Restoring Natural Habitats

WATERFRONT REGENERATION TRUST

SEPTEMBER 1995

Restoring Natural Habitats

A MANUAL FOR
HABITAT RESTORATION
IN THE GREATER TORONTO BIOREGION

PREPARED BY
HOUGH WOODLAND NAYLOR DANCE LIMITED
GORE & STORRIE LTD.

FOR THE
WATERFRONT REGENERATION TRUST

SEPTEMBER 1995

Canadian Cataloguing in Publication Data

Main entry under title:
Restoring natural habitats: a manual for habitat restoration in the Greater Toronto bioregion

ISBN 0-7778-4607-1

1. Restoration ecology-Handbooks, manuals, etc. I. Hough Woodland Naylor Dance Limited. II. Gore & Storrie Limited. III. Ontario. Waterfront Regeneration Trust.

QH541.15.R45R47 1995 333.7'153 C95-964086-X

The text paper meets the Canadian Environmental Choice Program (E.C.P.) guidelines; its manufacturing process is in full compliance with environmental regulations. The paper contains 50% post commercial waste with a minimum 10% post consumer waste. Kinder to the environment, the paper is acid free and can be expected to last longer without becoming brittle or changing colour.

All printing inks are manufactured from renewable vegetable base resources that replace traditional petroleum base inks. The text pages were printed on non-polluting coldset printing presses that do not emit hydrocarbons into the atmosphere.

Cover and text pages are recyclable.

Waterfront Regeneration Trust

Fiducie de régénération du secteur riverain

Commissioner
The Honourable David Crombie, P.C.

Commissaire
L'honorable David Crombie, p.c.

Deputy Commissioner
David A. Carter

Sous-commissaire
David A. Carter

September 1995

Dear Colleague:

I am pleased to provide a copy of *Restoring Natural Habitats.*

This manual was prepared to provide assistance to agencies, groups, companies and individuals engaged in ecological restoration in the Greater Toronto Bioregion. It supports such recent initiatives as the *Lake Ontario Greenway Strategy, Oak Ridges Moraine Area Strategy,* and numerous watershed/waterfront strategies and plans within the Bioregion.

This document represents the opinion of the authors and not necessarily that of the Trust or the project Steering Committee.

I hope that you will find this manual useful and timely. I will appreciate your feedback, comments or questions; please direct them to Suzanne Barrett, Director of Environmental Studies at the Waterfront Regeneration Trust.

Thanks, as always, for your continued interest and involvement in this work.

Sincerely,

David Crombie

207 Queen's Quay West • Suite 580, Box 129 • Toronto, Ontario M5J 1A7
Telephone (416) 314-9490 • Facsimile (416) 314-9497

WATERFRONT REGENERATION TRUST
RESTORATION MANUAL STEERING COMMITTEE

Jim Kelleher (chair)	Waterfront Regeneration Trust
Suzanne Barrett	Waterfront Regeneration Trust
Tija Luste	Waterfront Regeneration Trust
Mark Browning	Ministry of Natural Resources
George Elgear	Ganaraska Region Conservation Authority
Fred Johnson	Ministry of Natural Resources
Brian McHattie	Canadian Wildlife Service
Gordon MacPherson	Metropolitan Toronto Region Conservation Authority
Bob Morris	Credit Valley Conservation Authority
John Riley	Ministry of Natural Resources
Steve Hounsell	Ontario Hydro

CONSULTING TEAM

Hough Woodland Naylor Dance Limited
Carolyn Woodland
Michael Hough
Maria Kaars Sijpesteijn

Gore & Storrie Ltd.
Al Sandilands (now with Ecological Services for Planning)
Sarah Mainguy

The Steering Committee gratefully acknowledges the contribution of the Ministry of Natural Resources to the printing costs of this manual.

PRODUCTION CREDITS

Photo Credits:
All photographs by *Hough Woodland Naylor Dance Limited*, except for the following:

Ecological Services for Planning:
pages: 18, 19 (bottom); 20 (top), 21, 22 (top), 23 (bottom), 53, 55, 101.

Gore & Storrie Ltd.:
pages: 85 (bottom), 86, 87.

Ministry of Natural Resources:
pages: 3 (top), 20 (bottom), 90, 98 (bottom), 99, 111, 139, 143, 144, 145, 146, 147.

Metropolitan Toronto Region Conservation Authority:
pages: 4 (middle), 68, 78, 134, 140.

City of Oshawa:
pages: 62, 63.

Editor: *Margaret Carney*

Cover Design: *Hambly & Woolley Inc.*
Barbara Woolley

Cover Images:
watercolours: Aleta Karstad
background sketch: *Envirosense Consultants Limited*
photo: *Hough Woodland Naylor Dance Limited*

Graphics: *Hough Woodland Naylor Dance Limited*
Ian Dance
Jillian McColgan

Graphic Layout: *Hough Woodland Naylor Dance Limited*
Lesley Bodimead

Printing: *Gullons Printing, Toronto, Ontario*

TABLE OF CONTENTS

SECTION 5

Woodlands

SECTION 6

Riparian Zones

SECTION 7

Pit and Quarry Restoration

SECTION 8

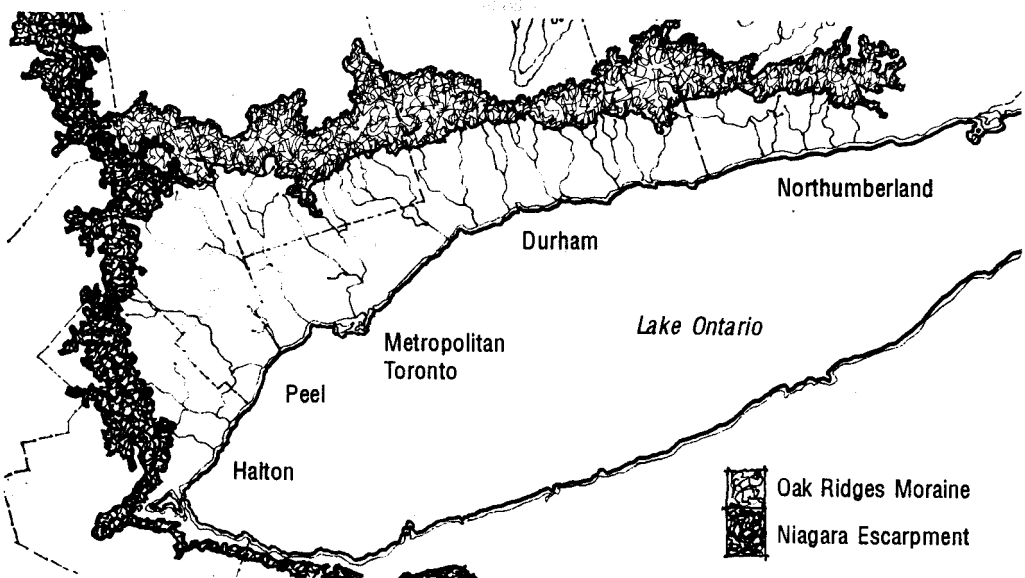
Stormwater Management

APPENDIX

INTRODUCTION

Along the Lake Ontario shoreline and in the Greater Toronto Bioregion, urban development and extensive engineering have fragmented the natural environments that once existed. Only a patchwork of woods, meadows, wetlands, and riparian habitats remain, many of them isolated and in need of protection, or in a seriously disturbed condition. This manual addresses those habitats most likely to be found along the Lake Ontario Waterfront Trail between Hamilton and Trenton and within the valleys, natural areas and urbanizing lands that link the lakeshore to the Greater Toronto Bioregion.

Ongoing planning work in the province is being undertaken to establish priority habitats for restoration, together with a wealth of research and practical programs that are being initiated by citizen groups, professionals, and municipalities. This manual brings together some of this knowledge and experience and provides a starting point for restoration initiatives in a field that is continually evolving.



Greater Toronto Bioregion

1.1 THE PURPOSE OF THE MANUAL

This is a how-to manual. Designed to provide assistance in preparing restoration and management plans, it also outlines techniques for implementing them. It has been prepared for both professionals and non-professionals who may be required or want to do restoration work. Individuals and organizations likely to find this manual useful include:

- anyone planning and carrying out restoration projects, such as public and private landowners, government agencies, developers, community groups and environmental consultants;
- those reviewing restoration projects, such as municipal planners and local politicians;
- those looking for reference and educational material, such as students, consultants and the general public.

1.2 THE NATURE OF LANDSCAPE RESTORATION

Ecological restoration consists of re-establishing biological diversity and resilience to land and its life processes that have been seriously disturbed or destroyed, usually by human intervention. The need for restoration is one of the most important environmental issues of our day and is a consequence of many factors including a growing awareness of the role of natural processes in urbanization, its connections to sustainability and the quality of life, and community concerns and commitments to healing environmental ills of the past.

In its purest form, restoration means returning disturbed natural communities to their original state. In practice, however, such goals cannot be achieved in environments that have been infinitely complicated by human intervention. Farming, changes to physiography, soils and drainage, the introduction of domesticated animals and alien plants and urban activities have upset successional and interactive processes that once existed. In some situations, restoration may come close to achieving a semblance of endemic conditions. In others, it will not be possible to do so, although the diversity and natural quality achieved will be a marked improvement over what existed before.

Ecological restoration is a process that begins with nature, but recognizes the realities of human culture and intervention. It involves a continuum of interrelationships between natural processes, the human environment, cultural history, planning, design and management, and its practice and implementation is tied to a partnership of community groups, government agencies and the private sector.

1.3 PRINCIPLES OF LANDSCAPE RESTORATION

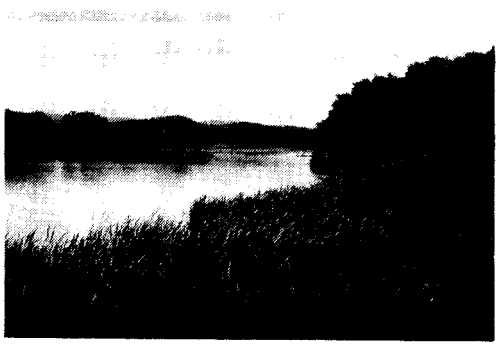
Guiding principles to be followed in ecological restoration are practical ones.

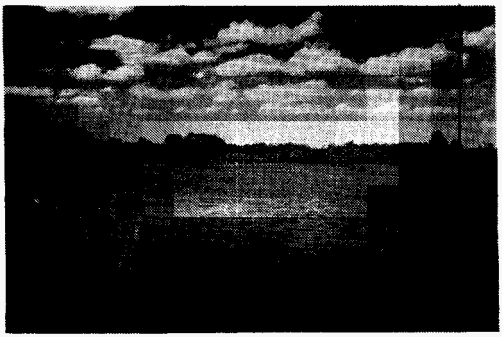
Respect regional identity

Landscape restoration should reflect the natural and cultural character of a region—those inherent qualities and conditions that make one place different from another. This is fundamental to the restoration process, which is based on reintroducing features indigenous to the local and regional landscape.

Recognize the unique ecological character of each site

It is important to have a thorough understanding of a site's special nature, including not only plant communities, wildlife and heritage features, but also hydrology, soils and microclimate. The latter ultimately determine the diversity, quality and character of the former.





Protect significant natural features

Detailed examination of a site may reveal physical, biological or cultural features that are locally or regionally significant. Restoration efforts should, as a priority, focus on protecting them.

Establish priorities for restoration efforts

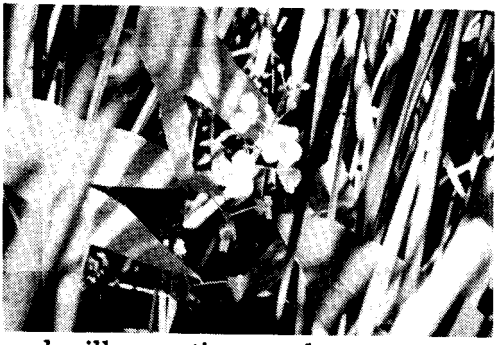
Focus restoration/enhancement where it will work and do the most good for the least cost.

Create low-maintenance, ecologically self-sustaining solutions

In an economic climate of dwindling budgets, restoration strategies need to focus on ecologically self-sustaining solutions that minimize human intervention. Approaches that mimic natural processes are, therefore, more likely to succeed than those that involve high levels of human effort and financial resources.

The natural regeneration of complex biotic communities on disturbed sites provides important lessons for establishing natural areas. The evolution of the Leslie Street Spit from recent lake fill to a complex ecosystem of plants and animals is one example where natural-succession processes have created remarkably rich natural communities in a very short time.

Use native species



To maintain biodiversity, it is best to plant native species grown from local seed sources.

The usual focus of the landscaping industry on cultivated plants might limit the availability of some native species. Changes in demand, however, are creating shifts in the trade and will, over time, make native plants more available. The industry is also developing expertise in the installation, maintenance and management of restoration initiatives.

Accommodate human use

Restoration design must accommodate human uses where they are likely to occur. Trails, boardwalks, viewing stations and activity areas can control uses and limit them to appropriate locations. It is important to determine patterns of human activity early in the planning process to avoid interference with restoration efforts.

1.4 How to Use This Manual

The manual outlines the steps needed to implement an ecological restoration program. It includes:

- how to evaluate diverse types of landscape habitat;
- how to identify restoration opportunities associated with various kinds of disturbance;
- what measures should be taken to protect and/or restore different habitats;
- specific implementation techniques and design criteria to be considered for protection, restoration, and ongoing management.

This guide offers a logical sequence of procedures and decision-making steps in the restoration process. The reader should note the use of icons to denote important problem areas, reality checks, and cautionary considerations. In reading the following chapters, please note the following icons.

Reality Check

Caution

Community Involvement

The manual provides details on the four most common types of habitat likely to be found in the Greater Toronto Bioregion:

- wetlands (lakeshore, river mouth, inland types);
- meadows and grasslands;
- woodlands/forest;
- riparian (streams, river edge and shoreline habitats).

It does not deal with more specialized habitats such as bogs, fens, alvars, prairies and dunes, although some of these are discussed briefly. The user should look to other relevant sources for guidance in restoring these habitats. Some references are provided in the Appendix.

Five easy steps to a restoration plan

The manual is arranged in a series of sections outlining the best approach to restoration and detailing five steps required to produce documents, obtain approvals, and implement and manage the project. Section 2 explains these steps.

Step 1 Determine regional contexts
(natural, human influences, heritage, jurisdictional, political, watershed, planning)

Step 2 Inventory and evaluate site conditions
(protection/restoration opportunities, ecosystem functions)

Step 3 Set restoration objectives
(protection, restoration, management, community involvement)

Step 4 Draw up the restoration plan

Step 5 Implement, manage and monitor

Sections 3 through 6 contain specific detailed approaches and technical information for restoring the four most common habitat types.

- Section 3 - wetlands
- Section 4 - meadows and prairies
- Section 5 - woodlands
- Section 6 - riparian habitat

Pits and quarries (Section 7) are used as an example of how a severely affected site can be restored to a self-sustaining natural area with a variety of habitats.

Stormwater ponds (Section 8), which are often incorporated into urban developments, provide an opportunity to protect waterways and, if carefully designed, provide wildlife habitat.

Resulting products

The key steps and products in preparing a restoration strategy are summarized in the accompanying table. The left column provides an example of a brief report outline and the right column lists illustrative material that may accompany a restoration report. By following the five-step process, you will end up with the information needed to prepare a restoration report, drawings, and plans.

Sample Restoration Report Outline

	REPORT	ILLUSTRATIVE MATERIAL
	Introduction ◆ the purpose of the document; ◆ site location and general site description.	
STEP 1	*Determine Regional Context* a) What do planning documents say about the site and surrounding areas? b) How does the site fit within regional ecological goals? c) How do the site's natural and cultural features link with the larger natural context? d) What are the policy requirements?	*Context maps* ◆ site location/regional context; ◆ context plan with surrounding natural and man-made features; ◆ ownership patterns/jurisdictions.

STEP 2	*Inventory and Evaluate Site Conditions* a) Reading the landscape and its function: ◆ surrounding landscape types; ◆ immediately adjacent habitats; ◆ on-site physical conditions (topography, soil types, drainage characteristics); ◆ habitat types, characteristics, condition (woodland, wetland, meadow, riparian, river mouth, shoreline); ◆ access, man-made features and human use. b) Assessing the significance of the landscape: ● ecological age, native species, habitat size, continuity, rarity, diversity.	*Site inventory maps* ◆ natural, human-made features; ◆ ecological conditions of habitats; ◆ evaluation notes. *Photos* ◆ accompanying photos of site (panoramic, specific habitats); ◆ aerial photographs.
STEP 3	*Set Restoration Objectives* a) General considerations. b) Implications of current conditions. c) Establishing restoration opportunities and benefits. d) Ensuring restoration objectives are realistic.	
STEP 4	*Draw up the Restoration Plan* a) Physical layout of restoration areas. b) Protecting significant habitat. c) Identify what habitats to enhance and where to create new habitats. d) Human access and impacts. e) Restoring degraded habitats. f) Prepare the detailed restoration plan.	*Restoration drawings and documents* ◆ overall protection/restoration concept; ◆ detailed design showing existing natural features, areas of natural succession, planting zones and public access and trails; ◆ sketches for educational/ interpretive features.
STEP 5	*Implement, Manage and Monitor* a) Implement the restoration plan: ◆ installation. b) Prepare management plan: ◆ short-term management (maintenance practices during establishment phase); ◆ long-term management (periodic intervention required to manage and/or maintain habitats). c) Monitoring.	*Contract documents* ◆ detailed working drawings; ● technical specifications. *Management plan* ◆ detailed plan showing specific management treatments for different site areas.

DEVELOPING A RESTORATION STRATEGY

The evaluation of a specific site and its regional and local context are key steps in the restoration process. The regional context considers adjacent lands and ecosystems and will indicate the limitations and opportunities for restoration. These physical conditions in combination with the planning or policy environment will set the overall direction for restoration. The site inventory and evaluation consists of a detailed description of the site and adjacent lands, assessment of habitat significance, and the need or potential for restoration. It lays the framework for setting objectives and developing the plan.

STEP 1 DETERMINE REGIONAL CONTEXT

No site can be understood in isolation. The purpose of this step is to focus attention on how the property fits into its larger regional and local context—the biophysical and cultural features, urban and rural land uses, service corridors, official plans and policies of the area.

Step 1 contributes to the following elements of the restoration plan:

	REPORT	ILLUSTRATIVE MATERIAL
	Introduction	
STEP 1	*Determine Regional Context* a) What do planning documents say about the site and surrounding areas? b) How does the site fit within regional ecological goals? c) How do the site's natural and cultural features link with the larger context? d) What are the policy requirements?	*Context maps* ◆ site location/regional context; ◆ context plan with surrounding natural and man-made features; ◆ ownership patterns/jurisdictions.
STEP 2	*Inventory and Evaluate Site Conditions*	*Site inventory maps* *Photos*
STEP 3	*Set Restoration Objectives*	
STEP 4	*Draw up Restoration Plan*	*Restoration drawings and documents*
STEP 5	*Implement, Manage and Monitor*	*Contract Documents* *Management plan*

a) What do planning documents say about the site and surrounding areas?

To understand the site within its regional context, examine existing studies and plans that might provide an overall context for restoration initiatives. These could include:

- watershed studies (conservation authorities);
- regional and municipal official plans;
- waterfront studies, such as the Lake Ontario Greenway Strategy (Waterfront Regeneration Trust) or municipal waterfront planning studies;
- regional planning studies, such as the Oak Ridges Moraine studies (Ministry of Natural Resources).

Reality Check

Such planning documents are often broad in scope, and might not include specific regional goals for restoration.

Ideally, regional (and bioregional) goals for protection and restoration should include a representation of all habitat types in each stage of succession. It is, therefore, advisable to ask agencies such as the Waterfront Regeneration Trust, Ministry of Natural Resources, or local conservation authority whether or not a bioregional habitat priorities study or similar document exists. Such a study would identify existing habitats and those that have disappeared from the landscape, and could help to focus restoration efforts to create the most value for the bioregion.

b) How does the site fit within regional ecological goals?

When evaluating a site, focus on the regional significance of its habitats and consider the following questions. Does it:

- satisfy regional priorities and targets for specific areas or habitat types? (these may be found in the documents listed above)
- link existing natural features and reduce fragmentation?
- complete or reinforce riparian habitat and other biological corridors?
- increase regional or local diversity of habitat?
- re-establish habitat(s) where none exists?

- provide buffers between significant natural features and existing or proposed land uses?
- provide educational initiatives for direct involvement by the public and existing communities?

c) How do the site's natural and cultural features link with the larger context?

A review of the site's natural attributes within its regional and local context may identify important opportunities to integrate it with surrounding natural and cultural areas. Consider the following possibilities.

- Are there water features, such as streams, rivers, ponds, lakes, wetlands, on the site or nearby?
- Are there other features of regional or local significance such as old-growth woodland, geological formations, groundwater reserves on site or in adjacent areas?
- Are there significant and/or designated cultural, historic, or archeological sites present?
- What is the zoning of the adjacent lands? Are existing natural features protected?

Air photos and topographic maps are useful tools for assessing regional and local character and gaining a general understanding of the relationship of the site to its surroundings. Official plans can shed light on zoning, the ultimate use of surrounding lands, and what natural features will be protected.

d) What are the policy requirements?

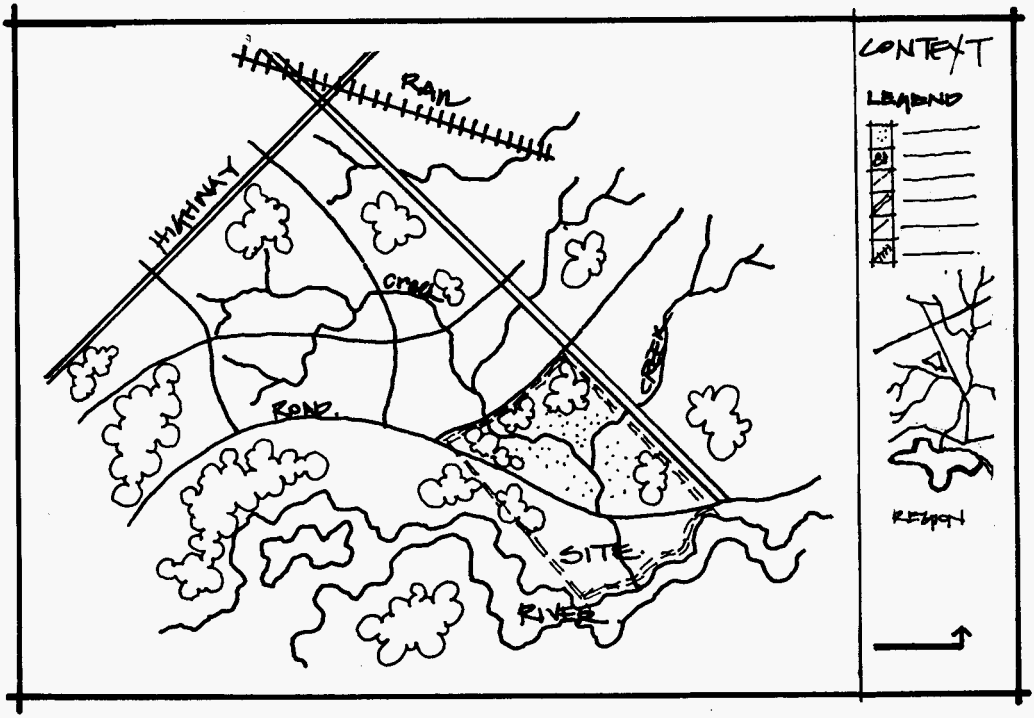
Policies and guidelines of the Planning Act are incorporated into regional and municipal official plans. These plans are important documents in guiding protection and restoration of natural habitats. Additional relevant information can be found in the policy statements. Natural Heritage, Environmental Protection and Hazard policies, and the Economic Community Development and Infrastructure policies contain important considerations for restoration.

Other applicable legislation includes the Fisheries Act. This statute protects fish habitat, which can be broadly defined as anything a fish species may require during its life cycle including water quality and quantity, substrate, aquatic and riparian vegetation, phytoplankton, zooplankton and macroinvertebrates. The goal of the associated policy is to achieve a net gain in fish habitat.

In addition to these acts and policy statements, conservation authorities may have specific regulations and guidelines on riparian habitats, and municipalities may have pertinent zoning by-laws and other caveats.

Step 1 Summary

The review of a site's larger context provides a key to understanding its significance from ecological, planning and policy points of view. Such a study reveals the constraints and opportunities that influence the site, provides direction for actions that should be taken, and reveals how the property can contribute to the health of the larger



Sample site context map

STEP 2 INVENTORY AND EVALUATE SITE CONDITIONS

Prior to embarking on a restoration project it is essential to understand how the ecological features of the site function, as well as the significance of different habitats, their relationship to present and proposed human uses, and how badly they have been disturbed. This step should be undertaken with the previous analysis of context in mind.

Step 2 contributes to the following elements of the restoration plan:

	REPORT	ILLUSTRATIVE MATERIAL
	Introduction	
STEP 1	*Determine Regional Context*	*Context maps*
STEP 2	*Inventory and Evaluate Site Conditions* a) Reading the landscape and its function: ◆ surrounding landscape types; ◆ immediately adjacent habitats; ◆ on-site physical conditions (topography, soil types, drainage characteristics); ◆ habitat types, characteristics, condition (woodland, wetland, meadow, riparian, river mouth, shoreline). b) Assessing the significance of the landscape: ◆ ecological age; ◆ native species; ◆ habitat size; ◆ continuity; ◆ rarity; ◆ diversity.	*Site inventory plan* ◆ natural, human-made features; ◆ ecological conditions of habitats; ◆ evaluation notes. *Photos* ◆ accompanying photos of site (panoramic, specific habitats); ◆ aerial photographs.
STEP 3	*Set Restoration Objectives*	
STEP 4	*Draw up the Restoration Plan*	*Restoration drawings and documents*
STEP 5	*Implement, Manage and Monitor*	*Contract documents* *Management plan*

a) Reading the landscape and its function

The following checklist will help identify the characteristics, physical conditions, and types of habitat on the site and surrounding lands. These will influence the possibilities and nature of the proposed restoration.

I. Identify the predominant type of surrounding landscape (arranged from most to least disturbed):

- residential/commercial;
- industrial/utility;
- rural village;
- agricultural area;
- natural area;
- other.

Although there may be similar habitats in several landscapes, they may function differently. In urban areas, the habitat will be subjected to stresses by humans, pets, and introduced plant species, and will likely support only very common plants and animals. This does not lessen the importance of these habitats, however. They can be extremely valuable locally, but have less priority than more regionally important sites. At the other end of the scale, there is potential to provide or enhance habitat for forest-interior and area-sensitive species in forested landscapes.

II. Identify the immediately adjacent habitat:

- urban;
- row crops;
- manicured park or cemetery;
- hay or pasture;
- pits with cooperative rehabilitation plans;
- herbaceous meadow;
- shrub meadow;
- forest;
- wetland;
- other.

This will indicate whether or not there are opportunities to enlarge an existing natural area or if the site is constrained by adjacent land uses.

If the habitat is isolated by adjacent land uses, determine the distance to the nearest natural area that is 4 ha in area or larger:

- > 2 km
- 1.5 to 2 km
- 1 to 1.5 km
- 0.5 to 1 km
- < 0.5 km

The farther the site is from adjacent natural patches, the more it will have to function on its own, with limited plant and wildlife recruitment from external sources. Areas within 500 m of an adjacent patch will support a greater diversity of species than an isolated area of the same size.

Is the area:

- isolated from adjacent natural areas?
- connected by:
  - → a narrow grassy fencerow;
  - → a shrubby or treed fencerow 5 m wide or less;
  - → a vegetated corridor 5 to 30 m wide;
  - → a vegetated corridor 30 to 100 m wide;
  - → a vegetated corridor wider than 100 m;
  - → a first- or second-order stream;
  - → a third- or greater-order stream?

Chapter 3 of *Ecological Restoration Opportunities for the Lake Ontario Greenway* provides a discussion on corridors and wildlife species likely to use them.

Corridors:

- provide habitat for certain species, some of which may not occur in adjacent habitats;
- facilitate movement of plants and animals through the landscape;
- act as a filter or barrier to species movement;
- may be a boundary to home ranges, and may increase wildlife diversity by creating visual boundaries between territorial birds.

Corridors also result in more soil moisture, more organic matter in the soil, and changes in wind and solar radiation.

Urban corridors are beneficial because they provide habitat for species that might otherwise be absent. Common wildlife species such as White-Footed Mouse and Eastern Chipmunk will use them to move between habitat patches.

In rural areas, narrow corridors have the potential to guide predators into connected natural areas, potentially reducing the reproductive success of more sensitive species. It has been suggested that rural corridors should be at least 100 m wide. Streams and stream corridors frequently have a dual function, acting as travelways for wildlife and providing a hydrological connection and flow of nutrients through the site.

By characterizing a site using the above checklists and consulting the *Ecological Restoration Opportunities for the Lake Ontario Greenway* report, you should be able to predict how your site will interact with the broader landscape, and what opportunities and constraints exist.

III. Determine the on-site physical conditions that present opportunities and constraints for landscape restoration.

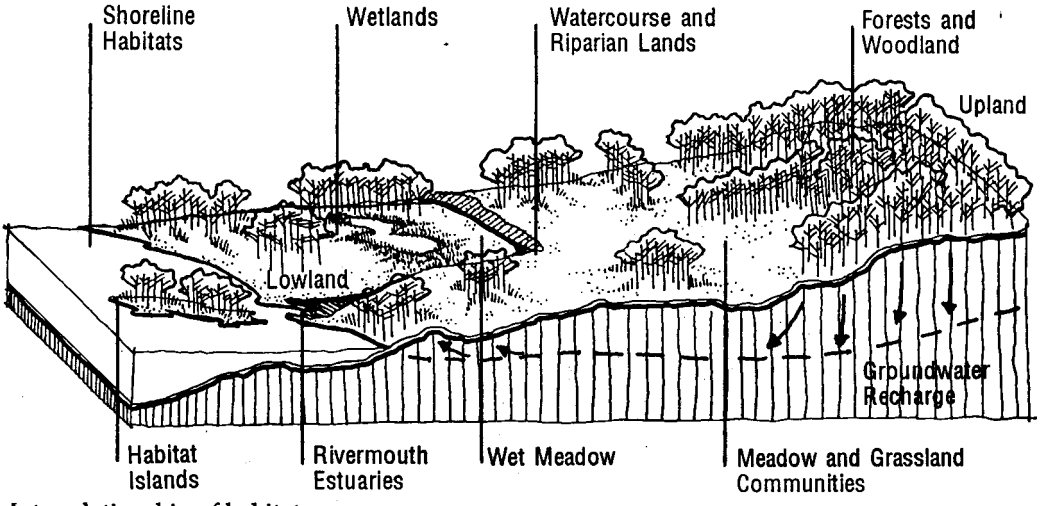
Certain physical (abiotic) features are critical in determining what plant and wildlife communities an area can support. These factors are listed in the following table.

FACTOR	*CONDITION*	*IMPLICATION*
SOIL DRAINAGE	• well drained (gravel, coarse sand, silt, loam till)	• upland
	• imperfectly drained (alluvium, silt loam, clay loam)	• possibly a combination of upland and wetland
	• poorly drained (clay, fine sand over clay)	• wetland
SOIL DEPTH	• deep	• will support a wide variety of plant species
	• shallow to bedrock	• favourable for grasslands and prairies
SOIL FERTILITY	• fertile	• will support a wide variety of plant species
	• infertile	• favourable for grasslands and prairies
TOPOGRAPHY	• steep	• potential erosion problems, opportunities for habitat diversity
	• rolling	• opportunity for wide variety of habitats and species
	• flat	• less diversity in soils, drainage, and micro-habitat

SLOPE	◆ south facing	◆ warm microclimate
	◆ east	◆ cold microclimate
	◆ north	◆ cold microclimate
	◆ west	◆ warm microclimate, but may be affected by dominant winds
WATER	◆ absent	◆ upland, but potential for isolated marsh if soils are poorly drained
	◆ standing for 3 to 4 months or more	◆ potential wetland
	◆ running	◆ potential for riparian and/or marsh habitat
	◆ seeping	◆ potential for wide variety of wetland and riparian species

Information on streams and other aquatic habitats is often available from the Ministry of Natural Resources. Ministry staff may also assist in interpreting the effects that abiotic features can have on biological resources. Groundwater movement can frequently be determined from visual clues such as springs, cold streams, or up-swelling areas in watercourses. Alternatively, the groundwater regime can be determined by examining maps of aquifers and existing data on boreholes and wells.

Groundwater at or near the surface provides unique opportunities for habitat restoration and enhancement. It results in a cool microhabitat that has the potential to support specialist plant, fish, wildlife and aquatic invertebrate species.



Interrelationship of habitats

Saturated soils sustain wetland communities, depending on the type of soil, the length of time soils are flooded, and the amount and type of water reaching them.

IV. Identify the habitats present on the site and evaluate their quality.

The resulting information, coupled with your knowledge of relevant abiotic factors will help you focus on potential opportunities for habitat rehabilitation and creation.

The most common habitats likely to be encountered in the Greater Toronto Bioregion include:

- woodlands and forests;
- wetlands;
- meadow and grassland communities;
- watercourses and adjacent riparian lands;
- river mouths and estuaries;
- natural shoreline habitats.

Woodlands and forests

Continuous forest was the major habitat type in the Greater Toronto Bioregion prior to settlement. Fragmentation has since resulted in the creation of patches, affecting the size and age of stands and overall ecological functioning. Where there once were forests, only isolated woodlands remain. The main factors influencing woodland character are soil texture, hydrology (which influences soil moisture levels), age and size of the stand. Major woodlands consist of deciduous, mixed deciduous/evergreen, and evergreen stands in either upland or lowland conditions.

Woodland structure can indicate the relative health and renewal capabilities of the stand. To assess structure, investigate the presence or absence of the following.

- Closed or semi-closed canopy of large mature deciduous and occasional coniferous trees. A closed canopy creates shade, which

eliminates many woody plants and favours the colonization by more specialist plant species. A closed canopy is also required for most forest-dependent wildlife species. The more mature the woodland, the greater the diversity of plant and wildlife species it will support. Some wildlife species, such as those that use cavities, require mature trees. The presence of some coniferous trees increases diversity and provides habitat for some specialist wildlife species.

- Understorey vegetation. The ground layer of vegetation reduces the potential for erosion, ameliorates the microclimate of the woodland floor, and provides food and cover for wildlife. It may disappear due to grazing, soil compaction, or very dense shrubs or saplings.

- Shrubs. A diversity of layers is important for bird species that nest at different heights from the ground. Rotting trees function as rich micro-habitats and are frequently used by cavity nesting birds. Ruffed Grouse may also use logs as drumming sites. The duff layer is rich in organic matter and is an excellent rooting medium.

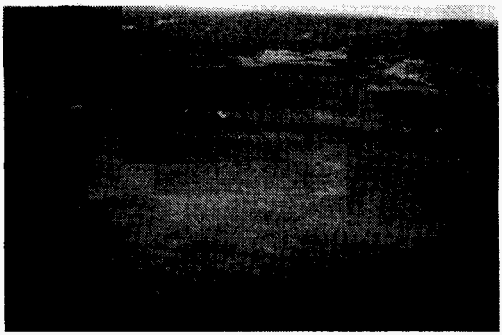
- Size and shape of woodland and presence of interior or edge species of birds, mammals and other fauna. Some wildlife species avoid edges and are usually found 100—200 m or farther from an edge. Therefore, the size and shape of woodlands determine the amount of habitat available for these species.

Wetlands

The four primary types of wetland are marshes, bogs, fens, and swamps.

Marshes lend themselves well to restoration and habitat creation. Most marshes contain standing water most of the time. They are vegetated predominantly with non-woody plants

such as cattails, grasses, sedges and submergent species. Marshes are dynamic ecosystems that depend on fluctuating water levels and relatively high inputs of nutrients. A large proportion of Ontario's fish and wildlife species depend on marshes for some facet of their life history. Marshes may also perform other functions such as erosion control, sediment removal, and water quality improvement.



Bogs are acidic, nutrient-poor wetlands that receive most of their nutrients and water from precipitation. They have a ground layer of sphagnum moss, and the dominant vascular plants are adapted to acidic conditions, or are evergreen so that photosynthesis can take place year round. Carnivorous plants such as sundews and pitcher plants, which do not rely on soil nutrients, may be common. Open bogs are dominated by sedges and shrubs such as leatherleaf, Labrador tea, laurels and blueberries. Treed bogs have a similar understorey with a relatively open canopy of black spruce and tamarack. Bogs are sensitive to changes in water level and nutrient inputs and are not readily enhanced or created.

Fens receive most of their water and nutrients from groundwater. They can either be acidic, with vegetation communities very similar to bogs, or alkaline. Acidic fens may also be dominated by sedges. Calcareous fens may have an understorey that includes plants such as variegated scouring-rush, hooded ladies-tresses, and Kalm's lobelia. White cedar is the dominant tree in calcareous fens. Fens are also difficult to rehabilitate or create, but unique opportunities for them may exist when restoring pits or quarries connected with the water table.

Swamps receive water from overland flow, often including watercourses, and frequently from groundwater. They may contain standing water most of the year, or may be wet only for short periods of time. They are characterized by shrub or tree cover. Common shrubs are red osier dogwood, buttonbush, willows and speckled alder. A variety of trees may dominate swamps, including willows, red and silver maple, white and black ash, white elm, bur oak, cedar, tamarack, and black spruce. Swamps can be enhanced or created by planting appropriate shrub and tree species in damp soils.

For a more complete description of wetlands, refer to the *Wetlands Evaluation System for Southern Ontario*, prepared by MNR. This manual deals with marshes in the wetlands section and swamps in the woodlands section.

Meadow and grassland communities

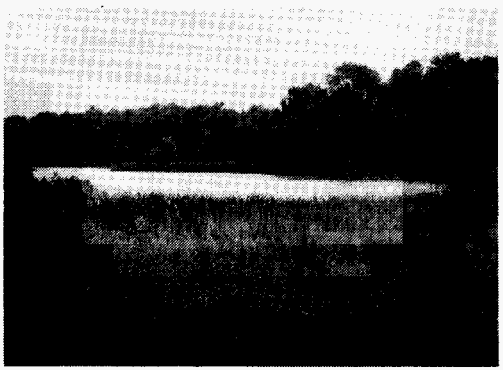
Meadows are diverse habitats of grasses and wildflowers. They occur as stable plant communities in the floodplains of rivers and streams and adjacent to wetlands. Most areas comprising grasses and wildflowers are in reality old field communities that evolve largely from human disturbance, such as abandoned agricultural fields, waste places, or naturalized turfed areas. Such diverse successional habitats of grasses and wildflowers include both native and introduced species and will eventually progress naturally into woodland if left undisturbed. However, many are fairly stable and may persist for decades. Old field communities are host to small mammals and a wide variety of birds, and consequently provide important habitat diversity when mixed, and linked with other habitat types.

Oak savanna describes a plant community where the density of trees is so low that dominance is shared with grasses and other herbaceous vegetation. Tall-grass prairie is composed of many of the same species as oak savanna, but without the trees and understorey species characteristic of savanna. A few remnants of prairie and savanna remain in southern Ontario, occurring primarily along the old Lake Iroquois shoreline.

Watercourses and adjacent riparian lands

Streams and rivers form natural corridors connecting the urban areas along Lake Ontario with natural features in the rural hinterland. Wooded valley slopes are among the few natural habitats that provide continuity and linkages in the Greater Toronto area. Their function as corridors for wildlife movement is, therefore, critical.

The character of stream and river corridors varies with the size of the stream and the form and width of the valley or surrounding lands. Both deciduous and coniferous woodland plant communities (i.e., hemlock or pine stands) are associated with river valleys. In bottomland areas, plant communities are characteristic of riparian zones and may include lowland forest, wet meadows and wetland areas. The amount of riparian forest cover also affects critical ecological functions, such as protection of headwater flows, the maintenance of cold water streams and fish habitats, and the maintenance of ground and surface waters.

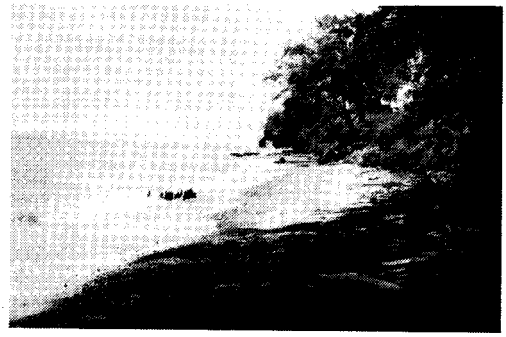


River mouths and estuaries

River mouths and estuaries are zones where a variety of site conditions converge to form highly complex environments. Where the river enters the shoreline zone, it widens to form the river mouth and estuaries. Riparian habitat occurs along the banks of the river, shoreline habitat

along Lake Ontario. Often these zones contain wetlands, wet meadows, and woodland vegetation.

Natural shoreline habitats



Natural shorelines are dynamic zones. Topography, sediment type, and wave action have resulted in a range of distinct shoreline types, which include sandy beach communities, dunes, barrier beaches, and shoreline bluffs. Sandy beach communities along the waterfront are typically dominated by grass, herb and shrub associations. Dune vegetation is similar to that of beaches, though in early stages of succession, dunes are unstable due to low vegetative cover. They occur in a few waterfront locations.

Forested barrier beaches are constantly exposed to natural disturbance associated with storms. Lake winds, wave action, shifting sands give rise to an environment in constant transition. Plants, therefore, are typically tough, and include early pioneer species such as willows, poplars, and dogwoods.

Shoreline bluffs or cliffs are environments where areas in close proximity may exhibit considerable differences in growing conditions. Exposed soils give rise to differences in soil types and drainage characteristics at the bluff face. These differences create variations in growing conditions for vegetation on these slopes. In areas prone to natural disturbance, such as slumping and eroding cliffs, vegetation consists primarily of herbaceous species. In more stable areas woodland species are the climax vegetation.

For information on other habitat types see *Ecological Restoration Opportunities for the Lake Ontario Greenway* (June 1994, Waterfront Regeneration Trust).

The following organizations may also be able to provide information:

- Natural Heritage Information Centre
  P.O. Box 7000, Peterborough, Ontario K9J 8M5.
- Natural Habitat Restoration Project
  Essex Region Conservation Authority
  380 Fairview Avenue West, Essex, Ontario N8M 1Y6
- Society for Ecological Restoration, Ontario Chapter
  P.O. Box 93, Schomburg, Ontario L0G 1T0

V. Ecological Land Classification

In preparing vegetation and animal inventories, it may be useful to tie in to the ecological land classification currently being compiled by MNR. The project will create a comprehensive database for the description, classification and inventory of ecosystems at local, regional and provincial levels and is intended to provide comprehensive geographical coverage. All types of ecosystems are included, as well as different successional stages.

b) Assessing the significance of the landscape

It is important to recognize the significance of various habitat types in the Greater Toronto Bioregion—how they function ecologically and the types of disturbance that affect their functioning. Opportunities for both protecting and rehabilitating them must be understood. Significant natural heritage features are now defined under the Planning Act as those natural features and functions that are "ecologically important to the natural environment in terms of amount, content, representation, or effect, thereby contributing to the quality and integrity of an identifiable ecological region or natural heritage system". A cultural heritage landscape is defined as "a landscape which has been altered through human activity and has been identified as being important to a community".

Many other techniques have been used to measure landscape significance or the degree to which habitats are undisturbed. Among these are the following.

Ecological age

This technique assumes that older habitats are more valued than young ones, since they are the product of a longer and less replicable process. Older habitats tend to be more resilient to invasion by non-native species. To illustrate, a woodlot dominated by old hardwood trees (100 years of age) is assumed to be of higher value than an old field (5 years of age). This is not to ignore the fact that old fields are necessary for overall habitat diversity, or that there are species that depend on these habitats.

Native species

With this approach, inventories of plants are compiled to determine which species are present on a site and whether they are native or introduced. Those areas with the highest percentage of native species are considered to be the most natural. Inventories are useful in determining existing plant diversity, plant associations, and the nature of wildlife habitat on the site. Plant associations are indicative of soil conditions and especially moisture levels. For sites that are relatively undisturbed, plant inventories should be carried out over several seasons in order to be truly comprehensive and to assess whether rare species are present. While this approach is time consuming and requires skilled field work, a plant inventory will tell much about the site, the significance of the existing plant community and wildlife habitat, and the possibilities for restoration or enhancement.

Habitat Size

Generally, the larger the size of a habitat type, the more diverse will be the plant and animal species found there. To illustrate, the size and area of a woodland interior and the extent of its edge will determine the presence and diversity of both interior and edge species. For instance:

- woodland areas as small as 0.1 hectare will attract common species of breeding birds adapted to disturbance, predation and parasitism (Song and Chipping Sparrows, House Wren, American Robin, American Goldfinch). These patches may also support small mammals (i.e., deer mouse, vole, shrew, chipmunk) provided there are connections to other natural habitats;

- 1.0 hectare woodlands may support some common forest-dependent species (Eastern Wood-Pewee, Northern Oriole, Blue Jay, Grey Squirrel). Some forest-dependent plants may pioneer in these small woodlands (Enchanter's nightshade, violets, trout lily, Jack-in-the-pulpit);
- 4.0 hectare woodlands begin to attract common forest edge birds (Downy Woodpecker, Great Crested Flycatcher). These birds understand such a habitat size as pure edge with no interior habitat. Hardy and aggressive forest-dependent plants will do well in a 4.0 hectare woodland;
- 10 hectare woodlands may have some areas greater than 100 metres from the edge and may support some forest interior species (Hairy Woodpecker, White-Breasted Nuthatch). There is also a greater diversity of shade tolerant plants;
- 50 to 75 hectare woodlands provide habitat for almost all forest-dependent birds except those with very large home ranges;
- 100 hectares and larger woodlands can support almost all forest-dependent birds, but many will have very low populations.

Habitat Continuity

Continuous individual habitats (valleys and streams, wetlands, woodlands, meadows and shorelines) act as corridors that allow movement of terrestrial and aquatic animals and plants, and the flow of water and nutrients from one place to another. Two habitats in close proximity, or connected to one another, are richer in species and support more wildlife than those that are isolated. The wider the corridor, the more effective it is. Corridors as wide as 50 metres facilitate movement of only common species, while specialist species require widths of 100 to 500 metres.

Habitat Rarity

The abundance of individual habitat types in a landscape should be considered. Habitats may be rare because they depend upon an unusual combination of abiotic features, or because a large proportion of them have been converted to other land uses. Bogs and fens are rare in southern Ontario primarily because of their special nutrient and water requirements; they are the predominant habitats on the Hudson Bay Lowland, where upland forests are rare. In

settled landscapes, formerly common habitats (cedar swamps, mature upland forest, etc.) may be rare.

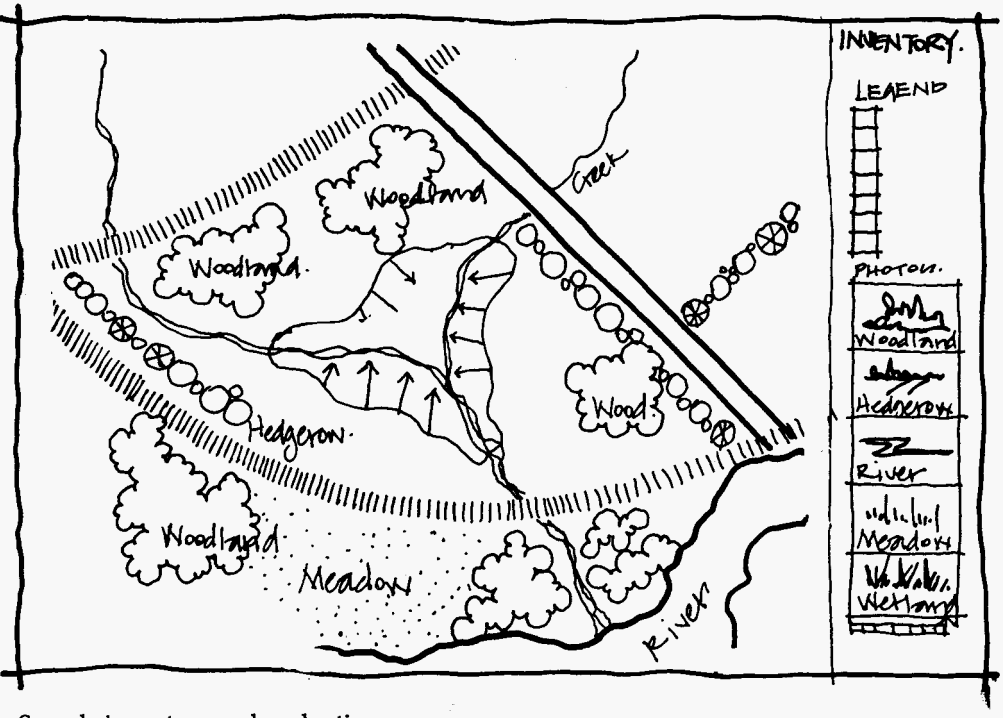
Rare habitats should have high priority for preservation and rehabilitation. They maintain biodiversity in a landscape, frequently support populations of rare species, and may represent the outer extent of some species' range. In these cases, they may even support species genetically distinct from the main population.

Habitat diversity

The greater the variety of habitats, the greater the number of plant and wildlife species an area will support. Habitat diversity refers not only to different vegetation communities, but also to different ages and structures of the same general habitat type. For instance, different plant and wildlife species inhabit immature, intermediate-aged, and mature hardwood forests. Habitat diversity also provides resiliency and protection from natural catastrophes, such as fire, drought, Dutch elm disease, sweet chestnut blight, etc. Rehabilitation efforts should strive to enhance habitat diversity. A mix of different habitats provides considerably greater ecological diversity, variety of species and visual interest than a homogeneous expanse.

Step 2 Summary

Discovering how different types of landscapes function ecologically and deciding their significance are important in determining what should be restored, what kind of restoration is appropriate, and what should be left alone. The completion of this step should provide a clear understanding of the site's natural processes and the implications of possible intervention and action. See the following sample inventory and evaluation map.



Sample inventory and evaluation map

STEP 3 SET RESTORATION OBJECTIVES

The restoration possibilities for a site depend on its current condition and on the vision of what it should become. Setting objectives, therefore, is a priority in achieving and guiding this vision and involves four sub-steps:

- general considerations;
- implications of current conditions;
- establishing restoration opportunities and benefits;
- ensuring that restoration objectives are realistic.

	REPORT	ILLUSTRATIVE MATERIALS
	Introduction	
STEP 1	*Determine Regional Context*	*Context maps*
STEP 2	*Inventory and Evaluate Site Conditions*	*Site inventory maps* *Photos*

STEP 3	*Set Restoration Objectives* a) General considerations. b) Implications of current conditions. c) Establishing restoration opportunities and benefits. d) Ensuring restoration objectives are realistic.	
STEP 4	*Draw up the Restoration Plan*	*Restoration drawings and documents*
STEP 5	*Implement, Manage and Monitor*	*Contract documents* *Management plan*

a) General considerations

Restoration objectives reflect proactive ideas about how a degraded site can be returned to an ecologically healthy condition, in balance with human uses and site history. In setting objectives, therefore, consider the following:

- some plant and wildlife communities are better left alone;
- some require remedial action to halt further degradation or to return them to health;
- a great majority of restoration projects in southern Ontario will be associated with various levels of urbanization and culturally modified landscapes. Educational experiences in natural settings become, therefore, important objectives;
- many highly developed urban sites will not be restorable to a purely natural state. Objectives in such situations may focus on diversifying existing conditions to enhance biological resilience and sustainability, in context with human uses and cultural features (i.e., a park where continuous mown turf can be diversified with meadow and woodland associations);
- objectives will of necessity be modified as circumstances change and as the plan progresses;
- objectives may reflect a single priority (i.e., wildlife habitat, a special vegetation community, passive recreation, environmental education) or multiple priorities. In the latter case, ensure that potential conflicts between objectives are resolved early;
- if necessary, property ownership and responsibility for short- and long-term management should be resolved prior to finalizing objectives and the restoration plan.

b) Implications of Current Conditions

Knowledge of the interrelationships of plants, terrestrial and aquatic wildlife, and abiotic factors can be used to reach conclusions about which areas to protect and which to restore (see discussion in Step 2) and/or actions to be taken. The following table summarizes this information.

SITE COMPONENT	*TYPE OF INVESTIGATION*	*PURPOSE*	*CONCLUSIONS AND/OR ACTION*
VEGETATION INDICATORS	◆ plant surveys ◆ soil surveys ◆ landform surveys	◆ identify plant communities; ◆ identify factors governing existing vegetation.	◆ identify, delineate and buffer areas of significant vegetation and identify areas where restoration would enhance or restore ecological integrity; ◆ delineate vegetation sensitive to changes in surrounding land use; reduce surrounding impacts.
TERRESTRIAL FAUNA INDICATORS	◆ breeding bird surveys ◆ reptile and amphibian surveys ◆ mammal surveys ◆ invertebrate surveys	◆ identify habitat elements important for wildlife: → a high diversity of concealing vegetation such as snags (e.g., for woodpeckers), leaf litter and fallen logs (wrens) → large, contiguous blocks of forest (forest interior birds) → adjacent wet areas (frogs, ducks) → connecting links (deer)	◆ determine the needs of significant species, so that buffers and corridors can be designed to encourage their survival; ◆ identify for restoration habitat elements that may be in short supply, difficult to access or vulnerable to change in surrounding land use.
AQUATIC INDICATORS	◆ fish surveys ◆ benthos surveys	◆ identify terrestrial and aquatic variables that affect aquatic resources (e.g., water temperature, which is affected by groundwater, density of vegetation around stream).	◆ determine significant species, what is necessary for their survival, and vulnerable aspects of habitat to identify restoration opportunities.
CULTURAL INDICATORS	◆ use surveys ◆ archaeological surveys ◆ visual surveys	◆ allow estimate of the extent of pathways and other high use areas; ◆ identify features most attractive to humans, assess human impact.	◆ identify, if possible, culturally, recreationally, and aesthetically valued features that should be maintained, enhanced or protected from over-use.

c) Establishing restoration opportunities and benefits

Once ecosystem form and function has been determined, look for restoration and enhancement opportunities and evaluate the benefits that emerge. Identifying these will provide a basis for formulating detailed restoration objectives.

OPPORTUNITY	*LANDSCAPE ACTIONS*	*OBJECTIVES*
RESTORE WATER REGIME	◆ landscape restoration of actively eroding area; ◆ natural design to replace channelized stream; ◆ stabilizing eroding stream bank; ◆ restoration of disrupted recharge area; naturalized restoration of erosion control works.	◆ improve water quality; ◆ reduce water temperature; ◆ increase biological production; ◆ increase natural habitat.
ENHANCE VEGETATION	◆ removal of invasive non-native plants and seed sources on site and in adjacent areas; ◆ increase size of buffers; ◆ reconnect natural areas and reduce fragmentation in the landscape; ◆ restore natural successional processes; ◆ enhance resilience of existing habitats.	◆ enhance wildlife habitat; ◆ create greater diversity of plant and animal communities.
EDUCATION	◆ assess areas of site that show natural processes; ◆ assess variety of habitats; ◆ assess rare or unique habitats; ◆ identify interesting physical conditions; ◆ identify natural heritage sites.	◆ create greater diversity of plant communities.
RECREATION	◆ identify scenic areas; ◆ identify variety of habitats; ◆ identify panoramic views; ◆ assess variety of bird and wildlife species; ◆ assess fishing opportunities; ◆ assess cultural and natural heritage sites.	◆ create greater diversity of plant communities.

Reality Check

Once restoration objectives have been listed in detail, check site constraints to determine their appropriateness or feasibility. Some constraints may limit or modify the final restoration strategy. Objectives may need to be revised accordingly (i.e., costs may outweigh benefits.)

- *Vegetation:*
  - → *what habitat types are involved and can these be restored? (i.e., is it a bog, fen, alvar, or other sensitive habitat type not suitable for restoration?);*

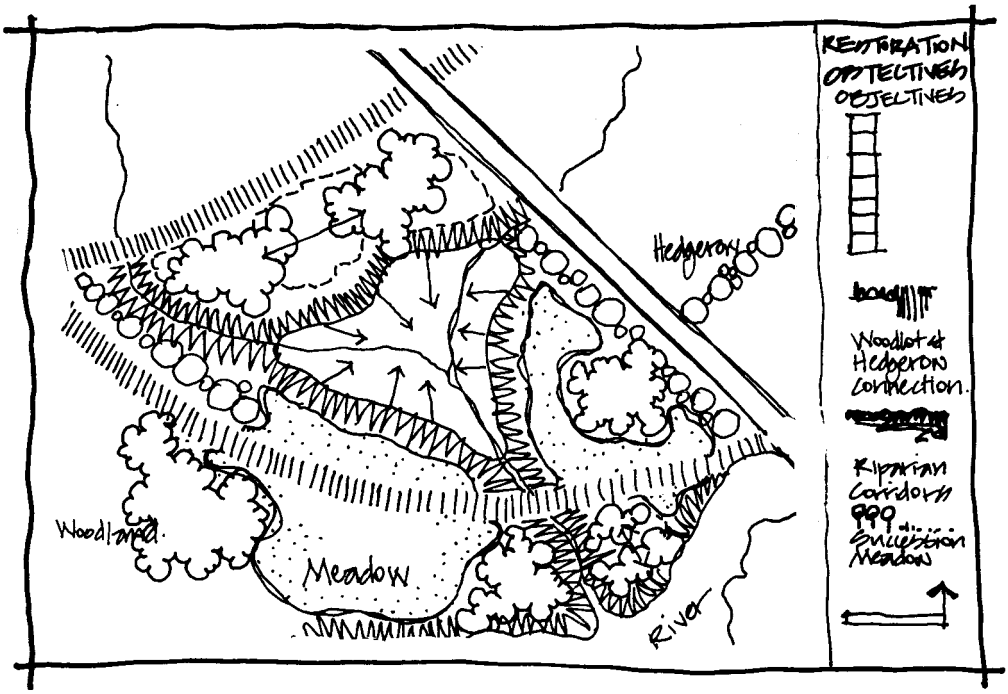
REALITY CHECK cont'd

- → *will damage occur to the natural environment as a result of restoration works?*
- → *will significant plants survive if restoration is carried out?*
- → *will proposed vegetation survive?*
- → *does a required seed source exist?*

- *Wildlife use:*
  - → *will significant animals survive proposed restoration?*
  - → *will wildlife be able to immigrate from surrounding areas?*
  - → *will human activities conflict with wildlife?*
- *Human use:*
  - → *will anticipated human traffic degrade restored habitat?*
  - → *will restoration be accepted?*
- *Cost:*
  - → *is there enough money for these objectives to be realistic?*
  - → *what is the cost of maintaining and managing the site after restoration?*
- *Existing physical/chemical conditions:*
  - → *are the underlying physical conditions present for long-term continuity of this habitat type?*
  - → *are soil conditions and moisture levels appropriate?*
- *Other considerations:*
  - → *will natural regeneration provide the same benefits as restoration and within an acceptable time frame?*
  - → *is the site accessible for carrying out restoration works?*
  - → *what impact do existing or proposed utilities have on the restoration plan?*

Step 3 Summary

The setting of objectives establishes clear directions for what actions should be taken on the site, what should be done to protect significant features, what restoration may be necessary to return it to a healthy condition (i.e., natural regeneration, managed succession, community plantings), and what approach should be taken to design, as well as future management. The following sample map demonstrates restoration objectives.



Sample restoration objectives map

STEP 4 DRAW UP THE RESTORATION PLAN

Once specific habitats and areas for protection and restoration work are determined, a restoration strategy can be formulated. Protection is the first priority. Restoration recommendations should be designed to enhance this objective. Restoration and management plans for sites without significant vegetation or wildlife may not be constrained by existing values.

This step contributes to the following elements of the restoration plan.

	REPORT	ILLUSTRATIVE MATERIALS
	Introduction	
STEP 1	*Determine Regional Context*	*Context plans*
STEP 2	*Inventory and Evaluate Site Conditions*	*Site inventory plan* *Photos*
STEP 3	*Set Restoration Objectives*	

STEP 4	*Draw up the Restoration Plan* a) Physical layout of restoration areas. b) Protecting significant habitat. c) Identify what habitats to enhance and where to create new habitats. d) Human access and impacts. e) Restoring degraded habitats. f) Prepare the detailed restoration design.	*Restoration drawings and documents* • overall protection/restoration strategy; • detailed design showing existing natural features, areas of natural succession, planting zones, and public access and trails; • sketches for educational/ interpretive features.
STEP 5	*Implement, Manage and Monitor*	*Contract documents* *Management plan*

a) Physical layout of restoration areas

At this stage, restoration objectives need to be refined in order to identify specific restoration techniques and where they are to be used on the site. Based on site conditions and objectives, a detailed concept should be prepared showing:

- the location and form of habitat types;
- zones of special restoration treatments;
- whether they should be natural regeneration or planting.

Sections 3 to 8 in this report provide detailed information on restoration techniques and implementation for different habitat types.

Physical site conditions will influence the restoration concept. For example, the most appropriate vegetation for a site will be governed by moisture and soil conditions, tempered by what kind of habitat needs to be restored. Dry soils permit a range of opportunities. If impoverished (as in quarries, or on sand or dry hillsides), they can be revegetated with plants naturally adapted to sandy or stony soil (i.e., certain types of old field plants, prairie plants, certain oak and hickory species). If fertile, such as those found in abandoned pasture or hayfields, they can support various old field, shrubland, or forest communities.

The restoration strategy must identify those areas and habitats that were determined to be significant in Step 2, those habitats requiring enhancement, and those areas where new habitat can be created. Once habitat types are decided, determine size, boundaries, interrelationships, character, and physical form of the habitats you want to create in a manner that satisfies the objectives set in Step 3.

Other factors influencing design and layout of the restoration plan include contextual issues and human use considerations identified in Step 2. For example:

- adjacent land use and resulting impacts may indicate that visual or physical buffers are needed;
- human requirements include the need for access, education, safety considerations;
- visual concerns may influence the aesthetics of restoration areas.

In developing a restoration plan, obtain community input, consult stakeholders, and reconfirm that you are responding appropriately to the objectives. Agency contact may be essential where approvals are required.

b) Protecting significant habitat

Where habitat is determined to be rare, highly sensitive or otherwise significant, it should be left alone to the fullest extent possible. Significant habitat includes such communities as swamps, mature natural forests, prairies, and peatlands such as bogs and fens. For these types of habitat, start with steps for conserving sensitive species, then consider what restoration approaches may be required. In cases where the health of a significant habitat is threatened or is already being degraded, an effective monitoring plan must be set in place and objectives modified accordingly.

Three key questions need to be asked in preparing plans for maintaining and enhancing significant habitat. (Significant habitats are assessed as part of the inventory in Step 2; "Implications for Restoration of Ecosystem Form and Function" in Step 3 provides a useful summary.)

Is significant vegetation threatened by disturbance, changes in moisture regime, instability of soils, succession, introduced species?

- Reduce disturbance and change human use patterns to eliminate disturbance from trampling, vehicles, etc. through:
  - → judiciously placed barriers (these can be created by simple methods such as laying brush piles, planting prickly vegetation);

- → clearly delineated buffer areas;
- → educating the public to use trails through signage or community-based efforts;
- → control of herbivores that may be affecting plants.

- Eliminate factors leading to changes in moisture regime (see sections on restoration of wetlands and other references):
  - → identify causes for change in drainage (i.e., impoundment due to construction, change in watercourse);
  - → plan to restore natural drainage patterns in communities that have begun to degrade because of changes in moisture regime;
  - → prevent soil compaction to allow infiltration;
  - → rectify if possible (e.g., install culverts, reinstate natural channel);
  - → buffer edges of "see through" woodlots to prevent dessication.
- Stabilize succession by removing woody species (e.g., mowing, fire, grazing, periodic flooding).
- Stabilize soils. Many remnants of rare vegetation communities are on slopes subject to erosion. Eroded (and therefore disturbed or compacted) soils not only make it difficult for plants to become established, but also invite the invasion of introduced species, which can out-compete native plants. Solutions include:
  - → engineering (stabilizing the slope);
  - → planting stabilizing species;
  - → bioengineering (using plant species to serve engineering purposes).

Plants Used For Stabilization
◆ wetlands: herbaceous species (cattails)
◆ meadows: shrubs (hawthorn, dogwood and sumac species)
◆ woodland: shrubs (dogwoods, chokecherry) and tree saplings
◆ riparian zones: herbaceous species and shrubs (shrub willows, dogwoods)

- Remove introduced species. Restoration objectives for sensitive vegetation or wildlife can be difficult to meet if certain species of weedy, non-native plants are not controlled. Control of such vegetation (or in rare cases, wildlife) may necessarily form a part of any restoration plan for significant areas. However, removing

introduced species is complicated by the fact that methods of control often create ideal conditions for their growth, because they are highly adapted to colonizing disturbed or exposed soil. In addition, methods of controlling invasive plant species are sometimes extreme (because they involve potent herbicides or mechanical methods that indiscriminately destroy vegetation).

Does the community provide habitat for significant wildlife species?

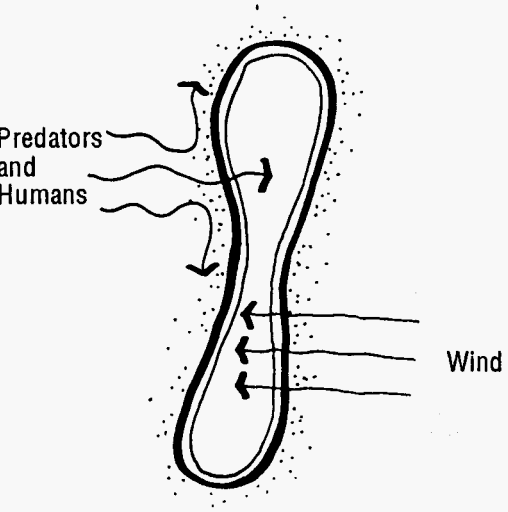
In those areas where significant wildlife habitat occurs, consider the following.

- Identify and retain existing vegetation and other elements that provide habitat.
- Add elements of habitat that are difficult for animals to reach, are in short supply, or are vulnerable to changes in land use. This may increase populations of rare species.
- Delineate adequate buffers.
- Plant or erect protective barriers.

Will enlarging the existing natural area improve habitat quality for significant vegetation and wildlife?

Generally, increasing the size of a natural area will benefit vegetation and wildlife, especially since natural areas in southern Ontario are expected to serve a variety of functions. Many species are restricted to large habitat patches, but none are restricted to small habitat patches. This is especially true of woodlands, but has also been found to be valid with other habitats. The interior-to-edge ratio is crucial. Restoring habitats to less fragmented forms is one of the most important tasks of restoration ecology.

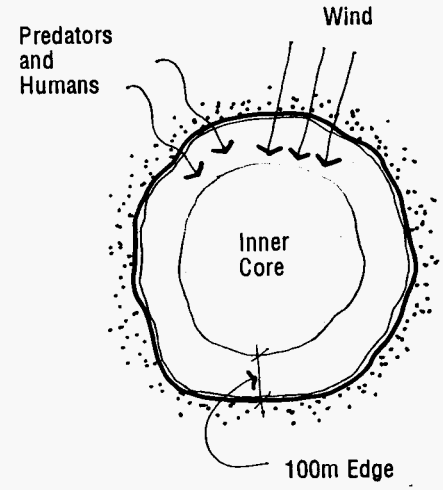
Reducing the edge and increasing the core area maximizes availability of interior habitat for sensitive and increasingly rare species in developed landscapes.



Narrow patch of habitat

In a long, narrow patch of habitat:

- winds penetrate to centre, drying moist habitat favoured by wetland plants and animals, increasing the danger of blowdowns;
- predators patrol edges to find prey;
- nest parasites use edges to monitor breeding pairs;
- human disturbance penetrates to centre.



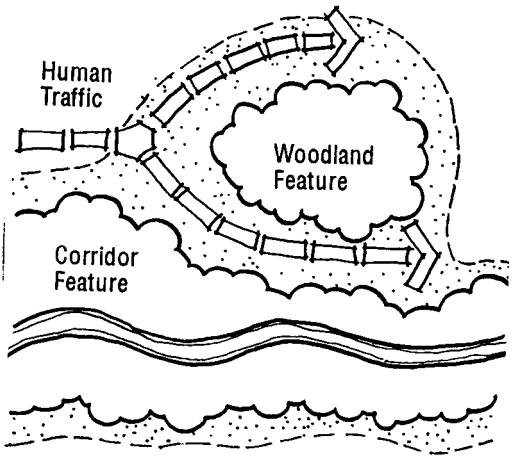
Habitat patch with outer "edge" and inner core area

In a relatively spherical patch of habitat a core area is created, which acts as a comparative oasis for birds intolerant of disturbances found at edges. Many rarer woodland and grassland birds require habitat away from edges. Reptiles and amphibians are also vulnerable to edge effects.

Incorporating adjacent natural or semi-natural sites into an existing habitat can increase the interior-to-edge ratio. This is a relatively simple way of improving habitat quality, especially if the infilled area can be restored to a community similar to the one to be protected. Even an area of dissimilar vegetation can help buffer a core area from edge effects.

Incorporating land adjacent to a protected natural area can also help to dissipate the impacts of human use. Other reasons for doing so are:

- human traffic can be more easily routed around sensitive natural features;
- additional natural areas may provide a corridor for some species;
- land is secured; later plans can incorporate it into specific restoration objectives.



Rerouted traffic around sensitive areas

Caution

A drawback to incorporating adjacent land dissimilar to a core of sensitive vegetation is that habitat is maintained for edge predators and parasites, which then have a foothold for forays into the adjoining sensitive habitat. For example, researchers have observed Brown-headed Cowbirds, a nest parasite, using hedgerows as perches from which to monitor nests in grasslands, in order to detect the optimum moment for laying their eggs.

c) Identify what habitats to enhance and where to create new habitats

This is the stage where objectives are tied to specific areas of the site, locations for different habitat types are identified, and relative size is determined. When selecting the locations for new habitat types, consider the physical conditions of the site (identified in Step 2) that determine what habitat types are possible. The following points provide useful guidance in identifying areas for locating new habitat types.

- Communities considered candidates for restoration include sites dominated by planted introduced species and where the diversity of both wildlife and plant life is very low. Examples include

groves of Austrian pines or Norway maples and lawns planted with commercial fescues.

- Prior to cutting down any trees, check with community groups and the municipality to see if opposition is likely or if approvals or permits are required. Involve the public where necessary.

- Plant communities in an early stage of succession are often not considered significant and are frequently suggested as candidates for restoration to different habitat types. Examples include old fields, small cattail stands, and disturbed riparian meadows.

Reasons for this dismissive attitude toward early succession habitats include:

- the high value placed on trees, especially by urban dwellers;
- the scarcity of mature woodlands relative to successional lands;
- the fact that most successional vegetation on abandoned agricultural land is common and there is a high introduced species component;
- the need for deep-rooted woody vegetation for engineering purposes (to combat erosion, for example);
- the desire to provide habitat for forest-dwelling wildlife;
- the perceived "untidy" look of successional landscapes compared to manicured lawns;
- the perception that successional land will eventually grow into forest in any case;
- possible public pressure to revegetate abandoned quarries and other sites having impoverished soils, since they are often considered unsightly.

Public attitudes toward early successional communities, however, are changing, and preserving meadows does not have the low priority it did in the past. Reasons for preserving early stages of succession include:

they create a greater diversity of plants and animals than conventional landscaping;
old fields are resilient to trampling and other disturbances and can therefore sustain relatively heavy use with little harm to the vegetation. Old fields and open floodplains are often popular

walking spots and are perceived as attractive by a growing number of people;

- there are some common wildlife species of successional lands that appear to be undergoing long-term declines (e.g. Brown Thrasher, Gray Catbird);
- as early successional lands are frequently used for development, once-common species decline in developing areas. For example, bird species of larger grasslands, such as Upland Sandpiper and Grasshopper Sparrow, are now rare in the Greater Toronto Area.

d) Human access and impacts

Once the general layout of habitat types has been plotted, other considerations may further refine the design. Objectives relating to recreation, educational opportunities, and other considerations may influence boundaries, access points, trails, lighting, setbacks, boardwalks, and viewing areas.

Restricting public access may be required to ensure the integrity of sensitive habitat features. This may be accomplished through the use of fencing, or other barriers such as branches and logs. Buffering sensitive areas with tree or dense shrub planting can also discourage access. Public education via signage can be used where indiscriminate access may harm the natural environment.

Properly designed trails and boardwalks can provide access while limiting damage to the natural environment. In areas with large adjacent human populations, it is easier to establish desirable use patterns at the outset, rather than try to change established ones.

e) Restoring degraded habitats

The physical conditions of a site may indicate that changes to hydrology, soil compaction, and depletion of organic matter in the soil have occurred. Other indicators include:

- lack of diversity;
- presence of invasive introduced species;
- densely growing early successional species that will impede the regeneration of desired species;
- impacts such as trampling of vegetation.

Enhancement of existing habitat can consist of remedial measures to restore proper physical conditions, management techniques to control introduced species and enhance desired species, and planting. *For specific techniques consult the technical section for each habitat type in this document.*

For new habitat areas, identify what steps need to be taken to create the physical conditions necessary to establish these habitats successfully. Measures may involve changes to drainage patterns, addressing soil conditions and constraints, establishing buffers against road salt or wind, addressing erosion problems.

Other considerations that influence the approach to restoration or the techniques used include available budgets, who will implement the plans, and who will manage and maintain the restored area.

f) Prepare the detailed restoration design

Once appropriate physical conditions are in place for the selected habitat type, determine which techniques are to be used and refine the layout of the design based on how these techniques are to be implemented. For example, if the habitat type is wetland, not all parts of the proposed wetland will necessarily be planted.

Where a combination of techniques is used, it is helpful to:

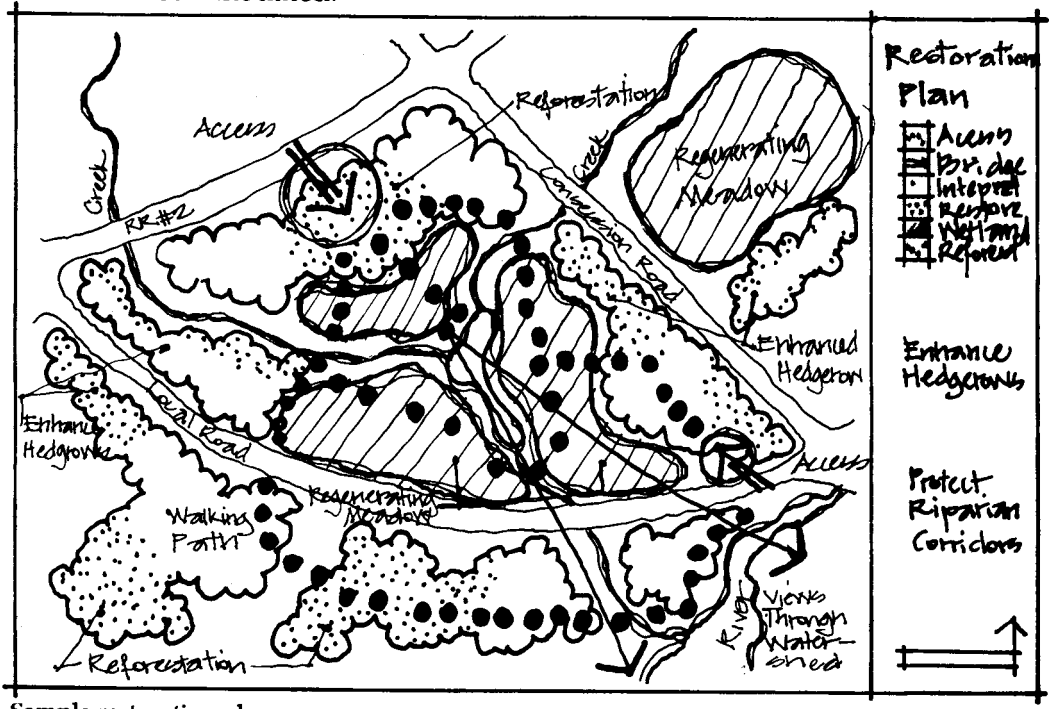
- identify where each technique will be applied;
- identify the location of planting, seeding, and natural regeneration;
- create a plant pallet for each planting zone;

- check that plant material is available. If it cannot be obtained from commercial nurseries, other arrangements, such as contract growing, can be made if sufficient time is available.

The detailed restoration design focuses on the creation of the physical environment and identifies the relative mix of species, spacing, quantities, and size of plant material on the plan. At this point, the need for mulch, staking, and fencing must be reviewed. For some restoration projects aesthetics are important, so plant selection and arrangement must address visual criteria.

Step 4 Summary

The preparation of an overall strategy and detailed design for restoration brings together all the natural and human elements identified up to this stage—an understanding of regional context, the specific opportunities of the site, and the establishment of objectives. The site design identifies those habitats that should be protected, those that require restoration measures, and the human activities that must be accommodated.



Sample restoration plan

STEP 5 IMPLEMENT, MANAGE AND MONITOR

The last aspects of a restoration design to consider are the implementation, management and monitoring of the site. How the restoration is implemented may affect the chosen approach. Management and monitoring will ensure the ongoing success of the restoration and provide direction where adjustments need to be made.

This step contributes to the following elements of the restoration plan:

	REPORT	ILLUSTRATIVE MATERIAL
	Introduction	
STEP 1	*Determine Regional Context*	*Context maps*
STEP 2	*Inventory and Evaluate Site Conditions*	*Site inventory maps* *Photos*
STEP 3	*Set Restoration Objectives*	
STEP 4	*Draw up Restoration Plan*	*Restoration drawings and documents*
STEP 5	*Implement, Manage and Monitor* a) Implement the restoration plan: ◆ installation. b) Prepare management plan: ◆ short-term management (maintenance practices during establishment phase); ◆ long-term management (periodic intervention required to manage and/or maintain habitats). c) Monitoring.	*Contract documents* ◆ detailed working drawings; ◆ technical specifications. *Management plan* ◆ detailed plan showing specific management treatments for different site areas.

a) Implement the restoration plan

During the preparation of a detailed restoration plan, it is important to know early on whether the project will be carried out by the community or involve a contractor. Some restoration techniques requiring large equipment or expertise may not be suitable for implementation by local communities. At the same time, community plantings are likely to be the prevailing method in the foreseeable future.

Contractor installation

The benefits of professional installations include:

- they permit a variety of restoration techniques to be used;
- they result in a reliable, guaranteed product;
- technically appropriate techniques can be selected for different situations.

Drawbacks include:

- the need for working drawings and specifications that are costly to prepare;
- an installation is likely to be considerably more expensive in the short term than volunteer effort.

For a successful contractor installation, prepare detailed working drawings and technical specifications. When preparing the specifications, consider that few contractors have expertise in natural restoration techniques. While the level of expertise is improving, improper installation can result in erosion and a poor plant success rate. Pre-qualification of contractors or invited bids can ensure that only experienced firms are asked to bid on the restoration work. As with all construction projects, regular site inspections will be essential at critical times during the process.

Community installation

The benefits of community-based projects include:

- more can be accomplished for less money;
- projects can involve people in a meaningful educational and community-building experience;
- projects instill a sense of responsibility and stewardship in the participants.

Drawbacks include:

- project techniques must be simple, flexible, and easy to learn;
- plants may be poorly installed. Lack of maintenance may compromise the effectiveness of the project;
- projects must be small enough to be accomplished in a half day. Larger projects should be phased, or organized with successive groups of people;
- community plantings require considerable organization and coordination to be successful.

Goals for citizen involvement must be balanced with the success of the planting itself. The following are some steps to be considered:

- nurturing community experience in planting techniques. Leadership in training local people through nongovernment organizations (i.e., the Evergreen Foundation, Tree Canada) has value where planting remains a community initiative over a number of years;
- workshops on restoration philosophy, ecology and techniques are required for the staff of municipal departments (parks, works, roads, etc.), who may have had little or no experience in ecological restoration, plant selection and propagation, nongovernment organization management, retraining of personnel, community involvement, or in developing collaborative agreements with other departments;
- the involvement of municipalities and other government agencies in community projects is essential for coordination between agencies, obtaining approvals, supplying plants, mulch, water, short- and long-term management;
- partnerships between conservation authorities or other government agencies and volunteer groups or private landowners have been very successful. Government staff provide the technical expertise and assist the volunteer groups or private landowners with the restoration program.

Organizing community planting days

Before embarking on a community planting day, the organization sponsoring the planting event should make a commitment to maintain the planting during the first 3 to 4 years.

Checklist for community planting:
Obtain public agency approvals for planting on agency lands and address liability/public safety (steep slopes, near or within highway right-of-way, etc.).

Obtain plant materials:
- resolve funding and acquisition of the right plant material and transport to site;
- consider site storage requirements;
- bundle different species for different site type.

Provide mulch:
- supply by parks departments, other;
- on-site storage;
- application.

Provide tools:
- spades, forks, buckets;
- supply by parks departments or by citizen organizations.

Provide water:
- available sources, hydrants, supply valves, water truck.

Provide amenities:
- refreshments and washrooms are needed if the planting is to take more than a half day.

Site layout is important for the success of community planting days. Different site types should be laid out on the ground, identified with a number or letter, and appropriate plant groupings bundled and identified for each site type:

- steep slopes;
- wet areas;
- dry areas;
- areas for mixed associations of plants (i.e., woodland mix);
- areas for single species (i.e., sumac on steep slopes).

Pedestrian routes should be marked out for access to planting areas to avoid trampling. Areas should be marked out for storage of plant material, mulch, tools, water.

b) Prepare the management plan

A management plan consists of those procedures necessary to ensure the success of the restoration over time. Management objectives can be varied and can serve to reinforce the restoration strategy. Some objectives are common to all habitats, others specific to distinct habitat types. Specific management procedures are discussed in more detail under individual habitats discussed in Sections 3 - 8.

Every project is different, and a management program needs to be adapted to the individual circumstances of a project. While management strategies for wetlands, woodlands, or meadows will differ, there are also differences *within* habitat types. Not all wetlands are identical. Management treatments must therefore be modified to suit particular site conditions and restoration objectives.

Other factors to be considered are:

- who will be responsible for management?
- what financial and human resources (technical expertise and manpower to carry out management plans) are available?
- what is the role of the public?
- is there a need for public involvement in management plans?
- what are the requirements for public access?

Completion of the restoration plan will result in:

- a clear understanding of existing conditions and the desired outcome of the project;
- short- and long-term management objectives that reflect habitat types and the restoration procedures being undertaken.

Short-term management

The establishment phase must contain procedures to ensure the success of the restoration. Depending on the habitat type involved and the type of restoration procedures implemented, short-term management may last between one to five growing seasons. This phase includes:

- maintenance practices such as watering during dry periods in the first year;
- replacement of plant material where the mortality rate is excessive;

- control measures to minimize damage from rodents, deer browse, insects or disease;
- removal of introduced plant species and undesirable vegetation to reduce competition.

Long-term management

A long-term management plan is especially important for plant communities such as woodlands that take a long time to develop. Long-term management plans for highly dynamic communities may have to be updated regularly, as site conditions change.

c) Monitoring

Monitoring should include biological parameters (plants and wildlife), physical parameters (i.e., water quality), and evaluating the effectiveness of cultural initiatives, (i.e., barrier planting or trails to reduce human impacts on a particular habitat).

As part of the ongoing management of restored areas, the following broader questions need to be asked:

- were the techniques successful?
- did the restoration achieve the desired objectives?
- is there a need for remedial works or wholesale change?

Measuring success

Monitoring can measure the success of restoration techniques and provide valuable information on the health and status of natural habitat. This information can then be incorporated into the ongoing management strategy for the site.

Monitoring procedures must reflect the type of habitat restored, specific restoration approaches, and techniques used (i.e., monitoring of erosion on steep slopes; assessment of water quality of streams and wetlands during initial years).

Record of a site's development over time

Before beginning restoration work, baseline data need to be established against which the project can be assessed. For water quality issues, this may require testing for a variety of parameters with the help of experts. Vegetation, wildlife, bird or fish surveys can

provide a useful baseline against which to judge results. Photographs, especially panoramas, taken from an easily identifiable point can record change over time. In most instances, the site inventory and the evaluation of the site context (Steps 1 and 2) will provide the necessary baseline data for monitoring results.

Human use and impacts

Other aspects of monitoring relate to human use and potential impacts from surrounding land uses. Assessing human use patterns is particularly important in urban areas where a large population can lead to overuse. Access and safety may be issues in isolated areas.

Undesired species

Monitoring undesired species, such as purple loosestrife in wetlands and Norway maples in woodlands, is an ongoing factor in their control. Native species can also be considered undesirable when a certain stage of succession is to be maintained. Information gained from the monitoring process will help to assess the need for new management strategies, further restoration work, or remedial measures. The management strategy must therefore be flexible enough to incorporate new information about the site.

Monitoring limitations

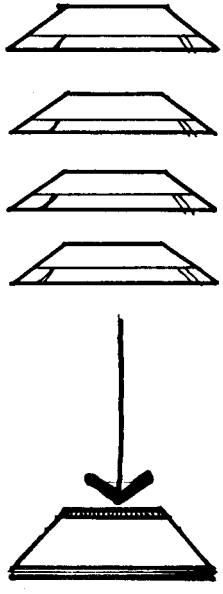
Monitoring can put a strain on the dwindling resources of public agencies. Due to lack of funds and staff to carry out evaluations, restoration projects are often not reviewed. Frequently, it is unclear who is responsible for monitoring and no formal mechanisms require the evaluation of projects. As a result, the opportunity to learn from previous successes or failures is not followed up. The need for monitoring must be determined at the outset and be accounted for in budgetary allowances. Where restoration is related to proposed urban development, the cost of monitoring should be the responsibility of the proponent.

Community Involvement

The role of the public in monitoring is becoming more extensive. Naturalists and community groups can contribute a useful information base and ongoing monitoring. For example, the Canadian Wildlife Service involves volunteers for their forest bird and marsh bird monitoring. Wildlife and amphibian protocols guide volunteers in those monitoring activities. Naturalist groups, such as the Federation of Ontario Naturalists, track bird migration and nesting and keep yearly records.

Step 5 Summary

Successful restoration of natural landscapes requires an ongoing commitment to the project throughout the planning and implementation phases. As the site matures, management and monitoring programs are extremely important to ensure the success of the restoration and identify new concerns that may arise over time. The commitment to management and monitoring should be taken into consideration during planning phases of the restoration project. The monitoring program needs to identify who will carry it out and what parameters and critical indicators should be measured to assess the health of the site.



WETLANDS

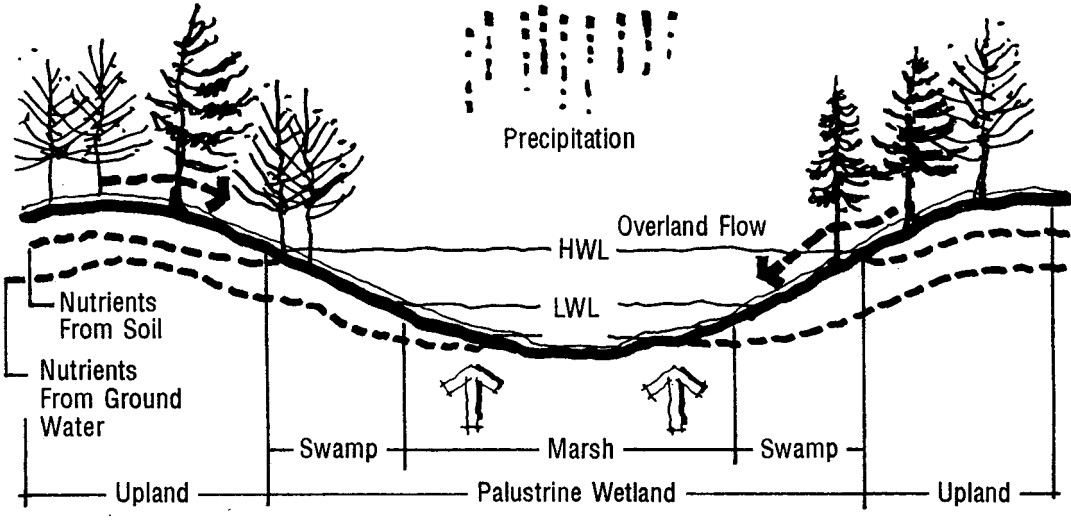
A wetland is an area that has standing water at or near the surface for most of the year and that supports plant species requiring wet conditions.

3.1 SITE CHARACTERISTICS AND TYPICAL PLANT ASSOCIATIONS

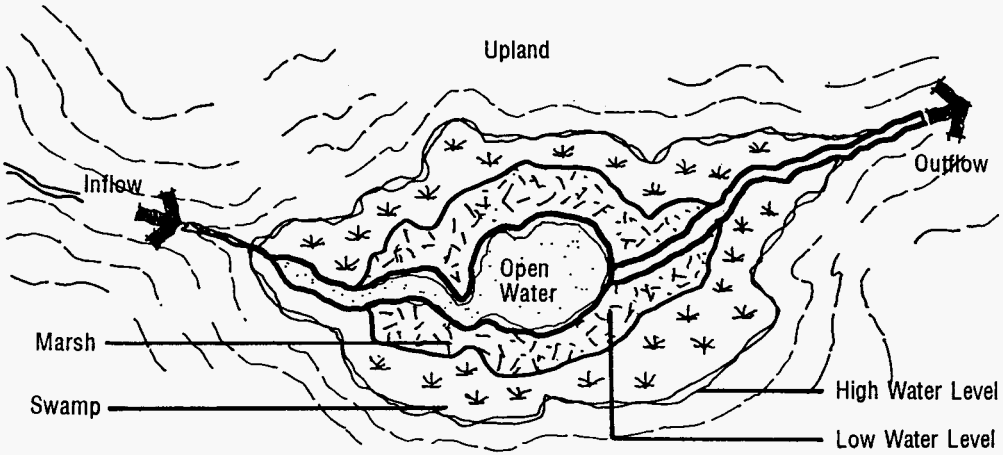
Four major wetland types can be distinguished by their vegetation communities which are determined primarily by the source of their nutrients and water.

Marshes

Marshes receive water and nutrients mostly from surface concentrations such as overland runoff, streams, rivers, ponds, and lakes. They are usually situated on mineral soils and have open water most of the year.



Section of water and nutrient flow into marshes and palustrine swamps (Adapted from: Cowardin *et al.*, 1979)



Plan view of water and nutrient flow into marshes and palustrine swamps (Adapted from: Coward *et al.*, 1979)

Annual changes in water level are an essential part of a marsh ecosystem. Most marsh plants are adapted to high spring levels, low summer levels, and slightly increasing levels in autumn. Marshes are very dynamic, with vegetation communities changing frequently in response to water fluctuations. If water levels remain static, marshes often evolve into another habitat type such as shrub swamp or open water. On the Great Lakes, there are also long-term cycles in water levels, with peaks occurring approximately every six years.

Depending upon the water regime, marshes may be relatively simple or highly complex. They may range from pure stands of cattails to more diverse areas of riparian vegetation, with emergent macrophytes in shallow areas and submergents in deeper water.

Riparian vegetation adds great diversity to a marsh. Such species are able to accommodate everything from having their feet in water to growing on slightly moist soils. Many of these species are lost if water levels cease to fluctuate, or if they fluctuate too widely.

Swamps

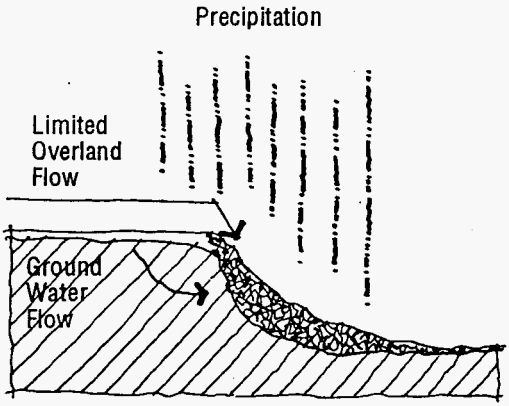
Swamps receive water and nutrients from several sources, but particularly from surface water combined with groundwater. The surface water may come directly from overland sheet flow, a stream or river, from an adjacent lake, or from most or all of these sources. Swamps are also frequently situated in areas of groundwater discharge. They may contain standing water most of the year or be wet only for short periods of time. Many are situated in riparian areas and are flooded regularly. Soils may be either organic or mineral, and there are frequently both in a single swamp.

Because of their varied sources of nutrients and water, swamps are very nutrient rich. They may be divided into two general types: shrub swamps and treed swamps.

- Shrub swamps may be dominated by species such as red osier dogwood, buttonbush, willows or speckled alder.
- Treed swamps can be further subdivided into coniferous and deciduous. In southern Ontario, white cedar is the most common coniferous dominant, but tamarack and black spruce swamps may also occur. Balsam fir may be a common species. Several deciduous trees may form the dominant cover in swamps depending upon climate, soils, moisture regime, age of the swamp, and disturbance factors. Common ones include willows, red and silver maple, white and black ash, white elm and bur oak.

Most swamps are very complicated ecosystems. A change in water level of only a few centimetres can result in a complete transformation of the plant communities. Many contain small hummocks, often around the base of tree trunks, that provide a microhabitat for upland species. Of all the wetland types, swamps support the greatest diversity of plant and animal species. The character of a swamp may also change dramatically seasonally and annually depending on hydrological cycles. In many cases, it takes an expert to distinguish a swamp from an upland forest in the drier seasons.

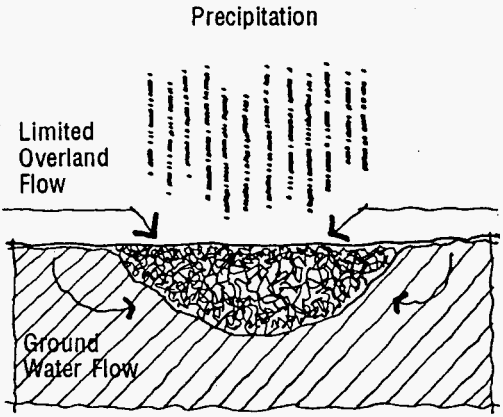
Fens



Water and nutrient flow of a sloped fen (Source: Ministry of Transportation, Ontario)

Fens receive most of their water and nutrients from groundwater and precipitation, usually with relatively minor contributions from surface flow.

The vegetation communities that fens support depend on the quality and quantity of groundwater flow. In acidic and low-flow conditions, fens may appear almost identical to bogs, with subtle differences in the species of mosses, sedges and other low plants that are present. Some large wetlands contain adjacent bog and fen communities, and some wetlands may exhibit characteristics of both. In these cases, an expert botanist, and possibly a hydrologist and hydrogeologist, may be necessary to determine wetland type.



Water and nutrient flow of a fen (Source: Ministry of Transportation, Ontario)

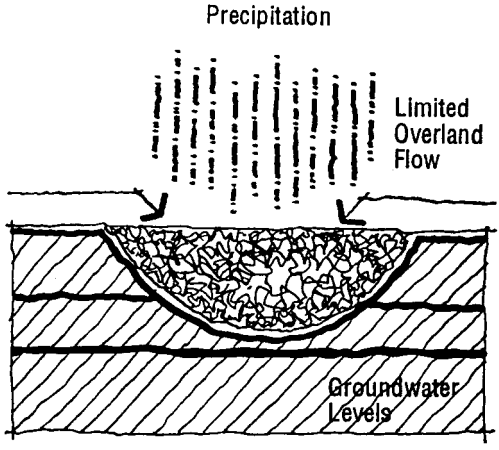
Another type of fen that may develop under acidic conditions is one dominated by sedges. Superficially, these appear to be sedge meadows but closer examination will usually reveal some of the nonwoody and low shrub species that are typical of acidic bogs and fens. They may also have an overstorey of tall shrubs or conifers.

In limestone areas, groundwater discharge to a fen may be calcareous, resulting in entirely different plant associations. Soils supporting calcareous fens are predominantly mineral, while acidic fens are dominated by organics. Soils supporting calcareous fens are predominantly mineral. Many such fens are open and dominated by nonwoody vegetation, but they may also have an overstorey of white

cedar. Calcareous fen species may include water horsetail, variegated horsetail, hooded ladies-tresses, downy willow-herb and Kalm's lobelia.

Bogs

Bogs get almost all their water and nutrients from precipitation. They are isolated from groundwater and receive minimal surface water. The soils are organic and the water highly acidic. Although some bogs have central areas of open water, the surface of others may be relatively dry, even convex.



Water and nutrient flow in bogs (Source: Ministry of Transportation, Ontario)

Bog vegetation is characterized by a ground layer of sphagnum moss, and the wetland surface is often very hummocky. Because of the low nutrient flow, the dominant plant species are those adapted to acidic conditions or that are evergreen so photosynthesis can take place year round. Carnivorous plants such as sundews and pitcher plants that do not rely on soil nutrients may be common on bogs.

Bogs may be predominantly open, being dominated by mosses, non-woody vegetation and short shrubs, or they may have overstorey layers of tall shrubs or trees. The lower level of vegetation is often similar regardless of whether the bog has an overstorey or is open. Typical plants found in bogs are listed in the Appendix.

Abiotic factors that control wetlands

Vegetation communities are usually used to describe wetland types and most other habitats. However, it is critical to realize that the vegetation is essentially a result, as well as an indicator, of abiotic or non-living factors. These include:

- soil types;
- topography;
- surface water;

- groundwater;
- climate;
- nutrient and sediment flows and cycles.

It is essential to have a clear understanding of how these factors affect a wetland being considered for rehabilitation.

Restoration opportunities for wetland types

Only marshes are considered further in this section; however, techniques presented for woodlands are also applicable to swamps and are explained in the section on woodlands. Because of their sensitivity to changes in water quality and quantity, bogs and fens are not generally suitable for restoration.

Caution

Public acceptance of marshes is now high and wetlands are enjoyed by a wide spectrum of people. Your restoration/ rehabilitation work may not ***find immediate public acceptance*** *if:*

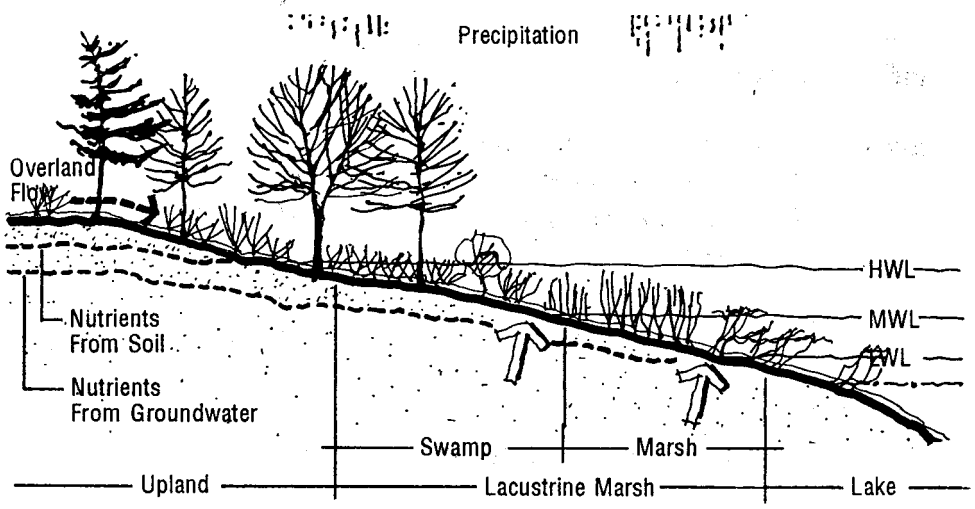
- *water is currently turbid;*
- *there are algae blooms;*
- *aggressive species such as cattails, reed canary-grass or reed grass have taken over the entire area;*
- *it is dominated by species such as purple loosestrife;*
- *it is a potential safety hazard;*
- *it is perceived as a mosquito breeding area.*

A public education session would be useful to clear up apprehensions and recruit community members to help with the restoration plan.

Types of marshes

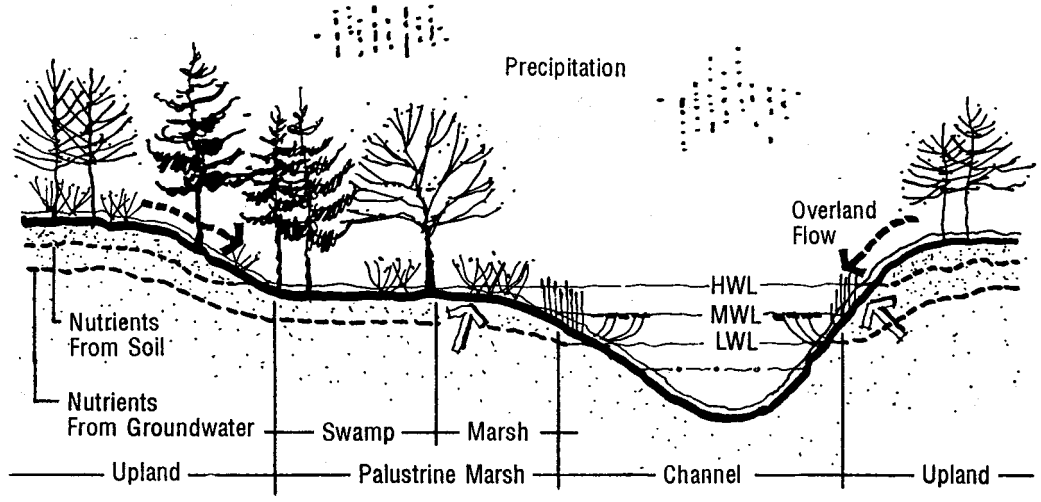
Not only are there different wetland types, there are also different types of marshes. These, again, are defined by abiotic factors, especially by source of water. For the purpose of this manual, wetlands have been placed into three general categories: lacustrine, palustrine and isolated.

Lacustrine marshes are those situated at the shoreline of a lake. Their primary source of nutrients and water is the lake, and their plant species distribution is highly dependent on water-level fluctuations and water depths.



Section of a lacustrine marsh and swamp (Adapted from: Cowardin *et al.*, 1979)

Palustrine marshes may have a stream running through them and receive nutrients from the watercourse. Often they are in groundwater discharge areas and form the headwaters of a stream. They have the potential to be more productive than lacustrine marshes, as they receive nutrients constantly from the flowing water. Marshes along rivers are called riverine marshes, but are considered palustrine here as the same general processes occur regardless of the size of the watercourse.



Section of palustrine swamp and marsh (Adapted from: Cowardin *et al.*, 1979)

Estuarine marshes—those occurring at the mouth of a river—are considered palustrine as well, although they are also greatly influenced by lake dynamics.

Isolated marshes are not connected to watercourses or other water bodies. Most of their water is received from precipitation and overland flow. They are frequently situated on clays that inhibit percolation of water.

3.2 DESIGN CONSIDERATIONS

Before you start

Consider the biophysical characteristics of the marsh site:

- how big will it be?
- how deep is it now and are there options for altering depths?
- what soils exist there?
- where will the marsh get its water?
- is it connected to groundwater?
- what is the resultant water quality likely to be?
- will there be large influxes of sediment?
- will it be subject to wave action or flows that may move sediments?
- what is the anticipated magnitude of water-level fluctuations?
- what are the potential effects on the existing environment?

Prior to project initiation, it is useful to predict what species of fish and wildlife may benefit from the marsh. For areas connected with watercourses or water bodies, the Ministry of Natural Resources will be able to provide data on fish species present and those likely to benefit from marsh enhancement or creation. Information on fish and wildlife may also be available from the local conservation authority.

Potential Wildlife Species in Different-sized Marshes in the Toronto Bioregion

SPECIES	*MARSH SIZE*				
	Under 2 ha	2 ha	5 ha	10 ha	20 ha or larger
* Mudpuppy		x	x	x	x
American Toad	x	x	x	x	x
Spring Peeper	x	x	x	x	x
Gray Treefrog	x	x	x	x	x
Striped Chorus Frog	x	x	x	x	x
Northern Leopard Frog	x	x	x	x	x
Green Frog	x	x	x	x	x
Bullfrog		x	x	x	x
Snapping Turtle	x	x	x	x	x
Midland Painted Turtle	x	x	x	x	x
* Map Turtle		x	x	x	x
Blanding's Turtle	x	x	x	x	x
* Eastern Spiny Softshell Turtle			x	x	x
Eastern Garter Snake	x	x	x	x	x
Northern Ribbon Snake		x	x	x	x
Northern Water Snake		x	x	x	x
Pied-billed Grebe	x	x	x	x	x
American Bittern			x	x	x
Least Bittern				x	x
Mute Swan					x
Canada Goose	x	x	x	x	x
Mallard	x	x	x	x	x
Northern Pintail		x	x	x	x
Blue-winged Teal	x	x	x	x	x
Gadwall			x	x	x
American Wigeon			x	x	x
Osprey					x
Northern Harrier					x
Virginia Rail	x	x	x	x	x
Sora	x	x	x	x	x
Common Moorhen				x	x
American Coot				x	x
Spotted Sandpiper	x	x	x	x	x
Black Tern				x	x

Marsh Wren		x	x	x	x
Common Yellowthroat	x	x	x	x	x
Song Sparrow	x	x	x	x	x
Swamp Sparrow	x	x	x	x	x
Red-winged Blackbird	x	x	x	x	x
Muskrat	x	x	x	x	x
Mink	x	x	x	x	x

* Species that require access to larger bodies of water

Sources: Brown and Dinsmore (1986). DeGraaf and Rudis (1986), Sandilands and James (in prep.)

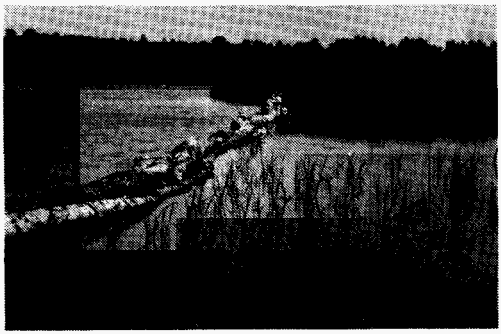
Note: Only breeding birds and wetland-dependent mammals are listed. Marshes will attract many species of birds during migration, and several mammal species will visit in search of food.

The table demonstrates that the larger a marsh is, the greater is its potential to support wildlife species. However, even the smallest wetlands will attract and support a wide variety.

3.3 Creating or Rehabilitating Lacustrine Marshes

Such a project will greatly improve fish habitat, although other wildlife species will also benefit. Because it involves working in waters inhabited by fish, it is essential to cooperate closely with the Ministry of Natural Resources and adhere to the provisions of the Fisheries Act.

This portion of the manual, which focuses on creating wetland lagoons that provide access to lake fish, is most relevant to Lake Ontario. The technique can be used to increase the size of an existing marsh, to create marsh where there is only open-water habitat, and to provide fish and wildlife habitat that is currently limited. This enhancement technique is also highly accepted by the public and pedestrian trails, boardwalks, and bridges can be worked into the design.



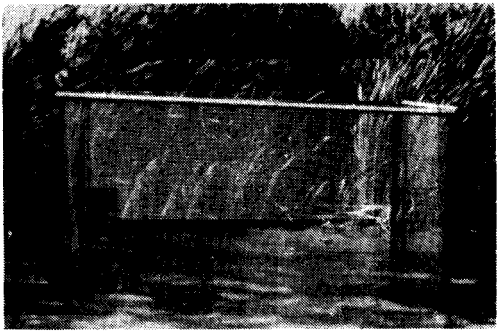
Oshawa Second Marsh: barrier beach enhancement/planting area

Marshes in lakes may also be enhanced by creating islands that dissipate wave action. However, these types of projects result in the loss of some existing fish habitat. A coastal engineering study is usually essential for understanding current and wave action and sediment transport. Experts are required to predict the outcome. Such projects have high potential to increase fish and wildlife productivity in lakes, but are beyond the scope of this manual.

Oshawa Second Marsh: rootwad island

Several other techniques can be used to create or enhance wetlands (see McHattie *et al.*, 1995). They include:

- adding fill to a river or lake to create wetland. This can be very effective, but sediment drift and effects on fish habitat and navigation may have to be determined;
- controlling water levels. Appropriate water-level management can optimize the ratio of open water to vegetation in marshes. If this is being attempted on a large scale, it may be advisable to contact Ducks Unlimited, an organization with considerable experience in this technique;
- encouraging deposition of sediments in streams by adding brush to slow flows;
- stabilizing mudflats to promote growth of aquatic plants;



Oshawa Second Marsh: finished exclosure

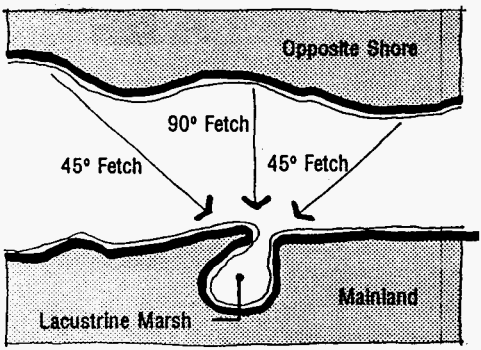
Oshawa Second Marsh: volunteers cleaning up site

- diversifying existing wetlands. This can often be accomplished by deepening portions, planting additional species, creating hummocks or islands, or adding logs.

Critical design considerations

There are five critical design considerations when creating or rehabilitating lacustrine marshes.

- What is the prevailing wind and fetch?
- Is there erosion and how should it be controlled?
- What is the water depth and bottom gradient?
- What is the substrate type?
- What vegetation should be planted and where?

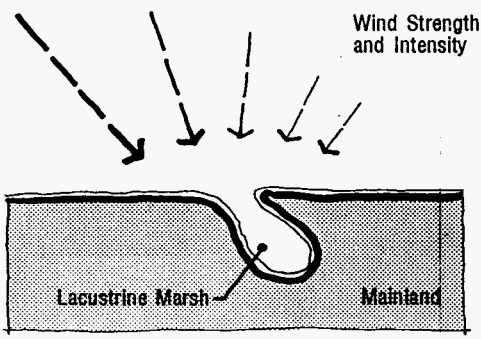


Fetch

Prevailing wind and fetch

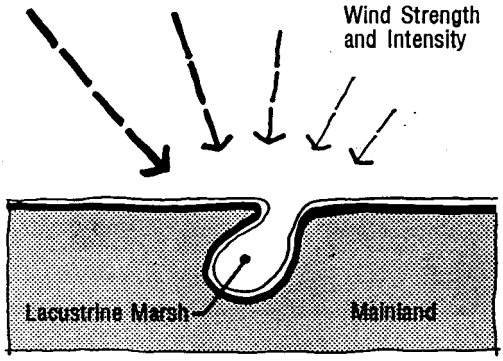
Aquatic plants do not do well when exposed to wind and waves, but require sheltered areas. Therefore, it is essential to minimize wave and scouring action. The fetch—the distance of open water the wind passes over—is also critical in determining wave height and scouring action.

Avoid positioning the opening so that a lagoon is exposed to a long fetch. Even more importantly, consult meteorological data to determine predominant wind directions. These may vary seasonally, but Atmospheric Environment Canada provides information on frequency and intensity of winds. If its mouth faces prevailing winds, a lagoon is highly unlikely to support aquatic plants—particularly submergents which are limited in many areas of Lake Ontario anyway.



Incorrect alignment of lagoon opening

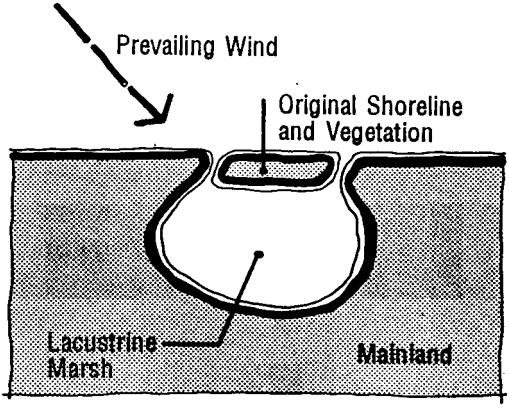
Correct alignment of lagoon opening



Erosion Control

Lake Ontario is very dynamic, and shoreline erosion is a natural process. Unless extreme care is taken, a new lagoon exposed to the lake may be literally blown wide open, resulting in large-scale shoreline erosion problems.

One of the best ways to avoid this is to minimize the size of the opening to the lagoon. Only a very narrow area is required to provide access for fish, and maintaining the original shoreline minimizes the need for engineered solutions to erosion control. Another method is to emulate a barrier beach, such as occurs at Second Marsh. In this case, it is essential to know the water-level regime, to allow overtopping of the barrier at suitable times.



Lagoon with barrier beach

Even using these techniques, it may be necessary to harden newly exposed areas to prevent excessive erosion. The local conservation authority should be consulted to determine natural shoreline erosion rates in the area. This will be necessary to determine how wide a plug of original shoreline is required to protect the lagoon.

Caution

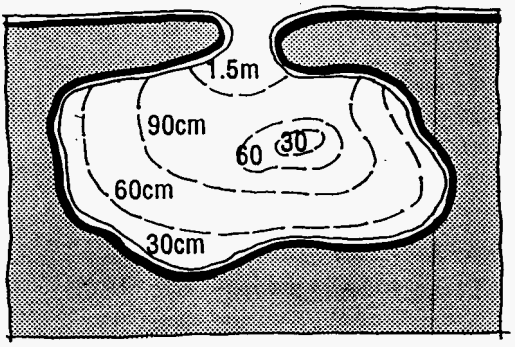
No sediments should escape from the construction site. Excavate the lagoon in a dry state and open it up to the lake last. Silt curtains will have to be in place until sediments in the lagoon settle. Construction drawings, techniques and timing of work must be approved by MNR.

Water depths and bottom gradient

When designing a lagoon, it is essential to know how much water levels fluctuate. A design that does not address this issue may result in unvegetated open water or an unsightly mudflat. There may be situations, however, where mudflats are desirable for shorebird habitat. The local conservation authority will have information on water levels.

For general fish and wildlife purposes, it is best to vary the water depths. Doing so also provides habitat for a wide variety of plants and prevents aggressive species from taking over the entire lagoon.

A good design approach is to create a series of flat terraces, or slopes no greater than 1:10. Aquatic plants do best in these conditions. Slopes may be more appropriate when water levels fluctuate considerably or are unpredictable. Depending on the size of the lagoon, and water-level fluctuations, the minimum depth should be about 30 cm. Terraces can be designed to drop off at about 30 cm intervals to a maximum depth of 1.5 m or greater.



Possible Depth Gradients in a Lagoon

Terraces of 30 cm will be used by short emergents and riparian species. Terraces of 60 cm should provide habitat for taller emergents. Depths greater than 60 cm will be suitable for submergents.

Terraces should be designed so that deeper areas do not become isolated stagnant pools during low water levels. Inappropriate design can result in fish being trapped.

A high interspersion or mix of open water and emergents provides optimum habitat for fish and wildlife. A ratio of 1:1 for open water and emergents has been recommended and, if possible, the design of the lagoon should take this into account. The shoreline can also be shaped to maximize interspersion and edge effects.

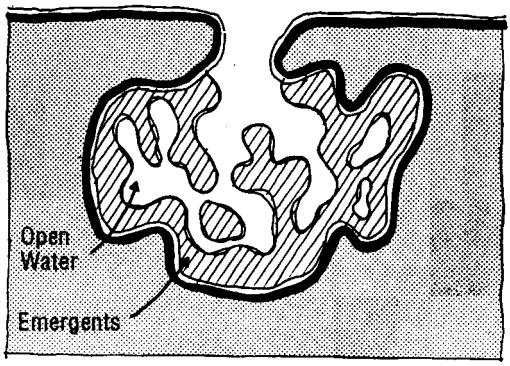
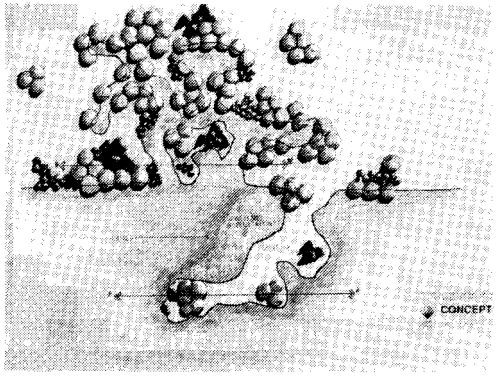


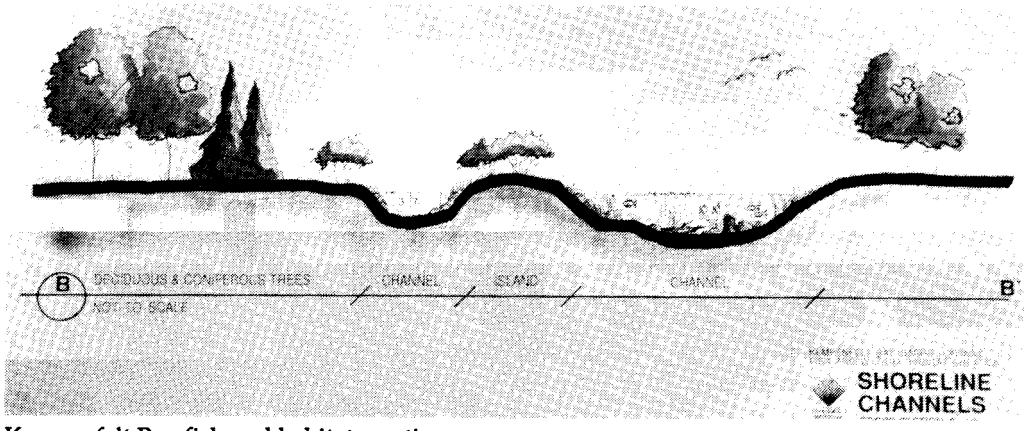
Diagram Illustrating Interspersion

If the lagoon is large enough, consider having an island in the centre for waterfowl nesting and turtle basking.

Terrace depth and gradients do not have to be exact. A few unplanned-for hummocks and excavations will enhance habitat.

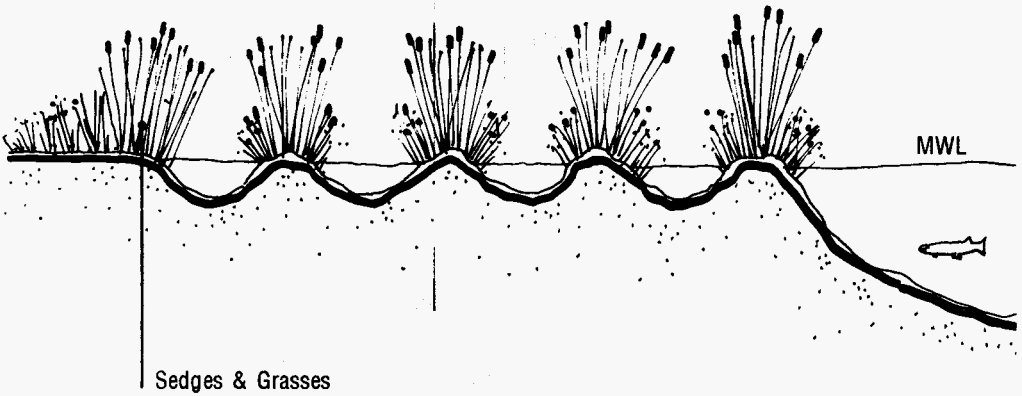


Kempenfelt Bay fish and habitat creation: plan view of bays and peninsulas



Kempenfelt Bay fish and habitat creation

Lagoons or channels connected to the lake may also be designed specifically for northern pike habitat. Their spawning requires maximum water depths of about 30 cm among hummocks vegetated with grasses and sedges. The connection to the lake should be designed to minimize mixing lagoon and lake water, as the colder water reduces pike embryo survival. This technique has been used with success at Lake Wilcox and is planned for Humber Bay Park East.

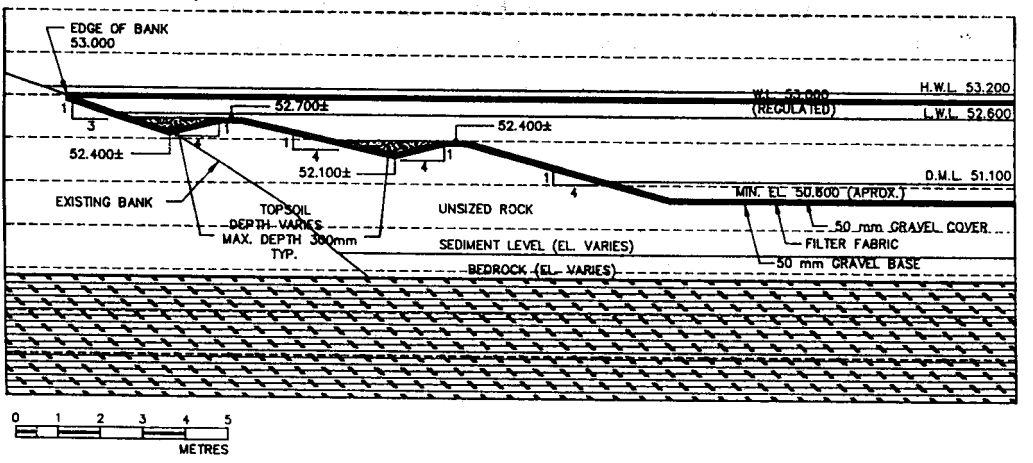


Section of pike spawning habitat

Substrate Type

Fine substrates such as clay, silt and mud are ideal growing media. In many cases, it will be sufficient to simply leave excavated material.

Sand should be avoided as a substrate unless it will be stable (i.e., not exposed to currents or wind). If the material to be excavated is sand, remove more than necessary. Then shape the lagoon floor with coarse rocks capped with gravel to provide a firm substrate. This in turn should be capped with filter fabric and then topsoil. The topsoil must meet the MOEE guidelines for open water disposal. This technique is considerably more expensive than simple excavation, but it has been used successfully on Lemieux Island in the Ottawa River. It can also be used to make more littoral habitat in deep waters.



Typical Section of Lagoon Terrace Structure - Lemieux Island

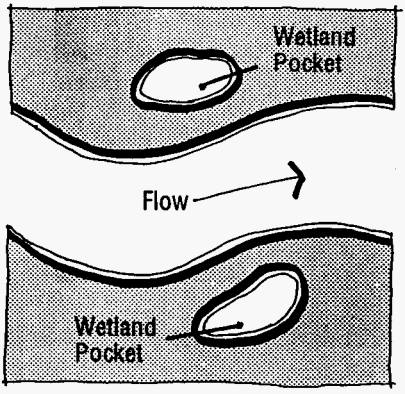
The substrate should not be uniformly soft. The greater the substrate diversity, the more invertebrate and fish species will be present. Cobblestones and boulders should be spread randomly throughout (unless the area is specifically designed for pike spawning), or in specific areas or depths if individual fish species are being targeted. A few logs, Christmas trees, etc., will also greatly enhance aquatic habitat.

Planting

Lakes are usually rich plant seedbeds. If appropriate habitat has been designed, aquatic plants should establish themselves. Nothing should be done initially until macrophytes invade the area. An inspection can then determine the need to plant additional species. If so, refer to the sections on seed collection and propagation, and transplanting. However, there may be instances where it is desirable to plant before invasive species become established. If there is a high probability of prolific growths of species such as purple loosestrife or Eurasian water-milfoil, it may be necessary to plant desired species to give them a head start.

3.4 CREATING OR REHABILITATING PALUSTRINE MARSHES

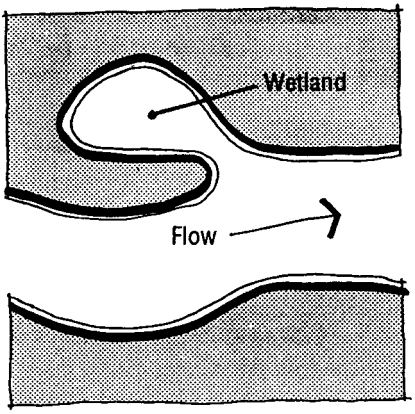
Palustrine wetlands may contain only small watercourses or intermittent streams, while riverine wetlands are in the floodplain of a large stream, but the management techniques are similar. For the purposes of this manual, stream and river related marshes are combined under the single heading "palustrine".



Wetland Pockets in a Flood Plain

The techniques used to create or enhance wetlands along watercourses are very similar to those for lacustrine marshes. Fish species will greatly benefit, and wetlands in riparian zones may attract more wildlife species than those along the Lake Ontario shore or larger inland lakes. Since development is not allowed in floodplains, they tend to be more naturally vegetated than the waterfront, and there is usually less human activity.

Two additional techniques are described: wetland pockets connected to a stream, and wetlands in a floodplain that are isolated from the watercourse. The design considerations are similar to those for lacustrine marshes, although fetch is not a concern. Erosion potential is related to flowing water for palustrine marshes as opposed to wave action for lacustrine marshes.



Wetland connected to a stream

For either wetland type, it is first necessary to do a biological survey of the site to ensure that important resources will not be affected by excavation. Careful consideration must also be made of the route that heavy equipment will take to get to the area, and of how dredged material will be disposed.

Wetlands attached to the stream must be designed so that the main flow (thalweg) of the watercourse is not hitting the bank near the mouth of the wetland. It should also not be in an area where sediment deposition will occur, as a barrier will soon build up isolating the wetland. The services of a hydrologist or fluvial geomorphologist may be required.

As with lacustrine marshes, extreme care must be taken to ensure that sediments do not reach the watercourse.

Palustrine marsh design is also similar to that for lacustrine marshes. They can be designed for specific fish species or to provide a diversity of habitat for a wide range of plant, fish and wildlife species.

Isolated wetlands in a floodplain may receive their water supply in two ways: by being filled up during floods, and by being made deep enough so that they are connected to the water table. In close proximity to a stream, the wetland should not have to be excessively deep to reach groundwater.

Isolated wetlands in the floodplain will not provide fish habitat. However, they can be important breeding and rearing areas for amphibians.

In the absence of fish, adding boulders or rocks is unnecessary. A substrate that is entirely clay, silt or mud is perfect. Without water currents, even sand is acceptable, although it is considerably more sterile than the other soil types.

Logs, sticks, and other woody debris should be added, since many amphibians attach their eggs to wood and aquatic vegetation. Logs may also be used for basking by frogs and turtles.

In most cases, there will be sufficient wetland seeds in the stream and adjacent riparian areas that planting is not necessary. If planting is required, consult the latter portions of this section.

Estuarine Marshes

Wetlands situated at the mouth of a river on the Great Lakes require special consideration. They may be influenced by river and lake levels, and these may change considerably seasonally and annually. These wetlands are particularly dynamic and are affected by lake and river sediment transport as well as water levels. In some cases, barrier beaches may be involved. McHattie *et al.* (1995) provided information on rehabilitation of these types of marshes.

Restoration techniques directly applicable to estuarine marshes are excavation into the shoreline to create additional aquatic and marsh habitat (either on the lakeshore or along the river), and creation of floodplain wetlands isolated from the watercourse. Offshore or in-river islands can also be used to enhance aquatic and terrestrial habitats, but knowledge of how this will affect sediment transport is essential. The design considerations mentioned under lacustrine and palustrine wetlands apply. Water-level fluctuations, wind directions, and river flows are particularly critical in designing restoration projects for estuarine marshes. These dynamics must be understood before proceeding with restoration design. It may be necessary to review long-term water levels in Lake Ontario to determine how often the restoration site will be dominated by lake levels as opposed to river flows.

When working in a floodplain, permission must be obtained from the local conservation authority. The work must not reduce the storage capacity of the floodplain. MNR approval is also required when working in or immediately adjacent to streams.

3.5 Creating or Rehabilitating Isolated Marshes

Isolated marshes are typically situated in low-lying depressions in poorly or imperfectly drained areas. Frequently, they are simply ponds with a fringe of wetland plants around them. At the other end of the scale, they may be damp areas with little standing water. This latter type of wetland is frequently a monotypic stand of an aggressive wetland species such as cattail, reed grass, reed canary-grass or purple loosestrife.

Deepening existing marshes is often done to rehabilitate them and to provide more diverse habitat. This can be an excellent technique to greatly enhance wetlands.

Caution

Many of these wetlands are situated on clay lenses well above the water table. If the lens is punctured by excavation, the entire wetland may dry up.

When planning creation or rehabilitation of an isolated marsh, review the discussion on depths and substrates under lacustrine marshes. Except for larger marshes, fish are unlikely to be present, and an entirely soft substrate is suitable. Even if fish are present, they are most likely to be minnows or sticklebacks, which do well in areas of soft substrates. Provision of logs for invertebrates, amphibians and turtles should be considered.

Reality Check

If a new wetland is proposed, careful study is required. There are probably some very good reasons why a wetland doesn't occur naturally.

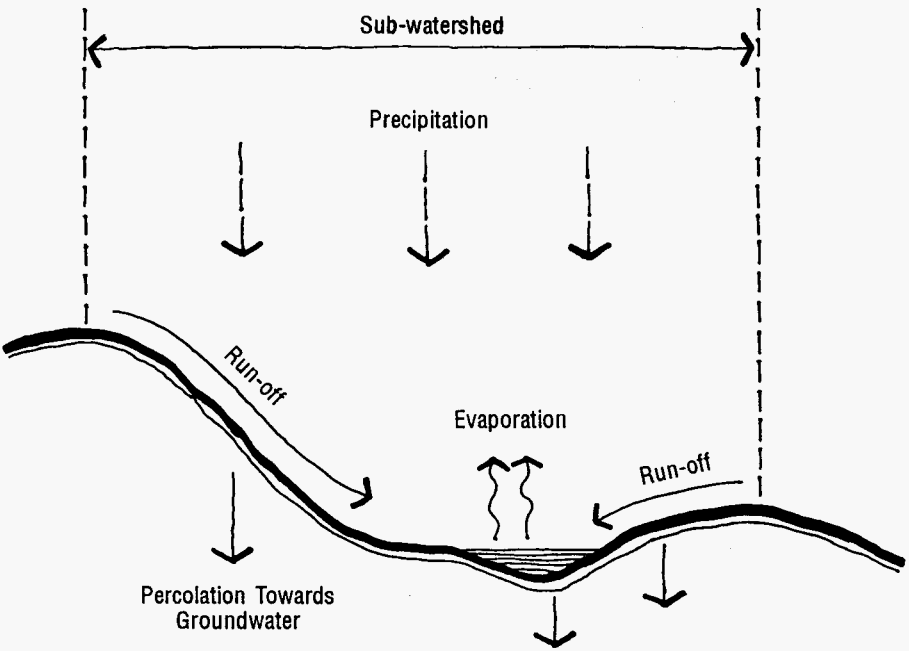
Key parameters to study include:

- watershed area;
- soil types;
- precipitation rates and runoff coefficients;
- evaporation rates;
- depth to water table.

The above work is best done by a hydrologist, possibly with input from a soils scientist.

The study will determine:

- what area contributes water to the potential wetland site;
- how much rain falls in this area;
- what percentage of precipitation soaks into the soil and how much would run into the wetland;
- how much of the water in the wetland would be lost to evaporation;
- if the soils below the wetland are permeable or impermeable;
- if the wetland will be connected to the water table.



Factors affecting water retention in a potential wetland site

After completion of this work, you will know if the proposed wetland will hold water and whether or not it will dry up in the summer.

If creating a wetland is feasible, a hydrologist should also do most of its design, with input from a biologist. Water delivery and retention in the wetland will determine its optimum size, shape and underwater contours. These, however, must take into account the preferred water depths and other habitat requirements of the plant and wildlife species that the marsh is being designed for.

Design of isolated marshes must be done on a site-specific basis, since the abiotic factors influencing the site will be unique in each case.

These wetlands should be designed so that they contain water until at least the end of July. Otherwise, they may become ecological traps for amphibians, with the wetland drying up before larvae or tadpoles transform into adults.

Unlike lacustrine and palustrine wetlands, there may not be a nearby seed source of aquatic plants, so planting may be required. The next two sections describe methods of propagating and transplanting macrophytes.

3.6 SEED COLLECTION AND PROPAGATION

For many emergents and riparian species, it is possible to collect seeds and raise native stock for planting.

Most aquatic plants flower late in the season, so late summer or autumn is an ideal time to collect seeds. Before embarking on a seed collection program, consider the following.

- Seeds should be collected locally to ensure you have appropriate genetic stock that is climatically adapted.
- Collect only seeds of common species. Collection of rare plants may adversely affect existing populations, and they will not survive in newly created wetlands unless their precise microhabitats are present.

- Do not collect plants from sensitive habitats. A high proportion of desired species can be obtained from roadside ditches or sites that are soon to be developed.
- Collect only native plant species.
- Avoid collecting seeds of aggressive native species such as cattails and reed canary-grass. They are likely to appear in most wetlands without assistance.
- Collect a high diversity of species (40 or 50). This provides a wide range of alternatives in case some seeds do not germinate. It will also provide greater habitat diversity and visual appeal. Collect species that prefer a variety of water depths (riparian, emergent, and submergent species).

When collecting seeds, cut off the entire seed head and put it in a paper bag. Each bag should contain only one species. Label the species, indicate the collection area if seeds have been taken from more than one location, and note the water depth and other important site characteristics.

Dry the collected seeds inside the bags for about three weeks. Once dried, seeds should be planted in fibre pots. A suitable growing medium is 60% potting soil and 40% perlite mixed evenly and kept moist at all times. Maximize the likelihood of germination by planting seeds of each species in rows at various depths and by scattering some on the surface of the growing medium.

After planting, place the pots outside in a cold frame. They should be heavily watered to initiate moist stratification. A simple cold frame can be built of pressure-treated lumber covered with high-density plastic. Water weekly over the winter until the soil begins to thaw in early spring. If planting does not occur immediately, apply an antidessicant to the growing medium to prevent damping-off of the seedlings.

There are advantages to planting in either spring or fall. Spring planting allows early establishment before invasion by aggressive species can occur and allows plants to produce seeds during their first season. The disadvantages of spring planting is that plants will

be small and susceptible to grazing or being pulled out by wildlife species such as Canada geese, ducks, and muskrats.

The primary advantage of autumn planting is that by that time, the plants will be more robust. They may, however, be susceptible to frost heaving. Mid to late summer planting may result in larger plants that may still have an opportunity to grow and produce seed.

If plants are going to be retained until autumn, additional work is required. In spring, remove the cold frame during the day and replace it at night to allow exposure to sunlight and protection from frost. Later in the summer the entire cold frame can be removed. Install overhead cover to reduce daily exposure of plants to the sun. Seedlings should be lightly watered every morning and thoroughly watered every evening. Regular weeding will also be required.

Seedlings can be planted individually, in groups, or in their entire fibre pots. Critical factors:

- ensure planting is done in an area of appropriate water depth;
- the plant or pot is firmly anchored in the substrate.

If backshore areas are being planted with riparian species, they should be dug up and raked prior to planting.

3.7 TRANSPLANTING AQUATIC MACROPHYTES

If submergents are desired in a newly-created wetland, transplanting may be required. Some emergents may also be established best through transplanting.

Caution

Transplanting programs must be very carefully designed so they do not have adverse effects on an existing wetland. In many cases, there may also be negative public reaction to removal of plants from a wetland.

If transplanting is feasible:

- pick a nearby wetland;
- identify which species in the wetland are appropriate for transplanting based on water depth preferences;
- minimize the time spent in the existing wetland, and the amount of sediment that is stirred up;
- do not collect large patches of plants. Take only a few from selected beds of aquatic vegetation. After completion, there should be no indication that you have been there;
- do not remove rare species or those that are locally scarce in the existing wetland.

Many plants can be removed by gently pushing your hand into the substrate beneath them and pulling the root mass out. A shovel may be required for some larger emergents. Place the plants into pails of water for transportation to the planting site.

Plant the macrophytes as soon as possible after removing them from the wetland. Make sure they are planted at the same depth and in the same substrate type as where they originally occurred.

There may be some difficulty in getting plants firmly rooted. While not a problem for small plants, larger ones have a tendency to float. For these, tie a small stone or brick fragment onto the root mass with a short length of twine. Then push the weight well into the bottom

and pack substrate firmly around the roots to the same depth as before.

Late summer or early autumn is an optimum time for transplanting because:

- water levels are at their lowest;
- at least some plant species will have developed seeds.

Even if the actual transplanting is not successful, a seed source will have been introduced into the new wetland.

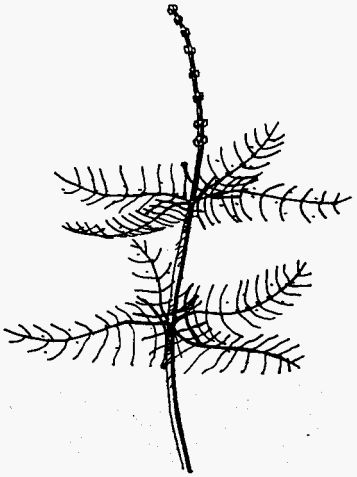
An alternative to transplanting is to transfer some substrate from an existing wetland where even unvegetated areas will contain a seed bank of aquatic plants. This can be done with minimal disturbance. Conversely, it is difficult to know what species are being introduced and there are no guidelines to determine how much substrate is enough.

Vegetative cuttings can also be collected. For many species, these will root and form new plants.

Collecting and propagating seeds or transplanting is practical for relatively small (<1 ha) wetlands. Several thousand seedlings can be raised in a small area. For large-scale planting, consider involving the resources of a conservation authority or Ministry of Natural Resources office. The Royal Botanical Gardens (905-527-1158) has established an aquatic vegetation nursery and may be able to provide plants or assist in seed propagation.

3.8 DEALING WITH PROBLEM SPECIES

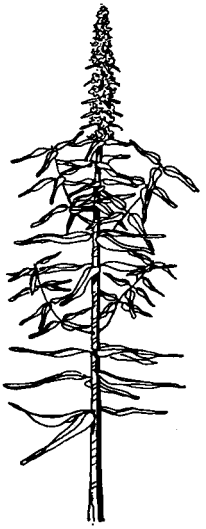
There are three introduced invasive plants that can become major problems in wetlands: Eurasian water-milfoil (*Myriophyllum spicatum*), reed-canary grass (*Phalaris arundinacea)* and purple loosestrife (*Lythrum salicaria).*



Eurasian water-milfoil is a submergent that can grow in water 0.5 to 10 m deep, but occurs mostly at depths of 0.5 to 3.5 m. It reproduces primarily by vegetative fragmentation, with roots developing on plant fragments. It grows so densely that it may crowd out all other plants within the preferred depth range. It is unlikely to occur in isolated wetlands unless it is accidentally introduced. In lacustrine and some riverine wetlands, it may become the dominant or only submergent. At present, there are no known practical control methods. It does, however, provide habitat for aquatic invertebrates and fish.

Reed canary-grass has both native and alien strains. A perennial that can reproduce asexually by dense rhyzome growth, it is able to inhibit or eliminate other species to form monotypic stands. Large-scale control techniques are unknown. In small areas, removal by hand two or three times a year can be very effective. The best method of control is to make the habitat unsuitable. Reed canary-grass does well where soils are saturated or near saturation most of the year, but does not persist in areas that are inundated throughout the growing season.

Purple loosestrife is an aggressive perennial with prolific seed production (2.7 million seeds/plant) that also can spread vegetatively by roots, shoots and broken stems. It can form dense stands at the expense of native species, particularly where existing wetlands have been disturbed or altered by human activities. As yet, no practical, widespread control measures are known. Removal by hand and herbicides may be partially effective in small areas. Control techniques must be continued for many years due to the long-term viability of the seeds. However, it does not do well in water much deeper than 30 cm, so wetlands should be designed to include deep areas.



Two native plants, common cattail and reed grass, can also form dense, monotypic stands. These can be controlled to a limited extent by cutting and/or burning on a regular basis. Of the two, cattails can withstand deeper water, up to a maximum of about 60 cm. Deeper areas will provide open water and habitat for submergents.

Reed grass provides very limited habitat for fish and wildlife species and is generally not desirable. Cattails, however, are used by a wide variety of species, some of which prefer large monotypic stands. Therefore, there will be many instances where pure cattail stands are desirable.

Marsh creation or rehabilitation can also be thwarted by some fish and wildlife species. These include carp, Canada goose, and muskrat.

Carp uproot submergents and some emergents when they are foraging. Their feeding habits also increase water turbidity, which in turn decreases light penetration into the water and inhibits submergents. The effects of carp have been devastating in many marshes, including those in Cootes Paradise and Lake St. Francis. Chain-link fencing is currently being explored as an option to keep them out of Second Marsh. Large-scale removal plans and barriers

have so far met with limited success. Barricades around small areas can be made with snow fence or other materials that keep out large fish. On a site-specific basis, these can be highly successful. However, they will also exclude large specimens of desirable fish and some wildlife species.

Canada geese will graze on young shoots and pull recent plantings out of the ground. A flock can quickly decimate a planted area. Consider this before planting and discuss appropriate control techniques with MNR. Mute swans can reach down a metre into the water to pull up plants.

Muskrats graze on emergents, particularly cattails. They are a problem only when extremely abundant.

3.9 MANAGEMENT

The most common and necessary management practice will be the control of invasive plant species, particularly purple loosestrife and reed grass. This will be a long-term program unless the habitat can be altered to discourage them from spreading.

3.10 MONITORING

Monitoring of restored wetlands is an essential part of the restoration process. It can reveal additional opportunities for habitat enhancement, such as introducing new plant species, adding more structure for fish and other aquatic fauna, improving the mix of vegetation and open water, and altering water depths or water level fluctuations.

At the very minimum, restored wetlands should be checked for the presence and abundance of undesired plant species, and whether they are on the increase.

Since there is limited information on constructed or enhanced wetlands in Ontario, monitoring can provide invaluable data that may lead to significant insights. Some of the key questions that monitoring can answer are:

what species pioneer in different types of wetlands?

- what species transplant well and what is the best time to move them?
- what species do not transplant well?
- what are the optimum water depths for individual species?
- what species do well or fail when propagated from seed?
- what are the best ways of treating seeds to ensure germination?
- what are the optimum times for planting seedlings of various species?
- does the relative abundance of different plants change annually in response to changing water levels and other factors?
- what wildlife species are present and how long did it take them to colonize the wetland?
- was the timing of wildlife colonization related to the establishment of particular plant species?
- did some expected species fail to inhabit the wetland? if so, why?

Managers undertaking wetland creation or enhancement are strongly encouraged to disseminate their knowledge by publishing the results of their efforts.

Selected References

Brown, M. and J.J. Dinsmore. 1986. *Implications of marsh size and isolation for marsh bird management*. Journal of Wildlife Management 50: p.392-397.

Cowardin, L. M., V. Carter, F. C. Golet and E. T. Lahoe, 1979. *Classification of wetlands and deep water habitats of the United States*. U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

DeGraaf, R.M. and D.D. Rudis. 1986. *New England Wildlife: habitat, natural history and distribution*. United States Department of Agriculture, Forest Service, Northeastern Forest Experiment Sation. General Technical Report NE-108. 491p.

Department of Fisheries and Oceans. 1990. *Fish habitat enhancement. A manual for freshwater, estuarine and marine habitats*. Prepared by Envirowest.

Environment Canada. Ontario Ministry of Environment and Energy. Metropolitan Toronto and Region Conservation Authority and Ontario Ministry of Natural Resources. 1993. *Proceedings of a*

workshop on Toronto waterfront aquatic habitat rehabilitation. Organized by Gartner Lee Limited.

Kusler, J.A and M.E. Kentula, eds. 1990. *Wetland creation and restoration: The status of the science.* Island Press, Washington, D.C.

Marble, A.D. 1992. *A guide to wetland functional design.* Lewis Publishers Inc. Chelsea, Michigan.

McHattie, B., M. Taylor, D. Hoysak, C. Seburn, D. Seburn, D. Dennis, C.A. Bishop, P.J. Ewins, and D.V. Weseloh. 1995. *Habitat rehabilitation in the Great Lakes. Techniques for enhancing biodiversity.* Ontario Region, Environment Canada, and Great Lakes 2000 Cleanup Fund.

Ontario Ministry of Natural Resources. n.d. *Community Fisheries Involvement Program (CFIP) field manual. Part 2: Lake and river fisheries rehabilitation.*

Sandilands, A.P. and R.D. James. In prep. *Habitat requirements, limiting factors, and status of the birds of Ontario. Volume I: Nonpasserines.* Royal Ontario Museum Miscellaneous Life Sciences Publications.

Tarandus Associates Limited and the Metropolitan Toronto and Region Conservation Authority. 1993. *Fish habitat compensation plan: Etobicoke Waterfront Park.*

Vincent, J. 1994. *Toronto Waterfront habitat rehabilitation pilot projects: technical report: 1993.* The Metropolitan Toronto and Region Conservation Authority, the Municipality of Metropolitan Toronto, and the Canada-Ontario Agreement Respecting Great Lakes Water Quality.

White, D.J., E. Haber, and C. Keddy. 1993. *Invasive plants of natural habitats in Canada.* Prepared for the Canadian Wildlife Service, Environment Canada in cooperation with the Canadian Museum of Nature.

MEADOWS AND GRASSLANDS

4.1 SITE CHARACTERISTICS AND TYPICAL PLANT ASSOCIATIONS

A meadow is a naturally vegetated, abandoned agricultural field or other open area with relatively fertile soil and less than 50% woody ground cover or 25% tree crown cover.

Three broad types of meadows can be distinguished, depending on the successional stage or the amount of woody vegetation present:

- grasslands;
- brushy grassland or scrubland;
- shrubland.

Grasslands

Grasslands are meadows in the early stage of succession. They are typically covered with old stumps, matted grasses, rock piles, a variety of seed-bearing herbs and grasses.

If woody vegetation is not controlled, in about 10 to 25 years the grassland will develop into the next successional stage.

Brushy grassland or scrubland

A meadow in an intermediate stage of succession (i.e., 15-30% woody ground cover, less than 25% crown cover of trees) is sometimes called brushy grassland or scrubland.

Brushy grassland typically includes a variety of shrubs, matted vegetation, herbs, tangles of grapevines and creepers, and raspberry clumps.

If woody vegetation is not controlled, in about 10 to 25 years the brushy grassland will develop into shrubland.

Shrubland

A meadow in a late stage of succession (sometimes called shrubland) has 30-50% woody plant coverage with shrubs being dominant, and tree crown coverage less than 25%.

These types of meadows include a variety of shrubs of different heights, entwined with vines, overgrown raspberry canes, interspersed with a variety of herbs and grasses, and much matted vegetation.

Plant associations for the different types of meadows vary, but typically include various proportions of plants that may be woody, grass-like or herbaceous; native (indigenous to the area) or introduced (opportunistic plants usually indigenous to Europe, Asia or distant parts of North America).

Some typical meadow species are listed in the following table.

MEDIUM HEIGHT GRASSES (mostly introduced)	*HERBS (both native and introduced)*	*SCATTERED WOODY PLANTS (both native and introduced)*
smooth brome (I)	goldenrod (N)	hawthorns (N, I)
timothy (I)	teasel (I)	buckthorns (I)
orchard grass (I)	asters (N)	poplars (N)
redtop (I)	dandelion (I) milkweeds (N)	dogwoods (N)
reed canary grass (N) (in moist areas)	clovers (I)	raspberries (N, I)
Kentucky bluegrass (I)	plantains (I)	elms (N)
		apple (I)

Plant composition in a meadow is variable, with fertile soil on level ground often alternating with patches of sandy or stony soil on dry hillsides. These are colonized by species such as Canada bluegrass, staghorn sumac, hawkweeds, grey goldenrod and heath aster, and wet pockets sustaining sedges, rushes and grasses.

A hedgerow "invading" an old field.

The species present will depend mostly on how long the field has been left undisturbed, but other factors include:

- what the field was used for before (e.g., fields used for crops may have tile drains and residuals of herbicides and pesticides, hayfields have a high cover of grasses);
- what the surrounding vegetation is like;
- soil characteristics and surface water patterns.

Caution

Seek expert opinion if:

- *prairie or other rare plant communities have been identified on the site;*
- *the site contains any of the prairie/savannah indicators listed in the Appendix;*
- *the site is sandy, with little woody vegetation and no history of disturbance;*
- *the site is on thin soil over bedrock, with little history of disturbance.*

4.2 DESIGN CONSIDERATIONS

Before you start

Review the constraints and biophysical conditions of the site:

- what is the current vegetation cover?
- is it too dense for meadow species to become established?
- what are the soil characteristics, depth, moisture levels, and fertility levels?
- are there noxious weeds that may be a concern?
- is the site located in an urban area or in a more natural or rural setting?
- what will the public perception of a meadow be?
- is there a need for public education?

Restoration goals can be flexible because meadow communities are variable and change over time. Often, the objective for creating meadow is to attract wildlife. The species of wildlife will depend on stage of succession, size of meadow, surrounding vegetation, the presence of other habitat elements like nest sites, concealment cover, etc.

Meadows often contain numerous wildflowers. While introduced species frequently form a large component, native species usually hold their own. Eradication of introduced species will likely be both unnecessary and undesirable.

Meadows are among the easiest communities to establish, and a natural succession process may be the only requirement. Plants are widely available from commercial nurseries or from other meadow sites.

POTENTIAL DIFFICULTIES	POTENTIAL SOLUTION
• Public acceptance can be difficult to achieve in some urbanized surroundings.	• Increase public acceptance by signage, interpretation, planting colourful species; adding elements to create interest such as benches, well-marked paths. Create well-defined edges; border with shrubs, mow borders.
• Bird and larger mammal use is low if grassland is small (less than 20 ha); however, even small grasslands can create additional habitat for insects and small mammals. They can be used as foraging areas by insect- and mammal-eating birds.	• Increase wildlife use by planting or retaining trees or shrubs on the periphery or in discrete groups, so as not to change the "grassland" character. • Add habitat elements such as ponds, rock piles, logs, sand piles.
• If the grassland is to be retained, woody species must be removed.	• Selective removal of undesired species
• Some species are highly invasive (e.g., buckthorns) and will quickly change the character of the grassland if not controlled.	• Selective removal of undesired species
• A number of species come under the 1974 Weed Control Act. Some can cause injury to people (e.g., poison ivy), some are responsible for hay fever (e.g., ragweed), and some can cause crop diseases (e.g., common barberry). In the great majority of urban and rural situations, however, most of these weed species should be seen as an important part of the grassland community, attracting birds, insects, and butterflies.	• Selective removal of undesired species

Trade-offs

- There will be trade-offs, depending on which stage of succession is present. As succession proceeds, some wildlife species will leave and others will appear.
- If a certain stage of succession is to be retained, meadow vegetation must be managed (i.e., removal of woody vegetation by mowing, burning, etc.).

Wildlife Species Found in Grasslands and Shrublands

Different types of meadows provide opportunities for different wildlife species. Before beginning a restoration project, evaluate which species may benefit.

Cultivated hayfields or pastures have little concealment cover such as matted stems of previous years' growth, variety of seed-bearing plants, old stumps, and scattered woody vegetation. A greater density of matted vegetation will attract a greater variety of wildlife. Two or three years after a field is abandoned, there is generally enough concealing cover to attract voles and ground-nesting birds.

Heavily matted vegetation in brushy grasslands attracts many wildlife species. More nest sites are offered by shrubs and small trees, clumps of raspberries, grapevines and shrubs.

Shrubland wildlife is attracted not only to taller bushes, but also to the greater shelter and litter associated with woody cover. The diversity of concealing vegetation is most important, e.g., raspberry patches; tangles and thickets where grapevines or creepers entwine shrubs and grasses; matted herbs and grasses that can provide tunnels for mice; decaying logs and rock piles which provide habitat for reptiles and amphibians.

Potential Wildlife Species in Different Types of Meadows in the Greater Toronto Bioregion

SPECIES	*GRASSLANDS*	*BRUSHY GRASSLAND*	*SHRUBLAND*
BIRDS			
Canada Goose	x		
Mallard	x		
Blue-Winged Teal	x		
* Northern Harrier	x	x	
Common Snipe	x	x	
* Upland Sandpiper	x		
Morning Dove		x	x
* Short-Eared Owl	x		
Willow Flycatcher		x	x
Eastern Kingbird		x	x
Blue Jay			x
House Wren			x

American Robin		x	x
Gray Catbird		x	x
Brown Thrasher		x	x
Cedar Waxwing		x	x
Golden-Winged Warbler		x	
Blue-Winged Warbler		x	x
Yellow Warbler		x	x
Chestnut-Sided Warbler		x	x
Northern Cardinal			x
Indigo Bunting			x
Field Sparrow		x	x
Savannah Sparrow	x		
Grasshopper Sparrow	x		
Song Sparrow		x	x
Bobolink	x		
Red-Winged Blackbird	x	x	
Eastern Meadowlark	x		
American Goldfinch		x	x
MAMMALS			
Short-Tailed Shrew	x	x	
Eastern Cottontail		x	x
Eastern Chipmunk			x
Woodchuck	x	x	x
Deer Mouse	x	x	x
Meadow Vole	x	x	
Meadow Jumping Mouse	x		
Coyote	x	x	x
Red Fox	x	x	x
White-Tailed Deer	x	x	x

* Species that require extensive (>20 ha) habitat

4.3 RESTORATION OPTIONS AND TECHNIQUES

Existing meadows

A wide variety of species can be planted in existing meadows in order to achieve the appropriate stage of grassland, to enhance public acceptance or to attract wildlife. The following table shows some considerations when planting a meadow.

CAVEATS	COMMUNITY INVOLVEMENT
• Even though introduced species are common in meadows, it may be best when planting to stick to natives to avoid the risk of introducing highly invasive plants. Introduced species will, nonetheless, soon colonize the area. • Obtain plants from nearby sources. Species should be common and easily obtainable, and there may be no need to buy from nurseries.	• Plant transfers are popular. • Species that add colour and interest (without adding woody material) are most successfully established if dug from donor sources (areas to be developed) or other fields and roadsides; small holes will soon revegetate. These "plugs" can be planted directly into fields. They need very little maintenance after they have been watered. • Seeds can be collected from nearby sources in fall, planted in a cold frame over winter (or cold treated for 6 weeks in a refrigerator), sown in pots, germinated, grown into hardy specimens that can then be planted. The community can be involved in growing plugs.

Reality Check

Is eliminating introduced species a realistic restoration objective?

Eradication of introduced species is not necessary or desirable in meadow restoration, because:

- introduced plants are an integral and persistent part of most old fields. They contribute to wildlife habitat and survive in balance with other vegetation;
- old fields often become increasingly dominated by native plants; the time frame required may be longer than is usually tolerated, but public attitudes are changing in this respect;
- introduced plants are well adapted to colonizing disturbed or open soil; many efforts to eradicate them only result in an influx of new ones.

If some introduced species are found to jeopardize the presence of desired wildlife or vegetation, their eradication should be considered (e.g., buckthorns can invade fields quickly; they eliminate old field vegetation, are considered unattractive, have marginal value as wildlife habitat, and are long lived).

Woody plant species to add colour, interest, attraction to wildlife:

→ willow (*Salix sp.*)
→ dogwood (*Cornus sp.*)

- → Canada plum and pin cherry (*Prunus nigra* and *P. pensylvanica*)
- → raspberry (*Rubus sp.*)
- → hawthorn (*Crataegus sp.*)
- → Eastern white cedar (*Thuja occidentalis*)
- → poplar, aspen and cottonwood (*Populus sp.*)
- → nannyberry (*Viburnum lentago*)
- → Virginia creeper (*Parthenocissus sp.*)
- → wild grape (*Vitis sp.*)
- → ninebark (*Physocarpus opulifolius*)

- if planted in groves or clumps, grassland character can be retained. Woody vegetation must be controlled if this is the objective. Succession can be advanced by planting shrubs in a scattered pattern. Avoid planting in geometric rows;
- if small enough, these plants can be dug from donor sites or fruits collected and sown in pots after appropriate treatment (refer to *Growing native woody plants from seed* by Henry Kock, the University of Guelph Arboretum);
- native herb and grass species should be used in grasslands where the objective is to maintain the existing stage of succession. (See Appendix IV and V for list of native and introduced meadow species.)

Starting a meadow from scratch

Natural regeneration

Picture of a corn field or playing field.

Any area of bare soil will quite quickly become vegetated with pioneering species, usually a combination of old field herbs and grasses and tree species such as poplar, cedar, etc. Some areas, such as lawns sodded with commercial fescues and fertilized, and recently cultivated agricultural fields may take much longer to evolve into an old field (particularly if there is no seed source from adjoining areas). They will be dominated by aggressive species for most of that time.

If time is not a constraint, naturalization may be allowed to take its course.

Soil preparation and planting in fertile soil

Land occupied by crops or lawn can be:

- tilled every two weeks in spring to discourage the growth of introduced grasses or agricultural weeds;
- covered with black plastic or other mulch, which kills the existing vegetation.

Consider variations in the contours of a site that naturally form micro-habitats, with growing conditions suited to a wide variety of plants (i.e., wet depressions and drier hillsides).

Seeding

There are several methods for obtaining seed. The most accurate to ensure the widest variety of viable seed is to gather it ripe from individual plants by hand at the appropriate time of year. However, this method is costly, time consuming and requires expert knowledge. Seed can also be collected in the fall from an appropriate source with a combine, or from smaller fields with a seed stripper harvester, which is less damaging to the soil.

Seeds can be prepared (husked) before planting, but good results can also be obtained with unprepared seed. Sow the seed randomly over the site to "match" the greatest variety of species to the greatest variety of micro-habitats. Doing so before winter ensures they receive adequate cold treatment. Growth should be monitored, but objectives for this type of restoration should be somewhat flexible to take into account the length of time needed for a meadow to become established.

Meadow strips

"Sod" strips from an existing meadow can also be used to revegetate a site, creating natural results. Drawbacks to this methods include:

- the damage caused to the donor meadow (unless it is about to be converted to another use);

- the higher probability of a mismatch of sod species and the underlying soil.

However, the result is usually very close to a naturally vegetated meadow.

Sod can be obtained from appropriate donor sites with a sod peeler or sod hoe, which can strip large blocks that can then be transported on pallets to the site.

Topsoil application

Many old field seeds stay viable in the ground for decades. Topsoil spread over prepared soil can also be a seed source for a natural community. This method may be biased toward some introduced species, which have been found to have the longest viability.

By mixing in topsoil or fertilizing, soils of degraded habitat can be reconditioned. alternatively, species suited to impoverished soils may be planted, including those common in old fields or those characteristic of tall-grass prairies. (See Appendix VI for typical species found in meadows and tall-grass prairies.)

Natural succession

Natural succession, or the naturalization of maintained meadow, is being allowed to proceed in many parks and along roads throughout the city. Often, naturalization proves that fascinating, pleasing and diverse plant and animal communities can colonize areas on their own with no interference (as has occurred, for example, in Tommy Thompson Park). Wildflowers have also been planted in many small sites throughout Metro Toronto. They are raised by a grower from seed collected by Metro Parks personnel and plugs are delivered for planting in the fall.

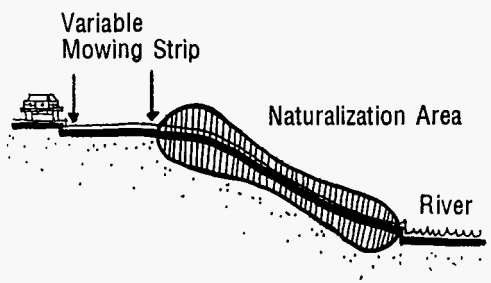
4.4 MANAGEMENT

Techniques for managing meadows mainly involve removing woody vegetation, depending on the successional stage required. In old fields—characteristically a mixture of introduced and native species—control of introduced species is seldom necessary.

A number of other management issues must be considered, however, particularly in urban parklands, parkways, and highway landscapes.

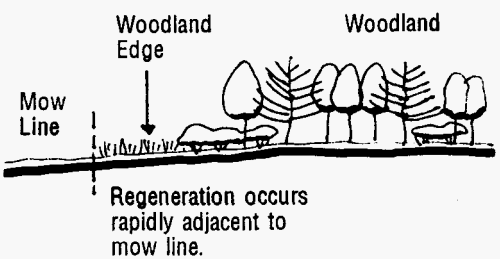
Urban mowing regimes

In urban areas, highly manicured parkland is coming under increasing public criticism as a sterile environment in which differences in sites are ignored, and where only a few exotic bird species thrive. It is also becoming increasingly costly to maintain, and is often hazardous to maintenance operators. The following problems frequently encountered in the field require practical solutions. They involve a variety of approaches to designing and managing turf and meadows to create visual interest, as well as habitat diversity.



Steep slopes

Mowing slopes of a 25% grade or more is a hazard to the operator and produces a poor turf due to slippage and erosion. Mowing should be discontinued and the slope planted with self-sustaining shrubs adapted to site conditions.

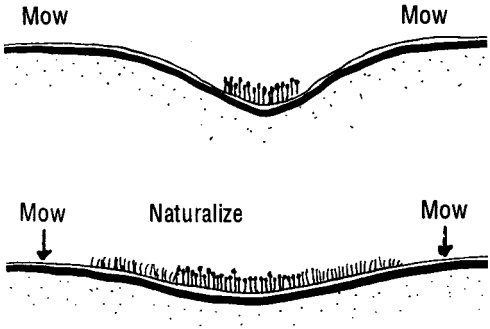


Significant natural areas

Mowing near natural areas can damage their ecological diversity and habitat. A buffer of 5 m to 10 m should be left unmown and allowed to naturalize.

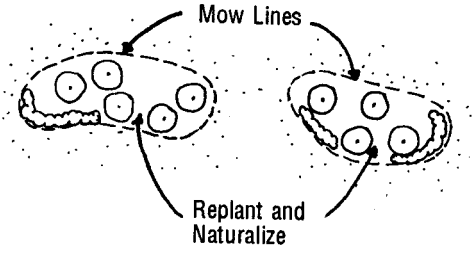
Wet areas of turf

Where turf areas are subject to spring floods and frequent rains, they are difficult to mow and produce poor turf. Alternatives include naturalization, replanting to woodland, or the development of small, possibly isolated, wetland communities.



Widely spaced trees in turf

The frequent incidence of trees maintained as individuals, disconnected from others, involves considerable handwork by small mowers. Such areas can be filled in with other plant materials to create bosques and wildlife habitat, with a new mowing line around them.

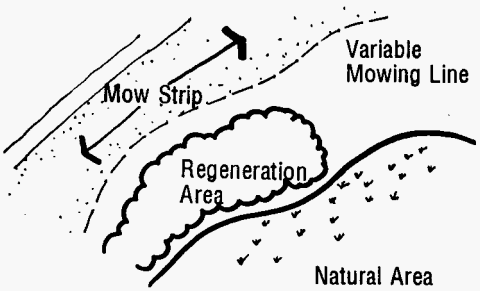


Dense tree groupings

Turf under dense tree canopies is always difficult to keep in good condition. Mowing under trees should be discontinued to permit a natural groundcover and understorey to develop, either through naturalization or with restoration procedures. Where treed areas are used for picnicking or passive recreation, a new mowing regime that creates areas of maintained turf within a meadow environment can be introduced to accommodate both recreational activities and woodland re-establishment.

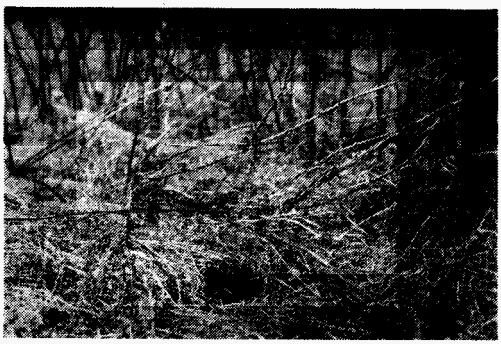
Edges

Landscape appears neglected where the edges between one kind and another have not been adequately considered, particularly between manicured and rough turf or meadow. Edges should be laid out in sweeping lines, as an obviously designed edge looks purposeful. Well laid out and carefully considered, it creates an attractive landscape of contrasting elements, with the meadow habitat enhancing the mown turf.



Safety and litter

Mowing along road edges to maintain quality turf minimizes chance fires and facilitates litter pick-up. A variable mowing line of 3 m to 5 m should be maintained, depending on the class of road and site conditions.



Rodents

Naturalized turf encourages the immigration of small rodents in the initial stage of succession. Where natural areas are adjacent to residential property, this may be perceived as a problem. While rodents cause more problems to young trees and shrubs than to people, they are often considered a pest near habitation. They are controlled most effectively near residential areas by maintaining a mown strip close to fence lines.

Songbirds

Grasslands and shrublands are important habitats for birds (see table in Subsection 4.2). Where occasional cutting of these lands is required, it should be done as late in the fall as possible, after migratory birds have flown. Cutting before late fall interferes with seed sources and the birds' essential food supply prior to migration.

4.5 MONITORING

Monitoring requirements in naturalized areas are, by definition, minimal; the main objective of restoration by naturalization is usually to increase plant and animal habitat and decrease costs, and both are almost certain to happen. If the restoration objective is to retain a meadow at a certain stage of succession, then monitoring of woody growth will be required. If certain species of plants or animals are desired, monitoring should reflect this type of objective.

Selected References

Restoration and Management Notes: a journal published twice yearly by the University of Wisconsin - Madison Arboretum. Some of the most up-to-date methods can be found in this journal.

Curtis, J.T. 1959. *The Vegetation of Wisconsin: an ordination of plant communities*. The University of Wisconsin Press, Madison, Wisconsin. The classic text on the structure and composition of prairies.

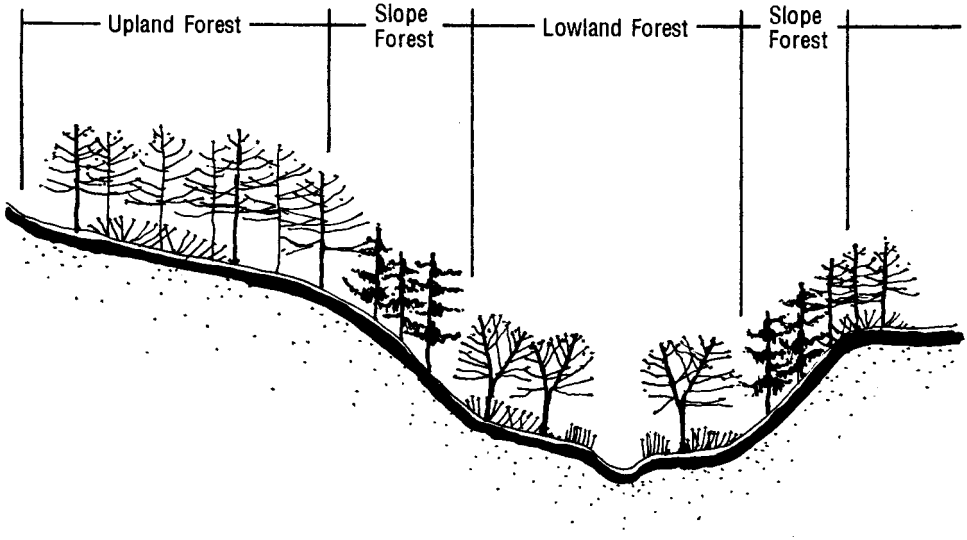
Courtenay, Booth, and James H. Zimmerman. 1972. *Wildflowers and Weeds*. Van Nostrand Reinhold Company, New York.

Also, please see the list of prairie references in Hough Stansbury Woodland Naylor Dance Limited and Gore & Storrie Limited, 1994. *Ecological Restoration Opportunities for the Lake Ontario Greenway*, Waterfront Regeneration Trust.

WOODLANDS

5.1 SITE CHARACTERISTICS AND TYPICAL PLANT ASSOCIATIONS

A woodland is defined as an area naturally vegetated with forest species of at least 10 cm diameter at breast height, with a tree canopy cover of 20% or more and a woodland understorey. Its stage of development will determine both canopy cover and species. Woodland is frequently initiated by predominantly pioneer species. Gradually, climax species will establish and eventually form the canopy. The species composition of a woodland varies with moisture regime and soil type. Generally, three distinctions are made: upland forest, valley slope vegetation and lowland forest (swamp).



Upland, lowland and slope forests

Upland forest

In the Great Lakes/St. Lawrence Forest Region, the dominant upland forest type is the maple-beech association. Upland forest, which occurs on table lands, was the primary forest cover prior to settlement. Soil conditions are generally well-drained and sometimes dry, yet impervious clay soils can lead to poorly drained conditions.

Valley slopes

Valley slopes are generally moist, but well drained. The wide range of species on valley slopes includes many upland plants.

Lowland forest (swamp)

In low lying areas adjacent to water courses and lakes, or in localized wet areas, soils with a high moisture content give rise to distinct plant associations. Lowland forest may have high moisture levels due to overland runoff, temporary flooding, or groundwater discharge at peak periods, particularly during spring and fall. In coniferous woods, cedars often are the predominant species. Lowland deciduous woods may include a variety of species, depending on stage of succession, soils, and moisture regime.

Site characteristics, reviewed during the site inventory, will affect the nature of woodland restoration. Soil type, moisture level and microclimate of the site influence plant associations and the ultimate character of the woodland. Prior to finalizing restoration plans, the type of woodland should be determined: upland vs. lowland vs. valley slope; sandy soils vs. clay soils; exposed conditions vs. sheltered; or dry vs. wet vs. moist but well drained. The following chart summarizes soil moisture conditions and the predominant plant associations.

References at the end of this section provide more detailed information on the natural occurrence of plant species, their soil requirements and typical associations.

FOREST TYPE	*UPLAND FOREST* (dry to well drained)	*UPLAND FOREST* (moist, well drained)	*VALLEY SLOPE* (moist, poorly drained)	*LOWLAND FOREST* (poorly drained)
EVERGREEN OR CONIFEROUS - COMMON SPECIES	white pine eastern white cedar hemlock	white pine hemlock	white pine hemlock	eastern white cedar tamarack
DECIDUOUS - COMMON SPECIES	red oak white oak sugar maple American beech white ash	sugar maple American beech white ash red oak basswood	red maple silver maple sugar maple white ash basswood American beech	silver maple red maple green ash elm
DECIDUOUS - ADDITIONAL SPECIES	hackberry white pine	red maple white pine black cherry	hackberry butternut bur oak red oak	Manitoba maple hackberry black ash bur oak willow
CAROLINIAN SPECIES	black maple shagbark hickory Chinquapin oak black oak sassafras	black maple bitternut hickory shagbark hickory	shagbark hickory bitternut hickory black walnut sycamore swamp white oak	shagbark hickory black walnut sycamore swamp white oak
UNDERSTOREY	serviceberry witch-hazel ironwood	alternate-leafed dogwood witch-hazel ironwood	mountain maple blue beech	red osier dogwood willow

Most pioneer species (including paper birch, trembling and large-tooth aspen, cottonwood and balsam poplar) occur widely irrespective of soil type and moisture. However, many of the species listed in the table have specific growing conditions that must be met. Some, such as mountain maple, require the shade found in an established woodland environment. White pine is intolerant of exposed conditions. Many species are susceptible to salt spray from highways. It may not be possible, therefore, to establish some of these species at the outset of a woodland restoration project.

Other site characteristics that influence the establishment of plant material include soil fertility, organic content, and soil pH. These factors also affect growth rate. In general, soil pH in the Greater Toronto Bioregion is predominantly alkaline. Sites with acidic soils

or low pH have different plant associations. While increasing soil fertility is relatively easy, it is neither necessary nor desirable in most restoration efforts. Exceptions may be highly altered sites, such as where topsoil has been stripped or mining has occurred.

5.2 DESIGN CONSIDERATIONS

Before you start

Review factors that will influence woodland establishment, including:

- soil conditions;
- wind exposure;
- current vegetation type;
- past herbicide use;
- adjacent land uses that might affect success of woodland restoration.

Wildlife considerations

A primary consideration for wildlife is the size of the woodland. Large, continuous woodlands are necessary for interior woodland species. Generally, the larger the habitat, the more diverse the plant and animal species that will be found there.

Caution

Human impacts on woodlands, which range from trampling to deliberate destruction of vegetation or dumping of garbage, can be greater than ordinary edge effect. Road access increases impacts on the interior of the forest, whereas pedestrian trails through a wood appear to reduce overall impacts, as people tend to stay on the trails. (Matlack, Glenn R., 1993).

Enhancing wildlife habitat in woodlands

To enhance interior woodland habitat:

- enlarge existing wooded areas;
- increase woodland interiors;
- create blocks (nodes) rather than narrow strips;

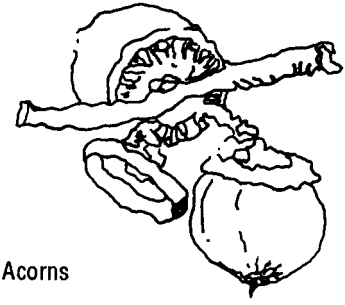
- infill gaps in the woodland fabric;
- provide edge vegetation to protect the interior from desiccation and intrusion;
- plant species for food and shelter.

To create a diversity of habitats:

- provide a balance between open and forested plant communities on larger sites (not within woodland communities);
- create wooded areas in a variety of soil conditions;
- provide different sized wooded areas linked by other habitat types;
- provide both nodes and corridors;
- provide uneven aged woodland representing of different seral stages (pioneer, climax species);
- provide edge vegetation immediately adjacent to woodlands to protect the forest community.

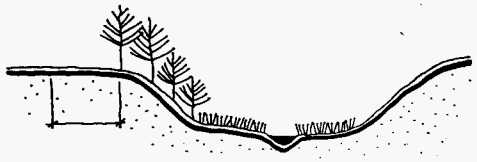
To provide food and shelter for wildlife:

- plant trees and shrubs with edible twigs, buds, seeds, nuts and berries;
- plant evergreens and edge species that form dense thickets.



Acorns

	BERRIES	*NUTS*	*SEEDS*	*EDIBLE TWIGS AND BUDS*	*SHELTER*
TREES	hawthorn pin cherry black cherry mountain ash	hickory American beech black walnut oaks	maples birch ash spruce pine poplars/aspen willow cedar	birch poplars/aspen	hawthorn thickets cedar
SHRUBS	service-berry dogwood choke-cherry shrub roses raspberries elderberry viburnum wild grape	hazel beaked hazel	staghorn sumac willow	dogwood	shrub roses dogwood wild grape

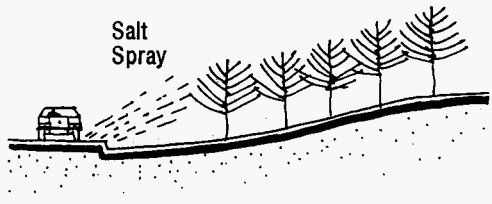


Top of Bank Setback
from Valley Slope

Buffer requirements

The proposed wooded area may need to be buffered from adjacent land uses and other impacts. Setbacks, such as top-of-bank setbacks along valley slopes, may be regulated through the official planning process.

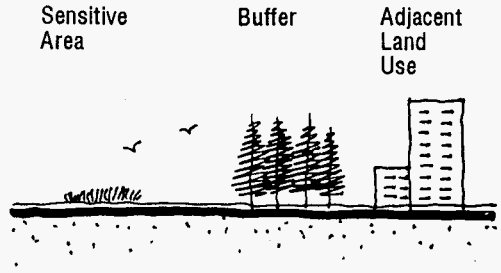
Top of Bank Setback
from Adjacent Natural Area



Salt spray from roads adversely affects a large number of native species, including maples, oaks, beech, white pine, and hemlock. In these situations, a buffer of salt-tolerant species may be necessary. They include poplars, aspen, white ash, chokecherry, mountain ash, and staghorn sumac.

Caution

For more information on salt-tolerant plant species, refer to horticultural publications and OMAF Factsheet 83-037: Salt damage to roadside plants *available from the Ministry of Agriculture and Food. Please note that most publications list both native and non-native species, and ratings in the different publications sometimes conflict.*



Evergreen buffers can reduce the visual impact of adjacent land uses. Buffers can protect existing woodland areas from new impacts or be part of a remedial strategy to enhance existing natural features. Woodlands can also be used as buffers to protect other habitat types, such as wetlands.

Edge treatment

Woodland edge is important to the overall health of the forest. Edge species serve to protect the woodland from drying winds, and ground flora from sunlight and competition from aggressive herbaceous plants. A dense woodland edge can also reduce human impacts by discouraging access and trapping litter.

SOIL MOISTURE	*DRY TO WELL DRAINED*	*MOIST, WELL DRAINED*	*MOIST, POORLY DRAINED*
EDGE SPECIES	serviceberry bittersweet gray dogwood bush honeysuckle pin cherry chokecherry staghorn sumac shrub roses flowering raspberry red raspberry snowberry	bittersweet gray dogwood red osier dogwood honeysuckle Canada plum staghorn sumac flowering raspberry red raspberry elderberry red elderberry highbush cranberry nannyberry	red osier dogwood firecherry staghorn sumac shrub willows elderberry nannyberry highbush cranberry wild grape

Access

Clearly demarcated access points and trails are important to reduce trampling through the understorey of a woodland. A well designed trail system can also enhance the woodland experience, by guiding the pedestrian through areas with different characteristics.

Caution

Mountain bikes and motorized recreational vehicles can cause tremendous damage to trails and to woodland understorey and ground flora. If trails are to be used for these types of recreation, their design should accommodate this type of use. Where mountain bikes are already causing damage to trails, or where habitat is too sensitive to tolerate bike traffic, signage, regular control, and alternate routes can discourage use in those areas.

5.3 RESTORATION OPTIONS AND TECHNIQUES

Prior to getting started, review some of the factors that will influence the establishment of woodland on a site, such as soil conditions, wind exposure, current vegetation type, herbicide use in the past. Are there nearby land uses, such as highways or industry, that could affect the success of the woodland? Ensure that you have collected the necessary information in order to select the appropriate restoration techniques.

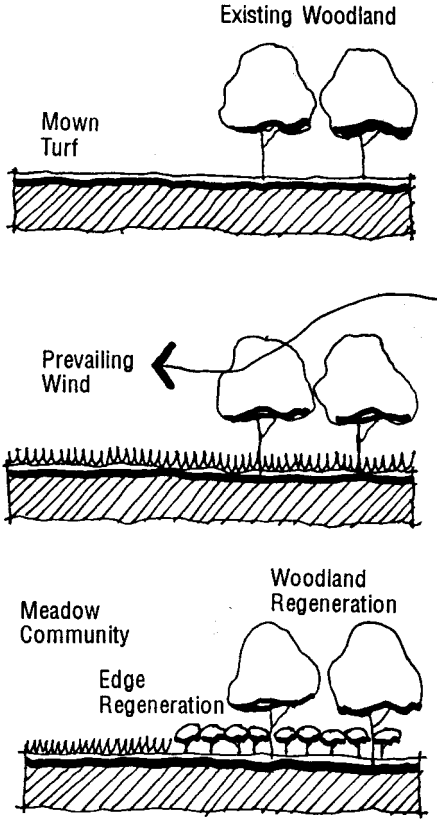
The selection of woodland restoration techniques is dependent on the time frame it takes to establish wooded habitat, the cost of implementation, and subsequent management requirements. The following techniques will be discussed:

- natural regeneration;
- nucleation;
- managed succession.

Direct seeding and topsoil applications, mentioned in *Ecological Restoration Opportunities for the Lake Ontario Greenway*, have not been successful in Ontario and have had only limited success elsewhere.

Natural regeneration

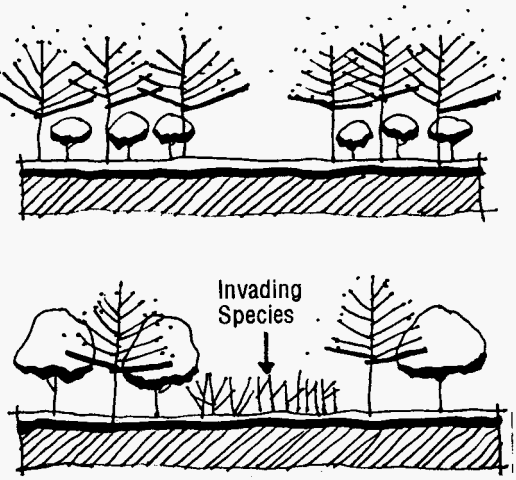
Natural regeneration occurs where mowing and other types of intervention are discontinued. In the absence of disturbance, the process of succession occurs naturally and woodland vegetation is re-established over time. This is the least costly approach. However, it takes longer to restore an area to woodland. Grasslands and old field communities have an inhibiting, or allelopathic, effect on the germination of trees and shrubs, and rodents, prevalent in grasslands, reduce the number of seeds available for regeneration.



Caution

Lands may appear abandoned in the initial phases of succession, which may affect public acceptance in urban areas. Where this is a concern, edge planting can be used to enhance the appearance of naturalizing areas and to protect them from trampling and vandalism. Edge species can also enhance wildlife habitat, providing food and shelter.

Natural regeneration is probably best suited to the expansion of existing woodlands, or sites for which a long time frame is acceptable.



Nucleation

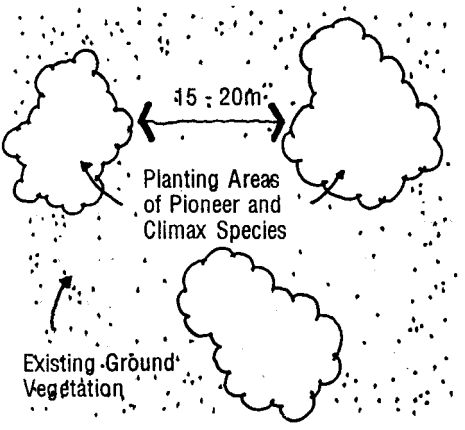
Nucleation consists of planting patches of trees. This allows for key species to become established, thereby accelerating natural regeneration. Clumps must be sufficiently large to ensure that the trees are viable and survive in good condition. Over time, groves gradually become larger and eventually coalesce, creating an uneven, aged woodland.

Nucleation is a cost-effective method where large areas are to be restored to forest. It is a useful technique to introduce desirable species in a woodland lacking diversity.

The most desirable species for nucleation are those that produce a heavy annual seed crop and root suckering. Since the technique relies on natural regeneration, seeds must have high viability and be competitive in a grasslands or old field community. Species that rely on wind dispersal, or dispersal by birds, will produce seeds that are distributed over a large area. A few examples are given below.

	ROOT SUCKERING	*BIRD DISPERSED SEED CROP*	*WIND DISPERSED SEED CROP*
TREES	trembling aspen balsam poplar	black cherry hawthorn	paper birch poplars and aspen elm
SHRUBS	gray dogwood red osier dogwood staghorn sumac blackberry red raspberry	dogwoods pin cherry chokecherry staghorn sumac	shrub willow

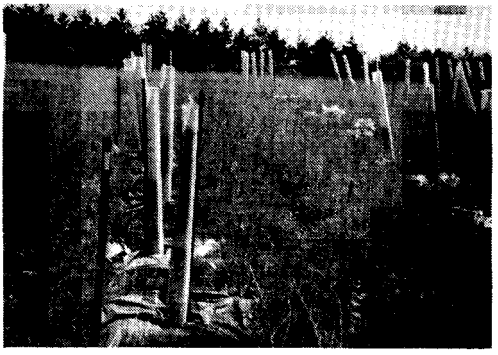
The distance between patches can vary, creating a more natural effect as they grow together. Distances could be as small as 10 metres, or 50 metres or greater. Planting shrubs as edge species may help by reducing wind desiccation and by providing a buffer between tree species and old field vegetation.



New plantings need protection from winter rodent damage to ensure survival. Alternative approaches include:

- fencing small (50-100 m²) patches with fine mesh;
- placing plastic or paper sheeting over small patch surface;
- wrapping individual tree guards around whips or seedlings.

(See also alternative weed control measures under Natural Regeneration.)



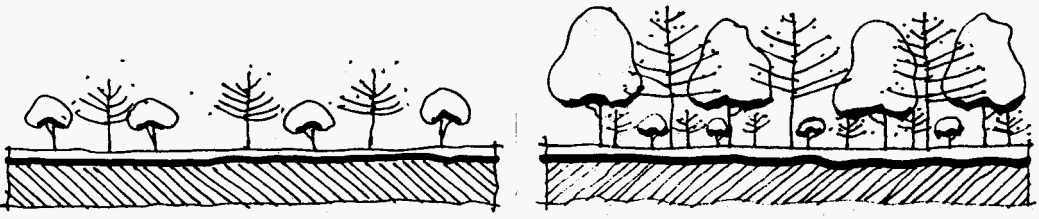
Tree shelters providing rodent protection and microclimate control

Where plantings are not protected from rodents, increase patch size substantially. Such damage occurs at the base of plants primarily in winter.

Managed succession

This approach, first developed in the Netherlands and Britain, is based on the principle of natural succession assisted through management. Planting is initiated with pioneer or fast growing nurse species, continues with slow growing trees, and evolves over time into a climax stand.

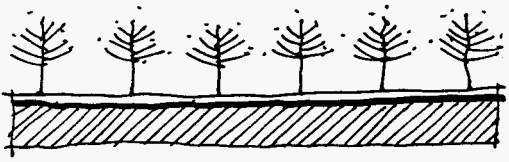
Composition, character and uses of the woodland will be quite different as it evolves. Site conditions in initial stages are less critical than they are in standard plantations, since the nurse crop functions



to ameliorate soil drainage, fix nitrogen, stimulate soil micro-organisms, and create a microclimatic environment suited to the development of climax vegetation.

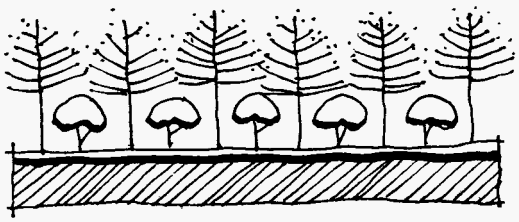
Approaches to Planting

Irrespective of the density of planting, several options can be considered.



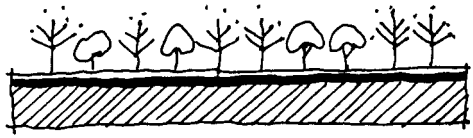
Initial planting of pioneer species only:

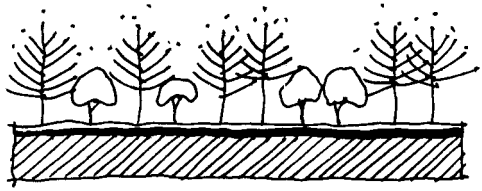
- quickly creates the woodland environment, with canopy closure. Improves the microclimate for climax species;
- requires planting of climax species at a later date;
- relies on natural succession for introducing climax species (requires a seed source and may be slower);
- the final composition of the woodland will be different from the species originally planted.



Combination of pioneer and climax species:

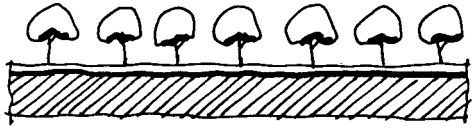
- fast growing pioneer species and climax species are planted at the same time;
- they quickly improve microclimate while the slower growing climax species become established;
- replaced naturally by climax species as the woodland matures;
- the final composition of the woodland will change over time;
- establishment of climax species may take longer or they may not survive.





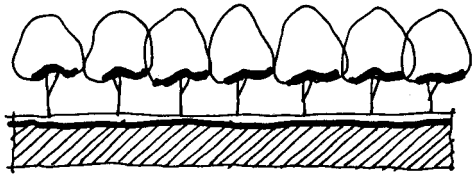
Initial planting of climax species only:

- slower growth of climax species results in a much longer restoration process;
- the final composition of the woodlands reflects the species originally planted.



Planting of a single species:

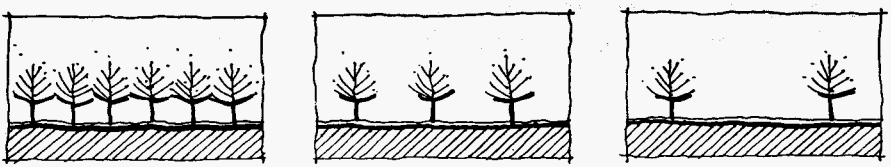
- common in forestry applications;
- results in plantations that are not self-sustaining and are considered to have low ecological value.



Plantations may be suitable for cedar stands, which naturally occur as a single species, but the spacing of the plant material should be random, not regular. As part of ecological restoration, a mixture pioneer and/or climax species is more appropriate.

Spacing

Differences in spacing reflect three basic possibilities: planting the ultimate quantity, planting greater-than-ultimate quantities, and planting less-than-ultimate quantities. Each approach has advantages and disadvantages.



	GREATER-THAN-ULTIMATE QUANTITY	*ULTIMATE QUANTITY*	*LESS-THAN-ULTIMATE QUANTITY*
SPACING	1 m, 1.5 m or 3 m on centre	5 m to 6 m on centre	10 m or more on centre
PLANTING COSTS	high	moderate	low
WOOD-LAND CREATION	fast canopy closure (some pioneer species 5 years)	slow canopy closure	very slow canopy closure
VISUAL APPEAR-ANCE	woodland	open woodland	grasslands with some woody vegetation
MANAGE-MENT	regular thinning of the stand	reducing weed competition	reducing weed competition and replanting bare areas
MANAGE-MENT COSTS	post canopy closure thinning, which is labour intensive and relatively costly	low	low
RODENT DAMAGE	unlikely to create significant gaps in planting	may require some replanting	extensive damage may require replanting of areas
REMARKS	some management until climax species are established (depending on approach to woodland establishment)	initial planting requires neither ongoing management nor extensive time frame	trees planted initially act as seed source and create a suitable microclimate for natural regeneration

Plant material

The size of the planting stock is largely a question of cost. Acreage of most restoration projects precludes the use of large plant material. As a result, seedlings and lining out stock are often used. Both bare root and container grown material have advantages and disadvantages. Planting methods usually rely on hand labour, but

the use of mechanical planting sticks could be a possibility for the planting of large quantities of seedlings.

Plant Material

	BARE ROOT MATERIAL	*CONTAINER GROWN*
COST	cheap	more expensive
HANDLING	easy to transport	bulky and heavy
CARE PRIOR TO PLANTING	roots must be kept moist at all times	potted, less susceptible to drying out
STORAGE	requires cold storage facilities or must be planted right away	can be stored for long periods with occasional watering
PLANTING TIME	narrow window in spring and fall	any time during the growing season
SUCCESS RATE	varies with care given prior to planting	more consistent results

Site preparation

Site preparation is a crucial factor in woodland restoration. As old field vegetation and grasses compete for nutrients, moisture and sunlight, these species must be eliminated before woody species are planted. (For specific remedial measures see Section 5.4 on soil rehabilitation.)

Alternative weed control measures

TREATMENT	*ACTION*	*COMMENTS*
MECHANICAL/ MANUAL CULTIVATION	◆ cultivate planting area prior to planting to kill ground vegetation ◆ cultivate manually during growing season (monthly)	◆ labour intensive ◆ application to small or awkwardly sheltered areas ◆ application to close planting where fast canopy closure is a high priority ◆ constant maintenance during growing season
BLACK PLASTIC:	◆ cultivate ground 30 to 45 cm deep; ◆ apply plastic sheeting to surface and peg in place; ◆ puncture holes with a garden fork at 15 cm on centre; ◆ cut crosses in sheeting in planting locations; ◆ install plant material and re-cover with sheeting; ◆ apply 2 to 3 inches of wood chips or leaf mulch over area. ◆ applying mulch prior to the installation of the plant material is more convenient when a random spacing is used.	◆ highly effective ◆ easy to install ◆ low to no maintenance costs to control weeds ◆ non-biodegradable, and must be removed after canopy closure ◆ potential visual problems without mulching on top of sheeting

PAPER PRODUCTS	• install plant material; • remove herbaceous vegetation around the plant; • install paper collar; • apply 2 to 3 inches of wood chips or leaf mulch over area.	• effective • easy to install • low maintenance costs to control weeds • biodegradable in approximately 5 years • suitable for low planting densities and random planting

Mulching

Mulching reduces competition from grasses and other herbaceous species. Mulch should be 7 to 10 cm (3 to 4 inches) thick. The area to which mulch is applied depends on the spacing of plant material. In densely planted areas, the mulch layer can be continuous. For trees and shrubs planted individually, the mulch should be applied over the root zone (60 to 90 cm diameter). Mulch generally consists of wood or bark chips, although other biodegradable materials have been used.

Caution

Do not apply mulch over areas with high soil moisture, until the soil has dried out. Mulch can trap moisture and encourage rotting of newly installed plant material.

5.4 RESTORATION OF DEGRADED HABITAT

For plantations, grazed and biologically stressed woodlands, restoration techniques focus on reintroducing diversity and redressing site conditions. Soil rehabilitation techniques discussed here are also appropriate for areas where topsoil has been removed.

Soil rehabilitation

Three common problems are soil compaction, soil fertility, and lack of organic matter. These conditions often occur simultaneously, especially where topsoil has been removed. Soil compaction will require different solutions from low nutrient levels, or lack of organic matter.

Compaction or poor soil structure

Soil compaction due to grazing or overuse results in reduced water penetration and a lack of oxygen. It creates adverse conditions for roots and seriously limits plant growth, as well as seed germination and establishment.

Soil rehabilitation requires aeration or cracking of soil to improve its physical structure.

Traditional aerators generally effect the root zone of sod and have little benefit for woody species. Newer aerators pull a solid plug object through the soil, loosening compacted soil much more deeply and effectively. Where existing plant material limits the use of other techniques, small explosive charges in the ground can give the desired result. Companies specializing in these techniques should be consulted. Disking or rototilling can also loosen compacted soil.

Caution

Disking or rototilling exposes seeds in the soil to light, resulting in increased weed growth. It disturbs the root zones of existing trees.

Soil fertility and organic matter content

Check soil nutrient and organic matter levels. Consider the application of fertilizers only where a gross imbalance exists that would jeopardize the success of the restoration. Native plant species generally create viable, self-sustaining communities in soils with low nutrient levels. Of greater concern are those soils with higher-than-normal fertility, since this encourages competition from weeds and introduced species. To remove soil nutrients, harvest plant growth for one or more seasons prior to restoration of woodland species.

Deficiencies in organic matter can be improved by:

- adding leaf compost to enhance soil composition and structure;
- adding manure to provide soil nutrients in soluble form;
- growing a green manure crop such as clover or annual grasses. These are plowed under after one growth season;
- planting deep rooting clovers and other legumes to improve soil structure and enhance water penetration.

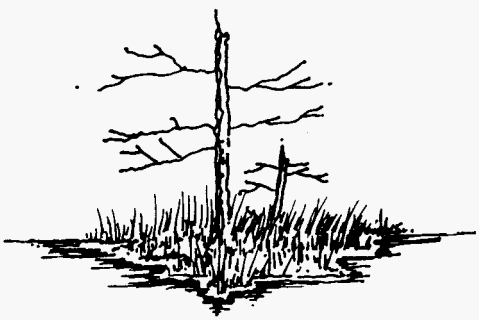
Caution

During the decomposition process, organic matter can tie up available nitrogen and make it unavailable for plant growth. In soils with low nutrient levels, it may be necessary to add a nitrogen fertilizer.

Manure and municipal compost may contain introduced plant seeds. Peat moss is a nonrenewable material and should not be used.

Thinning existing stands and gap creation

Gap creation, or thinning, opens up the canopy and allows light to penetrate to the forest floor. This improves growing conditions for seedlings, enhances their survival, and can add diversity in a plantation or a dense early successional woodland. Several small gaps are preferable to one larger one. Gaps should be small enough that excessive growth of early successional herbaceous species is not encouraged.



Selective removal of a few trees will be sufficient to create a gap. Do not remove large, healthy specimens or dead trees (snags), which serve an important function for many wildlife species.

Planting in or near an existing stand can introduce desired species that become the seed source for natural regeneration. Planting may not be necessary where suitable a seed source exists.

Interplanting

In pioneer stands, interplanting of climax canopy species will speed up the development of mature woodland. Interplanting is also used to introduce midstorey and understorey plants in existing stands that have an established canopy.

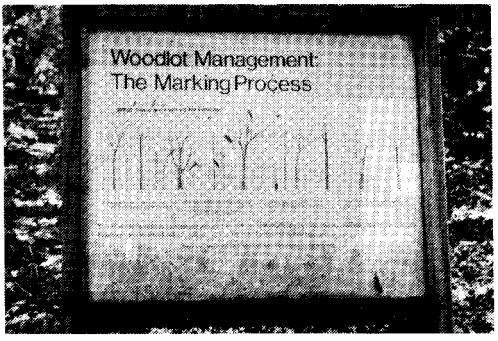
Control of introduced species is difficult in the urban environment. The best control is prevention. Avoid planting introduced species

adjacent to natural areas, and if they are present, remove them. Since this is labour intensive, expensive, and sometimes causes damage to natural areas, it is important to remove the seed source as well. If doing so is not possible, control measures will become part of the ongoing management for the area.

Bioengineering techniques

For steep slopes, bioengineering techniques may be useful. Contour wattles or fascines are used to stabilize cut slopes, and brush layering can be used in fill situations. Both techniques create sheet drainage across the slope, since erosion channels, or rills, can seriously undermine newly placed plant material. For a more detailed discussion of these techniques see Section 6 on Riparian Habitat.

5.5 MANAGEMENT



Management of woodlands occurs primarily during their establishment. The initial period involves maintenance measures to achieve canopy closure. Later, management techniques are aimed at achieving a self-sustaining woodland. Management approaches for different types of woodland landscapes should reflect site specific conditions and restoration objectives. Some general guidelines are given below.

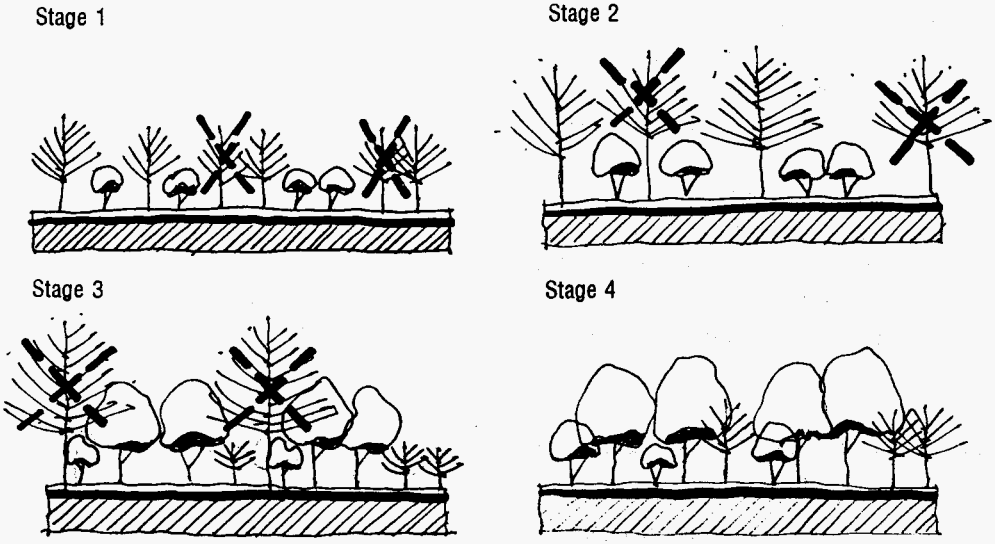
During the initial maintenance period, which lasts until canopy closure (4-6 years):

- evaluate the survival of plant material, and implement remedial measures if required. Small patches where survival has been poor will not affect woodland establishment, but widespread problems need to be addressed;
- check for gnawing or browsing damage, and determine if remedial measures are required;
- control grasses and herbaceous vegetation in planted areas. Reinstall mulch if necessary;

- remove black plastic, if used, once canopy closure has occurred.

Management considerations to achieve a self-sustaining woodland include:

- thinning of stands to reduce overplanting. This generally involves the removal of pioneer species in 2 to 3 successive thinning operations, allowing the slower growing climax species to gradually form the woodland canopy;
- interplanting of climax species in pioneer stands, or addition of midstorey or understorey plants (depending on natural volunteering of species);
- replacing trees in areas where there has been poor take, rodent damage or deer browsing;
- controlling undesired species through burning or manual removal of introduced plant material.



Opportunities:

- leave trees felled as part of the thinning process to enhance wildlife habitat;
- leave snags to provide nesting habitat for birds.

Dealing with invasive species

Garlic mustard, a herbaceous groundcover, is a very prolific grower that displaces native flora. Preferring shady, moist locations, it reaches a height of 60 to 90 cm, lower in dry or sunny locations. Control methods are limited. Hand removal prior to flowering in late May or early June is feasible for small areas.

Tatarian honeysuckle is a deciduous shrub that has escaped from cultivation. It is adapted to shady locations, but also occurs in sunny but moist areas, such as riparian habitat. Removal is very labour intensive due to the dense branching structure. Either roots have to be dug up, or the stumps painted with herbicide to prevent regrowth. The use of herbicides is controversial in urban areas and is often banned. Burning the understorey has also been tried in New England, with varying degrees of success. Burning may not be an acceptable alternative in some urban areas.

European buckthorn is a deciduous shrub that displaces native understorey species and ground flora in woodlands. It is continuing to spread northward. The shrub creates a dense thicket of branches. The heavy shade prevents native flora and understorey species from competing. Eradication is very labour intensive, since both branches and roots must be removed to prevent regrowth. Painting stumps with herbicide is an alternative (often controversial in natural areas).

Norway maple is a deciduous tree that has escaped from cultivation. A number of cultivars have been widely planted in built-up areas, due to their tolerance of urban conditions. In many cities, Norway maples have become so popular that they have been planted—and continue to be planted—as street trees, in park settings and on residential properties. Norway maples are prolific seeders, and their seedlings have a high success rate. They now occur in natural valleys and ravines throughout urban areas, and even in rural zones. Mature trees cast a very dense shade, displacing native canopy trees and understorey species. The lack of understorey contributes to erosion on the slopes of ravines and valleys. On all sites, Norway maples displace native flora and alter habitat. Control in urban areas will be difficult, due to the steady seed supply. In natural areas, management must include the removal of both trees and the seed

source. Norway maples should not be planted near ravines, valleys, or other natural areas.

5.6 MONITORING

A self-sustaining woodland requires little supervision. In the initial phases, the success of restoration may be monitored. In order to obtain relevant results, evaluate both the success of the technique and the survival of the different species. Monitoring rodent damage may indicate the need for remedial measures or additional planting. Consider what went right and what went wrong during the installation and subsequent establishment phase, and the reasons for those results.

Densely planted areas restored by managed succession must be monitored to assess the need for thinning. They require ongoing attention and periodic thinning.

Invasive introduced species should be monitored to determine whether to implement control measures, and, when carried out, how effective they have been.

In urban areas, woodlands should be monitored for safety. Dead or hazardous trees and large dead limbs should be removed where they jeopardize the safe use of public walkways, trails and open areas. Woodlands and other treed areas should be monitored regularly to ensure that no hazardous situations develop.

Selected References

Dougan & Associates and Ecological Consulting Services, July 1993. *A Short List of Desirable Woody Plant Materials For Use Within the Jurisdiction of Metropolitan Toronto and Region Conservation Authority.* Metropolitan Toronto and Region Conservation Authority, Toronto, Ontario

Hosie, R.C., 1979. *Native Trees of Canada.* Ministry of Supply and Services Canada. Fitzhenry & Whiteside Limited, Don Mills, Ontario

Hough Stansbury Woodland Naylor Dance and Gore & Storrie, June 1994. *Ecological Restoration Opportunities for the Lake Ontario Greenway.* Waterfront Regeneration Trust, Toronto, Ontario

Soper, J.H. and M.L. Heimburger, 1982. *Shrubs of Ontario.* The Royal Ontario Museum, Toronto, Ontario

Von Althen, F.W., 1990. *Hardwood Planting on Abandoned Farmland in Southern Ontario: Revised Guide.* Great Lakes Forestry Centre, Forestry Canada, P.O. Box 490, Sault Ste. Marie, Ontario

RIPARIAN ZONES

6.1 SITE CHARACTERISTICS AND TYPICAL PLANT ASSOCIATIONS

A riparian zone is defined as land that is saturated by groundwater or subject to flooding every 2 to 20 years.

There are two broad categories of riparian habitat:

- shoreline zones;
- riparian zones along stream corridors.

Both the near shore zone and streams are sensitive natural systems that contain fish habitat.

Near shore zones

Shorelines are complex and dynamic. The character of a shoreline riparian zone is closely linked to its geomorphology and the type of material that constitutes the lakebed near it. Under natural conditions, wave action shapes the shoreline through erosion and sediment transport. However, most of the Lake Ontario shore in the highly urbanized area between the Rouge River and Burlington has been modified by lake filling or erosion and flood protection measures. Natural shoreline processes have been drastically altered.

The natural shoreline types listed below support characteristic plant communities. Some, such as dynamic beaches and dunes, are very specialized systems requiring expert advice. Detailed information regarding specific plant associations will also require professional input.

Shoreline types and features along Lake Ontario include:

- dynamic sandy beaches with dunes (Burlington Beach, Presqu'ile);
- shoreline bluffs (Scarborough Bluffs);
- shingle beaches (Halton);
- sand and cobble beaches (Northumberland);
- river mouths with associated low lying areas (Humber River);
- shoreline wetlands (Rouge River);
- barrier beaches (Lynde Shores).

Modified and altered natural shorelines include:

- lake fill areas (Tommy Thompson Park);
- beaches (Toronto Islands);
- places where the shoreline has been reinforced with riprap, rock, groynes, or piers.

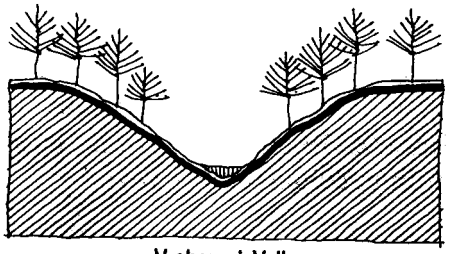
In these modified areas, vegetation can mimic the plant associations that typically occur along natural shorelines. This manual will not deal with the restoration of shoreline structure or processes. It is concerned with habitats along the shore that are quite similar to riparian habitats.

Stream corridors

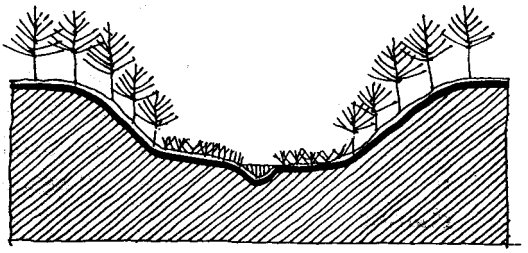
The riparian zone of a stream is closely related to its geomorphology and that of the surrounding lands. The valley and watershed influence the character and condition of a stream. Modifications to the permeability, groundwater recharge and surface runoff components of a watershed can all lead to changes in the stream class, shape, bank erosion, sedimentation, base flows, etc. A natural stream is dynamically stable, biologically self-regulating, and self-sustaining. Its valley corridors contain healthy plant communities and diverse habitat.

Definition of stream corridor and width is based on valley profile:

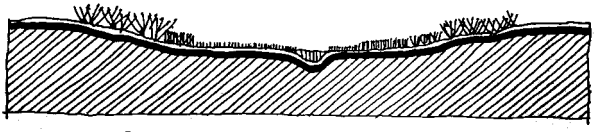
- V-shaped valley;
- U-shaped valley;
- irregular shaped valley;
- riverine wetland or riparian/bottomland;
- stream with no defined valley system.



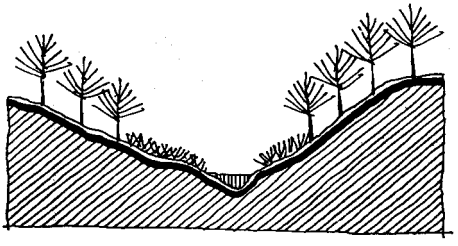
V-shaped Valley



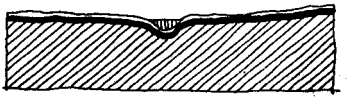
U-shaped Valley



Stream Corridor Defined by a Wetland

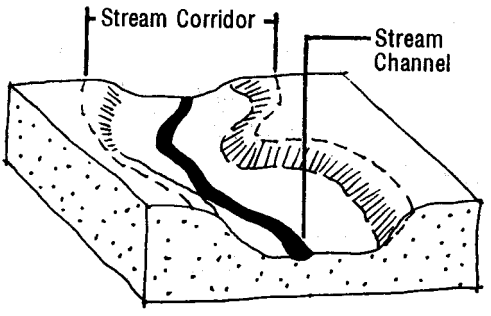


Irregular Valley



No Defined Valley

In urban locations, the extent to which development may encroach on the natural system is regulated via setbacks. A number of factors influence setbacks, such as cold water fish habitats, flood and fill lines and the presence of wetlands. Setbacks included in the stream corridor are typically:



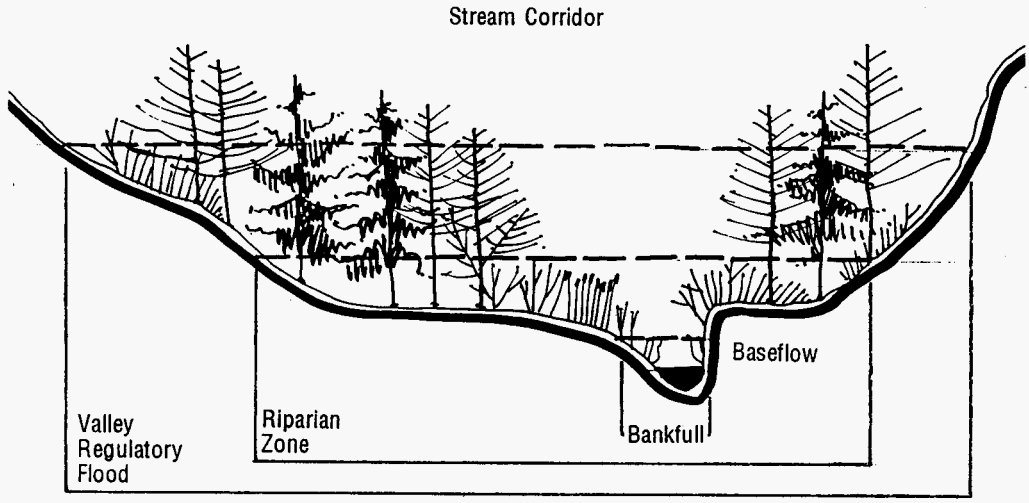
- 10 metres from stable top of bank for valleys;
- 15 metres from minor wetlands.

For watercourses with no defined valley system, setbacks are based on whether they are cold or warm water streams. The setback for the former is 30 metres and 15 metres for the latter. Contact the Ministry

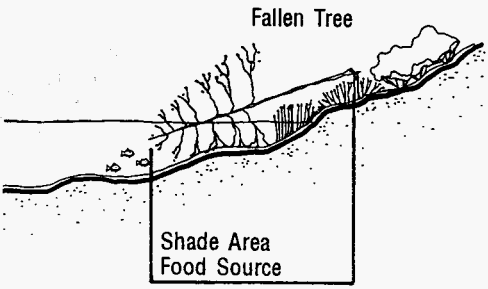
of Natural Resources and local conservation authority for specific information.

Defining the riparian zone for stream corridors

The width of a riparian zone varies with the type of stream corridor. The riparian zone buffers the banks from the erosive forces of flowing water, which in turn keeps vegetation from colonizing a stream channel.



Cross-section of stream corridor



The near stream zone provides shading, leafy debris and a food source for aquatic species. Fallen trees and branches trap sediment, reduce bank erosion and provide valuable fish habitat. Log jams normally form on the outside bends of a meandering section of stream. Woody debris can also enhance pool depth. Healthy riparian zones help maintain a high water table, reduce nutrient levels and improve water quality.

The following chart summarizes typical plant communities in the riparian zone. (For wetland species see Section 4.)

SWAMP THICKETS	*TREE SPECIES*	*RIVER AND STREAM EDGE*	*SANDY, GRAVELLY RIVER EDGE*
mountain maple	red maple	speckled alder	gray dogwood
speckled alder	silver maple	buttonbush	red osier dogwood
bittersweet	green ash	silky dogwood	firethorn
firethorn	black walnut	gray dogwood	common ninebark
winterberry	cottonwood	red osier dogwood	pin cherry
honeysuckle	trembling aspen	firethorn	chokecherry
sweet gale	bur oak	sweet gale	staghorn sumac
chokecherry	peachleaf willow	Virginia creeper	sand bar willow
swamp rose	black willow	Canada plum	wild grape
peachleaf willow	eastern white	chokecherry	
pussy willow	cedar	flowering dogwood	
sand bar willow	basswood	pussy willow	
black willow	white elm	sandbar willow	
elderberry		slender willow	
meadowsweet		elderberry	
whithrod		meadowsweet	
nannyberry		nannyberry	
highbush		highbush cranberry	
cranberry		wild grape	

6.2 DESIGN CONSIDERATIONS

Before you start

Consider the following:

- Is it shoreline? If so:
  - → what are the predominant soil types?
  - → is active erosion occurring?
  - → is soil eroding from the site being deposited in adjacent wetlands or along beaches?
  - → what are the characteristics of the adjacent aquatic habitat (substrate type, aquatic vegetation, water clarity, and temperature)?
  - → will restoration require working in the water and, if so, can this be done without adversely affecting fish habitat?

- Is it a new stream riparian area? If so:
  - → is the stream stable or eroding?
  - → does it have a well defined floodplain or valley?

- → is the floodplain inundated seasonally?
- → does the stream exhibit wide fluctuations in flow?
- → what vegetation is present along it and in the floodplain?
- → will restoration require working in the water and, if so, can this be done without adversely affecting fish habitat?

Restoration of shoreline and stream habitats generally involves one or more of the following:

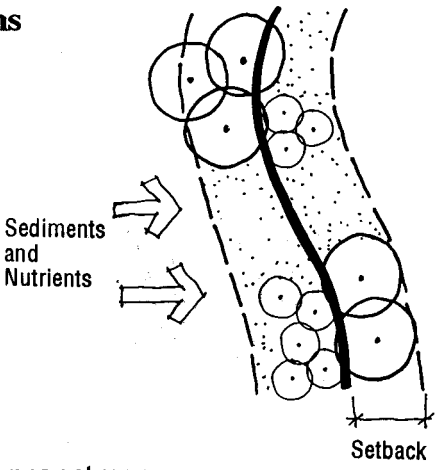
- flood protection;
- erosion control;
- fisheries habitat creation;
- terrestrial wildlife habitat enhancement.

If flood protection or erosion control is contemplated in the near shore zone or in stream and river corridors, exploring fisheries habitat improvement is a priority. In all cases expert advice should be sought and the appropriate regulatory agencies contacted to obtain the necessary permits and approvals. Only some of the terrestrial habitat enhancement techniques do not require permits.

Condition of the stream channel

In all projects involving the riparian zone of streams and rivers, consider their hydrological condition before embarking on planting to reduce erosion. Recently established vegetation can easily be washed away during floods because of the regular scouring action of the flowing water. The physical condition of the stream must function to maintain a dynamically stable geomorphological condition. Once this is achieved, planting in the riparian zone can create considerable benefits for fisheries and wildlife.

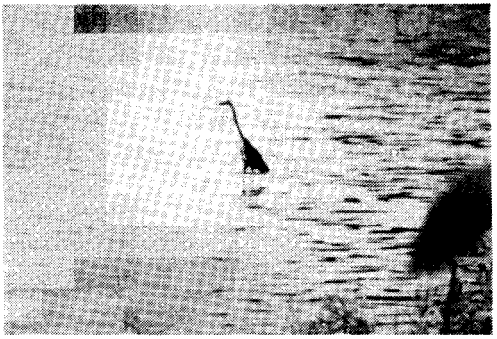
Buffer requirements and edge conditions



The purpose of setbacks and buffers is to allow streams to regain their floodplain, dissipate energy over larger areas, and improve water quality, fisheries and wildlife habitat. Setbacks discussed under valley and stream characteristics (Sub-section 6.1) indicate the minimum buffer requirements. In general, wider buffers will be more beneficial to wildlife. Buffer design should consider:

- shading requirements for fisheries in the near stream zone;
- the need for rough vegetation, such as sedges, grasses and other herbaceous species;
- shrubby plants to trap sediments and nutrients.

Wildlife considerations



Some wildlife areas will require wide corridors along streams. It should be noted that a 30 m wide corridor is not adequate for many wildlife species. (For a discussion on corridors and the need for further research see *Ecological Restoration Opportunities for the Lake Ontario Greenway*, June 1994, prepared for the Waterfront Regeneration Trust.)

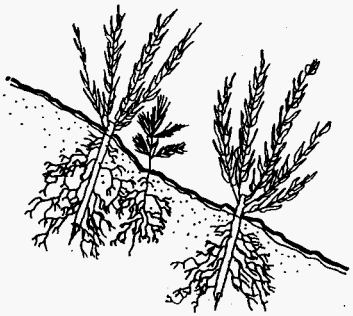
6.3 Restoration Techniques for Terrestrial Habitat

Within the riparian zone, protect edges of streams with planting and, where necessary, with rocks. Shading enhances fish habitat and serves to reduce water temperature. Fertilizers and herbicides should not be used. The primary techniques for establishing plant material include:

- planting of shrubs and trees;

- bioengineering techniques, including live stakes, mats and hydroseeding herbaceous vegetation.

Bioengineering techniques

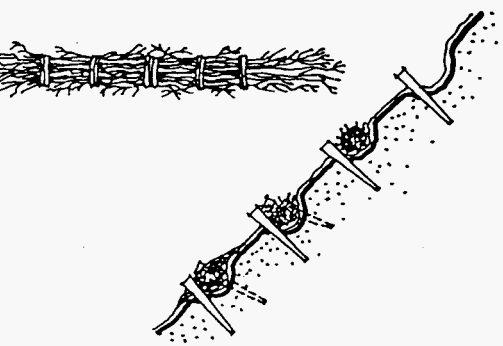


Live Stakes

Cuttings of certain species will root easily when planted. To make live stakes, take cuttings of last season's growth from suitable stock, such as poplar, willow or dogwood. The cuttings should be approximately 1 m in length with a diameter of approximately 2 to 3 cm. Insert each stake wide end first into the ground, burying it approximately 70 to 80 percent of its length. If the soil is too hard to insert the cutting directly, use a metal stake to make a hole, taking it out carefully to ensure the live stake has good contact with the soil. Cuttings are often planted in rows following the contours of the land. Spacing is typically 30 cm on centre within the row, with approximately 1 metre distance between rows.

Rooting and substantial growth occur during the first growing season, so live stakes can provide quick and effective cover. Success of the installation depends on:

- the use of suitable species (those that root easily);
- ensuring that the small end is above ground;
- ensuring that the lower end of the cutting is inserted deeply into the ground.

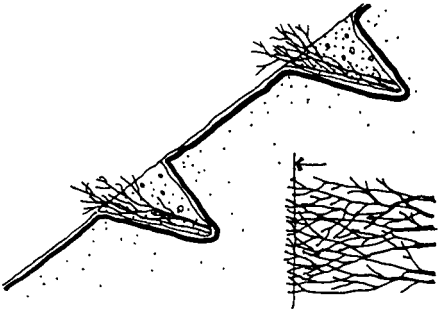


Fascines

Fascines can be used to stabilize eroding stream banks. Live branches of species that root readily (e.g., willows and dogwoods) are bound together with binder twine to form tight bundles approximately 2 m long and 20 cm in diameter. These are placed horizontally along the edge of the bank starting at the bottom of the

stream. They are stacked along the eroding bank. Soil is carefully tamped around the fascines. Compaction of the soil around the sides of the bundle is critical to get good plant-soil contact. The top of the bundle should remain showing above the soil. For best results, cuttings should be taken, bound, and placed on the same day.

Brush layering



Brush layering can be used to stabilize severely eroded banks and slopes where fill is required. Cuttings of shrubs, i.e. branches, are laid in horizontal rows across the slope to maintain sheet drainage and reduce the speed of the water and thereby its erosive force. The cuttings should be at least 1 m long and are inserted into the slope with only 25% of the branch length extending beyond the slope. The ends of the branches which stick out from the slope should form a horizontal row. The individual branch cuttings are placed perpendicular into the slope as shown in the diagram. After placement of the cuttings the soil is carefully compacted to ensure that no air pockets remain. Good soil compaction is critical to the success of brush layering.

The type of plant material used should root easily, i.e., willows, dogwoods, alders and native viburnums. If such cuttings are difficult to obtain, filler shrubs can be used in combination with species that root more easily or in combination with potted material. Ensure that the wide ends of the branches are inserted into the slope and that the top extend outward.

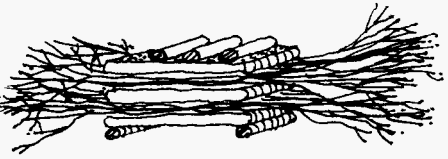
When using bioengineering techniques, consider:

- the ease of rooting of the plant material;
- the time of year. Spring installations may perform better than mid-summer installations. For fall installations, cuttings from hardwood species that root well over the winter can be selected;
- where to obtain the source material.

These techniques are relatively labour intensive and require specialized knowledge and experience. Installation crews should be carefully supervised by an experienced leader. Use of a combination of techniques is common.

Before stream bank restoration

After stream bank restoration



Other techniques include the construction of crib walls with logs to retain newly placed soil along stream banks. Live stakes can be placed in the cribwall to accelerate plant regeneration.

Live stakes can also be used to introduce plant material in riprap slopes or along stream edges.

Fibre mats and rolls

Mats and rolls are often made from coco fiber, a natural product that is very strong and disintegrates slowly. They provide a growing medium for establishing plants. In order to withstand stream currents and potential floods, the mats and rolls must be tightly secured with long stakes anchored into the ground. Sediments and seeds accumulate naturally within the fibrous structure, protected from the scouring effect of the water flow. Over time (generally one growing season), herbaceous species begin to establish themselves. Mats are particularly useful for gentle slopes. Rolls can be stacked and are used to rehabilitate steeper stream banks.

Wildflowers in rolls or flats

Herbaceous plant material can be grown either in flats or, as with sod, in strips that can be cut and rolled. These can be laid out to create an instant herbaceous cover along stream banks. However, the cost of growing the plant material is a limiting factor.

Hydroseeding

Hydroseeding is often used as a cost effective alternative for establishing groundcovers. Where extensive work has been undertaken along a stream, hydroseeding can provide fast cover. In this process, a mixture of water, mulch and seed is sprayed on the surface to be seeded.

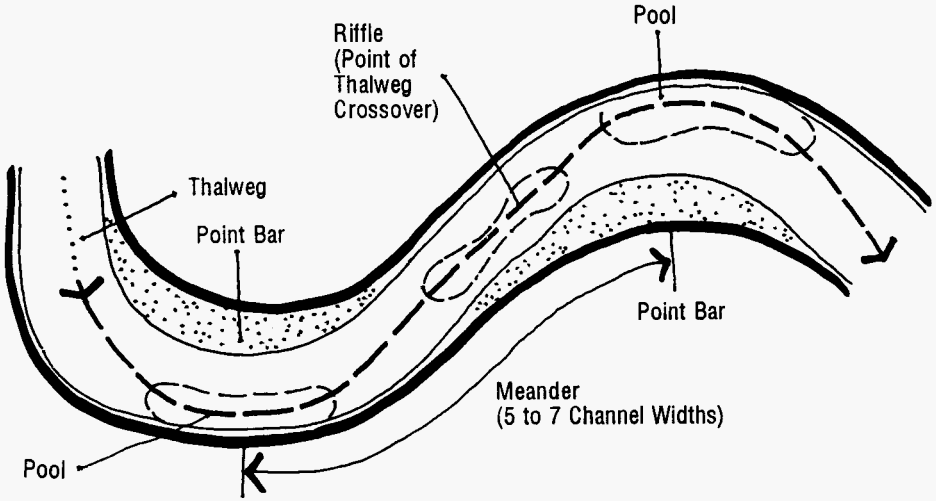
Caution

Most commercial grass and wildflower seed mixtures contain introduced species. To ensure the use of native species, wildflower mats must be custom grown. When hydroseeding, insist on custom seed mixes and identify the native grass and wildflower species to be included.

6.4 Restoration Techniques for Aquatic Habitat

Restoration of stream channels

Where a stream channel requires restoration work or must be relocated, natural channel design is the preferred approach. It involves using the natural geomorphological structure of the stream to provide the framework for a range of self-sustaining terrestrial and aquatic communities. Stream channel work will require expert advice. (For further information on natural stream channel design see bibliography or contact the MNR.)



Plan of channel meander (Source: MNR)

Restoration of fisheries habitat

Permits are required for in-stream or near shore work. The project is usually carried out during the summer to lessen the impact on fisheries and reduce possible flood damage.

Restoration of fisheries habitat may involve correction of bank erosion problems, improvement of water quality and temperature and enhancement of spawning areas, as well as juvenile and adult habitat. It is important to determine whether erosion is active and accelerated as opposed to "natural", and whether or not it requires remedial measures. Consult an expert who can carry out simple checks, including width/depth ratio measurements and extent of point bar formation (a process of deposition that may offset the erosion on the opposite bank).

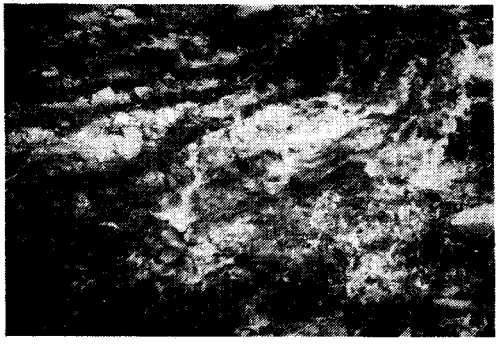
Placement of boulders can protect eroding banks from the force of the flowing water. Channel deflectors can be installed to reduce bank erosion.

Caution

Gabions, ledge rock, and riprap have been overused in the past and have led to the removal of in-stream and riparian habitat. These erosion control measures can result in the erosive energy being transmitted downstream, where more erosion occurs. To minimize downstream impacts, use different sized rocks and stagger placement as much as possible.

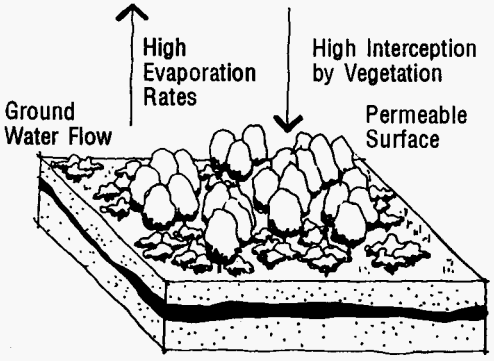
In many cases cabling logs in an artificial logjam or incorporating them into rock placements may be preferable. Root wads can be installed in the stream bank to reduce the erosive force of the water.

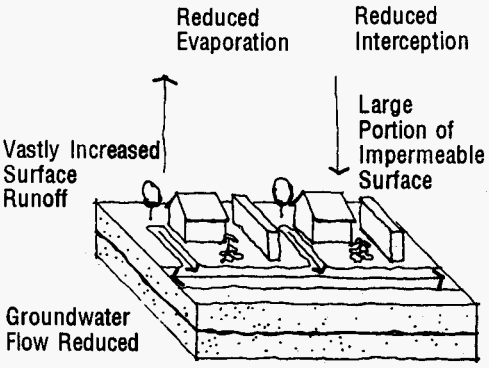
Fallen trees and branches can alter the flow of the stream, create pools, and provide shade. Careful placements of rocks, trees and limbs can enhance pool and riffle sequences. Gravel bars, ledges and overhanging vegetation can be installed to improve spawning habitat. Detritus provides food sources for aquatic organisms.

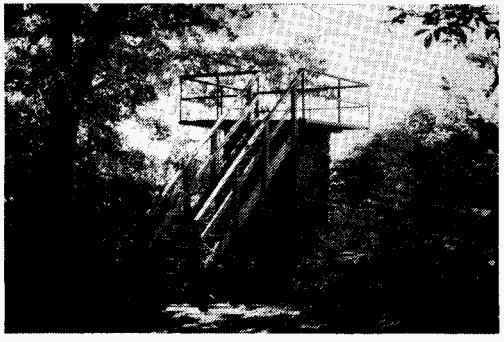


Restoration of the riparian zone

The key to restoring these habitats is determining the cause of impacts and then devising a strategy to address them. One of the greatest negative factors affecting streams and their associated riparian habitat is the amount of hardened surface in the watershed. When about 15% of a watershed is impervious, cold water streams become warm due to decreased groundwater infiltration and increased runoff from roofs, parking lots, etc. When 25% is impervious, stream integrity begins to decline. Higher peak flows result in erosion, the stream widens and becomes very shallow during low flows, pools and riffles are lost and the substrate becomes finer. Nutrient concentrations increase and pollution intolerant species of invertebrates and fish disappear.







Riparian zones are sometimes degraded due to indiscriminate access. Trampling of vegetation along a stream results in bank erosion. In urban areas, finding effective methods to limit human encroachment must precede any restoration effort. It is important to create access points in less sensitive locations and to design access structures that limit damage to the natural environment. Dense, shrubby vegetation can be used to protect sensitive and erosion-prone areas from human access.

In rural areas, where cattle have access to streams for drinking, fencing and an alternate source for drinking water may be required.

Where riparian planting is included with stream channel work, the techniques for establishing plant material may need to be adapted. As noted above, such work is usually carried out during the summer when the success of bioengineering techniques may be more limited than it would be in spring or fall.

6.5 PONDS IN A STREAM SYSTEM

The presence of ponds may affect the water quality and temperature of streams. Both natural and man-made ponds provide habitat for wildlife. Cold water fisheries, however, are often adversely affected by the rise in water temperature down-stream from a pond. In urban areas, stormwater ponds provide water quality improvements, i.e., reductions in sediments and contaminants, but unless they are appropriately designed, they, too, can release large quantities of water and affect water temperatures. (Further information on stormwater ponds is given in Section 8.)

Small streamside pools and former oxbows provide vital amphibian habitat, for example for frogs and salamanders.

Creation of isolated ponds in riparian zones can greatly enhance habitat for aquatic plants and wildlife as well. By separating such ponds from the stream, adverse effects on fish habitat are avoided, and amphibians can avoid predation by fish. In the floodplain of cold water streams, care should be taken to ensure that created ponds will not intercept groundwater discharging to the stream.

Techniques for creating ponds or wetlands in riparian habitat are discussed in Sub-section 3.4.

Newly constructed pond

Finished pond habitat

6.6 MANAGEMENT

The management of riparian zone restoration projects is likely to focus on controlling problems that have been identified by the monitoring program. This may involve replanting in some areas, or adding further erosion control techniques in others. Monitoring may also reveal other opportunities for restoration, or that the initial work has not achieved the desired objectives. In these situations it may be necessary to reevaluate objectives and initiate further management measures.

6.7 MONITORING

Both the aquatic and terrestrial components of stream corridors should be monitored. The former can be very complex, as it involves water quality, water temperature and biotic components, such as stream-bottom organisms and migratory and resident fish populations. Water temperature and quality (i.e., suspended solids, turbidity, dissolved organic carbon, particulate organic matter, dissolved oxygen, nutrients [TKN, phosphorus]) and contaminants (lead, zinc, fecal coliforms) have direct implications for fisheries.

For each of these components, baseline data should be collected prior to undertaking restoration work. As the restoration proceeds and matures, its effect can be measured. Stream flow and volume data are often collected as part of flood control studies and may not have to be compiled as part of the monitoring of restoration efforts.

Where stream bank erosion has been a concern, restored areas should be closely monitored during spring floods and fall storm events, particularly during the establishment phase of the plant material. If problems arise, remedial measures should be taken as soon as possible so as to correct them prior to the next flood. Erosion of valley banks should also be monitored and remedial measures implemented as required. New planting should be evaluated to determine success rates and to assess the need for maintenance.

Selected References

Commonwealth of Pennsylvania, 1986. *A Streambank Stabilization and Management Guide for Pennsylvania Landowners.* Department of Environmental Resources.

Gray, Donald H., and Andrew T. Leiser, 1989. *Biotechnical slope protection and erosion control.* Robert E. Krieger Publishing Co., Inc., Malbar, Florida.

Shrubcole, D., Ed. 1994. *"Natural" Channel Design: Perspectives and Practice. Proceedings of the First International Conference on Guidelines for "Natural" Channel Systems.* Niagara Falls, Ontario.

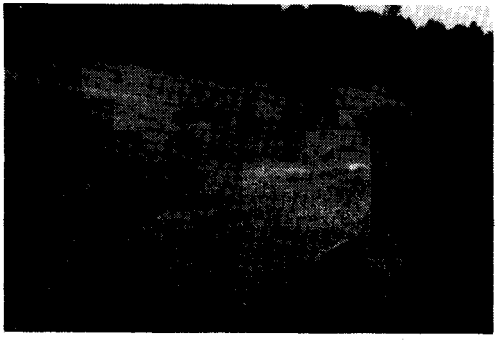
Ministry of Natural Resources, June 1994. *Natural Channel Systems: An Approach to Management and Design.* Province of Ontario.

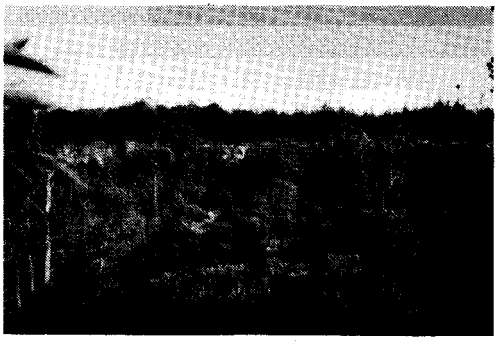
SECTION 7

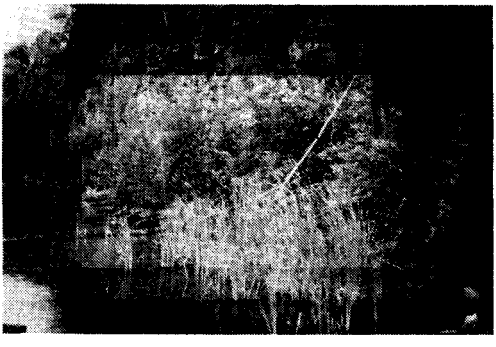
PIT AND QUARRY RESTORATION

7.1 SITE CHARACTERISTICS

Pits are areas where granular deposits are mined. Quarries are areas where solid rock, shale, or other solid deposits are mined. Pits and quarries pose a challenge for restoration efforts, as there is usually little overburden and topsoil left for establishing plant material. The extraction process leaves exposed rock and shale faces, and rubble or subsoils on the quarry floor that are generally exposed to high summer temperatures.







The physical and chemical constraints of the growing medium include low fertility, low organic matter and minimal capacity for soil moisture retention. In spite of these considerable challenges, natural regeneration of sites has often been quite successful in creating a self-sustaining, diverse plant community and wildlife habitat. Many good examples exist in quarries that have been abandoned for 40 or more years, while some pits have good natural regeneration after only 10 years. Both terrestrial and wetland habitats have developed naturally in these places.

Since the extraction process is a temporary land use, the final condition of these sites should be planned for. As part of the licensing of the extraction operation, the Aggregate Resources Act requires the eventual rehabilitation of new pits and quarries. Some older pits and quarries, however, precede rehabilitation legislation.

The natural regeneration of thriving plant communities is an indication that great potential for restoration exists if the right physical elements are present. Some of the adverse conditions found in pits and quarries can be an advantage to the restoration of certain sensitive habitat types. For example, low nitrogen levels may result in fewer weeds and provide opportunities for the establishment of prairie communities.

7.2 DESIGN CONSIDERATIONS

Before you start

Consider the following:

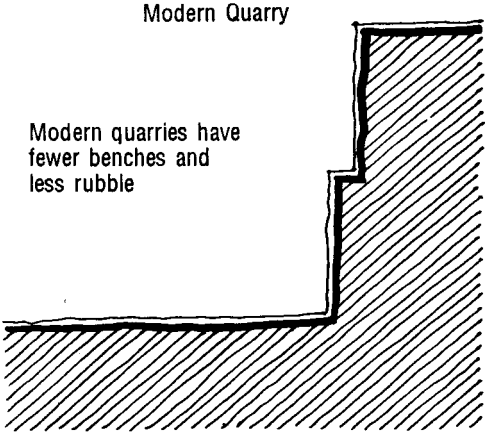
- what is the depth to groundwater?
- is surface water present?
- what is the fertility and texture of existing soils?
- was the original topsoil stockpiled so that it can be used as part of the restoration?
- what plant species and communities (if any) are present? Pits and quarries often provide unusual habitats that may support uncommon species.
- what wildlife species are present? Pits and quarries may provide nesting habitat for species such as waterfowl, kingfishers, swallows, and grasshopper sparrows. They may also be important nest sites for vultures.

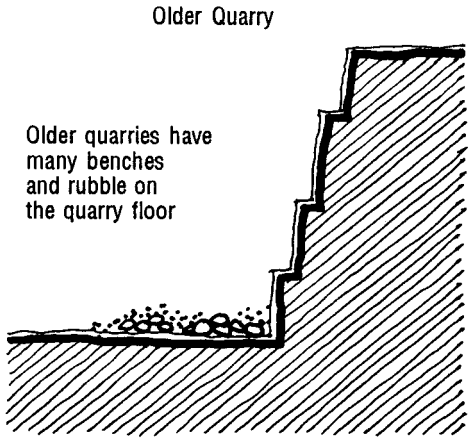
Pits and quarries provide special opportunities for restoration. The often extreme conditions that result from the extraction process allow a creative approach not possible on other sites. To a large extent the

environment must be created before restoration can take place. Topography, drainage patterns, and soil conditions can be manipulated to create a variety of habitat types. Many of the techniques outlined in previous sections can be used in pit and quarry sites provided the required physical conditions are present.

7.3 Restoration Options and Techniques

Newer pits and quarries pose a challenge, as modern extraction methods have become more efficient, leaving less rubble and fewer benches. The lack of physical diversity that results restricts biological diversity, and so the process of restoration must initially focus on creating a physical form that integrates better with the surrounding landscape. This can provide conditions more conducive to establishing a diverse and self-sustaining plant community.





For physical diversity:

- create a varied quarry face. Blasting quarry walls can replicate a more natural appearance and provide ledges and spaces for plants. A series of benches is preferable over a continuous flat surface. A variety of angles and aspects allows different exposures to sunlight and shade.

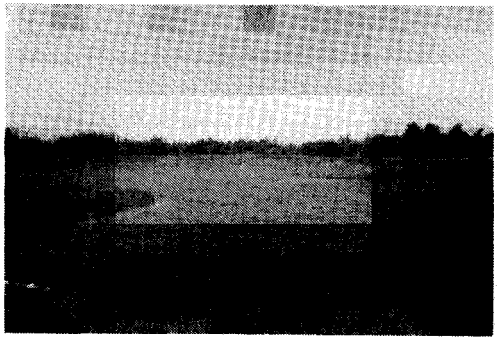
Overtipping of quarry wastes:

- granular and finely crushed materials become lodged in crevices and along ledges of the roughened quarry face. They will provide a rooting medium for plants.

Provide a variety of growing mediums:

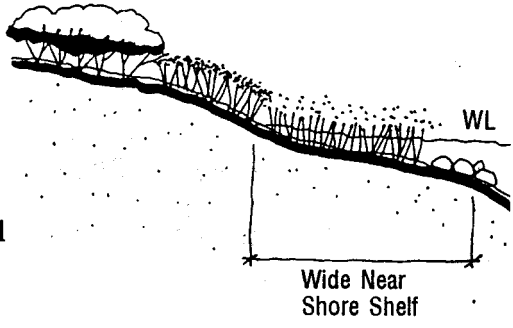
- exposed rocks, rubble and fine granulars create a rough topography on the floor and face of the quarry. Provide a variety of depths and allow some rubble piles to remain. Provide different combinations of subsoils and overburden;
- placement of local topsoil to cover the overburden creates planting pockets;
- adding limited quantities of nutrients and organic matter to the native soils and overburden can improve growing conditions and accelerate natural regeneration. However, adding too many nutrients favours exotic weeds over native species;
- organic matter will enhance soil moisture retention; most sources, however, including manure, contain seeds of exotic species. Leaf compost may be the best source of organic matter. Although municipal compost also includes seeds of exotic species, sawdust and bark chips have high carbon-to-nitrogen ratios and tie up available nitrogen or require nitrogen fertilizer. Peat is a non-renewable material and should not be used;
- assess the potential for water in the quarry. Ponds and wetlands will enhance wildlife habitat and contribute to overall site diversity. If the site has groundwater discharge or is close to the water table, consider excavating to create one or more ponds, temporary pools or seepage areas to increase wildlife habitats.

Deep ponds that rely on groundwater are potentially cold. Ponds that are shallow or rely on surface water runoff are more likely to be warmer. Irrespective of water temperature, ponds should be deep enough to allow fish and other species to survive the winter, unless they are designed for spring flooding only.

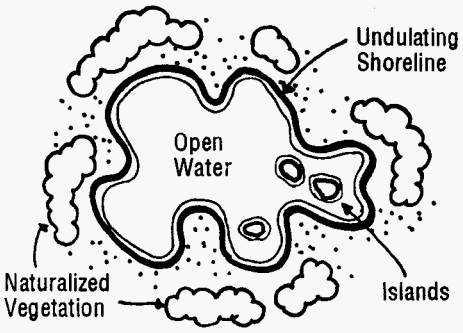


Uneven topography of bottom of pond (above) to increase habitat opportunities, and after flooding (below)

Shoreline banks should include some shallow, gradual slopes. Long slopes are especially important, since it is difficult to predict accurately the final water level in pits and quarries. Steeper banks will provide shaded, cooler areas. A wide near shore shelf will provide opportunities for wetland vegetation. Ponds should include extensive shallow areas 0.1 to 0.2 m deep.



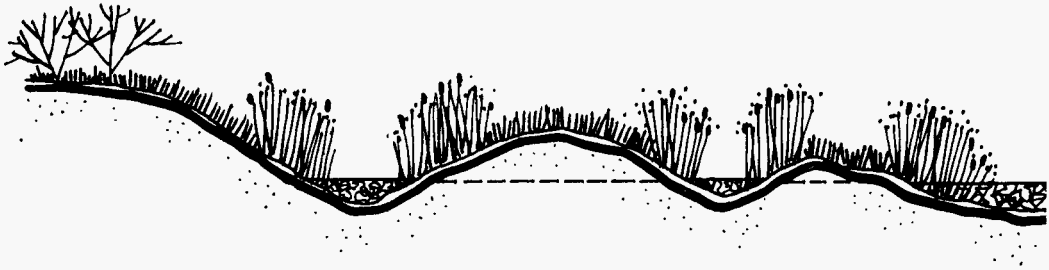
Section illustrating wide near shore shelf



Islands and peninsulas increase shoreline length, create still water and provide nesting areas. Islands are less accessible to predators.

Introduce organic muck and peats in shallow areas. These soils contain seedbanks of emergent wetland species and will naturally regenerate.

Diagram illustrating increased shoreline length



Section showing pockets of organic muck and peat

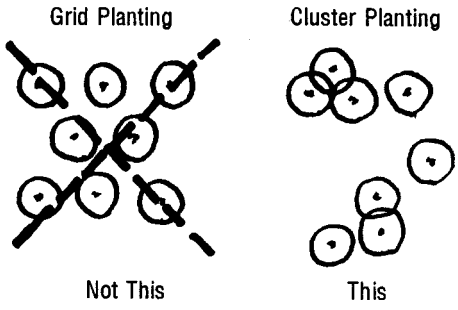
Caution

Do not damage existing wetlands to obtain organic muck or peats. Use only limited quantities as a seed source of emergent wetland species and to inoculate shallow pond edges.

Floating and submergent species can be transplanted. Doing so introduces invertebrate eggs and larvae attached to the plants.

Tree planting should focus on creating windbreaks, providing cover, and improving microclimate and soil characteristics. Select native species that are tolerant to difficult growing conditions. Pioneer species are particularly useful for that reason. Certain species are specifically adapted to soils with poor fertility and low moisture. Nitrogen fixing species such as alder and buffaloberry can ameliorate soil conditions, but when using them specify that they must be properly inoculated with mycorrhizae. Black locust is sometimes used even though it is not native to southern Ontario. Check at time of planting that root nodules are formed.

- Plant trees and shrubs in clusters; do not space them evenly over large areas.
- Use introduced topsoils only in those areas that are planted, since they can be a source of exotic species.



- Use hydroseeding to establish wildflowers and native grasses. Commercial seed mixtures usually contain non-native species, so custom mixes may be more appropriate. Some agricultural grasses, such as tall fescue and smooth brome, inhibit natural succession. Clump forming grasses are preferable.

- To establish native grassland species, use sod strips from native grassland communities.

- Prairie species are well adapted to the site conditions found in pits and quarries (i.e., low fertility and soil moisture) and can be established in these locations.

7.4 MANAGEMENT

Once a restoration project has been completed in a pit or quarry, no additional management should be necessary. Management should focus on opportunities and problems identified by the monitoring program.

7.5 MONITORING

The survival rate of plantings should be monitored, and replanting undertaken if the mortality is excessive. Although much more is known about pit and quarry rehabilitation than about wetland restoration, additional monitoring can provide valuable information. Monitoring can define which plants do best in these settings, what plants colonize the area on their own, and what wildlife species are attracted to them.

Andrews, John and David Kinsman, 1990. *Gravel Pit Restoration for Wildlife: A Practical Manual.* The Royal Society for the Protection of Birds, Sandy, Bedfordshire, England.

Svedarsky, W. Daniel and Richard D. Crawford, Eds., June 1982. *Wildlife Values of Gravel Pits, Symposium Proceedings.* Miscellaneous Publication 17-1982. Agricultural Experiment Station, University of Minnesota.

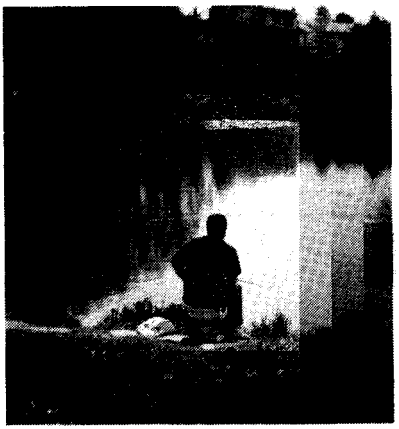
Michalski, M.F.P., Gregory, D.R., and Usher, A.J., 1987. *Rehabilitation of Pits and Quarries for Fish and Wildlife.* Ministry of Natural Resources.

Limestone Research Group, Manchester Polytechnic, June 1992. *Landform Replication as a Technique for the Reclamation of Limestone Quarries: A Progress Report.* Department of the Environment, Minerals and Land Reclamation Division, London, England.

STORMWATER MANAGEMENT

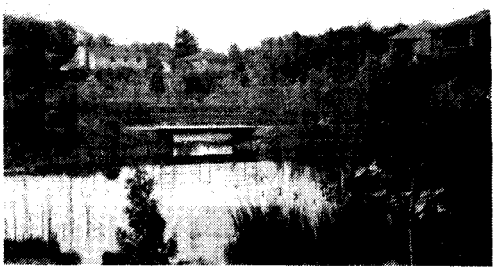
8.1 SITE CHARACTERISTICS

General considerations



Detention Pond

Stormwater ponds and surface treatment of urban runoff are increasingly becoming a feature of development areas as municipalities require alternative methods and approaches to conventional piped systems for treating urban drainage. They aim to redress hydrological imbalances by storing runoff and releasing it slowly to receiving water bodies; restore water quality by removing contaminants before they enter streams, rivers, and lakes; and protect aquatic life. Technical guidance to environmentally sustainable stormwater management is provided in the manual *Stormwater Management Practices* developed for the Ministry of Environment and Energy, Ontario (1994). For purposes here, several factors should be highlighted.



Wetland developing in stormwater pond

- The effects of urbanization on the water cycle are felt throughout the watershed and are linked to groundwater, streams, lakes and lakeshores, habitat and wildlife, and human activities.
- The functional requirements of stormwater management go beyond engineering and provide opportunities for an integrated approach that combines engineering with biologically productive aquatic and terrestrial habitats. The most relevant restoration efforts are centered on storage ponds, wetlands, naturalized drainage swales, and stream channels.

- As a general principle, the land required for stormwater retention should be an integral part of associated development and be designed for multiple uses that include recreation and education, as well as habitat regeneration.

Caution

Best Management Practices for stormwater are intended to promote environmentally sustainable development. However, concerns have been raised by various government agencies about the potential impact on fish and wildlife of contaminants collected in storage ponds. Warm stormwater can increase temperatures in receiving streams and affect cold water fisheries. Of prime importance, therefore, when integrating wildlife habitat with stormwater management, is the need to design pond systems that address these concerns.

8.2 DESIGN CONSIDERATIONS

Before you start

Consider the following:

- what are the soil conditions (type, moisture, nutrients, organic matter, drainage)?
- is the site exposed to winds and storms?
- what types of vegetation are there (cultivated, natural)?
- what are the flooding characteristics of the impoundment ponds?
- does the site lend itself to natural regeneration or direct planting?
- is this a site for contractor or community based planting?
- how can the pond be protected and made safe for children?
- is collaboration in pond design possible?

Habitat requirements for stormwater ponds

Permanent retention ponds and lakes are designed to retain urban runoff in new development where adequate space is available, where conditions for continuous natural drainage or springs are present, and where a variety of terrestrial and aquatic habitats can be developed.

Temporary storage ponds are designed for occasional and short-term retention, infiltration and groundwater recharge where a permanent water body may not be possible.

Two-pond systems have better biological and design characteristics for creating wildlife habitats. The first pond is used for settling out sediments and removing associated contaminants, and can be designed to *discourage* use by wildlife. The second acts to purify the water through the action of aquatic plants and can be designed to *encourage* wildlife.

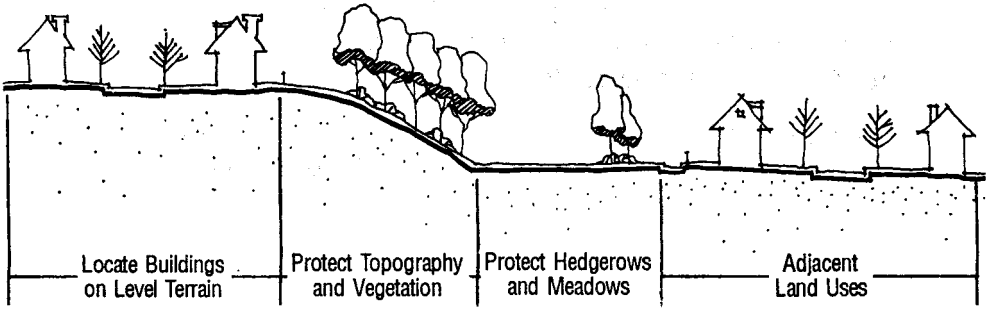
Since stormwater draining off paved surfaces is generally warmer than the receiving stream or water body, it will have an impact on water quality and aquatic life. Providing shade for surface water will help cool it before it is released into streams. Where edges can be maximized, shading by trees and edge vegetation can enhance cooling and habitat quality.

Where space permits, overland swales can form naturalized corridors while at the same time increasing the volume of water storage and infiltration.

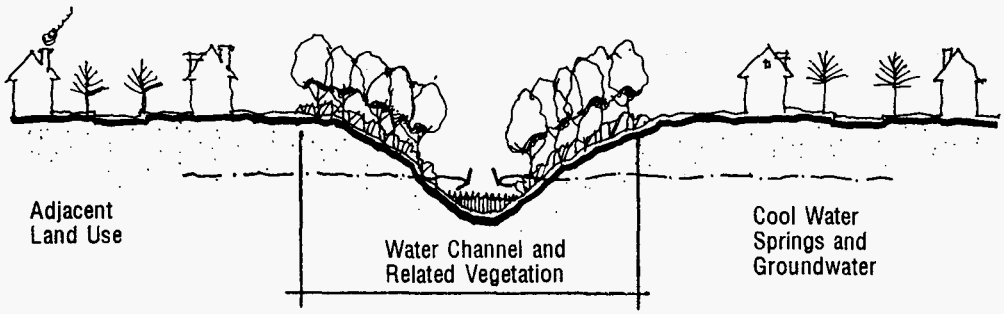
Objectives

Collaboration and integration of objectives is necessary between the restoration agency/individual and the site planner and developer, not only in the design of stormwater ponds and marsh habitats, but also in the protection of the existing landscape. Where collaboration exists, prior to and/or during project construction, consider opportunities for:

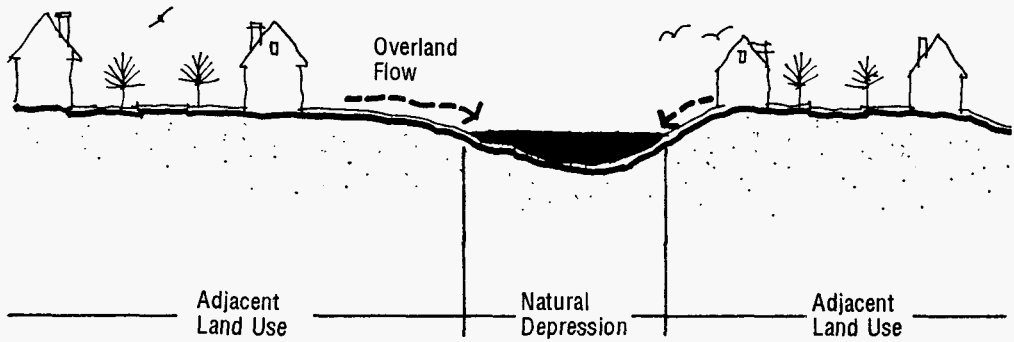
- protecting existing topography, vegetation, and cultural landscape features such as hedgerow links to other habitats, woodland;



- protecting surface water drainage channels, cold water springs and streams;

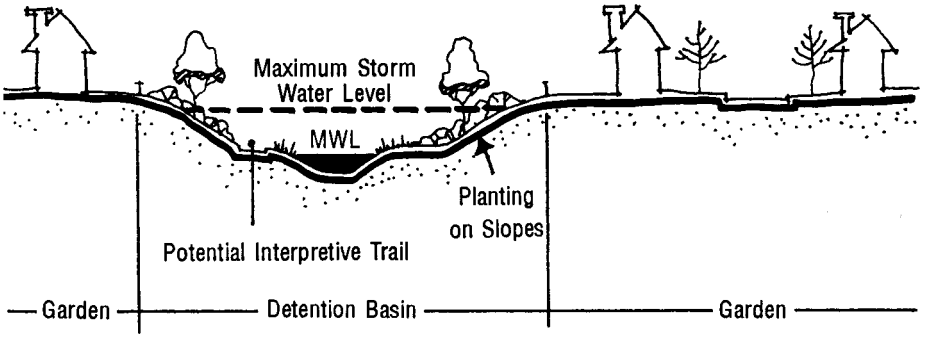


- preserving natural depressions that might be used for water detention/ retention ponds;

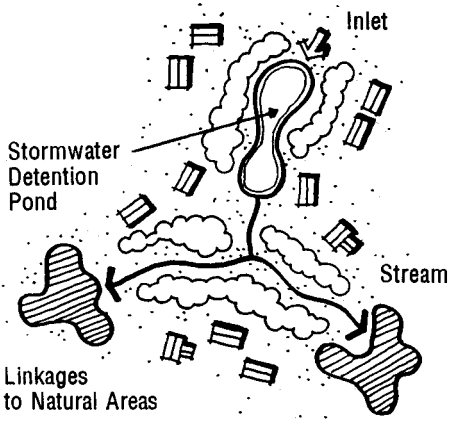


Where collaboration is not possible, i.e., in an existing or newly developed subdivision, or where stormwater drainage ponds are already constructed, consider:

- the presence of existing natural regeneration of drainage ways and wet areas, and whether active planting is needed;



- the potential for natural regeneration or planting of existing water courses and ponds in relation to existing gardens and landscaping;
- existing circulation routes and activity areas;
- existing drainage ways and the character/design of storm ponds;
- potential for linkages between naturalized storm ponds and other habitat areas;
- the need for a public participation process to determine the community's attitudes towards naturalization and their willingness to become involved in planning and management of a restoration plan.

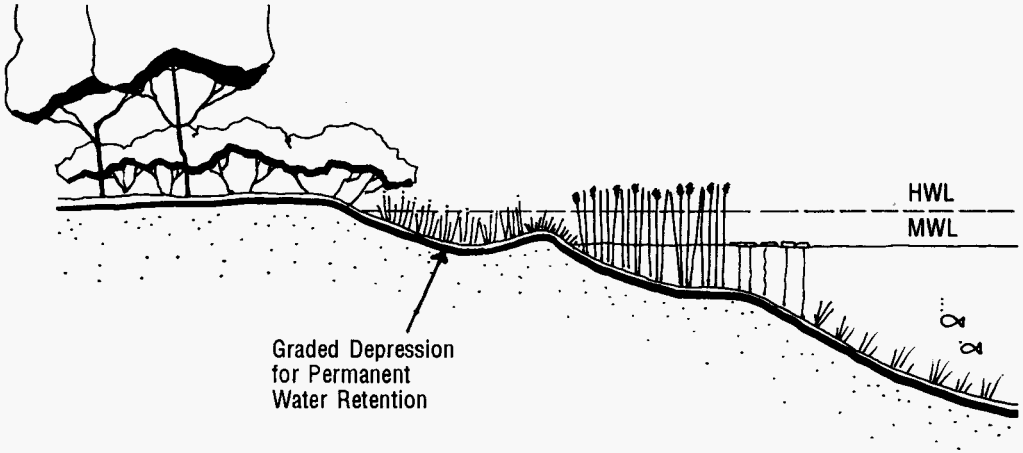


8.3 RESTORATION OPTIONS AND TECHNIQUES

Permanent ponds

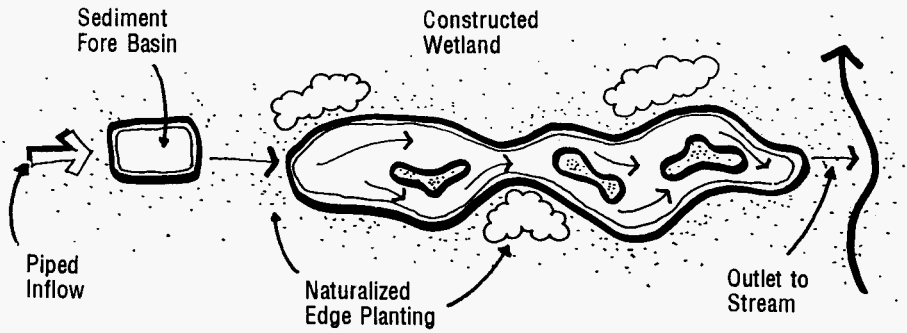
Where the right conditions exist, a permanent water body can be allowed to develop naturally and/or be planted for a variety of habitat types. (For plant associations, see sections on wetlands [4], meadows [5], woodlands [6] and riparian zones [7].)

Appropriate landforming and shaping of pond edges is essential for achieving productive and varied plant communities. In such situations, they can be left to naturalize on their own or be assisted by active planting.

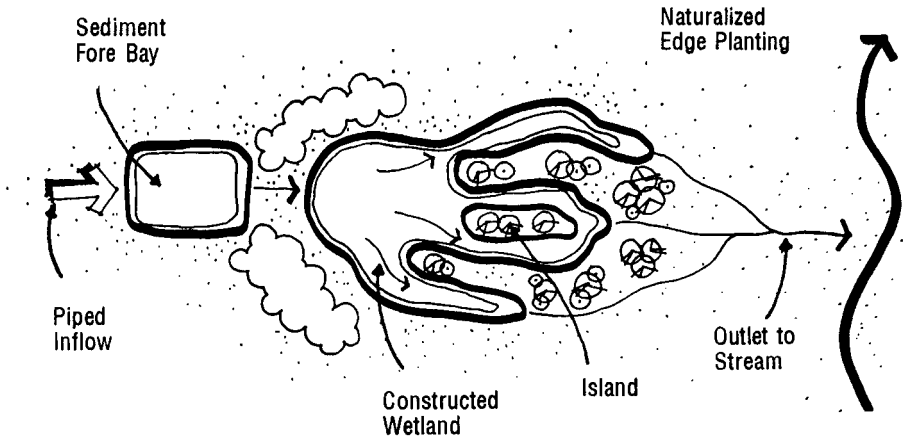


Two pond systems

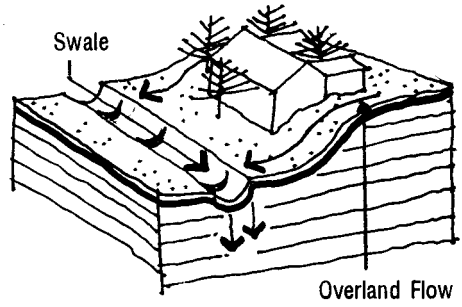
Inlet ponds act as a sedimentation basin with a stormwater detention time of 24 hours (see MOEE *Stormwater Management Practices*, 1994). Water then flows into a shallow, constructed wetland and overland to the receiving water body.



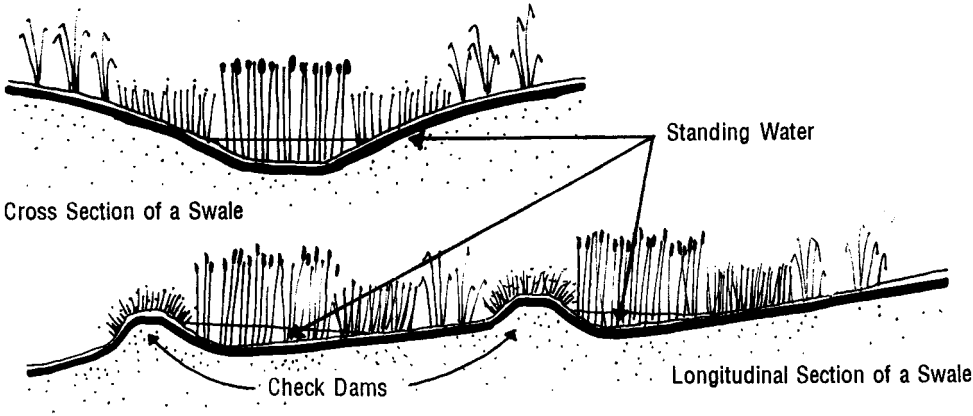
Pond form should preferably be long and narrow to maximize edges and opportunities for planting of vegetation to provide shading and cooling over the water surface.



Swales



Vegetated swales are generally associated with low density development. When designed as shallow, wide drainage areas, they can be effective for filtering and detaining stormwater runoff, and may be used to establish linear connections to other habitats. (For further information on design, see MOEE *Stormwater Management Practices*, 1994; and on plant species, other sections of this manual).



8.4 MANAGEMENT

With the appropriate design of two pond systems, several important management practices may be required, including:

- the sedimentation pond, or forebay, will require periodic removal of accumulated sediments and disposal in accordance with required MOEE procedures;
- water levels should be managed to minimize fluctuations downstream of the sedimentation pond (this will require appropriate engineering at the design phase);
- management of plant species are similar to the procedures noted in Section 3 Wetlands, of this manual.

8.5 MONITORING

Monitoring of wetland species established in stormwater pond systems is similar to procedures noted in the wetland section of this manual. Monitoring should also include:

- water sampling for phosphorus, nitrogenous compounds, suspended solids, heavy metals, and organic compounds;
- periodic sediment sampling for metals and organic materials;
- monitoring of plant survival. Where survival is low, determine possible causes, i.e.:
  - → high sediment loads (decreased light penetration into the water column, shifting substrate);
  - → excessive water level fluctuations;
  - → improper selection of plant species;
- checking for algae blooms. If these are present determine possible causes, i.e.:
  - → high phosphorus concentrations;
  - → warm water.

Where monitoring reveals problems objectives may require reevaluation and/or remedial management may be needed.

Marshall Macklin Monaghan Limited, June 1994. *Stormwater Management Practices Planning and Design Manual.* Prepared for Environmental Sciences & Standards Division, Program Development Branch, Ontario Ministry of Environment and Energy.

Taylor, Mark E. & Associates, April 1992. *Constructed Wetlands for Stormwater Management: A Review.* Prepared for Water Resources Branch, Ontario Ministry of the Environment and Metropolitan Toronto and Region Conservation Authority.

Taylor, Mark E. & Associates, April 1992. *Constructed Wetlands for Stormwater Management: An Annotated Bibliography.* Prepared for Water Resources Branch, Ontario Ministry of the Environment and Metropolitan Toronto and Region Conservation Authority.

APPENDIX I

Selected General References

1. Hough Stansbury Woodland Naylor Dance Limited and Gore & Storrie Ltd. *Ecological Restoration Opportunities for the Lake Ontario Greenway*. Prepared for the Waterfront Regeneration Trust, June 1994. A survey of ecological restoration and implementation strategies for the Greater Toronto Bioregion. Adresses the benefits and general approaches for a wide variety of habitats. Includes chapters on site selection, assessment of ecosystem functions, vegetation communities, and the urban landscape. Extensive annotated bibliography.
2. Stewart Hilts and Peter Mitchell. *Caring for your Land: A Stewardship Handbook for Niagara Escarpment Landowners*. Prepared for the Niagara Escarpment Commission, 1994. This document is oriented to help rural non-farm landowners care for and sustain their land. It contains information on the homestead, paths and trails, the cliff face, a range of habitats found in the escarpment area, and suggestions on developing a stewardship plan.

3. Jean-Marc Daigle and Donna Havinga. *Restoring Nature's Place: A Naturalization Program for Ontario Parks and Greenspace* (in progress). Prepared with the Ontario Parks Association. This document is intended to inform citizens and professionals undertaking environmentally related work across the province. The guide outlines steps to a community-based approach to restorative naturalization. Drawing on current theory and case studies, it focuses on naturalization within the context of health and sustainable communities; guidelines for community participation; and incorporating long-term monitoring and maintenance strategies. Companion workshop and bibliography/resource directory also available.

APPENDIX II

Common Plant Species of Marshes

Riparian or Backshore Areas	*Emergents*	*Submergents*	*Floating Plants*
Sensitive Fern *(Onoclea sensibilis)*	Water Horsetail *(Equisetum fluviatile)*	Curly-leaved Pondweed **(Potamogeton crispis)*	Lesser Duckweed *(Lemna minor)*
Marsh Fern *(Thelypteris palustris)*	Narrow-leaved Cattail *(Typha angustifolia)*	Variable-leaved Pondweed *(Potamogeton gramineus)*	Star Duckweed *(Lemna trisulca)*
Bluejoint *(Calamagrostis canadensis)*	Common Cattail *(Typha latifolia)*	Floating Pondweed *(Potamogeton natans)*	Greater Duckweed *(Spirodela polyrhiza)*
Barnyard Grass **(Echinochloa crusgalli)*	Greater Bur-reed *(Sparganium eurycarpum)*	Sage Pondweed *(Potamogeton pectinatus)*	Waterweed *(Wolffia borealis)*
Float Grass *(Glyceria borealis)*	Water Plantain *(Alisma plantago-aquatica)*	Richardson's Pondweed *(Potamogeton richardsonii)*	Waterweed *(Wolffia columbiana)*
Rattlesnake Grass *(Glyceria canadensis)*	Broad-leaved Arrowhead *(Sagittaria latifolia)*	Flat-stemmed Pondweed *(Potamogeton zosteriformis)*	
Red Meadow Grass *(Glyceria grandis)*	Spike-rush *(Eleocharis obtusa)*	Bushy Naiad *(Najas flexilis)*	
Fowl Meadow Grass *(Glyceria striata)*	Spike-rush *(Eleocharis smallii)*	Tape Grass *(Vallisneria americana)*	
Rice Cut Grass *(Leersia oryzoides)*	Hardstem Bulrush *(Scirpus acutus)*	Coontail *(Ceratophyllum demersum)*	
Common Reed Grass *(Phragmites australis)*	Dark Green Bulrush *(Scirpus atrovirens)*	Northern Water-Milfoil *(Myriophyllum exalbescens)*	
Fowl Meadow Grass *(Poa palustris)*	Wood Grass *(Scirpus cyperinus)*	Eurasian Water-Milfoil **(Myriophyllum spicatum)*	
Water Sedge *(Carex aquatilis)*	Softstem Bulrush *(Scirpus validus)*	Flat-leaved Bladderwort *(Utricularia intermedia)*	
Bebb's Sedge *(Carex bebbii)*	Sweet Flag *(Acorus calamus)*	Common Bladderwort *(Utricularia vulgaris)*	
Fringed Sedge *(Carex crinita)*	Wild Calla *(Calla palustris)*		
Porcupine Sedge *(Carex hystericina)*	Soft Rush *(Juncus effusus)*		

Lake-bank Sedge *(Carex lacustris)*	Water Smartweed *(Polygonum amphibium)*		
Retrorse Sedge *(Carex retrorsa)*	Water Dock *(Rumex orbiculatus)*		
Awl-fruited Sedge *(Carex stipata)*	Bullhead Lily *(Nuphar variegata)*		
Larger Blue Flag *(Iris versicolor)*	Fragrant Water-lily *(Nymphaea odorata)*		
Lady's Thumb **(Polygonum persicaria)*	White Water-Buttercup *(Ranunculus longirostris)*		
Tall Meadow Rue *(Thalictrum pubescens)*	Marsh Cinquefoil *(Potentilla palustris)*		
Spotted Touch-me-not *(Impatiens capensis)*	Water Willow *(Decodon verticillatus)*		
Sticky Willow-herb *(Epilobium ciliatum)*	Purple Loosestrife **(Lythrum salicaria)*		
Purple Willow-herb *(Epilobium coloratum)*	Water Purslane *(Ludwigia palustris)*		
Fringed Loosestrife *(Lysimachia ciliata)*	Bulb-bearing Water-Hemlock *(Cicuta bulbifera)*		
Swamp Milkweed *(Asclepias incarnata)*	Spotted Water-Hemlock *(Cicuta maculata)*		
Blue Vervain *(Verbena hastata)*	Water Parsnip *(Sium suave)*		
Cut-leaf Water Howhand *(Lycopus americana)*	American Brooklime *(Veronica americana)*		
Bugleweed *(Lycopus uniflorus)*			
Turtlehead *(Chelone glabra)*			
Square-stemmed Monkey-flower *(Mimulus ringens)*			
Bedstraw *(Galium spp.)*			
Great Lobelia *(Lobelia siphilitica)*			

Purple-stemmed Aster *(Aster puniceus)*			
Bur Marigold *(Bidens cernua)*			
Beggar's Ticks *(Bidens frondosa)*			
Joe-Pye-Weed *(Eupatorium maculatum)*			
Boneset *(Eupatorium perfoliatum)*			

* non-native species

APPENDIX III

Common Native Plant Species of Bogs

Non-Woody Species	*Low Shrubs*	*Tall Shrubs*	*Trees*
Sphagnum	Leatherleaf *(Chamaedaphne calyculata)*	Swamp Birch *(Betula pumila)*	Tamarack *(Larix laricina)*
Fen-seeded Sedge *(Carex oligosperma)*	Sheep Laurel *(Kalmia angustifolia)*	Chokeberry *(Aronia prunifolia)*	Black Spruce *(Picea mariana)*
Fen-flowered Sedge *(Carex pauciflora)*	Bog Laurel *(Kalmia polifolia)*	Mountain Holly *(Nemopanthus mucronata)*	
Three-fruited Sedge *(Carex trisperma)*	Labrador Tea *(Ledum groenlandicum)*		
Cottongrass *(Eriophorum virginicum)*	Low Blueberry *(Vaccinium angustifolium)*		
White-fringed Orchid *(Platanthera blephariglottis)*	Highbush Blueberry *(Vaccinium corymbosum)*		
Pitcher Plant *(Sarracenia purpurea)*	Velvet-leaf Blueberry *(Vaccinium myrtilloides)*		
Intermediate Sundew *(Drosera intermedia)*			
Round-leaved Sundew *(Drosera rotundifolia)*			
Northern St. John's-wort *(Hypericum boreale)*			
Pale St. John's-wort *(Hypericum ellipticum)*			
Bog Aster *(Aster nemoralis)*			

APPENDIX IV

Common Native Plant Species of Meadows

Species of Fertile Soil (Abandoned Agricultural Fields)	*Species of Impoverished Soil (Abandoned Quarries, Dry Hillsides)*
Bracken Fern *(Pteridium aquilinum)*	Canada Bluegrass *(Poa compressa)*
Canada Bluegrass *(Poa compressa)*	Poverty Grass *(Danthonia spicata)*
Wild Strawberry *(Fragaria virginiana)*	Ensheathed Dropseed *(Sporobolus vaginiflorus)*
Silvery Cinquefoil *(Potentilla argentea)*	Witch Grass *(Panicum capillare)*
Yellow Avens *(Geum allepicum)*	Sleepy Catchfly *(Silene antirrhina)*
Hairy-stemmed Spurge *(Euphorbia vermiculata)*	Wild Strawberry *(Fragraria virginiana)*
Spotted Spurge *(Euphorbia maculata)*	Early Goldenrod *(Solidago juncea)*
Climbing Bittersweet *(Celastrus scandens)*	Grey Goldenrod *(Solidago nemoralis)*
Common Milkweed *(Asclepias syriaca)*	Heath Aster *(Aster ericoides)*
Spreading Dogbane *(Apocynum androsaemifolium)*	Annual Fleabane *(Erigeron annuus)*
Hedge Bindweed *(Calystegia sepium)*	Horseweed *(Conyza canadensis)*
Heal-All *(Prunella vulgaris)*	Pussytoes *(Antennaria spp.)*
Common Bergamot *(Monarda fistulosa)*	Pearly Everlasting *(Anaphalis margaritacea)*
Dogmint *(Satureja vulgaris)*	Fragrant Cudweed *(Gnaphalium obtusifolium)*
Clammy Ground-Cherry *(Physalis heterophylla)*	Low Cudweed *(Gnaphalium uliginosum)*
Purslane Speedwell *(Veronica peregrina)*	Black-eyed Susan *(Rudbeckia hirta)*
Canada Goldenrod *(Solidago canadensis)*	Woodland Sunflower *(Helianthus divaricatus)*
Tall Goldenrod *(Solidago altissima)*	Poison-Ivy *(Rhus radicans)*
Lance-leaved Aster *(Aster lanceolatus)*	
Calico Aster *(Aster lateriflorus)*	
Heath Aster *(Aster ericoides)*	
New England Aster *(Aster novae-angliae)*	

Annual Fleabane *(Erigeron annuus)*	
Philadelphia Fleabane *(Erigeron philadelphicus)*	
Sunflowers *(Helianthus spp.)*	

APPENDIX V

Common Non-Native Plant Species of Meadows

Species of Fertile Soil (Abandoned Agricultural Fields)	Species of Impoverished Soil (Abandoned Quarries, Dry Hillsides)
Witch Grass *(Agropyron repens)*	Squirrel-tail Grass *(Hordeum jubatum)*
Smooth Brome *(Bromus inermis)*	Prostrate Knotweed *(Polygonum aviculare)*
Orchard Grass *(Dactylis glomerata)*	Sheep Sorrel *(Rumex acetosella)*
Timothy *(Phleum pratense)*	Lamb's Quarters *(Chenopodium album)*
Curled Dock *(Rumex crispus)*	Sweet Clover *(Melilotus spp.)*
Mouse-ear Chickweed *(Cerastium fontanum)*	Viper's Bugloss *(Echium vulgare)*
Deptford Pink *(Dianthus armeria)*	Common Mullein *(Verbascum thapsus)*
Bladder Campion *(Silene vulgaris)*	Ox-eye Daisy *(Chrysanthemum leucanthemum)*
Common Buttercup *(Ranunculus acris)*	Chicory *(Cichorium intybus)*
Rough-fruited Cinquefoil *(Potentilla recta)*	Canada Thistle *(Cirsium arvense)*
Birdsfoot Trefoil *(Lotus corniculatus)*	Orange Hawkweed *(Hieracium aurantiacum)*
Cow Vetch *(Vicia cracca)*	King Devil *(Hieracium pratense, H. floribundum)*
Common St. John's Wort *(Hypericum perforatum)*	Pineapple Weed *(Matricaria matricariodes)*
Wild Carrot *(Daucus carota)*	Coltsfoot *(Tuasilago farfara)*
Field Bindweed *(Calystegia arvensis)*	
Catnip *(Nepeta cataria)*	
Butter-and-Eggs *(Linaria vulgaris)*	
Common Plantain *(Plantago major)*	
Yarrow *(Achillea millefolium)*	
Common Burdock *(Arctium minus)*	
Bull Thistle *(Cirsium vulgare)*	
Black-eyed Susan *(Rudbeckia serotina)*	

Common Dandelion *(Taraxacum officinale)*	
Goat's Beard *(Tragopogon dubius, T. pratensis)*	

For species suitable for wet pockets and swales in meadow areas, see wetland and riparian section.

APPENDIX VI

Indicator Plant Species for Prairies

(* regionally or provincially rare)

Big Bluestem *(Andropogon gerardii)*	Hairy Bush-clover *(Lespedeza hirta)**
Little Bluestem *(Andropogon scoparius)*	Wand-like Bush-clover *(Lespedeza intermedia)**
Side-oats Grama *(Bouteloua curtipendula)**	Wild Lupine *(Lupinus perennis)**
Kalm's Brome Grass *(Bromus kalmii)*	Flowering Spurge *(Euphorbia corollata)**
Canada Wild Rye *(Elymus canadensis)*	Fragrant Sumac *(Rhus aromatica)**
Prairie June Grass *(Koeleria macrantha)**	New Jersey Tea *(Ceanothus americanus)*
Forked Panic Grass *(Panicum dichotomum)**	Narrow-leaved New Jersey Tea *(Ceanothus herbaceus)**
Few-flowered Panic Grass *(Panicum oligosanthes)**	Virginia Flax *(Linum virginianum)**
Panic Grass *(Panicum lanuginosum var. praecocius)**	Racemed Milkwort *(Polygala polygama)**
Switch Grass *(Panicum virgatum)*	Seneca Snakeroot *(Polygala senega)*
Indian Grass *(Sorghastrum nutans)*	Whorled Milkwort *(Polygala verticillata)*
Tall Cord Grass *(Spartina pectinata)*	Shrubby St. John's Wort *(Hypericum prolificum)**
Rough Dropseed *(Sporobolus asper)**	Whorled Loosestrife *(Lysimachia quadrifolia)*
Sand Dropseed *(Sporobolus cryptandrus)*	Cleland's Evening Primrose *(Oenothera clelandii)**
Overlooked Dropseed *(Sporobolus neglectus)*	Violet *(Viola fimbriatula)*
Ensheathed Dropseed *(Sporobolus vaginiflorus)*	Birdsfoot Violet *(Viola pedata)**
Needle Grass *(Stipa spartea)**	Early Sweet Blueberry *(Vaccinium pallidum)*
Sedge *(Carex foenea)**	Gentian *(Gentiana puberulenta)**
Sedge *(Carex muhlenbergii)*	Gentian *(Gentiana quinquefolia)**

Nut Grass *(Cyperus houghtonii)**	Butterfly-Weed *(Asclepias tuberosa)*
Nut Grass *(Cyperus lupulinus)*	Green Milkweed *(Asclepias viridiflora)**
Nut Rush *(Scleria triglomerata)**	False Foxglove *(Aureolaria pedicularia)**
Yellow Stargrass *(Hypoxis hirsuta)**	Hoary Mountain-Mint *(Pycnanthemum incanum)**
White Camas *(Zigadenus glaucus)**	Virginia Mountain-Mint *(Pycnanthemum virginianum)**
Northern Slender Ladies' Tresses *(Spiranthes lacera var. gracilis)**	Pinweed *(Lechea intermedia)*
American Hazel *(Corylus americana)*	Dragonhead *(Dracocephalum parviflorum)*
Hill's Oak *(Quercus ellipsoidalis)**	Bluets *(Houstonia longifolia)*
Bastard Toadflax *(Comandra umbellata)*	Puccoon *(Lithospermum canescens)**
Long-fruited Anemone *(Anemone cylindrica)*	Gromwell *(Lithospermum incisum)**
Early Buttercup *(Ranunculus fascicularis)*	Harebell *(Campanula rotundifolia)*
Prairie Buttercup *(Ranunculus rhomboideus)**	Sky Blue Aster *(Aster azureus)*
Rock-Cress *(Arabis divaricarpa)*	Smooth Aster *(Aster laevis)*
Saskatoon-Berry *(Amelanchier alnifolia)*	Arrow-leaved Aster *(Aster sagittifolius)*
Prairie Cinquefoil *(Potentilla arguta)**	Field Thistle *(Cirsium discolor)*
Sand Cherry *(Prunus pumila var. besseyi)**	Robin's-Plantain *(Erigeron pulchellus)*
Sand Cherry *(Prunus pumila var. susquehanae)*	Sneezeweed *(Helenium autumnale)**
Pasture Rose *(Rosa carolina)*	Rockrose *(Helianthemum bicknellii)**
Tick-Trefoil *(Desmodium canadense)*	Frostweed *(Helianthemum canadense)**
Tick-Trefoil *(Desmodium cuspidatum)**	Sunflower *(Helianthus strumosus)**
Tick-Trefoil *(Desmodium paniculatum)*	Blazing Star *(Liatris cylindracea)**
Wild Licorice *(Glycyrrhiza lepidota)**	Blazing Star *(Liatris spicata)*
Bush-Clover *(Lespedeza capitata)**	

APPENDIX VII

Common Woodland Species

TREE SPECIES	*UNDERSTOREY AND EDGE SPECIES*
Manitoba maple *(Acer negundo)*	mountain maple *(Acer spicatum)*
black maple *(Acer nigrum)*	serviceberry *(Amelanchier spp.)*
red maple *(Acer rubrum)*	blue beech *(Carpinus carolinianum)*
silver maple *(Acer saccharinum)*	bittersweet *(Celastrus scandens)*
sugar maple *(Acer saccharum)*	alternate-leaved dogwood *(Cornus alternifolia)*
paper birch *(Betulapapyrifera)*	gray dogwood *(Cornus racemosa)*
bitternut hickory *(Carya cordiformis)*	red osier dogwood *(Cornus stolonifera)*
shagbark hickory *(Carya ovata)*	hazel *(Corylus americana)*
hackberry *(Celtis occidentalis)*	beaked hazel *(Corylus cornuta)*
American beech *(Fagus grandifolia)*	firethorn *(Crataegus chrysocarpa)*
white ash *(Fraxinus americana)*	hawthorn *(Crataegus spp.)*
black ash *(Fraxinus nigra)*	bush honeysuckle *(Diervilla lonicera)*
green ash *(Fraxinus pennsylvanica)*	witch-hazel *(Hamamelis virginiana)*
butternut *(Juglans cinerea)*	honeysuckle *(Lonicera spp.)*
black walnut *(Juglans nigra)*	ironwood *(Ostrya virginiana)*
tamarack *(Larix laricina)*	Canada plum *(Prunus nigra)*
white pine *(Pinus strobus)*	pin cherry *(Prunus pennsylvanica)*
sycamore *(Platanus occidentalis)*	chokecherry *(Prunus virginiana)*
trembling aspen *(Populus tremuloides)*	staghorn sumac *(Rhus typhina)*
balsam poplar *(Populus balsamifera)*	shrub roses *(Rosa spp.)*
poplar *(Populus spp.)*	blackberry *(Rubus allegheniensis)*
black cherry *(Prunus serotina)*	flowering raspberry *(Rubus odoratus)*

white oak *(Quercus alba)*	raspberry *(Rubus spp.)*
swamp white oak *(Quercus bicolor)*	red raspberry *(Rubus strigosus)*
bur oak *(Quercus macrocarpa)*	willow *(Salix spp.)*
Chinquapin oak *(Quercus muehlenbergii)*	elderberry *(Sambucus canadensis)*
red oak *(Quercus rubra)*	red elderberry *(Sambucus pubens)*
black oak *(Quercus velutina)*	mountain ash *(Sorbus americana)*
willow *(Salix spp.)*	snowberry *(Symphoricarpos albus)*
sassafras *(Sassafras albidum)*	nannyberry *(Viburnum lentago)*
eastern white cedar *(Thuja occidentalis)*	highbush cranberry *(Viburnum trilobum)*
basswood *(Tilia americana)*	wild grape *(Vitis riparia)*
hemlock *(Tsuga canadensis)*	
elm *(Ulmus spp.)*	

APPENDIX VIII

Common Riparian Species

TREE SPECIES	*UNDERSTOREY AND EDGE SPECIES*
red maple *(Acer rubrum)*	mountain maple *(Acer spicatum)*
silver maple *(Acer saccharinum)*	bittersweet *(Celastrus scandens)*
speckled alder *(Alnus incana)*	buttonbush *(Cephalanthus occidentalis)*
firethorn *(Crataegus chrysocarpa)*	silky dogwood *(Cornus obliqua)*
green ash *(Fraxinus pennsylvanica)*	gray dogwood *(Cornus racemosa)*
black walnut *(Juglans nigra)*	red osier dogwood *(Cornus stolonifera)*
cottonwood *(Populus deltoides)*	winterberry *(Ilex verticillata)*
trembling aspen *(Populus tremuloides)*	honeysuckle *(Lonicera canadensis)*
Canada plum *(Prunus nigra)*	sweet gale *(Myrica gale)*
pin cherry *(Prunus pennylvanica)*	Virginia creeper *(Parthenocissus inserta)*
bur oak *(Quercus macrocarpa)*	common ninebark *(Physocarpos opulifolius)*
peachleaf willow *(Salix amygdaloides)*	chokecherry *(Prunus virginiana)*
black willow *(Salix nigra)*	staghorn sumac *(Rhus typhina)*
eastern white cedar *(Thuja occidentalis)*	swamp rose *(Rosa palustris)*
basswood *(Tilia americana)*	flowering raspberry *(Rubus odoratus)*
white elm *(Ulmus americana)*	pussy willow *(Salix discolor)*
	sand bar willow *(Salix exigua)*
	slender willow *(Salix petiolaris)*
	elderberry *(Sambucus canadensis)*
	meadowsweet *(Spiraea alba)*
	witherod *(Viburnum cassinoides)*
	nannyberry *(Viburnum lentago)*

	highbush cranberry *(Viburnum trilobum)*
	wild grape *(Vitis riparia)*

GLOSSARY

Abiotic	Physical elements such as geological features, soils, topography, climate and water.
Allelopathic effect	The effect of grasslands and old field vegetation inhibiting the germination of woody species.
Backshore	The area above the average water level of a wetland, watercourse or water body.
Bathymetric	Measurements of depth under water.
Benthic	On the bottom of a watercourse or water body.
Benthos	Flora or fauna living on the bottom of a watercourse or water body.
Clay lens	A clay layer in otherwise well-drained soils that results in a locally high water table.
Damping-off	The death and decay of seedlings as a result of a fungal infection.
Dredgeate	Sediments removed from a watercourse or water body.
Emergents	Aquatic plants that have roots below the surface of the water and leaves above it.
Fascine	Similar to wattle, but less tightly bound.
Fetch	Line of continuous open water from point to point.
Fines	Fine soils or sediments, usually with a diameter of 0.3 mm or less.
Forbs	Non-woody plants, excluding grasses, sedges, and ferns.
Geomorphology	Study of the earth's surface and its relation to geological features.
Hydroseeding	Spraying of a mixture of water, mulch, seed, and fertilizer onto the soil.

Impermeable	Non-porous surfaces that impede the flow or percolation of water.
Infiltration	The act of gradual permeation and penetration of the earth's surface.
Innoculate	Bacteria which assist plants by fixing nitrogen in root nodules.
Littoral zone	The nearshore area of a water body where sunlight can penetrate to the substrate with sufficient intensity to support aquatic plant photosynthesis.
Macrophytes	Multi-celled aquatic plants, usually with well-defined roots, stem, and leaves.
Mycorrhizae	A system of fungi in plant roots.
Nurse crop	The establishment of a species that creates a better growing environment for another species.
Permeable	Porous surfaces through which water can percolate.
Plant Pallet	A selection of plant material appropriate to the site conditions and design intent.
Plug	A rooted cutting or seedling which is grown in individual self-contained soil medium.
Riffles	Rapids caused by the naturally undulating profile of most streams.
Riparian	Occuring on the bank of a watercourse.
Runoff coefficient	The percent of precipitation not absorbed into the ground, which causes overland flow and drains into streams and ponds.
Seral stage	A stage in natural succession.
Stratification	The process of storing seeds at cold temperatures in a moist environment for a given length of time to induce germination.

Stream order	A method of ranking stream segments in a drainage basin in which larger segments are given higher order numbers.
Submergents	Aquatic plants that grow below the water surface.
Thalweg	The line where the slopes of opposite banks meet beneath a watercourse.
Wattle	A wired bundle of cuttings.

Abbreviations

LWL	Low water level
MWL	Median water level
HWL	High water level