THE ECOLOGICAL DESIGN OF A TRAIL SYSTEM THROUGH A

BROWNFIELD REDEVELOPMENT AT LIBERTY STATE PARK

by

JOSEPH CHERICHELLO

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Jean Marie Hartman

and approved by

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ABSTRACT OF THE THESIS

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In this post-industrial age, many opportunities present themselves to convert urban brownfields into open green space. In doing so, as with any other land development, landscape architects rely on the principles of ecological design.

Ecological principles unique to this brownfield pertaining to soil and plant relationships were tested on site; the results provide recommendations for the planting design. Ten soil amendment treatments (25% and 50% the recommended fertilizer, 10% and 20% sand by volume, compost, hydrogel, 10% sand + compost, 10% sand + hydrogel, mulch and a control) were compared for their impact on survival and growth of eight native species (*Aronia melanocarpa, Myrica pensylvanica, Prunus maritima, Solidago sempervirens, Baptisia tinctoria, Eupatorium coelestinum, Chamaecrista fasciculate,* and *Lolium multiflorum*). Only one statistically significant difference was found for one of three growth measures in one of the eight species tested. This implies that the soil amendments in the full scale planting scheme may not be important.

The design of three nodes along a trail (with information and educational opportunities) investigates the blending of ecological design principles with the art of

designing an engaging experience through a series of successional plant assemblages. 'The Trailhead' (Node 1) provides a shaded gathering space at the start of the trail surrounded by a bioretention swale to collect stormwater runoff. 'Succession and Space' (Node 2) engages the user by displaying the spatial significance of emerging from a forested area to an open meadow through various sub-nodes. And finally, 'The Crossroads' (Node 3) is the convergence of many trails with information and views of nearby constructed wetlands and also provides experimental opportunities for further research.

The designs are evaluated using the 2009 Guidelines and Performance Benchmarks, as prepared by Sustainable Sites Initiative. Each design achieved three stars (out of four) even though the entire design process was completed before in depth study of the Guidelines commenced. It became clear that the evaluation system favors the inclusion of building in the design and, thereby, lowers the potential rating of open space.

Acknowledgements

I would like to begin by thanking my thesis committee. Dr. Jean Marie Hartman, the committee chair, has guided my through this process and provided her hard work, knowledge and expertise particularly in the field of ecology and how it applies to landscape architecture. Dean Cardasis, the director of the Landscape Architecture Graduate Program has provided great insight into the design of space as an engaging and meaningful experience. Dr. Jason Grabosky has expanded my knowledge in the field of urban forestry, forestry management and data analysis while giving valuable advice regarding my thoughts and concerns. Dr. Frank Gallagher has provided me the opportunity to study this thesis at Liberty State Park and has guided me through the experimentation process. His views on land ethics and open space have been an inspiration throughout my time in the graduate program.

I would like thank two people for their great advice and willingness to help. Dr. Laura Lawson, Chair of the Landscape Architecture Department has gone through great lengths to ensure this process was as smooth as possible and always made time for a quick (or sometimes lengthy) conversation. Roy DeBoer, Professor Emeritus of Landscape Architecture, Rutgers University, gave me my first look into the world of landscape architecture as an undergraduate over ten years ago. The knowledge and advice he has shared with me over the years have been of great worth to me and my career as a Landscape Architect.

I also owe much to Jake Sacks, Megan Clock and Carolyn Haines for their help during the installation, watering, and measuring processes.

Dedications

Always many thanks to my close family and friends, in particular to my parents, Anthony and Maryann for their lifelong support of my endeavors and their ability to be the greatest parents a son could ask for.

Finally, I would not have made it without the support of my wife Stacey and the loving smile of my son Joey. They have both been so strong and patient through this time and reminded me every night how easy it is to laugh. I am forever grateful.

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Chapter 1

Introduction

This thesis investigates the application of the Sustainable Sties Initiative to the design of a trail at Liberty State Park. In order to conduct this study, I compile information about the site history and current conditions. This background study incorporates ongoing documentation and research that is being conducted in the park as well as a master plan completed by Wallace, Roberts, and Todd (WRT) for the New Jersey Department of Environmental of Protection (US Army Corps of Engineers 2008).

Humans have manipulated natural resources in the past centuries at rates that have never been seen before, with damaging effects. From chemical products, now found in our streams, to the invention of new materials, now found in our landfills, to the depletion of non- renewable and renewable natural resources, a disconnection has developed between humans and the environment. It is time to reconnect with the environment and the ecological processes that sustain it by redirecting the antiquated and destructive methods of manipulating the environment to becoming excited and intuitive about finding ways to work with ecological processes and provide healthy ecosystems and environments in which we are intertwined.

Ecological design techniques can be implemented into any process that affects the biological and physical environment. For example, finding new ways to use or dispose of construction materials without negatively impacting the environment, or providing alternative to chemical solutions for pest management are a couple of examples of these techniques, many of which can be incorporated when developing landscapes for human use (Van Der Ryn and Cowan 1996).

Many sites developed for human use have relied on mechanical techniques to redirect and manipulate physical and biological processes for the benefit of fitting structures such as buildings and parking lots into the landscape. For example, water has been collected from impervious surfaces, forced into pipes (increasing rate of flow), and released into nearby streams (increasing temperature and volume compared to pre-development). This one example of overpowering an environmental structure can result in an increase of downstream flooding frequency and volume, an increase in temperature and nutrient levels within the stream, negatively impacting wildlife and human activity in a number of ways. Working with environmental structure and ecological processes mitigates these and other environmental issues that result from most development techniques (New Jersey Department of Environmental Protection 2010).

Ecological design can improve air and water quality, restore plant and animal habitats and increase bio-diversity of native and non-invasive species (Van Der Ryn and Cowan 1996). It can provide social as well as environmental benefits. As landscape architects it is our responsibility to provide stimulating user experiences with a clear understanding of environmental structure and ecological principles. The mission statement of our professional society includes stewardship of natural resources while providing shelter and refuge for humans as well as wildlife species (American Society of Landscape Architects 2011). We can learn to do this by observing healthy ecosystems, understanding the processes involved and applying these observations to our designs. A site 'developed' by a landscape architect should not be degraded when compared to the preexisting condition, but enhanced or in some cases restored.

More specifically, ecological design has been defined by Sim Van der Ryn and Stuart Cohen in their book *Ecological Design* (1996, pg 18) as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes." They propose three basic components for successful ecological designs: conservation, regeneration, and stewardship (Van Der Ryn and Cowan 1996). Further, as Hartman (2011) said in a recent lecture:

> "Ecological design provides a number of principles that provide design guidance. Ecological design should not be confused with a design style, such as naturalistic, or a design theory, such as modernism. Ecological design principles need to be developed into performance standards, similar to those used for construction, so that they are applied more generally and within designs that are based on all styles and theories."

Conservation can be defined as an attempt to limit the amount of damage to resources by using them wisely. A common example would be the conservation of forested land. The selective harvesting of trees in a forest for timber has a greater ability to conserve the forest's resources as opposed to clear- cutting. If not done at the appropriate scale and in the appropriate forest assemblage, clear-cutting can disrupt nearly all of the ecological processes and habitats previously protected by the forest canopy. Conserving the forest by selective harvesting would more closely mimic the current ecological processes while providing timber for use. In land development, conservation can include the calculated selection of trees for removal, but incorporates the design of sites for human use while limiting the amount of damage to the soil, vegetation, habitat, and hydrologic cycles.

Regeneration can be defined as the ability for living systems to repair themselves. Using the forested land as an example, a clear-cut plot of land will regenerate itself, but in most cases with diminished ecological characteristics. Soil may be lost to erosion, flooding may occur down slope from increased runoff, and invasive species may colonize the area because of the drastic change in the forest's ecology.

Stewardship is being conscious of ecological process and making efforts to respect and maintain these processes over time. Knowing how a forest will react to clear-cutting vs. selective harvesting and making decisions to allow for the conservation and regeneration of resources contributes to stewardship of the land. Stewardship is a mindset of ecological design, and if followed as a central theme to development, will lead to a more cohesive blending of human use and ecological processes in the landscape.

Site Description

Located on the west bank of Upper New York Bay, along with the Statue of Liberty and Ellis Island, the site now known as Liberty State Park was an intertidal mud flat and salt marsh before it was developed by the Central Rail Road of New Jersey (CRRNJ) beginning in the 1860s (NJ Division of Parks and Forestry 2001). As a salt marsh, the native people of the land and eventually the colonial settlers took advantage of the resources of fish and shellfish the harbor had to offer (NJ Division of Parks and

Forestry 2001). Then with the rise of industry, and the massive increase in immigration, particularly through nearby Ellis Island, the view of resources that the harbor had to offer changed to that of technology and the shipment of goods (NJ Division of Parks and Forestry 2001).

The construction of the rail yard required the existing salt marsh to be filled using materials that came from various places, most of which was from construction projects in Manhattan and refuse from the surrounding areas. By 1967, the rail yard's use was discontinued and removal of its infrastructure within the park began (NJ Division of Parks and Forestry 2001). Features such as the Terminal Building along the waterfront, which has been refurbished and currently in use, and the attached rail shed are reminders of the site's rich history.

Since the abandonment of the rail yard, the interior section of Liberty State Park was left, and continues to be unused. Fenced off from the public because of soil contamination (in 1990 tests showed the levels of polynuclear aromatic hydrocarbons, pesticides and metals in the soil are above the New Jersey Department of Environmental Protection soil cleanup criteria), it allowed for the regeneration of plant communities tolerant of these soil conditions to begin forming and continue for the last 40+ years (NJ Division of Parks and Forestry 2001).

The successional hardwood communities within the interior section of the park include areas dominated by *Betula populifolia, Populus deltoides,* and *Poplulus tremuloides*. These communities appear to be novel assemblages that offer interesting models for ecological design. However, it is clear that patterns of contamination and variable characteristics of the fill material resulted in a challenging palette for construction and planting design (Gallagher, et al. 2011) (Figures 1.1 and 1.2).



Figure 1.1 (Left) and Figure 1.2 (Right): Two views of the varying vegetative communities within the interior section of Liberty State Park

In recent years other portions of the park have been developed for active and passive recreation. There are currently extensive areas of regularly mowed lawns, interspersed with shrub and shade tree plantings. These areas are used for informal play, relaxation and exercise (Figures 1.3 and 1.4).



Figure 1.3 (Left): View of Statue of Liberty across expanse of lawn.
Figure 1.4 (Right): Exercise station along path.

The Master Plan

The interdisciplinary planning committee established for the development of the master plan of this project consisted of members from the Friends of Liberty State Park, the Liberty State Park Development Corporation, the Liberty State Park Conservancy, the Liberty Science Center, New Jersey Audubon, the Natural Resource Conservation Service, the Hudson/Passaic Soil Conservation District, the City of Jersey City, and staff from the Division of Parks and Forestry. In general, their primary objectives are as follows:

1. Provide public access for interpretive programs allowing visitors to touch the natural world.
2. Maintain as much of the site as possible, especially wetlands and special plant communities, under a conservation mandate while providing public access.
3. The landscape of the interior should reflect the history of the park as well as the connection to the harbor/estuary.
4. Provide public access to the perimeter of the site for multiple uses.

Secondary objectives include:

1. Improve topography, enhance wetland and provide open water and enhance aesthetic values and site lines where possible.
2. The planning effort will be conscious of other neighboring redevelopment efforts (NJ Division of Parks and Forestry 2001).

From these objectives a plan for redeveloping the interior section has been prepared by Army Corps of Engineers in collaboration with Wallace Todd and Roberts and the New Jersey Division of Parks and Forestry. The plan consists of multiple phases which include the construction of freshwater wetlands, a biofiltration basin, salt marsh, warm weather grasslands and forest enhancements. These assemblages are connected by an interpretive trail system throughout the park (Figure 1.5). Multiple trails have been proposed for the site including a wetland walk, a rail trail and a hydrologic trail. This thesis will concentrate on the phase one hydrologic trail which connects the Liberty Science Center along Phillip Street with the Interpretive Center along Freedom Way through the interior section of the park (Figure 1.6).

Figure 1.5: Schematic plan of plant cover for the interior zone of Liberty State Park (WRT http://www.wrtdesign.com/projects/markets/parks 2012).

Figure 1.6: WRT trail system redrawn over aerial

Construction details are provided for each structural stormwater management feature along with details for the elevated trails, boardwalk, overlooks and bird blind designs. The proposed trails are to be elevated at least one foot above the existing contaminated soil and taper back down to existing grade fifty feet from each side of the trail. Public access to these buffer areas, according to the master plan is restricted; this is accomplished by the installation of a split rail fence along both sides of the trail. Since the plan incorporates these buffers along the trails, a distance of about 110 feet wide (including the trail width) is to be cleared of vegetation the entire length of the trail to allow for construction. These buffer areas are designated for new planting in the master plan, however a detailed planting plan has not been developed.

Purpose of the Project

The main goal of this project is to provide the public safe access to the interior section of Liberty State Park offering educational and passive recreational opportunities while maintaining the site's existing plant communities and ecological functions. In a brownfield project such as this, the initial challenge is to provide the public as much access to nature as possible while protecting their safety. For a contaminated brownfield site, one option for redevelopment is to clear the entire area of all vegetation and cover the contaminated soil with soil that is considered 'clean'. This would provide an open expanse ready for most any type of development. However, this would also eliminate many educational opportunities as well as any habitat for wildlife that has taken refuge in this environment.

The option developed in the Master Plan is to leave the existing vegetation and soil in their current state and provide limited access to the site while giving the user an opportunity to walk through and learn about the various plant communities and ecological processes in this unique environment.

While some areas will be developed with nodes along the trail, efforts will be made to mitigate any displacement of these ecological processes through the collection and infiltration of stormwater and through the regeneration of plant communities.

Planting design and plant selection will provide a seamless transition from the constructed areas of the trail system to the existing vegetative conditions. Using plant species currently found on site will help make this successful, but also studying and replicating the patterns in which these plants have colonized is also important. In addition, incorporating other plant species tolerant of similar environmental conditions would add ecological diversity and visual interest to the site. Once plant species of the region are compiled, the list should be broken down into the light, water and soil requirements of each species. Plants will be placed in the landscape based on their requirement for light (i.e. in full sun or in shade), and also based on their requirement for soil conditions (i.e. well drained, poorly drained). Since the amount of light will not change, for the most part, for any given location, it is important to direct attention to the soil properties to establish acceptable nutrient levels and water holding capacities. For this reason this thesis includes an experiment to study plant growth and survival in relation to varying soil treatments using plants that will be included in the design and fill soil material that will be used in the construction of the trail system. The results of this experiment will assist in determining a soil specification which can increase the probability of plant survival.

With these ecological processes in mind, I will be applying the Sustainable Sites Initiative Guidelines and Performance Benchmarks (2009) to each of the three nodes along the trail and the master plan. The Sustainable Sites Initiative's Guidelines provides a systematic outline to evaluate design projects. Site selection and design are evaluated in nine major categories:

1. Site Selection
2. Pre-Design Assessment and Planning
3. Site Design – Water
4. Site Design - Soil and Vegetation

5. Site Design - Materials Selected
6. Site Design - Human Health and Well Being
7. Construction
8. Operations and Maintenance
9. Monitoring and Innovation

Within the major categories, the Guidelines set fifteen pre-requisites for classifying a site design as sustainable:

1. Prerequisite 1.1 Limit development of designated farmland soils
2. Prerequisite 1.2 Protect floodplain functions
3. Prerequisite 1.3 Preserve wetlands
4. Prerequisite 1.4 Preserve threatened or endangered species and their habitats
5. Prerequisite 2.1 Conduct a pre-design site assessment and explore opportunities for site sustainability
6. Prerequisite 2.2 Use an integrated site development process
7. Prerequisite 3.1 Reduce potable water use for landscape irrigation by 50% from established baseline
8. Prerequisite 4.1 Control and manage known invasive plants found on site
9. Prerequisite 4.2 Use appropriate, non-invasive plants
10. Prerequisite 4.3 Create a soil management plan
11. Prerequisite 5.1 Eliminate the use of wood from threatened tree species
12. Prerequisite 7.1 Control and retain construction pollutants

13. Prerequisite 7.2 Restore soils disturbed during construction

14. Prerequisite 8.1 Plan for sustainable site maintenance

15. Prerequisite 8.2 Provide for storage and collection of recyclables

Within the major categories, there are specific items where points are given as credit for sustainability (Table 1.1). I will use the fifteen pre-requisites and the credit system to evaluate the Master Plan. Then, I will evaluate each of the nodes I have designed for credits. The purpose of using the Sustainable Sites Initiative's Guidelines is to become familiar with the guidelines, their requirements, and suggestions while applying them to a real project. Since their goal is to 'do no harm' and keep ecological processes in tact throughout design I believe this is a promising method to apply and test their procedures.

Table 1.1: Point Allotment Overview for Sustainable Sites Guidelines 2009

Possible Points	Grand Total (maximum)	250 pts
Site Selection		
Prerequisite 1.1 Limit development of designated farmland soils		
Prerequisite 1.2 Protect floodplain functions		
Prerequisite 1.3 Preserve wetlands		
Prerequisite 1.4 Preserve threatened or endangered species and their habitats		
credit 1.5 Select brownfields or greyfields for redevelopment		5-10 pts
credit 1.6 Select sites within existing communities		6 pts
credit 1.7 Select sites that encourage non-motorized transportation and use of public transit		5 pts
	Total	**21 pts**
Pre-Design Assessment and Planning		
Prerequisite 2.1 Conduct a pre-design site assessment and explore opportunities for site sustainability		
Prerequisite 2.2 Use an integrated site development process		
Credit 2.3 Engage users and other stakeholders in site design		4 pts
	Total	**4 pts**
Site Design - Water		
Prerequisite 3.1 Reduce potable water use for landscape irrigation by 50% from established baseline		
Credit 3.2 Reduce potable water use for landscape irrigation by 75% or more from established baseline		2-5 pts
Credit 3.3 Protect and restore riparian, wetland, and shoreline buffers		3-8 pts
Credit 3.4 Rehabilitate lost streams, wetlands, and shorelines		2-5 pts
Credit 3.5 Manage stormwater on site		5-10 pts
Credit 3.6 Protect and enhance on-site water resources and receiving water quality		3-9 pts
Credit 3.7 Design rainwater/stormwater features to provide a landscape amenity		1-3 pts
Credit 3.8 Maintain water features to conserve water and other resources		1-4 pts
	Total	**44 pts**

Site Design - Soil and Vegetation

Prerequisite 4.1 Control and manage known invasive plants found on site		
Prerequisite 4.2 Use appropriate, non-invasive plants		
Prerequisite 4.3 Create a soil management plan		
Credit 4.4 Minimize soil disturbance in design and construction	6	pts
Credit 4.5 Preserve all vegetation designated as special status	5	pts
Credit 4.6 Preserve or restore appropriate plant biomass on site	3-8	pts
Credit 4.7 Use native plants	1-4	pts
Credit 4.8 Preserve plant communities native to the ecoregion	2-6	pts
Credit 4.9 Restore plant communities native to the ecoregion	1-5	pts
Credit 4.10 Use vegetation to minimize building heating requirements	2-4	pts
Credit 4.11 Use vegetation to minimize building cooling requirements	2-5	pts
Credit 4.12 Reduce urban heat island effects	3-5	pts
Credit 4.13 Reduce the risk of catastrophic wildfire	3	pts
Total	**51**	**pts**

Site Design - Materials Selected

Prerequisite 5.1 Eliminate the use of wood from threatened tree species		
Credit 5.2 Maintain on-site structures, hardscape, and landscape amenities	1-4	pts
Credit 5.3 Design for deconstruction and disassembly	1-3	pts
Credit 5.4 Reuse salvaged materials and plants	2-4	pts
Credit 5.5 Use recycled content materials	2-4	pts
Credit 5.6 Use certified wood	1-4	pts
Credit 5.7 Use regional materials	2-6	pts
Credit 5.8 Use adhesives, sealants, paints, and coatings with reduced VOC emissions	2	pts
Credit 5.9 Support sustainable practices in plant production	3	pts
Credit 5.10 Support sustainable practices in materials manufacturing	3-6	pts
Total	**36**	**pts**

Site Design - Human Health and Well Being

Credit 6.1 Promote equitable site development	1-3	pts
Credit 6.2 Promote equitable site use	1-4	pts
Credit 6.3 Promote sustainability awareness and education	2-4	pts
Credit 6.4 Protect and maintain unique cultural and historical places	2-4	pts
Credit 6.5 Provide for optimum site accessibility, safety, and wayfinding	3	pts
Credit 6.6 Provide opportunities for outdoor physical activity	4-5	pts
Credit 6.7 Provide views of vegetation and quiet outdoor spaces for mental restoration	3-4	pts
Credit 6.8 Provide outdoor spaces for social interaction	3	pts
Credit 6.9 Reduce light pollution	2	pts
Total	**32**	**pts**

Construction		
Prerequisite 7.1 Control and retain construction pollutants		
Prerequisite 7.2 Restore soils disturbed during construction		
Credit 7.3 Restore soils disturbed by previous development	2-8	pts
Credit 7.4 Divert construction and demolition materials from disposal	3-5	pts
Credit 7.5 Reuse or recycle vegetation, rocks, and soil generated during construction	3-5	pts
Credit 7.6 Minimize generation of greenhouse gas emissions and exposure to localized air pollutants during construction	1-3	pts
Total	**21**	**pts**

Operations and Maintenance		
Prerequisite 8.1 Plan for sustainable site maintenance		
Prerequisite 8.2 Provide for storage and collection of recyclables		
Credit 8.3 Recycle organic matter generated during site operations and maintenance	2-6	pts
Credit 8.4 Recycle outdoor energy consumption for all landscape and exterior operations	1-4	pts
Credit 8.5 Use renewable sources for landscape electricity needs	2-3	pts
Credit 8.6 Minimize exposure to environmental tobacco smoke	1-2	pts
Credit 8.7 Minimize generation of greenhouse gases and exposure to localized air pollutants during landscape maintenance activities	1-4	pts
Credit 8.8 Reduce emissions and promote the use of fuel-efficient Vehicles	4	pts
Total	**23**	**pts**

Monitoring and Innovation		
Credit 9.1 Monitor performance of sustainable design practices	10	pts
Credit 9.2 Innovation in site design	8	pts
Total	**18**	**pts**

(The Sustainable Sites Initiative 2009)

Chapter 2

Plant/Soil Experiment

The soils of the interior section of Liberty State Park are composed of fill material brought in for the construction of a rail yard, material brought in during the use of the rail yard for the transportation of goods and passengers, and material that was deposited and relocated as the rail yard was dismantled and the land was smoothed over. In order to develop a successful planting design, information about soil structure and fertility is needed. The soil that will be used as fill for planted areas along the trail will be dredge spoil (US Army Corps of Engineers 2008). Therefore, this fill is used in the experiment and samples have been taken from a plot area and analyzed to determine the soil properties in order to make decisions on the various soil treatments for experimentation which is the focus of this chapter. Additionally, soil samples were taken of extant soil along the proposed trail, the results of which will help determine proper plant and soil specifications in the next chapter.

Plot Preparation

A rectangular area of approximately 13 meters (northeast to southwest) by 7 meters located within the interior section of Liberty State Park (Figures 2.1 through 2.3) was cleared of existing *Artemisia vulgaris* species and scraped to a depth of 15-20 cm with a backhoe. Fill from consistent source, and consistent with the material to be used in construction, of the proposed trail system, was added and graded flat.

Figure 2.1 (Top Left): Aerial, Entire Liberty State Park
Figure 2.2 (Top Right): Aerial, Freedom Way
Figure 2.3 (Bottom): Aerial, Study Area.

Thirty plots, measuring 1m x 2m, were laid out in a grid pattern (three columns and ten rows) and spaced 0.25m apart within the cleared 91m^2 study area. Columns labeled 'A','B' and 'C' each contained ten rows labeled 1-10. The treatment types were also labeled 1-10 (Table 2.1) and randomly matched to each plot location using a random number generator (randomizer.org) (Figure 2.4).

The intention of selecting the treatments shown in Table 2.1 was to have varying effects on soil chemistry resulting in varying amounts of plant growth or survival. Some treatments were selected to increase the nutrients in the soil, some were selected to increase or decrease the soil's water holding capacity, while others were selected to decrease the number of colonizing species. Control plots were added for comparison purposes. The treatments were added as outlined below.

TREATMENT	PLOT LOCATIONS		
1. Control	2C	3B	10A
2. 25% recommended fertilizer	2A	4B	5C
3. 50% recommended fertilizer	1C	4A	6B
4. 10% sand addition	4C	6A	9B
5. 20% sand addition	5A	6C	8B
6. Hydrogel addition	2B	3A	10C
7. Compost addition	1B	7A	8C
8. 10% sand addition + Hydrogel	5B	7C	9A
9. 10% sand addition + compost	1A	9C	10B
10. 2 inch cedar mulch cover	3C	7B	8A

Table 2.1: Treatment Plot Locations

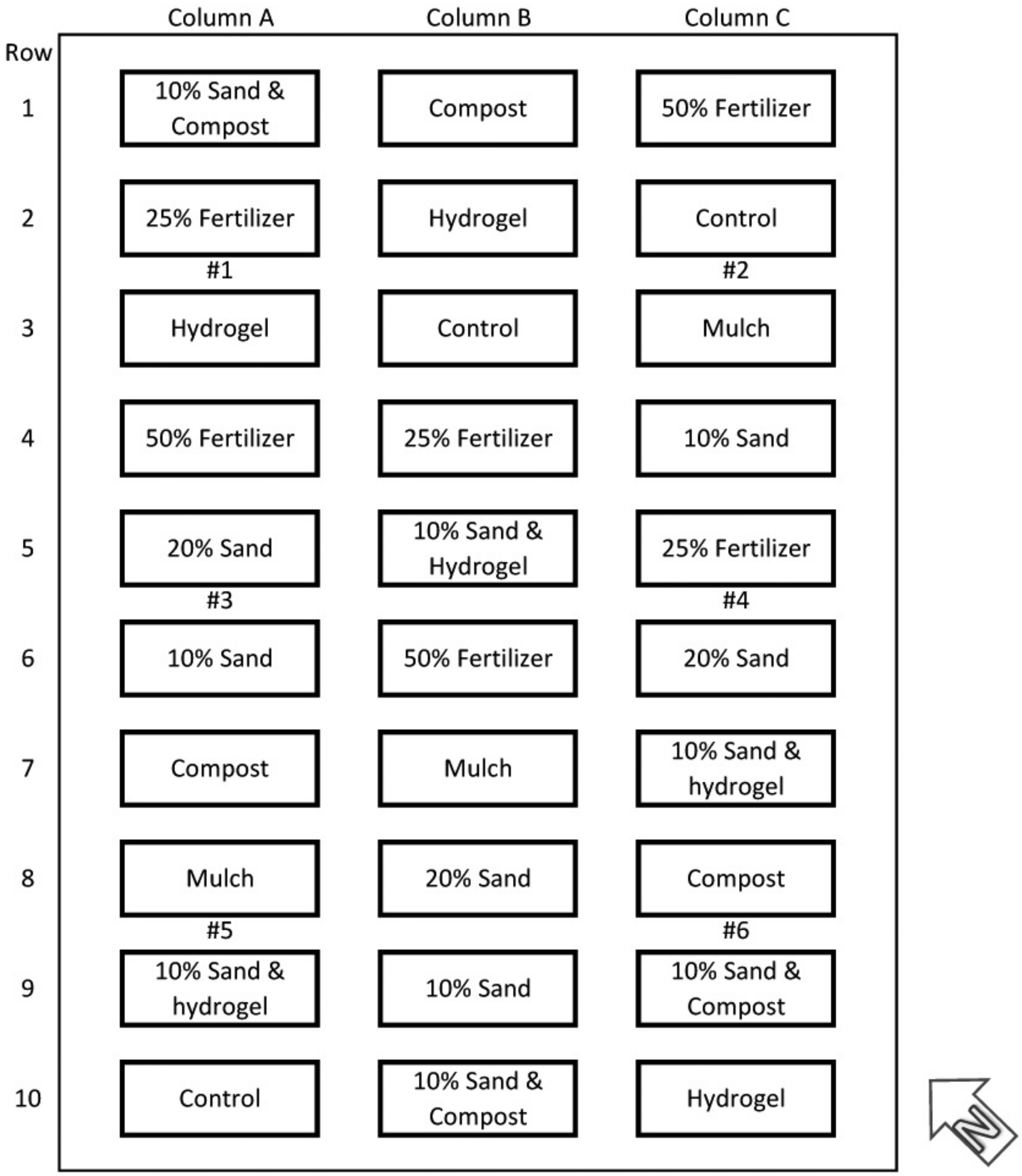

Figure 2.4: Treatment layout within the experimental plot.

Soil samples were collected from six locations within the study area as shown in Figure 2.4. Each sample was approximately 18 centimeters deep. The samples were air dried and delivered to the Rutgers Soil Testing Laboratory. Appendix A summarizes the test results, which listed the texture as sandy clay loam for all six samples. The soil is slightly acidic throughout the test plot area ranging in pH from 6.05 to 6.39. The organic matter is considered low-medium, ranging from 2.2% to 3.3%.

The pH results of the soil tests is considered within the optimum range for many plants with only the sample area (sample #6, pH of 6.05) having a recommended limestone application of 20 lbs. per 1000 sf. Limestone was added to the plots immediately surrounding the deficient sample #6 location (plots 8C and 9C) at the recommended rate (181.4g per plot), while the plots adjacent to plots 8C and 9C (plots 7C, 8B, 9B, and 10C) received half the recommended rate (90.7g). The plots were tilled with a front-tine rotating gas tiller to a depth of about 15 cm.

Control plots were tilled when other tilling was conducted. No other amendments were made.

Fertilizer was recommended by the soil test results. However, fertilizer additions are often avoided in native plant gardens because weeds are more responsive than the native plants. I compromised by adding fertilizer 25% the recommended fertilizer addition and 50% recommended fertilizer addition. The soil sample test results recommended using a fertilizer with a N:P:K ratio of 2:0:1 at a rate to achieve 2 lbs N per 1000 sf. A plot that is 1m x 2m (21.5 sf) would need 0.043 lbs to achieve the equivalent to 2 lbs N per 1000 sf. The fertilizer requirements for the plots called for 25% and 50% of the recommended rates, which calculates to 0.0108 lbs and 0.0215 lbs respectively. The fertilizer used had a 24:0:11 ratio which requires the 0.0108 lbs and 0.0215 lbs to be multiplied by 4.17 to reach the desired level of N for the application. This resulted in 0.045 lbs (20.4 g) of the selected fertilizer to be added to the plots requiring 25% the recommended rate, and 0.09 lbs (40.8 g) of the selected fertilizer to be added to the plots requiring 50% the recommended rate. This amount was spread evenly over the appropriate plots.

Sand was added to improve soil drainage, shifting the classification from Sandy Clay Loam towards a Sandy Loam. Sand treatment amounts were calculated by volume. The soil in each plot was tilled to a depth of 15 cm, 1 m x 2 m wide resulting in a volume of soil of 0.3 m^3. This required an addition of 0.03m^3 of sand for the 10% sand addition, and 0.06m^3 of sand for the 20% sand additions. A cardboard box which measured 0.06 m^3 was filled or half-filled with sand accordingly, spread evenly over the appropriate plots and tilled.

Hydrogel is a granular polymer that has the ability to “reversibly absorb and desorb more than 500 times its weight in distilled water, and more than 150 times its weight in a standard fertilizer solution” (Amereq, Inc. 2007-2012). This material was used in two treatments, one where there was a 10% sand addition and one where it was the only amendment. In both cases, it was added to each planting hole at the time of planting, using the manufacture’s recommended rate of ¼ teaspoon per planting hole.

Compost addition was selected as a treatment because of the very low organic content of the soil. The compost was from an on-site source, composed primarily of landscape waste. It was spread evenly to a depth of about 7.5 cm and then tilled into the soil to a depth of about 15 cm.

Cedar mulch cover was selected to retain moisture and limit the establishment of colonizing species. It was spread evenly to a depth of about 5cm after planting.

Plant Installation and Watering

Each plot contained three shrubs (*Aronia melanocarpa, Myrica pensylvanica, and Prunus maritima*), three perennials (*Solidago sempervirens, Baptisia tinctoria, and Eupatorium coelestinum*) and two annuals *(Lolium multiflorum, Chamaecrista fasciculata*). The three shrubs were located in a line along the northerly 2m length of each plot; the perennials were located along the southerly length. The annuals seeds were located between the two rows of shrubs and perennials (Figure 2.5). The planting was completed on June 13, 2011.

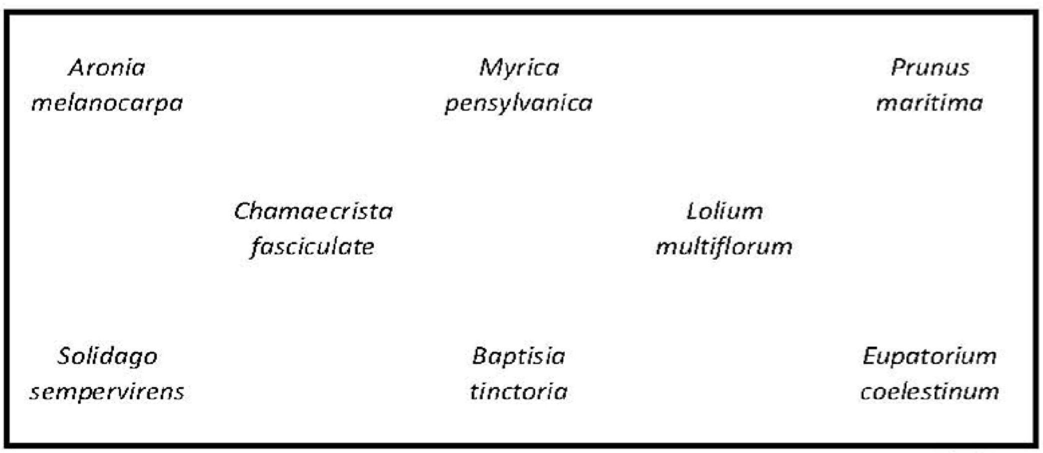

Figure 2.5: Plant arrangement for each plot

Each shrub and perennial was taken out of its container. Bound roots were trimmed and the soil was loosened. A hole double the width of the plant's root area and slightly shallower than its depth was dug. This ensures that the plant is not planted too low relative to the existing grade, and provides enough room for the roots to grow before meeting another soil interface created by digging of the hole. The shrubs and perennials were installed and the soil was gently patted down. Soil removed from the plot for each particular plant was added around the root area to fill any voids. Water was applied at the time of planting to settle the newly added soil and eliminate air pockets. Additional soil was added and water applied until there was no decrease in soil level surrounding the plant.

The annual seeds were spread in a circular area about 15-20 cm in diameter and covered with 0.5 to 1 cm of soil. The amount of ¼ teaspoon of inoculant was added to the *Chamaecrista fasciculata* seeding area prior to covering the seeds with soil to assist in germination and plant growth by increasing the bacteria in the soil to more favorable levels. Seeded areas were irrigated with low water pressure, to avoid disturbing the seeded area.

Weather conditions and precipitation were monitored daily using the Liberty Science Center's weather station located 0.5 miles north of the study site (Appendix B). Manual watering was provided 2 to 3 times per week depending on rainfall events that occurred or were predicted for the week. The site was located in full sun and received 10-12 hours of sunlight per day during the time of the experiment (June-October 2011).

Plant Measurements

Height and canopy width measurements were taken for all shrub and perennials at the time of installation and repeated every first week of the month through October. Only height measurements were taken for the annuals since the widths were determine by the area seeded. The leaf area measurements were taken two weeks after installation and every four weeks thereafter for the shrubs only. This was done by randomly selecting ten leaves on each plant and measuring their length and width. The total number of leaves for each plant was multiplied by the average leaf area to get the total leaf area of each plant. When there were less than ten leaves on the plant then all leaves were measured for leaf area and multiplied by the total number of leaves to get the total leaf area of the plant.

Photographs were taken of the plots and individual plants at least once a month to record any visual changes or evidence of herbivory.

Colonized Species

The selected plant species were installed June 13th, and by June 24th plant species began to colonize in the study plots. Whether these ruderal species colonized from seeds transported in the fill material used for the experiment or from neighboring plant communities after the plots were prepared, they needed to be located and identified. This is important for maintaining biodiversity and the integrity of the planting design of the trail system. It also helps in the preparation of a maintenance plan for management techniques, which can also save time and money in the future.

A point sampling technique was used to determine species type and frequency by placing 28 flags 20cm apart along four rows in each plot. A 40cm buffer on each side of the 2m length of plot and a 20cm buffer on each side of the 1m length of plot ensured that the sampled plants were sufficiently within the treatment area. Next, all plants touching the flag post were identified with the tallest plant measured for height.

Newcomb's Wildflower Guide and Wild Urban Plant of the Northeast were referenced for species identification purposes (Newcomb 1977) (Del Tredici 2010). This method provided a list and frequency of colonizing species for each individual soil treatment (Table 2.2). It also shows that all treatments had nearly the same amount of colonizing species and no species was partial to any particular treatment.

Figure 2.6 shows the number of the colonized or ruderal species by plot. Knowing which species is most abundant will also help with the development of the maintenance plan by prioritizing the plan of attack.

	control	25% fertilizer	50% fertilizer	10% sand	20% sand	Hydrogel	10% sand & compost	10% sand & Gelscape	compost	mulch
artemesia	13	4	9	5	4	9	10	4	12	14
barnyard grass	4	3	18	3	5	12	2	2	6	13
beech grass	22	50	37	53	53	40	35	37	30	27
crabgrass	44	56	56	68	71	57	70	51	53	55
cyperus	11	14	11	14	17	13	4	13	14	5
flower of an hour	0	3	0	0	0	0	0	0	0	0
foxtail	1	3	1	1	1	1	1	0	1	0
hibiscus sp.	0	2	0	0	0	1	0	0	1	0
ivy-leaved morning glory	1	2	0	0	0	1	0	0	1	3
jimson	1	0	0	1	0	4	2	0	1	1
lambsquarters	3	3	6	1	0	2	2	3	3	3
leadwort	0	1	0	2	0	2	5	0	1	1
oxalis sp.	5	3	1	3	0	3	2	2	5	4
panicum sp1	9	17	3	4	4	12	2	6	13	10
panicum sp2	1	8	4	7	2	4	0	0	5	1
plantain	3	0	2	3	0	2	0	0	1	1
pokeweed	0	0	2	0	0	0	0	0	0	1
primrose	0	0	0	0	0	1	0	1	1	1
purslane	10	6	9	20	11	4	14	17	9	4
ragweed	0	0	0	0	0	5	1	1	1	3
rocacea	0	0	3	1	0	0	0	0	0	0
smartweed	5	2	0	2	0	0	0	0	1	0
sumac	0	0	1	0	0	0	0	0	1	1
trembling aspen	0	0	0	0	0	0	0	0	1	0
white snakeroot	8	2	0	0	0	1	0	0	2	0

Table 2.2: Frequency of species colonized in experiment plots. Note: the numbers refer to the number of point contacts made during the survey.

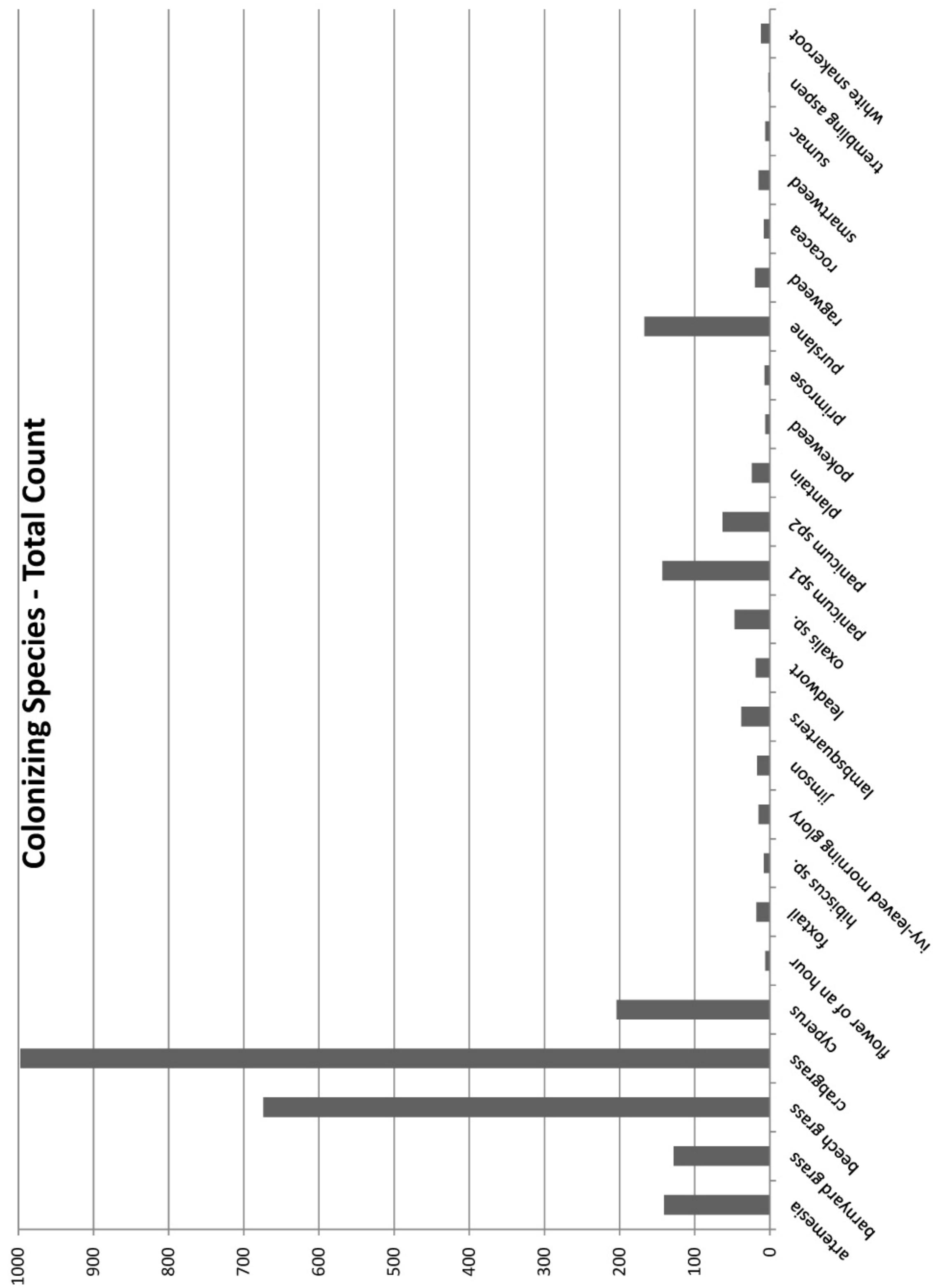

Figure 2.6: Total count of colonized species in experiment plots

Experiment Results

Shrubs

The average height and average width for the *Aronia melanocarpa* showed no real increase or decrease with varying soil treatments from the time of planting through October. However, a decrease in average height did occur in three of the treatment types where 7 to 10 cm of the single-stemmed tubelings were snapped off the base, most likely the result of wildlife damage or browsing. Although rabbits and voles have been spotted on occasion, herbivory of these specific plants was not physically observed. Four weeks later, at the next measurement interval, the snapped stems showed new buds and leaves. Only the 50% fertilizer treatment showed an initial decrease in average height which may be attributed to the treatment since no stems were snapped in these plots. However, the average height remained constant from that point on (Figure 2.7).

The average leaf area for *A. melanocarpa* only showed an increase during the August measurement in the Hydrogel and mulch treatment plots with the mulch treatment showing the greatest leap from 80 to 120 cm^2 (Figure 2.8).

The analysis of variance (ANOVA) calculated for the August measurements of *A. melanocarpa* showed no statistical difference between treatments for average height and width. However, there was a difference statistically between treatments in the average leaf area with the mulch treatment and Hydrogel treatment having the greatest positive effect on average leaf area (Tables 2.3a through 2.3c).

Table 2.3a: *A. melanocarpa* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-AM

Source	DF	SS	MS	F	P
trt	9	1031.1	114.6	1.28	0.304
Error	20	1784.2	89.2		
Total	29	2815.2			

S = 9.445   R-Sq = 36.62%   R-Sq(adj) = 8.11%

```
                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level  N    Mean   StDev  ------+---------+---------+---------+---
 1     3  46.667  14.110       (---------*--------)
 2     3  56.167   2.566               (---------*--------)
 3     3  42.500   5.268    (--------*---------)
 4     3  52.167   7.077            (--------*---------)
 5     3  44.833  13.696      (--------*---------)
 6     3  55.333   3.786               (--------*---------)
 7     3  40.667  13.429  (---------*--------)
 8     3  55.000   8.185              (---------*--------)
 9     3  58.000  11.435                 (--------*---------)
10     3  51.833   5.346            (--------*---------)
                          ------+---------+---------+---------+---
                               36        48        60        72
```

Pooled StDev = 9.445

Table 2.3b: *A. melanocarpa* Analysis of Variance (average width versus treatment)

One-way ANOVA: avg wdth versus trt AUG-AM

Source	DF	SS	MS	F	P
trt	9	147.9	16.4	1.32	0.286
Error	20	248.5	12.4		
Total	29	396.5			

S = 3.525   R-Sq = 37.31%   R-Sq(adj) = 9.10%

```
                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean  StDev  ------+---------+---------+---------+---
 1     3   5.833  2.005  (----------*---------)
 2     3   9.083  4.626          (----------*---------)
 3     3   7.583  2.241      (----------*----------)
 4     3   9.583  3.146           (----------*----------)
 5     3   5.750  2.634  (---------*----------)
 6     3  12.667  1.443                   (----------*---------)
 7     3   8.000  4.380       (----------*----------)
 8     3  12.000  6.083                 (----------*----------)
 9     3   9.417  3.556           (----------*---------)
10     3  10.667  2.466              (----------*---------)
                         ------+---------+---------+---------+---
                             4.0       8.0      12.0      16.0
```

Pooled StDev = 3.525

Table 2.3c: *A. melanocarpa* Analysis of Variance (total area versus treatment)

One-way ANOVA: total area versus trt AUG-AM

```
Source  DF     SS    MS     F      P
trt      9  21266  2363  3.59  0.008
Error   20  13166   658
Total   29  34432

S = 25.66   R-Sq = 61.76%   R-Sq(adj) = 44.55%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean  StDev  --+---------+---------+---------+-------
 1     3   40.92  18.98       (------*-------)
 2     3   54.32  46.40          (-------*------)
 3     3   36.01  24.70     (-------*-------)
 4     3   57.51  26.02           (------*-------)
 5     3   21.32  15.93  (------*-------)
 6     3   78.33  16.72                (-------*------)
 7     3   38.43  23.71      (-------*------)
 8     3   27.47  19.40   (-------*-------)
 9     3   46.59  26.60        (-------*------)
10     3  117.00  24.55                          (------*-------)
                         --+---------+---------+---------+-------
                           0        40        80       120

Pooled StDev = 25.66
```

Myrica pensylvanica showed a steady increase in average height and average width in 5 out of the 10 treatment types from June 15 to October 1. These include the treatments of 20% sand, Hydrogel, 10% sand + compost, mulch and the control plots. The rest showed a decrease, due to breakage or leaf loss, after July or August but began to increase again or level off thereafter (Figure 2.9).

From July to September there was a slight increase in average leaf area for all treatments except 10% Sand + Hydrogel. The greatest increase occurred in the mulch treatment with the Hydrogel and 20% sand also showing significant increase in leaf area (Figure 2.10).

The ANOVA calculated for the August measurements of *M. pensylvanica* showed no statistical difference in average height, average width or average leaf area as a result of the various soil treatments (Tables 2.4a through 2.4c).

Seven *M. pensylvanica* were leafless by September and no new growth was observed. The remaining Mp continued to produce high leaf counts in comparison to the other plant species selected for the study.

Table 2.4a: *M. pensylvanica* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-MP

```
Source  DF    SS   MS     F      P
trt      9  1308  145  1.41  0.247
Error   20  2055  103
Total   29  3362

S = 10.14   R-Sq = 38.89%   R-Sq(adj) = 11.39%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level  N   Mean  StDev  ---------+---------+---------+---------
 1     3  32.67   2.52              (-------*-------)
 2     3  21.67  18.93      (-------*--------)
 3     3  31.33   1.53             (-------*-------)
 4     3  12.67  21.94  (-------*--------)
 5     3  36.33   7.02                (-------*-------)
 6     3  32.17   1.04             (-------*--------)
 7     3  30.17   5.58            (-------*-------)
 8     3  32.83   5.80              (-------*-------)
 9     3  32.00   6.24             (-------*-------)
10     3  32.00   5.00             (-------*-------)
                        +---------+---------+---------+---------
                        0        15        30        45

Pooled StDev = 10.14
```

Table 2.4b: *M. pensylvanica* Analysis of Variance (average width versus treatment)

One-way ANOVA: avg wdth versus trt AUG-MP

```
Source  DF     SS    MS     F      P
trt      9  300.0  33.3  1.44  0.237
Error   20  463.2  23.2
Total   29  763.2

S = 4.812   R-Sq = 39.31%   R-Sq(adj) = 12.00%


                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level  N    Mean  StDev  --+---------+---------+---------+-------
 1     3  11.583  1.774              (--------*---------)
 2     3  10.167  9.088           (---------*---------)
 3     3  13.000  6.062                (---------*--------)
 4     3   4.500  7.794  (---------*--------)
 5     3  14.417  0.520                  (---------*---------)
 6     3  16.417  1.627                      (--------*---------)
 7     3  11.667  3.512              (--------*---------)
 8     3  13.500  2.291                 (---------*--------)
 9     3  13.417  3.843                 (--------*---------)
10     3  15.333  3.617                    (---------*--------)
                         --+---------+---------+---------+-------
                         0.0       6.0      12.0      18.0

Pooled StDev = 4.812
```

Table 2.4c: *M. pensylvanica* Analysis of Variance (total area versus treatment)

One-way ANOVA: total area versus trt AUG-MP

```
Source  DF      SS     MS     F      P
trt      9  164129  18237  1.91  0.109
Error   20  190747   9537
Total   29  354876

S = 97.66   R-Sq = 46.25%   R-Sq(adj) = 22.06%


                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level  N    Mean   StDev  -----+---------+---------+---------+----
 1     3   84.18   11.49     (-------*------)
 2     3  141.55  170.56       (------*-------)
 3     3   91.23  158.01     (-------*-------)
 4     3   46.14   79.91  (-------*-------)
 5     3  132.90   66.34      (-------*-------)
 6     3  173.59   65.13         (-------*------)
 7     3   75.98   65.61    (-------*-------)
 8     3  109.89   94.95     (-------*-------)
 9     3  134.33   41.88       (-------*-------)
10     3  326.77  105.26                 (-------*-------)
                          -----+---------+---------+---------+----
                               0       150       300       450

Pooled StDev = 97.66
```

Prunus maritima showed a relatively steady average height and average width throughout all treatment plots. However, it was observed that three stems were snapped (similar to the *A. melanocarpa* previously discussed), one in a control plot, one in a 50% fertilizer treatment and one in a compost treatment, causing their numbers in average height and width to decrease (Figure 2.11).

Similar results are showing for *P. maritima* in the average leaf area due to the snapped stems. The only significant increase in average leaf area occurred in the 20% sand treatment plot between July and August (Figure 2.12). The rest remained at constant levels with five *P. maritima* leafless by October and not sign of new growth.

The ANOVA calculated for the August measurements of *P. maritima* showed no statistical difference in average height, average width or average leaf area as a result of the various soil treatments (Tables 2.5a through 2.5c).

Overall no *P. maritima* ever reached over 30 cm and was quickly enveloped by colonizing species within the plot area.

Table 2.5a: *P. maritima* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-PM

Source	DF	SS	MS	F	P
trt	9	249.7	27.7	1.52	0.209
Error	20	365.7	18.3		
Total	29	615.3			

S = 4.276   R-Sq = 40.58%   R-Sq(adj) = 13.83%

```
                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean  StDev  ---+---------+---------+---------+------
 1     3  24.333  3.512       (--------*-------)
 2     3  31.167  3.753                   (--------*--------)
 3     3  25.167  3.547        (--------*--------)
 4     3  25.500  2.179         (--------*-------)
 5     3  27.333  4.619            (--------*-------)
 6     3  22.000  2.000   (--------*-------)
 7     3  23.500  5.895     (-------*--------)
 8     3  21.167  7.234  (-------*--------)
 9     3  25.667  3.215         (--------*-------)
10     3  21.333  4.041  (--------*-------)
                         ---+---------+---------+---------+------
                          18.0      24.0      30.0      36.0
```

Pooled StDev = 4.276

Table 2.5b: *P. maritima* Analysis of Variance (average width versus treatment)

One-way ANOVA: avg wdth versus trt AUG-PM

Source	DF	SS	MS	F	P
trt	9	72.40	8.04	1.05	0.438
Error	20	153.39	7.67		
Total	29	225.79			

S = 2.769   R-Sq = 32.07%   R-Sq(adj) = 1.50%

```
                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level  N   Mean  StDev  -------+---------+---------+---------+--
 1     3  4.333  2.323  (----------*-----------)
 2     3  6.417  2.126         (----------*-----------)
 3     3  9.500  6.557                    (----------*----------)
 4     3  8.250  1.561              (-----------*----------)
 5     3  8.083  1.233              (----------*----------)
 6     3  5.375  2.509      (----------*----------)
 7     3  5.417  0.878      (----------*----------)
 8     3  5.333  2.673      (----------*----------)
 9     3  5.833  1.422       (----------*-----------)
10     3  7.333  1.893            (----------*-----------)
                        -------+---------+---------+---------+--
                             3.0       6.0       9.0      12.0
```

Pooled StDev = 2.769

Table 2.5c: *P. maritima* Analysis of Variance (total area versus treatment)

One-way ANOVA: total area versus trt AUG-PM

```
Source  DF    SS   MS     F      P
trt      9  2417  269  1.71  0.153
Error   20  3144  157
Total   29  5562

S = 12.54   R-Sq = 43.46%   R-Sq(adj) = 18.02%


                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level  N   Mean  StDev  ---+---------+---------+---------+------
 1     3  16.65  11.03      (--------*---------)
 2     3  24.07  14.53           (--------*--------)
 3     3  23.14  22.29          (--------*---------)
 4     3  10.43   8.87  (---------*--------)
 5     3  40.91  15.69                    (---------*--------)
 6     3  13.57   2.18    (--------*---------)
 7     3  11.84   8.77   (--------*---------)
 8     3  17.32   7.57      (---------*--------)
 9     3  17.91  12.53       (--------*---------)
10     3  31.17  11.03               (--------*---------)
                        ---+---------+---------+---------+------
                           0        16        32        48

Pooled StDev = 12.54
```

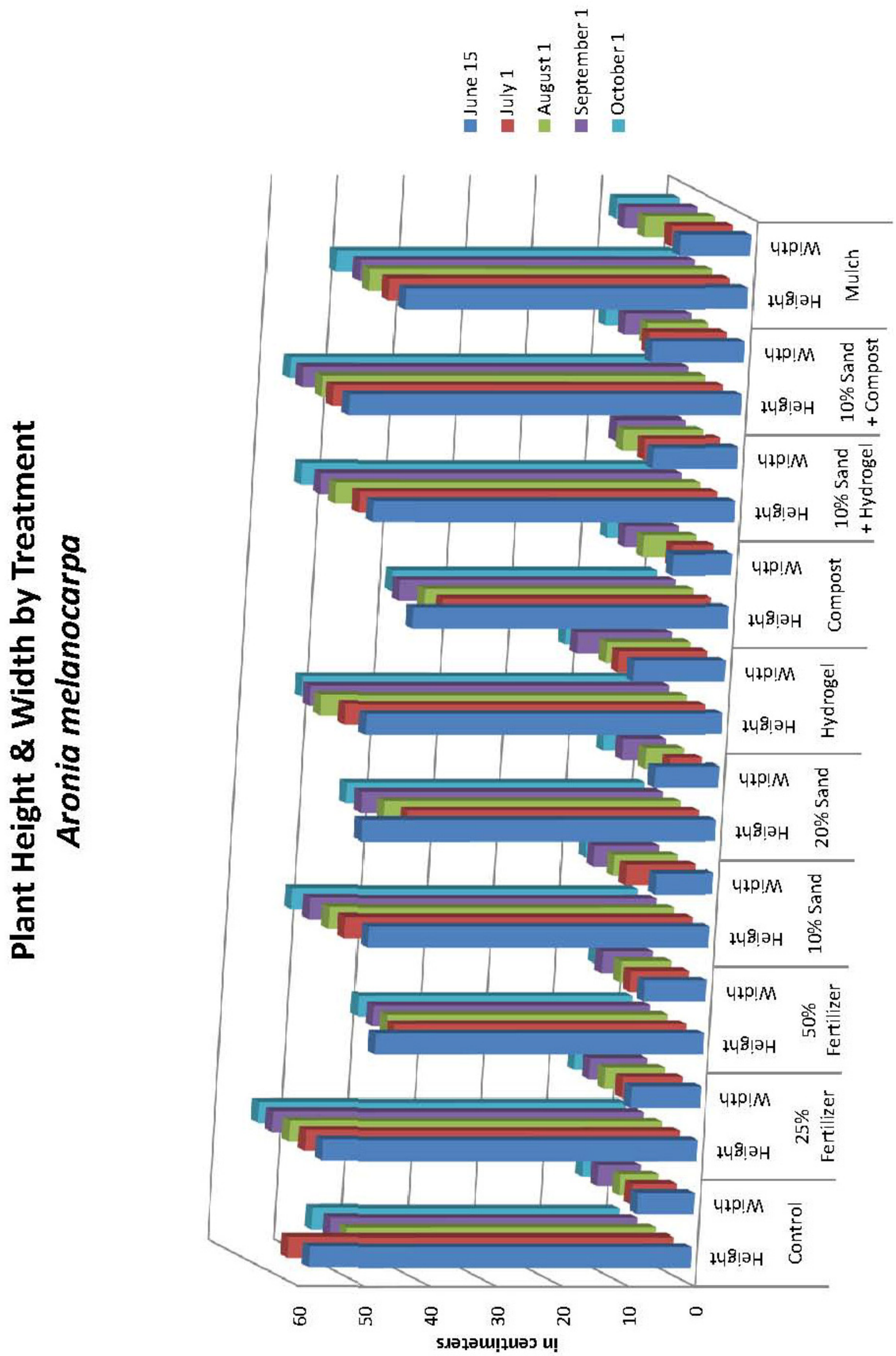

Figure 2.7: Raw Data of *A. melanocarpa* Plant Height and Width by Treatment

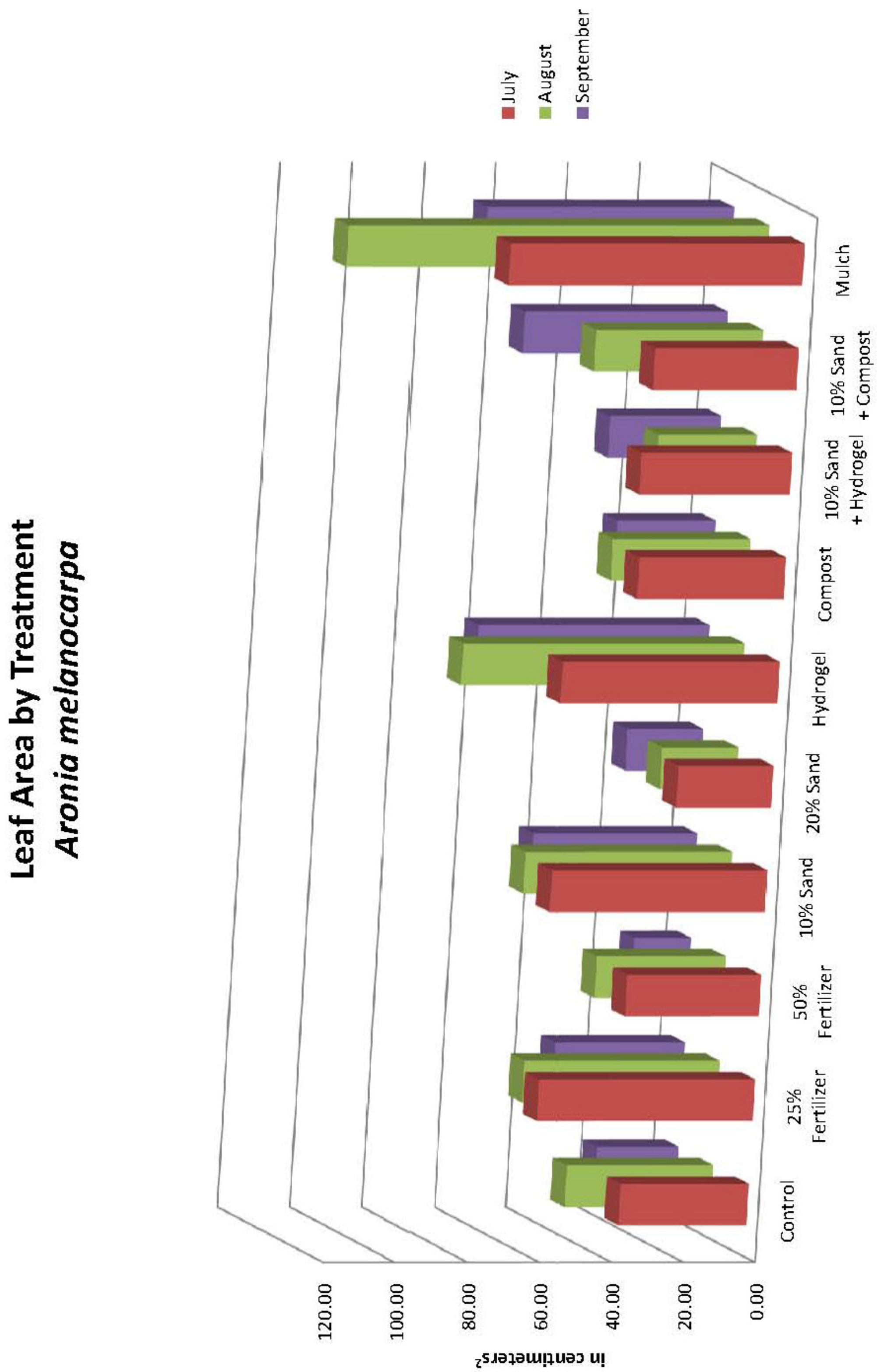

Figure 2.8: Raw Data of *A. melanocarpa* Leaf Area by Treatment

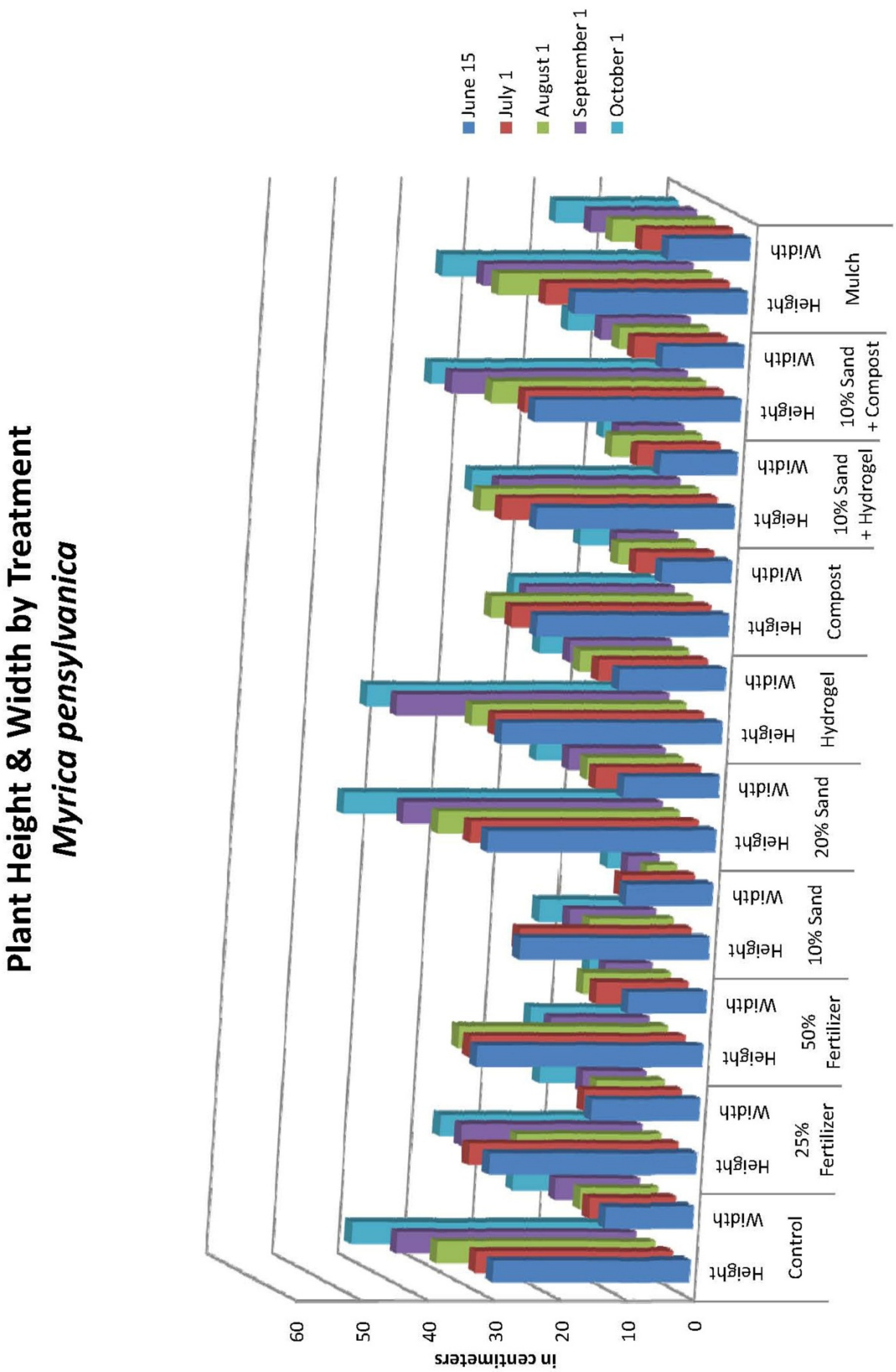

Figure 2.9: Raw Data of *M. pensylvanica* Plant Height and Width by Treatment

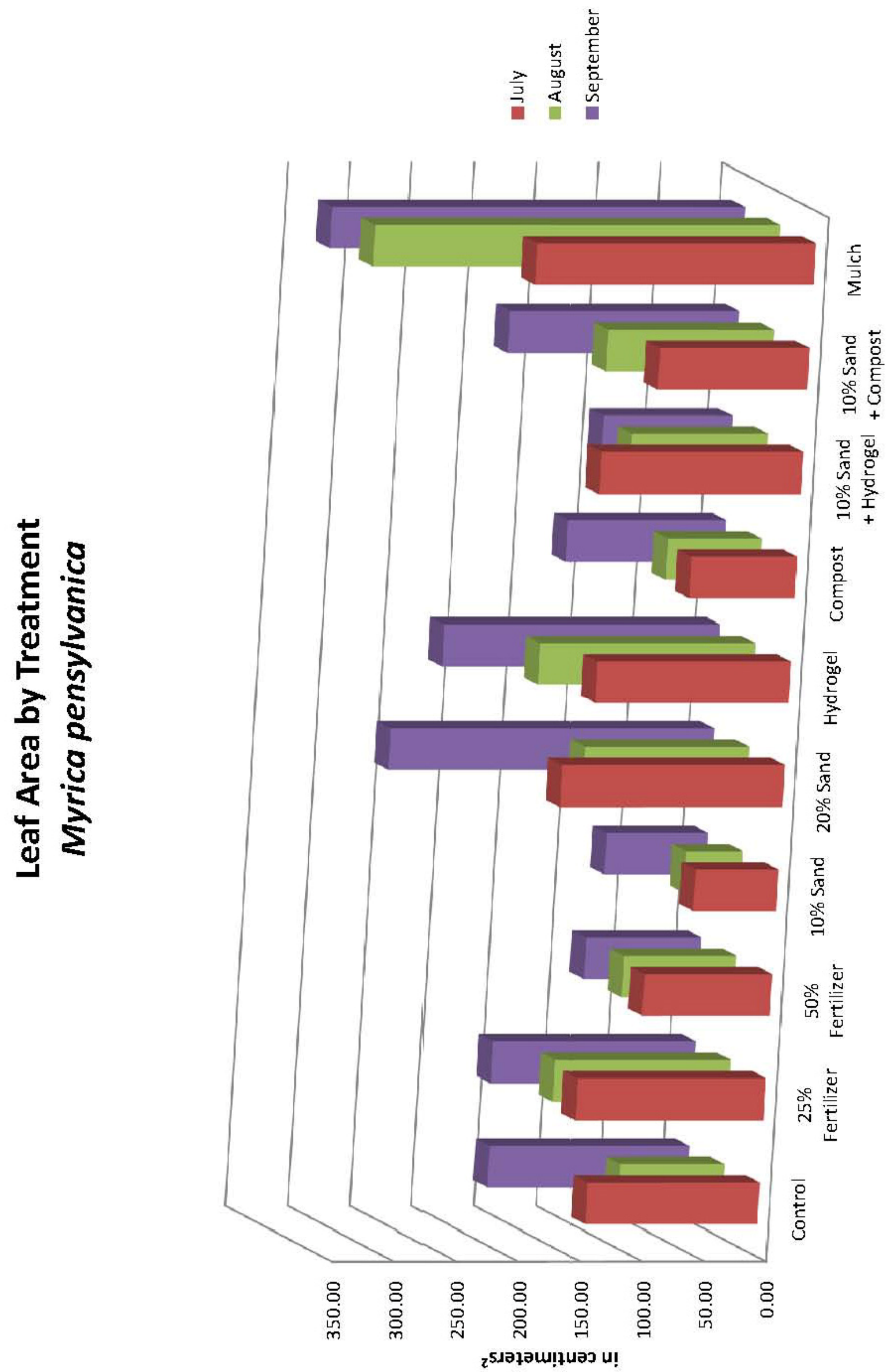

Figure 2.10: Raw Data of *M. pensylvanica* Leaf Area by Treatment

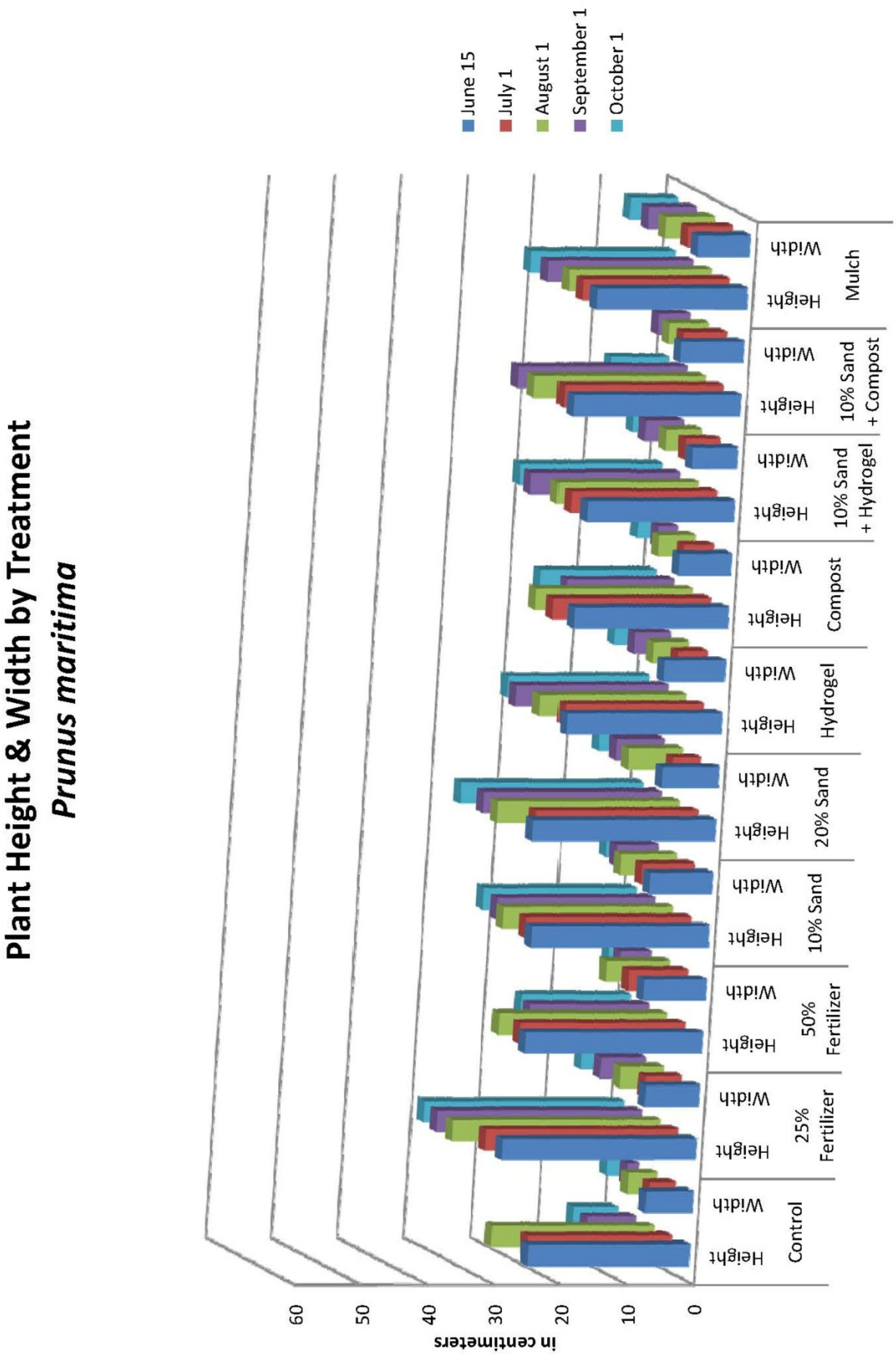

Figure 2.11: Raw Data of *P. maritima* Plant Height and Width by Treatment

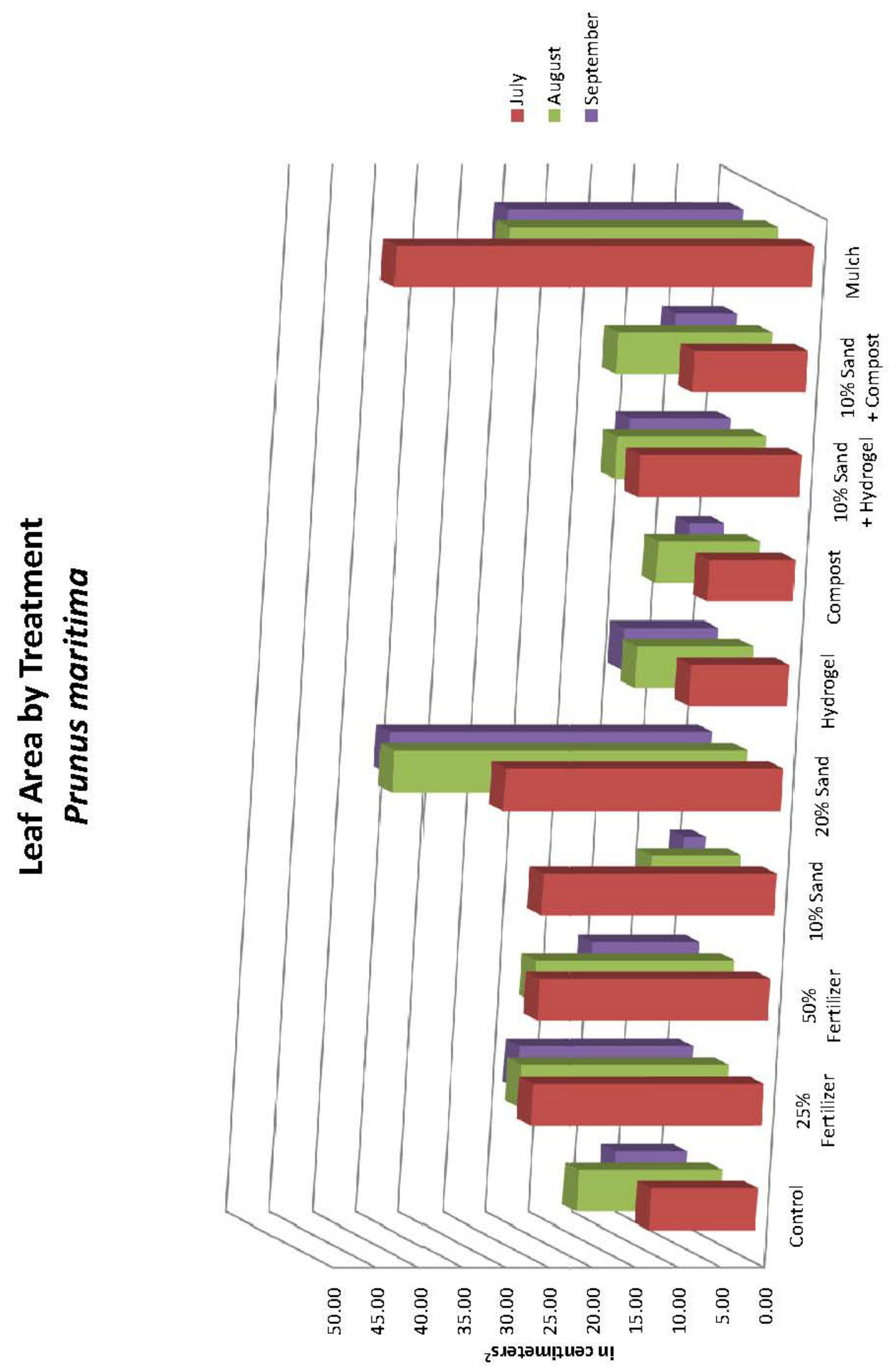

Figure 2.12: Raw Data of *P. maritima* Leaf Area by Treatment

Perennials

Solidago sempervirens seemed quite successful with all treatments showing increases in average height from June to October in all soil treatments with the greatest increase found in the control plot. Mulch and 20% sand also showed substantial increases in average height (Figure 2.13).

The ANOVA calculated for the August measurements of *S. sempervirens* showed no statistical difference in average height or average width as a result of the various soil treatments (Tables 2.6a and 2.6b).

Table 2.6a: *S. sempervirens* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-SS

```
Source  DF      SS    MS     F      P
trt      9   378.8  42.1  1.23  0.331
Error   20   684.0  34.2
Total   29  1062.8

S = 5.848   R-Sq = 35.64%   R-Sq(adj) = 6.68%


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level  N    Mean   StDev  -------+---------+---------+---------+--
 1     3  24.833   2.021    (---------*----------)
 2     3  33.667  14.224                (---------*---------)
 3     3  26.000   2.646     (---------*---------)
 4     3  22.833   0.764  (---------*---------)
 5     3  32.000   6.928              (---------*---------)
 6     3  24.667   3.215    (---------*---------)
 7     3  23.667   4.619   (---------*---------)
 8     3  27.000   5.568      (---------*---------)
 9     3  24.500   3.775    (---------*---------)
10     3  22.833   1.756  (---------*---------)
                          -------+---------+---------+---------+--
                              21.0      28.0      35.0      42.0

Pooled StDev = 5.848
```

Table 2.6b: *S. sempervirens* Analysis of Variance (average width versus treatment)

One-way ANOVA: avg wdth versus trt AUG-SS

```
Source  DF     SS    MS     F      P
trt      9  268.9  29.9  1.53  0.204
Error   20  389.9  19.5
Total   29  658.8

S = 4.415   R-Sq = 40.82%   R-Sq(adj) = 14.19%


                         Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean  StDev  --------+---------+---------+---------+-
 1     3  17.167  2.754          (--------*-------)
 2     3  22.000  0.500                  (--------*--------)
 3     3  17.083  7.642          (-------*--------)
 4     3  17.583  2.155          (--------*--------)
 5     3  22.000  5.895                  (--------*--------)
 6     3  17.750  4.337           (--------*-------)
 7     3  12.583  3.376  (--------*--------)
 8     3  16.000  4.583        (--------*--------)
 9     3  20.167  6.166               (--------*-------)
10     3  13.583  0.289    (--------*--------)
                         --------+---------+---------+---------+-
                              12.0      18.0      24.0      30.0

Pooled StDev = 4.415
```

Evidence of browsing was observed in July. A great increase in average height and width occurred between August and September for nearly all soil treatments (10% sand+Hydrogel showed a decrease, evidence of browsing). Fifteen out of thirty *S. sempervirens* were flowering or budding by October, with at least one plant flowering or budding in each soil treatment type. *S. sempervirens* was flowering or budding in two out of the three soil treatments of 25% fertilizer, 50% fertilizer, 10% sand+Hydrogel, mulch and the control.

Baptisia tinctoria showed a decrease in average height and average width in all treatments from June through October (Figure 2.14).

The ANOVA calculated for the August measurements of *B. tinctoria* showed no statistical difference in average height or average width as a result of the various soil treatments (Tables 2.7a and 2.7b).

B. tinctoria showed a steady decline, drying out and turning black in most cases then becoming dominated by colonizing species throughout the summer, making this plant quite unsuccessful in this study.

Table 2.7a: *B. tinctoria* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-BT

```
Source  DF      SS     MS     F      P
trt      9  1383.2  153.7  1.83  0.124
Error   20  1678.2   83.9
Total   29  3061.3

S = 9.160   R-Sq = 45.18%   R-Sq(adj) = 20.51%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean   StDev  ---------+---------+---------+---------+
 1     3  22.833   7.489                     (--------*--------)
 2     3   6.667  11.547       (---------*--------)
 3     3   0.000   0.000  (--------*--------)
 4     3   8.000  13.856        (---------*--------)
 5     3   7.667  13.279        (--------*---------)
 6     3  18.000   1.732                 (--------*--------)
 7     3  12.000  10.817            (--------*--------)
 8     3   6.667  11.547       (---------*--------)
 9     3  18.500   3.969                 (--------*---------)
10     3  17.500   3.500                (---------*--------)
                          ---------+---------+---------+---------+
                                   0        12        24        36

Pooled StDev = 9.160
```

Table 2.7b: *B. tinctoria* Analysis of Variance (average width versus treatment)

One-way ANOVA: avg wdth versus trt AUG-BT

```
Source  DF      SS    MS     F      P
trt      9   561.8  62.4  1.28  0.308
Error   20   977.0  48.9
Total   29  1538.9

S = 6.989   R-Sq = 36.51%   R-Sq(adj) = 7.94%


                            Individual 95% CIs For Mean Based on Pooled StDev
Level  N    Mean   StDev    -+---------+---------+---------+--------
 1     3  12.167   7.112                     (---------*----------)
 2     3   4.167   7.217            (---------*----------)
 3     3   0.000   0.000     (----------*----------)
 4     3   7.333  12.702                (---------*----------)
 5     3   3.667   6.351          (----------*---------)
 6     3   9.583   1.010                  (----------*----------)
 7     3  10.333   9.005                   (----------*---------)
 8     3   2.500   4.330         (---------*----------)
 9     3  12.583   8.413                     (----------*---------)
10     3  12.000   3.544                    (----------*----------)
                            -+---------+---------+---------+--------
                          -8.0       0.0       8.0      16.0

Pooled StDev = 6.989
```

Eupatorium coelestinum showed an increase in average height and average width in all soil treatments and from month to month with the most significant increases between August and September (Figure 2.15).

The ANOVA calculated for the August measurements of *E. coelestinum* showed no statistical difference in average height or average width as a result of the various soil treatments (Tables 2.8a and 2.8b).

Twenty-seven out of the thirty soil treatment plots showed *E. coelestinum* flowering or budding by October with only the 10% sand, 10% sand+Hydrogel, and the 10% sand+compost having *E. coelestinum* without flowers or buds. Overall *E. coelestinum* did very well throughout all soil treatments.

Table 2.8a: *E. coelestinum* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-EC

```
Source  DF     SS    MS     F      P
trt      9  152.3  16.9  0.57  0.809
Error   20  598.0  29.9
Total   29  750.3

S = 5.468   R-Sq = 20.30%   R-Sq(adj) = 0.00%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean  StDev  ---------+---------+---------+---------+
 1     3  19.000  4.000            (----------*----------)
 2     3  20.833  3.175               (----------*----------)
 3     3  16.167  2.754       (----------*----------)
 4     3  13.333  4.726  (----------*----------)
 5     3  13.833  4.072   (----------*----------)
 6     3  16.000  5.074       (----------*----------)
 7     3  14.833  6.825     (----------*----------)
 8     3  18.000  7.000          (----------*----------)
 9     3  15.000  9.539     (----------*----------)
10     3  15.167  3.753     (----------*----------)
                         ---------+---------+---------+---------+
                              12.0      18.0      24.0      30.0

Pooled StDev = 5.468
```

Table 2.8b: *E. coelestinum* Analysis of Variance (average width versus treatment)

One-way ANOVA: avg wdth versus trt AUG-EC

```
Source  DF     SS    MS     F      P
trt      9  170.4  18.9  1.59  0.187
Error   20  238.7  11.9
Total   29  409.1

S = 3.455   R-Sq = 41.64%   R-Sq(adj) = 15.38%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean  StDev  ---+---------+---------+---------+------
 1     3  15.833  1.041        (--------*-------)
 2     3  21.000  1.000                   (-------*-------)
 3     3  16.167  3.512         (-------*--------)
 4     3  14.000  3.041     (-------*-------)
 5     3  13.500  1.323    (-------*-------)
 6     3  14.250  3.072     (--------*-------)
 7     3  12.583  4.216  (-------*-------)
 8     3  14.417  2.673      (-------*-------)
 9     3  12.750  6.805  (--------*-------)
10     3  12.917  3.643   (-------*-------)
                         ---+---------+---------+---------+------
                         10.0      15.0      20.0      25.0

Pooled StDev = 3.455
```

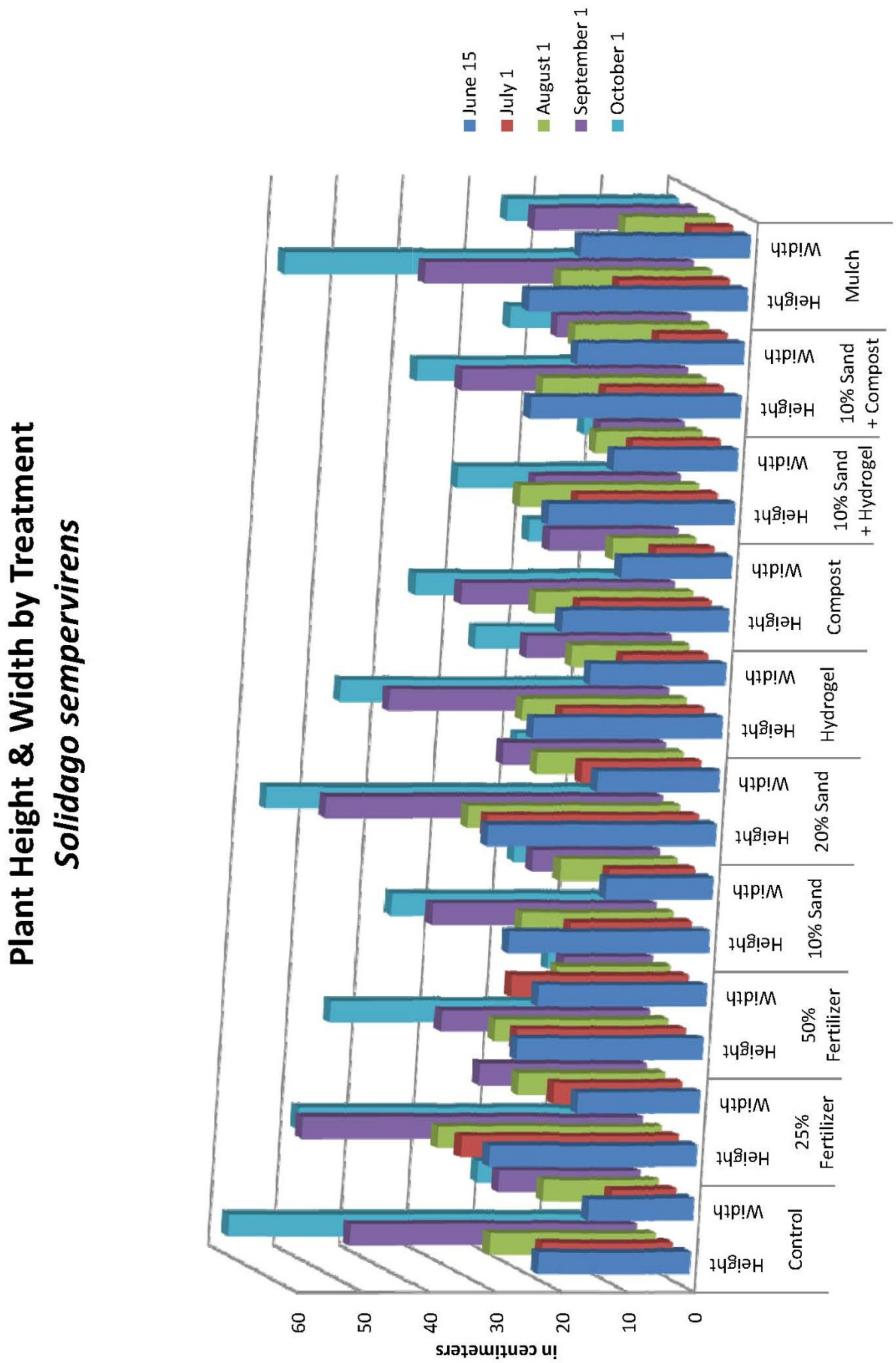

Figure 2.13: Raw Data of *S. sempervirens* Plant Height and Width by Treatment

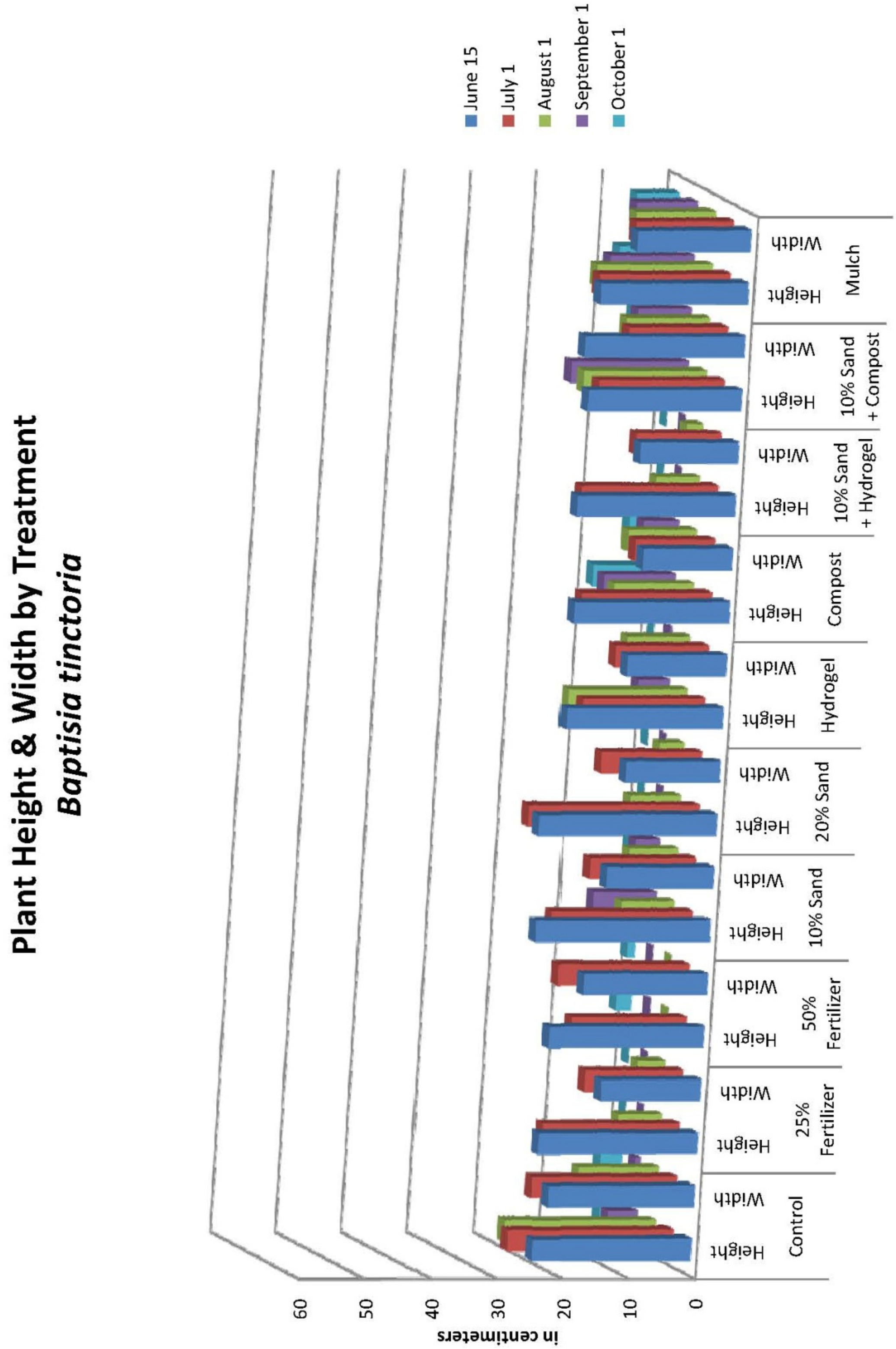

Figure 2.14: Raw Data of *B. tinctoria* Plant Height and Width by Treatment

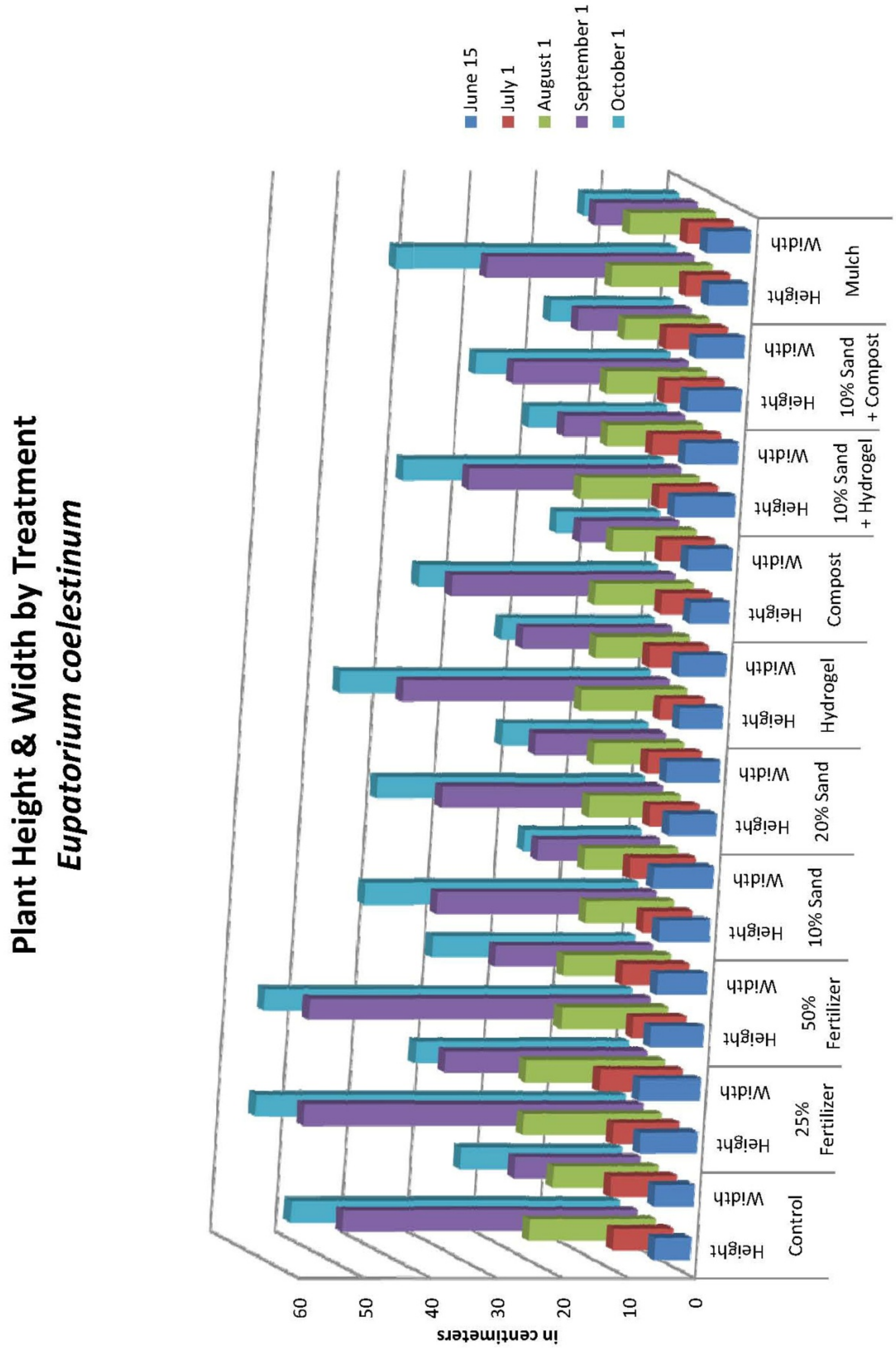

Figure 2.15: Raw Data of *E. coelestinum* Plant Height and Width by Treatment

<u>Annuals</u>

Chamaecrista fasciculate showed a great increase in growth between July and August in all soil treatments with continued increased between August and September in the 25% fertilizer, compost, 10% sand+Hydrogel, 10% sand+compost, and mulch soil treatments (Figure 2.16).

The ANOVA calculated for the August measurements of *C. fasciculate* showed no statistical difference in average height as a result of the various soil treatments (average width was not measured since *C. fasciculate* was planted from seed and spread over a specific area) (Table 2.9).

Table 2.9: *C. fasciculate* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-CF

```
Source  DF     SS    MS     F      P
trt      9  247.3  27.5  1.03  0.452
Error   20  534.5  26.7
Total   29  781.8

S = 5.170   R-Sq = 31.63%   R-Sq(adj) = 0.87%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean  StDev  ------+---------+---------+---------+---
 1     3  30.500  2.784                 (----------*---------)
 2     3  28.333  3.215              (---------*----------)
 3     3  23.667  9.504      (---------*----------)
 4     3  20.667  2.082  (---------*----------)
 5     3  25.000  6.245        (----------*---------)
 6     3  29.833  4.481                (----------*---------)
 7     3  28.333  4.752              (---------*----------)
 8     3  28.500  7.566              (----------*---------)
 9     3  25.667  2.517         (----------*---------)
10     3  26.500  3.041           (---------*----------)
                             ------+---------+---------+---------+---
                                18.0      24.0      30.0      36.0

Pooled StDev = 5.170
```

Seventeen out of the thirty soil treatment plots showed *C. fasciculate* flowering or with pods by October with at least one flowering or budding in all soil treatment types. *C. fasciculate* was successful in this study.

Lolium multiflorum showed no substantial growth and seemed to fluctuate in average height between months, leaving no evidence of survival come September. However, October measurements showed that *L. multiflorum* began to grow again in the 10% sand, 20% sand, Hydrogel, 10% sand+compost treatments and the control plot. Observations in January showed these persisting (Figure 2.17).

The ANOVA calculated for the August measurements of Lm showed no statistical difference in average height or average width as a result of the various soil treatments (average width was not measured since *L. multiflorum* was planted from seed and spread over a specific area) (Table 2.10).

Lolium multiflorum was not successful in this study.

Table 2.10: *L. multiflorum* Analysis of Variance (height versus treatment)

One-way ANOVA: ht versus trt AUG-LM

```
Source  DF     SS    MS     F      P
trt      9  263.0  29.2  1.36  0.270
Error   20  430.0  21.5
Total   29  693.0

S = 4.637   R-Sq = 37.95%   R-Sq(adj) = 10.02%


                         Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean  StDev  ---------+---------+---------+---------+
 1     3  10.333  1.155                   (--------*---------)
 2     3   6.333  5.686            (---------*--------)
 3     3   4.000  6.928        (---------*--------)
 4     3   0.000  0.000  (--------*--------)
 5     3   3.333  5.774       (---------*--------)
 6     3   6.667  5.859             (--------*--------)
 7     3   5.667  4.933           (--------*---------)
 8     3   0.000  0.000  (--------*--------)
 9     3   4.333  3.786         (--------*---------)
10     3   3.000  5.196       (--------*--------)
                         ---------+---------+---------+---------+
                               0.0       6.0      12.0      18.0

Pooled StDev = 4.637
```

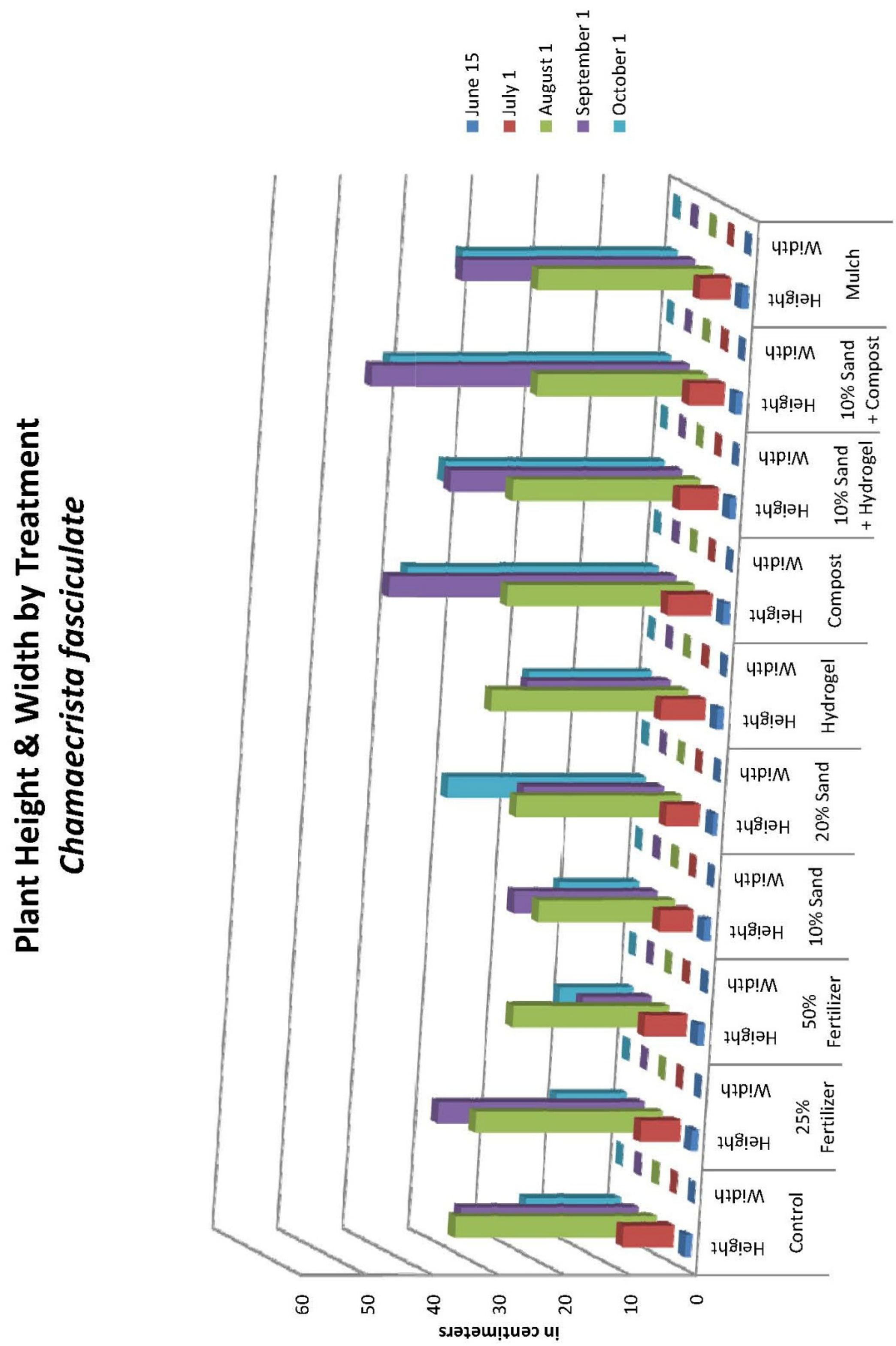

Figure 2.16: Raw Data *C. fasciculate* Plant Height and Width by Treatment

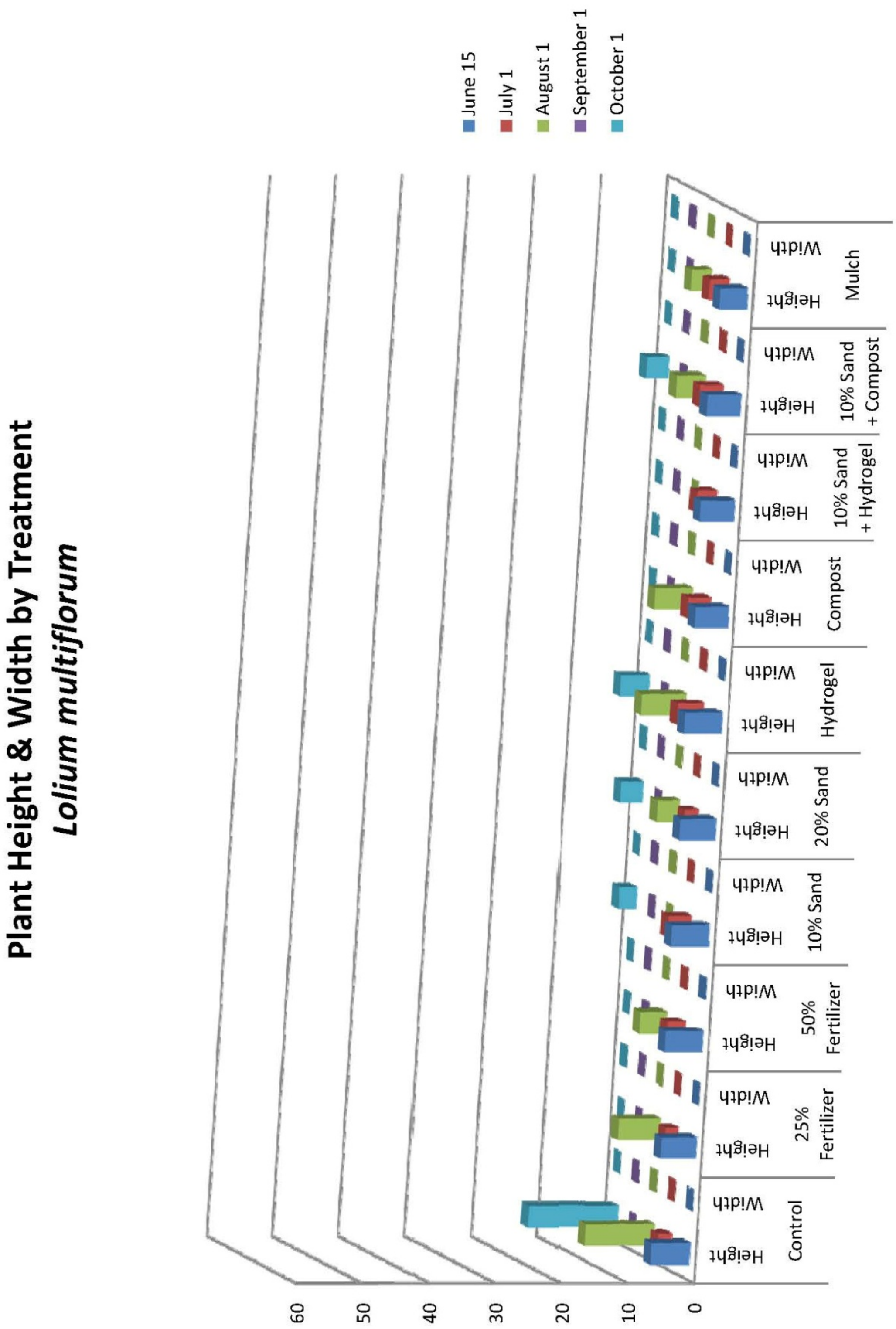

Figure 2.17: Raw Data of *L. multiflorum* Plant Height and Width by Treatment

Vegetation Loss

As with any plant experiment one must accept the fact that there may be some die-back, leaf loss, or death. Since this experiment ran for only one growing season with the plants installed in mid-June, the long term survival cannot be determined.

Figure 2.18 shows loss in size by month for each species regardless of treatment. This includes plants that lost their leaves, were snapped by possible herbivory, or were unable to locate due to the abundance of colonizing species. We can see from the chart that the *Lolium multiflorum* and *Baptisia tinctoria* showed the most loss through time. One possibility for this is *L. multiflorum* and *B. tinctoria* were seeds at the time of installation and they appeared to be quickly shaded out by the colonizing species.

If this experiment continued through the next growing season the chart may show less loss since many of the plants observed as having vegetation loss are possibly still alive and would leaf out next spring.

Timing and plant size at installation can be contributing factors to survival. For example, *L. multiflorum* would have benefited greatly if it were planted in the fall. This way it would have a chance to establish while other plants are dying off or becoming dormant. Also, it is possible that it would have a better chance of survival if a larger patch was planted. This experiment allowed for only a small space (about 15-20 cm in diameter) for the rye to be planted, giving nearby taller colonizing plants an opportunity to outcompete the grass. If the rye was spread over a larger area it is more likely that the interior of that space would have had more successful results.

The installation size and rate of growth of plants such as the *Baptisia tinctoria* and *Prunus maritima* possibly made it difficult for them to maintain access to sunlight. These plants were installed at 20 cm in height and were quickly outgrown by neighboring colonizing species. Planting species at a larger size may maintain their access to sunlight and help compete with other species.

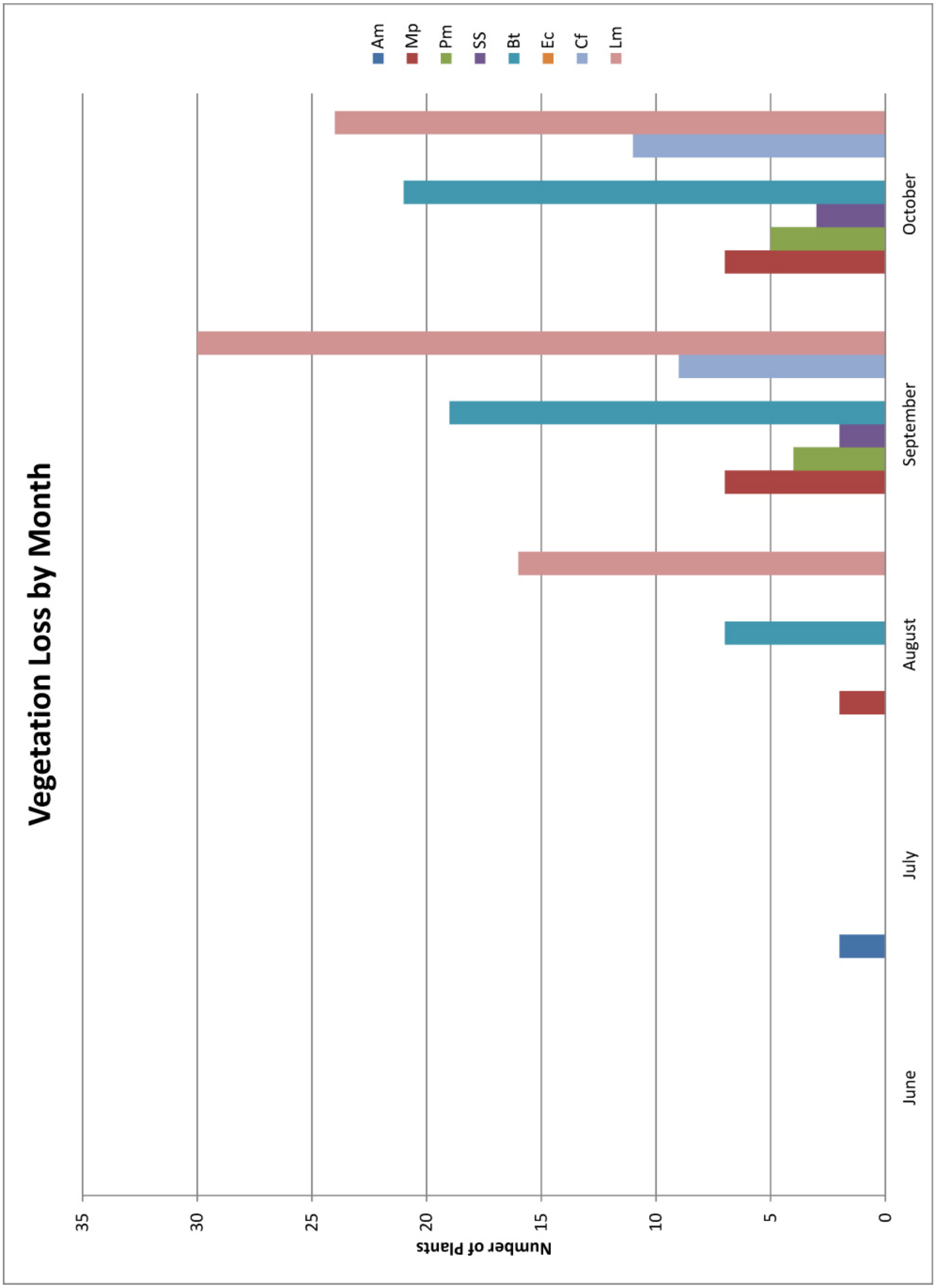

Figure 2.18: Vegetation Loss by Month

Discussion

This experiment was proposed to aid in the selection of plant material and in the design of a soil specification. However, the result of this experiment has shown that there was no statistically significant difference between soil treatments with respect to growth rate. While some treatments, such as mulch, appear to have shown greater plant growth, but show no statistically significant differences. Similarly, treatments that may have been thought to be more successful, such as compost, were not. There may be a few reasons for this. First, the compost used was not tested for quality and may have not been allowed to reach its full potential through the composting process. Second, since the plants were installed at a later date than preferred, watering frequency may have been overcompensated, essentially masking differences between treatments that might have shown up with more drought stress.

In the process of observing the plant growth and survival in these plots additional questions have come to light. What growth and survival rates of the shrubs and perennials show in the second growing season? Would any of the plants that seemed to have died in the first year have enough root growth to come back next year? How different would the results have been if the plants were installed one month earlier? Two months earlier? Or watered less? Some of these questions would be able to be answered next year, but not in the timeframe of this thesis.

Even though the results from this experiment seem to be negative (for the most part there was no statistically significant difference between soil treatments and plant growth), there is a value to them. The results tell us that no soil treatment is necessary to increase plant survival or growth in this case. This would save money on the project and also decrease the chance of applying excessive chemicals into the soil. The recommendation I would make, not based off of the experiment results, is to add sand to the fill material. In trying to prepare the plots, the fill material became impenetrable with a shovel and a power tiller needed to be used. The sand would be added for the sole purpose of making the soil more friable.

Chapter 3

Design and Evaluation

This chapter of the thesis will focus on the design of the approximately 251-acre interior section of Liberty State Park and how it fits into *The Sustainable Sites Initiative – Guidelines and Performance Benchmarks 2009 (the Guidelines).* Generally speaking, the guidelines identify "the specific and measurable criteria for site sustainability" (The Sustainable Sites Initiative 2009) (Table 3.1).

Guiding Principles of a Sustainable Site

Do no harm
Make no changes to the site that will degrade the surrounding environment. Promote projects on sites where previous disturbance or development presents an opportunity to regenerate ecosystem services through sustainable design.

Precautionary principle
Be cautious in making decisions that could create risk to human and environmental health. Some actions can cause irreversible damage. Examine a full range of alternatives—including no action—and be open to contributions from all affected parties.

Design with nature and culture
Create and implement designs that are responsive to economic, environmental, and cultural conditions with respect to the local, regional, and global context.

Use a decision-making hierarchy of preservation, conservation, and regeneration
Maximize and mimic the benefits of ecosystem services by preserving existing environmental features, conserving resources in a sustainable manner, and regenerating lost or damaged ecosystem services.

Provide regenerative systems as intergenerational equity
Provide future generations with a sustainable environment supported by regenerative systems and endowed with regenerative resources.

Support a living process
Continuously re-evaluate assumptions and values and adapt to demographic and environmental change.

Use a systems thinking approach
Understand and value the relationships in an ecosystem and use an approach that reflects and sustains ecosystem services; re-establish the integral and essential relationship between natural processes and human activity.

Use a collaborative and ethical approach
Encourage direct and open communication among colleagues, clients, manufacturers, and users to link long-term sustainability with ethical responsibility.

Maintain integrity in leadership and research
Implement transparent and participatory leadership, develop research with technical rigor, and communicate new findings in a clear, consistent, and timely manner.

Foster environmental stewardship
In all aspects of land development and management, foster an ethic of environmental stewardship—an understanding that responsible management of healthy ecosystems improves the quality of life for present and future generations.

Table 3.1: Guiding Principles of The Sustainable Sites Initiative

Since a Master Plan has been prepared for the site by Wallace, Roberts and Todd and the Army Corps of Engineers which includes an extensive stormwater management plan and a basic trail layout, I will score this as one section applying all relevant credits from the Guidelines for an overall site design.

Three nodes have been designed along a ¾ mile long trail which will be scored for each of the remaining guideline credits. Each node's score will then be separately added to the score of the master plan to obtain a total of three scores, one for each design. Finally, the scores will be compared to the 2009 Rating System for comparison to determine how 'sustainable' the designs are.

It should be noted that all the designs, the master plan and all three nodes, were prepared before a working knowledge of the Guidelines was established. In particular, the nodes were designed using ecological design principles before studying the Guidelines to ensure that features were not added to the designs just to accumulate points.

The Master Plan

<u>Site Selection</u>

The first section of the *Sustainable Site Initiative's Guidelines and Benchmarks* deals with site selection and has four prerequisites required for any site to be considered sustainable. These include limiting the development of soils designated as prime farmland, unique farmland, and farmland of statewide importance. It also requires protecting floodplain functions, preserving wetlands and preserving threatened or endangered species and their habitats.

The soils at Liberty State Park were brought in as fill, mainly from construction projects in lower Manhattan for the development of the Central Railroad of New Jersey (CRRNJ) rail yard. As a result, they have not been designated by the Natural Resources Conservation Service as prime farmland, unique farmland, or farmland of statewide importance, fulfilling the prerequisite 1.1 of the *Site Selection* section.

The site does however lie within the 100-year floodplain and certain measures must be taken to fulfill the requirements of prerequisite 1.2. Specifically development in brownfields within the 100-year floodplain must ensure that there is not an increase in flood elevations and must maintain or increase existing floodplain storage. Also vegetation and soil protection zones must be established to minimize the impacts to the site from construction equipment and processes. The design of the master plan addresses these requirements by implementing stormwater management techniques that will increase storage on site. This includes the construction of a biofiltration basin, freshwater wetlands and a saltwater marsh that will receive overflow from the Upper Hudson Bay.

In addition, there will only be one entrance where construction vehicles can access the site. This construction access point is proposed at the current entry gate and along current asphalt drives. Protection fences have been included in the master plan to ensure the protection of the nearby vegetation and soil.

Prerequisite 1.3 is fulfilled by the master plan such that all existing wetlands will be preserved at their current state. This is accomplished by locating trails along existing asphalt drives near the wetland areas or providing low impact boardwalk structures in sensitive areas. These areas will also be protected during construction with fencing or another physical barrier.

Prerequisite 1.4 deals with the perseveration of threatened or endangered species and their habitats. Threatened or endangered species have been found at this site and through careful site analysis their habitats will be preserved (US Army Corps of Engineers - New York District 2005)

Credits for the Site Selection section can be obtained by selecting brownfields or greyfields for redevelopment, selecting sites with existing communities, or selecting sites the encourage non-motorized transportation and use of public transit.

The site of this project, as mentioned earlier, is a brownfield and would collect 10 points for being such according to Credit 1.5. It is an abandoned industrial site of a former rail yard and contains contaminated soils. Measures will be taken as to restrict access to sites or soils with high levels of contamination.

The project would also qualify as a site within existing communities since it is on an infill site, according to Credit 1.6, where an infill site is one that must have 75% of its perimeter bordering sites that consist of at least 75% previously developed land.

For Credit 1.7, the project would not qualify as a site that encourages non-motorized transportation and use of public transit since the site is not within walking distance in or located near transit service. So no credit will be given for this.

Pre-Design Assessment and Planning

The pre-design focus will be on hydrology, soils and vegetation since the other categories of buildings; materials and human use are non-existent or have been restricted for the past forty years.

The hydrology of the site is quite varied. The removal of the rails, railroad ties and other associated features of a rail yard have left a multitude of undulations in topography and microtopography (Figures 3.1 and 3.2). The topographic map shows great variation in elevation, but only ranging between 5 and 12 feet above sea level, with an overall average between 6 and 9 feet. This varying topography has created many depressions that collect water and may hold it for extended periods of time (Figure 3.3).


Figure 3.1 (Left) and Figure 3.2 (Right): Two views showing the variation in topography throughout the site.

The majority of the topography is lower than its surrounding areas so the overland flow of water stays on site and either infiltrates into the soil or is collected in the existing wetlands. The existing wetlands are protected in the master plan and some will be rehabilitated in conjunction with the trail system design.

The soils are a gravely sand mix containing high levels of metal contamination. The amount and types of metal varies throughout the site and will be restricted to access by the public. The concentration of soil metal generally exceeds both residential and ecological standards for New Jersey (F. Gallagher, The Role of Soil Metal Contamination in the Vegetative Assemblage Development of an Urban Brownfield 2008). They have been classified by the New Jersey Department of Environmental Protection as 'historic fill' and have access and use limitations. The soils are a byproduct of local development in the late 1800s and were used to fill the marsh and part of the bay that were the original forms of the site. The industrial uses of the rail yard in the early 1900s lead to the eventual contamination of the soil which remains to this day. These soils will not be remediated as part of the master plan, but will be left to continue to successfully support the vegetation that has established and thrived since that time. This decision allows for the dense and functioning vegetation that has become established over the last 40+ years to maintain.

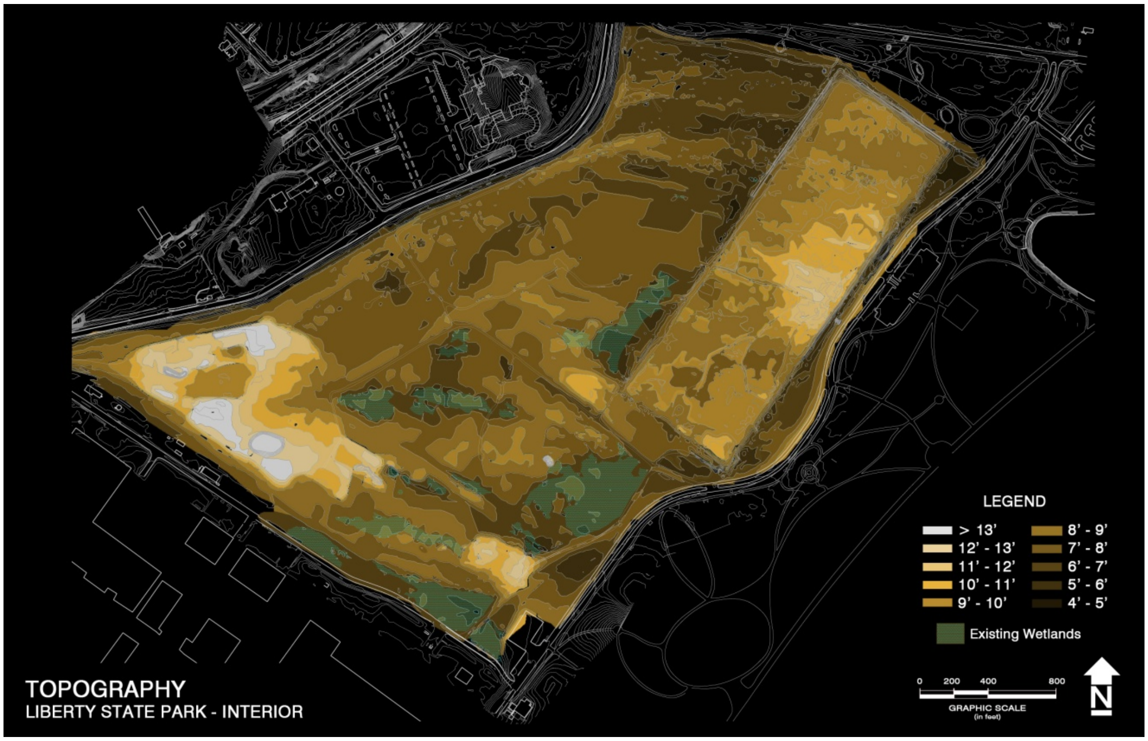

Figure 3.3: Topographic Study and location of Existing Wetlands of Project Site

The vegetation of the site will be preserved throughout site except where the basins and marshes will be constructed. Efforts have been made in the master plan to locate trails to preserve existing vegetation and to provide the user with an experience through varying vegetation heights and plant communities (Figure 3.4). The plan also proposes species native to the ecoregion to complement the existing vegetation and increase the plant biomass on the site.

Figure 3.4: Vegetation Map showing varying heights in vegetative communities.

Site Design - Water

Since most of the site will remain undisturbed by the nature of the design most of the hydrologic conditions will remain as they were. The master plan includes the construction of a bioretention basin along with a constructed wetland that will be receiving stormwater from off-site locations and stored on-site, increasing the water storage capacity. Since the design allows for and increase water storage capacity of more than 60%, 10 points will be added.

Credit 3.6 has to do with protecting and enhancing on-site water resources and receiving water quality. Since the stormwater on site will not be collected and treated in the master plan, no points will be added for this section.

Human Health and Well-Being

The first section "Promote equitable site development" deals with providing opportunities for employment to local workers and low-income individuals, committing to a living wage requirement, or developing a community benefits agreement for the construction of the site. The park staff includes approximately 20 fulltime and 30 part-time positions. Over 80% of these positions are currently filled with individuals from the surrounding community (F. Gallagher, Administrator: Division of Parks and Forestry, NJ 2011). Three points will be given for this credit.

The next section "Promote equitable site use" recommends organizing meetings with local communities to obtain information on their desires for amenities such as events, performances and activities. The original master plan for Liberty State Park included construction of a golf course in the area now proposed for ecological conservation. It was the people of Jersey City who objected to the construction of the golf course. It was through the public planning process that the current plan was derived. The purpose of the plan was to provide the best use for the greatest number of people given the demographic profile of the surrounding community. Four points will be given for this section.

The next portion of the guidelines that applies to the overall master plan is Credit 6.4 in the *Human Health and Well-Being* section. The study site is currently closed off to the public due to its classification as a brownfield and its high levels of soil contamination. The proposed trail system will be such that access off trail will still be restricted, protecting the users while simultaneously preserving the rest of the 285 acres that was once a large part of the development and success of the community and beyond. The historic rail yard of The Central Rail Road of New Jersey once occupied this location and has been abandoned and left to the colonization by a variety of novel plant assemblages (Gallagher, et al. 2011). What is left is a culturally and ecologically significant site with a rich history. Four points will be added to the master plan total for this section.

Credit 6.6 of this section deals with providing opportunities for outdoor physical activities. One of the main goals of this project is to get people onto the trail system and learn about the ecology and history of the site. The trail system for this project is one of many proposed for the site. Just taking in to account the trail for this project, it meets the standard of supporting 30 minutes of walking or 20 minutes of jogging by exceeding the 0.25 miles of uninterrupted pathway. The “hydrologic trail”, as termed by the master plan, provides 0.75 miles of uninterrupted pathway since two of the three nodes designed are offset from the trail. This along with the requirements of safety and accessibility set forth for each node earns the master plan 5 points for Credit 6.6.

Construction

The sections of this topic that applies to the Master Plan are Prerequisite 7.1 and Credit 7.3, control and retain construction pollutants and restoring soils disturbed by previous development. The Master Plan includes a soil erosion and sediment control plan as part of its submittal which covers the prevention of soil loss and runoff and the protection of any vegetation during construction fulfilling prerequisite 7.1.

No points will be applied for Credit 7.3 since the Master Plan does not propose to restore the existing soils.

Points Scored – Master Plan

The total points accumulated for the master plan as a sustainable site are 68 out of a possible 101. Refer to Chart 3.1 for specific point distributions.

Master Plan Point Allotment

			Possible Points	Points Earned
1 **Site Selection**				
Prerequisite 1.1	Limit development of designated farmland soils			
Prerequisite 1.2	Protect floodplain functions			
Prerequisite 1.3	Preserve wetlands			
Prerequisite 1.4	Preserve threatened or endangered species and their habitats			
credit 1.5	Select brownfields or greyfields for redevelopment		5-10 pts	10
credit 1.6	Select sites within existing communities		6 pts	6
credit 1.7	Select sites that encourage non-motorized transportation and use of public transit		5 pts	5
		total	21	21
2 **Pre-Design Assessment and Planning**				
Prerequisite 2.1	Conduct a pre-design site assessment and explore opportunities for site sustainability			
Prerequisite 2.2	Use an integrated site development process			
Credit 2.3	Engage users and other stakeholders in site design		4 pts	4
			4	4
3 **Site Design - Water**				
Credit 3.3	Protect and restore riparian, wetland, and shoreline buffers		3-8 pts	0
Credit 3.4	Rehabilitate lost streams, wetlands, and shorelines		2-5 pts	0
Credit 3.5	Manage stormwater on site		5-10 pts	10
Credit 3.6	Protect and enhance on-site water resources and receiving water quality		3-9 pts	9
			32	19
4 **Site Design - Soil and Vegetation**				
Credit 4.10	Use vegetation to minimize building heating requirements		2-4 pts	0
Credit 4.11	Use vegetation to minimize building cooling requirements		2-5 pts	0
Credit 4.12	Reduce urban heat island effects		3-5 pts	0
Credit 4.13	Reduce the risk of catastrophic wildfire		3 pts	0
			17	
6 **Site Design - Human Health and Well Being**				
Credit 6.1	Promote equitable site development		1-3 pts	3
Credit 6.2	Promote equitable site use		1-4 pts	4
Credit 6.4	Protect and maintain unique cultural and historical places		2-4 pts	4
Credit 6.6	Provide opportunities for outdoor physical activity		4-5 pts	5
		total	16	16
7 **Construction**				
Prerequisite 7.1	Control and retain construction pollutants			
Credit 7.3	Restore soils disturbed by previous development		2-8 pts	8
Credit 7.6	Minimize generation of greenhouse gas emissions and exposure to localized air pollutants during construction	**total**	1-3 pts 11	0 8
		total for master plan	101	68

Table 3.2: Sustainable Sites Initiatives point distribution for the Master Plan design

The Hydrologic Trail

The proposed hydrologic trail begins near the Interpretive Center at the corner of Freedom Way and Thomas McGovern Drive. The area of the proposed trailhead is a small open field of turf grass that is surrounded by roadways, a two parking lots and the edge of the forest where the trail continues. This part of the forest is a mix of naturally established plant species and species planted in earlier construction and community projects consisting of a mix of *Pinus strobes, Acer rubrum, Betula populifolia, Populus deltoides* and *Populus tremuloides* amongst of other hardwoods and shrubs (Figures 3.5 and 3.6). The soils here are classified as loamy sand with high concentrations of iron and a very high level of organic matter for loamy sand according to the Rutgers Soil Testing Laboratory.

Figure 3.5 (Left) and Figure 3.6 (Right): Two views of forested areas along proposed trail location.

The trail continues through the forested area, with areas of open canopy and areas of densely populated cover, giving the walk a varied and interesting experience.

Continuing through the forest for about 1000 feet the canopy begins to open revealing views of downtown Manhattan and a large expanse of open meadow and wetland, a great contrast to the previous stretch of trail (Figures 3.7 and 3.8). The soils here are also classified as loamy sand with high concentrations of iron and a very high level of organic matter for loamy sand according to the Rutgers Soil Testing Laboratory.


Figure 3.7 (Left) and Figure 3.8 (Right): Two views of downtown Manhattan and open meadow along proposed trail location.

In another 300 feet or so the trail enters into an area with less canopy cover than previously encountered. This portion of the trail meanders through a section dominated by *Rhus typhina* which are only about 10-12 feet tall and situated close enough together that it made it difficult to pass through for at least 200 feet. The soils here are classified as a loam and sandy loam with high concentrations of iron and a very high level of organic matter for loam and sandy loam according to the Rutgers Soil Testing Laboratory.

 

Figures 3.9 (Left) and Figure 3.10 (Right): Two views of *Rhus* species along the proposed trail location.

After emerging from the stand of *Rhus* , forbs and grasses dominate the landscape. This expanse is not as vast as the previous meadow, however it is open enough that one is separated from the protection of the canopy (Figures 3.11 and 3.12). The soils here are classified as loamy sand with high concentrations of zinc, copper and magnesium and a very high level of organic matter for loamy sand according to the Rutgers Soil Testing Laboratory.

 

Figures 3.11 (Left) and Figure 3.12 (Right): Two views of smaller meadow along proposed trail location.

The trail now enters the last stretch of canopy cover, approaching the Liberty Science Center. This assemblage is dominated by *Betula populifolia, Populus deltoides* and *Populus tremuloides.* Species of *Quercus rubra* and *Ilex opaca* saplings were spotted during the site walk. The trail here would only pass through a hundred feet or so of canopy finally opening up to a small section at the end of the trail with an area of *Phragmites* occupying a swale the runs parallel to Phillip Street. This is where the trail would cross the road and end at the Liberty Science Center (Figures 3.13 and 3.14). The area under canopy have soils classified as loamy sand with high concentrations of zinc, copper and iron and very high organic matter for loamy sand. The area just past the canopy, closer to the road has soils classified as silt loam with high concentrations of zinc, copper and iron and very high organic matter for silt loam.

Figure 3.13 (Left) and Figure 3.14 (Right): Two views of forested area and end of the proposed trail location near the Liberty Science Center.

From this site analysis it is evident that this path location provides the user with a variety of views and changes in spatial dimensions allowing for engaging experiences and educational opportunities. The three nodes designed along this trail are discussed in the next section.

Node 1 – The Trailhead

The design of Node 1, the Trailhead (Figures 3.15 and 3.16), consists of inclined pathways which comply with the Americans with Disabilities Act (ADA) standards for handicap access (Department of Justice 1991). These pathways lead from the Nature Interpretive Center and the adjacent parking lot to an elevated gathering space with views of downtown Manhattan and the Statue of Liberty to the east. This shaded node will serve as a place for classes to organize themselves, for teachers or guides to inform the visitors about trail safety and the history of the site and to obtain wayfinding information about the trail system before heading off into the forest.

Node 1 will not only provide information about the trails and history of the site, but it will also demonstrate the process of capturing rainwater in a biofiltration swale to allow for infiltration back into the soil. This important stormwater management technique is a useful ecological design principle particularly in the urban environment to help filter the rainwater, recharge aquifers and prevent flooding.

The various aspects of the design will be evaluated in order and terms of the sections that apply as laid out in the Guidelines.

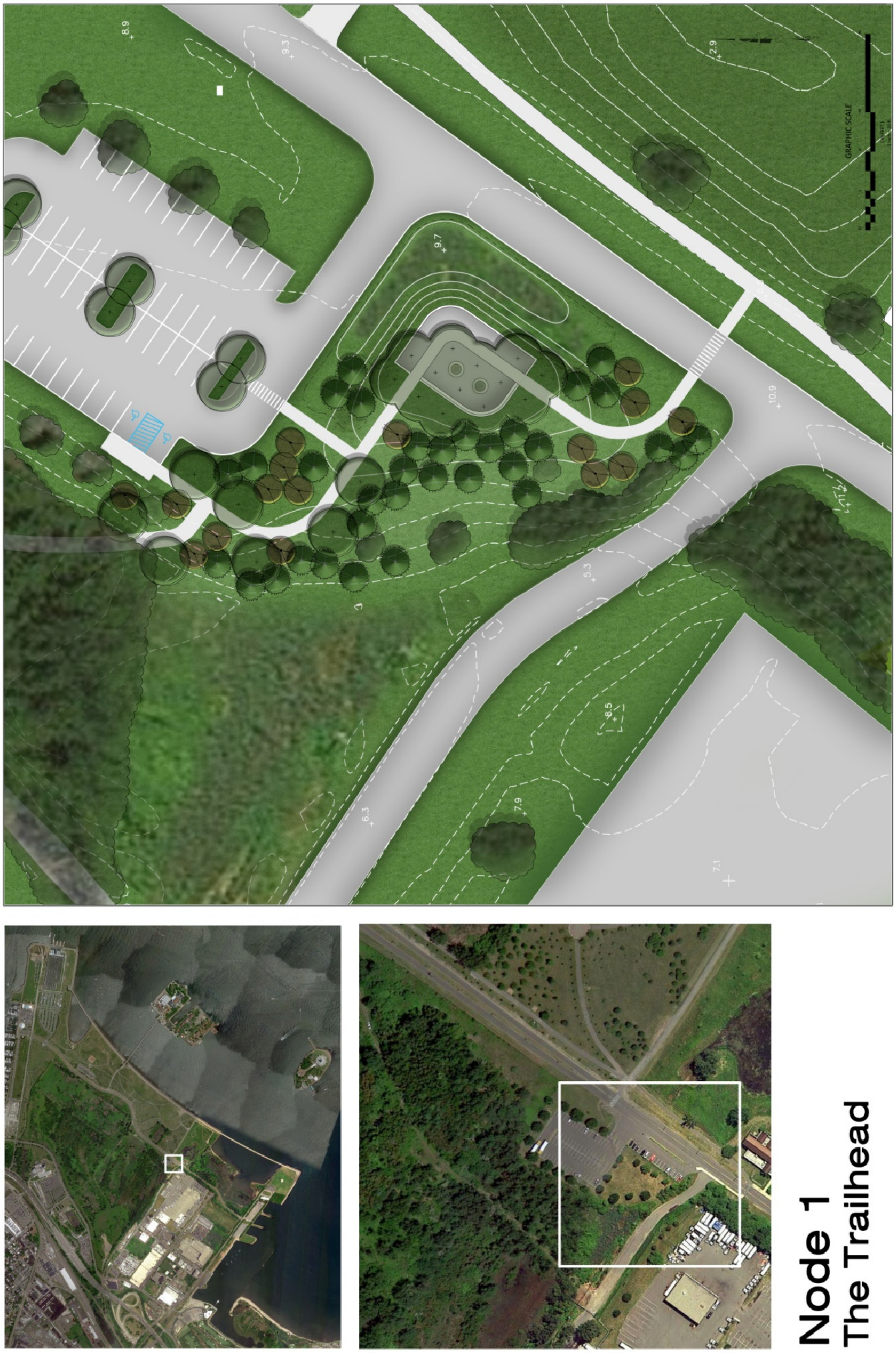

Figure 3.15: The Trailhead Site Plan, Node 1

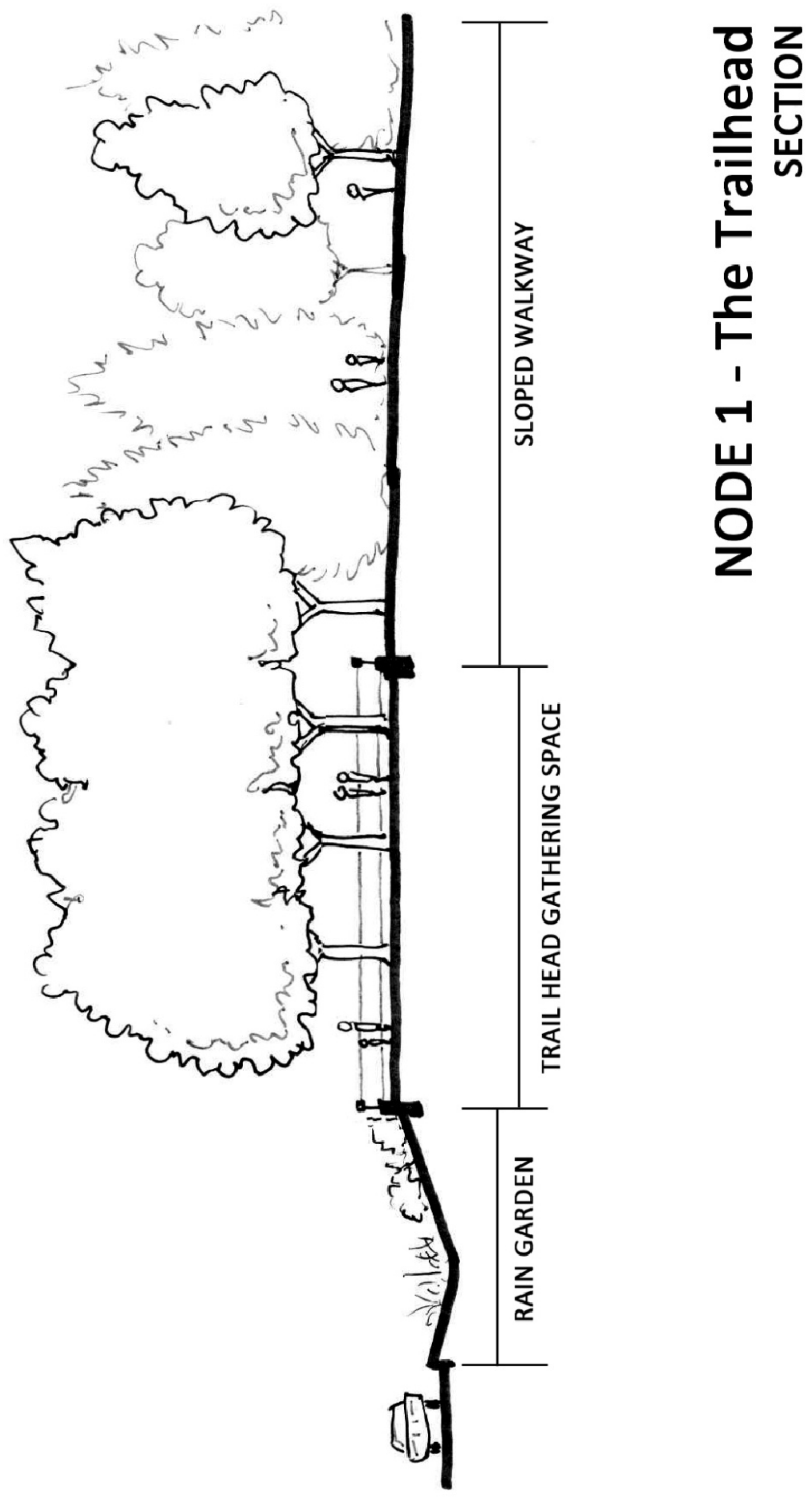

Figure 3.16: The Trailhead Section, Node 1. An elevation change of approximately five feet occurs from street level to the gathering space.

Site Design – Water

The prerequisite and first credit allocation for this section involves reducing potable water use for landscape irrigation after plant establishment by 50% or 75%. Since plants will be selected based on their water and soil requirements, manual watering frequency will diminish and finally cease once the plants are established.

However, potable water may be used during the establishment phase but must be removed or discontinued once established. Since potable water will be used for plant establishment instead of non-potable, this type of irrigation technique will earn the site 3 points instead of 5 points.

For Credit 3.7, a bioretention swale will follow the shape of the gathering space along the north and east sections of the site and collect runoff from the built structure as well some of the surrounding vegetated areas. Since this stormwater feature will not provide a primary contact recreation such as swimming, it will receive 2 points as opposed to 3 points.

Credit 3.8 suggests using non-potable water for any water features proposed for the site. No water features are proposed so no points will be given for maintaining them.

Site Design – Soil and Vegetation

Two of the three prerequisites for this section deal with invasive species control and use. There are no invasive species observed at Node #1 of the trail and the plant list does not include any known invasive species, fulfilling prerequisites 4.1 and 4.2.

A soil management plan will be provided for the site to complete prerequisite 4.3 of the guidelines. Vegetation and soil protection zones will be delineated and disturbed, restored and re-vegetated soils will be indicated in plan. Soil treatment specifications will be outlined to enhance the soil nutrient level of the fill material.

Soil disturbance will be minimized during construction by having all construction vehicles use the existing adjacent parking lot. This will ensure the no healthy soils will be disturbed and will add 6 points for the site.

The next six credit allocations for this site have to do with vegetation. There are no species of special status to preserve, but there are other plant species on site that will be preserved and biomass will be restored. The guidelines provide calculations using the site's existing biomass density index (BDI) and the site's planned BDI to determine a point value this section. Refer to Tables 3.3 through 3.5 for the calculations and results.

CALCULATIONS FOR EXISTING SITE BDI			
Land cover/vegetation type zone	Biomass density value* for this zone	Percent of total site area for this zone	Biomass density value x percent of total site area (column B x column C)
A	B	C	D
Trees with understory	6	6.8%	0.41
Trees without understory (less than 10 percent herbaceous/shrub cover)	4	5.7%	0.23
Shrubs	3	-	-
Desert plants	1.5	-	-
Annual plantings	1.5	-	-
Grasslands and turfgrass	2	57.3%	1.15
Wetlands**	6	-	-
Impervious cover or bare ground not shaded by vegetation or vegetated structures	0	30.2%	0.00
SUBTOTAL (sum of all rows)	n/a	100%	1.79
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			0.00
Existing Site BDI (sum of Subtotal and Additional Value)			1.79

* *The biomass density values in column B are based on a literature review of leaf area index for various vegetation types.*
** *This category includes wetlands with emergent vegetation and does not include open water.*

Table 3.3: Calculations for existing site BDI, Node 1

CALCULATIONS FOR PLANNED SITE BDI			
Land cover/vegetation type zone	**Biomass density value* for this zone**	**Percent of total site area for this zone**	**Biomass density value x percent of total site area (column B x column C)**
A	**B**	**C**	**D**
Trees with understory	6	12.0%	0.72
Trees without understory (less than 10 percent herbaceous/shrub cover)	4	35.5%	1.42
Shrubs	3	5.6%	0.17
Desert plants	1.5	-	-
Annual plantings	1.5	-	-
Grasslands and turfgrass	2	46.9%	0.94
Wetlands**	6	-	-
Impervious cover or bare ground not shaded by vegetation or vegetated structures	0	0.0%	0.00
SUBTOTAL (sum of all rows)	n/a	100%	3.25
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			0.00
Planned Site BDI (sum of Subtotal and Additional Value)			3.25

* The biomass density values in Column II are based on a literature review of leaf area index (LAI) for various vegetation types which included LAI for approximately 1,000 historical estimates of LAI summarized by biome/cover type in JMO Scurlock, GP Asner, and ST Gower, *Worldwide Historical Estimates of Leaf Area Index, 1932-2000* (Oak Ridge, TN: Oak Ridge National Laboratory, 2001).
** This category includes wetlands with emergent vegetation and does not include open water.

Table 3.4: Calculations for planned site BDI, Node 1.

Point value look-up table for sites in **Temperate Broadleaf and Mixed Forests biome.** Use this table to look up the applicable point value (no credit, 3 points, 5 points, or 8 points) for the difference between the Existing Site BDI and Planned Site BDI on your site.

Existing Site BDI	Planned Site BDI: 0–1	1–2	2–3	3–4	4–5	5 or above
0–1	No Credit	3 points	5 points	8 points	8 points	8 points
1–2	No Credit	No Credit	3 points	5 points	8 points	8 points
2–3	No Credit	No Credit	No Credit	3 points	5 points	8 points
3–4	No Credit	No Credit	No Credit	No Credit	3 points	8 points
4–5	No Credit	No Credit	No Credit	No Credit	No Credit	8 points
5 or above	No Credit	No Credit	No Credit	No Credit	No Credit	8 points

Table 3.5: Point value table and result for planned site BDI, Node 1.

The calculation for the Exiting Site BDI falls between 1 and 2 while the calculation for the Planned Site BDI falls between 3 and 4 resulting in the addition of 5 points according to Table 3.5.

The use of native plants is encouraged in the next section. Points are distributed in terms of percentage of areas at least 2000 sf. Percentage calculations are measured by surface areas of vegetated area, using estimated vegetated cover within 10 years of installation. For this node, 100% of the site vegetated area is composed of native plants, adding 4 points to the total. See Table 3.6 for a sample plant list.

Plant List for Node 1
Acer rubrum
Amelanchier lavis
Betula populifolia
Juniperus virginiana
Pinus strobus
Asclepias incarnate
Eupatorium coelestinum
Eupatorium maculatum
Lobelia cardinalis
Lobelia siphilitica
Solidago sempervirens

Table 3.6: Plant List, Node 1

Preserving and restoring plant communities native to the ecoregion are covered in the next two sections. Five points will be allotted for the preservation of over 75% of the total area of existing native plant communities on site. An extra point will be added if these plant communities connect to off-site natural area. This is the case for Node 1. *Juniperus virginiana* species along the southern edge of the site will be preserved and designated as a vegetation and soil protection zone which connects to an off-site natural area towards the interior section of the park.

Plant communities will also be restored within the site by incorporating species native to the ecoregion which in this case are the plant communities that have established themselves since the deconstruction of the rail yard. This will occur in at least 75% of the site vegetated area, earning 4 points for plant community restoration.

An additional point will be added for providing a habitat corridor that connects to the existing forested area for wildlife species of special concern within the region.

Site Design – Materials Selected

The prerequisite for the Materials Selected section of the guidelines requires that wood products used would be from non-threatened tree species. The guideline specifically states that no wood should be used that is listed on the Convention on International Trade in Endangered Species (CITES) threatened with extinction list or the International Union for Conservation of Nature (IUCN) Red List of Threatened Species.

Credits 5.3-5.5, 'Design for deconstruction and disassembly, Reuse salvaged materials and plants and the Use of recycle content materials' will not be met in the design of Node 1.

For this node, only the bench seats will be made of wood and will consist of a certified cedar wood. The guidelines recommend the use of recycled plastic or composite lumber instead of wood, however, the manufacturing of these products have their own environmental issues and may cause more damage in the long run as far as air and water pollution. In addition, composite wood lumber, since it is a mix of wood and plastic can make recycling challenging (Winandy, Stark and Clemons 2004). Since certified wood will be used for all wood material at this node Credit 5.6 allots 4 points for this.

The use of regional materials for plants, soils and construction to support local resources and reduce energy use from transportation is the topic of the next section.

Soils and aggregate are required to be extracted and manufactured within 50 miles of the site. Plants must be grown within 250 miles of the site, and all other materials must be within 500 miles of the site. Since all of these materials will be acquired within the acceptable range, Node 1 will receive 6 points for falling within the 90% and above range.

Credit 5.8, which provides points for the use of adhesives, paints, and coatings with reduced volatile organic compounds to lessen contributions to air pollution, will not be met with the design of Node 1.

Supporting sustainable practices in plant production from nurseries where the plant material would be purchases is the topic of Credit 5.9. The business where the plants for this node will be purchased from does not meet enough of the requirements of this section which include the use of sustainable soil amendments, reduce runoff from irrigation, reduce greenhouse gas emissions, reduce energy consumption, use integrated pest management techniques, reduce waste and recycle organic matter. No points will be added for this section.

No points will be added for Credit 5.10 for supporting sustainable practices in material manufacturing. The manufacturers would be required to have "increased energy efficiency, reduced resource consumption and waste, and minimize negative effects on human health and the environment. It may be possible to gain points for this area, however more research would need to be done verifying each manufactures practices.

Site Design – Human Health and Well-Being

Promoting sustainability awareness and education, Credit 6.3, is the topic of the next section that applies to node design. The maximum of 4 credits will be given since the design portion of this node encourages sustainable learning. This node will provide information on biofiltration and stormwater management.

Credits 6.5-6.8 (Credit 6.6 has been applied to the Master Plan) deal with providing accessibility, safety and wayfinding; providing views of vegetation and quiet outdoor spaces for mental restoration; and providing outdoor spaces for social integration. Node 1 addresses all of these concerns and will receive points for each.

All paths leading to and leaving Node 1 are ADA accessible and maintain a slope of less than 5% providing accessibility to the public. There are clearly defined spaces and access with high visibility and a variety of access points to ensure safety. Entrances and gateways are clear and the node acts as a landmark to provide wayfinding features. The node is a decision point that will provide users with maps and information regarding the trail system and ecology of the site. The node will earn 3 points for Credit 6.5 for providing optimum site accessibility, safety, and wayfinding.

Besides the views of downtown Manhattan and the Statue of Liberty, Node 1 will provide views of vegetation and other natural elements. Conifers and deciduous trees will line the southeast side of the node blocking unsightly views and noise from the neighboring industrial properties. In addition, the bioswale north and east of the node will be planted with herbaceous and woody species native to the region, some flowering at different times of the year. Shade will be provided by the shade trees proposed throughout the space amongst the seating. The paths leading to the node along with the shade trees within will provide the user with an aesthetic experience along with access to the vegetation. Four points will be added for Credit 6.7 for providing views of vegetation and quiet outdoor spaces for mental restoration.

Credit 6.8 includes the incorporation outdoor spaces for social interaction. Node 1 will receive 3 points for this credit since it provides a variety of seating with visual access to vegetation and enough space and seating for an outdoor classroom or community building activities. It also considers the microclimate by proposing a bosque of tightly spaced shade trees with seating underneath to provide refuse from the sun.

Light pollution is the topic of the last credit for human health and well-being. It suggests reducing light pollution from the site by meeting certain footcandle standards. Since this section of the park is open until 10pm everyday lighting will need to be provided at node 1. This will be in the form of low intensity lighting and will not infringe on any neighboring property or produce sky-glow. Two points will be added for Credit 6.9 for reducing light pollution.

Construction

The construction section of the guidelines that pertain to Node 1 include restoring soils, diverting construction and demolition materials from disposal, and reusing or recycling vegetation, rocks and soil generated during construction.

Restoring soils disturbed during construction, a prerequisite for this section, will be accomplished for this node by amending the fill material used to grade the elevation of the trail head and also in the formation of the bioswale for Node 1. Organic matter will be added so that the top 12 inches will contain at least 3% organic matter as required. Compaction will be avoided and infiltration rates will remain comparable to or improve previous soil conditions. Finally, soil biological functions and chemical characteristics will be restored by referencing the original soil sample test results performed in the experiment portion of this study, and applying the amendments to the fill material as necessary to reach the acceptable levels.

Since there are no existing structural materials to dispose of, no points will be allotted for Credit 7.4 which suggests recycling, reusing or salvaging 50 or 75% of structural materials and 95% of roads/infrastructure materials.

For Credit 7.5, vegetation, rocks and soil generated during construction of Node 1 will be reused or recycled and retained on site adding 5 points to the score. Existing trees that are proposed for removal will be chipped and used as mulch for planting beds or along future trails throughout the site. Soil and rock will most likely not be reused since the construction of Node 1 does not call for existing soil to be disturbed and no rocks currently exist on the site.

Operations and Maintenance

A plan for sustainable site maintenance is the first prerequisite for this section. A detailed maintenance plan and procedure is beyond the scope of this project, however the specific topics that apply will be covered here.

The maintenance plan is divided into twelve sections which include plant stewardship, invasive species management, organic materials management, soil stewardship, irrigation and water use, stormwater management features and BMPs, snow and ice, materials management, recyclable materials, landscape maintenance equipment, sensitive site features, and adaptive management.

Plant stewardship is meant to ensure that vegetation is maintained and healthy. This includes monitoring the plants for pests and diseases and having a list of acceptable replacement species available in case unhealthy or damaged plants need to be removed.

A list of invasive species identified in the area will also be available. Treatment procedures, monitoring and methods of disposal are key components to this section and will be established for each known invasive plant species on site.

The management or organic materials includes the composting of healthy plant material and the disposal of diseases or invasive species that should not be composted. There is currently a composting process implemented at the park and this project will be included as part of it.

The management plan will also outline proper soil stewardship. Testing soils before applying fertilizers or other amendments is required to prevent the overuse of treatments which has a negative effect on the environment overall. It also includes the observation of soil erosion areas and correcting problems if they exist.

Irrigation procedures will be laid out in detail. A watering schedule will be provided with potable water being used only until the plants are established. Once plants are established, manual watering will cease.

Maintenance for any stormwater management features will be outlined. In the case of Node 1, the bioswale will be checked and cleared of debris and will be mowed once a year in fall to prevent any large woody plants from establishing.

Snow and ice removal for this is not recommended since the paths are constructed of crushed stone and any machinery or shoveling would damage the surface. This is part of a trail system and access at all times is not necessary.

Procedures will be outlined for material maintenance and repair. In the case that a structure or any hardscape is damaged, instructions for their repair and/or replacement will be provided. Also, a list of replacement materials will be included in the management plan.

Recyclable material collections along with the maintenance of landscape equipment will be performed as currently done by park employees. These procedures will be evaluated on an annual basis as required by the guidelines.

Prerequisite 8.2 which requires the storage and collection of recyclables will be obtained at Node 1 by providing recycle bins to encourage the users to recycle.

Organic materials generated during site operations and maintenance will be composted and or recycled on site, adding 5 points for Credit 8.3. It should be noted that any species of plant collected in maintenance operations that are considered invasive will be separated and disposed of instead of being composted. Invasive species known throughout the site will be listed in the maintenance plan required in prerequisite 8.1.

Credits 8.4 and 8.5 deal with reducing energy consumption on site. Four points will be added by selecting energy-efficient LED outdoor lighting for Node 1. The lighting must achieve a 90% average annual energy reduction from the estimated baseline energy use for the product. The base line energy use is that of the lowest-cost comparable item.

No renewable source for electricity has been proposed for this site. Also, there is no plan to minimize exposure to environmental tobacco smoke or for the timing and use of power maintenance equipment as suggested for Credits 8.5, 8.6 and 8.7. So no points will be allotted for these credits.

Monitoring and Innovation

The process of monitoring is an important aspect of determining if a design is sustainable. This process requires qualified people to evaluate the performance of a site over time. A plan can be implemented to perform such tasks especially given the current relationship between Liberty State Park and universities within the state. Students can be assigned the task of monitoring known invasive plants on site (which is already done in other areas of the park), or confirming the reduction of potable water use for irrigation. They can monitor the restoration of plant communities or review the success of design elements such as site accessibility, view opportunities, and social interaction. Ten points will be added for the plan to implement these procedures.

Finally, Node 1 will receive 8 points for innovation in site design since it encourages sustainable practices and goes beyond the categories laid out in the guidelines by including a soil treatment and plant growth experiment to assist with the selection of soil amendments and plant species which increase plant survival and reduce the chance of excessive soil treatments.

Points Scored – Node 1

The total points accumulated for Node 1 as a sustainable site are 89 out of a possible 149. Refer to Table 3.15 for specific point distributions.

Node 2 – Succession and Space

The design of Node 2, Succession and Space (Figures 3.17 and 3.18), consists of three sub-nodes ranging in size from small to large that begins in an area closely surrounded by mature trees and gradually brings the visitor into a large space surrounded by small saplings. The intent of this design sequence is to give the user a varying sense space that is created by the construction of varying sized viewing platforms. The sense of space within these platforms is also dictated by the size and spacing of the surrounding plant material, from tightly forested to an open expanse of meadow. Through this sequence of spaces, the user also has an outstanding view of downtown Manhattan as one exits the urban forest. Since the trajectory of vegetation assemblages is unique for this site in comparison to the typical succession in the region,

Figure 3.17: Succession and Space Site Plan, Node 2.

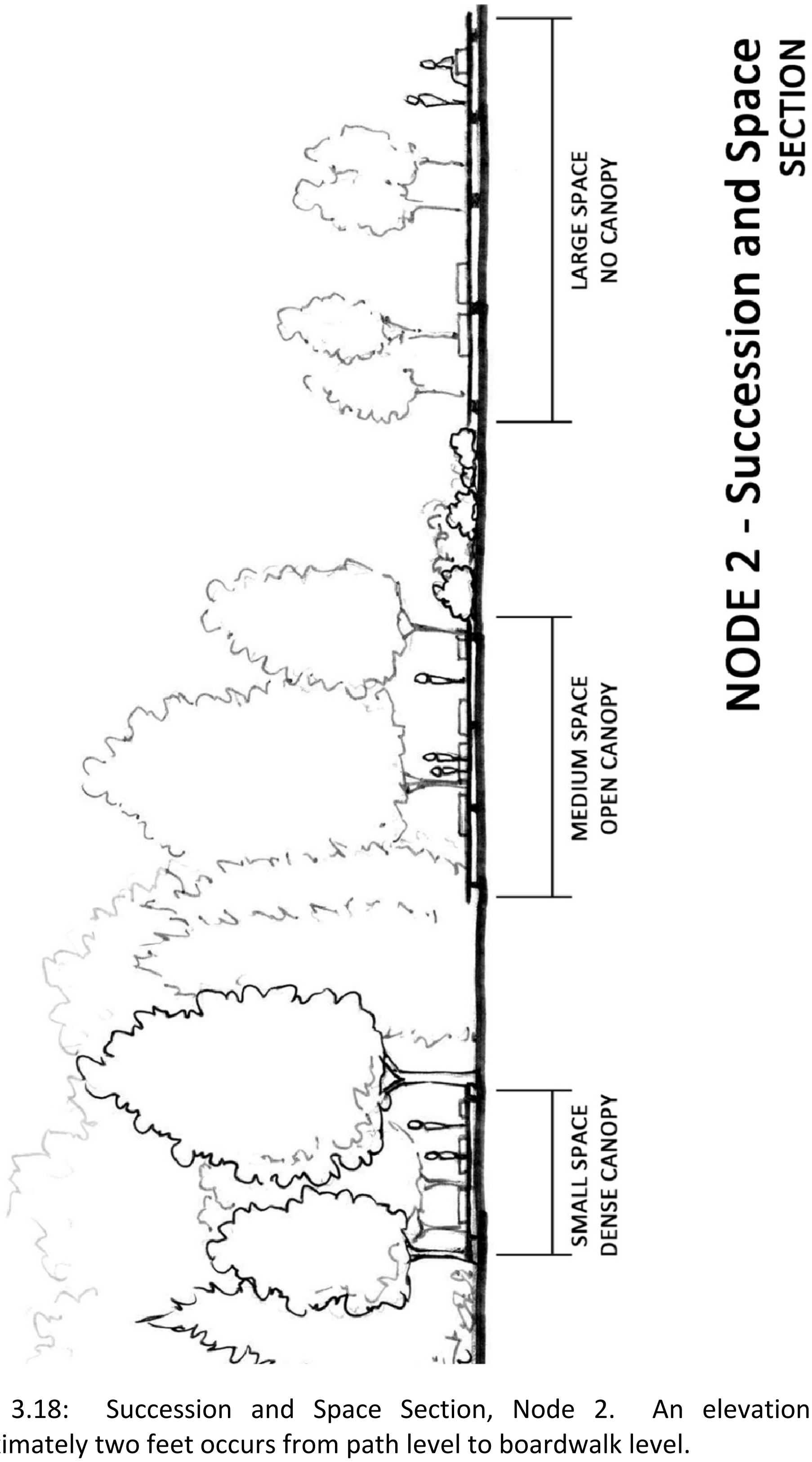

Figure 3.18: Succession and Space Section, Node 2. An elevation change of approximately two feet occurs from path level to boardwalk level.

information regarding the comparisons will be provided at each corresponding sub-node (or stage of succession) (Gallagher, et al. 2011).

The various aspects of the design will be evaluated in order and terms of the sections that apply as laid out in the Guidelines. Also, to avoid repetition, sections of the Guidelines that receive points for the same reasons as Node 1 will not be discussed here.

<u>Site Design - Water</u>

Credit 3.7 will not apply to the design of Node 2 since no physical stormwater feature is planned for this site. The node consists of an elevated walkway leading to three elevated sub-nodes. All stormwater will seep through the permeable surface of grated metal walkway and between the planks of wood decking and into the soil below, similar to the predevelopment condition. No points will be given for this credit.

<u>Site Design – Soil and Vegetation</u>

The biomass density index calculations will be figured for Node 2. As done earlier, the existing BDI and proposed BDI will be calculated according to the Guidelines and a value will be applied. The calculation for the Exiting Site BDI falls between 3 and 4 while the calculation for the Planned Site BDI falls between 4 and 5 resulting in the addition of 3 points according to Tables 3.7 through 3.9.

CALCULATIONS FOR EXISTING SITE BDI			
Land cover/vegetation type zone	**Biomass density value* for this zone**	**Percent of total site area for this zone**	**Biomass density value x percent of total site area (column B x column C)**
A	B	C	D
Trees with understory	6	26.7%	1.67
Trees without understory (less than 10 percent herbaceous/shrub cover)	4	-	-
Shrubs	3	10.0%	0.03
Desert plants	1.5	-	-
Annual plantings	1.5	-	-
Grasslands and turfgrass	2	46.5%	0.93
Wetlands**	6	10.0%	0.60
Impervious cover or bare ground not shaded by vegetation or vegetated structures	0	6.7%	0.00
SUBTOTAL (sum of all rows)	n/a	100%	3.23
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			0.00
Existing Site BDI (sum of Subtotal and Additional Value)			3.23

* *The biomass density values in column B are based on a literature review of leaf area index for various vegetation types.*
** *This category includes wetlands with emergent vegetation and does not include open water.*

Table 3.7: Calculations for existing site BDI, Node 2.

CALCULATIONS FOR PLANNED SITE BDI			
Land cover/vegetation type zone	**Biomass density value* for this zone**	**Percent of total site area for this zone**	**Biomass density value x percent of total site area (column B x column C)**
A	B	C	D
Trees with understory	6	35.8%	2.15
Trees without understory (less than 10 percent herbaceous/shrub cover)	4	5.0%	0.20
Shrubs	3	13.3%	0.40
Desert plants	1.5	-	-
Annual plantings	1.5	-	-
Grasslands and turfgrass	2	35.8%	0.72
Wetlands**	6	10.0%	0.60
Impervious cover or bare ground not shaded by vegetation or vegetated structures	0	0.0%	0.00
SUBTOTAL (sum of all rows)	n/a	100%	4.07
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			0.00
Planned Site BDI (sum of Subtotal and Additional Value)			4.07

* The biomass density values in Column II are based on a literature review of leaf area index (LAI) for various vegetation types which included LAI for approximately 1,000 historical estimates of LAI summarized by biome/cover type in JMO Scurlock, GP Asner, and ST Gower, *Worldwide Historical Estimates of Leaf Area Index, 1932-2000* (Oak Ridge, TN: Oak Ridge National Laboratory, 2001).

Table 3.8: Calculations for planned site BDI, Node 2.

Point value look-up table for sites in **Temperate Broadleaf and Mixed Forests biome.** Use this table to look up the applicable point value (no credit, 3 points, 5 points, or 8 points) for the difference between the Existing Site BDI and Planned Site BDI on your site.

Existing Site BDI	Planned Site BDI					
	0–1	1–2	2–3	3–4	4–5	5 or above
0–1	No Credit	3 points	5 points	8 points	8 points	8 points
1–2	No Credit	No Credit	3 points	5 points	8 points	8 points
2–3	No Credit	No Credit	No Credit	3 points	5 points	8 points
3–4	No Credit	No Credit	No Credit	No Credit	3 points	8 points
4–5	No Credit	No Credit	No Credit	No Credit	No Credit	8 points
5 or above	No Credit	No Credit	No Credit	No Credit	No Credit	8 points

Table 3.9: Point value table and result for planned site BDI, Node 2.

The use of native plants is encouraged in the next section. Points are distributed in terms of percentage of areas at least 2000sf. Percentage calculations are measured by surface areas of vegetated area, using estimated vegetated cover within 10 years of installation. For this node, 100% of the site vegetated area is composed of native plants, adding 4 points to the total. See Table 3.10 for a sample plant list.

Plant List for Node 2

Populus tremuloides
Betula populifolia
Juniperus virginiana
Aronia melanocarpa
Myrica pensylvanica
Vaccinium angustifolium
Viburnum dentatum

Table 3.10: Plant List, Node 2

Site Design – Human Health and Well-Being

Node 2 will get points for Credit 6.3 as Node 1 did, but for different reasons. While Node 1 promoted sustainable awareness and education by demonstrating biofiltration and stormwater management, Node 2 will demonstrates forest sustainability by displaying the process of succession with plants and signage. Four points will be given for this credit.

The views provided by Node 2 are of the forest interior and graduates to a view of downtown Manhattan and finally to an open meadow within the park. Shade is provided by the existing shade trees and quiet outdoor spaces are provided by the three sub-nodes. Four points will be added for Credit 6.7 for providing views of vegetation and quiet outdoor spaces for mental restoration.

Credit 6.9 suggests reducing light pollution by maintain certain footcandle standards. There is no lighting proposed for Node 2 since this section of the trail will be closed at dusk. Two points will be added for keeping the site below the recommended footcandle level.

Operations and Maintenance

Credit 8.4 gives up to 4 points for using energy efficient lighting and appliances for outdoor fixtures while Credit 8.5 gives up to 3 points for using renewable sources for electricity. Since there are no fixtures or electricity required for Node 2, 7 points will be added.

Points Scored – Node 2

The total points accumulated for Node 2 as a sustainable site are 85 out of a possible 149. Refer to Table 3.15 for specific point distributions.

Node 3 – The Crossroads

The design of Node 3, the Crossroads (Figures 3.19 and 3.20), consists of a large circular space that is at the convergence of three trails. Future phases will include a 'wetland trail' and a 'rail trail' that will meet here with the 'hydrologic trail'. Besides being a place of convergence for these trails, this node will also have views and information regarding the constructed wetlands proposed for the area. Also included at this node are areas for plant experimentation. A biofiltration basin will be constructed for the study of the success of various plant species used in rain gardens or to study plants that may help in the collection of particulate matter from stormwater runoff. An elevated landform will also be constructed to compare the effects of the typically hot and dry southern aspect versus more shaded and moist northern aspects on native plant species. Lastly, a area will be dedicated to conventional rectilinear experimentation plots to continue the research being conducted on site.

The various aspects of the design will be evaluated in order and terms of the sections that apply as laid out in the Guidelines. Also, to avoid repetition, sections of the Guidelines that receive points for the same reasons as Node 1 will not be discussed here.

Site Design - Water

Stormwater for Node 3 will be collected in the center of the node in a small rain garden. Since the node's surface will be of permeable crushed stone water will infiltrate

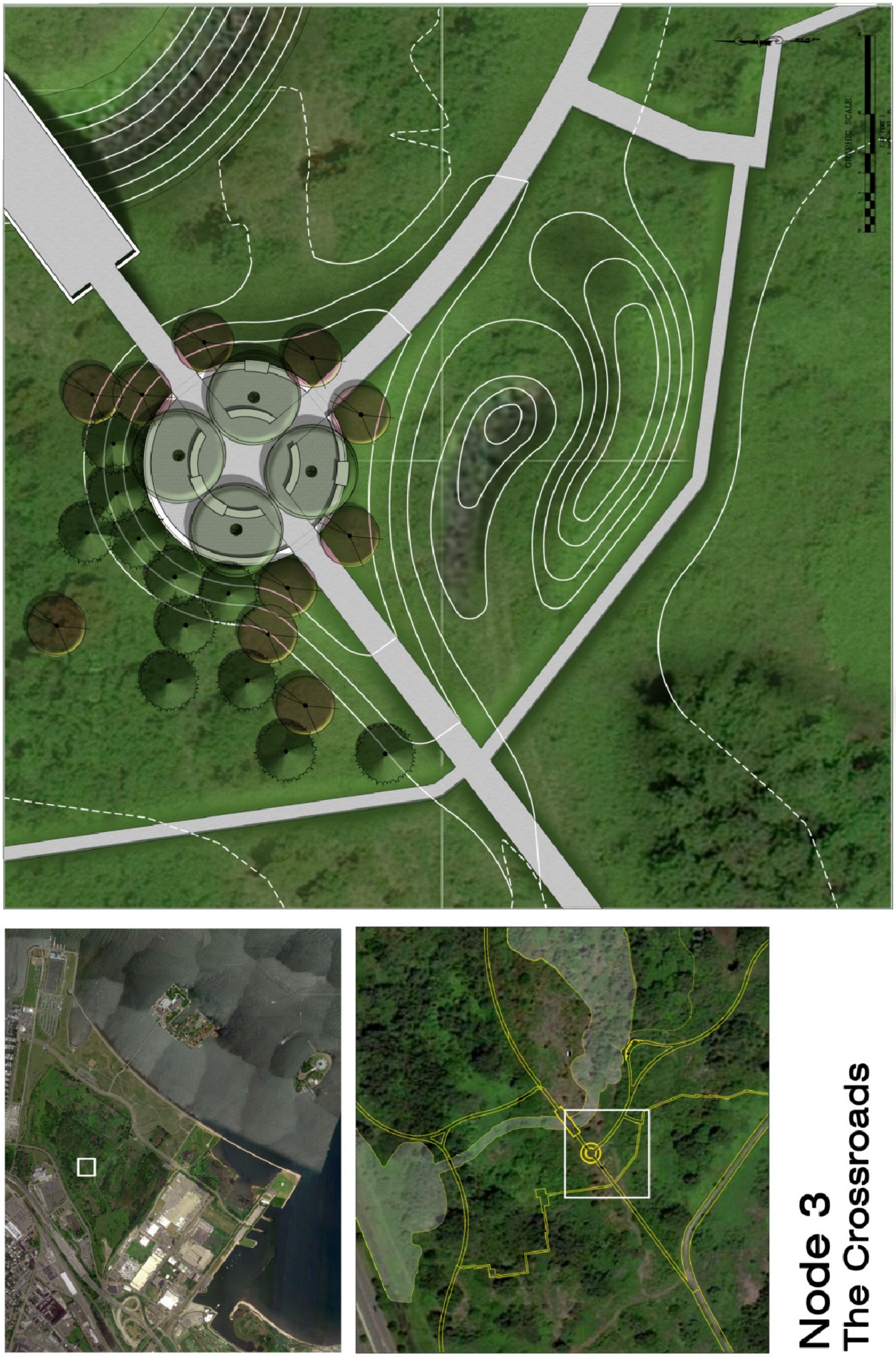

Figure 3.19: The Crossroads Site Plan, Node 3

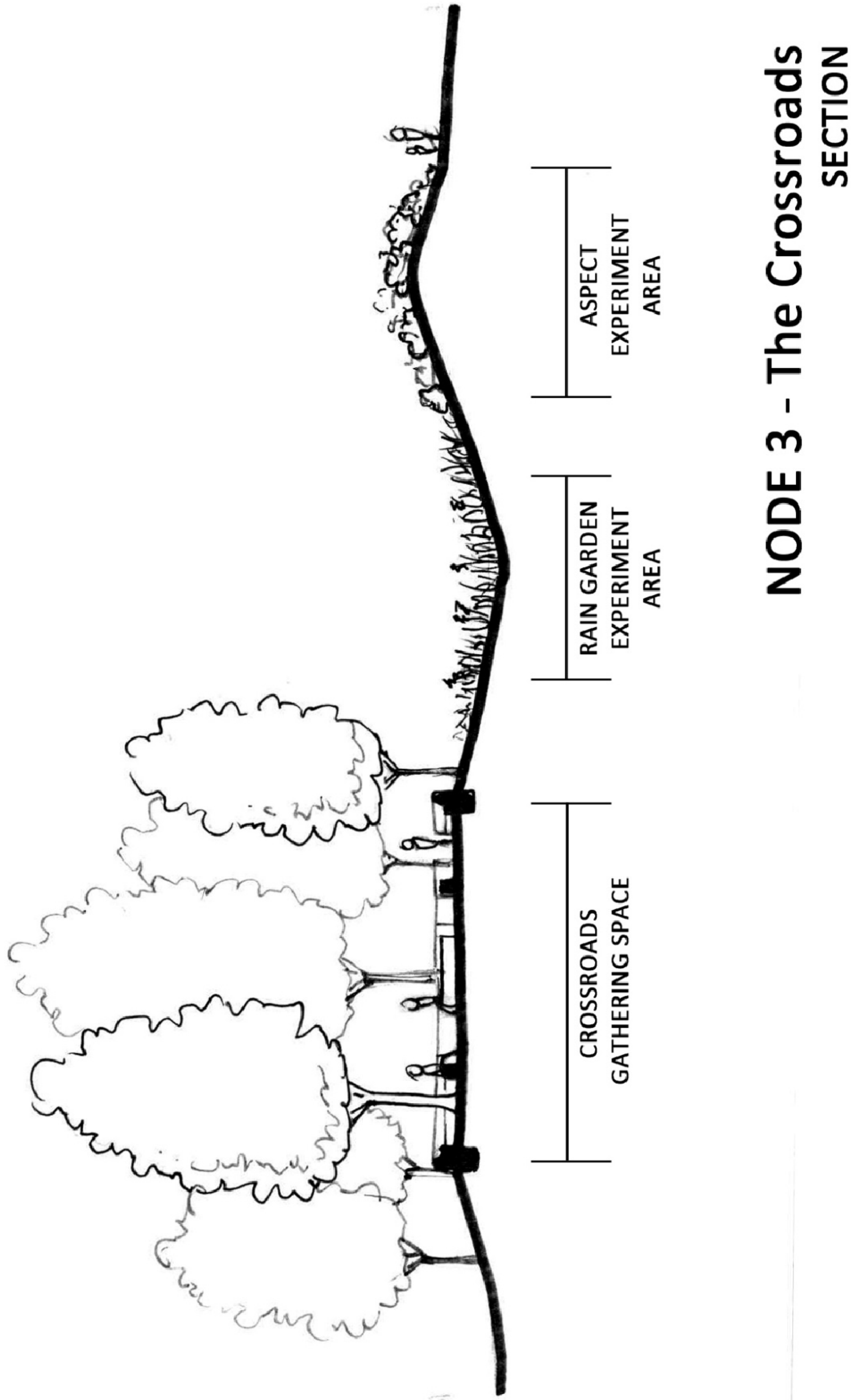

Figure 3.20: The Crossroads Section, Node 3. An elevation change of approximately three feet occurs from existing grade to the gathering space.

through, but whatever remaining run-off will be collected in the rain garden. Node 3 will receive 2 points for credit 3.7 for the design of a rainwater feature.

Site Design – Soil and Vegetation

The biomass density index calculations will be figured for Node 3. As done earlier, the existing BDI and proposed BDI will be calculated according to the guidelines and a value will be applied. The calculation for the Exiting Site BDI falls between 2 and 3 while the calculation for the Planned Site BDI also falls between 2 and 3 resulting in the addition of 0 points according to Tables 3.11 through 3.13.

CALCULATIONS FOR EXISTING SITE BDI			
Land cover/vegetation type zone	**Biomass density value* for this zone**	**Percent of total site area for this zone**	**Biomass density value x percent of total site area (column B x column C)**
A	B	C	D
Trees with understory	6	3.1%	0.19
Trees without understory (less than 10 percent herbaceous/shrub cover)	4	-	-
Shrubs	3	16.7%	0.50
Desert plants	1.5	-	-
Annual plantings	1.5	-	-
Grasslands and turfgrass	2	80.2%	1.60
Wetlands**	6	-	-
Impervious cover or bare ground not shaded by vegetation or vegetated structures	0	-	-
SUBTOTAL (sum of all rows)	n/a	100%	2.29
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			0.00
Existing Site BDI (sum of Subtotal and Additional Value)			2.29

* *The biomass density values in column B are based on a literature review of leaf area index for various vegetation types.*
** *This category includes wetlands with emergent vegetation and does not include open water.*

Table 3.11: Calculations for existing site BDI, Node 3.

CALCULATIONS FOR PLANNED SITE BDI			
Land cover/vegetation type zone	Biomass density value* for this zone	Percent of total site area for this zone	Biomass density value x percent of total site area (column B x column C)
A	B	C	D
Trees with understory	6	9.6%	0.58
Trees without understory (less than 10 percent herbaceous/shrub cover)	4	13.9%	0.57
Shrubs	3	8.6%	0.26
Desert plants	1.5	-	-
Annual plantings	1.5	-	-
Grasslands and turfgrass	2	61.0%	1.22
Wetlands**	6	-	-
Impervious cover or bare ground not shaded by vegetation or vegetated structures	0	6.8%	0.00
SUBTOTAL (sum of all rows)	n/a	100%	2.63
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			0.00
Planned Site BDI (sum of Subtotal and Additional Value)			**2.63**

* The biomass density values in Column II are based on a literature review of leaf area index (LAI) for various vegetation types which included LAI for approximately 1,000 historical estimates of LAI summarized by biome/cover type in JMO Scurlock, GP Asner, and ST Gower, *Worldwide Historical Estimates of Leaf Area Index, 1932-2000* (Oak Ridge, TN: Oak Ridge National Laboratory, 2001).

** This category includes wetlands with emergent vegetation and does not include open water.

Table 3.12: Calculations for planned site BDI, Node 3

Point value look-up table for sites in **Temperate Broadleaf and Mixed Forests biome.** Use this table to look up the applicable point value (no credit, 3 points, 5 points, or 8 points) for the difference between the Existing Site BDI and Planned Site BDI on your site.

Existing Site BDI	Planned Site BDI: 0–1	1–2	2–3	3–4	4–5	5 or above
0–1	No Credit	3 points	5 points	8 points	8 points	8 points
1–2	No Credit	No Credit	3 points	5 points	8 points	8 points
2–3	No Credit	No Credit	No Credit	3 points	5 points	8 points
3–4	No Credit	No Credit	No Credit	No Credit	3 points	8 points
4–5	No Credit	No Credit	No Credit	No Credit	No Credit	8 points
5 or above	No Credit	No Credit	No Credit	No Credit	No Credit	8 points

Table 3.13: Point value table and result for planned site BDI, Node 3

The use of native plants is encouraged in the next section. Points are distributed in terms of percentage of areas at least 2000sf. Percentage calculations are measured by surface areas of vegetated area, using estimated vegetated cover within 10 years of installation. For this node, 100% of the site vegetated area is composed of native plants, adding 4 points to the total. See Table 3.14 for a sample plant list.

Plant List for Node 3

Acer rubrum
Betula populifolia
Juniperus virginiana
Pinus strobus
Asclepias incarnate
Eupatorium coelestinum
Eupatorium maculatum
Lobelia cardinalis
Lobelia siphilitica
Solidago sempervirens

Table 3.14: Plant List, Node 3

Site Design – Human Health and Well-Being

Node 3 will get points for Credit 6.3 as Node 1 and 2, but for different reasons. Node 3 will promote sustainable awareness and education by demonstrating biofiltration and stormwater management within the node and with the constructed wetlands proposed in the master plan. Node 3 will use strategically placed signage to describe the processes performed by these features. Also the demonstration of plant/soil experiments at this node will be explained with signage and add to the sustainable and educational information. Four points will be given for this credit.

The views provided by Node 3 are of open meadows and of the constructed wetlands. Shade is provided by the proposed shade trees throughout the node. Four points will be added for Credit 6.7 for providing views of vegetation and quiet outdoor spaces for mental restoration.

Credit 6.9 suggests reducing light pollution by maintain certain footcandle standards. There is no lighting proposed for Node 2 since this section of the trail will be closed at dusk. Two points will be added for keeping the site below the recommended footcandle level.

Operations and Maintenance

Credit 8.4 gives up to 4 points for using energy efficient lighting and appliances for outdoor fixtures while Credit 8.5 gives up to 3 points for using renewable sources for electricity. Since there are no fixtures or electricity required for Node 2, 7 points will be added.

Points Scored – Node 3

The total points accumulated for Node 3 as a sustainable site are 84 out of a possible 149. Refer to Table 3.15 for specific point distributions.

Node Designs Point Allotment			Possible Points	Points Earned		
3 **Site Design - Water**				Node 1	Node 2	Node 3
Prerequisite 3.1	Reduce potable water use for landscape irrigation by 50% from established baseline					
Credit 3.2	Reduce potable water use for landscape irrigation by 75% or more from established baseline		2-5 pts	3	3	3
Credit 3.7	Design rainwater/stormwater features to provide a landscape amenity		1-3 pts	2	0	2
Credit 3.8	Maintain water features to conserve water and other resources		1-4 pts	0	0	0
		total	12	5	3	5
4 **Site Design - Soil and Vegetation**						
Prerequisite 4.1	Control and manage known invasive plants found on site					
Prerequisite 4.2	Use appropriate, non-invasive plants					
Prerequisite 4.3	Create a soil management plan					
Credit 4.4	Minimize soil disturbance in design and construction		6 pts	6	6	6
Credit 4.5	Preserve all vegetation designated as special status		5 pts	0	0	0
Credit 4.6	Preserve or restore appropriate plant biomass on site		3-8 pts	5	3	0
Credit 4.7	Use native plants		1-4 pts	4	4	4
Credit 4.8	Preserve plant communities native to the ecoregion		2-6 pts	6	6	6
Credit 4.9	Restore plant communities native to the ecoregion		1-5 pts	5	5	5
		total	34	26	24	21
5 **Site Design - Materials Selected**						
Prerequisite 5.1	Eliminate the use of wood from threatened tree species					
Credit 5.2	Maintain on-site structures, hardscape, and landscape amenities		1-4 pts	0	0	0
Credit 5.3	Design for deconstruction and disassembly		1-3 pts	0	0	0
Credit 5.4	Reuse salvaged materials and plants		2-4 pts	0	0	0
Credit 5.5	Use recycled content materials		2-4 pts	0	0	0
Credit 5.6	Use certified wood		1-4 pts	4	4	4
Credit 5.7	Use regional materials		2-6 pts	6	6	6
Credit 5.8	Use adhesives, sealants, paints, and coatings with reduced VOC emissions		2 pts	0	0	0
Credit 5.9	Support sustainable practices in plant production		3 pts	0	0	0
Credit 5.10	Support sustainable practices in materials manufacturing		3-6 pts	0	0	0
		total	36	10	10	10
6 **Site Design - Human Health and Well Being**						
Credit 6.3	Promote sustainability awareness and education		2-4 pts	4	4	4
Credit 6.5	Provide for optimum site accessibility, safety, and wayfinding		3 pts	3	3	3
Credit 6.7	Provide views of vegetation and quiet outdoor spaces for mental restoration		3-4 pts	4	4	4
Credit 6.8	Provide outdoor spaces for social interaction		3 pts	3	3	3
Credit 6.9	Reduce light pollution		2 pts	2	2	2
		total	16	16	16	16
7 **Construction**						
Prerequisite 7.2	Restore soils disturbed during construction					
Credit 7.4	Divert construction and demolition materials from disposal		3-5 pts	0	0	0
Credit 7.5	Reuse or recycle vegetation, rocks, and soil generated during construction		3-5 pts	5	5	5
		total	10	5	5	5
8 **Operations and Maintenance**						
Prerequisite 8.1	Plan for sustainable site maintenance					
Prerequisite 8.2	Provide for storage and collection of recyclables					
Credit 8.3	Recycle organic matter generated during site operations and maintenance		2-6 pts	5	5	5
Credit 8.4	Recycle outdoor energy consumption for all landscape and exterior operations		1-4 pts	4	4	4
Credit 8.5	Use renewable sources for landscape electricity needs		2-3 pts	0	0	0
Credit 8.6	Minimize exposure to environmental tobacco smoke		1-2 pts	0	0	0
Credit 8.7	Minimize generation of greenhouse gases and exposure to localized air pollutants		1-4 pts	0	0	0
Credit 8.8	Reduce emissions and promote the use of fuel-efficient vehicles		4 pts	0	0	0
		total	23	9	9	9
9 **Monitoring and Innovation**						
Credit 9.1	Monitor performance of sustainable design practices		10 pts	10	10	10
Credit 9.2	Innovation in site design		8 pts	8	8	8
		total	18	18	18	18
		total for nodes	149	89	85	84

Table 3.15: Sustainable Sites Initiatives point distribution for each Node design

Total Points Scored

The 68 points scored for the Master Plan have been added to each node separately since each node's design was different. The total points in the Guidelines gives four stars for 200 points or more (80% of the total possible points), three stars for 150 points (60 % of the total possible points), two stars for 125 points (50% of the total possible points), and one star for 100 points (40% of the total possible points). Nodes 1, 2 and 3 all fell within the three star point total with 157 (89+68), 153 (85+68), and 152 (84 +68) points respectively plus the points for the overall master plan

Discussion

Since the design of each node was performed prior to reviewing the point allotments for the Sustainable Site Initiative's Guidelines, a true evaluation of the nodes has been provided. Features were not added and designs principles were not compromised for the sake of obtaining the greatest amount of points. Designing towards point accumulations should not be intent of the designer and the Guidelines should not be used in such a manner.

How a designer uses the Guidelines is beyond the responsibility of the Sustainable Sites Initiative. However, certain aspects of the Guidelines may need to be further investigated. For example, certain credits deal with reducing energy costs for buildings or reducing the heat island effect, and no points would be given if one has not done so (see credits 4.10-4.12). But what if there is no building proposed to reduce energy costs from, or what if there is not parking lot proposed to reduce the heat island effect of? A design deserves points for not including these built structures into a design. The absence of energy used to build these features or to manufacture the products is worthy of sustainability status and a credit should be added for such instances. The Guidelines specifically indicates how they can be applied to sites with and without buildings (The Sustainable Sites Initiative 2009, pg. 8). However the examples above leads me to believe that the Guidelines may be more appropriate for sites that include built structures even though the designs for this open space earned 3 out of 4 stars. However, the Guidelines do appear to work well with the ecological design principles as described by Hartman (2011).

Chapter 4

Lessons Learned

Brownfields can be seen as blight in the community, however, from this study we can see how, with a bit of creativity, a brownfield can be redeveloped in to an engaging and educational open space. Certain perimeters must be followed in order to keep visitors safe if there are contamination concerns. This is a minimal task in comparison to the value of ecosystem services a site like this can provide. The site demonstrates ecosystem services by its forest cover and diversity, sequestering carbon and providing wildlife habitat (Burger, Gochfeld and Niles 1995). In addition, the Master Plan for the Interior Section demonstrates the ability to use a contaminated brownfield for collecting and filtering stormwater from neighboring parking lots to reduce the possibility of downstream flooding and to reduce the amount of runoff which otherwise would be headed to our streams and rivers untreated.

This thesis and the Interior Section of Liberty State Park is a case study example in the use of urban brownfields a green refuge from the nearby city life. It has demonstrated a creative approach for regenerative landscape use and can give insight into the possibilities and values too often hidden in these sites.

This study has also shown methods to help determine the selection plant species and possible soil treatments. Learning how to look at the landscape to determine what species have established and have been successful over time is an important first step in preparation of a planting schedule. This site is unique in the fact that just under 200 years ago it consisted of mud flats and tidal marshes until it was filled, developed, deconstructed and left abandoned for nature to take over. Within the 50 or so years since deconstruction was completed, many species have established themselves, some native, some non-native and some considered invasive to the region. This is why it is important to research the success of the desired plant material to determine management techniques for species considered a threat to diversity and wildlife habitat.

The research for this project came in the form of a plant/soil experiment, a study which is basic to all landscape design. This type of experiment, although basic, takes much time, thought and effort to create, install, manage and analyze. However, the results are always a source of valuable information. The results led to an understanding for plant selection and soil specifications. In this case, there is no clear benefit to any specific treatment. This may seem like a negative result since no treatment benefitted plant growth or survival over the other, but it is positive in the fact that money will be saved minimizing labor and purchasing costs and in avoiding unnecessary chemical applications will be an ecological benefit. The recommendation I would make as a result of the experiment is the addition of sand to the fill material. Not for any increase in plant growth or survival observed, but from personal observation of the difficulty encountered attempting to penetrate the fill material in the plot preparation. A standard shovel, and my strength were not up for the task and a power tiller needed to be used and the addition of as little as 10% sand per unit volume made the soil more friable. In addition, as with any good planting schedule, proper soil testing and plant selection are the most important aspects. As the experiment results show, if one selects plants based on the soils of the site, and the plants' basic light and water requirements, no additional amendments should be needed.

The design of the site provides the user with an engaging experience that is dictated by the existing vegetation and topographic features. The slightly varying topography along with the varying plant communities' heights and spatial dimensions create an interesting experience as well as a sequence of diverse educational opportunities. Each node of the trail design provides a distinct space and different message regarding ecology and ecological design principles, and also, through its ecological history outlined in this thesis, this site demonstrates the regenerative potential of an ecosystem.

Through this process I have expanded my knowledge of ecological processes and ecological design principles. Ecological design should not be confused as a style of landscape architecture, but as the basis for any landscape architecture project. Even with brownfield sites such as this one, an ecological approach should still be taken. Stormwater runoff can still be collected to prevent direct flow into streams, vegetation can still be protected and their understories used as corridors for interested hikers. There are even options to working with sites with contaminated soils if we are creative in the process. This chapter has given examples of such procedures and as we are taught to listen to our clients' needs and wants, it is our job to also listen to the land and what it wants and needs.

There are many dimensions to creating a successful project in the world of landscape architecture, some of which have to do with selecting the right building materials or providing objects of visual interest. However, the basis for all landscape architecture starts with sufficient site analysis and the design of space and ecology. We are to provide stimulating experiences for users throughout the landscape while maintaining the integrity and beauty which lies within nature. Landscape architecture is the melding of science and art. Landscape Architects need to know the functions of the landscape in order for us to use it as our canvas. We have the difficult task for every project to understand the workings of nature within our site. Determining the project site's climate and microclimate, understanding its unique hydrologic functions and its relationship to the watershed, researching its specific soil properties and understanding the ecological dynamics between vegetation and wildlife are the first steps in any landscape architectural project. The Sustainable Sites Initiative's Guidelines provides an outline consistent with these procedures.

This study can assist in future site development projects not only by providing an example of how the Sustainable Site Guidelines can be utilized, but also by providing a general procedure for site developers and landscape architects to use. The emphasis on site analysis, as shown is very important, but is useless if not followed through in design. Certainly not every project will have the ability to perform a plant survival experiment on site, however it does show how different treatments can have different effects on plant growth and that knowing the soil properties is an important step to increasing the probability of plant survival. Ultimately, this study shows the complexity involved in the preparation and incorporation of site analysis to ensure the desired outcome with regards to the design of space and ecology.

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Appendix A: Example of a Soil Sample Test Results provided by the Rutgers Soil Testing Laboratory in the Experiment Plots.

RUTGERS
New Jersey Agricultural Experiment Station

Soil Testing Laboratory
Rutgers, The State University
ASB II
57 US Highway 1 South
New Brunswick, NJ 08901-8554

Soil Test Report
Lab #: 2011- 10417

Name: Rutgers Univ.
Dr. Jean Marie Hartman
Address: Ecology/Landscape Arch.
Blake Hall, 93 Lipman Drive
New Brunswick, NJ 08901

Date Received: 2011-05-16
Date Reported: 2011-05-27

Sample ID: 1

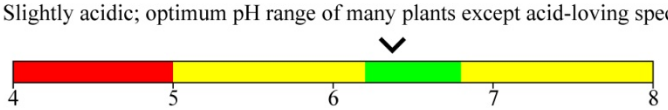
Phone:
Fax:
Email: jhartman@rci.rutgers.edu

Crop or Plant
Ornamental flowers, perennial

Soil Tests and Interpretations

Sandy Clay Loam

pH: 6.37 Slightly acidic; optimum pH range of many plants except acid-loving species.

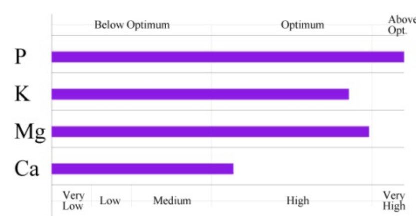


Lime Requirement Index: 7.75

The Lime Requirement Index (LRI) is a measure of the buffering capacity of the soil, its resistance to pH change, and is used to determine the appropriate amount of limestone, when necessary. LRI value near 8.0 indicates low buffering capacity of soil and a lower rate of limestone amendment compared to soil with high buffering capacity (LRI near 7.0).

Macronutrients (pounds per acre)

Phosphorous:	245	(Above Optimum)
Potassium:	259	(Optimum)
Magnesium:	294	(Optimum)
Calcium:	1454	(Optimum)



by Mehlich 3 extraction

Micronutrients (parts per million)

Zinc(Zn)	**Copper(Cu)**	**Manganese(Mn)**	**Boron(B)**	**Iron(Fe)**
7.09 (Adequate)	4.04 (Adequate)	69.79 (High)	0.46 (Low)	236.20 (High)

Soil Test Report for Lab # 2011- 10417 Page 1/4 V2.0

Special Tests Results

Soluble Salts- Electrical conductivity= 0.08 mmho/cm
(Low)

Organic matter by dichromate oxidation- Organic Matter= 2.6% Organic Carbon= 1.5%
Medium for Sandy Clay Loam

Mechanical Analysis- Sand= 58% Silt=20% Clay= 23% Texture: Sandy Clay Loam

Total Kjeldahl Nitrogen: 0.10%

Inorganic Nitrogen- Nitrate-N: 5 ppm Ammonium-N: 10 ppm

pH, Calcium, and Magnesium Recommendations

The soil pH is in the optimum range of 6.20 to 6.80 for the growth of most Ornamental flowers, perennial . Do not apply any limestone.

Fertilizer Recommendations

BEFORE PLANTING

Target ratio for fertilizer product is: 2-0-1 ,which represents the fertilizer's relative amounts of nitrogen (N), phosphorus as P_2O_5, and potassium as K_2O.

How do I find the proper fertilizer product?
For help finding appropriate fertilizers and rates, consult the Rutgers Soil Testing Laboratory website: rci.rutgers.edu/~soilslab/FertProducts/. The website lists commercially available products according to their nutrient analyses to assist you with product selection and calculation of amount required.

Select a fertilizer that has a nutrient grade (also known as guaranteed minimum analysis) the same as or a multiple of the values recommended, or select a close match to that ratio. When no single fertilizer product matches or approximates the recommended $N:P_2O_5:K_2O$ nutrient ratio, it will be necessary to use two or more fertilizers to reach the correct balance of nutrients. The proper amount of fertilizer to apply in a single application depends on the actual fertilizer grade of the fertilizer product selected, the total area (square feet) to be treated, and the total number of fertilizer applications to be made throughout the year.

DO THIS: using a fertilizer with the N:P:K ratio indicated, broadcast the perennial bed at a rate to achieve 2 pound N per 1000 squre feet. Mix well to 6 inch depth of soil before transplanting.

For heavy feeders only: TWO WEEKS BEFORE BLOOM, at midseason of plants' growth. Do not fertilizer after August 1.

While many perennials perform best with minimal fertilization, some perennials are haevy feeders (for example, peony and chrysanthemum) and will perform better with a second application of fertilizer. Very sandy soils are susceptible to leaching and so might also warrant a second application after high rainfall totals if not using slow-release products.

DO THIS: For heavy feeding perennials, topdress a fertilizer with N:P:K ratio of 4-1-1 to achieve a N application of 1 pounds per 1000 square feet.

WHAT ABOUT NEXT YEAR?

The fertilizer prescription above is intended to bring soil nutrients to optimal or near-optimal conditions, and subsequent management recommendations are intended to maintain soil nutrients levels near optimum. The best nutrient ratio for maintenance fertilization of the perennial flowers beyond 2 years is best determined by another soil test.

DO THIS: In spring as new shoots of perennials emerge, broadcast fertilizer with N:P:K ratio of 4:1:2 at a rate to achieve 1 pound N per 1000 squre feet. Where available, use a slow release fertilizer product for season-long effectiveness and minimal loss to leaching. Water lightly to rinse fertilizer from plant shoots and into soil.

Micronutrient Statements

Zinc does not appear to be a limiting factor. For information about zinc in soil for plant nutrition, see FS721.

Copper does not appear to be a limiting factor. As with most other micronutrients, copper availability is related to soil pH. Do not over-lime. For more information about soil copper, see FS720.

Manganese may be toxic to sensitive crops when grown on low pH soil. Adding lime to the soil raises the pH and decreases manganese toxicity. Liming is generally not recommended for acid-loving plants, which are more tolerant of high levels of manganese. In excessive amounts, soil manganese can cause plant damage. This occurs primarily in low pH soil. Lime soil as recommended to decrease availability of manganese to plants. Avoid fertilizers that contain manganese. See FS973 for more information.

Plant types differ in their susceptibility to boron deficiency; certain fruit, vegetable, and field crops are most susceptible. Symptoms include improper development or dieback of growing tips, poor flowering or fruit set, twisting and yellowing of young leaves from base to tip, and black heart of roots. Lime only as necessary, since pH above 7.0 limits boron availability. Building up organic matter content of soil will increase boron availability. Use of boron fertilizer must be done only with extreme care because of the toxicity that might occur if over-applied and the difficulty of applying the low rates necessary. See FS873 for more information and follow recommendations above.

Plant availability to iron is highly dependent on soil pH. Although soil iron appears plentiful, high soil pH could limit its availability. On the other hand, plant damage due to iron toxicity, though not common, could occur at low soil pH (acidic soil). Maintain soil pH in the optimum range as described in Recommendations. See FS971 for more information.

Comments:

Find Rutgers Cooperative Extension Fact Sheets at www.njaes.rutgers.edu/pubs

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Note: The full set of Soil samples taken along the length of the Hydrologic Trail and the results issued by the Rutgers Soil Testing Laboratory can be provided upon request to the author.

Appendix B: Weather data from Liberty Science Center's weather station, located 0.5 miles north of the study experimental plot.

city	state	datetime	temp max	temp min	precip	windspmax	windspmaxdir	manually watered
Jersey City (LSC)	NJ	6/7/2011	90	57	0.00	20	NW	Y
Jersey City (LSC)	NJ	6/8/2011	96	63	0.00	12	W	Y
Jersey City (LSC)	NJ	6/9/2011	97	66	0.40	24	WNW	N
Jersey City (LSC)	NJ	6/10/2011	85	65	0.00	13	S	Y
Jersey City (LSC)	NJ	6/11/2011	71	60	0.70	22	ENE	N
Jersey City (LSC)	NJ	6/12/2011	73	59	0.02	12	NE	N
Jersey City (LSC)	NJ	6/13/2011	75	61	0.07	15	WNW	Y
Jersey City (LSC)	NJ	6/14/2011	71	56	0.11	13	NNW	N
Jersey City (LSC)	NJ	6/15/2011	85	50	0.00	14	NNW	Y
Jersey City (LSC)	NJ	6/16/2011	84	58	0.00	15	SSW	N
Jersey City (LSC)	NJ	6/17/2011	77	61	0.88	24	NW	N
Jersey City (LSC)	NJ	6/18/2011	84	60	0.00	13	SW	N
Jersey City (LSC)	NJ	6/19/2011	83	63	0.00	14	ENE	N
Jersey City (LSC)	NJ	6/20/2011	77	60	0.00	13	SSW	Y
Jersey City (LSC)	NJ	6/21/2011	80	63	0.00	13	SSW	N
Jersey City (LSC)	NJ	6/22/2011	80	65	0.00	14	SE	Y
Jersey City (LSC)	NJ	6/23/2011	74	67	0.05	16	E	N
Jersey City (LSC)	NJ	6/24/2011	73	66	0.03	12	ESE	Y
Jersey City (LSC)	NJ	6/25/2011	80	65	0.01	15	W	N
Jersey City (LSC)	NJ	6/26/2011	82	60	0.00	14	W	N
Jersey City (LSC)	NJ	6/27/2011	80	61	0.00	14	S	Y
Jersey City (LSC)	NJ	6/28/2011	83	70	0.00	13	S	N
Jersey City (LSC)	NJ	6/29/2011	84	71	0.00	20	WNW	Y
Jersey City (LSC)	NJ	6/30/2011	83	65	0.00	16	W	N
Jersey City (LSC)	NJ	7/1/2011	85	55	0.00	14	NNW	Y
Jersey City (LSC)	NJ	7/2/2011	85	61	0.00	13	S	N
Jersey City (LSC)	NJ	7/3/2011	76	65	0.58	17	W	N
Jersey City (LSC)	NJ	7/4/2011	88	67	0.00	17	WNW	N
Jersey City (LSC)	NJ	7/5/2011	90	60	0.00	17	W	N
Jersey City (LSC)	NJ	7/6/2011	88	65	0.00	15	SW	N
Jersey City (LSC)	NJ	7/7/2011	92	67	0.28	16	ESE	Y
Jersey City (LSC)	NJ	7/8/2011	82	70	0.00	10	SW	N
Jersey City (LSC)	NJ	7/9/2011	89	68	0.00	15	WNW	N
Jersey City (LSC)	NJ	7/10/2011	82	60	0.00	12	SSW	N
Jersey City (LSC)	NJ	7/11/2011	89	66	0.00	18	SW	Y
Jersey City (LSC)	NJ	7/12/2011	94	78	0.00	19	NW	N
Jersey City (LSC)	NJ	7/13/2011	87	71	0.00	26	NNE	N
Jersey City (LSC)	NJ	7/14/2011	83	64	0.00	19	NE	N
Jersey City (LSC)	NJ	7/15/2011	86	60	0.00	14	NW	Y
Jersey City (LSC)	NJ	7/16/2011	90	61	0.00	15	SSE	N
Jersey City (LSC)	NJ	7/17/2011	92	64	0.00	15	NW	N
Jersey City (LSC)	NJ	7/18/2011	96	72	0.01	20	WNW	N
Jersey City (LSC)	NJ	7/19/2011	94	71	0.00	13	NE	N
Jersey City (LSC)	NJ	7/20/2011	86	68	0.00	14	SSE	Y
Jersey City (LSC)	NJ	7/21/2011	99	71	0.00	20	SSW	Y
Jersey City (LSC)	NJ	7/22/2011	106	80	0.00	18	WNW	N
Jersey City (LSC)	NJ	7/23/2011	100	78	0.00	15	W	Y
Jersey City (LSC)	NJ	7/24/2011	94	75	0.00	16	NNE	N
Jersey City (LSC)	NJ	7/25/2011	80	70	0.42	16	SE	Y
Jersey City (LSC)	NJ	7/26/2011	92	70	0.17	24	NNW	N
Jersey City (LSC)	NJ	7/27/2011	86	65	0.00	15	NNW	N
Jersey City (LSC)	NJ	7/28/2011	85	67	0.00	12	S	Y
Jersey City (LSC)	NJ	7/29/2011	84	71	0.81	12	S	N
Jersey City (LSC)	NJ	7/30/2011	93	74	0.00	17	NNW	N
Jersey City (LSC)	NJ	7/31/2011	89	70	0.00	16	NW	N

source: http://climate.rutgers.edu/njwxnet/station.php

city	state	datetime	temp max	temp min	precip	windspmax	windspmaxdir	manually watered
Jersey City (LSC)	NJ	8/1/2011	92	66	0.10	17	WNW	Y
Jersey City (LSC)	NJ	8/2/2011	91	69	0.00	20	NNW	N
Jersey City (LSC)	NJ	8/3/2011	84	66	0.77	15	SSW	N
Jersey City (LSC)	NJ	8/4/2011	81	67	0.01	15	WSW	N
Jersey City (LSC)	NJ	8/5/2011	82	63	0.00	16	SSE	Y
Jersey City (LSC)	NJ	8/6/2011	83	70	0.10	19	S	N
Jersey City (LSC)	NJ	8/7/2011	91	74	0.01	14	WNW	N
Jersey City (LSC)	NJ	8/8/2011	91	72	0.00	19	ENE	N
Jersey City (LSC)	NJ	8/9/2011	84	71	2.21	17	SSE	N
Jersey City (LSC)	NJ	8/10/2011	86	64	0.00	19	W	N
Jersey City (LSC)	NJ	8/11/2011	83	65	0.00	16	W	N
Jersey City (LSC)	NJ	8/12/2011	85	55	0.00	13	NNW	N
Jersey City (LSC)	NJ	8/13/2011	83	60	0.00	13	S	N
Jersey City (LSC)	NJ	8/14/2011	73	67	5.00	21	SSE	N
Jersey City (LSC)	NJ	8/15/2011	81	66	0.04	19	WNW	N
Jersey City (LSC)	NJ	8/16/2011	79	64	0.08	12	ENE	N
Jersey City (LSC)	NJ	8/17/2011	83	61	0.00	11	S	N
Jersey City (LSC)	NJ	8/18/2011	82	65	0.10	21	SSW	N
Jersey City (LSC)	NJ	8/19/2011	82	64	1.05	28	NNE	N
Jersey City (LSC)	NJ	8/20/2011	82	60	0.01	11	SSW	N
Jersey City (LSC)	NJ	8/21/2011	85	66	0.80	17	S	N
Jersey City (LSC)	NJ	8/22/2011	79	66	0.01	17	W	N
Jersey City (LSC)	NJ	8/23/2011	81	55	0.00	14	N	N
Jersey City (LSC)	NJ	8/24/2011	79	56	0.00	19	S	N
Jersey City (LSC)	NJ	8/25/2011	79	70	0.54	15	SW	N
Jersey City (LSC)	NJ	8/26/2011	83	67	0.00	12	SSW	N
Jersey City (LSC)	NJ	8/27/2011	78	71	2.68	33	ENE	N
Jersey City (LSC)	NJ	8/28/2011	77	65	5.83	40	W	N
Jersey City (LSC)	NJ	8/29/2011	80	53	0.00	13	NNW	N
Jersey City (LSC)	NJ	8/30/2011	83	58	0.00	13	SSW	N
Jersey City (LSC)	NJ	8/31/2011	85	57	0.00	11	S	N
Jersey City (LSC)	NJ	9/1/2011	80	59	0.00	15	SE	N
Jersey City (LSC)	NJ	9/2/2011	76	58	0.00	13	SSW	N
Jersey City (LSC)	NJ	9/3/2011	85	62	0.00	15	SW	N
Jersey City (LSC)	NJ	9/4/2011	85	70	0.00	12	SSW	N
Jersey City (LSC)	NJ	9/5/2011	81	71	0.00	14	S	N
Jersey City (LSC)	NJ	9/6/2011	74	61	2.61	21	N	N
Jersey City (LSC)	NJ	9/7/2011	72	62	1.36	19	ENE	N
Jersey City (LSC)	NJ	9/8/2011	80	64	0.84	18	ENE	N
Jersey City (LSC)	NJ	9/9/2011	87	67	0.00	13	N	N
Jersey City (LSC)	NJ	9/10/2011	81	68	0.02	10	ENE	N
Jersey City (LSC)	NJ	9/11/2011	71	63	0.00	11	ENE	N
Jersey City (LSC)	NJ	9/12/2011	80	62	0.00	14	SSW	N
Jersey City (LSC)	NJ	9/13/2011	85	60	0.00	15	SSW	N
Jersey City (LSC)	NJ	9/14/2011	85	67	0.00	11	S	N
Jersey City (LSC)	NJ	9/15/2011	78	53	0.07	26	NNW	N
Jersey City (LSC)	NJ	9/16/2011	68	49	0.00	17	NNW	N
Jersey City (LSC)	NJ	9/17/2011	66	52	0.00	13	ENE	N
Jersey City (LSC)	NJ	9/18/2011	68	49	0.00	19	ENE	N
Jersey City (LSC)	NJ	9/19/2011	69	51	0.00	13	ENE	N
Jersey City (LSC)	NJ	9/20/2011	70	60	0.05	11	W	N
Jersey City (LSC)	NJ	9/21/2011	74	56	0.05	11	SSE	N
Jersey City (LSC)	NJ	9/22/2011	78	67	0.02	10	SSW	N
Jersey City (LSC)	NJ	9/23/2011	74	67	2.23	13	S	N
Jersey City (LSC)	NJ	9/24/2011	77	67	0.00	9	S	N
Jersey City (LSC)	NJ	9/25/2011	82	67	0.00	9	ENE	N
Jersey City (LSC)	NJ	9/26/2011	80	65	0.00	11	SSE	N
Jersey City (LSC)	NJ	9/27/2011	77	65	0.00	13	SSW	N
Jersey City (LSC)	NJ	9/28/2011	75	69	0.10	16	SE	N
Jersey City (LSC)	NJ	9/29/2011	75	59	0.26	18	WNW	N
Jersey City (LSC)	NJ	9/30/2011	79	53	0.43	17	SW	N

source: http://climate.rutgers.edu/njwxnet/station.php

city	state	datetime	temp max	temp min	precip	windspmax	windspmaxdir	manually watered
Jersey City (LSC)	NJ	10/1/2011	69	50	0.38	15	NE	N
Jersey City (LSC)	NJ	10/2/2011	65	49	0.03	17	SE	N
Jersey City (LSC)	NJ	10/3/2011	59	43	0.04	11	SW	N
Jersey City (LSC)	NJ	10/4/2011	65	45	0.00	16	NNW	N
Jersey City (LSC)	NJ	10/5/2011	74	56	0.00	22	NNW	N
Jersey City (LSC)	NJ	10/6/2011	71	40	0.00	15	ENE	N
Jersey City (LSC)	NJ	10/7/2011	67	43	0.00	9	S	N
Jersey City (LSC)	NJ	10/8/2011	78	44	0.00	8	SE	N
Jersey City (LSC)	NJ	10/9/2011	87	49	0.00	10	NW	N
Jersey City (LSC)	NJ	10/10/2011	85	52	0.00	8	NNW	N
Jersey City (LSC)	NJ	10/11/2011	77	63	0.00	12	ENE	N
Jersey City (LSC)	NJ	10/12/2011	64	59	0.24	23	ENE	N
Jersey City (LSC)	NJ	10/13/2011	66	59	0.11	19	NE	N
Jersey City (LSC)	NJ	10/14/2011	72	58	0.56	22	SSW	N
Jersey City (LSC)	NJ	10/15/2011	67	46	0.00	25	WNW	N
Jersey City (LSC)	NJ	10/16/2011	69	50	0.00	22	W	N
Jersey City (LSC)	NJ	10/17/2011	68	52	0.00	22	WNW	N
Jersey City (LSC)	NJ	10/18/2011	69	46	0.01	9	S	N
Jersey City (LSC)	NJ	10/19/2011	63	58	0.86	31	ENE	N
Jersey City (LSC)	NJ	10/20/2011	68	53	0.01	27	SW	N
Jersey City (LSC)	NJ	10/21/2011	58	51	0.00	22	W	N
Jersey City (LSC)	NJ	10/22/2011	62	43	0.00	16	WNW	N
Jersey City (LSC)	NJ	10/23/2011	60	44	0.00	11	S	N
Jersey City (LSC)	NJ	10/24/2011	62	40	0.00	13	S	N
Jersey City (LSC)	NJ	10/25/2011	65	42	0.00	22	WSW	N
Jersey City (LSC)	NJ	10/26/2011	63	42	0.00	13	WNW	N
Jersey City (LSC)	NJ	10/27/2011	58	38	0.72	21	NNW	N
Jersey City (LSC)	NJ	10/28/2011	52	35	0.00	14	NNW	N
Jersey City (LSC)	NJ	10/29/2011	46	32		24	NE	N
Jersey City (LSC)	NJ	10/30/2011	49	31		20	NNW	N
Jersey City (LSC)	NJ	10/31/2011	54	28	0.00	11	SSE	N

source: http://climate.rutgers.edu/njwxnet/station.php