

WILLIAM H. TATHAM CENTRE

ECOLOGICAL RECONCILIATION



April 2004
Professor Stephen Murphy

ERS 381 Restoration Ecology
By: Rob MacLachlan #99169129
Katherine Sparkes, #99098531
Sandy Kiang, #99081171

Table of Contents

EXECUTIVE SUMMARY	4
1. INTRODUCTION.....	5
1.1. URBAN ECOLOGICAL RECONCILIATION.....	5
1.2. THE TATHAM BUILDING.....	6
2. RATIONALE	7
3. OBJECTIVES	8
4. METHODOLOGY.....	8
5. SITE DESCRIPTION.....	9
5.1. LOCATION	9
5.2. CLIMATE	10
5.3. TOPOGRAPHY	12
5.4. HYDROLOGY	12
5.5. SOILS.....	13
5.6. EXISTING VEGETATION	14
6. DESIGN CONSIDERATIONS	14
6.1. SOCIAL.....	14
6.1.1. <i>Problems with existing site</i>	15
6.1.2. <i>Suggestions for a New Site</i>	16
6.1.3. <i>Conclusions from social study</i>	16
6.2. LEGAL / POLITICAL	17
6.3. HISTORICAL	18
6.4. ECOLOGICAL	18
6.4.1. <i>Native Species</i>	19
6.4.2. <i>Required Species Characteristics</i>	19
6.4.3. <i>Species Tolerance</i>	20
6.4.4. <i>Desired Species Characteristics</i>	20
7. FINAL DESIGN PLAN	21
7.1. FINAL DESIGN PLAN.....	21
7.2. MEADOW ECOSYSTEM CONFIGURATION.....	21
7.3. SPECIES SELECTION.....	23
7.3.1. <i>Maintenance Requirements</i>	24
7.3.2. <i>Flowering and Blooming Period</i>	24
7.3.3. <i>Wildlife Attracted</i>	24
7.3.4. <i>Functional Requirements</i>	25
8. SITE PREPARATION AND IMPLEMENTATION.....	25
8.1. DESIGNING A PLANTING LAYOUT.....	25
8.2. REMOVING EXISTING TURFGRASS AND INVASIVE SPECIES	26
8.3. PLANTING BED PREPARATION	27
8.4. SPECIES ACQUISITION	27
8.5. SEEDS VS. TRANSPLANTS	28
8.6. SEED STORAGE AND TREATMENT	29
8.7. PLANTING A SEED	29
8.8. TRANSPLANTS	30
8.9. ESTABLISHING AND MAINTAINING ECOSYSTEM FUNCTION	30
9. MAINTENANCE AND MONITORING	31

9.1.	MAINTENANCE	31
9.1.1.	First year	31
9.1.2.	Second Year	31
9.1.3.	Long-term Management.....	31
9.2.	MONITORING WILDLIFE	32
9.3.	MONITORING VEGETATION DEVELOPMENT	33
10.	PROJECT MILESTONES	38
11.	BUDGET	40
12.	CONCLUSIONS.....	40
13.	WORKS CITED	42

List of Figures

Figure 1 - Ecological Reconciliation Site	6
Figure 2 - Detailed Site Measurements.....	10
Figure 3 - Water Pooling in Depressed Areas	12
Figure 4 – Surrounding Slopes Affecting Hydrology.....	13
Figure 5 - Unofficial Paths.....	15
Figure 6 - Erosion as a Result of Frequent Disturbance Figure 7 - Need for Shade	15
Figure 8 – Final Design Plan.....	22

List of Tables

Table 1 – List of Selected Species	23
--	----

Executive Summary

At the University of Waterloo landscaping is usually limited to turfgrass. In order to create a safer and lower maintenance landscape design, this study includes a plan for the ecological reconciliation of the 997m² site located next to the William H. Tatham Centre. With particular consideration of social, legal, political, historical, and ecological aspects, the aim was to establish a meadow ecosystem that could withstand changing natural and human activities.

Our design considerations led us to select species with few maintenance requirements, varying blooming periods, colourful, attractive to butterflies, capability to survive within edge environments, fairly rapid growth rate, and specific to the site's soil type, pH range, drainage patterns, sun coverage and the surrounding disturbance regime. Methodology for implementation requires the initial removal of the existing turf grass through tillage and the application of herbicides. It is recommended that a meadow seed mix is purchased from a local nursery. To aid in glare reduction, larger shrubs such as the *Cornus racemosa* (Gray Dogwood) and *Rhus typhina* (Staghorn Sumac) would be acquired from North Campus, or rescued from local sites undergoing development. The budget for such a site plan is approximately \$2200. Within the first two years, the site would require mowing on a monthly basis. Monitoring requirements would be tailored to evaluate the successful colonization of butterflies and vegetation, Seven steps for monitoring have been outlined and explained. It is estimated that the project will begin April 2004, and by May 2005, planting would be complete and an open-house would be ready for education and demonstration purposes.

1. Introduction

1.1. *Urban Ecological Reconciliation*

With its increasing integration within contemporary policy and thought, the concept of sustainability has challenged the viability of the traditional turfgrass landscape (Ingram, 1999). Citing turfgrass as one of the foremost illustrations of modern society's detachment from the natural world, sustainable landscape efforts have looked to re-establish the presence of native natural areas within urban regions, dissolving the perceived "mutually exclusive" relationship between the built and natural environments (Ingram, 1999). In pursuing sustainable objectives, environmental restoration, and management strategies have provided for the establishment of previously existing and self-sustaining ecosystems within a variety of previously altered urban areas. However, in light of the inevitable spatial conflicts between society and the environment within urban areas, such efforts are rarely realized in full (Quon et al., 2001). As such, ecological restoration efforts within urban areas may give way to ecological reconciliation approaches, grounded in the balancing of social, political, and ecological priorities to:

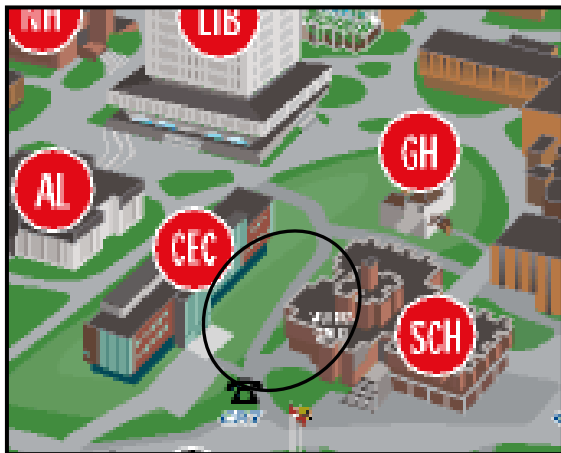
- create healthy, safe, natural and low maintenance (i.e., sustainable) urban settings which maintain a diversity of plants and animals;
- ensure the integrity and genetic diversity of native species through the restoration and preservation of ecosystems and ecological communities within these settings; and,
- generate positive and constructive attitudes towards the environment.

(Harker et al., 1999)

1.2. The Tatham Building

Members of the University of Waterloo's (UW) community have recognized the need for a more sustainable landscape in replace of existing manicured turfgrass. This recognition is reflected in the *Campus Master Plan*, which calls for the enhancement of natural features, the introduction of native plant communities, and "the fostering of self-sustaining ecosystems appropriate to the...campus" (Campus Master Plan, 1992). Thus, in pursuing the promotion of sustainable landscapes within the University of Waterloo campus, this plan outlines the design, implementation and monitoring requirements for the ecological reconciliation of an existing turfgrass setting into a meadow landscape outside of the William H. Tatham Centre at the University of Waterloo campus (Waterloo, Ontario) (see Figure 1). In providing for the reconciliation of this area of campus the university stands to benefit from an overall contribution to the desirability of the campus as a whole (Clay et al., 2000).

Figure 1 - Ecological Reconciliation Site



2. Rationale

To ascertain that the establishment of a meadow ecosystem was the desired outcome of the ecological reconciliation, the various relevant social, political and ecological considerations were investigated. Such considerations included obtaining input from the public on campus, consulting relevant University of Waterloo policies regarding landscape management, and ensuring compliance with the ecological principles of ecological restoration. Each of these is further detailed in Section 4.0.

With regards to social priorities, it was recognized that what people perceive as natural may differ from “naturalized areas with high ecological function”, as research has often shown that the public generally disapproves of the apparent disorganized state of nature (Hands et al., 2002). As such, campus staff and students were consulted to determine the desired state of the site. In which, options were presented and political and ecological priorities were identified.

To ensure that the meadow ecosystem was consistent with University policy concerning landscape management, members of the University of Waterloo Plant Operations were also consulted. Through discussions with this group, not only was a plan formulated which conformed to relevant University policy, but also provided for the assurance of a more acceptable reconciliation option.

From an ecological standpoint, several key principles of ecological restoration were taken into consideration. These included the need for the use of native species, and the requirement for a landscape which is dynamic in the face of continuously changing natural and human activities.

3. Objectives

In providing for the establishment of a meadow ecosystem which reconciles the identified biophysical, social and political considerations, the following objectives were employed:

1. Remediate current topsoil composition.
2. Design a low-maintenance landscape.
3. Design a landscape which does not present any safety concerns (no hiding places or tripping hazards).
4. Design an aesthetic and appealing site.
5. Design a purposeful site which responds to university community and operational needs.
6. Create an affordable design plan for implementation.
7. Use species native to Southern Ontario exclusively.

4. Methodology

In providing for the establishment of a meadow ecosystem which reconciles the relevant social, political and ecological considerations towards a sustainable landscape, the following methodology was employed:

1. Identification of the ecological reconciliation site and baseline conditions;
2. Identification of the social, political and ecological design considerations;
3. Development of a final design plan;
4. Identification of site preparation and implementation requirements; and,
5. Identification of maintenance and monitoring requirements.

The following sections detail each of the above methodological steps.

5. Site Description

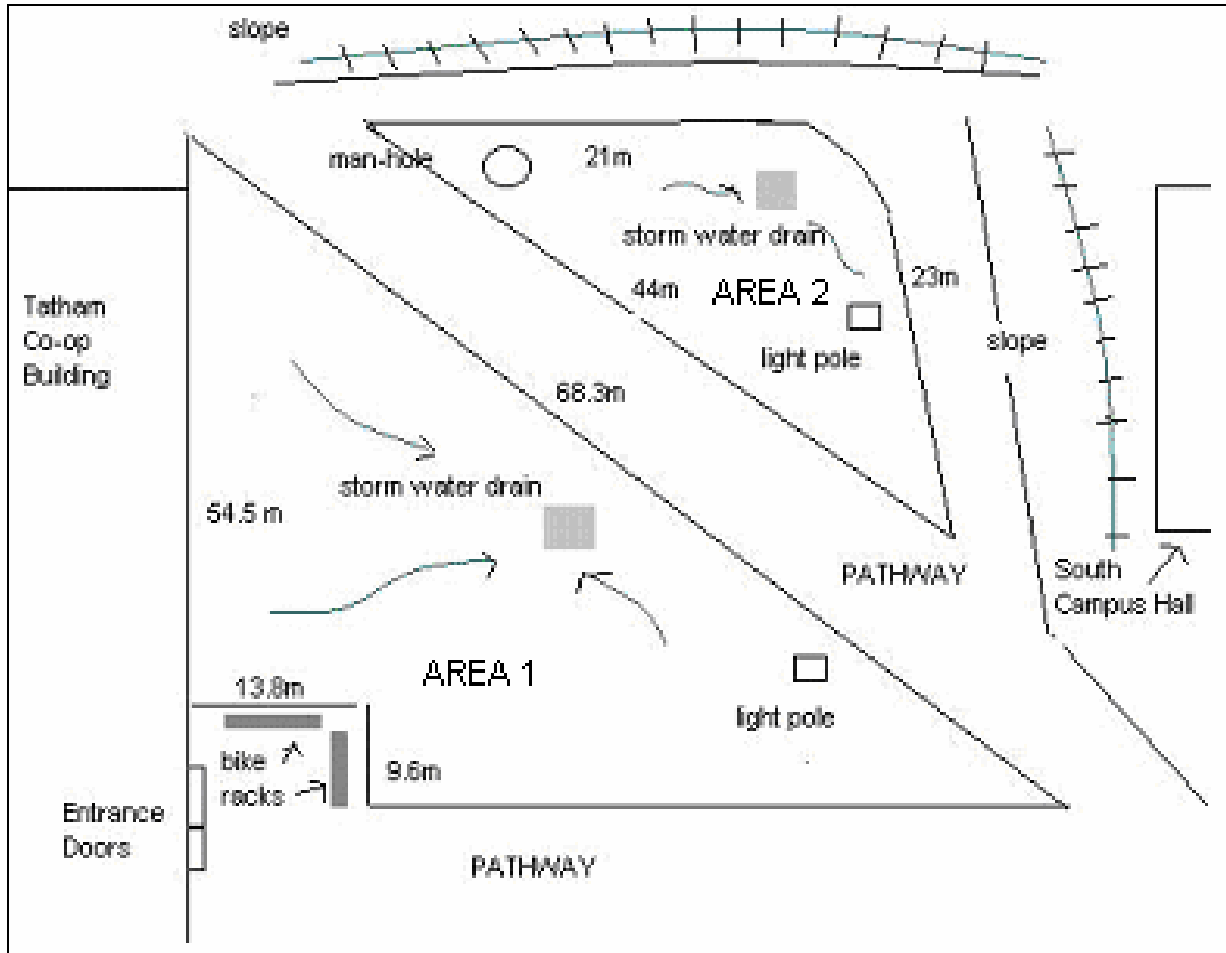
5.1. Location

The subject site of this ecological reconciliation project lies on the University of Waterloo's (UW) campus in Waterloo, Ontario. UW lies at an elevation of 334.4 metres above sea level and is located at the following coordinates:

- latitude: 43°28' 25.6"N
- longitude: 80°33' 27.5"W.

Within UW, the study site is located immediately east of the William H. Tatham Centre, just north of Ring Road on the southern edge of UW's main campus. Before developing site-specific reconciliation design criteria for the proposed meadow landscape, essential baseline information was collected to provide a foundation upon which reconciliation considerations could be based and evaluated. As identified by Harker et al. (1999), such information includes climate, topography, hydrology, soils and existing vegetation, which should be characterized prior to any design plans for the site are initiated. The study site consists of two existing turfgrass landscapes, separated by a pathway encompassing 755 m² (area 1) and 241.5 m² (area 2) respectively (see Figure 2 for details).

Figure 2 - Detailed Site Measurements



5.2. Climate

Regional climatic effects of precipitation, wind, temperature and moisture will influence the types and success of vegetation found in the Waterloo area. In addition, microclimates, influenced by local conditions including topography and built structures will influence the types and success of vegetation within the specific site itself (Harker et al., 1999). This section details the regional and local climate conditions, including precipitation, wind and sun/shading which can be expected within the ecological reconciliation site.

On the basis of data for the period of 1971 to 2000 obtained from Environment Canada's Waterloo Wellington website, mean annual precipitation measures were calculated, and are considered to represent climate norms in the area (Environment Canada, 2004). Given a calculated mean annual rainfall of 765.0 mm and mean snowfall of 159.5 cm, the mean annual precipitation for the site was estimated to be 907.9 mm (Environment Canada, 2004).

Wind direction within the UW campus was found to originate from the Northwest (Lamb, L. 2004). Thus it was assumed that the study site will be, on average, sheltered from the wind because of its location on the east side of the Tatham building. During a site visit on March 12, the wind speed was recorded at 10.1 km/h from the west (University of Waterloo, 2004).

In the report, Campus Landscape Study: The Conversion of Turf Areas to Alternative Forms of Groundcover, Hassan (2000) notes the importance of determining the amount and timing of sun received by an area as an influence on the type and success of plants within a given area. Specifically, Hassan (2000) identifies three categories of solar exposure which are typical within any given area: sun (5-6 hours sun/day), semi-shade (3-4 hours sun/day) and shade (0-2 hours sun/day). On the basis of periodic site visits and the testimony of staff who work in the Tatham Centre year-round, it was estimated that, given the eastern-facing orientation of the site, it receives sun for 5-6 hours/day, from mid-morning to mid-afternoon, after which the Tatham building shades the site for the duration of the day.

5.3. *Topography*

Topography will have an influence on microclimate and specifically surface drainage, as slopes are better drained than level areas (Harker et al., 1999). The subject site is predominantly concave, sloping inwards towards installed storm sewers, with several small depressions scattered within its area. Figure 3 illustrates the effect of these small depressions on the site, indicating that they allow for the pooling of water. However, aside from such pools that occur after major rainfall events, it is assumed that the gradual slope towards the installed storm sewers provides for an adequate level of surface runoff.

Figure 3 - Water Pooling in Depressed Areas



5.4. *Hydrology*

The study site is isolated within a developed portion of UW's campus and only experiences hydrologic inputs from precipitation and surface water runoff from adjacent berms located in front of the Graduate House and South Campus Hall (see Figure 4). Given these inputs, described previously in sections 4.2 and 4.3, the site appears to receive a fairly high input of water.

Figure 4 – Surrounding Slopes Affecting Hydrology



5.5. Soils

Prior to the excavation of the site for the construction of the William H. Tatham Centre, a soil study was undertaken for Plant Operations to determine the soil conditions at the site. On the basis of this study, native deposits appear to consist of different sequences of sand, underlain by layers of silt and then clayey silt, however given recent construction activity, the original topsoil sequence no longer exists (Parent, 2004). After completion of the Tatham building, approximately 6 inches of topsoil was placed over the existing sand, silt and clayey silt layers. This topsoil consists of a sandy silt layer comprised of very dense fine to medium sand followed by a layer of very stiff to hard grey clayey silt (Parent, 2004).

On the basis of the soil composition the site appears to be moderately to well-drained, however given previously identified climate, topographic, and hydrologic conditions may experience periods of high soil saturation.

5.6. *Existing Vegetation*

After the completion of the Tatham building, the site was landscaped with grass seed to protect against erosion. Given the landscaping trends on campus, the researchers assume that grass is the perennial *Poa pratensis*. However at the time of the

6. Design Considerations

6.1. *Social*

In integrating the needs and desires of those who will use the site or be affected by its presence as part of the ecological reconciliation of the site, public support and acceptance of the design will be greater ensured. To facilitate the identification and incorporation of these social aspects into the design of the landscape reconciliation plan, a survey of the attitudes of building users towards existing site conditions and desires for a renewed site was conducted. After obtaining approval from UW's Department of Ethics, a booth was set up in the William H. Tatham Centre to distribute questionnaires in order to obtain staff and student input on the project. Appendix 1 contains the original data obtained from the study as well as a sample questionnaire. Thirty-five people shared their thoughts and ideas on landscaping at the William H. Tatham Centre. The following discussion summarizes their key concerns and ideas.

Of the 35 responses to the study, 28 participants indicated that they were familiar with conditions on the site. Only one person indicated that they were not familiar with the site, and the remaining six people were unsure what the current conditions of the site were like.

6.1.1. Problems with existing site

With respect to the existing conditions of the site, both staff and students identified the creation of unofficial paths (77% indicated they were guilty of walking along such paths)(Figure 5), as well as erosion (Figure 6), and a lack of aesthetic diversity and shade (Figure 7) as problematic. Also, only 20% of respondents indicated that they currently make use of the site, while others provided that if the indicated desirable changes were instituted, they may be more inclined to spend time within the site.

Figure 5 - Unofficial Paths



Figure 6 - Erosion as a Result of Frequent Disturbance



Figure 7 - Need for Shade



6.1.2. Suggestions for a New Site

Questionnaire respondents were asked to identify which types of plants, paths and landscape features (if any), they would like to see incorporated into a new landscape plan for the William H. Tatham Centre. The most popular plant choice were trees (85% of respondents), followed by flowering plants (80% of respondents), shrubs (71% of respondents) and grasses (60% of respondents). Respondents overwhelmingly agreed that new paths were needed on the site (80% of respondents), further providing that such new paths should be created along the identified unofficial paths. With respect to landscape features, many respondents indicated a desire for rocks (80% of respondents) and benches (77% of respondents).

6.1.3. Conclusions from social study

On the basis of the above described responses the following key social considerations have been identified for consideration in the ecological reconciliation design plan:

- *Pathways*: current pathways do not reflect the desired travel routes of staff and students between buildings to the Tatham Centre. Additional paths should be created based on the most travelled, desired routes from locations around the building to the main door of the Tatham building.
- *Aesthetics*: staff and students desire an increase in diversity of plant type in order to improve the look and impression of the site to both building users and visitors.
- *Plants*: building users support the incorporation of a variety of plant types into the landscape design, with particular support for trees and flowering plants to meet their aesthetic and functional (i.e. lack of shade/glare from sun) concerns.

- *Landscape features:* staff and students are overwhelming supportive of the incorporation of furniture and rocks into the landscape design. Recreational opportunities (i.e. lunching, breaks and etc.) on the site may be enhanced by the provision of furniture, such as benches.

6.2. *Legal / Political*

Given the proposed site is located on university property conformance with regional and municipal by-laws was not considered an issue (City of Waterloo, 2004). As such, the UW campus master plan was utilized as the guiding policy framework for the ecological reconciliation.

The UW Campus Master Plan encourages landscape maintenance practices which provide for “ecological approaches with self-sustaining, naturalized landscapes as well as formal ones (Master Plan, 1992).” The Master Plan further promotes the use of the landscape itself as a recreational space, and as a learning resource for “tying land use to coursework and research” (Master Plan, 1992). As such, the Master Plan indicates that planting programs should promote the use of native plant materials as well as reducing the university’s reliance on pesticides and maintenance (Master Plan, 1992). In addition, new buildings are encouraged to make use of natural settings in absorbing run-off, improving microclimate, and linking open space and trails to natural features such as the Laurel Creek watershed (Master Plan, 1992).

To ensure the adequate reflection of the Master Plan objectives within the design plan, the following aspects were recommended for inclusion by UW Plant Operations:

- the use of all Southern Ontario native species (as further described in section 5.4);
- the site to be as low maintenance as possible;

- safety considerations: visual aspects with regards to site lines and hiding as well as the avoidance of noxious weeds;
- pedestrian movement;
- bicycle considerations; and,
- correction of top soil deficiency.

(Galloway, 2004)

6.3. Historical

Prior to UW's construction, the site area was used for agricultural purposes (OGS, 1984). Such agricultural practices occurred up to the UW's construction in 1957, at which time the site was converted to the traditional turfgrass landscape. As this plan deviates from traditional ecological restoration goals which aim to re-establish previously existing ecosystems, consideration of the environmental history of the site was not considered relevant as part of the design plan. The rationale for this decision was based largely on the absence of historic native plant meadow complexes for use as a reference site (which existed during pre-settlement times within Southern Ontario and the Region of Waterloo), the high degree of disturbance which has already occurred at the site, and the primary goal of arriving at a sustainable landscape which looks to integrate social, political and ecological concerns (Daigle et al., 1996, Grand River Conservation Authority, 1998).

6.4. Ecological

In conjunction with the identified social and political elements, several key ecological criteria were identified for consideration as part of the design plan, and

specifically with respect to species composition. These included the use of only species native to Southern Ontario, and specifically those species which,

- are compatible with the specific site conditions;
- are resilient and robust in light of the high degree of disturbance evident at the site;
- will promote the desired function, as identified through consultations with members of the campus; and,
- demonstrate a high degree of self-sufficiency, in light of the management requirements stipulated by the UW Master Plan.

6.4.1. Native Species

Beyond the recommendations of UW Master Plan, in restricting the site's composition to exclusively native species, it is anticipated that landscape will both enhance and benefit from the local environment, as local micro and macro fauna will already be adapted to the selected species, and conversely these species will be theoretically more tolerant to local climate conditions and diseases (Lamb, 1996). Native species will also help to reinforce the local ecological identity and biodiversity through the preservation of local genetic stock (Lamb, 1996, Canadian Wildflower Society, 2001). To ensure the integrity of native biodiversity within the site, commonly observed invasive species of Southern Ontario, such as those listed in Appendix 3, will require specific monitoring to identify possible cost effective management (Price et al., 2003 [text]). Such monitoring requirements are identified in section 8.0.

6.4.2. Required Species Characteristics

To ensure the continued survival of the landscape the selection of native species

will be further limited to those which can survive in both moderately drained to periodically saturated soils, a pH range of 7.3-7.8, and sunlight exposure.

6.4.3. Species Tolerance

Given the high level of human traffic and disturbance due to the site's location, the selection of native species will also depend on their resiliency and tolerance levels, as indicated by:

- the ability to survive in edge microenvironments;
- the colonization or seed production rate (particularly those of the grasses and forbs during the early establishment of the site, when large numbers are desired) as determined by the species documented ability to multiply, rapidly germinate, flower early, and allocate substantial resources to reproduction; and,
- the competitive ability of the plant, as determined by seedling or transplant growth rates.

(Pywell et al., 2003)

6.4.4. Desired Species Characteristics

To ensure that those selected native species provide for the aesthetic appeal identified in section 5.1, the frequency and duration of flowering, colour and the ability to attract desired fauna are also considered as part of the design plan.

5.4.5 Self-sufficiency

Finally, in accounting for the University of Waterloo landscaping requirements, consideration was given to those species which require the least maintenance and do not represent any health and safety concerns.

7. Final Design Plan

7.1. Final Design Plan

On the basis of the above social, political and ecological considerations identified, the following design plan recommends the establishment of a meadow ecosystem as a sustainable alternative to the existing turfgrass setting. The establishment of a meadow ecosystem is considered to provide for a reconciliation of the social, political and ecological landscape requirements as it includes a repertoire of native Southern Ontario species which:

- meet the aesthetic requirements;
- are limited in height so as to avoid any safety concerns;
- provide shade to the William H. Tatham Centre;
- require little to no maintenance; and,
- are capable of surviving within the identified site conditions.

7.2. Meadow Ecosystem configuration

To establish a meadow ecosystem which provides for the ecological reconciliation of the identified social, political and ecological considerations, Figure 8 represents the recommended species configuration.

7.3. Species Selection

The following section provides detail on the selected species. Specifically, Table 1 provides information concerning the aesthetic qualities of these species.

Table 1 – List of Selected Species

Scientific Name	Common Name	Flower Colour and Bloom Period	Height**
<i>Aster ericoides</i>	Heath Aster	White and Yellow / August – October ¹	30-100 cm ¹
<i>Aster novae-angliae</i>	New England Aster	Purple / September – October ⁶	60-150 cm ⁶
<i>Aster laevis</i>	Smooth Aster	Purple and Yellow / September – October ¹	60-120 cm ¹
<i>Aster oolentangiensis</i>	Sky Blue Aster	Blue / September – October ⁶	15-25 cm ⁶
<i>Cornus racemosa</i>	Gray Dogwood	White / May – June ⁶	3-5 m ¹
<i>Rhus typhina</i>	Staghorn Sumac	Yellow ¹	upto 14m ⁵
<i>Solidago canadensis</i>	Canada Goldenrod	Yellow / August – October ²	30-175 cm ²
<i>Solidago nemoralis</i>	Gray Goldenrod	Yellow / September – October ⁶	10-50 cm ⁶
<i>Solidago altissima</i>	Tall Goldenrod	Yellow / August – October ⁴	upto 150 cm ⁴
<i>Rudbeckia hirta</i>	Black-eyed Susan	Yellow / July – August ⁶	30-150 cm ⁶
<i>Helianthus divaricatus</i>	Woodland Sunflower	Yellow / July – August ⁶	40-125 cm ⁶
<i>Asclepias syriaca</i>	Common Milkweed	Purple / June – August ⁶	60-90 cm ⁶
<i>Asclepias tubrose</i>	Butterfly Milkweed	Orange / June – August ⁶	40-80 cm ⁶
<i>Epilobium angustifolium</i>	Firewood	Pink / July – August ⁶	60-180 cm ⁶
<i>Monarda fistulosa</i>	Wold Bergamot	Lavender / July – September ⁵	100-120 cm ⁵
<i>Sisyrinchium montanum</i>	Montane or Common Blue-eyed Grass	Blue and Yellow / May – June ⁶	15-25 cm ⁶
<i>Anemone virginiana</i>	Tall Anemone	White / June ⁶	30-80 cm ⁶
<i>Cyperus esculentus</i>	Yellow Nutsedge	Yellow ³	up to 30 cm ³
<i>Panicum virgatum</i>	Switch Grass	August ⁶	60-150 cm ⁶
*All of the above species are native to Ontario			
**To ensure safety requirements species height was restricted to 3 metres beyond the immediate perimeter of the Tatham building (as taller species along the building function to shade the building interior) .			

Notes

¹Missouri Botanical Garden, 2003

²OMAFRA, 2004

³Virginia Tech Weed Identification Guide, 2003

⁴Uriarte, 2000

⁵Wildflower Farm Inc., 2004

⁶Limestone Creek Restoration Nursery, 1999

All of the selected species are considered native to Southern Ontario and, aside from the *Cornus racemosa* and *Rhus typhina* which serve the particular function of providing shade for the staff of the William H. Tatham Centre, are limited to heights of 3 m for the sake of safety considerations.

7.3.1. Maintenance Requirements

Aside from required occasional mowing to maintain the succession state of the ecosystem, all species are considered to require little to no maintenance. As is for example, demonstrated by the *Asters*, and specifically the *Aster novae-angliae*, which readily self-seeds (Johnson, 1995).

7.3.2. Flowering and Blooming Period

A diversity of species with respect to flower colour and blooming period were selected within the design consideration restraints. Thus, in looking to extend the duration of flowering within the site, the species composition provides for a blooming period from May through to October.

7.3.3. Wildlife Attracted

To provide for the attraction of desired wildlife, several species were selected as butterflies attractors. These included *Aster ericoides*, *Aster novae-angliae*, *Aster laevis*, *Aster oolentangiensis*, *Asclepias syriaca*, *Asclepias tubrose*, *Cornus racemosa*, *Rhus typhina* and *Rudbeckia hirta*. Specifically *Aster ericoides*, *Aster laevis*, *Aster oolentangiensis* and *Rudbeckia hirta* have been identified as adult butterfly attractors

(Missouri Botanical Garden, 2003, Limestone Creek Restoration Nursery, 1999, Canadian Wildflower Society, 1999). While *Asclepias syriaca*, *Asclepias tubrose*, *Cornus racemosa*, *Rhus typhina* and some of the above listed *Asters* are considered larval host plants (Canadian Wildflower Society, 1999). It should be noted however, that the existence of these species does not predicate the existence of butterflies within the site, as such guarantees require specific assessments of the particular butterfly species beyond the scope of this report (Pullin, 1996). As such, actions towards monitoring the presence of butterflies within the site are provided in section 8.

7.3.4. Functional Requirements

With respect to functioning within the physical constraints of the site, each species has been selected on the basis that it can survive within:

- sandy silt soils;
- a pH range of 7.3-7.8 (Presant et al., 1971);
- a well drained to periodically saturated environment;
- a non-shaded environment; and,
- an area frequented by human traffic and impacted by the associated activities.

Specifically regarding the surrounding disturbance regime, species selection was restricted to those which (in addition to meeting the other design requirements) demonstrated an ability to survive within edge environments, and provide for a fairly rapid growth rate. Such as the observed ability of *Solidago Canadensis*, *Solidago nemoralis* and *Solidago altissima* to thrive within disturbed environments (Uriarte, 2000).

8. Site Preparation and Implementation

8.1. Designing a Planting Layout

While a true meadow includes approximately 50% native grass species and additional forbs, the proposed meadow ecosystem has deviated from this composition, using a number of typical meadow species planted in larger clumps to result in a “more subtle” meadow effect (Johnson, 2001). Mixed seed can be spread randomly throughout the site. Transplants can also be placed randomly or in predetermined patterns (Daigle et al., 1996). In order to address the shade/glare concerns of building users and the creation of new paths, a plan will be created for the placement of transplants, especially taller species of shrubs

8.2. Removing existing turfgrass and invasive species

Invasion weeds are the enemy of meadow species, hardy *Poa pratensis* included. Accordingly, the site must be cleared of all bluegrass prior to planting. There are several methods of removing the grass from the site, including tillage, herbicides, solarizing and smothering. Solarizing employs the use of a tarp laid down over the subject area which traps heat on the site, killing seeds and grass in the upper soil level (Daigle et al., 1996). Solarizing may work well on small areas, however given the size of the subject site it is not recommended. By laying down a black plastic sheet or newspaper over the site, sunlight and gas exchange can be cut off, effectively smothering growth on the site. Smothering requires that the covering remain in place for an entire growing season (Johnson, 2001). Given the importance of aesthetics on the site (as a first impression to campus visitors and building staff), and the large area that would require covering, smothering is also not recommended. The speed and effectiveness of results of tillage and herbicidal removal methods are discussed below. Each of these methods is appropriate to the size of the site and used individually or in combination, each of these removal techniques will deliver quick results.

In late spring or early fall the site should be tilled to a depth of 7-12 cm (Daigle et al., 1996). Root clumps and pieces should be raked off of the site. The site should be left to allow for germination of dormant seeds (from 10 to 14 days). The site should then be tilled again. If a till-only method of grass removal is desired, and time is not a factor in planting, than this process should be completed for an entire season (Johnson, 2001). However, the location of the site in question and its importance to visitor's impressions of UW and staff and students using the William H. Tatham Centre leads the researchers to recommend a combination of herbicide and till methods of removal. By applying herbicide immediately prior the second tillage of the site (still 10-14 days after the first till), additional tillage is unnecessary and final bed preparations can begin immediately, therefore dramatically shortening the preparation time (Daigle et al., 1996).

8.3. Planting Bed Preparation

After the turfgrass has been removed from the site, all stones, sticks, roots and other debris should be cleared off (Johnson, 2001). One final till should be completed to eliminate remaining weeds. The site should be thoroughly watered (by rain or hand) prior to planting.

8.4. Species Acquisition

Seeds for many of the meadow species can be purchased from local native-plant nursery. For instance, the Limestone Creek Catalogue offers a meadow seed mix consisting of wildflowers & grasses (94%), and shrubs & vines (6%). Located in Campbellville Ontario, purchasing these seeds can be achieved with the convenience of

shipping costs included.¹ One important consideration to note is that by purchasing from nurseries, there is the disadvantage of low genetic diversity (Environment Canada, 2000). These cultivars can include asters, goldenrods, black-eyed Susan, all of which is present in our site.

Another method of acquiring species is to collect them from the wild. While there are some ethical factors to consider (e.g. species which are not vulnerable, taking too much seeds, removing food for birds, etc.), some of the species can be collected from UW's north campus. Doing so may be advantageous for a couple of reasons: lower costs, established root systems, and higher survival rates (since it is adapted to local growing conditions).

Lastly, another technique is to rescue them from local plots of land which may be being prepared for development. If this is to be achieved, permission must be sought from landowners.

8.5. Seeds vs. Transplants

Seeds and transplants offer benefits and challenges to establishing a meadow-like landscape. Seeds are cheaper and usually available in a greater number of species than seedlings. However transplants establish more quickly and have a greater chance of out competing weeds. Based on the prominent location of the site, the many visitors to the Tatham Centre and the concerns of staff and students with the site, it is important that the development of the site take place as quickly as possible without undermining the viability of the proposed plant community. It is therefore recommended that a combination of seedlings and seed be used in the development of site. Slow growing

¹ Note: A "2004-2005 Native Plant Resource Guide" with a directory of Ontario nurseries can be ordered from the Ontario Chapter of the Society for Ecological Restoration website. Published by Environment Canada.

species (i.e. shrubs) should be transplanted. Faster growing grasses and herbaceous plants can be started from seed.

8.6. Seed Storage and Treatment

Seeds that are purchased need to be stored at low temperatures (4 degrees Celsius) and low humidity (no more than 10 percent) for two weeks in a dry, airy place. Once it's dried, it can be stored in airtight containers in a refrigerator (Environment Canada, 2000). By chilling the seeds, it prepares them for fall and winter conditions. Depending on the type of species, cold-dry stratification or cold moist stratification treatment techniques is required. Once germination has occurred, species can be moved to pots. When seedlings have four to six leaves, they can be planted.

8.7. Planting a Seed

It is recommended that prairie grasses or forbs be planted in late spring or early summer when warmed soils reflect favoured meadow conditions. However fall seeding is also appropriate and simulates the timing of natural seed distribution (Daigle et al., 1996). The small size of the landscape site makes the rental of a seed drill (a machine that plants and covers seed) an expensive alternative. Hand broadcasting can be used to disperse seed on the site. Daigle et al. (1996) recommend adding a moistened dispersal material, such as sand or sawdust to the mix to ensure even distribution. The mix can be placed in a bag and a team of volunteers can scatter the mix onto the site. The seed should be distributed in two rounds. Planters should first walk across the site in parallel lines, ensuring full coverage of the area with the seed mix. Planters should then walk in paths perpendicular to their original routes, spreading a second round of

seed (Daigle et al., 1996). The seeds should be raked and roller packed to ensure soil-seed contact. Johnson recommends the use of 113-141 grams of seed per 92 m² of land.

Accordingly, approximately 1.5 kg of seed should be applied to the landscape site adjacent to the Tatham Centre (note that this number has not been adjusted to account for the seedlings that will also be planted on the site). Spring-planted seeds should be watered weekly for the first season (Johnson, 2001).

8.8. Transplants

Seedlings can be planted in Spring or Fall, it would probably be most convenient to plant with seed plantings. Prior to planting, a layer of mulch should be placed over the soil (Daigle et al., 1996). Seedlings should be transplanted into holes that are large enough to cover their root balls. Soil (2-4 cm) should then be placed over the roots (Government of Ontario, 2000).

8.9. Establishing and Maintaining Ecosystem Function

Productive restoration sites in the Waterloo Region require the following nutrient levels: Nitrogen (100-200 kg/ha/y), Potassium (50-100 kg/ha/y), Magnesium (25-50 kg/ha/y), Calcium (10-25 kg/ha/y), and Phosphorus (10-20 kg/ha/y) (Murphy, 2004). Prairie and meadow species are adapted to irregular environments and can therefore survive a variety of soil conditions. However, many of these species, especially herbs and sedges, are vulnerable to high nitrogen levels in soil that result from fertilization (Zechmeister et al, 2003). The site preparation outlined earlier in this report should ensure that any fertilizers that have been applied to the turf grass in the past have the opportunity to leach from the soil prior to planting. Each of the plants identified within

the design plan were selected for their adaptability to meadow-like conditions and their known compatibility with one another on other garden sites. The monitoring plan outlined below will allow the reconciliation team to monitor the structural success of individual species; this information can be used to infer conclusions about the function of the ecosystem based on the success of indicator species.

9. Maintenance and Monitoring

9.1. Maintenance

9.1.1. First year

During the first season, the site should be mowed bi-weekly or monthly to protect native seedlings from excessive shade (Daigle et al., 1996). Cuttings should be left on site so seedlings are not raked off accidentally. The site should be watered each week.

9.1.2. Second Year

The site should be mowed monthly to remove invasive species. Litter should be carefully raked from the site after mowing. During the second year, the site should be monitored for the appearance of biennial weeds, such as Queen Anne's lace (Daigle et al., 1996). These plants should be hand-pulled where identified. The site should be monitored for invasive weeds during the second and subsequent few years, especially *Poa pratensis* (currently grown on and all around the site). Mowing the site before these species seed will prevent reproduction (Daigle et al., 1996). No watering is necessary during the second year.

9.1.3. Long-term Management

Given their hardiness and adaptability, grassland communities require little maintenance. Occasional mowing is necessary to control the growth of woody species. Given the prominent location of the study site and the political need to minimize maintenance requirements, burning is not a recommended option for management of the site. Mowing should be completed in mid-spring while warm-season native species are dormant and cold weather weeds are blooming. Litter should be raked from the site after mowing. Excessive mowing can result in an increase in cold weather weeds. It is therefore important that the growth of weeds be monitored and mowing schedules adapted accordingly (Daigle et al., 1996).

9.2. Monitoring wildlife

The reconciliation design plan includes several plant species that are known to provide food and shelter for butterflies. In order to determine if the development of the site has successfully attracted butterflies, a monitoring scheme tailored to these insects should be undertaken. According to Block et al. (2001), monitoring treatment effects on wildlife is an integral part of assessing the success of restoration projects. The challenge in evaluating the effects of restoration on wildlife is determining an appropriate variable with which to measure success. The challenge is deciding what to monitor; populations of specific species, groups of functionally similar species and broader groups. Mammals and birds are both examples that could all be monitored. In order to measure the success of the restoration, a threshold should be identified. This could be a population number. Observation of this threshold could signal to that restoration should continue on its path, or that adjustments to the site are needed. Both observational and experimental study methods can be used to assess the achievement of a threshold by a target species. As no experimental plot is included in the design of

this project, observational study is the most practical and easier method to apply in this study.

There are many regional and national examples of butterfly monitoring programs that employ the butterfly monitoring scheme (BMS). BMS data is collected in a standardized manner. The site should be divided into transects and visual counts of butterflies are completed under defined weather conditions. The counts should be completed weekly in successive years (Stefanescu et. al, 2003). At the end of each year an abundance index can be calculated. These annual abundances can be compared over a number of years to determine changes in butterfly populations on site.

A BMS can provide several useful types of information. Fluctuations in the populations of species and their causes can be identified with accuracy if the study period is long enough (approximately 7-8 years). As it is not known what species of butterflies will be attracted to the selected plants, the first season of BMS should include an identification of all species identified and an inventory of the environmental conditions required to sustain these species. This information will allow the researchers to identify possible environmental causes of changes in butterfly populations. Long term monitoring of butterfly populations will also provide information on butterfly evolution in the area. Results from site monitoring can be compared to regional data to determine whether trends are usual for the area or not. By studying the butterflies along transects, the researchers can identify habitat preferences of the insects over time and (if recorded) lifecycle (Natural Heritage, 2000).

9.3. Monitoring Vegetation Development

Monitoring has two purposes 1) to allow for application of adaptive management by identifying problems and suggesting responses and 2) evaluate effectiveness of

restoration techniques and methods (Pastirok et al., 1997). Monitoring is necessary to determine whether management actions should be continued, altered or discontinued. Changes or trends on a site can be evaluated through monitoring (Block et al, 2001). If monitoring is to assess trends, repeated sampling of selected variables is required. Brock et al. (2001) note that wildlife responses may differ over the short-term and long-term, therefore sampling over time is necessary to determine long-term success of selected species.

There are four types of monitoring: implementation, effectiveness, validation and compliance monitoring. For our site, effectiveness monitoring will be utilized to determine whether actions achieved the various objectives set-out in Section 3.0

Monitoring involves several steps: 1) setting monitoring goals 2) identifying the resource(es) to monitor 3) establishing a threshold 4) developing a sampling design 5) collecting data 6) analyzing data and 7) evaluating the results (Block et al, 2001). These steps have been described below as they should be undertaken to monitor the success of the reconciliation plan described within this study.

1. Monitoring Goals

The monitoring goals described below reflect the objectives of the reconciliation plan identified in Section 3.0 of this report. The monitoring goals for this project are as follow:

- a) Evaluate the success of establishing a self-sustaining native plant population.
- b) Assess the success of soil erosion-prevention on site.
- c) Evaluate the satisfaction of building users with the reconciliation project.

2. Identifying the resources to monitor

In order to assess the success of the native plant community, several indicator species are identified below. An indicator species is monitored to indicate the presence and population trends of a group of other species in a community of interest. In his determination of indicator species for an Australian grassland restoration, Lunt et al. (2003) identified several criteria for potential indicator species:

1. species should be conspicuous and easy to identify (i.e. to non-specialists)
2. species should be abundant in high quality diverse grassland remnants
3. species should have broad ecological tolerances
4. evidence should suggest that management that suits the indicator species will also benefit other native plants
5. evidence should exist that suggests that management that suits the indicator species will not unduly benefit invasive weeds (Lunt, 2003).
6. Species should respond vegetatively to changes in grassland management (i.e. to indicate potential effects of management on other species).
7. Some detailed information should be available on species ecology.

In its guide to prairie and meadow restoration in Ontario, Environment Canada identified core species of meadow communities. Core species are those forming the foundation of naturally occurring meadows and prairies (Environment Canada, 2000). The following species are identified as core meadow species and are also incorporated into our design plan and meet the basic requirements of an indicator species identified by Lunt et al. (2003).

Potential indicator species:

1. *Panicum virgatum*
2. *Aster ericoides*
3. *Aster novae-angliae*
4. *Aster laevis*
5. *Rudbeckia hirta*
6. *Solidago Canadensis*

7. *Solidago nemoralis*
8. *Solidago altissima*
9. *Monarda fistula*
10. *Sisyrinchium montanum*

While each of the above species is assumed to be acceptable as an indicator species, the monitoring of all twelve species would be time and resource consumptive. Accordingly, it is recommended that two of each plant type (grasses/sedges and forbs) be monitored.

3. Establishing a threshold

Thresholds are values to which a restoration project strives to achieve or avoid. When thresholds are achieved, they signal to restorers that management has been successful (or, further management actions are required (Block et al, 2001). Accordingly, thresholds have been established for each type of indicator species (grass/sedges and forbs) below.

4. Sampling design and data collection

At the end of the first growing season, an evaluation of germination rates in the subject area should be undertaken to determine if reseeding is necessary. Germination rates can be determined simply if preparation for this measurement is planned early. Concurrent to planting on the site, seeds should be sown in labelled trays. Stratified random sampling will be used as it is one of the more efficient methods of monitoring, requiring fewer resources and less time than a complete survey of the site (Stutter, 1996). At the end of the first season, a wooden 1 m x 1 m square quadrat can be placed randomly throughout the site. The number of seedlings in the quadrat can be counted and species can be identified with by comparing field samples with seedlings in the tray.

At least 20 grass seedlings per square metre are required in the first year to produce viable strands later on (Morgan et al., 1995). Reseeding may be required if this minimum threshold is not met.

A permanent sampling technique should be employed on site to monitor community composition. As an objective of this project is to maintain a meadow community and avoid succession to a woodland, permanent sampling will allow the researchers to evaluate the stability of the community structure over time by analyzing the species composition in sampling areas. Transient sampling can be done to determine spatial changes such as short-lived species (Michener, 1997). Examples include wildlife such as butterflies, or birds. Sampling frequency and number relates to any expected changes, such as movement of people, and/or environmental disturbances. Therefore, monitoring should occur once a year, before annual mowing occurs to eliminate weeds.

5. Analyzing Data

After the number of seedlings per quadrat is determined, an average density per square metre of native seedlings should be calculated. Given the small number of samples analysis of variance (ANOVA) can be used to determine the representativeness of the data (Michener, 1997). Populations determined through sampling should then be compared with the desired thresholds (20 grass seedlings/m² and five flower seedlings/m²) to determine if numbers are adequate for population viability.

Observational statistics will be used to describe any patterns of interest including: distribution of organisms in space, species-abundance relations, interspecific

association, similarities or dissimilarities of community structure, and community-habitat relationships.

10. Project Milestones

The following chart describes steps for the implementation of the reconciliation design plan proposed in this report. It should be noted that approval from UW's Plant Operations is a requisite to implementation of the project and the timeline included here is a hypothetical one, based on acquisition of approval. A complete description of each milestone follows the table below.

Milestone	Timeline
1. Reconciliation Design Plan Completed	April 1, 2004
2. Invitations to Open House sent out via email	Mid-April 2004
3. Open House to gather building user and plant operations feedback on proposed design plan	May 1, 2004
4. Reconciliation Design Plan amended according to feedback from consultation process	May 2004
5. Site Preparation	June 2004
6. Seeds Ordered	June 2004
7. Seeds Planted	September 2004
8. Seedlings Ordered	February 2005
9. Seedlings Planted	April 2004
10. Maintenance and Monitoring Program Begins	April 2004
11. Reconciliation Open-house	May 2005

1. Reconciliation Design Plan is completed and submitted to Professor Steve Murphy for comment and input. Steve's professional experience and knowledge of reconciliation will enhance the potential success of the project.
2. An Open House held in the Tatham Centre will provide an opportunity for building users and members of plant operations to provide feedback on the proposed design plan. This feedback will be reviewed by the reconciliation team and incorporated into the plan where amenable with dominant social and ecological themes of the plan.

3. It would be useful to bring pictures, or where available, live samples of plants proposed for the garden. Additional graphics of the predicted outcome of the garden should also be included in a display. The reconciliation team should also present information on the stages of development that will take place on the site to prepare building users for the changes they will see. A timeline for site development should also be presented to stakeholders. At this point, stakeholders could also be invited to participate in seed and seedling activities that will be held later.
4. Information gathered from the Open House will be incorporated into the plan along with the insights provided by Steve Murphy.
5. Site Preparation will begin in June. The number of people on campus during this time is the lowest of all seasons, and the negative aesthetic impacts associated with turf removal and site preparation will be minimized. Site Preparation will proceed as outlined in the Reconciliation Plan.
6. Seeds should be ordered from identified retailers and stored by the reconciliation team until planting.
7. Seeds planted in September will be subjected to winter conditions, simulating the lifecycle of naturally dispersed local seeds. Seeds will propagate in the Spring.
8. Seedlings should be ordered for species identified in the reconciliation design plan.
9. Seedlings can be planted after the last frost.
10. Maintenance and monitoring of site should begin immediately after seedlings are planted. The guidelines for maintenance and monitoring included in the design plan should be followed.
11. The Reconciliation Open-house will provide an opportunity for building users, staff and the reconciliation team to meet and celebrate the creation of the garden.

11. Budget

Item	Notes	Number	Cost/unit	Total cost
Meadow species mix ¹	Purchase from Limestone Creek Catalogue ²	10	\$50	\$567 (with shipping & tax)
Labour	Plant Ops, Volunteers, Staff	N/A	Free	N/A
Rocks	Purchase from White Rose	3	\$400	\$1200
Bench	Purchase from White Rose	1	\$175	\$175
Shrubs: Staghorn Sumac	Rescue from North Campus ³	6-10	Free	N/A
Shrubs: Gray Dogwood	Rescue from North Campus ⁴	6-10	Free	N/A
Wood Chips	Free from Region of Waterloo ⁴	1000 sq ft	Free	N/A
Gardening Equipment	Use Plant Operations Equipment ⁵	N/A	Free	N/A
Miscellaneous	Unexpected costs	N/A	N/A	\$300
Total				\$2242

Notes:

1: 100m² of seed mix = \$50.00, therefore with ~1000m² of seed mix = \$500

2: Limestone Creek Native Ontario Wildflowers, Grasses & Shrubs 1999 Catalogue
Address: RR #1 Campbellville, Ontario, L0P 1B0, (905) 854-2914

3: Small shrubs can be transplanted from North Campus along Laurel Creek. One benefit in doing this is that these species will already be adapted to local climatic conditions.

4: Woodchips can be donated from Region of Waterloo, or can be created using Plant Operations wood chipper. Branches trimmed from trees and shrubs can be mulched into woodchips to save costs.

5: Plant Operations Gardening Equipment will be used: shovels, rakes, wheel barrels, gloves, etc.

12. Conclusions

To provide for a sustainable landscape alternative which reconciles relevant social, political and ecological design elements, a plan for the establishment of a meadow ecosystem has been provided. Occasional dialogue with building users will be necessary as the site develops to ensure the plantings do in fact address the social concerns identified within this study.

Public support for this project has been impressive. Staff and students within the William H. Tatham Centre were very happy to be provided with the opportunity to give input to a project that will impact them. It is recommended that future projects undertaken on UW's campus make every effort to involve staff and students at each phase of the project.

There is little evidence to suggest that monitoring has been a significant part of existing restoration programs on campus. Accordingly it is essential that the monitoring program described within this report be carried out to assess the ability of the planted community to sustain itself. Long-term monitoring (7-8 years as identified in the monitoring plan) is necessary to evaluate the function of the ecosystem.

13. Works Cited

Block, W., Franklin, A., Ward, J., Ganey J., and White. G. 2001. Evaluate the Success of Ecological Restoration on Wildlife. *Restoration Ecology* 9: 158-169.

Campus Master Plan. 1992. Master Plan Components for the South Campus Pages 23-31. <http://www.uwaterloo.ca/documents/masterplan/>

Huxted, Cheryl. February 10, 2004. City of Waterloo Forestry Technologist. Personal Communication.

Clay, Gary R., and Terry C. Daniel. 2000. Scenic landscape assessment: the effects of land management jurisdiction on public perception of scenic beauty. *Landscape and Urban Planning* 49: 1-13.

Daigle, J.M. and D. Havinga. 1996. Chapter 7: Meadows and Tallgrass Prairies. Pages 145-165 in *Restoring nature's place: a guide to naturalizing Ontario's parks and greenspace*. Co-published by Ecological Outlook Consulting and Ontario Park Association, Schomberg and Toronto, Ontario.

Environment Canada, 2000. *Planting the Seed A Guide to Establishing Prairie and Meadow Communities in Southern Ontario*. Ministry of the Environment.: Downsview.

Environment Canada. 2004. *Canadian Climatic Normals 1971-2000 for Waterloo*. <http://www.climate.weatheroffice.ec.gc.ca>

Galloway, Tom. January 30, 2004. University of Waterloo Plant Operations. Personal Communications.

Grand River Conservation Authority, 1998. *State of the Environment Report: Background Report on the Health of the Grand River Watershed*.

Hands, Denise E., and Robert D. Brown. 2002. Enhancing visual preference of ecological rehabilitation sites. *Landscape and Urban Planning* 58: 57-70.

Harker, D. 1999. *Landscape Restoration Handbook* 2nd ed.. Boca Raton: Lewis Publishers.

Hassan,S. 2000. *Campus Landscape Study: The Conversion of Turf Areas to Alternative Forms of Groundcover*. University of Waterloo WATgreen Graduate Project. <http://www.adm.uwaterloo.ca/infowast/watgreen/projects/library/grass.pdf>

Ingram, John. 1999. *When Cities Grow Wild – Natural Landscaping from an Urban Planning Perspective*. <http://www.for-wild.org/whenciti/whenciti.htm>

Lamb, Larry. 2004. Environmental Studies Ecology Lab Technician. Personal Communication. February 29, 2004.

- Johnson, L. 1995. The New Ontario naturalized Garden. Toronto: White Cat Books.
- Lamb, Larry. 1996. Front and Backyard Naturalization Efforts. Ground Works. Pp52-53.
- Lunt, I. A Protocol for Integrated Management, Monitoring, and Enhancement of Degraded *Themeda triandra* Grasslands based on Plantings of Indicator Species. Restoration Ecology. Vol. 11, June 2003, pg 223-230.
- Michener, W.K. 1997. Quantitatively Evaluating Restoration Experiments: Research Design, Statistical Analysis, and Data Management Considerations. from Restoration Ecology, Vol. 5, Pp. 324-337, Blackwell Science Publications.
- Missouri Botanical Garden, 2003
(<http://ridgwaydb.mobot.org/kemperweb/plantfinder/Plant.asp?code=G420>)
- Murphy, S. 2004. Safe Sites for Organisms. Lecture Notes. University of Waterloo.
- Ontario Geological Society. 1984. The Physiology of Southern Ontario.
- Ontario Ministry of Food and Agriculture. 2002. Ontario Weeds. Canada Goldenrod. (http://www.gov.on.ca/OMAFRA/english/crops/facts/ontweeds/canada_goldenrod.htm)
- Parent, D. Personal Communication. Email. March 9, 2004.
- Pastirok, RA, A MacDonald, JR Sampson, P Wilber, DJ Yozzo, JP Titre. 1997. An ecological decision framework for environmental restoration projects. *Ecological Engineering* 9(1997):89-107.
- Price, C. and Weltzin, J. Managing non-native plant populations through intensive community restoration in Cades Cove, Great Smoky Mountains National Park, USA. Restoration Ecology 11: 351-358.
- Pullin, A. S. 1996. Restoration of Butterfly Populations in Britain. Restoration Ecology 4: 71-80.
- Parent, Daniel. March 9, 2004. University of Waterloo Plant Operations Design Architect. Personal Communication.
- Quon, S. P. et al. 2001 Effective planning and implementation of ecological rehabilitation projects: A case study of Regional Municipality of Waterloo. Environmental Management 27: 421-433.
- Region of Waterloo. February 10, 2004. Christopher Gosselin, Manager of Environmental Planning. Personal Communication. Email. February 10, 2004.

Stefanescu, C. Penuelas, J. and Filella, I. 2003. Effects of climatic change on the phenology of butterflies in the northwest Mediterranean Basin. *Global Change Biology* 9: 1494-1506.

The Monitoring Scheme for butterflies as bioindicators of environmental quality in Catalonia. Natural Heritage. Ministry of Environment. Government of Catalonia. Online: www.gencat.es

Uriarte, 2000 (<http://scholarsportal.info/pdflinks/04022422122717920.pdf>)

University of Waterloo Weather Station. 2004. Weather Station. Current Conditions Reading for March 12, 2004 1:15 p.m. <http://weather.uwaterloo.ca>

Urban Forest Associates Inc. 2002. Invasive Exotic Species Ranking for Southern Ontario.

Virginia Tech Weed Identification Guide, 2003
(http://www.ppws.vt.edu/scott/weed_id/cypes.htm)

Watgreen Native Species Planting list. 1997. Online: www.watgreen.ca

Wildflower Farm Inc. 2004. Bergamot - *Monarda fistulosa*.
http://admin.wildflowerfarm.com/Merchant2/merchant.mv?Screen=PROD&Store_Code=1&Product_Code=15960

APPENDIX 1

SOCIAL CONSULTATION INFORMATION

APPENDIX 2

NATIVE SPECIES LIST

APPENDIX 3

LIST OF IDENTIFIED INVASIVE SPECIES

Figure 8 - Final Design Plan

