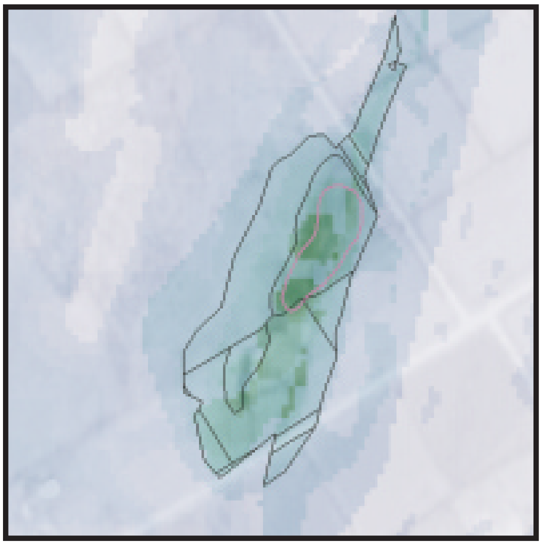
Severn Sound

Environmental Association

A METHOD FOR ANALYZING HISTORICAL WETLAND HABITAT CONDITIONS



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Prepared by : *Alexander K. McPhail, Applications Specialist*
Severn Sound Environmental Association

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FOREWORD

This report has been prepared under the auspices of the Canada-Ontario Great Lakes Remedial Action Plan Program. Although this report has received technical review, this does not necessarily signify that the contents reflect the views and policies of individual funding agencies, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

Introduction

Severn Sound, a group of bays located in the southeast portion of Georgian Bay is fed by a watershed area of over 1000 km². The drainage basin consists of a mixture of land uses including urban, agricultural and forest. The Severn Sound watershed, as part of the transition area between the Canadian Shield and the St. Lawrence Lowlands, has a wide variety of ecosystems ranging from forests in the upland areas to wetlands in the low lying valleys. Most of the watershed area has been changed from its original state by such human activities as logging, agriculture, urban development and the alteration of drainage. As part of the Remedial Action Plan process, which was put in place in the late 1980s to address degraded water quality and ecosystem health issues in the Severn Sound area, protection as well as enhancement of different wildlife habitats was a priority.

In the Severn Sound watershed, forest, riparian and wetland habitat conditions were measured and compared to “A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern” (Environment Canada, 1998) in 1998/99. At the subwatershed scale, a GIS method was developed by the Severn Sound Environmental Association office to complete the analysis. One of the main focuses of the GIS model was the comparison between 1983 and 1998 conditions which relied on an updated version of the Ontario Base Map (1983) wooded areas layer using 1998 aerial photographs. It was noted at the time of the analysis that wetlands were difficult to assess, especially when comparing the historic/original (before human activities) to the current coverage and condition.

Determining the extent of a watershed that was originally covered before land was cleared for such uses as urban development and agriculture can be useful in establishing a restoration goal for each watershed. As mentioned in the framework for guiding habitat restoration, areas in Southern Ontario, not including the Canadian shield, have lost approximately 70 % of their wetlands. Some watersheds are expected to have lost more than others. Identification of historical (lost) wetland areas may also help with site specific restoration of wetland habitat. Identifying areas of historical wetland, in the absence of complete historical information, requires a procedure to estimate the extent of wetlands before disturbance. These areas can then be used to develop watershed specific restoration goals. In addition, a method that estimates the extent of historical wetlands can be used to systematically guide targeting strategies for restoration activities.

The use of soils mapping, along with air photo interpretation, to estimate the coverage of historical wetlands is part of a method that has been widely used throughout Ontario (Snell, 1987). Given the upgrades in technology and available geographic data, the SSEA has enhanced the method by including topographic, land use and quaternary geology features and applying a multiple criteria evaluation. The enhanced method has been applied to the Hog Creek and Sturgeon River subwatersheds using ArcView 3.3 and the Spatial Analysis extension. The Hog Creek subwatershed results have been compared to the results from the “Wetland and Riparian Targets Pilot Application - Hog Creek Watershed” (Gartner Lee Limited, 1997).

This innovative approach includes the following:

- interpretation of soils mapping
- interpretation of Surficial Geology mapping (OGS)
- identification of flat slope areas
- the use of a proximity to existing water features model
- the use of groundwater discharge mapping
- identification of areas of deposition
- delineation of potential wetland sites based on proximity to other features
- the use of 2000/01 agricultural land use and other data to target sites for restoration

A number of candidate sites that were specifically identified in the Hog Creek and Sturgeon River subwatersheds have been selected for further analysis including a comparison between historic (1931, 1953, 1989 & 1998) air photos as well as field testing.

Method

In order to identify wetland areas that were once part of the landscape but are no longer present or have diminished substantially in size, a multiple criteria evaluation (MCE) model was applied using GIS technology. A site that was a wetland over a hundred years ago may have been harvested for wood in the adjacent areas and later drained to be converted to agricultural or urban land, resulting in a change of land use. For this study, it is assumed that changes in land use (wetland to agriculture or urban) are surficial as other factors soils, geology, slope and hydrology (groundwater/surface water interaction) may change only slightly. GIS coverages of most of the unaltered features associated with wetlands are available and with some enhancements, were used as part of the model.

The multiple evaluation criteria method used for this study involves applying a ranking score to each input layer. Components of each input layer are ranked according to an assumed ability or inability to sustain a wetland. For example the soil coverage consists of a number of different soil categories and drainage capabilities for each soil. Very poor drainage would be assumed to better retain water and sustain a wetland because the water table is considered to be close to the surface as opposed to well drained soils where the water table is much further away from the surface. Very poor drainage soils would receive a higher score where well drained soils would receive no score.

When the individual layers are ranked, the scores are combined to provide a polygon layer of "wetland potential" which identifies features, associated with wetlands. These areas are likely to have wetland characteristics unless changes in drainage and land use have occurred.

The information required in order to apply the method includes soil drainage, surficial geology, flat slope areas, proximity to existing water features, groundwater discharge areas and areas of potential deposition. The layers are combined into a probable wetland layer. The information was checked using aerial photography as well as existing wetland data. To identify sites with the most potential for sustaining a wetland the probable wetland layer was overlayed with land use. Privately owned vacant and idle farm land as well as some government owned properties are assumed to have the best chance for wetland restoration as the owner may be more willing to partake in a project than a site that is developed residential. Upon identifying potential sites, a restoration strategy would be developed.

Data Preparation

Preparation of the data took place in two phases. The soils, geology and shallow groundwater areas were reclassified into a ranking score. The distance to existing surface water, flat slope areas and deposition areas required some analysis before they were used in the model.

Soils

Soils information is an indicator of the type of materials found at the ground surface. Soils that are known to hold water are very poorly to imperfectly drained soils and may include very fine sand, silt and clay. These soil types are considered to have potential for sustaining wetlands. Coarser soils such as sand and gravel allow surface water to move deeper into the ground, away from the surface and are classed as moderately well to excessively drained soils. The substrate found in most wetlands also contains a layer of organic soils (Mansell et.al., 1998). The soils information for the Severn Sound watershed area was acquired from Simcoe County Soils information (Hoffman et. al., 1962) which was made available, digitally, by the County of Simcoe.

The Simcoe County soils coverage groups the data into drainage classes ranging from very poor to excessively drained soils. The soil drainage class is an interpretive grouping based on properties that influence water flow through the layers of soils. At the wettest end of the scale, the very poorly drained category is considered to have the water table at or near the surface for most of the year. At the driest end of the scale, the excessively drained soil class has a low water holding ability and water flows, rapidly, through the soil horizons rapidly (Singer and Munns, 1987). The other categories fall between the very poor to excessive drainage classes. The drainage classes were used to show how well suited an area is to sustaining a wetland given the types of soil. The drainage classes were attributed a ranking score and added to the multiple criteria evaluation model.

Table 1. Soil drainage classes found in Hog Creek and Sturgeon River subwatersheds and the corresponding score used in the wetland probability model

Drainage Class (Material)	Ranking Score
GOOD (ie. Sandy Loam Till)	0
IMPERFECT (ie. Sand with Silty Clay Loam)	5
POOR (ie. Silt Clay Loam)	8
VERY POOR (ie. Muck/Organic)	10

Surficial Geology

The surficial geology layer was classified based on materials in each area which were ranked according to ability to hold water. Primary materials which are prevalent in the layer were coupled with the secondary subordinate materials to assess the drainage capability. Similar to the soils layer, surficial geology listed a range of materials including sand and coarse gravel which quickly drain and clay and silt which holds water closer to the surface. Organic deposits are listed as wetlands and are highly ranked.

Table 2. Surficial geology material classes used for the Hog Creek and Sturgeon River subwatershed analysis and the corresponding score used in the wetland probability model

Primary Material	Secondary Material	Score
gravel		0
Precambrian Bedrock		0
sand, gravel		0
sand, gravel	diamicton	0
sand		0
sand	gravel	0
sand	gravel, diamicton	0
sand	silt, gravel	0
diamicton	loamy	1
diamicton	silt to sandy silt	1
diamicton	silty sand to sand	1
silt, sand	gravel	1
sand, gravel	clay, silt, diamicton	2
sand	clay, silt, gravel	2
silt, sand	clay, silt	2
clay, silt, sand, gravel		3
silt	clay	5
silt	clayey, sandy	5
clay, silt		7
clay	silt	7
organic deposits		10

*Flat Slope Area*s

From a wetland restoration stand point, level to gentle slopes are optimal for planned wetlands (USACE, 1993). On flat slope areas, surface water velocity slows and spreads out laterally allowing for sediments and nutrients to be deposited and wetland vegetation to uptake the nutrients. It is estimated that most wetland plants will not grow on areas with greater than 5% slope. For this analysis, areas with slopes of under 5 % were considered suitable for wetland conditions when combined with the other MCE model factors.

Using a digital elevation model (OMNR) a percent slope coverage was generated. The slope layer was reclassified to represent flat slope (under 5%) areas as a ranked score. The score was added to the multiple criteria evaluation model.

Table 3. Flat slope categories used for the Hog Creek and Sturgeon River subwatershed analysis and the corresponding score used in the wetland probability model

Percent Slope	Ranked Score
0 - 1	10
1 - 2	9
2 - 3	7
3 - 5	5
Over 5	0

*Groundwater Discharge Area*s

The depth to groundwater can be useful in the determination of probable wetland locations where the groundwater is close to the surface. Discharge areas are assumed to be a source of water that may sustain wetland conditions. Springs and seeps which can provide wetlands with water are likely more prevalent where the water table is closer to the surface.

The North Simcoe County Groundwater Study produced a digital coverage of the groundwater discharge areas by comparing shallow water table elevations to ground surface elevations (Dixon Hydrogeology,2003). The discharge areas mapping estimates the amount of above ground hydraulic head that occurs in an area. The larger the head distance, the greater the chance for groundwater to reach the surface. A ranked score was assigned to the discharge areas layer at one point per metre of head discharge. For example, 10 m of hydraulic head, received a wetland probability score of 10 while a 4 m head value receives a score of 4. The ranked layer was then applied to the multiple criteria evaluation model.

Distance to Existing Surface Water

Wetlands require a source of water either permanently or intermittently, to sustain the ecological function of the wetland. Existing surface water features were incorporated into the MCE model. The water related features used in the model included lakes, rivers and wetland areas. A weighted distance layer was created, assigning a higher ranking score to areas closer to water features than areas further away. A cutoff value of 750 metres was established which is also the maximum distance used when a wetland is complexed with adjacent wetlands.

Table 4. Distance to water features categories used for the Hog Creek and Sturgeon River subwatershed analysis and the corresponding score used in the wetland probability model

Distance to Water Feature	Ranking Score
0 - 10	10
10 - 20	8
20 - 94	4
94 - 375	2
375 - 750	1
Over 750	0

The distance to water features layer is two dimensional meaning that changes in elevation are not considered. By combining the distance to water information with the other criteria, existing conditions are represented, demonstrating the availability of surface water.

Deposition Areas

One field indicator of wetland hydrology is the evidence of water borne sediments deposited on plants and other objects (USACE, 1987). The identification of areas where deposition is most likely to occur based on changes in gradient along a path of flow, was used as an indicator for wetland conditions. A deposition area is the transitional zone where a large enough reduction in slope occurs to slow overland water velocity to a point where suspended sediments drop out of suspension. (Van Remortel, Hamilton and Hickey, 2001).

For the purpose of this study, a 50 percent reduction in slope is assumed to lead to the deposit of sediments. Using ArcView 3.3 and its customization language, Avenue, an automated GIS method was adapted from an Arc Macro Language script developed by Van Remortel, Hamilton and Hickey to produce a length of slope and deposition area coverage. The deposition areas were then identified and attributed a wetland probability score of ten points to be added to the wetland probability model.

Historical Wetland Boundary Interpretation

To approximate the boundary of each historical wetland, a transition point from low to mid score and mid to high score was determined. The threshold value was established by comparing the multiple criteria evaluation output to existing wetland boundaries. The threshold value was adjusted downwards from the highest score possible (55 points) until the existing wetlands were represented. The output grid file from the multiple evaluation criteria model was converted to a polygon coverage showing areas that ranged from 20 points or higher. A sample of the historical wetland areas was checked using aerial photo interpretation and ground truthing.

Preliminary Checking

Ground checking of selected wetland areas within the two subwatersheds was carried out to evaluate the model based on known conditions. Three predicted historical wetland areas were selected based on land use and a comparison to existing wetland conditions; an area that has some existing wetland but has had major alterations; an area that has a large component of existing wetland; and an area that has no existing wetland but meets the criteria for wetland conditions.

Table 5. Historical wetland areas used in land use and existing wetland area comparison.

Land Use	**Area 1**	**Area 2**	**Area 3**
Urban		0.2%	
Ag	75.5%	1.6%	40.5%
Idle		11.3%	0.8%
Wooded	21.6%	82.9%	58.7%
Road	2.9%	4.0%	
Predicted Wetland Area (Ha)	10.2	24.2	8.4
Existing Wetland Covering Predicted	11.6%	62.8%	0.0%

Area 1 is an example of an altered landscape and consists of a large agricultural component which is made up mainly of hay and pasture fields with some row crops (Figure 1) . The existing wetland area, based on OBM data, is located within the wooded area and covers slightly more than a tenth of the historic wetland area. Evidence of low lying land and wetland vegetation noted in adjacent areas, despite land use change, suggests reasonable agreement between the predicted historic wetland model results and field observations. Through ground truthing and an interview with the landowner, a large area of wetland that isn't included in the OBM data is located within the historical wetland boundary. The missing wetland area is within a hay field and is partially cropped which holds back the wetland vegetation.

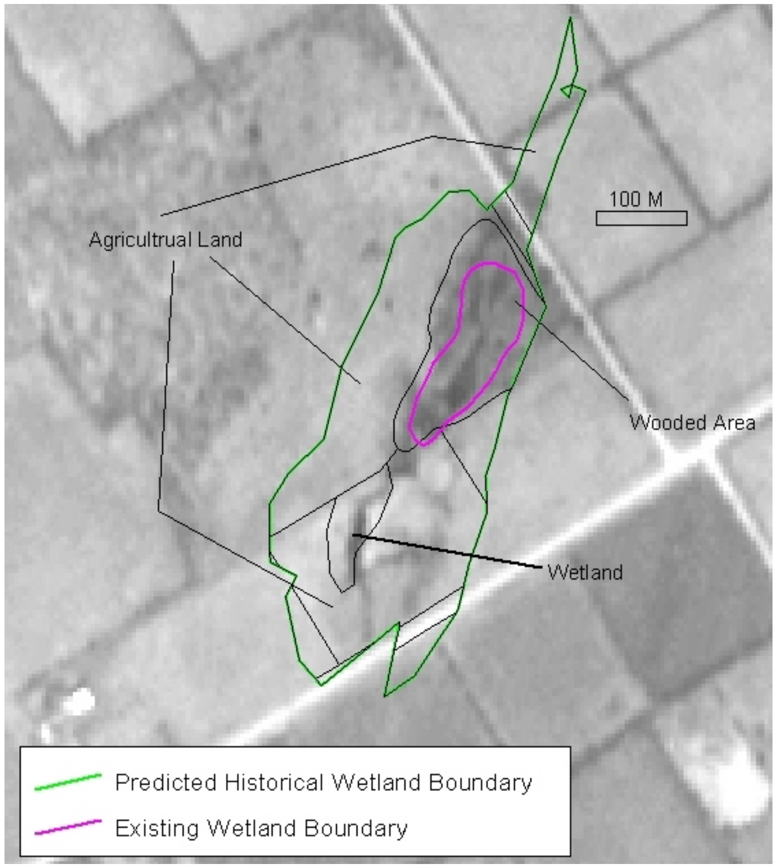

Figure 1. Area 1 example of a site that has some existing wetland but has had major alterations
(Includes material © Space Imaging L.P.)

Area 2 is a wetland that has had minor changes in the fringe area of the existing wetland due to some past agricultural activities (Figure 2). The existing wetland accounts for over 60 % of the predicted historic wetland area and can be considered a historical wetland. The existing wetland, which was also an OMNR evaluated wetland, falls completely within a wooded area. The wooded area accounts for over 80 % of the predicted historic wetland area. A large component of the fringe area is mostly idle agricultural land which may help with the enhancement of the wetland.

Area 3 consists of a site that has no existing wetland but meets some of the conditions used in identifying historic wetlands (Figure 3) . The land use found within the historic wetland boundary consists mainly of woodland and a hay/pasture system. This area is an example of a good candidate site for reestablishing wetland conditions but would require further field checking to determine the extent and feasability of restoration.

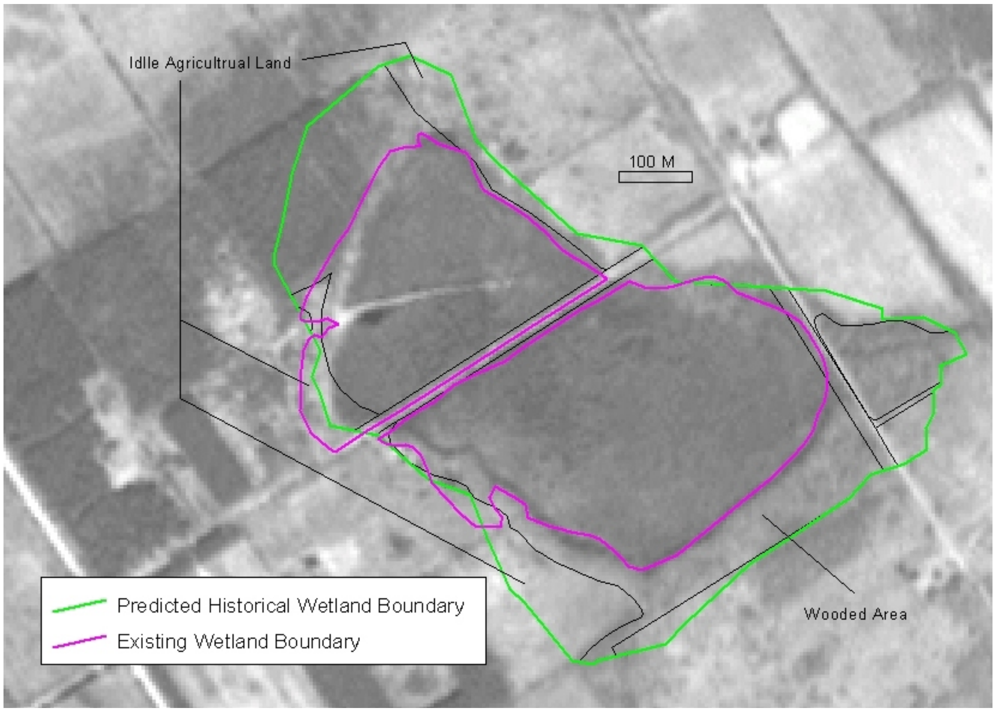

Figure 2. Area 2 example site that has a large component of existing wetland.

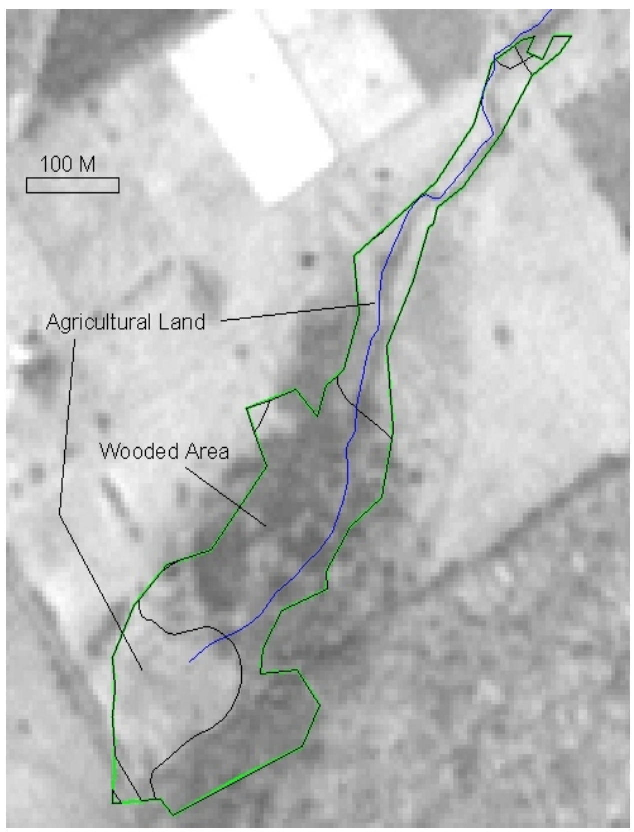

Figure 3. Area 3 example site that has no existing wetland but meets the criteria for wetland conditions

Evaluation of Hog Creek and Sturgeon River

- The method was applied to two subwatersheds in the Severn Sound Area
- The original estimate showed Hog Creek and Sturgeon River consist of 7 % and 12 % respectively of existing wetland habitat based on OBM wetland layer combined with NRVIS evaluated wetlands (SSRAP, 2002).
- The historical wetland model showed a potential historical wetland area of 11.1 km^2 or 18 % coverage for Hog Creek and 29.4 km^2 or 29 % coverage for Sturgeon River.
- This indicates that an estimated 61 % and 59 % of the wetlands in Hog Creek and Sturgeon River watersheds have been lost or are unaccounted for (not documented).

Concluding Remarks

The use of a multiple criteria evaluation method for identifying historical wetland areas helps to focus efforts on wetland enhancement and protection. This is achieved by locating areas that meet the wetland condition criteria which is based on an interpretation of data that is available at the time of the analysis. The model was designed with flexibility in mind so that as data is improved or new types of information become available, the model can be adjusted to include the new information. The dependability of the model is reliant on the accuracy and interpretation of the input data. This model is not meant to replace field assessment and interpretation of wetland conditions but will enhance and guide these activities.

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