clipboard and Data Sheets**
- **1 m^2 frame**
- **Field Notebook for noting work that needs to be done, posts to be replaced etc.**
- **Small Squirt Bottle of water to wash off posts**
- **Extra Pin Flags**
- **Baggies to collect unknown plants**
- **Orange Marking Paint to repaint rebar if necessary**
- **Slope Measurement Tool**
- **Ruler**
- **Extra Pin Flags (Blue or Yellow)**
- **Black Sharpie**

Note: Data about trees, shrubs, saplings, and herbaceous species will only be collected in every other plot. If time allows, this data will be collected in all plots. Trees with a DBH larger than 30cm will be marked and mapped in ALL plots.

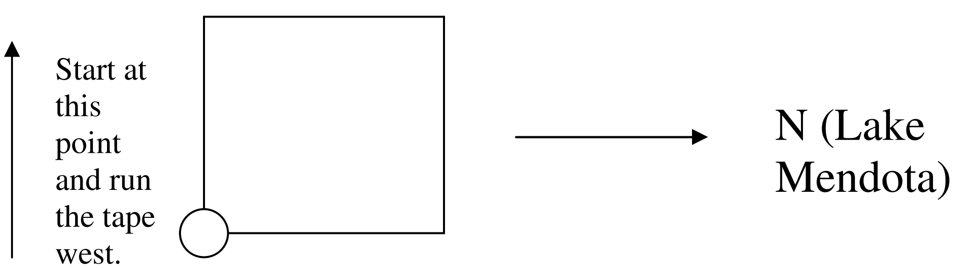
Locate the four corners of the plot. This process should be fairly easy if the aboveground markers are still present and visible. If they are not, a metal detector may be necessary to locate the belowground markers.
<u>Try to stay outside of the plot area that will be monitored for herbaceous vegetation as much as possible</u>. Data will be collected on these herb subplots first.



Once the corners have been located, run a chain from 0 to 10 meters from the easternmost point to towards the North. Draw the tape as taught and straight as possible. Use the chaining pins to hold the tape in place.



Now run a chain measuring 0 to 10 meters from the same zero point in the Western direction.



At this point, a tape can be run without regard to measurements along the remaining two sides of the grid.

<u>II.A. Monitoring Herb Subplots</u>

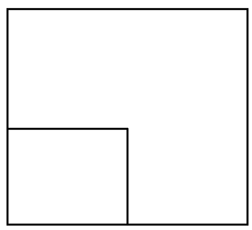
Place the 1 m^2 frame over the herbaceous subplot. If the vegetation is too tall, the frame will need to be held in place above the half-subplot.

1. Estimate the percent coverage of each herb species, separately, within the frame and record it on the data sheet.

2. Note if fruiting or flowering or if there is evidence of herbivory. Use the comment section to describe the damage.
3. Take an overall percent cover reading for the entire subplot.
4. Take a photograph of the herbaceous plot and note angle/distance from corner post that includes the subsample.

II.B. Monitoring Woody Plants in the Plot

II.B.i Monitoring Shrubs, Seedlings, and Saplings** in the Plot*

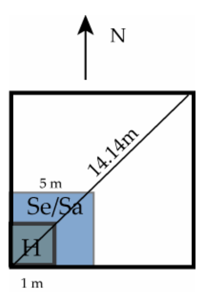


Using the meter measurements on the South and Eastern sides of the plot, run a tape 5 meters (using a 90 degree bearing) into the center of the plot. Clip both of the tapes to a chaining pin at the approximate center of the plot. Within this subplot, shrubs and saplings will be monitored.

* Seedling - a young tree, grown from seed, from the time of germination to the sapling stage, having a
dbh equal or less than 1 cm
** Sapling - a young tree no longer a seedling but not yet a pole, about 1 - 2 m high and 2 - 4 cm dbh.

Measuring Shrubs

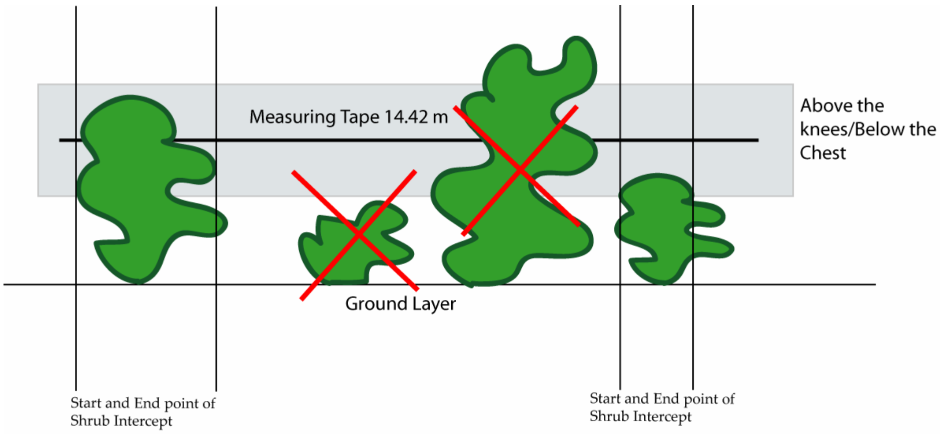
Shrubs will be measured using the line intercept technique.
Run a tape from the SW corner of the plot to the NE corner of the plot. The measure should be approximately 14.14 m.



a. Work your way from SW to SE along the transect line.
   i. Anytime you come into contact with a shrub that falls on/above/below the transect line AND is above your knees or below your chest, this shrub will be recorded.
   ii. Note the shrub species

iii. Note the measurement at which the shrub first makes contact with the transect (that falls within the target zone) and at which the shrub ends (within the target zone).

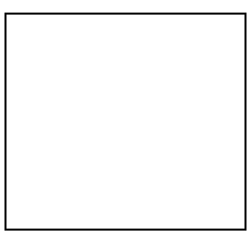
NOTES: If parts of the shrub fall out of the target zone DO NOT include these parts in the length of the shrub. Judge if it falls in the target zone by its tallest point.



Measuring Seedlings and Saplings

1. Measure the height with a leveling rod.
2. Note species.
3. Note overall condition of tree (fruiting/flowering, overall health of tree – herbivory etc).

II.B.ii Monitoring Trees and Fallen Logs in the Plot



Measure all Trees and Standing Snags with a DBH greater than 4cm in the entire plot. If the vegetation in the plot is particularly dense, another tape may be drawn between the other pair of opposite sides to divide the plot into quarters. Work in each section of the plot separately to keep track of which plants have already been counted and measured.

Measuring Trees

1. All trees up to 7.6m should be measured with a leveling rod.
2. DBH (at 4.5 feet above ground) should be taken on trees with a DBH greater than 4 cm.
3. If the height is over 7.6m, just record DBH.

4. Note species
5. Note overall condition of tree (fruiting/flowering, overall health of tree – herbivory etc.).
6. Measure to center of tree from 2 different known points (grid corners). Note known point and distance on data sheet.
7. Give all trees with a DBH greater than 30 centimeters a unique ID # and a tree tag. Note ID # on Data Sheet.

Measuring Standing Snags and Fallen Logs

1. Standing snags and Fallen Logs should be noted, DBH taken and their decay class listed. For fallen logs, the DBH can be estimated based on half the diameter.

Decay class 1 - snags that have recently died, typically have little decay, and retain their bark, branches and top
Decay class 2 - snags that show some evidence of decay and have lost some bark and branches, and often a portion of the top
Decay class 3 - snags that have extensive decay, are missing the bark and most of the branches and have a broken top.

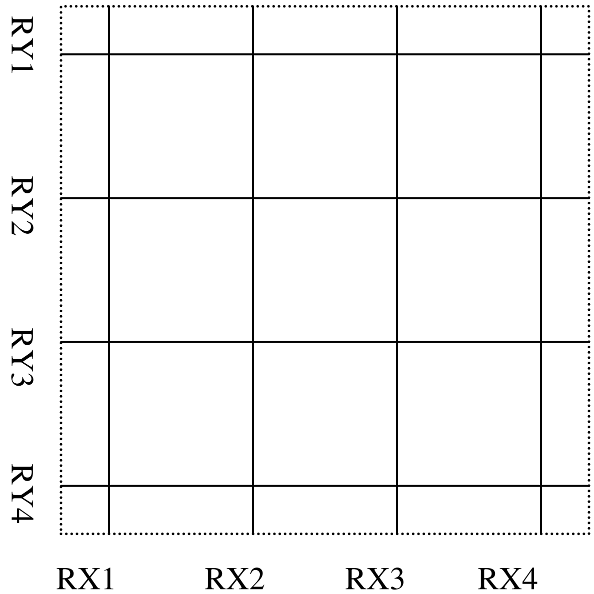
II.C. Monitoring Plot Conditions

II.C.i Canopy Cover

Take measurements only on clear sunny days.

Readings must be taken between 10:30am and 1:30pm

Quadrant size is 1/2m x 1/2m



Solid lines = light measurement
(ex: RY1 means measurement one on the y-axis; RX1 means measurement one on the x-axis)

Dotted lines = boundary of site (where quadrant was placed)

1. Find NW corner of white plots on Survey Map.
2. Set out ½ meter x ½ meter quadrat
3. Take 8 readings at approximately 4.5 feet, record average on data sheet
4. Take 8 readings at ground level, record average reading on data sheet
5. Note time of reading and any critical notes about the plot.
6. Cross plot off of master map.
7. Move onto next white plot.

To Use the Light Meter to take Cover Samples:

- Push ON
- Press ENTER
- Press F2 ("Read")
- Presss F2 ("Par Sample")
- Press F1 ("Full Probe")
- Press F4 ("No Seno.")

- Press F4 ("Par Sample")
- Press ENTER
- ** Once the set up is finished:
    1. Take canopy measurements - Press F1 for each light measurement
    2. After that, take floor measurements - Press F4 for each light measurement
    3. To compile the average for the canopy and floor light levels press ENTER
    4. Write down measurements
    5. To move on to the next replicate/measurement site clear data by pressing F2
    6. Repeat steps 1-5 as many times as required

II.C.iv Qualitative Description of the Plot

Under the "Site Comments" section on the data sheet, describe any noteworthy conditions of the site such as evidence of vandalism, trampling, fire, or other human disturbances to the plot. Also note any natural disturbances such as tree falls, substantial mortality due to drought or herbivory, or evidence of erosion etc. Give the plot a human disturbance rating of 1 to 4.

Once the site conditions have been recorded, the measuring tapes can be taken up. If any of the above ground or belowground markers are missing, replace these before removing the tapes. Respray rebar with orange spray paint

Muir Woods Vegetation Inventory 2006

Date: ____________________________

Personnel: ____________________________

Plot #: ____________________________

Trees

				Tree Mapping						
Species	Height (m)	DBH (cm)	ID Tag #	Known Point	Distance	Known Point	Distance	Fruiting (Y/N)	Flowering (Y/N)	Notes

Muir Woods Vegetation Inventory 2006

Shrub Line Intercept Data Sheet

Plot #: ________________ **Date:** ______________________

Length of Transect: ________________ (should be around 14.42)

Species	Start	Stop	Notes

	Above Strike Zone	Below "Strike Zone"
Species	Count	Count

Muir Woods Vegetation Inventory 2006

Seedlings and Saplings Data Sheet

Plot #: ________ **Date:** __________

Species	Height (m)	Length 1 (m)	Length 2 (m)	Fruiting (Y/N)	Flowering (Y/N)	Notes

Muir Woods Vegetation Inventory 2006

Herbaceous Data Sheet

Plot #: ________________ **Woody Plant Percent Cover:** __

Date: ________________ **Overall Percent Cover:** __

Species Name	# Of Stems	% Cover	Flowering (Y/N)

Muir Woods Vegetation Inventory 2006

Logs and Standing Snags Data Sheet

Plot #: _________ Date:__________

Species	Height/Length (m)	DBH (cm)	Log or Snag?	Decay Class (1-3)	Notes

Plot Descriptions

Include: all species not noted in survey data, % covered by trails, anything that might be altering plant growth on the site, including evidence of human use. Sketch trails within plot. Note what is left to complete in plot.

I	Invasive Removal (Note if Dabbing is Needed)
LM	Light Meter Reading

Plot #: _____________ **Date:________________**

Plot Description:

Invasive Species:

Other Herbs:
Other Shrubs:
Other Trees:

To Do:

Appendix C: List of Species Found in Muir Woods

Trees

CODE	Scientific Name	Common Name
ACSA	*Acer saccharum*	Sugar Maple
CAOV	*Carya ovata*	Shagbark Hickory
CEOC	*Celtis occidentalis*	Common Hackberry
COAL	*Cornus alternifolia*	Pagoda Dogwood
FRAM	*Fraxinus americana*	White Ash
OSVI	*Ostrya virginiana*	American Hophornbeam
PRSE	*Prunus serotina*	Black Cherry
QUAL	*Quercus alba*	White Oak
QURU	*Quercus rubra*	Red Oak
TIAM	*Tilia americana*	American Basswood
ULAM	*Ulmus americana*	American elm
ACNE	*Acer negundo*	Box elder
ACSA	*Acer saccharinum*	Silver Maple
FRNI	*Fraxinus nigra*	Black Ash
FRPE	*Fraxinus pennslyvanica*	Green Ash
QUMA	*Quercus macrocarpa*	Bur Oak
ACGI	*Acer ginnala*	Amur Maple
ACPL	*Acer platanoides*	Norway Maple
AESP	*Aesculus* sp.	Buckeye sp.
LADE	*Larix decidua*	Eurpean Larch
LITU	*Liriodendron tulip*	Tulip Tree
MOAL	*Morus alba*	White Mulberry
PRSP	*Prunus sp.*	Ornamental Cherry Species
ROPS	*Robinia psuedoacacia*	Black Locust

Shrubs

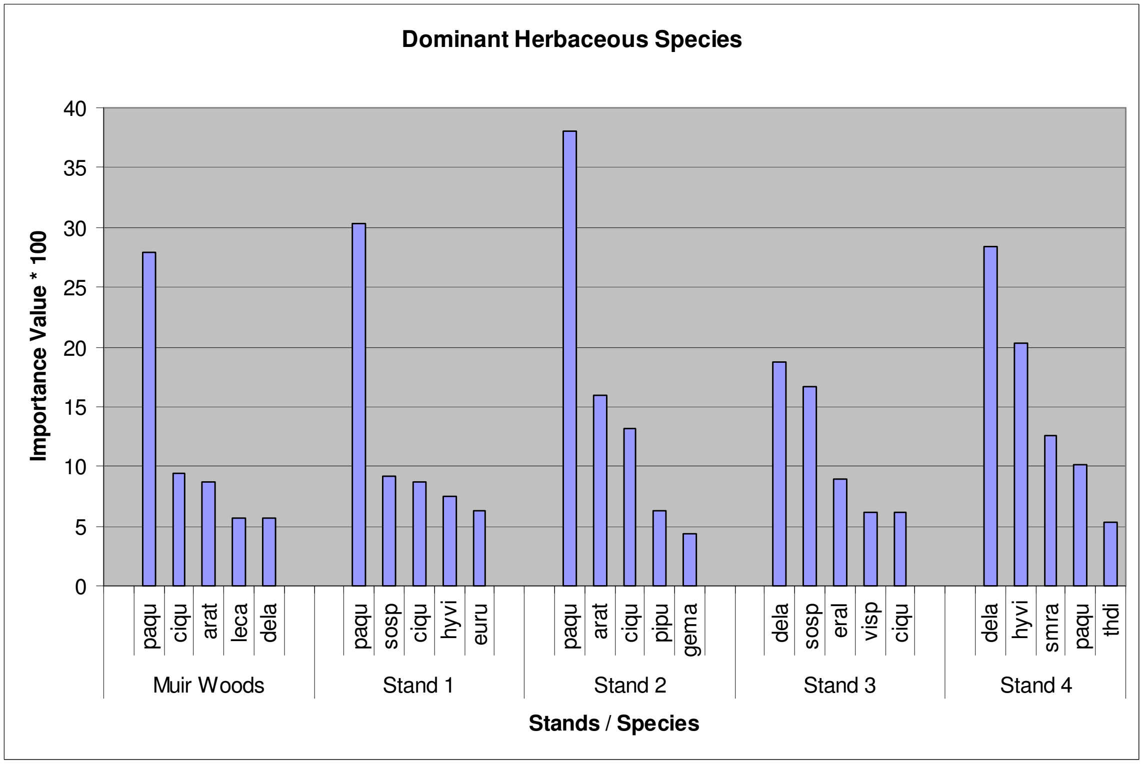
CODE	Scientific Name	Common Name
SACA	*Sambucus canadensis*	American Elderberry
PRVI	*Prunus virginiana*	Chokecherry
RIAM	*Ribes americanum*	Wild Black Currant
RIMI	*Ribes missouriense*	Missouri gooseberry
SARA	*Sambucus racemosa*	Red Elderberry
LISP	*Ligustrum sp.*	Privet Sp,
LOSP	*Lonicera sp.*	Honeysuckle sp.
RHCA	*Common buckthorn*	Rhamnus cathartica
VIOP	*Vibrunum opulus*	European Cranberrybush Viburnum
PHSP	*Philadelphus sp*	Mock-orange sp.
EUFO	*Euonymus fortunei*	Creeping Euonymus
EUAL	*Euonymus alata*	Burning Bush

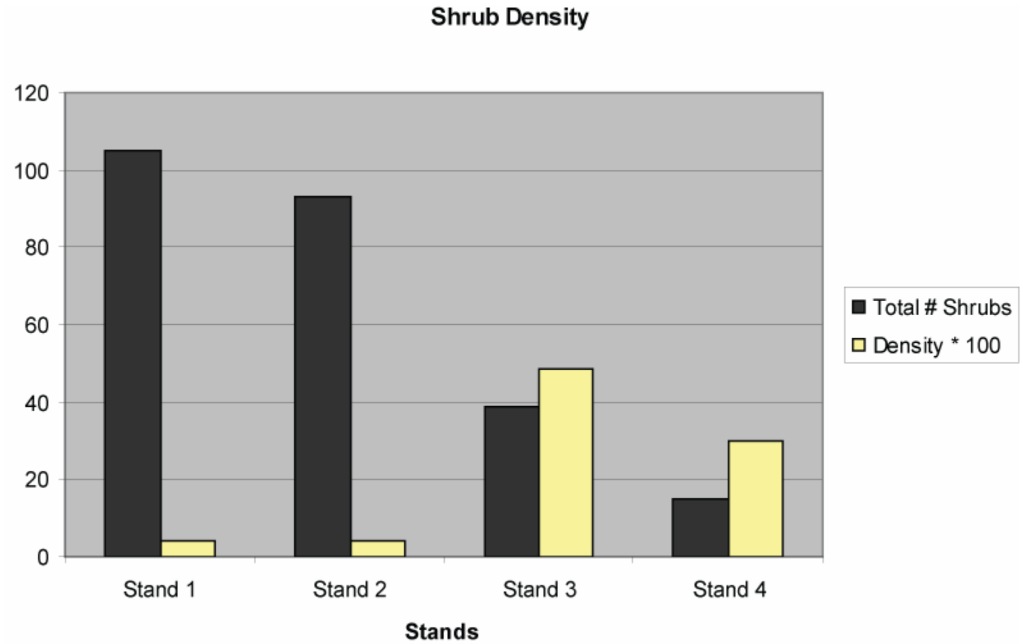
Herbs

ACSP	*Actaea sp.*	Baneberry sp.
AQCA	*Aquilegia canadensis*	Wild Columbine
ARAT	*Arisaema atrorubens*	Jack-in-the-pulpit
ARNU	*Aralia nudicaulis*	Wild Sarsaparilla
ASCA	*Asarum canadense*	Wild Ginger
CRCA	*Cryptotaenia canadensis*	Canadian Honewort
DELA	*Dentaria laciniata*	Cut leaved Toothwort
ERAL	*Erythronium albidum*	White trout lily
GAAP	*Galium aparine*	Stickwilly, Annual bed straw
GECA	*Geum canadense*	White Avens
GEMA	*Geranium maculatum*	Wild geranium
HYVI	*Hydrophyllum virginianum*	Virginia waterleaf
OSCL	*Osmorhyza claytoni*	Sweet Cicely
POBI	*Polygonatum biflorum*	Solomon's seal
POPE	*Podophyllum peltatum*	Mayapple
SACA	*Sanguinaria canadensis*	Bloodroot
SMRA	*Smilacina racemosa*	Solomon's Plume
SOSP	*Solidago sp.*	Goldenrod
THDI	*Thalictrum dioicum*	Early meadow rue
ALPE	*Allaria petiolata*	Garlic Mustard
ARSP	*Arctium sp.*	Burdock
GLHE	*Glechoma hederacea*	Creeping Charlie
LECA	*Leonurus cardiaca*	Motherwort
SODU	*Solanum dulcamara*	Climbing nightshade
TAOF	*Taraxacum officinale*	Common dandelion
CIQU	*Circaea quadrisulcata*	Enchanter's Nightshade
DIVI	*Dioscorea villosa*	Wild yamroot
ERAN	*Erigeron annuus*	Daisy Fleabane
EURU	*Eupatorium rugosum*	White snakeroot
HASP	*Hackelia sp.*	Stickseed
OXSP	*Oxalis sp.*	Wood-sorrel
PAQU	*Parthenocissus quinquefolia*	Virginia Creeper
PIPU	*Pilea pumila*	Clearweed
RAAB	*Ranunculus abortivus*	Small-flowered buttercup
TORA	*Toxicodendron radicans*	Poison Ivy
VISP	*Viola sp.*	Violet

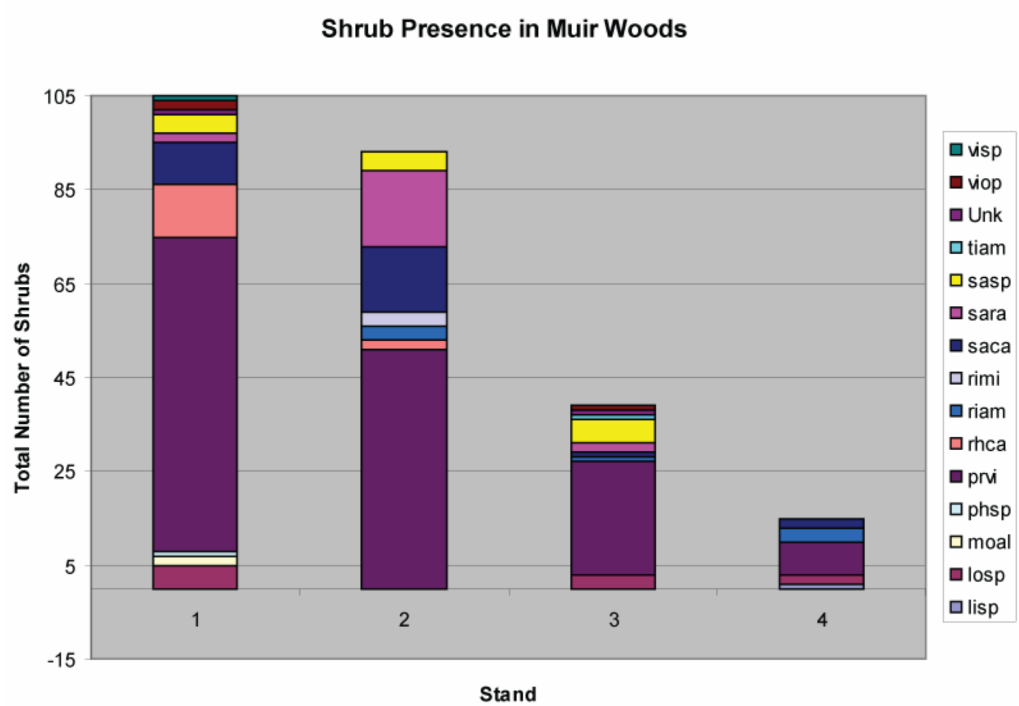
Appendix D: Data analysis of the Restoration Stands

Data was analyzed with the assistance of Paul Heiberger

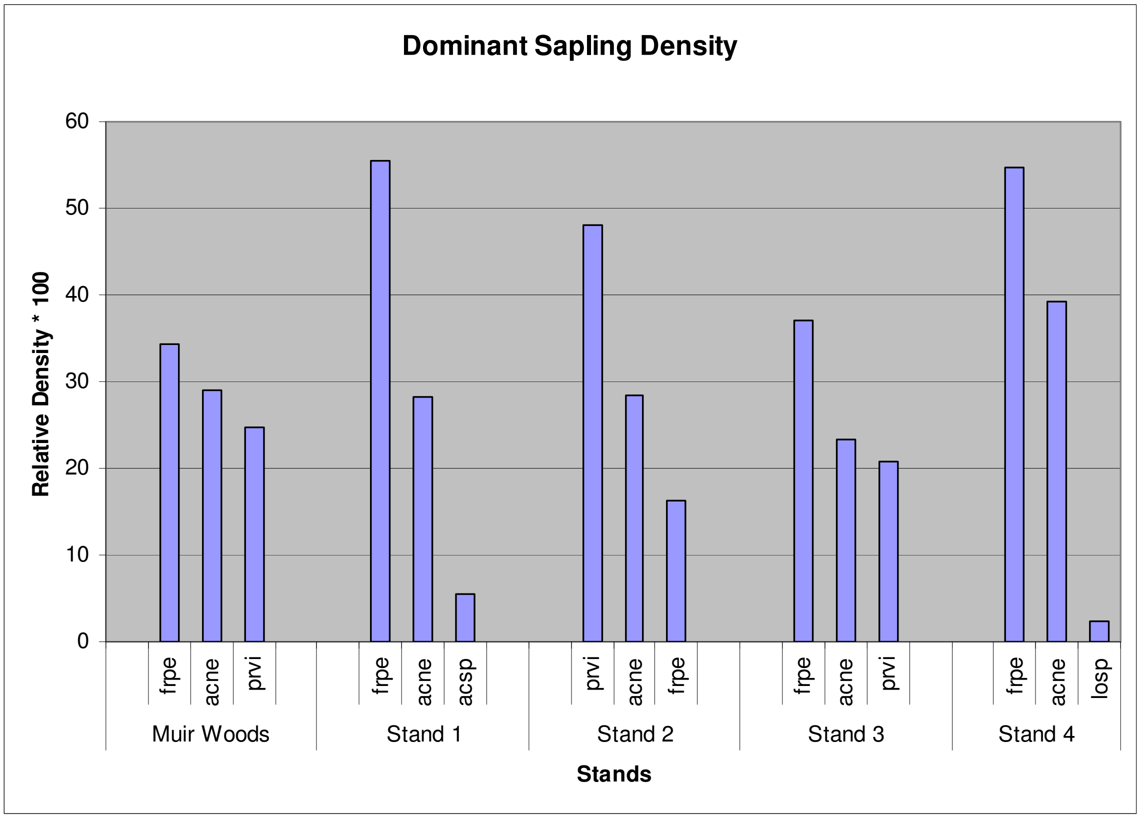


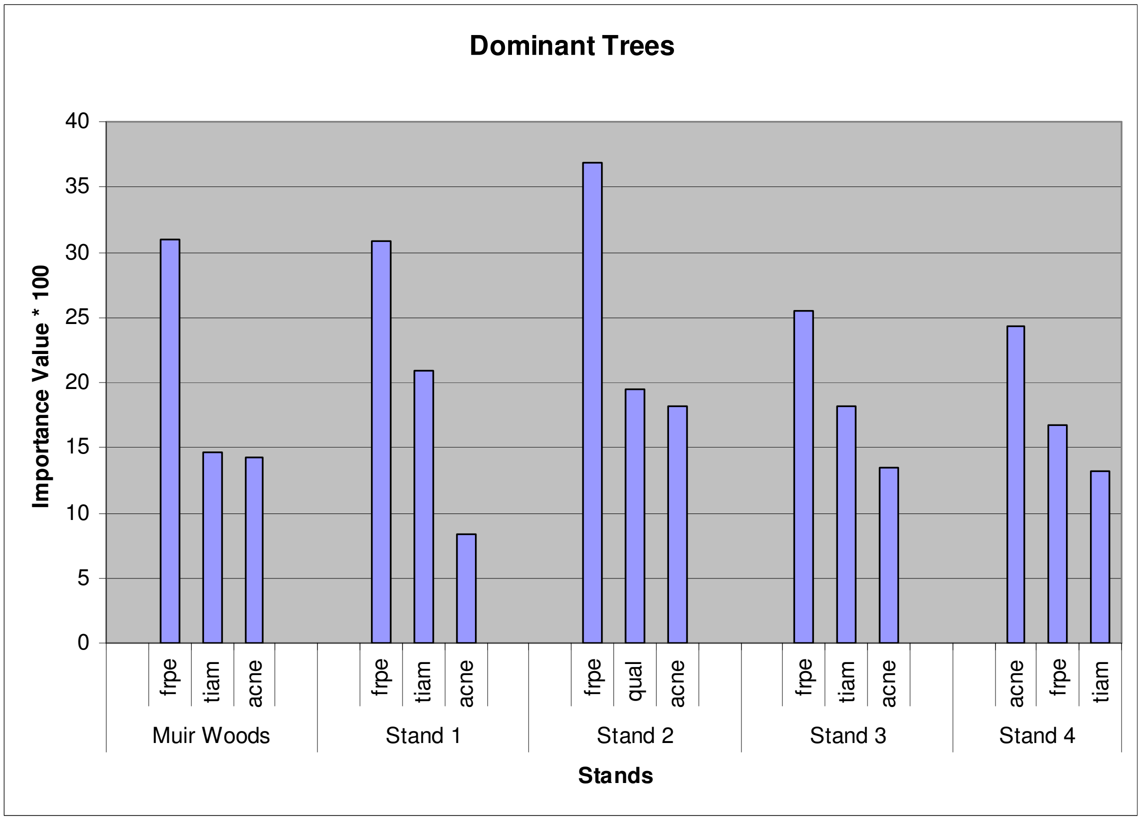


Shrub Density
120
100
80
60
40
20
0
Stand 1
Stand 2
Stand 3
Stand 4
Stands
Total # Shrubs
Density * 100



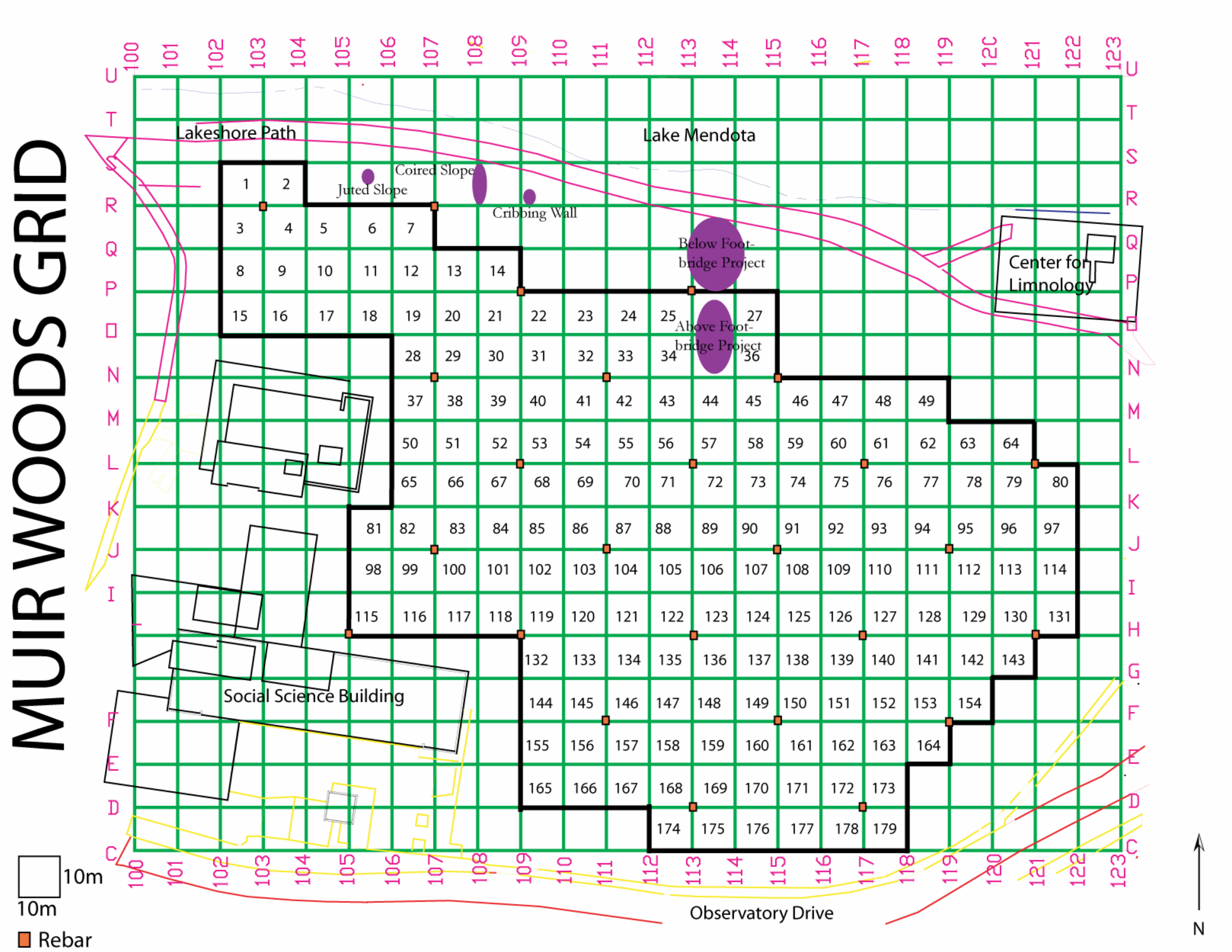
Shrub Presence in Muir Woods
Total Number of Shrubs
105
85
65
45
25
5
-15
1
2
3
4
Stand
visp
viop
Unk
tiam
sasp
sara
saca
rimi
riam
rhca
prvi
phsp
moal
losp
lisp

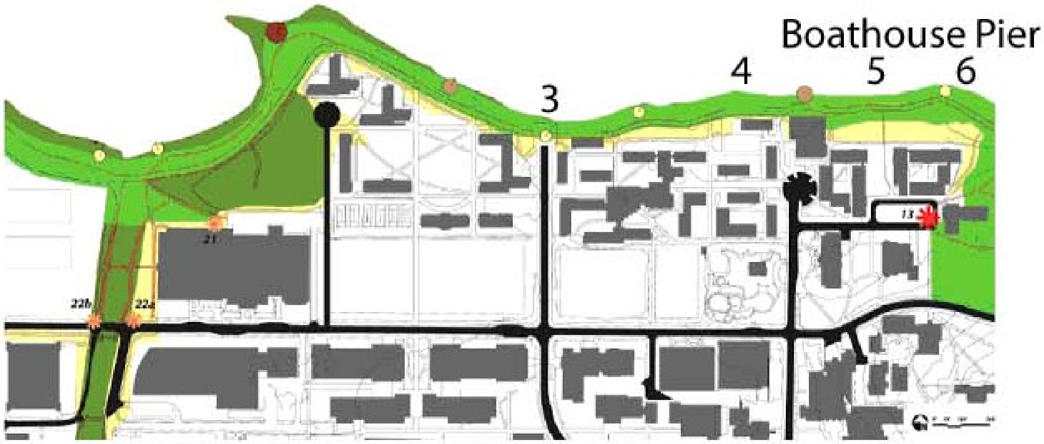

Dominant Sapling Density
Relative Density * 100
60
50
40
30
20
10
0
frpe
acne
prvi
Muir Woods
frpe
acne
acsp
Stand 1
prvi
acne
frpe
Stand 2
frpe
acne
prvi
Stand 3
frpe
acne
losp
Stand 4
Stands



Dominant Trees
Importance Value * 100
40
35
30
25
20
15
10
5
0
frpe
tiam
acne
frpe
tiam
acne
frpe
qual
acne
frpe
tiam
acne
acne
frpe
tiam
Muir Woods
Stand 1
Stand 2
Stand 3
Stand 4
Stands

Appendix E: Map of Projects in Muir Woods and Lakeshore Path




Boathouse Pier
3
4
5
6
21
22b
22a
13

Appendix F: Project Description Sheet Template

Preserve Section Location:

Project Title:

Grid Location:
Description of Site Location:
Map:

Project Rationale:

Description of Site Pre-Restoration: (Include photo)

Plant List

Date of Installation:
Plants obtained from:

Common Name	Species Name	# installed	Size

Description of Planting Technique:

Other Restoration Techniques Utilized:

Maintenance Regime:

Monitoring Regime:

Photo Spot Description (include direction faced):
Date Initial Photo Taken:
Interval at which Photos should be taken:

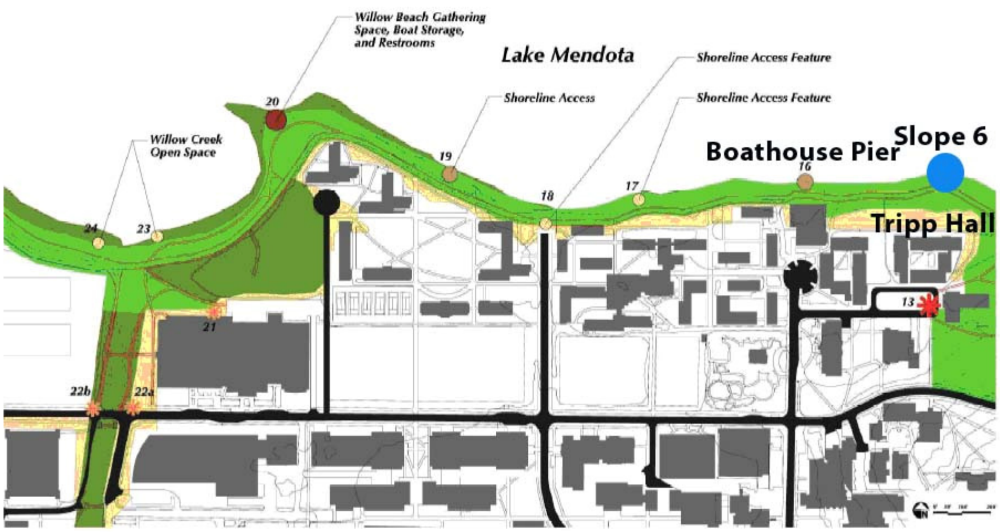
Notes and Observations (include date):

Appendix G: Example of a Project Description Sheet in Progress

Preserve Section Location: East Lakeshore Path

Project Title: Slope 6 - Promontory North of Tripp Hall

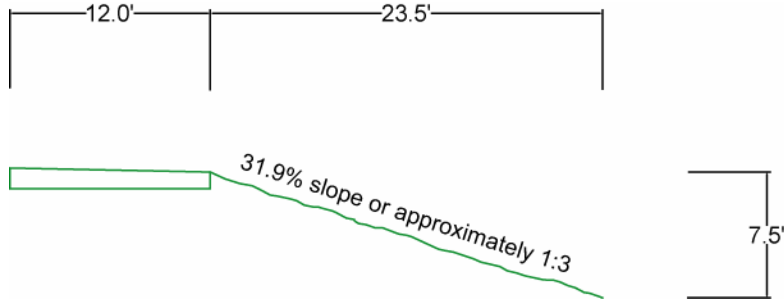
Grid Location: n/a
Description of Site Location: Area between Lakeshore Path and Lake Mendota across green from Tripp Hall. As of 05/07 the site is just east of a stone bench.
Map:



Project Rationale: Slope was cleared of invasive species and brush by grounds in December of 2005. Needed to be restored to protect slope from surface runoff and ice action.

Description of Site Pre-Restoration: (Include photo)

- Two distinct and different cross-sections.
- A moderate to generous bank zone to protect the path. Also a substantial toe zone on the west cross-section.
- East Cross-section: bench site level for 15’ to a severely eroded splash zone, 1:1, large boulders present. Suggested stabilization & master plan solution = vegetated gabions.
- West Cross-section: much less severe, low to no erosion, primarily bank zone, bouldered but 4:1 slope.



Restoration Goals for Site: 80% native plant cover, minimal evidence of surface erosion and damage from ice action.

Plant List

Date of Installation: 10/7, 10/13 and 10/14/2007

Plants obtained from: Taylor Creek

Common Name	Species Name	Qty	Size	Where Planted
Sky Blue Aster	*Aster azureus*	24	plug	Throughout
Heath Aster	*Aster ericoides*	19	plug	Throughout
Smooth Blue Aster	*Aster laevis*	12	plug	Throughout
Big-Leaved Aster	*Aster macrophyllus*	8	plug	Shade
New England Aster	*Aster novae-angliae*	20	plug	Throughout
Canada Milkvetch	*Astragalus canadensis*	17	plug	Throughout
Cream Wild Indigo	*Baptisia leucophea*	31	plug	Throughout
Downy Wood Mint	*Blephilia ciliata*	8	plug	Throughout
Side Oats Gramma	*Bouteloua curtipendula*	26	plug	Throughout
Tall Bellflower	*Campanula americana*	8	plug	Shade
Fringed Sedge	*Carex crinita*	8	plug	Water
Bottlebrush Sedge	*Carex hystricina*	5	plug	Water
Woodland Sedge	*Carex sprengelii*	12	plug	Shade
Wood Reed Grass	*Cinna arundinacea*	16	plug	Throughout
Stiff Coreopsis	*Coreopsis palmata*	32	plug	Throughout
Showy Tick Trefoil	*Demodium canadensis*	4	plug	Throughout
Riverbank Wild Rye	*Elymus riparius*	36	plug	Throughout
Virginia Wild Rye	*Elymus virginicus*	32	plug	Throughout
Western Sunflower	*Helianthus occidentalis*	14	plug	Throughout
Woodland Sunflower	*Helianthus strumosus*	24	plug	Shade
June Grass	*Koeleria cristata*	31	plug	Throughout
Prairie Blazingstar	*Liatris pycnostachya*	14	plug	Throughout
Bergamont	*Monarda fistulosa*	11	plug	Throughout
Yellow Coneflower	*Ratibida pinnata*	8	plug	Throughout

Black-eyed Susan	*Rudbeckia hirta*	8	plug	Throughout
Grass Leaved Goldenrod	*Solidago graminifolia*	8	plug	Throughout
Showy Goldenrod	*Solidago speciosa*	7	plug	Throughout
Prairie Cord Grass	*Spartina pectinata*	9	plug	Throughout
Prairie Dropseed	*Sporobolus heteroplepis*	45	plug	Throughout
Spiderwort	*Tradescantia ohiensis*	15	plug	Throughout
Ironweed	*Vernonia fasciculata*	8	plug	Water
Culver's Root	*Veronicastrum virginicum*	20	plug	Throughout
Golden Alexanders	*Zizia aurea*	18	plug	Throughout

Description of Planting Technique: Plugs planted fairly randomly in clumps of 3 or 4 of the same species. 18"on center. Almost all installed with help of volunteers. Coir was cut to allow planting of plugs.

Seed List
Date of Installation: Early October 2006
Seed obtained from: Agrecol (Custom Mesic Seed Mix)

Species	Description	Est. Quantity (ounces)
Schizachyrium scoparium	Little Bluestem	1.25
Elymus canadensis	Canada Wildrye	0.75
Carex bicknellii	Copper-shouldered Oval Sedge	0.5
Heuchera richardsonii	Alum Root	0.357
Aster sagittifolius	Arrow-leaved Aster	0.357
Kuhnia eupatorioides	False Boneset	0.357
Ratibida pinnata	Yellow Coneflower	0.357
Rudbeckia hirta	Black-eyed Susan	0.357
Rudbeckia triloba	Brown-eyed Susan	0.357
Solidago Speciosa	Showy Goldenrod	0.357

Seed obtained from: Middleton Farmer Coop

Species	Description	Est. Quantity (lbs)
Avena sativa	Certified Oats (Dane)	10

Seed obtained from: Tom and Cathie Brock's land
Date Collected: September 20, 2006

Descripton	Common Name	Amount (lunchbags)
Hystix patula	Bottlebrush Grass	.75
Elymus villosus	Silky Wildrye	.375
Elymus riparius	Riverbank Wildrye	.5

Bromus latiglumis	Ear-leaved Brome	.25
Desmodium glutinosum	Pointed Tick Trefoil	1/2 handful
Agrimonia spp.	Agrimony	.1
Phryma leptostachya	Lopseed	1/2 handful

Description of Planting Technique: All seeds listed above were mixed with sawdust obtained from the UW FPM carpentry shop. They were dampened with water and thrown around the site trying to gain full coverage. The site was watered heavily soon after seed was thrown (for the sake of the plugs) which likely caused much of the seed to be washed away.

Spring 2007 Slope 6 Extension
Date of Installation: 5/22 + 5/23/07
Plants obtained from: Taylor Creek (plants had overwintered from Fall 2006 order)

Qty	**Description**	**Common Name**	**Size**	**Where planted**
13	Aster ericoides	Heath Aster	Plug	Throughout
15	Astragalus canadensis	Canada Milkvetch	Plug	Throughout
38	Bouteloua curtipendula	Side Oats Gramma	Plug	Throughout
8	Carex stipata	Fox Sedge	Plug	Near the water
8	Carex vulpinoidea	Brown Fox Sedge	Plug	Near the water
22	Demodium canadensis	Showy Tick Trefoil	Plug	Throughout
14	Helianthus occidentalis	Western Sunflower	Plug	Throughout
21	Koeleria cristata	June Grass	Plug	Throughout
18	Liatris pycnostachya	Prairie Blazingstar	Plug	Throughout
2	Monarda fistulosa	Bergamont	Plug	Throughout
17	Solidago speciosa	Showy Goldenrod	Plug	Throughout
21	Spartina pectinata	Prairie Cord Grass	Plug	Throughout
5	Sporobolus heteroplepis	Prairie Dropseed	Plug	Throughout
17	Tradescantia ohiensis	Spiderwort	Plug	Throughout

Description of Planting Technique: Plugs planted fairly randomly in clumps of 3 or 4 of the same species. 18" on center. Seed was spread under coir before it was secured to ground. Much of the soil had been loosened in the orchard grass removal effort.

Other Restoration Techniques Utilized: Live staking (ninebark, elderberry, silky dogwood) in the late fall of 2006. Coir, biologs, and fencing to deal with stormwater.

Maintenance Regime: Watering and weeding as needed.

Monitoring Regime: Lakeshore Slope Monitoring Protocol each summer.
Photo Spot Description(include direction faced):
Date Initial Photo Taken:
Interval at which Photos should be taken:

Notes and Observations (include date):
5/16/07: Lots of orchard grass – hard to get it all because of coir. Dabbed ash sprouts, buckthorn, honeysuckle sprouts. Every single live stake is sprouting. Lots of dandelions – again, hard to get the roots. Seemed to be very good cover of natives and not as many weeds as other sites. Area that we going to extend into has lots of orchard grass that needs to be controlled and is starting to flower. Should be sprayed with roundup and fenced immediately to prevent human contact.

5/17/07: Restoration area was expanded into some of the area that is covered with orchard grass. Snow fence was expanded another 4.5x6m. Soil was cleared of duff for eventual seeding and the twisted Willow was trimmed of lower stems, as well as a few honeysuckle that were underneath the willow. That area was then sprayed with 3% Roundup to kill the grasses and other herbs, the stumps and cut willows were also treated by dabbing with 20% roundup.

5/22/07: Orchard grass did not die off completely from herbicide application, cuts were cut or raked up in order to plant into area. Area was raked to loosen soil for seed mix (Savanna Seed Mix from Spring 2007), seed and saw dust mix was placed on lower slope and then covered with coir. Upper slope was planted with a mix of plugs (leftovers from Fall 2006 planting). Lower half of upper slope (adjacent to coir) was seeded and then planted with plugs, whereas the upper half (closet to the path) had plugs put in and then was seeded. All areas were heavily watered before leaving for the day. Should place additional coir underneath willow and plants need to put into the coir covered area.

5/23/07: Additional coir installed under willow tree, and Fall 2006 plugs planted in coir segment. Sedge species placed in concentration closer to the water's edge. All plants of extended section were watered. During the afternoon returned to the site to spread approx. 5 pounds of oats as cover group. I would say that I did a fairly heavy spread of oats on the plot. Oat seeds were watered in.

5/29/07: Slope was watered in the morning and in the afternoon (roughly 10 gallons each time). Plants seem to be in good shape though the oat seeds have still not germinated.

6/5/07: Weeded slope and weed whacked orchard grass surrounding area. Lots of buckthorn and honeysuckle saplings. Should also return to the areas that the live stakes are in because there was some grape and Virginia creeper that were starting to take over the area around the live stakes.

Appendix H: Additional Infrastructure (Vehicles and Herbicide)

Vehicles

Currently, this project has full time access to one John Deere Gator. It is a 6 x 4 DIESEL.

From the website: (http://www.deere.com/en_US/ProductCatalog/GT/servlet/com.deere.u90785.ce.productcatalog.view.servlets.ProdCatProduct?pNbr=1971W&tM=GT)

658 cc, overhead valve, 3-cylinder, liquid-cooled, 4-cycle diesel engine improves fuel economy
4-wheel drive provides superior traction
Continuously variable transmission eliminates shifting; speeds from 0 to 18 mph
Standard differential lock helps vehicle pull through tough spots
Standard high flotation tires minimize ground compaction, improve traction in mud, and flex over bumps for a smooth ride
Low center of gravity enhances stability and handling
Tight, 24.8-ft. turning clearance circle
16-gauge-steel, 11.2 cu. ft. capacity cargo box hauls up to 1,000 lb.
Standard halogen headlights maximize visibility
Compact design allows unit to be hauled in the bed of most full-size pickup trucks

Gas

There is a diesel pump at grounds that we have access to. In order to fill the tank, you need the gas card, which should be stored in the glove box of the gator at all times. Swipe the card, enter the code: 001, enter a random milage #(I often enter the hours listed on the gauge), and then enter pump #1. Once this is complete, you can fill the tank. If you run into any problems with this, any of the ground supervisors can usually help.

In the past, we have been overlooked when the gas cards are changed, so it is important to keep Cathie aware of any problems with getting gas.

Additions

We had tall wooden sides built on our gator. The idea was that it would make it easier to move woodchips and soil with fewer trips and less assistance from grounds. This has proven useful, but the gator cannot dump a full load of chips, it is too heavy. So we reccomend taking smaller loads (especially if you will be driving up hills) or take larger loads and remove them manually. The sides can be removed, but we have yet to do this since they have been installed.

In the late fall of 2006, we purchased a 40 gallon water tank from John Deere and got the garage to install a great plug in on the back of the bed. We have yet to use this much, but expect this to become useful for projects along Lakeshore Path and other sites.

Herbicide

The methods and types of herbicide being used as part of the student manager protocol are currently up for review. We are using the Arboretum standards as our model as Steve Glass`s procedure guide is excellent. We do not have specific procedures in place for how much training of what kind allows an employee to do which procedure under whose direction.

Certification

At this point in time, each manager and student hourly who is committed to working with the project long term is asked to become certified as a way to assure that an individual has the opportunity to be informed about vital health and safety issues is the DATCP certification program. However, no certification is required of any one since we are UW employees applying pesticides as a work duty.

It is not a condition of employment that student employees apply pesticides. Individuals can decide at any time that they do not wish to do it, either before or after obtaining the certification.

In order to be certified, you must purchase the study book from the PAT (pesticide applicator training) program. Their website is: http://ipcm.wisc.edu/Default.aspx?alias=ipcm.wisc.edu/pat. The book gives you entrance to the exam.

For restoration, you can choose to be certificied in either Turf & Landscape or Forestry. There is a cost asssocaited with taking the exam, but as long as all of your application will be done on UW grounds the liscence is free.

Mixing and Storage

We currently store unmixed chemicals in a closest in the grounds garage area. There is a key that is stored in the office area of grounds. This key can only be accessed during work hours (7:00 - 3:30 M-F). If herbicide is going to be needed at additional times we mix it and then store it somewhere well venitlated until it is used. This is not a good solution to this problem.

Nalgene® Wide-Mouth Unitary™ Wash Bottles

Chemicals are currently mixed in a small storage area directly outside the closet where the chemicals are stored. The Preserve has its own graduated cyclinders, spraying backpacks and nalgene bottles for application.
Since we use different chemicals than grounds it is best to not use their measuring and spray equipment if at all possible.

Carefully measure the herbicide concentrate and add it to the tank water. Always use disposable gloves when mixing herbicide. The measuring container should be rinsed and the rinsate added to the tank solution. The container of liquid herbicides should be triple rinsed . Add rinsate to the tank solution or store it in a separate container labeled "WATER AND RINSATE FOR HERBICIDE ONLY, NONPOTABLE" There currently is no rinsate container.

Appendix I: Groups that have volunteered in the East Preserve

- Troy Gardens Farm and Field Program
- Lincoln Elementary School
- Bradley, Cole and Sullivan Dorms
- Discussion sections of IES 112
- Ways of Knowing Biology
- Women in Science and Engineering (WISE)
- Engineering Professional Development
- High School Girl Scouts
- Expanding Your Horizons Conference
- Delta Sigma Theta Sorority (Service Sorority)
- Muir Woods Mentors
- Landscape Architecture 651: Restoration Workshop

Other students have volunteered at regular events as part of the service learning aspect of a course. The classes that they have come to us from have included:

- BioCore
- Extinction of Species
- Restoration Ecology
- Conservation Biology

Appendix J: Spring Ephemeral Survey Protocol and Datasheets

Muir Woods Spring Ephemeral Survey 2006
Landscape Architecture 651

We will be conducting a random sample of up to12 $1m^2$ squares throughout Muir Woods to get a sense of species presence, density, and frequency throughout the woods. Students will break up into 4 groups and **collect 3 samples within each of the 10 m^2 plots** in which they work.

Materials Needed (for each group):

- Pin Flags (approx 20)
- 2 15m measuring tapes
- Something to mark off a 1m x 1m square (meter sticks, PVC square etc.)
- Herbaceous Plant Field Guide
- Data Sheet
- Random Number Table
- Map of Grid System in Muir Woods
- 1 small rebar or chaining pin
- Digital Camera

Locating Plots:

Use the map to locate the corner points of the plot you are trying to find. The points are labeled by a number and a letter (H112 or C101). These points will help you find the plots which are numbered 1 – 178.

Protocol:

1. Record date, people in the group and plot # on the data sheet.
2. Run one tape from the SW corner to the SE corner with the 0 marker at the marked grid point.
3. Run the second tape from the SW corner up to the NW corner with the 0 marker at the marked grid point. Inserting the rebar into the ground to mark the zero point and run the tape from it may be helpful.
4. You can put pin flags at each of the whole meter points along the tape if that will help.
5. Use the random number table to select both an X and Y point (from 0 to 9).
    a. Have a group member state the last two digits of their phone number. The second to last number is the # of rows that you will count across the table. Double the last number and use this value to count down this number of rows. Find the number in the table that corresponds to this row and column and this is your X value.
    b. Read the next # (Y value).
    c. Record these values on the data table.
6. Find the X value on the tape running between the SW and NE corner. Find the Y value on the tape running between the SW and NW corner of the grid. Find the intersection point.
7. At this point place the bottom lower corner of your $1m^2$ sample sub-plot. If your subplot is completely covered by debris, or there is a large tree that takes up most of the area, note this

on your data sheet and select another subplot by reading the next two numbers on the random number chart.

8. Within this $1m^2$ sample subplot, determine what percent of the area is covered with woody vegetation. Record this on your data sheet.
9. Within this $1m^2$ sample subplot, determine what percent of the area is covered with herbaceous vegetation. Remove any leaf litter in the plot that will prevent you from obtaining an accurate count.
10. Determine which species are in your subplot. For each species, record its overall % cover and a stem count. Also note if any of the individuals are flowering. If a species is particularly dense it might make sense to break the subplot up and count each area. (The overall % cover of the species summed may exceed 100% since they may overlap).

Note: We are looking at number of stems as another measure of stem cover so it is not important to determine if plants are new individuals or not. Try to count each leaf or group of leaves that enter the ground as an individual stem.

11. Take a digital photo of each subplot. Make sure that you note which photo is of which subplot.
12. If you record any Garlic Mustard, pull it after you have collected data on its presence.
13. Repeat steps 5 -11 twice more in this plot before moving on to further plots.
14. Before leaving the plot, do a quick visual survey to see if any herbaceous species are present in the 10m plot that were not present in any of the 3 sub-plots.
15. Please use the notes section to describe anything out of the ordinary in the plot and to make suggestions about how to refine this survey.
16. Download photos and title each one with plot number and subplot number (For example: 101_3 or 12_2). Send the photos to your TA as an email attachment.

2006 Spring Ephemeral Monitoring Data Sheet

Date: ____________________

Personnel: ____________________

Plot #: ____________________

Subplot 1

X coordinate: __________ **Y coordinate:** __________

Woody Plant Percent Cover: __________ **Photo #:** __________

Overall Percent Cover: __________

Species Name	Common Name	# Of Stems	% Cover	Flowering?
Aquilegia canadensis	Wild Columbine			
Asarum canadense	Wild Ginger			
Dentaria laciniata	Cutleaf Toothwort			
Dicentra cucullaria	Dutchman's Breeches			
Erythronium albidum	White Trout Lily			
Geranium maculatum	Wild Geranium			
Hydrophyllum virginianum	Virginia Waterleaf			
Podophyllum peltatum	Mayapple			
Sanguinaria canadensis	Bloodroot			
Smilacina racemosa	False Solomon's Seal			
Solidago Spp.	Goldenrods			
Thalictrum dioicum	Early Meadow Rue			
Viola Spp.	Violets			

Species Name	Common Name	# Of Stems	% Cover	Flowering?
Alliaria petiolata	Garlic Mustard			
Leonurus cardiaca	Motherwort			

Notes:

Species Observed in Plot but not in Subplots:

Appendix K: Shoreline Monitoring Protocol and Datasheets

Written by Lars Higdon

Broad Scale Survey (Transect Sample)

The purpose of this survey is to track the progression of the planting using a quick and simple method giving the overall status of the entire restoration.

Methods

Each shoreline restoration will be sampled twice a year, once in the spring (ideally June) and once in the fall (ideally October), using a 10cm belted transect. The transect will run at a 45 degree angle with the shoreline between two fixed points, marked with rebar. This angle was chosen to capture both east-west and north-south gradients. Transects should be sampled starting on the east side and moving west. The fixed points will assure that approximately the same area is sampled each time. Species presence will be recorded along the transect at 1 meter intervals. All species with any part of the plant falling within 5 cm of either side of the transect line will be recorded. This data will provide information on species presence and frequency.

Materials Needed

Tape Measure (in meters)
Clipboard
Data sheets
2 Rebar stakes/site
Planting list
Field guides

Time Required

Approx. <½ hour/site

Fine Scale Survey (Quadrat Sample)

This survey technique is a more intensive sampling of fixed individual plots, intended to track the progression of vegetation in each given area.

Methods

Two fixed plots within each planting will be sampled twice a year at the same time as the broad survey. Each of the four corners of the 1 sq. meter plots will be marked with rebar stakes. The data to be gathered in the plot will include species present and the % cover of each species. Cover will be determined by visual estimation. Only plants that are rooted entirely within the plot should be included in the data. East quadrats are labeled 1 and west quadrats are labeled 2. Lastly, a digital photograph should be taken of each quadrat at the time of sampling, preferably facing north.

Materials Needed

1 sq. meter quadrat
Clipboard
Data sheets
8 Rebar stakes
Planting list
Field guides

Time Required: *Approx ½ hour per site*

Shoreline Restoration Transect Sampling Data Sheet

Date: ____________________
Personnel: ____________________
Location: ____________________
Transect #: ____________________

Species Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Shoreline Restoration Quad Sampling Data Sheet

Date: ________________
Personnel: ________________
Location: ________________
Quad #: ________________
% Bare Ground: ________________

Scientific Name	Common Name	# Of Stems (Forbs Only)	% Cover

Notes:

Appendix L: Planting Density Study Information

Table 10. Plot Selection for Planting Density Study

Plot	Herb % Cover	Herb % Woody Cover	PAQU % Cover	Meets all Criteria?	Notes based on photos	Selected for study?
51	50	50	38	y	Large log across plot	y
55	25	0	20	y	small rock	y
63	40	70	15	y	ok	y
71	40	0	0	y	ok	y
73	30	0	4	y	ok	y
75	64	60	0	y	low cherry in plot, log	
77	15	50	9	y	ok	y
85	40	0	10	y	sticks and other small debris	y
89	45	0	40	y	ok	y
91	64	30	40	y	heavy herb cover	
93	30	40	2	y	ok	y
101	40	20	20	y	ok	y
105	60	0	34	y	dense	y
107	8	60	3	y	very bare	
111	20	20	0	y	very bare	y
123	40	0	25	y	log, med veg	y
125	60	30	0	y	ok	y
129	48	1	25	y	small debris, could be removed	y
117	28	10	20	y (excluded due to large tree)	substantial tree in plot	
53	95	30	80		too dense with herbs	
57	8	70	0		large tree root encroaches plot	
69	70	0	45		vegetation is somewhat sparse	
83	83	0	80		too dense with herbs	
95	70	6	40		dense veg and large tree in plot	
109	2	70	0		heavy woody cover	
119	10	65	25		fairly bare except for one choke cherry	
121	70	30	35		vegetation is somewhat sparse	
Average	**43**	**26**	**23**			
Std Dev	**24**	**27**	**23**			
Range	**18-64**	**<75**	**0 - 45**			

Planting Density Study Protocol

Data Collection

a. Prior to Planting a Plot collect the following information (on data sheet)
    i. % cover Herbaceous Plant
    ii. % cover Virginia Creeper
    iii. % cover Woody Species
    iv. % Cover Debris in Plot (large logs etc)
    v. Quick Description of Plot (especially note nearby trails, any evidence of human use of the site etc.)
    vi. Take a photo of the plot before planting with a label in the plot (1/2 sheet of paper with # and treatment written in big letters)

2. Planting
    a. For 1 ft on center plots
        i. Plant your first plant (as specified by the plant map for that site) in the corner closest to the permanent pin).
        ii. Use the PVC with the one foot markings to plant the next 5 plants in a row. Continue until finished with the 36 plants.
        iii. Take a photo of the site when complete with label in plot.
    b. For 2 ft on center plots
        i. Plant your first plant approximately 6 inches in from plot corner.
        ii. Use the PVC with the one foot markings to plant the next 2 plants in a row. Continue until finished with the 9 plants.
        iii. Take a photo of the site when complete with label in plot.
        iv. Note anything that you altered in the plot (see below).

Important Notes:

- Move any small debris from plots that would affect planting (ie – small sticks).
- Remove any invasive species in or surrounding plots.
- Remove any species that are annuals (i.e. clearweed, use newcombs as a reference for this) that are in the location where your plant should go. Ignore other individuals of these species.
- If there is something in the spot where your plant should go that should not/cannot be moved (large log, rock etc.), simply shift the location of the planting as need be, up to being adjacent with other plants. Do not plant outside the 5 x 5 plot.
- If there is room to plant under a fallen log (if it is sitting in a way that leaves room), do so.

Muir Woods Planting Density Study Data Sheet

Plot # ____________________

Treatment (1 ft, 2ft, control) ____________________

Date ____________________

	Class (1-6)
Overall Herbaceous Cover	
Overall Canopy Cover	
Virginia Creeper Cover	
Debris Cover (logs, sticks etc)	

Description of Plot:

Protocol Deviations:

Before Photo Taken? ____________________

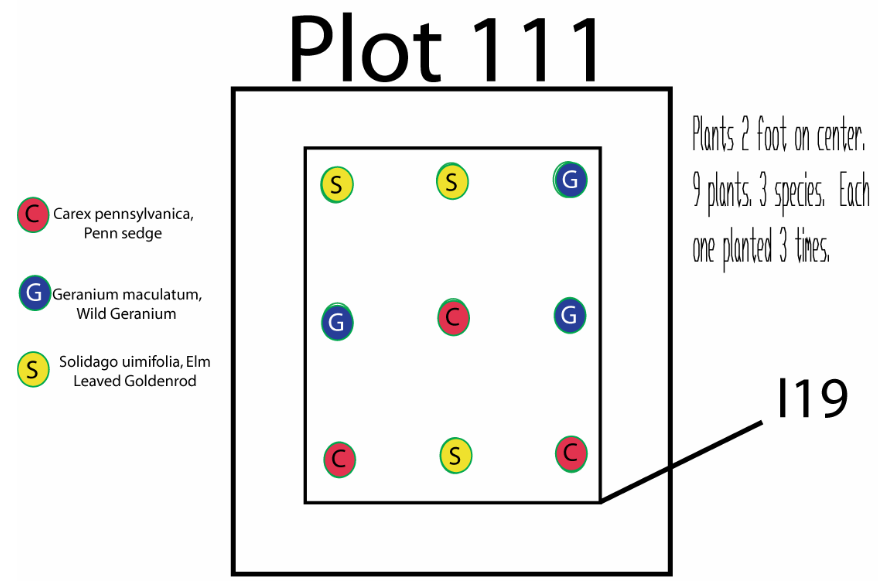
After Planting Photo Taken? ____________________

Cover Classes

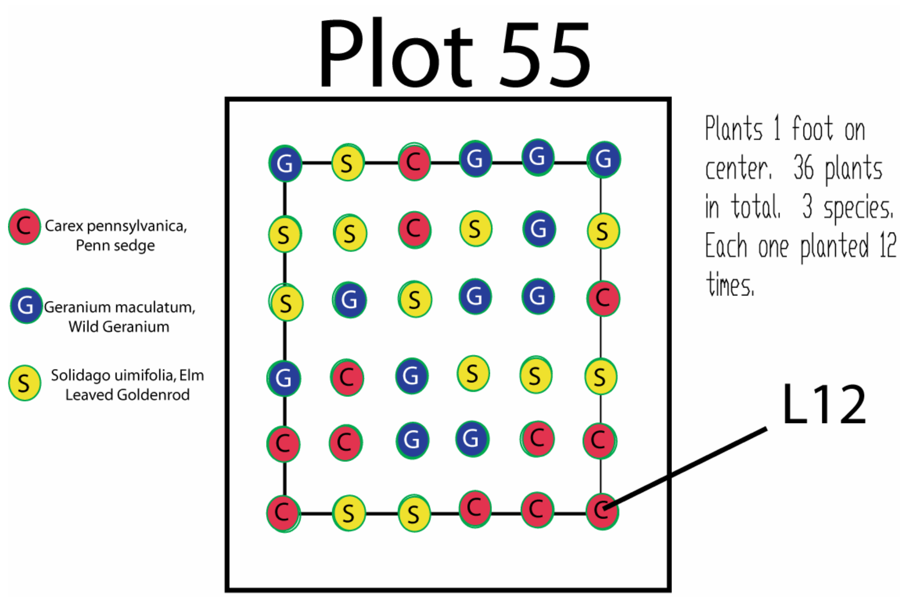
1	0-5%
2	6-25%
3	26-50%
4	51-75%
5	76-95%
6	96-100%

Sample Planting Plans

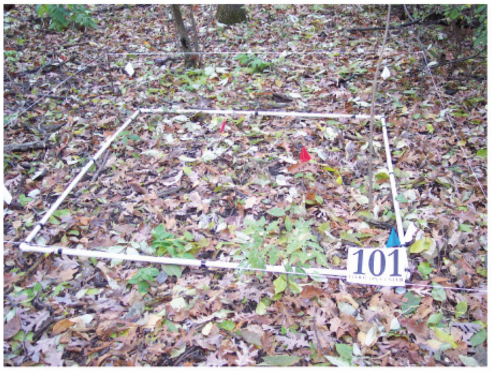
2 feet on center:



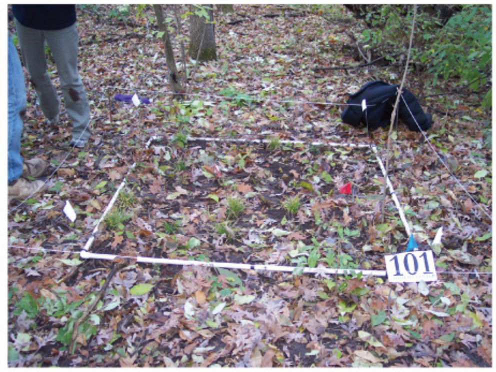
1 foot on center:



Plot 101 before planting.



Plot 101 after planting (1 ft o.c. - 36 plants)



Plot 125 before planting.

Plot 125 after planting (2 ft o.c. - 9 plants)

Appendix M: Planting Lists from the Shoreline Restoration Projects

Slope 3

Date of Installation: 10/6, 10/7, 10/14/06
Plants obtained from: Taylor Creek

Common Name	Species Name	Qty	Size	Where Planted
Sky Blue Aster	*Aster azureus*	8	plug	Throughout
Smooth Blue Aster	*Aster laevis*	8	plug	Throughout
Big-Leaved Aster	*Aster macrophylus*	8	plug	Shade
New England Aster	*Aster novae-angliae*	12	plug	Throughout
Cream Wild Indigo	*Baptisia leucophea*	1	plug	Throughout
Side Oats Gramma	*Bouteloua curtipendula*	32	plug	Throughout
Bottlebrush Sedge	*Carex hystricina*	3	plug	Water
Woodland Sedge	*Carex sprengelii*	32	plug	Shade
New Jersey Tea	*Ceanothus americanus*	8	plug	Throughout
Wood Reed Grass	*Cinna arundinacea*	32	plug	Throughout
Canada Tick Trefoil	*Desmodium canadense*	8	plug	Throughout
Riverbank Wildrye	*Elymus riparius*	48	plug	Throughout
Western Sunflower	*Helianthus occidentalis*	4	plug	Throughout
Woodland Sunflower	*Helianthus strumosus*	8	plug	Shade
June Grass	*Koeleria cristata*	44	plug	Throughout
Prairie Blazingstar	*Liatris pycnostachya*	8	plug	Throughout
Wild Bergamont	*Monarda fistulosa*	19	plug	Throughout
Mountain Mint	*Pycnanthemum virginianum*	40	plug	Throughout
Sweet Black-eyed Susan	*Rudbeckia subtomentosa*	8	plug	Throughout
Showy Goldenrod	*Solidago speciosa*	8	plug	Throughout
Elm-Leaved Goldenrod	*Solidago ulmifolia*	4	plug	Shade
Prairie Cordgrass	*Spartina pectinata*	34	plug	Throughout
Prairie Dropseed	*Sporobolis heterolepis*	14	plug	Throughout
Purple Meadow Rue	*Thalictrum dasycarpum*	8	plug	Throughout
Culvers Root	*Veronicastrum virginicum*	8	plug	Throughout
Heart Leaved Asters	*Ziza aptera*	4	plug	Throughout
Golden Alexanders	*Ziza aurea*	14	plug	Throughout

Description of Planting Technique: Plugs planted fairly randomly in clumps of 3 or 4 of the same species. 18" on center. Almost all installed with help of volunteers.

Seed List
Date of Installation: Early October 2006
Seed obtained from: Agrecol (Custom Mesic Seed Mix)

Species	Description	Est. Quantity (ounces)
Schizachyrium scoparium	Little Bluestem	1.25
Elymus canadensis	Canada Wildrye	0.75
Carex bicknellii	Copper-shouldered Oval Sedge	0.5
Heuchera richardsonii	Alum Root	0.357
Aster sagittifolius	Arrow-leaved Aster	0.357
Kuhnia eupatorioides	False Boneset	0.357
Ratibida pinnata	Yellow Coneflower	0.357
Rudbeckia hirta	Black-eyed Susan	0.357
Rudbeckia triloba	Brown-eyed Susan	0.357
Solidago Speciosa	Showy Goldenrod	0.357

Seed obtained from: Middleton Farmer Coop

Species	Description	Est. Quantity (lbs)
Avena sativa	Certified Oats (Dane)	10

Seed obtained from: Tom and Cathie Brock's land
Date Collected: September 20, 2006

Descripton	Common Name	Amount (lunchbags)
Hystix patula	Bottlebrush Grass	.75
Elymus villosus	Silky Wildrye	.375
Elymus riparius	Riverbank Wildrye	.5
Bromus latiglumis	Ear-leaved Brome	.25
Desmodium glutinosum	Pointed Tick Trefoil	1/2 handful
Agrimonia spp.	Agrimony	.1
Phryma leptostachya	Lopseed	1/2 handful

Description of Planting Technique: All seeds listed above were mixed with sawdust obtained from the UW FPM carpentry shop. They were dampened with water and thrown around the site trying to gain full coverage. The site was watered heavily soon after seed was thrown (for the sake of the plugs) which likely caused much of the seed to be washed away.

Slope 4

Date of Installation: August 2006
Plants obtained from: Taylor Creek

Plants	Quantity	Size/Container Type
Aster sagittifolius	128	2" x 4.5" Plug
Echinacea	64	2" x 4.5" Plug
Heuchera richardsonii	12	2" x 4.5" Plug
Penstemon digitalis	64	2" x 4.5" Plug
Ratibida pinnata	64	2" x 4.5" Plug
Verconicastrum virginicum	12	2" x 4.5" Plug
Schizachyrium scoparium	64	2" x 4.5" Plug
Corylus americana	6	3 Gallon Pots
Upland Savanna Seed Mix	.36 lbs	Seed
Certified Oats	2-3 lbs	Seed

Description of Planting Technique:
Seed and oats interspersed and planted randomly throughout upper slope. Plugs planted randomly at approximately 18" on center throughout entire site. Hazlenuts planted along "burritos".

Date of Installation: May 16, 2007
Plants obtained from: Taylor Creek

Common Name	Species Name	# installed	Size
White Oaks	*Quercus alba*	4	3 gallon

Description of Planting Technique:
Evenly spaced around mature QUAL on site, staggered along top of slope. Chicken wire cages placed around all oaks to prevent rabbit browse.

Slope 6

Date of Installation: 10/7**,** 10/13 and 10/14/2007
Plants obtained from: Taylor Creek

Common Name	Species Name	Qty	Size	Where Planted
Sky Blue Aster	*Aster azureus*	24	plug	Throughout
Heath Aster	*Aster ericoides*	19	plug	Throughout
Smooth Blue Aster	*Aster laevis*	12	plug	Throughout
Big-Leaved Aster	*Aster macrophyllus*	8	plug	Shade
New England Aster	*Aster novae-angliae*	20	plug	Throughout
Canada Milkvetch	*Astragalus canadensis*	17	plug	Throughout
Cream Wild Indigo	*Baptisia leucophea*	31	plug	Throughout
Downy Wood Mint	*Blephilia ciliata*	8	plug	Throughout

Side Oats Gramma	*Bouteloua curtipendula*	26	plug	Throughout
Tall Bellflower	*Campanula americana*	8	plug	Shade
Fringed Sedge	*Carex crinita*	8	plug	Water
Bottlebrush Sedge	*Carex hystricina*	5	plug	Water
Woodland Sedge	*Carex sprengelii*	12	plug	Shade
Wood Reed Grass	*Cinna arundinacea*	16	plug	Throughout
Stiff Coreopsis	*Coreopsis palmata*	32	plug	Throughout
Showy Tick Trefoil	*Demodium canadensis*	4	plug	Throughout
Riverbank Wild Rye	*Elymus riparius*	36	plug	Throughout
Virginia Wild Rye	*Elymus virginicus*	32	plug	Throughout
Western Sunflower	*Helianthus occidentalis*	14	plug	Throughout
Woodland Sunflower	*Helianthus strumosus*	24	plug	Shade
June Grass	*Koeleria cristata*	31	plug	Throughout
Prairie Blazingstar	*Liatris pycnostachya*	14	plug	Throughout
Bergamont	*Monarda fistulosa*	11	plug	Throughout
Yellow Coneflower	*Ratibida pinnata*	8	plug	Throughout
Black-eyed Susan	*Rudbeckia hirta*	8	plug	Throughout
Grass Leaved Goldenrod	*Solidago graminifolia*	8	plug	Throughout
Showy Goldenrod	*Solidago speciosa*	7	plug	Throughout
Prairie Cord Grass	*Spartina pectinata*	9	plug	Throughout
Prairie Dropseed	*Sporobolus heteroplepis*	45	plug	Throughout
Spiderwort	*Tradescantia ohiensis*	15	plug	Throughout
Ironweed	*Vernonia fasciculata*	8	plug	Water
Culver's Root	*Veronicastrum virginicum*	20	plug	Throughout
Golden Alexanders	*Zizia aurea*	18	plug	Throughout

Description of Planting Technique: Plugs planted fairly randomly in clumps of 3 or 4 of the same species. 18"on center. Almost all installed with help of volunteers. Coir was cut to allow planting of plugs.

Seed List
Date of Installation: Early October 2006
Seed obtained from: Agrecol (Custom Mesic Seed Mix)

Species	Description	Est. Quantity (ounces)
Schizachyrium scoparium	Little Bluestem	1.25
Elymus canadensis	Canada Wildrye	0.75
Carex bicknellii	Copper-shouldered Oval Sedge	0.5
Heuchera richardsonii	Alum Root	0.357

Aster sagittifolius	Arrow-leaved Aster	0.357
Kuhnia eupatorioides	False Boneset	0.357
Ratibida pinnata	Yellow Coneflower	0.357
Rudbeckia hirta	Black-eyed Susan	0.357
Rudbeckia triloba	Brown-eyed Susan	0.357
Solidago Speciosa	Showy Goldenrod	0.357

Seed obtained from: Middleton Farmer Coop

Species	Description	Est. Quantity (lbs)
Avena sativa	Certified Oats (Dane)	10

Seed obtained from: Tom and Cathie Brock's land
Date Collected: September 20, 2006

Descripton	Common Name	Amount (lunchbags)
Hystix patula	Bottlebrush Grass	.75
Elymus villosus	Silky Wildrye	.375
Elymus riparius	Riverbank Wildrye	.5
Bromus latiglumis	Ear-leaved Brome	.25
Desmodium glutinosum	Pointed Tick Trefoil	1/2 handful
Agrimonia spp.	Agrimony	.1
Phryma leptostachya	Lopseed	1/2 handful

Description of Planting Technique: All seeds listed above were mixed with sawdust obtained from the UW FPM carpentry shop. They were dampened with water and thrown around the site trying to gain full coverage. The site was watered heavily soon after seed was thrown (for the sake of the plugs) which likely caused much of the seed to be washed away.

Spring 2007 Slope 6 Extension
Date of Installation: 5/22 + 5/23/07
Plants obtained from: Taylor Creek (plants had overwintered from Fall 2006 order)

Qty	Description	Common Name	Size	Where planted
13	Aster ericoides	Heath Aster	Plug	Throughout
15	Astragalus canadensis	Canada Milkvetch	Plug	Throughout
38	Bouteloua curtipendula	Side Oats Gramma	Plug	Throughout
8	Carex stipata	Fox Sedge	Plug	Near the water
8	Carex vulpinoidea	Brown Fox Sedge	Plug	Near the water
22	Demodium canadensis	Showy Tick Trefoil	Plug	Throughout
14	Helianthus occidentalis	Western Sunflower	Plug	Throughout
21	Koeleria cristata	June Grass	Plug	Throughout
18	Liatris pycnostachya	Prairie Blazingstar	Plug	Throughout
2	Monarda fistulosa	Bergamont	Plug	Throughout

17	Solidago speciosa	Showy Goldenrod	Plug	Throughout
21	Spartina pectinata	Prairie Cord Grass	Plug	Throughout
5	Sporobolus heteroplepis	Prairie Dropseed	Plug	Throughout
17	Tradescantia ohiensis	Spiderwort	Plug	Throughout

Description of Planting Technique: Plugs planted fairly randomly in clumps of 3 or 4 of the same species. 18” on center. Seed was spread under coir before it was secured to ground. Much of the soil had been loosened in the orchard grass removal effort.

Limnology Slope

*Seed Mix for Extension of Slope 6 Planting
2007 Mesic Savanna Mix - Used on Limnology shoreline
Slope 3, Slope 6 extension.

*purchased 2500 ft of this mix

Agrecol® Agricultural Ecological Solutions

2918 Agriculture Drive
Madison, WI 53718
608-226-2544
ecosolutions@agrecol.com

Agrecol warranties that the product conforms to the description on the label. This warranty is limited to the amount of the purchase price. Agrecol has no responsibility to special, consequential or contingent damages

MESIC SAVANNA (STANDARD MIX)		
ITEM #	SM-MS	
COVERAGE AREA	43,560	SQ.FT.
SEEDS	60	PER SQ.FT.
PLS WEIGHT	11.254	POUNDS
TESTED	3/1/2006	
NOXIOUS WEED/LB	NONE	

MIX DIVERSITY BY TYPE	% OF SEED COUNT	SPECIES COUNT	PLS OUNCES	% PLS WEIGHT
GRASSES	44%	12	113.017	62.77%
SEDGES	6%	4	4.952	2.75%
WILDFLOWERS	43%	26	47.302	26.27%
LEGUMES	7%	3	14.789	8.21%
TOTALS	100%	45	180.060	100.00%

SPECIES INFORMATION

LATIN NAME	COMMON NAME	ORIGIN	TOTAL SEEDS	% OF TOTAL SEEDS
GRASSES				
~~ANDROPOGON GERARDII~~	BIG BLUESTEM	SE WI	71,874	2.75%
BOUTELOUA CURTIPENDULA	SIDE OATS GRAMA	KS	119,790	4.58%
BROMUS CILIATUS	FRINGED BROME	IOWA CO, WI	95,832	3.67%
DIARRHENA AMERICANA	BEAK GRASS	SW WI	47,916	1.83%
ELYMUS CANADENSIS	CANADA WILD RYE	DUBUQUE CO, IA	119,790	4.58%
ELYMUS VILLOSUS & HYSTRIX PAT	SILKY WILD RYE & BOTTLEBRUSH G	ROCK CO WI	119,790	4.58%
ELYMUS VIRGINICUS	VIRGINIA WILD RYE	ROCK CO WI	95,832	3.67%
KOELERIA CRISTATA	JUNE GRASS	COLUMBIA CO WI	119,790	4.58%
PANICUM VIRGATUM	SWITCH GRASS	KENOSHA CO WI	71,874	2.75%
SCHIZACHYRIUM SCOPARIUM	LITTLE BLUESTEM	COLUMBIA CO WI	119,790	4.58%
~~SORGHASTRUM NUTANS~~	INDIAN GRASS	GREEN CO WI	71,874	2.75%
SPOROBOLUS CRYPTANDRUS	SAND DROPSEED	KENOSHA WI	95,832	3.67%
SEDGES				
CAREX BICKNELLII	COPPER-SHOULDERED OVAL SEDGE	DANE CO WI	29,403	1.13%
CAREX BROMOIDES	BROME HUMMOCK SEDGE	SAUK CO, WI	29,403	1.13%
CAREX SPRENGELII	LONG-BEAKED SEDGE	DANE CO WI	49,005	1.88%
JUNCUS TENUIS	PATH RUSH	DANE CO WI	49,005	1.88%
WILDFLOWERS				
AGASTACHE SCROPHULARIAEFOLI	PURPLE HYSSOP	IOWA CO WI	43,225	1.65%
ALLIUM CERNUUM	NODDING ONION	RACINE CO WI	54,031	2.07%
ANEMONE VIRGINIANA	TALL ANEMONE	WI	43,225	1.65%
AQUILEGIA CANADENSIS	WILD COLUMBINE	DANE CO WI	43,225	1.65%
ASTER DRUMMONDII	DRUMMOND'S ASTER	IOWA CO WI	43,225	1.65%
ASTER LAEVIS	SMOOTH BLUE ASTER	IOWA CO WI	54,031	2.07%
ASTER SAGITTIFOLIUS	ARROW-LEAVED ASTER	ROCK CO WI	43,225	1.65%
~~COREOPSIS LANCEOLATA~~	LANCE LEAVED COREOPSIS	KENOSHA CO WI	43,225	1.65%
COREOPSIS PALMATA	PRAIRIE COREOPSIS	COLUMBIA CO WI	10,806	0.41%
~~ECHINACEA PALLIDA~~	PALE PURPLE CONEFLOWER	CO	32,419	1.24%
~~EUPATORIUM PURPUREUM~~	PURPLE JOE PYE WEED	ALLAMAKEE CO, IA	54,031	2.07%
HELIANTHUS STRUMOSUS	WOODLAND SUNFLOWER	COLUMBIA CO WI	10,806	0.41%
~~HELIOPSIS HELIANTHOIDES~~	EARLY SUNFLOWER	GREEN CO WI	54,031	2.07%
HEUCHERA RICHARDSONII	ALUM ROOT	WI	54,031	2.07%
KUHNIA EUPATORIOIDES	FALSE BONESET	COLUMBIA CO WI	54,031	2.07%
LIATRIS PYCNOSTACHYA	PRAIRIE BLAZING STAR	KENOSHA CO WI	32,419	1.24%
MONARDA FISTULOSA	WILD BERGAMOT	WAUKESHA CO WI	43,225	1.65%
~~PENSTEMON DIGITALIS~~	SMOOTH PENSTEMON	WI	43,225	1.65%
RATIBIDA PINNATA	YELLOW CONEFLOWER	JEFFERSON CO WI	43,225	1.65%
RUDBECKIA HIRTA	BLACK-EYED SUSAN	IA	43,225	1.65%
RUDBECKIA TRILOBA	BROWN EYED SUSAN	WI	43,225	1.65%
SCROPHULARIA LANCEOLATA	EARLY FIGWORT	DANE CO WI	43,225	1.65%
SOLIDAGO SPECIOSA	SHOWY GOLDENROD	DANE CO WI	54,031	2.07%
SOLIDAGO ULMIFOLIA	ELM-LEAVED GOLDENROD	WI	43,225	1.65%
TRADESCANTIA OHIENSIS	SPIDERWORT	RICHLAND CO WI	43,225	1.65%
VERONICASTRUM VIRGINICUM	CULVER'S ROOT	DANE CO WI	54,031	2.07%
LEGUMES				
DALEA CANDIDUM	WHITE PRAIRIE CLOVER	COLUMBIA CO, WI	60,984	2.33%
DALEA PURPUREA	PURPLE PRAIRIE CLOVER	JEFFERSON CO WI	60,984	2.33%
DESMODIUM CANADENSE	CANADA TICK TREFOIL	KENOSHA CO WI	60,984	2.33%

**Above mix is for 43,560 sq. ft. coverage area. We only purchased 2,500 sq. ft. of this mix. 625 sq. ft. was seeded on the limnology slope.