Assessing the Functional Role of Natural Areas for the Niagara Water Quality Protection Strategy

Elizabeth Snell[1] *and James Dougan*[2]
[1]*Snell and Cecile Environmental Research*
[2]*Dougan and Associates*

Abstract

The Niagara Water Quality Protection Strategy is a project of the Regional Municipality of Niagara, Niagara Peninsula Conservation Authority and Ministry of the Environment. The strategy is being developed with extensive public input and will help direct and coordinate the management of water quality and quantity in the region. Analyses and strategies, including the role of natural systems in protecting water and the impacts of water quality on natural systems, are being summarized for 32 sub-watershed assemblages. The natural heritage system was characterized. Water related functions of flow regulation and water quality improvement were rated relative to Remedial Action Plan habitat targets and to functional value ranges observed in the study area. Functional impairment of the natural heritage system from water related impacts was rated. Remaining steps involve development of the strategies and an implementation plan.

Introduction

The Niagara Water Quality Protection Strategy is a 14-month project of the Regional Municipality of Niagara, Niagara Peninsula Conservation Authority and the Ontario Ministry of the Environment. Its purpose is to direct the management of water in the Region. Technical studies are being conducted by lead consultants (MacViro Consultants, Philips Engineering and CH2MHill), with public advisory committees organized by LURA Consulting, and sub-consultants responsible for components including the natural environment: groundwater, aquatic systems; and, terrestrial natural heritage. Project phases include data collection, area characterization, strategy development, and implementation plan.

This paper summarizes the characterization phase of the terrestrial natural heritage system component, organized by:

- Features;
- Hydrological roles
  Flow regulation
  Water quality improvement;
- Water-related impacts/functional impairment
  Stressor level

Natural area sensitivity; and,

- Other values;

Study Area

The study area includes all watersheds affecting the Region of Niagara (Figure 1), in an area bounded by Lake Ontario, Lake Erie and the Niagara River and parts of Hamilton and Haldimand Regions.

Figure 1. *Study area.*

The study area is bisected east-west by the Niagara Escarpment, with a flat, slough-riddled clay plain above the Escarpment, and gently sloping sand plain, (major fruitlands) below it. Other features above the Escarpment include the coarse-textured kame and sand plain near Fonthill, limestone plains and shallow escarpments near Port Colborne and Fort Erie, large organic deposits (notably the Wainfleet Bog), south-western sand plain, Lake Erie dunes, and low till moraines just above the Niagara Escarpment. The sand plain below the Escarpment grades into a shale plain around Beamsville and into a clay plain in St. Catharines and Niagara-on-the-Lake.

Streams in the northern portion flow over the Escarpment into Lake Ontario (Figure 2). Much of the remainder of the area flows into the Niagara River, mostly via the Welland River. The Lake Erie watershed is a very narrow strip. The strategy is being developed to be applicable at local levels as well as area-wide; for local level analyses, sub-watersheds were organized into 32 Local Management Areas (LMAs) (see Figure 2).

Natural Heritage System Features

Existing information was assembled with emphasis on the data available from the project proponents and Ministry of Natural Resources Natural Resources and Values Information System (NRVIS).

Prior to settlement, the Niagara Peninsula was dominated by mesic and lowland forest. Characteristic sloughs, pits and hollows, ground detritus layer and the forest cover would have had a very large water storage capacity. Floods were likely less severe than today. The forests sustained good water quality by slowing erosive flows, protecting the soil from erosion, and shading the creeks. Today's landscape is dominated by agriculture and cities, with remnant natural ecosystems being wetlands, forest, scrubland and meadow. Wetlands evaluated under the provincial wetland evaluation system (Figure 3) are assumed to include all the large units as well as all lake and river-associated wetlands. Forests on Niagara's clay plains, however, contain hundreds of small wetlands below the resolution of evaluation, or too numerous to evaluate.

Forest extent mapped in 2000 by the Niagara Peninsula Conservation Authority (NPCA, 2002) was overlaid on soils maps and combined with evaluated wetland information to create Figure 4. Air photo interpretation of representative soils for slough-associated wetland extent (Snell *et al.,* 1998) allows an estimate of total wetland extent (all open wetlands, all wetland forest, 40% of lowland forest above the Niagara Escarpment and 50% of lowland forest below). The study area is estimated to have 15,425 ha of wetland (6.4%) and 42,700 ha of forest (17.6%). Figure 4 shows the low forest extent below the Escarpment and in western headwater areas, grading into higher forest extent towards the southeast portion of the study area where most forests are wetlands or lowlands. The east-west band of moist or dry forest corresponds with the Niagara Escarpment; the extensive area of drier forest in LMA #1.7 is associated with the Fonthill Kame.

Figure 2. *Watersheds and local management areas.*

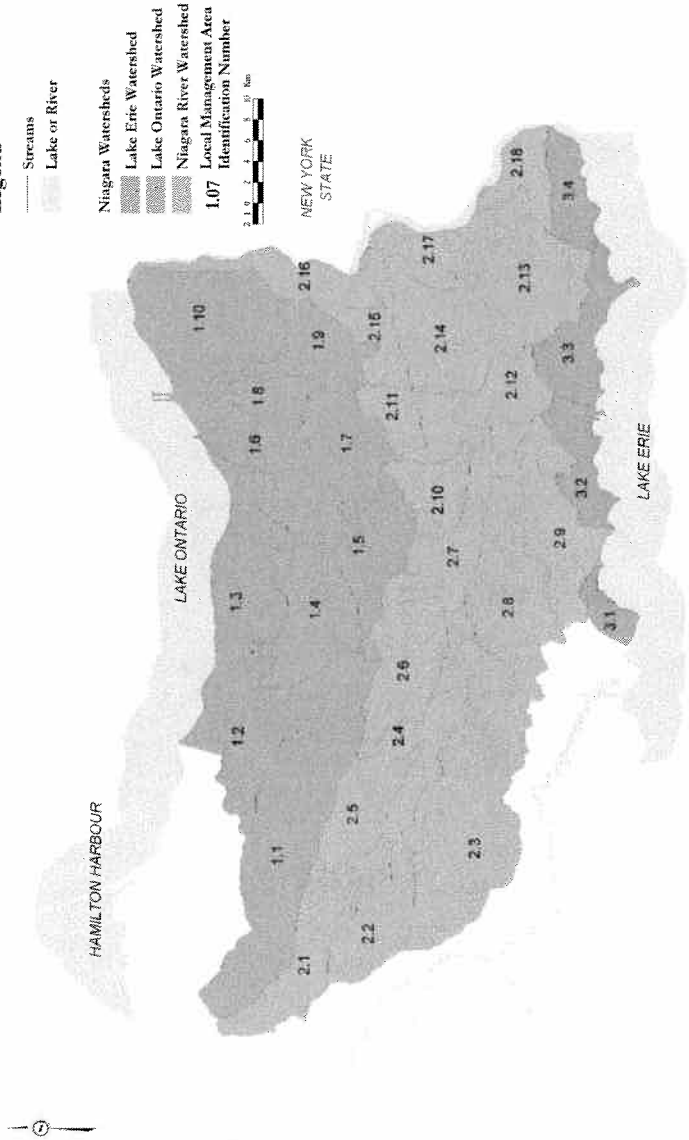


Figure 3. *Evaluated wetlands.*

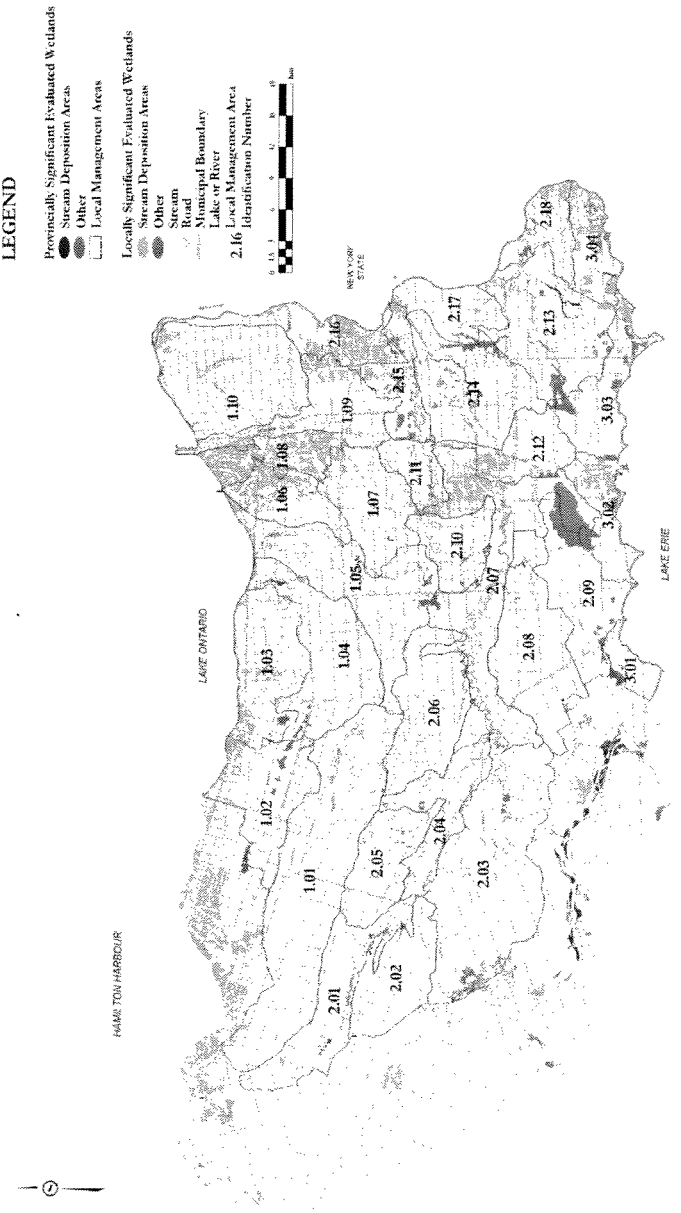
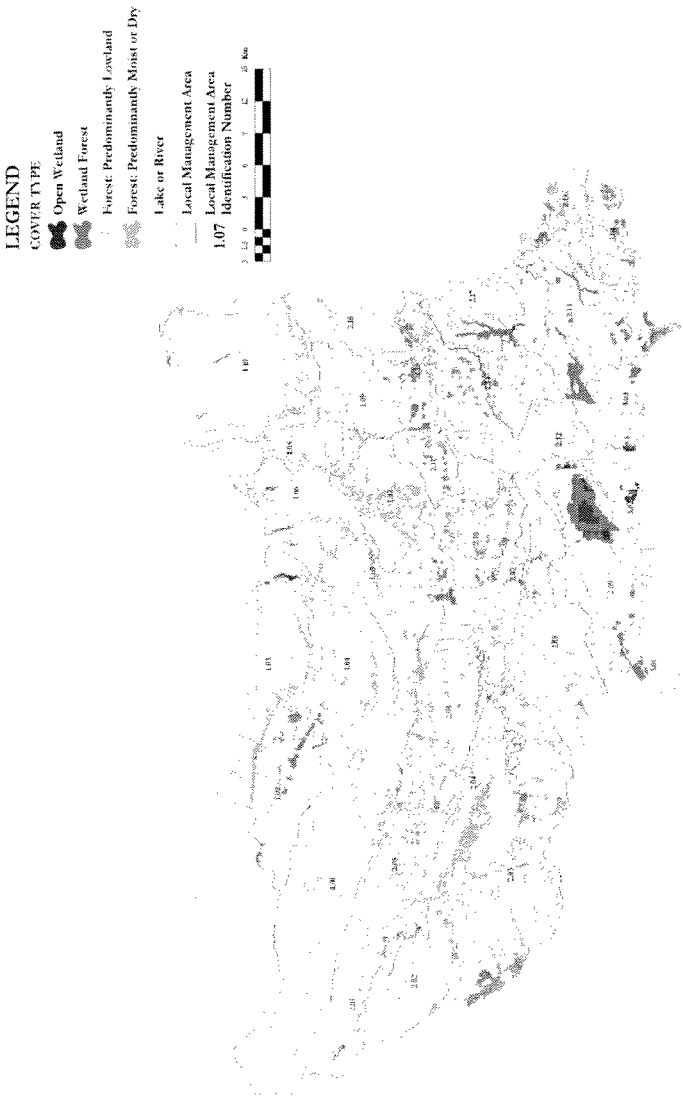


Figure 4. *All wetlands and forests.*



Comparison with 1967 maps (Canada Land Inventory, 1978) suggests that a great deal of the current forest is relatively immature, supporting the finding of Snell (1987) that although 80% of Niagara's original wetlands were converted by 1967, the area gained 30% (mostly thicket swamp) in the 15 years following.

Scrubland and meadow extent are less well documented. In 1983, idle land was concentrated in the southeast portion (Agriculture Canada, 1983). This category has now at least partially become immature forest.

Hydrological Roles

Each LMA was rated for natural area water protection roles. Indicators of hydrological roles of natural areas were chosen based on literature (Chang, 2002; Costanza *et al.*, 1997; Dougan and Associates, 2000; Kingston and Presant, 1989; Riley and Mohr, 1994) and available data. The chosen criteria and roles are listed in Table 1.

Table 1. *Indicators for hydrological roles of Niagara's natural areas.*

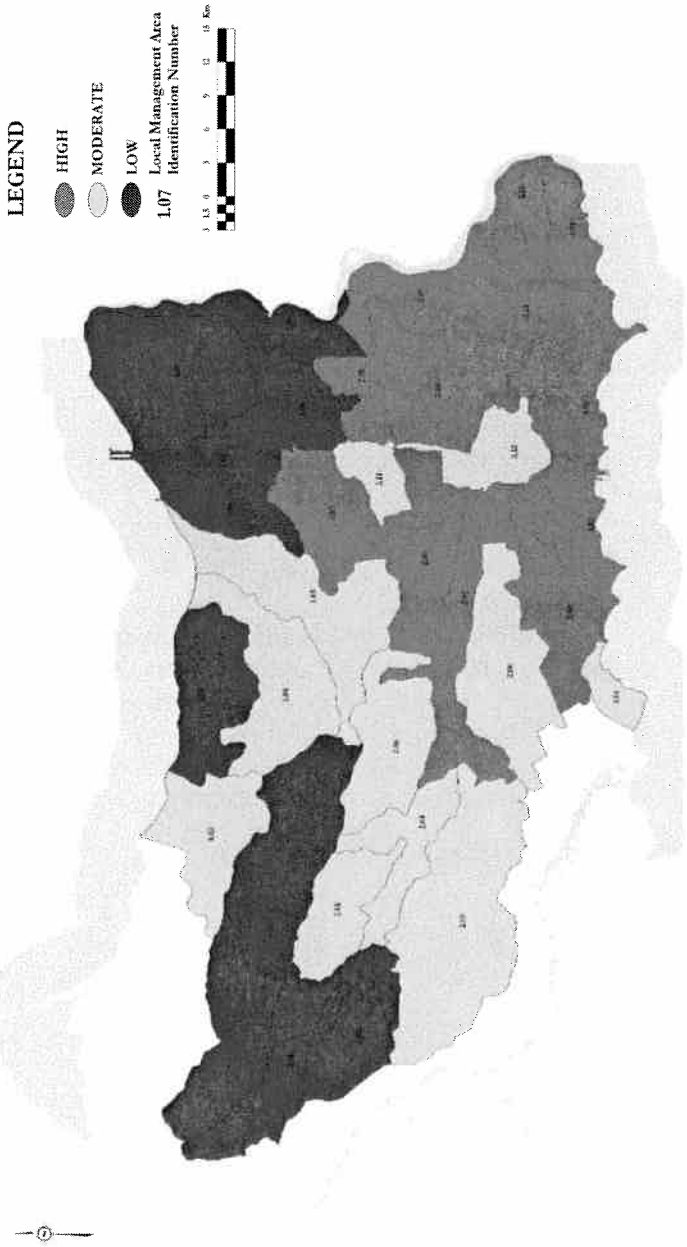
INDICATOR	ROLES INDICATED
% forest	Flow moderation
% wetland	Flow moderation, water quality improvement
% stream length through forest or wetland	Water quality improvement; buffers
Extent forested steep slopes per land area	Erosion and sedimentation control
% alluvial soils under forest or wetland	Floodplain protection, flow moderation, water quality improvement
Evenness of spatial distribution	Moderation of flood peaks
% of land area with coniferous cover	Flood reduction through delayed snowmelt
Evaluated wetlands' hydrological score/area	Flow moderation, water quality improvement
Extent of forest or wetland on kame or limestone	Protection of vulnerable groundwater recharge areas and associated discharge habitats

Relative thresholds of 'High', 'Moderate' and 'Low' were set to distribute the indicator ratings evenly among the LMAs. High was assigned 2 points; Moderate 1 point, with weightings reflecting the relative effectiveness at performing the associated role based on literature (e.g., Costanza *et al.*, 1997; Dougan and Associates, 2000) and the extent of the indicator relative to other criteria. Wetlands were weighted three times for their effectiveness; forest extent rated four times for the Upper Twelve Mile Creek which supports the only cold water creek system in the study area; and forest on steep slopes and coniferous forest each rated one half because of their very limited extent.

The resulting scores were added for each LMA and divided into High, Moderate and Low rating of natural area hydrological services to produce a relatively even distribution of

numbers among the LMAs. The outcome is shown on Figure 5.

Figure 5. *Hydrological services.*



For an absolute significance rating of natural area extent in LMAs, forest and wetland cover in each were compared with targets set for Remedial Action Plans, which were based, at least partially, on water protection goals (Environment Canada *et al.,* 1998). The Niagara and Erie LMAs rate very well for the wetland guideline attainment. Although several LMAs approach the forest target, only two attain it. Lake Ontario watershed's LMAs miss the targets. The upper Welland River areas rate poorly, except for the wetland area provided by the Binbrook Reservoir.

Other Values

Natural areas provide climate moderation, pollution uptake, recreation and aesthetic values. However, LMA rating was attempted only for biological values, using values developed by the Natural Heritage Information Centre's consensus of experts building *The Big Picture for Carolinian Canada* (Jalava and Sorrill, 1999). For each LMA, the values were multiplied by the area to which they applied, added and then divided by the LMA area for an average value. Relative High, Moderate and Low thresholds were chosen for an even distribution. The LMA ratings generally match their ratings for natural areas' hydrological roles; a few LMAs differ by one rating

Water-related Functional Impairment

Each LMA was rated for water-related impacts on terrestrial natural areas. In the absence of comprehensive impact data, indicators were chosen for stressor intensity and natural area sensitivity, using relationships gathered from literature (e.g., Detenbeck *et al.,* 1999; Schueler, 1992; Limnoterra, 1996; Chang, 2002; Keddy, 1995; Linzon, 1973; Whiteley, 1994; Transportation Board Research, 1991; Harris 1992; Hutchinson, 1968; Isabelle *et al.,* 1987; Azous and Horner, 2001; Wackernagel and Rees, 1996).

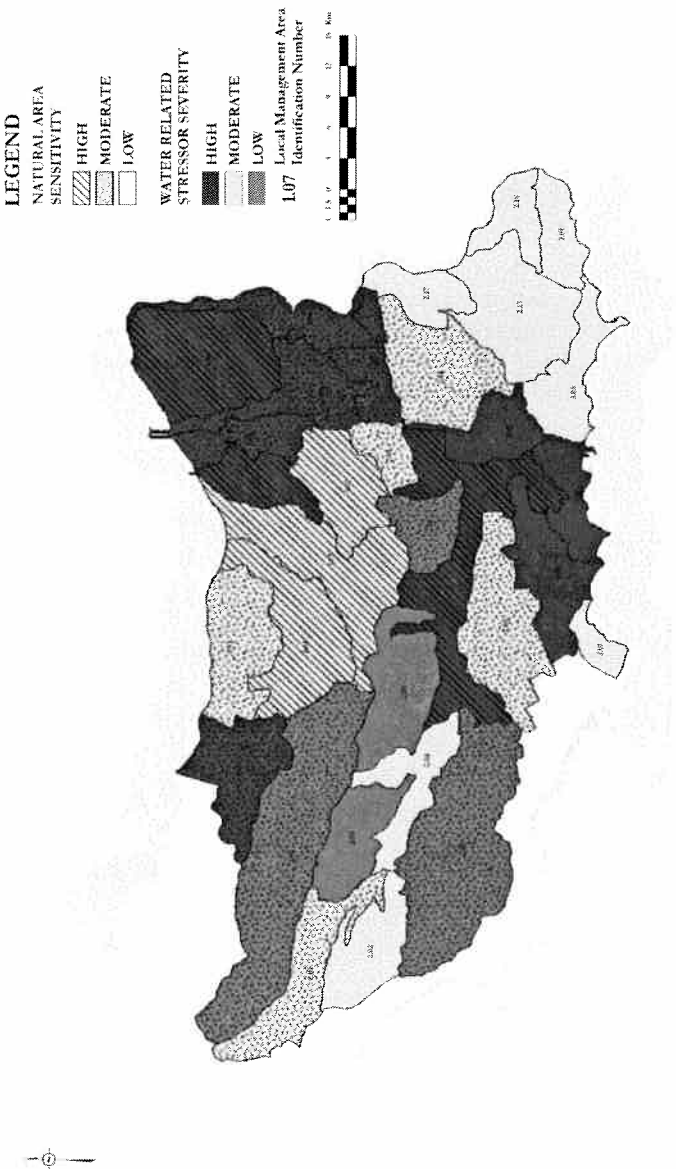
The stressor indicators were:

- presence of major water structures;
- % of streams that are municipal drains;
- % cropland;
- % built-up; and,
- presence of a 4-lane highway.

LMA rating of natural area sensitivity to surface water impacts was based on the presence of wetlands at river mouths or along streams in active deposition areas. LMA rating of natural area sensitivity to groundwater impacts was based on the presence of fens; or of natural areas on a kame, Niagara Escarpment, post-glacial shorecliff, till moraine, sand plain or sand dune.

Functional impairment ratings are presented in Figure 6. The High stressor areas generally combine urban uses and canal or hydroelectric water structures. Lower stressor levels occur in the upper Welland tributaries and upper Twenty Mile Creek areas where the

Figure 6. *Functional impairment of natural areas ratings (sensitivity and stressor severity) by Local Management Area.*



only major stressor is agriculture. High sensitivity ratings apply to several LMAs that cross the Escarpment; Low sensitivity applies to some upper Welland tributaries and areas draining into Lake Erie as well as some Fort Erie areas. Priority concerns apply to Lower Twelve Mile Creek, Niagara-on-the-Lake/Four Mile Creek and Welland areas where High stressors and High sensitivity coincide.

Summary and Strategy Implications

Areas of concern with combined Low-rated natural area roles and High-rated potential severity of impacts are in the northeast portion of the study area, including St. Catharines and areas to the east. Areas faring the best are in the southeast vicinity of Fort Erie where High roles, Moderate stressor levels and Low sensitivity coincide. In several areas, High rated natural area roles may be particularly valuable in dealing with High potential stressors.

The status of roles and impacts will offer guidance for strategy priorities for each LMA as outlined in Table 2.

Table 2. *Key strategies developed from water protection role and functional impairment.*

WATER PROTECTION ROLE	FUNCTIONAL IMPAIRMENT	KEY STRATEGY
High	Low	Preservation
High	Moderate or High	Protection
Moderate	Moderate or High	Enhancement
Moderate	Low	Preservation/Restoration
Low	All	Restoration

The major strategy features will include:

- maintenance of existing natural capital, preservation and protection, with education and planning tools;
- investments in improving ecological functioning, enhancement and restoration, via mitigation;
- sustainability of enhancement and restoration by reduction of stressors causing deterioration; and,
- restoration within landscape functioning as a condition for low maintenance.

Priorities will be guided by:

- preservation and protection over enhancement and restoration - on the basis of higher return for lower cost; and,
- opportunities for stressor reduction.

Acknowledgments

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References

Agriculture Canada. 1983. *Agricultural Land Use Systems of the Regional Municipality of Niagara. 1:25,000.* Land Resource Research Institute: Ottawa, ON.

Azous, A.L., and R. R. Horner. 2001. *Wetlands and Urbanization: Implications for the Future.* Lewis Publishers: Boca Raton, Florida.

Canada Land Inventory. 1978. *Present Land Use: 1967.* Available: www.geogratis.cgdi.gc.ca

Chang, M. 2002. *Forest Hydrology: An Introduction to Water and Forests.* CRC Press.

Costanza, R. R. R. d'Arge, S. de Groot, M. Farber, B. Grasso, K. Hannen, S. Limburg, R. Naeem, J. O'Neill, R. Paruelo, P. Ruskin, M. Sutton and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature,* 387: 253-260.

Detenbeck, N.E; S.M. Galatowitsch, J. Atkinson and H. Ball. 1999. Evaluating perturbations and developing restoration strategies for inland wetlands in the Great Lakes basin. *Wetlands,* 19(4): 789-820.

Dougan and Associates. 2000. *Warren Creek Watershed and Wet Forest.* Factsheet Warren Creek Watershed Master Plan Project for the City of Niagara Falls: Niagara Falls, ON.

Environment Canada, Ontario Ministry of Natural Resources and Ontario Ministry of Environment. 1998. *A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern.* Canada-Ontario Remedial Action Plan Steering Committee: Toronto, ON.

Harris, R.W. 1992. *Arboriculture: Integrated management of landscape trees, shrubs, and vines (2nd Edition).* Engelwood Cliffs: New Jersey.

Hutchinson, F.E. 1968. The relationship of road salt applications to sodium and chloride levels in the soil bordering major highways. Pp. 24-35. In: E. Carpenter (ed.) *Proc. Symp. Pollutants in the Roadside Environment.* University of Connecticut: Storrs, CT.

Isabelle, P.S., L. J. Fooks, P.A. Keddy and S.D. Wilson. 1987. Effects of Roadside Snowmelt on Wetland Vegetation: an experimental study. *Journal of Environmental Management,* 25: 57-60.

Jalava, J.V. and P.J. Sorrill. 1999. *Methodology for The Big Picture: Cores and Connections in Canada's Carolinian Zone.* Natural Heritage Information Centre, Ontario Ministry of Natural Resources: Peterborough, ON.

Keddy, P. 1995. *Principles of Wetland Restoration. Presented at Temperate Wetland Restoration Workshop.* Ontario Ministry of Natural Resources: Barrie, ON.

Kingston, M.S. and E. W. Presant. 1989. *The Soils of the Regional Municipality of Niagara. Report No. 60 of the Ontario Institute of Pedology.* Land Resource Research Centre Contribution No. 89-17, Agriculture Canada, Ottawa, ON.

Limnoterra. 1996. *Willoughby Marsh Project - Phase 1 Background Report (Draft).* Great Lakes Clean Up Fund, NPCA, MNR, Friends of Fort Erie Creeks, Ontario Hydro, MOEE: Region of Niagara: Niagara Falls, ON.

Linzon, S.E. 1973. Some effects of particulate matter on vegetation in Ontario. Pp. A118-A120. In: *Proceed. III International Clean Air Congress*: Dusseldorf, West Germany.

Niagara Peninsula Conservation Authority. 2002. Forest map for 2000. Niagara

Peninsula Conservation Authority: Welland, ON.

Ontario Ministry of Natural Resources (OMNR). 2002. *Natural Resources and Values Information System (NRVIS) data.* Ontario Ministry of Natural Resources (OMNR): Peterborough, ON.

Riley, J.L. and P. Mohr. 1994. *The Natural Heritage of Ontario's Settled Landscapes: A Review of Conservation and Restoration Ecology for Land-Use and Landscape Planning.* Ontario Ministry of Natural Resources: Southern Region, Aurora.

Schueler, T.R. 1992. *Design of Stormwater Wetland Systems: Guidelines for creating diverse and effective stormwater wetlands in the mid-Atlantic Region.* Metropolitan Washington Council of Governments: Washington, D.C.

Snell, E.A. 1987. *Wetland Distribution and Conversion in Southern Ontario.* Working Paper No. 48. Canada Land Use Monitoring Program, Inland Waters and Lands Directorate, Environment Canada, Ottawa.

Snell, E.A., L.Hua and B. McHattie. 1998. Wetland Extent Guidelines: Application to the Niagara River Area of Concern. Great Lakes 2000 Cleanup Fund, Burlington.

Transportation Research Board, 1991. Road salt impacts on the environment. Pp. 69-98, In: *Highway deicing: Comparing Salt and Calcium Magnesium Acetate.* Special Report 235. Transportation Research Board, National Research Council: Washington, D.C.

Wackernagel, M. and W. Rees. 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth.* New Society Publishers: Gabriola Island, British Columbia.

Whiteley, H.R. 1994. *Characterization of water quality of winter runoff from highways in southern Ontario.* Report prepared for MTO, Research and Development Branch: Downsview, Ontario.