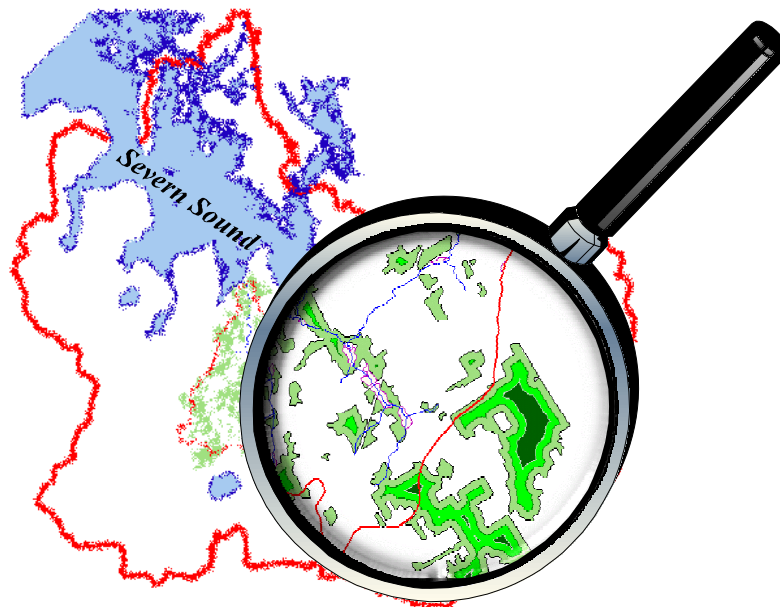


HABITAT RESTORATION STRATEGY FOR SEVERN SOUND

AUTOMATED ARCVIEW 3.1 HABITAT ANALYSIS METHOD



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FOREWORD

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SUMMARY

The Severn Sound Remedial Action Plan (SSRAP), as one of its delisting objectives, must assess the condition of fish and wildlife habitat within the watersheds that flow to Severn Sound. Using Environment Canada's framework for guiding habitat rehabilitation in Great Lakes areas of concern, the SSRAP is developing a strategy for habitat restoration in Severn Sound. The habitat guidelines were reviewed as habitat targets for the Hog Creek, one of six Severn Sound subwatersheds, by Gartner Lee Limited. Several habitat measurement methods were used requiring manual application by trained personnel. The SSRAP has developed an automated geographic information system (GIS) procedure that can measure several habitat conditions and provide locations of sites most suitable for restoration by combining standard vector GIS methods with innovative analysis techniques.

This report will provide a rationale outlining the targets measured and compare the methods used in the Pilot Application with the Automated GIS. A step-by-step guide will provide instruction for applying the automated method and detailed technical information is also included to give an understanding of the computer processes used in developing the automated GIS.

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SECTION 1

INTRODUCTION / BACKGROUND

Severn Sound, located in the southeast portion of Georgian Bay, has been listed by the International Joint Commission as an Area of Concern (AOC) in the Great Lakes. To address environmental issues, a remedial action plan was established in 1987.

The Severn Sound Remedial Action Plan (SSRAP) has identified degradation of fish and wildlife habitat as a significant environmental problem. In order to assess the condition of fish and wildlife habitat within the watersheds that flow to the Severn Sound, the SSRAP has adopted a habitat restoration strategy modelled after a framework developed by Environment Canada for habitat rehabilitation in the Great Lakes Areas of Concern.

The Habitat Framework was designed to guide the choice of restoration targets that relate to fish and wildlife habitat and populations. The framework also provides a method to prioritize locations for wetland, riparian and forested habitat rehabilitation projects at the watershed (landscape) level. Targets are based on an understanding of how much habitat is required to provide for the ecological needs of fish and wildlife species in three types of habitat (Environment Canada, 1998). By calculating percentages, general comparisons can be made between watersheds. Calculations include:

- wetland (percentage of watershed covered by wetland and amount of forest cover adjacent to wetland);
- riparian areas (percentage of upper stream reaches with adjacent forest cover and more than 30 m adjacent forest cover);
- forested areas (percentage of watershed covered by forest areas and interior forest areas).

The Severn Sound habitat restoration strategy is currently using the Habitat Rehabilitation Framework targets to measure the status of fish and wildlife habitat and identify priority sites for remediation within the six Severn Sound subwatersheds. These targets were applied to the Hog Creek watershed by Gartner Lee Limited for Tay Township (1997) to evaluate their appropriateness in the Severn Sound watershed. The report demonstrated several manual and computer aided habitat measurement techniques which enable a comparison to be made between existing habitat conditions and the Habitat Framework Targets.

Although the manual approach is adequate in measuring habitat conditions, it requires trained individuals to apply the analysis, making it time-consuming and difficult to update as major land use changes occur. The labour-intensive nature of the manual approach used in the pilot study suggested the benefits of developing an automated GIS approach for habitat condition measurement. This automated GIS approach is able to evaluate large data sets and has reduced the amount of time required to apply the habitat measurement methods by enabling repeatability both spatially (watershed basis) and temporally (time comparison).

An automated method of habitat measurement and site selection has been developed by the SSRAP, using GIS software, Arcview 3.1 (ESRI) and its object-oriented language, Avenue. As demonstrated by the Hog Creek Pilot Application (Gartner Lee Limited, 1997), several methods were used to measure habitat conditions. A comparison can be made between the Hog Creek Pilot Application manual methods and the Severn Sound automated analysis methods.

RATIONALE FOR AUTOMATING HABITAT REHABILITATION FRAMEWORK TARGETS

In using an automated approach for analysing habitat conditions, the SSRAP can measure spatial relationships at the watershed level, compare changes over time and identify priority areas for remediation. The GIS is used to enhance existing implementation programs by focussing resources on areas identified as potentially degraded. The output from the habitat analysis method is meant to provide an estimate of habitat conditions. Note that the resulting information is only as good as the input data and the interpretation skills of the user.

In developing an automated GIS for habitat analysis, the following considerations were made:

- (1) Measurement techniques must be applied consistently regardless of spatial or temporal variation in the digital data.
- (2) The GIS should identify priority areas for application of various restoration techniques (ie. tree planting) in order to maximize resources.
- (3) The automated GIS methods should be transferrable to other offices for application purposes such as municipal planning and natural resource management.
- (4) Automation of the GIS should be completed using ArcView 3.1 GIS software currently being used by the SSRAP implementation office.

Although the Habitat Analysis methods can be applied using other GIS packages, ArcView 3.1 was chosen for its availability within the RAP Implementation office and other agencies, portability through the creation of an ArcView extension, ease of use both through standard ArcView methods and application development/customization.

A Habitat Analysis Extension was designed in ArcView 3.1 to measure habitat conditions and identify potential sites for rehabilitation based on the following habitat targets:

- **Forest**
 - percent forest cover,
 - size of largest patch,
 - percent forest > 100m from edge,
 - percent forest > 200m from edge
- **Riparian**
 - percent vegetated streams,
 - percent streams with > 30m buffer
- **Wetland**
 - percent wetlands in watershed,
 - amount of vegetation adjacent to wetlands.

The Habitat Analysis Extension was designed as a stand-alone extension not requiring any other ArcView 3.1 extensions to access the customized graphic user interface (GUI). This allows for transfer to other agencies with access to ArcView 3.1.

FOREST HABITAT TARGETS

Forest habitat refers to woodland areas that accommodate a diversity of plant and animal species. Forest habitat analysis focuses on assessing conditions for area-dependant forest breeding birds. There are two components to automating the forest habitat analysis method; the measurement of habitat conditions for comparison with the habitat targets and the selection of suitable sites for restoration.

Target Measurement

Percentage of Forest Cover

To estimate the percentage of forest cover in the Hog Creek Pilot Application, the total forest area from the Ontario Base Map (OBM) digital vegetation layer was measured and divided by the total watershed area to output a percentage of forest cover for the watershed. This process was achieved by using AutoCad to determine the polygon areas (Gartner Lee Limited, 1997).

In this study, a process similar to that used for the Hog Creek Pilot Application was applied using ArcView 3.1. Forest polygons can be clipped to include only areas that fall within a watershed boundary. Clipping the forest layer removes any overlap between subwatersheds. The total area of forest cover is calculated and divided by the watershed area resulting in a percentage of forest cover for the watershed.

Size of Largest Forest Patch

The largest forest patch for the Hog Creek Pilot Application was calculated using AutoCad to determine the polygon areas. The polygon with the highest area was considered the largest forest patch. The ArcView method uses an identical process for measuring the forest polygons and identifying the largest forest patch.

The Percent Forest Cover and Size of Largest Patch targets were not fully automated as they can be effectively analysed using the standard graphic user interface (GUI) in ArcView 3.1.

Forest Area 100m and 200m From Edge

The Hog Creek Pilot Application used GIS (AutoCad) to precisely measure the amount of existing forest interior within woodlots that are both a minimum of 100 m and a minimum of 200 m in from the edge of a forest block. Forest polygons that are only partially located within the watershed boundary were included as the boundary creates an artificial forest “edge” and could result in an underestimate of interior habitat (Gartner Lee Limited, 1997). The Hog Creek Pilot Application method automates this process using AutoCad by running a series of batch file routines.

The ArcView method uses negative edge buffering to generate 100 m and 200 m from edge coverages. A buffer is an area of a specified width drawn around one or more map features (Aronoff, 1995). A negative buffer represents an area within a specified distance from the edge towards the inside of a polygon feature. The remaining area that is not overlapped by the negative buffer, depending on the defined distance, is considered the forest interior. The area of 100 m and 200 m forest interior is calculated and summarized to show the percentage of interior forest cover within and overhanging the watershed boundary. The Habitat Analysis GUI efficiently generates interior forest coverages.

Site Selection for Restoration

The Hog Creek Pilot Application identifies priority areas for planting by manually locating large, irregularly shaped or fragmented forest polygons. Identifying priority patches is intended to produce maximum interior forest for a minimum effort (cost, time and trees). Interior forest habitat is maximized by infilling holes within and spaces adjacent to highly convoluted forest patches with trees (see figure 1). Factors such as forest size, shape and degree of fragmentation all affect the viability of habitat for wildlife species. Therefore, these factors should be viewed collectively when applying a strategy to determine habitat rehabilitation needs and priorities (EC, 1998).

The SSRAP has developed an automated method of locating suitable sites for planting which involves identifying the sites by applying a set of criteria using ArcView. The target layer is a 1 Ha vector grid (a vector grid is a seamless polygon coverage consisting of a set of grid cells, similar to raster data). Each cell is subjected to a set of selection criteria; for example, size of forest patch, proximity to roads and forest edge to area ratio. A suitability value is either added or subtracted from the cell attribute based on the result of each criterion evaluated (See Table 1). The minimum suitability score possible is zero and the maximum possible score is six (eight with drainage criteria). Certain criteria may not be desirable (narrow trail corridors) when identifying habitat restoration sites. Once the user has assessed the criteria for a watershed, the option is available for the user to exclude certain criteria from the process.

Cells with the highest suitability value are considered most suitable for planting to maximize interior forest area. The most suitable cells can be intersected with a property assessment (cadastral) layer to generate a list of potential sites and landowners to be contacted by field staff.

Table 1: Site Suitability Criteria

Step	Criterion	Rationale	Priority Value Assigned (SUITCODE)
1	Grid Cells with centres that fall within the <i>Watershed Boundary</i>	all cells within watershed included	reset to 0
	Grid Cells with centres that do not fall within the <i>Watershed Boundary</i>	Cells outside of watershed excluded	Left as NO DATA
2	Grid Cells that are adjacent to <i>Vegetation Polygons</i> > 50 Ha in size	> 50 Ha forest area will support some Forest-Interior bird species	Add 1
3	Grid Cells that are adjacent to <i>Vegetation Polygons</i> > 50 Ha in size that also contain 200 m interior forest (<i>200m Buffer</i>) polygons	habitat value increases by expanding forest patches meeting criterion	Add 1
4	Grid Cells that are adjacent to <i>Vegetation Polygons</i> > 50 Ha in size that also contain 100 m interior forest (<i>100m Buffer</i>) polygons > 40 Ha in size	habitat value increases by expanding forest patches meeting criterion	Add 1
5	Grid Cells that are adjacent to <i>Vegetation Polygons</i> > 50 Ha in size that also contain 100 m interior forest (<i>100m Buffer</i>) polygons of any size	habitat value increases by expanding forest patches meeting criterion	Add 1
6	Grid Cells that are adjacent to <i>Vegetation Polygons</i> > 50 Ha in size with a Fractal Dimension > a user defined threshold ⁽¹⁾	Interior forest habitat can be maximized by planting in open spaces within convoluted patches	Add 1
7	Grid Cells that are <u>within</u> 100 m of <i>Vegetation Polygons</i> > 50 Ha in size ⁽²⁾	Depending on suitability of surrounding cells, habitat value may increase	Add 1
8 Optional	Grid Cells that have a SUITCODE of > 0 and fall within 30 m of the <i>Drainage Network</i>	Planting may enhance both forest and riparian habitat	Add 1
9 Optional	Grid Cells that have a SUITCODE of > 0 and intersect the <i>Drainage Network</i>	Planting may enhance both forest and riparian habitat	Add 1
10 Optional	Grid Cells that have a SUITCODE of > 0 and fall within 40 m of the <i>Road Network</i>	Habitat value decreases as proximity to road increases	Subtract 1
11 Optional	Grid Cells that intersect the <i>Road Network</i>	Planting roads low priority	Equals 0
12 Optional	Grid Cells that have a SUITCODE of > 0 and fall within 30 m of <i>Miscellaneous Transport</i> (Lanes, Driveways, etc.)	Habitat value decreases as proximity to driveways, etc. increases	subtract 1
13 Optional	Grid Cells that intersect <i>Miscellaneous Transport</i>	Planting driveways, etc. low priority	Equals 0
14 Optional	Grid Cells that intersect <i>Buildings</i>	Planting building sites low priority	Equals 0
15 Optional	Grid Cells that intersect <i>Railway/Abandoned Railway</i>	Planting railway/abandoned railway sites low priority	Equals 0

16	Grid Cells that have centres within <i>Vegetation</i> polygons	Already planted	Equals 0
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¹⁾ Fractal Dimension (D) is a perimeter-area method that quantifies the degree of complexity of planar shapes, such that the perimeter (P) is related to the area (A) of the same patch by $D = (P)_{Log} / (A)_{Log}$. (McGarigal & Marks, 1994). For example: a fractal dimension of 1, the minimum, represents a perfect circle; a fractal dimension of 2, the maximum range, represents highly convoluted shapes that are filled by their perimeter (convoluted). (see Figure 1).

²⁾ Cells within one cell width (100 m) of a vegetation patch > 50 Ha in area are considered in the selection process as they may fill spaces left over from previous steps or target marginal areas. It is up to the user to interpret the habitat value of these cells by assessing the priority values of adjacent cells.

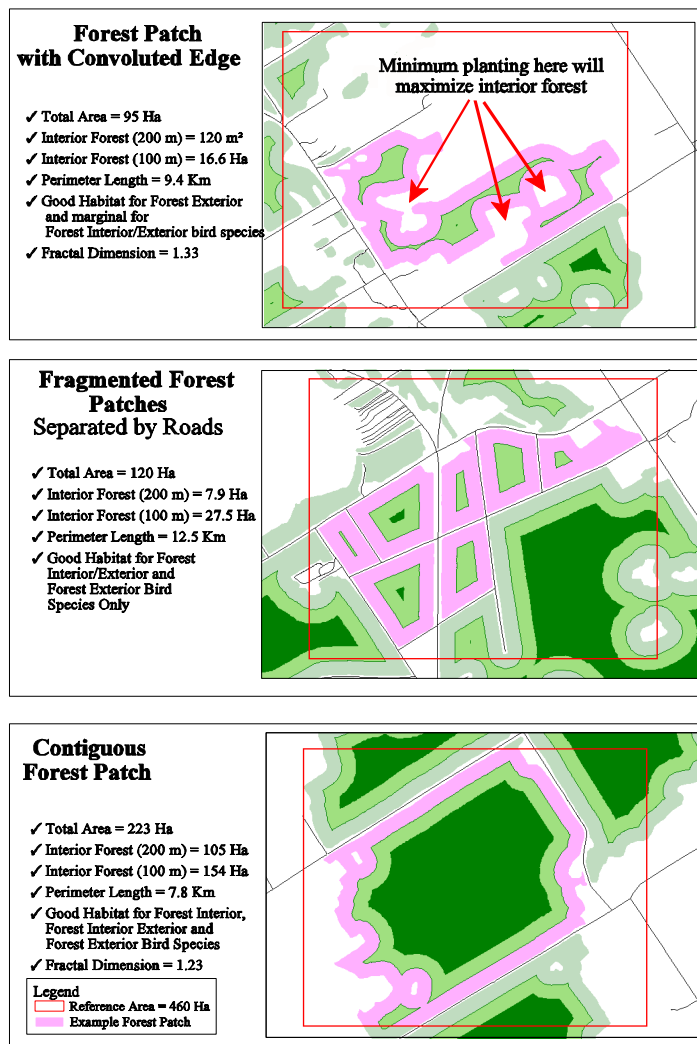


Figure 1: Examples of Forest Habitat in terms of patch type

RIPARIAN HABITAT TARGETS

The natural edges of streams (riparian habitat) are important in stabilizing banks, providing overhanging cover, providing wildlife corridors between forest patches and providing stable habitat in the stream for fish. The amount of riparian habitat along streams is an indicator of shading and detrital contributions that support fish productivity and maintain coldwater conditions. A lack of forested riparian cover does not necessarily imply bank instability and is dependant on factors such as stream gradient and other types of riparian vegetation that may be present (Gartner Lee Limited, 1997). Ranges of adjacent vegetation width affect the ability of a buffer to perform specific functions: species diversity (three to 100 m), wildlife movement (three to 200 m), water temperature moderation (15 to 30 m) (Environment Canada, 1998). Riparian habitat conditions are measured using an automated approach by calculating the percentage of first to third order streams with any vegetation (i.e. forest cover) and with more than 30 m of vegetation on both sides.

Target Measurement

Percentage of First To Third Order Streams With Vegetation

The Hog Creek Pilot Application uses air photos to identify sections of the watershed with and without riparian habitat.

Determining what stream segments flow through vegetation can be achieved by clipping the target themes in the habitat analysis interface. Summarizing the resulting clipped coverage by stream order will provide the length of first to third order stream segments that intersect with vegetation polygons.

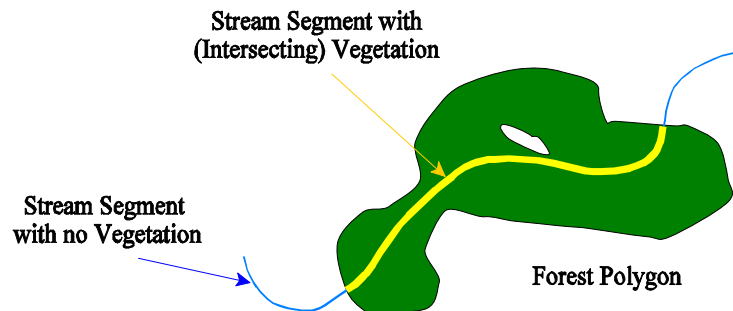


Figure 2: Example of forest polygon intersected by a drainage segment to show streams with vegetation.

Percentage of First To Third Order Streams With More Than 30 m of Vegetation

The width of vegetated buffers adjacent to Hog Creek tributaries was determined from a manual examination of aerial photographs in the pilot application and the percentage of each stream order with greater than 30 m riparian cover was determined (Gartner Lee Limited, 1997).

Using the standard ArcView 3.1 GUI, it is not possible to accurately determine lengths of stream with more than a 30 m vegetated buffer using simple buffering routines. A method of offsetting stream segments and testing the offsets in relation to a vegetation layer was developed.

Steps:

1. Each stream segment was divided further into approximately 10 m segments.⁽¹⁾
2. Each 10 m segment was offset by 5 m increments up to 30 m on both sides of the stream.
3. Offset segments were tested to determine if they are contained within a vegetation polygon.
4. If all segment offsets are contained within a polygon then the original segment is kept. If any one segment offset is not contained by a vegetation polygon, then the original segment is discarded from the output coverage.

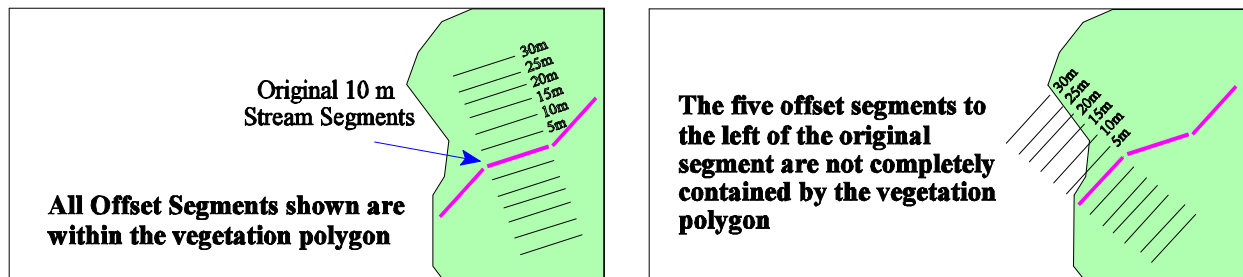


Figure 3: Example of segment offsetting used in analysing riparian habitat

⁽¹⁾ Due to their varying lengths, stream segments are subdivided into equal sections which are close to 10 metres in length. For example, a stream segment 52 m long will be divided into six 8.7 m sections rather than one 2 m and five 10 m sections. This eliminates offset analysis on smaller, tail end segments and is a more efficient method of processing.

The resulting theme is then joined to the Stream Order drainage theme and summarized by stream order to output the stream order lengths with greater than a 30 m vegetated buffer. Stream segments that are identified as having less than 30 m adjacent vegetation but are intersecting with vegetation are considered the most viable for restoration.

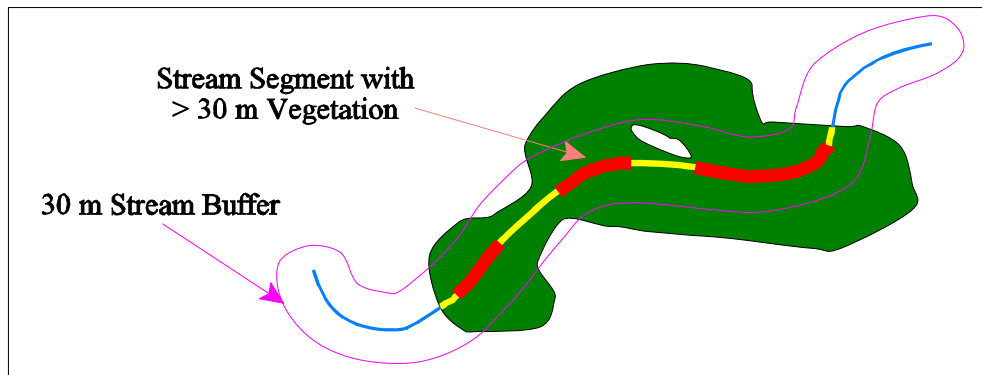


Figure 4: Demonstration of streams with more than 30 m vegetation buffer

Site Selection for Restoration

The Hog Creek Pilot Application relied upon the manual examination of 1:5000 scale photos to identify areas offering good stream rehabilitation potential on the main branch and its higher order tributaries (Gartner Lee Limited, 1997).

The Severn Sound RAP Habitat Analysis method provides information that can be readily applied to identify priority riparian habitat restoration sites. First to third order stream lengths most easily planted in order to establish a minimum 30m width of adjacent vegetation, on both sides of the stream, are assumed to be lengths that intersect forest patches but fall short of the 30m buffer target. These stream lengths can be intersected with the property assessment layer to provide a list of landowners who can be contacted by field personnel. This process has been automated using ArcView.

WETLAND HABITAT TARGETS

Wetlands include areas that are seasonally or permanently covered by shallow water or areas where the water table is close to or at the surface and have water-saturated soils and water-tolerant plants. They are transition zones between land and open water (OMNR, 1997). In order to assess current wetland habitat conditions, the percentage of wetlands in a watershed and the amount of vegetation adjacent to a wetland are measured.

Target Measurement

Percentage of Wetlands

The Hog Creek Pilot Application determined wetland areas within the watershed using air photographs. All areas approximately 1 ha and larger were delineated. Other areas were considered to be too small for measurements. The boundaries of the wetlands were delineated by air photo interpretation and areas were measured using a planimeter. The percentage of the watershed consisting of wetland was then determined. (Gartner Lee Limited, 1997)

The total area of wetland cover can be calculated by summing the area associated with each wetland polygon in the OBM wetland layer and dividing by the watershed area to provide the percentage of wetland for the watershed.

Amount of Vegetation Adjacent to Wetland

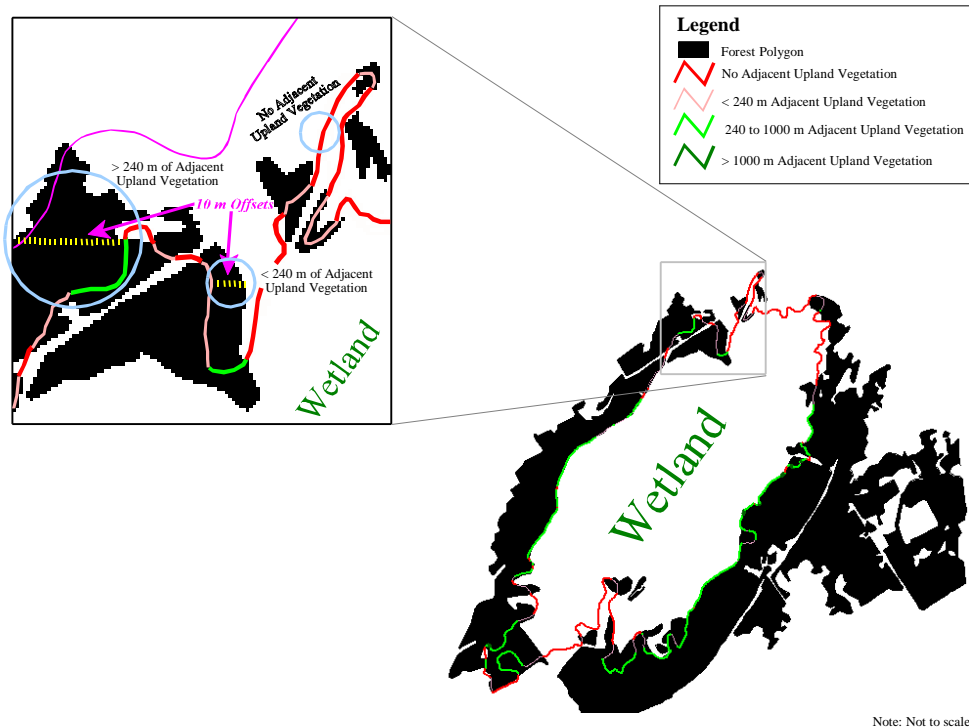
In the Hog Creek Pilot Application, the width of vegetation surrounding all wetlands was measured from air photos on which the boundaries of the wetlands were drawn. Width measurements adjacent to the wetlands consisted of a maximum, minimum and mean value. Manual measurements were collected for all wetlands since differentiation between wetlands and swamps was not possible using the air photos. (Gartner Lee Limited, 1997)

The SSRAP automated ArcView process measures the forest vegetation adjacent to wetlands.

Steps:

1. Divide wetland perimeters into 10 m segments.
2. Offset each 10 m segment incrementally away from the wetland.
3. Test the offset segments to determine if they are contained within a vegetation polygon. (If the offset is contained within the forest polygon, the increment increases, a larger offset is tested and the loop continues. If the tested offset segment is not contained by the vegetation polygon, the loop is terminated.)
4. After the loop is terminated, assign the last offset distance as an attribute of the original 10 m wetland perimeter segment.
5. Once all segments have been offset and tested, attribute to each wetland polygon the mean adjacent forest width derived from the wetlands perimeter (10 m segment) coverage.

The segment offset measurement method provides an estimate of the width of adjacent forest cover in relation to the perimeter of a target wetland.



Note: Not to scale

Figure 5: Example of wetland perimeter offset to determine width of adjacent forest habitat

Wetland Selection for Restoration

The Hog Cr. Pilot Application suggests that to prioritize wetlands for increased adjacent uplands, those wetlands with virtually no upland adjacent lands should be given highest priority, with those where larger or partial increases are required given the next level of priority. Adjacent lands beside provincially significant wetlands should also be given a high priority. (Gartner Lee Limited, 1997)

The SSRAP has developed an automated method of ranking wetland complexes and wetland areas to prioritize wetland restoration efforts. Wetlands are ranked by assessing the amount of adjacent vegetation, size and shape, land use occurring at the outer edge of the adjacent vegetation and provincial wetland class (or point system). Each wetland is analysed for the following:

Adjacent Vegetation Analysis (default calculations)

1. Average width of adjacent vegetation to *wetland area* perimeters that fall within each wetland complex boundary.
2. Minimum width of adjacent vegetation to *wetland area* perimeters that fall within each wetland complex boundary.
3. Maximum width of adjacent vegetation to *wetland area* perimeters that fall within each

- wetland complex boundary.
4. Standard Deviation of the width of adjacent vegetation to *wetland area* perimeters that fall within each wetland complex boundary (indicates the variation of adjacent vegetation width).
 5. Number of *wetland area* perimeter segments that have no adjacent vegetation that fall within each wetland complex boundary.
 6. Number of *wetland area* perimeter segments that have greater than a threshold (ie. 240 m) width of adjacent vegetation that fall within each wetland complex boundary.
 7. Average width of adjacent vegetation to *wetland complex* boundary.
 8. Minimum width of adjacent vegetation to *wetland complex* boundary.
 9. Maximum width of adjacent vegetation to *wetland complex* boundary.
 10. Standard Deviation of the width of adjacent vegetation to *wetland complex* boundary.
 11. Number of *wetland complex* boundary segments that have no adjacent vegetation.
 12. Number of *wetland complex* boundary segments that have greater than a threshold (ie. 240 m) adjacent vegetation.

Size Measurement (default calculations)

13. Measured area of *wetland areas* that fall within each wetland complex boundary.
14. Measured area of each *wetland complex*.
15. Percentage of *wetland complex* that is covered by wetland area (Item 13/ Item 14).

Shape Measurement - Fractal Dimension / Edge to Area Ratio (optional calculations)

16. Average fractal dimension of *wetland areas* that fall within each wetland complex.
17. Fractal dimension of each *wetland complex*.

Land Class / Use (optional calculations)

18. Percentage of *wetland area* segments of each land class that falls within each wetland complex. Segment land class is determined by offsetting each wetland area segment by its adjacent vegetation width and extracting the land class that occurs at the offset distance, in other words, the land class that is present at the outer edge of the adjacent forest to each wetland area segment.

Provincial Wetland Class / Significance / Points (optional calculations)

19. Provincial Wetland classification is attributed to wetlands that meet specific OMNR criteria. This information can be incorporated into the ranking process by setting higher priority to wetlands of higher significance. Provincial/Local significance or the evaluated points can be used in place of the wetland classification.

Ranking Process

To evaluate sites that are potentially suitable for restoration using the calculated wetland measurements, a scoring system was developed. Wetland complexes are ranked by totaling the score for each criterion. A default score is provided for the watershed by calculating the average for each criterion. For example, if the average vegetation width for *wetland area* perimeter segments that fall within a wetland complex is less than the average for the entire watershed (or a user specified value), the wetland will be identified as meeting the criteria and be given a higher priority for restoration within that watershed.

Assessing wetland complexes for restoration using Land Use information involves the use of weighted values. The potential for restoration is evaluated for each land use and the weight or rank is assigned. The higher the weight, the easier it is (in theory) to restore the particular land use. For example, vacant lands may be considered easier to restore than residential (occupied) lands.

Provincial wetland class information can be used to rank wetlands in the watershed. The more significant the wetland, the higher priority it has for restoration.

Each component, i.e. the amount of adjacent vegetation, size and shape, land use occurring at the outer edge of the adjacent vegetation, provincial wetland class can be weighted to reflect its significance. All components can be weighted equally or more priority can be given to some of the components. The ranking method is a flexible process that allows users to provide analysis weights and thresholds to reflect their own data interpretation and priorities.

Once the ranking process is complete, the site with the highest suitability value will have the highest priority for restoration. For example, if all components are weighted equally, a large class one (provincially significant) wetland with a highly convoluted boundary and no adjacent vegetation surrounded by vacant lands would have a higher priority for habitat restoration than a smaller, unclassified wetland with no adjacent vegetation, a convoluted boundary and a similar land use. A circular, unclassified wetland surrounded by over 240 m adjacent vegetation and residential land will be ranked low priority. Conversely, a large, provincially significant wetland with a convoluted boundary, very little adjacent vegetation, located on vacant land (easily planted) will be given a high priority.

SECTION 2

APPLYING THE AUTOMATED HABITAT ANALYSIS METHOD

In order to maintain a consistent procedure each time the habitat targets are analysed, it is necessary to document a detailed, step by step methodology. The Severn Sound Habitat Restoration Strategy Method should provide the user with the information needed to run the numerous tools, buttons and menu items.

GENERAL ASSUMPTIONS

Several assumptions have been made involving the user, the computer and the digital data required. The assumptions are as follows:

- ArcView 3.1 can be accessed at a dedicated workstation.
- C The user has advanced knowledge of Arcview 3.1, including queries, theme on theme selection, theme editing and feature table summarizing.
- C Seamless digital coverages (i.e. merged OBM tiles) are available for the entire watershed.
- C Digital watershed boundaries are available or have been interpolated and digitized.
- C The computer has enough processing power and memory depending on the size of the data sets involved (i.e. area of watershed, complexity of drainage system, amount of forest fragmentation) to handle the iterative processes used in the extension.


If any of these criteria can not be met, it may be difficult or time consuming to complete the habitat target measurement method in its entirety.

HABITAT ANALYSIS EXTENSION

To install the Habitat Analysis extension, copy the Habitat.avx file to the *ext32* directory in the ESRI directory for ArcView. Accessing the habitat analysis GUI, requires the loading of the Habitat Analysis extension through the extensions dialog.

Steps:

1. Create a new project.
2. In the Project Window menu *File/Extensions...* select the *Habitat Analysis* check box.

The habitat analysis GUI will load. The habitat analysis buttons, tools and menu items will be added. To help organize the numerous themes used in the analysis process, the user can add the following nine habitat analysis views to the project by clicking the *Add Habitat Analysis Views* button  :

1. Data Preparation
- 2a. Forest Habitat - Clipped Interior Forest

- 2b. Forest Habitat - Interior Forest
- 2c. Forest Habitat - Planting Suitability
- 3a. Riparian Habitat - Offset Data Preparation
- 3b. Riparian Habitat - 30 m Adjacent Vegetation
- 3c. Riparian Habitat - 30 m Vegetation Summary
- 4a. Wetland Habitat - Data Preparation
- 4b. Wetland Habitat - Adjacent Vegetation Analysis
- 4c. Wetland Habitat - Restoration Site Selection

The views added should have a *Geographic* projection and map units should be set to metres.

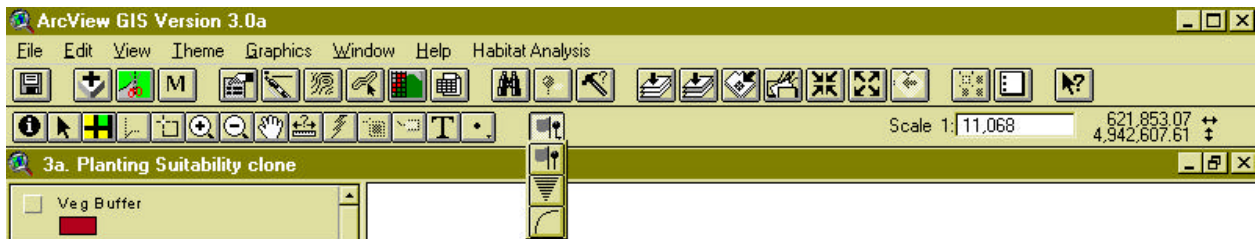


Figure 6: Habitat Analysis tools, menu items and buttons added to the standard ArcView GUI©

BASE DATA PREPARATION

A number of steps must be completed in order to ensure ArcView is handling the data properly. The following layers are required for completing all steps of the habitat analysis process:

Table 2: Coverages required for application of the habitat analysis method


Coverage	Theme Name	Source (used in Severn Sound)	Feature Class	Comments
Watershed Boundary	<i>Watershed Boundary</i>	SSRAP Imp. Office	Polygon	Interpolated from OBM <i>Contour</i> coverage
Vegetation	<i>Vegetation</i>	OBM (OMNR)	Polygon	Use vegetation polygons that intersect the target watershed
Transportation Network	<i>Road Network</i>	OBM(OMNR)	Line	Queried from OBM <i>Tranpor</i> coverage. MNRCODE 28, 42, 83, 106, 107
Miscellaneous Transportation	<i>Misc. Transport</i>	OBM (OMNR)	Line	Queried from OBM <i>Tranpor</i> coverage. MNRCODE 1, 4, 6, 7, 93, 185, 191
Rail Network	<i>Railway (Abandoned)</i>	OBM (OMNR)	Line	Queried from OBM <i>Tranpor</i> coverage. MNRCODE 26, 36, 94, 96
Lake	<i>Lake</i>	OBM (OMNR)	Polygon	Queried from OBM <i>Drainage(Polygon)</i> coverage. MNRCODE 62, 64, 152, 127

Wetland	<i>Wetland</i>	OBM (OMNR)	Polygon	Queried from OBM <i>Drainage(Polygon)</i> coverage. MNR CODE 57, 76, 77, 101, 102
River/ Stream	<i>Drainage Network</i>	OBM (OMNR)	Line	Use river system from target watershed
Building	<i>Buildings</i>	OBM (OMNR)	Polygon	
Optional Coverages				
Land Class (Use)	<i>Land Use</i>	Assessment (MOF)	Polygon	Land use classified using property code provides a generalized land classification
Classified Wetlands	<i>Wetland Complex</i>	OMNR	Polygon	

Add Themes:

The themes listed in Table 2 are required and should be added to the project.

Steps:

1. Add the appropriate themes to the “1. Data Preparation” view using the “Add Theme” button.  ©
2. To ensure consistency, name the themes with the proper “Theme Name” (refer to Table 2) using the *Theme/ Properties* dialog. Note that the Avenue scripts in the analysis process use the “Theme Name” as an identifier when looking for a specific layer and is case sensitive.

Clip Themes to Watershed:



To increase processing speed it is recommended that all digital coverages, except the 1 ha Grid layers, be clipped to within the confines of the subwatershed.

Steps:

Tip: open the “2c. Forest Habitat - Planting Suitability” and “1. Data Preparation” views and tile the windows.

Tip: create a watershed directory that will house all output from the analysis process.


Steps:

1. In the “1. Data Preparation” view set *watershed* to visible.
2. If more than one *watershed* is in the theme then query for the target watershed using the *Theme/ Properties/query* dialog. (*Description* = “Target Watershed”) or create a separate watershed shapefile using *Theme/Convert to Shapefile*.
3. Make sure the watershed is selected using the *Select Feature* tool.  ©
4. Clip the *Road Network* theme to the watershed using the *Clip Theme* Button  and add the new theme to the “2c. Forest Habitat - Planting Suitability” view (the *Road Network* is the intersect theme and the watershed boundary is the clipping theme).
5. Save the resulting shapefile to the appropriate directory.
6. Continue the previous steps for all themes except the 1 ha Grid layers.

Create 1 Ha vector Grid for Planting Suitability:

In order to apply the selection criterion using the *Planting Suitability* button, a 1 Ha vector grid must be created.

Steps:

1. Using the “*1 ha Vector Grid Tool*”, delineate a rectangle ensuring the entire watershed falls within defined extents. 
2. Use the *Theme/Select By Theme...* menu item to select the grid cells that have centres within the watershed boundary.
3. Convert the selected cells to a new shapefile using *Theme/Convert To Shapefile*.
4. Add the new watershed grid to the “*2c. Forest Habitat - Planting Suitability*” view.

Note: It is more effective to create a vector grid for an entire watershed and subdivide it into subwatersheds using *Select By Theme* than it is to create individual grids for each individual subwatershed. Creating a vector grid for the entire watershed will ensure a seamless coverage when displaying the subwatershed themes together.

Vegetation Layer Overlapping Watershed Boundary:

To create interior forest habitat layers a vegetation coverage is required maintaining vegetation features that overlap the watershed boundaries.

Steps:

1. With the *vegetation* theme active, use the *Theme/Select By Theme...* menu item to select the vegetation polygons that intersect the watershed boundary.
2. Convert the selected vegetation features to a new shapefile using *Theme/Convert To Shapefile*.
3. Add the new vegetation theme to the “*2b. Forest Habitat - Interior Forest*” view.

FOREST HABITAT ANALYSIS


The forest habitat conditions measured using the Habitat Analysis GUI are the percentage of watershed that is covered by forest, the size of the largest forest patch and the percentage of watershed that is covered by 100 m and 200 m interior forest.

Target Measurement

Percentage of Forest Cover

Calculating the percentage of watershed that is covered by forest is achieved by dividing the total area of forest (clipped to the watershed boundary) by the total area of watershed.




Steps:

1. Add the clipped vegetation and the watershed boundary themes to the “2a. Forest Habitat - Clipped Interior Forest” view.
2. Using *Theme/Properties/Query* dialog, query out vegetation polygons that have an *mnr*code of 0 to remove open spaces within vegetation polygons ([*mnr*code]<>0).
3. Make both themes active and click on the *Open Theme Table* button.  ©
4. In the clipped vegetation table, unselect all records and click on the heading for the “Area” field making it active.
5. Recalculate polygon areas using the *Field/Calculate* dialog ([*Area*] = [*Shape*].*returnArea*).
6. Click the *Statistics* menu item to show information on the active field (Area).
7. Copy and paste the total area from the statistics display into the appropriate cell in the Habitat Targets spreadsheet. (See Appendix 2 (2))
8. Follow the same procedure for the watershed boundary theme.

Size of Largest Forest Patch

Identifying the largest forest patch will provide the required area for comparison with the forest habitat targets.

Steps:



1. Using the “2a. Forest Habitat - Clipped Interior Forest” view make the clipped vegetation theme active and click on the *Open Theme Table* button.  ©
2. Use the *Window/Tile* menu item to make the view and table documents both visible.
3. In the table document, unselect all records and click on the heading for the “Area” field making it active.  ©
4. Clicking on the *Sort Descending* button will order the records from largest to smallest polygon areas.
5. Using the *Select* tool, select the largest area polygon to locate the polygon in the view document.  ©

6. With the largest area selected, click the *Statistics* menu item to show information on the area field.
7. Copy and paste the largest area into the appropriate cell in the Habitat Targets spreadsheet (See Appendix 2 (3)).

Forest Area 100 m and 200 m From Edge (Interior Forest)

Determining the percentage of interior forest covering a watershed is accomplished by creating two new coverages (100 m and 200 m interior forest) from the existing overlapping vegetation layer. The percentage of interior forest cover can be calculated by dividing the total area of the target interior forest (ie. 100 m or 200 m interior forest layer) by the total area of watershed.

Steps:

1. In the “2b. Forest Habitat - Interior Forest” view, with the overlapping vegetation layer active, use the *Theme/Properties/Query* dialog to query out vegetation polygons that have an *mnr*code of 0.
2. Name the overlapping vegetation theme “Veg Buffer” using the *Theme/Properties* dialog (this will enable the *Negative 100 and 200 m Buffer* button).
3. Make sure there are no graphics in the view.
4. Click on the *Negative 100 and 200 m Buffer* button to generate the interior forest shapefiles.  ©
5. Save the shapefiles to the appropriate directory.
6. Make both new themes active and click on the *Open Theme Table* button.  ©
7. In the 100 m interior forest table, unselect all records and click on the heading for the “Area” field making it active.
8. Recalculate polygon areas using the *Field/Calculate* dialog ($[Area] = [Shape].returnArea$).
9. Click the *Statistics* menu item to show information on the active field.
10. Copy and paste the total area into the appropriate cell in the Habitat Targets spreadsheet(See Appendix 2 (1)).
11. Follow the same procedure for the 200 m interior forest theme’s attributes table.

The percentage of interior forest covering the watershed will be calculated automatically once the values are pasted into the spreadsheet.

Selection of Suitable Planting Sites

Once the forest habitat conditions are assessed, they may be compared to the EC Habitat Framework Targets. If any of the forest habitat targets are not met, the user may want to apply the site selection process. The selection process will provide the approximate location of sites suitable for restoration to maximize the amount of interior forest bird habitat.

Steps:

1. Copy the 100 and 200 m buffer themes created in the “2b. *Forest Habitat - Interior Forest*” view to the “2c. *Forest Habitat - Planting Suitability*” view and name them “100 m Buffer” and “200 m Buffer” respectively.
2. Select the additional criterion from the drop-down list to include in the analysis.

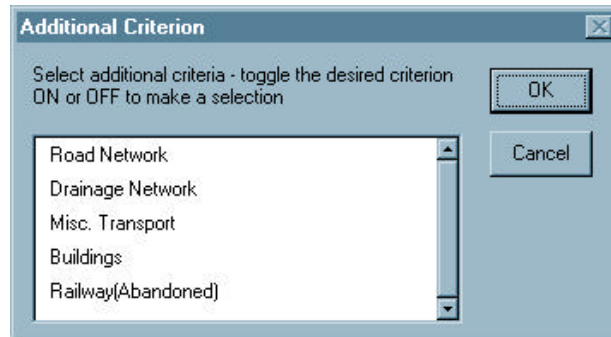


Figure 7: Additional criteria included in the site selection process

3. Make sure the 12 required theme names are correct (See Table 2). If they are incorrect, a text box will appear showing the proper theme names, when the *Planting Suitability* button is activated.
4. Once the theme names are correct, activate the *Planting Suitability* button.
5. The user will be prompted for a fractal dimension threshold value between the minimum and maximum of the > 50 ha forest polygons.
NOTE: At this point, the computer will process the selection criteria which may take a while depending on the size of the data sets.
6. Once complete, classify the legend to show the variation in *SuitCode*.
7. Summarize the grid by *SuitCode* to generate new theme of suitable areas.

NOTE: With larger datasets (watershed, number of grid cells) more processing time is required.

The suitability grid may require further analysis as some grouped cells will become stranded when transportation and other negative criteria are applied. This anomaly can be corrected by activating the *Habitat Analysis/ Grid Count* menu item. The grid count thins suitable grid cells by counting the number of suitable adjacent grid cells. If there are no suitable adjacent grid cells or a low number of mid range suitable grid cells, then the priority value of the original cell is reduced.

A summary theme should be generated and a comparison made between the original and thinned summary themes. By summarizing the grid themes, the size of the shapefile size can be reduced by approximately 95 % which is ideal for producing a “snap shot” of the grids *SuitCode* and storing it for future reference.

RIPARIAN FOREST HABITAT ANALYSIS

The riparian habitat conditions that are measured using the Habitat Analysis GUI are the percentage of first to third order streams with vegetation and percentage of first to third order streams with more than 30 m of vegetation.

Data Preparation Specific to Riparian Analysis

Before any data processing can occur, the digital vegetation layer must be assessed and stream order must be manually classified.

Vegetation Layer: A digital coverage showing forest and other types of riparian vegetation (ie. scrub) is currently unavailable for the Severn Sound AOC. Riparian habitat measurement methods can be effectively applied by updating existing digital vegetation (forest cover) data with information gathered by field personnel and remote sensing.


Stream Order Layer: Stream order is a numbering system that classifies stream segment (branch) to develop a relationship between order number and the number and length of stream segments in the watershed (Strahler, 1964). First to third order streams are considered the upper reaches of a watershed. The classification of streams that flow through lakes or wetlands can be complicated; therefore, arbitrary stream segments are added to help keep track of the stream order within the lake or wetland. A stream order update tool is used to assist in the manual classification of stream segments.





Target Measurement

Percentage of First to Third Order Streams with Adjacent Forest

Measuring the length of stream that is naturally vegetated is achieved by intersecting the drainage system with the vegetation layer. A manually classified stream order drainage theme is required in order to locate the upper reaches. The resulting coverage shows only stream segments that are within forest.

Steps:

1. Load the Drainage Network and Vegetation layer into the “3a. Riparian Habitat - Offset Data Preparation” view document (depending on the available drainage coverage, manual segment classification may be needed).
2. To facilitate the stream ordering process, add arbitrary stream segments through wetlands and lakes by using ArcView’s interactive snapping feature.
3. **Updating Definition:** to define the segments (no MNRCODE available), use the *Drainage Segment Update* tool by delineating a polygon around similar segments.  ©
4. A drop down list will provide a selection of generic definitions.


5. After the first definition is added, load the drain.avl legend to show stream definitions and “No Data”.
6. Continue describing the segments until all segments are updated.
7. **Updating Stream Order:** use the *Theme/Properties/Query* dialog to query drainage segments to show only segment described as stream and stream_A (arbitrary).  ©
8. To apply stream order using the *Stream Order Update* tool, first zoom to the upper portion of the watershed and chose a starting (first order) branch that has no tributaries.
9. Delineate a polygon around the starting branch.
10. After the first stream order is updated, load the drainord.avl legend to classify the stream orders and “No Data”.
11. Continue updating the segments until a junction is reached. If the converging segment is an equal stream order then the following segment will increase by 1.
12. Continue until all segments are ordered.
NOTE: If a segment continues through the juncture with another segment, the segment will have to be split using the interactive snapping feature. This may be caused by adding the arbitrary segments;
13. Using the *Copy to Clipboard* button, paste the summarized length from ArcView to a spreadsheet in the appropriate columns  © (See Appendix 2 (4)).
14. Query the clipped drainage theme for segment definition that equal “stream” to remove arbitrary segments.
15. Summarize the table by stream order again to determine length of stream that flows through vegetation without the arbitrary segments and paste the table to the spreadsheet (See Appendix 2 (7)).
16. **Clipping with Vegetation:** once the drainage theme is ready for processing, load it and the vegetation theme into the “3b. Riparian Habitat - 30 m Adjacent Vegetation” theme;
17. Select all features in the vegetation theme.
18. Click on the *Clip* button.  Two drop down lists will appear (the Drainage theme is the intersecting theme and the Vegetation theme is the Clipping theme).
19. In the attributes table for the clipped theme, calculate the length of all segments using *Field/Calculate* dialog.
20. Summarize both the original and clipped theme by stream order ensuring the length sums are included.
21. Using the *Copy to Clipboard* button, paste the summarized length from ArcView to a spreadsheet in the appropriate columns  ©(See Appendix 2 (5)).
22. Query the clipped drainage theme for segment definition that equal “stream” to remove arbitrary segments.
23. Summarize the table by stream order again to determine length of stream that flows through vegetation without the arbitrary segments and paste the table to the spreadsheet (See Appendix 2 (8)).

The percentage of first to third order streams with vegetation will be calculated automatically once the values are pasted into the spreadsheet.

Percentage of First to Third Order Streams with More Than 30 m of Vegetation

Calculating the percentage of streams with greater than 30 m buffer is accomplished by offsetting the 10 m segments to determine if they are contained within vegetation greater than 30 m from the origin.

Steps:

1. Add the clipped drainage theme and the vegetation theme to the *3b. Riparian Habitat - 30m Adjacent Vegetation* view.
2. Name the clipped drainage theme “Drainage” and the vegetation theme “Vegetation”.
3. Activate the *Habitat Analysis/ 30m Offset Drainage Segment* menu item. Two themes will be created (the 10 m Segment theme and the 30 m Offset theme) which will need to be named appropriately. This process is dependant upon the size of the data sets and may take a while.
4. Once complete, delete the *10 m Segment theme*.
5. Using the shape field as the common field, join the *30m Offset* theme with the *Clipped Drainage* theme.
6. Copy the values from the Stream Order field to the ID Field.
7. Add a “definition” field to the *30m Offset* attributes table and populate it with values from the definition field of the Clipped Drainage theme.
8. Remove all joins.
9. Add and populate a length field to the *30m Offset* attributes table.
10. Summarize the *30m Offset* theme by Stream Order ensuring the length sum is included.
11. Using the *Copy to Clipboard* button, paste the summarized length from ArcView to a spreadsheet in the appropriate columns  (See Appendix 2 (6)).
12. Query the *30m Offset* theme for segment definition that equal “stream” to remove arbitrary segments.
13. Summarize the table by stream order again to determine length of stream that flows through vegetation without the arbitrary segments and paste the table to the spreadsheet (See Appendix 2 (9)).

The percentage of first to third order streams with a vegetation buffer greater than 30m wide will be calculated automatically once the values are pasted into the spreadsheet.

Restoration Site Selection

Once the forest habitat adjacent to first to third order streams measurement process is complete, the user may require a prioritized list of sites that identify stream segments with adjacent forest but fall short of the 30 m target. Using the *Extract Parcels By Targeted Stream Segments* menu item allows the user to generate a layer of properties that contain streams intersecting with but have less than 30 m of adjacent forest.

Steps:

1. Add the “*Intersects but < 30M of Veg*” and the “*Parcels*” themes to the “*3c. Riparian Habitat - 30 m Vegetation Summary*” view.
2. Ensure the required themes are named “*Intersects but < 30M of Veg*” and “*Parcels*”.
3. Activate the “*Extract Parcels By Targeted Stream Segments*” menu item in the “*Habitat Analysis*” menu.
4. Provide a unique identifier field from the *Parcels* layer (ie. Property Number) in the list box.
5. Enter the number of ranked parcels are to be included in the output coverage into a message box.
6. Save the output coverage when prompted to the desired directory and filename.
7. Add the shapefile to the view.

The output coverage will be named “*Top ## Parcels*” in the views table of contents. The coverage will consist of the parcel polygons that have the highest overall length of stream segments that intersect with but have less than 30 m of adjacent forest.

WETLAND HABITAT ANALYSIS

The wetland habitat conditions that are measured using the Habitat Analysis GUI are the percentage of wetlands within the watershed and the amount of vegetation adjacent to wetlands.

Data Preparation Specific to Wetland Analysis

Prior to any analysis of wetland data, a digital wetland coverage must be assessed. The wetland coverages available at the time the extension was developed are the OBM wetlands (drainage system) layer and the Ontario Wetland Evaluation System (OMNR) layer. Both systems approach wetland boundaries differently. The OBM method is based on photo interpretation and wetland areas were interpreted as obvious wet areas exclusive of lakes or rivers. The Ontario Wetland Evaluation System layer was digitized from wetland evaluation mapping and shows the wetland or complex boundary with > 50% Wetland Vegetation plus a 120 m adjacent buffer. For the automated target measurement process, the wetland boundaries to consider are land areas which are permanently wet but are not covered by open water (OMNR, 1993) and the areas of open water that are contained within the boundaries. A wetland complex cannot be measured adequately as it may include portions of adjacent forest within the boundary. A digital layer may have to be edited to join wetland polygon features that are subdivided by the drainage system. Use the “*4a. Wetland Habitat - Data Preparation*” view to carry out any editing that may be required. Note that for the purpose of the wetland analysis, the OBM wetland layer was used.

To identify potential wetland sites for restoration, analysis must be carried out on a wetland layer which includes both wetland complexes and unclassified wetland areas. This layer will also house the resulting data from the analysis. In order not to leave out wetland areas that are unclassified, both the evaluated wetland (complex) layer and the OBM Wetland Area layer must be combined. It is more suitable to use wetland areas that are derived from the Ontario Wetland Evaluation System than the OBM wetland area because the evaluated wetland area boundaries coincide with the evaluated wetland complex boundaries. If an Evaluation System Wetland Area layer is available, substituting the OBM wetland area coverage with this layer is recommended or should at least be used in conjunction with the OBM wetland layer.

Target Measurement

Percentage of Watershed Covered by Wetland

Calculating the percentage of watershed that is covered by wetland is achieved by dividing the total area of wetland inside the watershed boundary, by the total area of watershed.

Steps:

1. Add the joined wetlands and the watershed boundary themes to the “*4a. Wetland Habitat - Data Preparation*” view.
2. Make both themes active and click on the *Open Theme Table* button.


3. In the joined wetlands table, unselect all records and click on the heading for the “Area” field making it active.
4. Recalculate polygon areas using the *Field/Calculate* dialog ($[Area] = [Shape].returnArea$).
5. Click the *Statistics* menu item to show information on the active field.
6. Copy and paste the total area into the appropriate cell in the Habitat Targets spreadsheet.
7. Follow the same procedure for the watershed boundary theme if the area is not already in the spreadsheet (See Appendix 2 (10)).

The percentage of wetlands covering the watershed will be calculated automatically once the values are pasted into the spreadsheet.

Amount of Vegetation Adjacent to Wetlands

Calculating the amount of vegetation adjacent to wetlands is accomplished by incrementally offsetting the 10 m segments away from the wetland perimeter and determining the maximum distance they are contained within the vegetation polygon.

Steps:

1. In the “4b. Wetland Habitat - Adjacent Vegetation Analysis” view, name the joined wetland theme “Wetland” and the vegetation theme “Vegetation”.
2. Activate the *Habitat Analysis/ Forest Habitat for Wetlands* menu item.
3. One theme (the 10 m wetland perimeter theme) will be created which will need to be saved under an appropriate name. Processing time is dependant upon the size and number of wetlands.
4. Once the offset process is complete, open the attributes table of the *wetland perimeter* theme and summarize it based on the wetland ID field (include the average, minimum and maximum width of vegetation in the summary theme).
5. Open the attributes tables for the *summarized wetland perimeter* and *wetland polygon* themes.
6. Using the ID field as the common field, join both themes ensuring that the *wetland boundary* table window is active.
7. Copy the values from the *summarized wetland perimeter’s* average length, minimum and maximum fields to new, corresponding fields in the *wetland boundaries* attributes table.
8. Remove all joins from the *wetland boundaries* table.
9. Using the *Copy to Clipboard* button  ©, paste the average, maximum and minimum adjacent vegetation widths for each wetland from ArcView to the appropriate columns in the habitat targets spreadsheet (See Appendix 2 (11)).

The average, maximum and minimum amount of vegetation adjacent to wetlands for the watershed will be calculated automatically once the values are pasted into the spreadsheet. Additional interpretation of wetlands that are adjacent to lakes may be necessary as segments

along lakes will show up as no adjacent forest cover. To fix this misrepresentation, segments that intersect lakes can be deleted from the Wetland perimeter theme leaving them out of the summary process entirely.

Wetland Selection for Restoration

Upon completion of the wetland target measurement, the user may want to identify suitable wetlands for remediation. A wetland site selection procedure has been included in the extension as a menu item. Once activated, the user will be prompted for input such as theme names, field names, cutoff and weight values and simple yes/no answers. The information provided by the user will be used in the analysis of a combined Wetland Complex (OMNR Classified Wetlands) / Wetland Area layer through numerous selection criteria and calculations. If a wetland complex is made up of several polygons (ie. subdivided by a road) then each individual polygon is analyzed separately. The analysis consists of four components: amount of adjacent vegetation to wetland complexes and areas; size and shape measurements of complexes and areas; land use occurring at the outer edge of the adjacent vegetation to wetland areas; provincial wetland classification. Once ArcView has completed processing, a result for each wetland complex or area will indicate the final suitability value. The higher the suitability value, the more the wetland reflects the selected criteria. The user is able to manipulate the results by attributing more weight (significance) to one or more components by inputting a weight value for each.

In order to begin the wetland selection site analysis using the *Wetland Complex Suitability Analysis* menu item, the view must have at least five themes with the correct theme names. ArcView will ask for the proper theme that corresponds to a theme name if it can't find any of the required themes.

Steps:

1. Load the Vegetation, Clipped Wetland Complex, Wetland Area, Wetland Area and Complex, Adjacent Vegetation Width to Wetland Areas (refer to Amount of Vegetation Adjacent to Wetlands portion above) layers using the Add Themes button into the View “4c. Wetland Habitat - Restoration Site Selection”.
2. Using the Theme Properties dialog name each theme appropriately:

Table 3: Required themes for Wetland Site Selection Process

Theme Name (Required)	Description	Shape Class
<i>Vegetation</i>	Vegetation layer	Polygon
<i>Wetland Complex (for Offset)</i>	Clipped Wetland Complex layer to watershed boundary	Polygon
<i>Wetland Area</i>	Clipped Wetland Area layer to watershed boundary	Polygon

<i>Wetland Complex</i>	Merged and unioned wetland complex and wetland area layer	Polygon
<i>Adjacent Veg width (Wetland area)</i>	Resulting adjacent vegetation layer from offset wetland area	Polyline

3. Activate the *Wetland Site Selection* Menu Item to begin the Wetland Complex selection process
4. **Fractal Dimension** - Respond to the message box asking whether Fractal Dimension should be included as a criteria. “YES” - Fractal Dimension calculations proceed on both Wetland Area and Complex layers. “NO” - Fractal Dimension is not included. “CANCEL” - exits Wetland selection Analysis.
5. **Land Use** - Provide an answer to a message box asking whether to include land use in the analysis. “YES” - Land Use will be included in the analysis. This involves the offsetting of each adjacent vegetation width segment by its adjacent vegetation width (distance) to determine what type of land use occur. A land use coverage and field will be asked for later. “NO” - Land use will not be used as part of the analysis. “CANCEL” - exits Wetland selection Analysis.
6. **Wetland Class** - Answer the message box asking whether to include complex class (OMNR). “YES” - Wetland class will be included. Ranking will depend on the number of different classes of wetland present within the watershed. For example, If there are three classes, class 1, class 3 and no class, the ranked value would be 2,1, and 0 respectively. The ranked value will then be weighted and the weighted value will be added to the overall suitability score.

To use Provincial and Local significance or the points assigned to each wetland through the evaluation process, some data preparation is required.

- Press Cancel in the Wetland Class message box.
- Start editing the Wetland Complex/Area layer attribute table.
- Add a new number field to the table.

Provincial/Local Significance:

- Query the Wetland Significance field for the Provincially Significant Wetland records and populate the new field with the number “1”.
- Query the Wetland Significance field for the Locally Significant Wetland records and populate the new field with the number “2”.
- Stop editing the table and restart the site selection process.

Wetland significance will be analyzed using the same method as the previous example. Provincially significant (assigned 1), Locally significant (assigned 2) and unclassified (remain at 0) wetlands will be ranked 2, 1 and 0 respectively.

Wetland Evaluation Points:

- Query the Evaluation Point field for wetland record values ≤ 0 and $\leq \text{nil}$.
- Select the Evaluation Point field and use the “Field/Statistics” menu item to determine the maximum number of points for the layer.
- Calculate the inverted point value for the selected records using “(Maximum Value + 1 - [the Evaluation Point Field])
- Restart the site selection process

There may be a range of evaluation points for all wetlands in a watershed. The site selection method was developed for ranking by evaluated wetland class where class 1 is the highest and class 8 is the lowest significance. The point system is opposite where the higher the point score, the higher the significance. The above method will invert the evaluation score in order to rank the wetlands as the lower the point score the higher the significance.

Alternative methods for showing wetland significance have been provided to accommodate the use of available wetland information. As time progresses, the available data may only include the two tier (provincially/locally significant) system.

Note: It is important that unclassified wetlands be kept at zero in all three methods.

”NO” -Wetland Class will not be considered as part of the analysis. “CANCEL” -exits Wetland Selection Analysis.

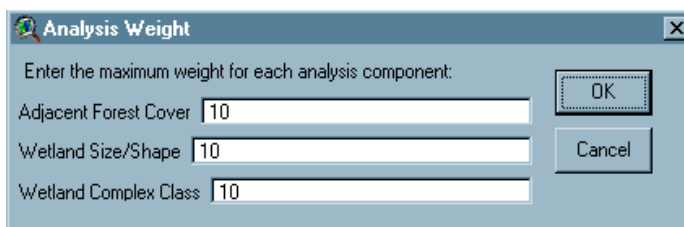


Figure 8: Component Weight input box

7. **Component Weight** - Assign a weight value in the multiple input box for each analysis component (Land Use is assigned later). The default weight value is an equal weight of ten. If one or more components are considered more important than others, the weight can be changed to reflect this difference. Keep in mind the higher the weight values, the higher the possible suitability score.

Note: If wetland class is not to be included, there will be no input for wetland complex in this message box

“OK” - Accepts weight values. “Cancel” - exits Wetland Selection Analysis.



Figure 9: Adjacent Forest Threshold input box

8. **Adjacent Forest Threshold** - Assign a threshold value for wetland complex and wetland area. An adjacent forest threshold is required in order to calculate the percentage of each wetland area and wetland complex adjacent vegetation segments that fall above the threshold. The percentage indicates the overall adjacent forest for the target polygon (wetland). The wetland area and complex are separate so that a different value can be assigned to each.

“OK” - Accepts weight values. “Cancel” - exits Wetland Selection Analysis

9. **Clip Wetland Complex Layer** - Indicate whether the Wetland Complex Layer requires clipping to the Watershed Boundary. “Yes” - ArcView proceed with the clipping process. A shapefile name will have to be provided in the save shapefile dialog. “No” - ArcView will use the Wetland Complex layer that has originally been defined.
10. **Offset Analysis of Wetland Complex Layer** - If ArcView can’t find the theme named “*Adjacent Veg Width (Complex)*”, indicate the shapefile name in the dialogue provided. Adjacent vegetation to each wetland complex will be measured using the offset analysis process.

Note: Offset analysis is an iterative process and may take time depending on the size of the data set

11. **Find Land Use Theme (if Step 5 is “YES”)** - Select the land use layer from the list of themes provided. This message box will not appear if the land use layer is already named Land Use. “OK” - submit the selected theme as land use. “Cancel” - exits Wetland Selection Analysis.
12. **Find Land Use field in Land Use theme (if Step 5 is “YES”)** - Select the land use field from the list of fields provided. If the land use field is named “LUSE” then this message box will not appear.

Note: The land use field must be a text field with less than 20 unique land use classifications and less than 10 characters per classification. If there are more than 10 characters, ArcView will use the first 10. The 10 character limit is used because each land

use will be added to the Wetland Complex layer attribute table as a field. ArcView does not support field names with more than 10 characters.

ArcView will then offset each wetland area segment by its adjacent vegetation width, determine the land use that intersects the offset segment and assign the land use value as an attribute of the segment.

- 13. Wetland Adjacent Forest, Size and Shape Selection Criteria** - Assign a cutoff value to each calculated criterion. The value is used to determine where each wetland complex / area falls for each criterion. The default value is the average out of all (not including null) wetland polygons in the watershed. Beside each label, the maximum value of all polygons in the watershed is given as a reference to indicate the highest value that can be used. Note where space is limited some maximum values may appear in scientific notation. An operator is required to indicate where the wetland complex value will fall in relation to the input value. The input should include the operator followed by a space followed by the threshold value. Enter “nil” if any criteria are to be ignored. “OK” - Accepts threshold values. “Cancel” - exits Wetland Selection Analysis.

Label	Maximum Value (M)	Threshold Value
WA Average Offset (m)	411	< 76
WA Minimum Offset (m)	45	< 5
WA Maximum Offset (m)	1645	< 373
% of WA Segments with no Adjacent Veg	100	> 50
% of WA of Segments with > 240 m Adjacent Veg	78	< 9
WC Average Offset (m)	141	< 60
WC Minimum Offset (m)	50	< 3
WC Maximum Offset (m)	1405	< 492
% of WC of Segments with no Adjacent Veg	100	> 58
% of WC of Segments with > 240 m Adjacent Veg	25	< 10
% of WA in WC	1.30843e+006	> 31924
WC Area (m ²)	1.51288e+006	> 75932
Mean WA Fractal Dimension/ Complex	1.51	> 1.36
WC Fractal Dimension	1.41	> 1.30

Figure 10: Wetland Adjacent Forest, Size and Shape Threshold input box

- 14. Find the Wetland Class Field (if Step 6 is “YES”)** - Select the wetland class field from the list of fields provided. If ArcView finds the default field named “WCLASS”, this step will be skipped.

15. **Land Use Priority (if Step 5 is “YES”)** - Assign a priority value to the land uses provided. To apply the same weight to the land use component as used for the other analysis components, the highest priority land use should be assigned an equal weight value and lower priority land uses lower weight values.

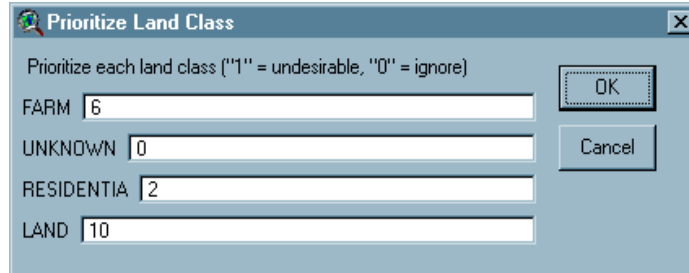


Figure 11: Land Use Priority message box

Example:

The Overall analysis component weight equals 10. There are four unique land uses consisting of VACANT, AGRICULTURAL, RESIDENTIAL and INDUSTRIAL in order of priority (ease of restoration / accessibility). To assign an equal weight to the land use as used in the other three components, the highest priority land use is 10. Therefore, VACANT land would be assigned a weight value of 10. The lowest priority value, INDUSTRIAL, is assigned a weight value of 1. AGRICULTURAL is assigned 6 and RESIDENTIAL is assigned 3. UNKNOWN data should be assigned 0 as it indicates offset segments that don't fall within the watershed boundary or don't intersect with a land use polygon.

The percentage of wetland area segments for each land use will be added to the appropriate land use field for each wetland complex. Based on the percentage, the land suitability value is calculated.

Table 4: Example Calculation to Prioritize Land Use at outer edge of adjacent forest for Wetland Areas

Land Use	Percent of wetland area segment in complex	Weight Value	Land Suitability Score
RESIDENTIAL	50	3	1.5
INDUSTRIAL	30	1	0.3
AGRICULTURAL	10	6	0.6
VACANT	10	10	1.0

Total	100	NA	3.4
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The highest attainable value equals 10 (100 percent VACANT). The score is then added to the overall wetland suitability score.

At this point, ArcView will process the information provided to rank wetland complexes by suitability for restoration.

The wetland suitability analysis process involves appending several new fields to the wetland complex and area attribute table.

Table 5: Fields added automatically to the Wetland Complex attributes table

Field Name	Analysis Component	Description	Type	Width	Dec
<i>Land Use *</i>	Land Use	Percent of land use occurring at the outer edge of the adjacent vegetation	Text	10	-
<i>WA_FD</i> Avg	size and shape	Average fractal dimension of <i>wetland areas</i> that fall within each wetland complex	Number	12	2
<i>WC_FD</i> Dim	size and shape	Calculated Fractal Dimension for each wetland complex/area	Number	12	2
<i>WA_AvgOff</i>	amount of adjacent vegetation	Average width of adjacent vegetation to <i>wetland area</i> perimeters that fall within each wetland complex boundary	Number	8	0
<i>WA_MinOff</i>	amount of adjacent vegetation	Minimum width of adjacent vegetation to <i>wetland area</i> perimeters that fall within each wetland complex boundary	Number	8	0
<i>WA_MaxOff</i>	amount of adjacent vegetation	Maximum width of adjacent vegetation to <i>wetland area</i> perimeters that fall within each wetland complex boundary	Number	8	0
<i>WA_SDOff</i>	amount of adjacent vegetation	Standard Deviation of the width of adjacent vegetation to <i>wetland complex</i> boundary	Number	8	0
<i>WA_ZCount</i>	amount of adjacent vegetation	Number of <i>wetland area</i> perimeter segments that have no adjacent vegetation that fall within each wetland complex boundary	Number	8	0
<i>WA_####</i>	amount of adjacent vegetation	Number of <i>wetland complex</i> boundary segments that have greater than a user defined threshold (####) adjacent vegetation	Number	8	0
<i>WC_AvgOff</i>	amount of adjacent vegetation	Average width of adjacent vegetation to <i>wetland complex</i> boundary	Number	8	0
<i>WC_MinOff</i>	amount of adjacent vegetation	Minimum width of adjacent vegetation to <i>wetland complex</i> boundary	Number	8	0

<i>WC_MaxOff</i>	amount of adjacent vegetation	Maximum width of adjacent vegetation to <i>wetland complex</i> boundary	Number	8	0
<i>WC_SDOff</i>	amount of adjacent vegetation	Standard Deviation of the width of adjacent vegetation to <i>wetland complex</i> boundary	Number	8	0
<i>WC_ZCount</i>	amount of adjacent vegetation	Percent of <i>wetland complex</i> boundary segments that have no adjacent vegetation	Number	8	0
<i>WC_####</i>	amount of adjacent vegetation	Percent of <i>wetland complex</i> boundary segments that exceed a user-defined threshold (####) of adjacent vegetation	Number	8	0
<i>WA_Area</i>	size and shape	Total area of wetland areas within each wetland complex	Number	8	0
<i>WC_Area</i>	size and shape	Area of wetland complex	Number	8	0
<i>WAWCP</i>	size and shape	Percent of wetland complex consisting of wetland area	Number	8	0
<i>LandSuit</i>	land use occurring at the outer edge of the adjacent vegetation	Calculated land use value based on percent of <i>wetland area</i> segments of each land class that falls within each wetland complex and user defined weight	Number	8	1
<i>Flag</i>	land use occurring at the outer edge of the adjacent vegetation	Signifies problem complex polygons that do not contain wetland area polygons. This may affect the interpretation of results.	Number	8	0
<i>WetSuit</i>	All	Calculated suitability value based on weighted criteria from land use, adjacent vegetation, wetland class and size and shape	Number	8	1

* Land Use fields are added based on the individual land use categories identified within the land use coverage.

The “WetSuit” value is calculated for each wetland complex/area using the weights and thresholds provided by the user. Results may be manipulated by changing the input information to reflect the user’s preferences. The wetland suitability value is interpreted by considering the number of analysis components and the maximum weight values used to calculate the value as well as the relationship between each wetlands value. For instance, if all components (land use, adjacent vegetation, wetland class and size and shape) are used and the maximum weight for each equals 10, the highest attainable suitability value would equal 40. The closer a wetland’s suitability value is to 40, the more criteria are met or suitable it is for restoration. If one component is left out of the process and the maximum weight for each component equals 10, then the highest calculated suitability value would equal 30.

SECTION 3

DISCUSSION

Analysing habitat conditions by means of an automated GIS requires understanding of issues such as the accuracy of the data and analysis methods, timeliness of the data and the relevance of habitat analysis output to the EC Framework.

DATA ACCURACY CONSIDERATIONS

In utilizing an automated method for analysis of habitat conditions and site suitability, the computer is relied upon to apply a set of predefined rules. The input layers analysed and the processes applied affect the accuracy of the output. Accuracy is the degree of likelihood that the information provided is correct (Aronoff, 1995).

The input layers are subject to data standards which are set by the producers of the digital data. The accuracy of input layers is influenced by data collection, input, storage and manipulation (Aronoff, 1995). For example, comparing a digital, 1:10,000 OBM wetland layer to a digital 1:50,000 National Topographic System wetland layer will result in differences such as polygon area and perimeter lengths due to the number of segments and vertices in each polygon. When analysis such as the segment offsetting to measure the width of adjacent vegetation is applied, these differences could produce varying output on the same wetland and vegetation features. An understanding of the input data accuracy is required to ensure proper interpretation of the resulting data. One other data source that may be considered for future analysis is the natural resources values information system.

By breaking line segments into subsections and offsetting these subsections to measure the width of adjacent features, a known error is introduced into this process. The offsetting method was used to provide an estimate of the width of adjacent polygon features and is not meant as an exact measurement technique. Accuracy could be increased by reducing the segment length (ie. from 10 m to 1 m) and offset distance (ie. increment from 5 m to 0.5 m); however, the processing speed may be greatly affected depending on the size of the data set. In applying the offsetting analysis method, the purpose and size of the study area will determine the desired accuracy for each individual case. The accuracy used for habitat analysis of Severn Sound at the subwatershed level is " 10 m for the stream length/ wetland perimeter and " 5 m for the buffer width of streams and wetlands. This accuracy is sufficient for the size of the watersheds.

Determining sites suitable for restoration by using a 1 ha vector grid is a method which provides the approximate location of sites and again is not intended to "pin-point" potential sites. Two considerations were made when determining cell size for the vector grid: cell resolution and processing speed. The site selection process depends on the area each individual cell covers (1 ha) in order to provide a range of potential sites. For example: a small, 100 m² cell sized grid

requires 100 times more cells to cover an equivalent area of a 10,000 m² (1 ha) cell sized grid.

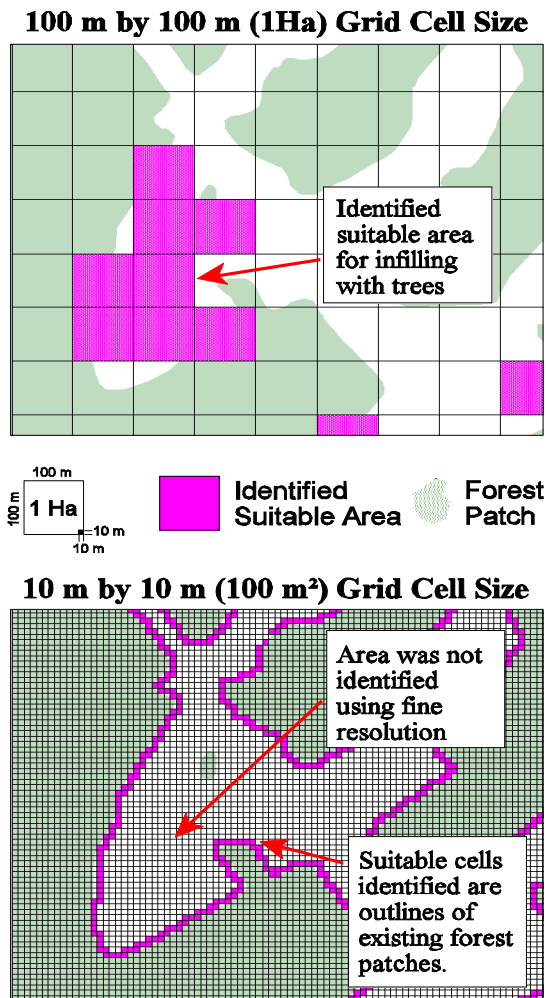


Figure 12 Comparison between 100 m² and 1 Ha vector grid resolutions used for site selection.

Suitable sites indicated by a 1 ha vector grid will show potential areas for restoration where a 100 m² vector grid will only show a rough outline of potential areas for restoration. Conversely, a vector grid with a large, 10 ha cell size will only identify large potential restoration areas and will not identify smaller suitable areas. Processing speed is affected by the number of cells in the vector grid. A small cell size (100 m²) will increase the amount of time it takes to complete the site selection process. A 1 ha vector grid is ideal for analysis of watershed areas of less than 100 km² which will consist of 10,000 vector grid cells (polygons). It is more efficient to subdivide large watersheds (> 100 km²) into subwatersheds.

DATA TIMELINESS

The timeliness of spatial data refers to how current the data is. For example, a land cover map describes the location of different classes of land cover as they existed at the time of data collection. As time progresses, changes in ground cover can render GIS layers out of date and unsuitable for decision making (Aaronoff, 1995). Habitat analysis of features such as vegetation or wetland areas relies upon timely data to assess current habitat condition within a watershed. For example, the OBM vegetation layer in use by the SSRAP is based upon 1982 air photos. The SSRAP will update the data used for analysing habitat conditions in the Severn Sound watershed by using more recent scanned aerial photographs and an Indian Remote Satellite scene to apply a method such as the Rapid Digitization of Woodland Polygons Using Landsat Imagery (OMNR, 1997). Along with remotely sensed data, ground truth and project data will also be used to assess the current land cover layers.

AUTOMATED ANALYSIS COMPARED TO THE PILOT STUDY OF HOG CREEK

The SSRAP's automated habitat analysis method is meant to be consistent with the EC Habitat Framework while at the same time providing a means of analysing habitat conditions using existing GIS technology. Habitat measurement methods used for assessing habitat conditions with the automated GIS are similar to the mixture of manual and CAD analysis methods used and evaluated by the Hog Creek Pilot Application. Analysis methods such as the segment offset (riparian and wetland habitat analysis) and vector grid require further evaluation to determine their adequacy in analysing spatial data in terms of wildlife habitat conditions. Table 3 compares the results of the Hog Creek Pilot Application with the output from the automated method analysing habitat conditions on the Hog Creek.

Table 6: Hog Creek Habitat Analysis

Forest TARGETS

<i>PARAMETER</i>	<i>TARGET</i>	<i>Pilot Application</i>	<i>Automated Method</i>
% Forest Cover	> 30%	28.9%	31.6%
Size of Largest Patch	> 100 ha	163	163.1
% Forest > 100 m from Edge	> 10%	10.1%	10.7%
% Forest > 200 m from Edge	> 6%	1.8%	1.8%

RIPARIAN TARGETS

<i>PARAMETER</i>	<i>TARGET</i>	<i>Pilot Application</i>	<i>Automated Method</i>
% of Natural Veg. Along First to Third Order Streams	75% of stream length should be naturally vegetated	49.7%	47.76%
	75% of stream length should have 30 m wide buffers ⁽¹⁾	48.5%	29.81%

WETLAND TARGETS

PARAMETER	TARGET	Pilot Application	Automated Method
% Wetlands in Watershed	10% of total watershed or to restore to the original extent of wetlands. ⁽²⁾	8.30%	2.52%
Amount of Vegetation Adjacent to Wetland	Wetlands should have 240 m of adjacent Forest habitat.	Mean Width (m)	89.86
		Min Width (m)	0.00
		Max. Width (m)	1645

⁽¹⁾ Note: The difference between the Pilot Application and Automated Method is partially attributed to the use of a complete range of vegetation types in the Pilot Application versus the use of the available OBM forest cover layer in the Automated Method.

⁽²⁾ Note: There is a difference between the Pilot Application and Automated Method results for all wetland analysis. The Pilot Application is based on aerial photo interpretation and involves measuring adjacent vegetation to wetland complex boundaries. The Automated Method is based on the OBM wetlands layer which was digitized from air photos and identifies the perimeters of predominantly wet areas.

The EC Habitat Framework will be applied over the entire Severn Sound watershed using the automated habitat analysis methods in order to continue evaluation of the methods and to demonstrate their effectiveness at estimating habitat conditions for RAP delisting purposes. Additional assessment of the wetland and riparian guidelines compared with other classifications is required for effective analysis of habitat conditions at the watershed level. The GIS methods developed provide a ready and repeatable means of measuring Habitat targets over extensive watersheds which would otherwise be time consuming. As more comprehensive layers become available (eg. wetlands classification and forest quality/other vegetation) the method could be adapted and targets revised.

CONCLUDING REMARKS

Using an automated approach to estimate habitat conditions at the watershed level will enable the SSRAP office and existing implementation programs to measure spatial relationships, compare changes over time and identify priority areas for restoration. The Habitat Analysis method may also benefit other agencies by providing insight into wildlife habitat at the watershed level for purposes such as planning and natural resource management. One component of delisting the Severn Sound from the list of AOCs involves confirming the remediation and sustainability of fish and wildlife habitat within the Severn Sound watershed. The Automated Habitat Analysis method is one tool that will aid the SSRAP in achieving the goals of making Severn Sound a healthy ecosystem in terms of fish and wildlife habitat.

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APPENDICES

APPENDIX 1

AUTOMATION OF HABITAT ANALYSIS

In order to simplify the transferring of ArcView 3.1 customization and Avenue scripts, an ArcView extension was created. This provides the user with access to the habitat analysis GUI. In ArcView, when the user clicks a button or selects a menu item, certain scripts attached to the selected item are activated. The Avenue scripts that are accessed by the interface include a series of SSRAP developed scripts, ESRI system scripts and modified system scripts. This section will describe the habitat analysis GUI and SSRAP scripts developed to support the GUI.

HABITAT ANALYSIS GUI

In order to apply the habitat analysis method, the user must interact with the GUI. To use the GUI, the Habitat Analysis Extension is loaded and several controls and objects are added to the view, project and table documents. A description of all Habitat Analysis GUI controls will be provided however, code detail will only be outlined for the SSRAP developed scripts. For simplicity, the detailed script description will not include error checking or user dialog.

View Document Controls

The view document handles most of the analysis processes to be applied by the user. When the habitat analysis extension is loaded into an ArcView project, several controls are added to the view document:

- three System buttons (*Clip Theme, Merge Theme and Graphic Buffer*);
- two habitat analysis buttons (*Negative Buffer and Planting Suitability*);
- one tool (*1 ha grid*);
- one tool list consisting of three update tools (*Forest Stand Update, Drainage Segment Update and Stream Order Update*);
- three habitat analysis menu items (*30 m Offset Drainage Segment, Forest Adjacent to Wetlands and Query, Suitability Grid*);
- one menu item (*Intersect Theme*).

“PSEUDO-CODE” FOR THE HABITAT ANALYSIS EXTENSION

BUTTONS



© Clip Themes (*ArcView sample script*)

Clips one theme by a selected polygon theme, returning a new shapefile with the clipped features and their attributes (ESRI,1997). Clipping a theme refers to the process of extracting data that reside entirely within the boundaries of features in another coverage (ESRI,1995). This button was included to assist in reducing theme size to only include features falling within a watershed boundary.



© Merge Themes (*ArcView sample script*)

This button merges the selected themes into a single theme. A new shapefile is created which combines the shapes and attributes of the active themes. The themes to be merged should have the same set of attributes (fields). Only the fields from the first active theme are preserved in the output theme (ESRI, 1997). This button can be useful if a large watershed has been subdivided and requires merging two or more sections together after analysis.



© Graphic Buffer (*ArcView sample script*)

This button places a graphic buffer around the selected feature of a theme (ESRI,1997) and is used to show certain habitat target buffer distances.



© Negative Buffer (*SSRAP, ArcView sample and system scripts*)

Once clicked, this button creates 100 m and 200 m negative buffer shapefiles from a polygon coverage. For the purpose of habitat analysis, the original coverage should be a vegetation coverage.

Steps:

1. Find the vegetation (named “veg buffer”) theme [*theView.findTheme*].
2. Get the selected features [*theFTab.getSelection*].
3. If no features are selected, select all features [*theFTab.getSelection.setAll*].
4. Delete all graphics before continuing [*av.run(“ View.CutGraphics, ”nil”)*].
5. Assign value of -.1 km to buffer distance variable.
6. While loop ensuring only two iterations.
7. For each selected feature run the *Habitat2.buffer-100* (similar to graphic buffer)script.
8. Select all graphics.
9. Cut the selected graphics [*av.run(“ View.CutGraphics, ”nil”)*].
10. Create a new polygon theme [*av.run(“ Habitat2.NewPolyTheme”, ”nil”)*].
11. Paste the clipboard contents to the new theme.
12. Add an area field to the attributes table and calculate the area of each feature.

13. Stop editing the new theme [*av.run("View.ToggleEditing", "nil")*].
14. Change the buffer distance variable to -.2 km.
15. Repeat steps 6 to 13 for one more iteration.

The *Habitat2.buffer-100* script is a modified ArcView sample script that uses -0.1 and -0.2 km as the buffer distances rather than using a user specified distance. The *View.NewPolyTheme* script is a modified system script that automatically creates a polygon theme rather than allowing the user to select a theme type.



Planting Suitability (SSRAP, ArcView sample and system scripts)

The Planting Suitability button, when activated, applies certain spatial criteria to a 1 Ha vector grid shapefile. Using the selection criteria, an equal weight suitability code is attributed to each cell. Table 1 shows the 16 criteria that can be applied to the vector grid. A positive selection process refers to a desirable trait such as grid cells that are adjacent to vegetation polygons greater than 50 Ha in size. Conversely, a negative selection process indicates cells which intersect features that are undesirable or are already planted. Whether a criteria is positive or negative, dictates the action taken on the suitability code field for selected cells (ie. positive add 1, negative equals 0).

Steps:

- **Find the required themes with the proper theme names** [*findTheme*].
1. Positive - **select and populate cells within the watershed boundary**
 - select grid squares within watershed boundary [*selectByTheme...HASCENTERWITHIN...*];
 - add the SuitCode field if it is not found within the grid attributes table;
 - populate selected cells with 0 [*Calculate(0, theSuitField)*];
 2. Positive - **Select and populate cells within vegetation polygons**
 - select grid cells that have centres within vegetation polygons [*selectByTheme...HASCENTERWITHIN...*];
 - add a status field that shows vegetated cells to the grid attributes table [*addFields*];
 - populate selected cells with 1 indicating vegetated [*Calculate(1, theVegField)*];
 3. Positive - **Select and populate cells adjacent to vegetation polygons > 50 Ha in size;**
 - select vegetation polygons with areas > 500,000 m²[*Query*];
 - select grid cells that have centres within the selected vegetation polygons [*selectByTheme...HASCENTERWITHIN...*];
 - select grid squares within a distance of 0 m (adjacent) from previously selected grid squares [*selectByTheme...ISWITHINDISTANCEOF,0...*]
 - add 1 to the SuitCode field of selected cells [*Calculate*]
 4. Positive - **Select and populate cells adjacent to vegetation polygons that contain a 200 m interior forest polygon;**
 - select vegetation polygons containing a 200 m interior forest polygon [*selectByTheme...COMPLETELYCONTAINS...*];

- select grid cells that have centres within the selected vegetation polygons [*selectByTheme...HASCENTERWITHIN...*];
 - select grid squares within a distance of 0 m (adjacent) from previously selected grid squares [*selectByTheme...ISWITHINDISTANCEOF,0...*]
 - add 1 to the SuitCode field of selected cells [*Calculate*]
5. **Positive - Select and populate cells adjacent to vegetation polygons that contain a 100 m interior forest polygon > 40 Ha in size;**
- select 100 m interior forest polygons with areas > 400,000 m²[*Query*];
 - select vegetation polygons containing selected 100 m interior forest polygons [*selectByTheme...COMPLETELYCONTAINS...*];
 - select grid cells that have centres within the selected vegetation polygons [*selectByTheme...HASCENTERWITHIN...*];
 - select grid squares within a distance of 0 m (adjacent) from previously selected grid squares [*selectByTheme...ISWITHINDISTANCEOF,0...*];
 - add 1 to the SuitCode field of selected cells [*Calculate*];
6. **Positive - Select and populate grid cells adjacent to vegetation polygons > 50 Ha in size and a user defined fractal dimension ;**
- select vegetation polygons with areas > 500,000 m²[*Query*];
 - add fractal dimension field to vegetation attributes table;
 - apply the fractal dimension formula to the selected features [*...calculate("([Perimeter].Log(10)/[Area].Log(10))*2"...*];
 - select vegetation polygons with fractal dimension > a user defined value from selected polygons [*Query*];
 - select grid cells that have centres within the selected vegetation polygons [*selectByTheme...HASCENTERWITHIN...*];
 - select grid squares within a distance of 0 m (adjacent) from previously selected grid squares [*selectByTheme...ISWITHINDISTANCEOF,0...*];
 - add 1 to the SuitCode field of selected cells [*Calculate*];
7. **Positive - Select and populate cells within 100 m of vegetation polygons > 50 Ha in size;**
- select vegetation polygons with areas > 500,000 m²[*Query*];
 - select grid cells that are have centres within the selected vegetation polygons [*selectByTheme...HASCENTERWITHIN...*];
 - select grid squares within a distance of 0 m (adjacent) from previously selected grid squares [*selectByTheme...ISWITHINDISTANCEOF,0...*];
 - select grid squares within a distance of 0 m (adjacent) from previously selected, adjacent to forest, grid squares [*selectByTheme...ISWITHINDISTANCEOF,0...*];
 - select only the grid cells that are not within forest polygons (from previously selected set) [*Query("([vegStat]<>1)"...*];
 - add 1 to the SuitCode field of selected cells [*Calculate*];

8. Drainage Criteria (Optional) **Select and populate grid cells that have a suitability code of greater than 0 and fall within 30 m of the *Drainage Network***
 - select grid cells with a suitCode of > 0[*Query*];
 - select grid squares within a distance of 30 m from drainage network features [*selectByTheme...ISWITHINDISTANCEOF,0.03...*];
 - add 1 to the suitCode field of selected cells [*Calculate*];
9. Drainage Criteria (Optional) **Select and populate grid cells that have a suitability code of greater than 0 and intersect the *Drainage Network***
 - select grid cells with a suitCode of > 0[*Query*];
 - select grid squares that intersect drainage network features [*selectByTheme...INTERSECTS,0...*];
 - add 1 to the suitCode field of selected cells [*Calculate*];
10. Negative - **Select and populate grid cells that have a suitability code of greater than 0 and fall within 40 m of the *Road Network***
 - select grid cells with a suitCode of > 0[*Query*];
 - select grid squares within a distance of 40 m from *Road network* features [*selectByTheme...ISWITHINDISTANCEOF,0.04...*];
 - subtract 1 from the suitCode of selected cells [*Calculate*];
11. Negative - **Select and populate grid cells that have a suitability code of greater than 0 and intersect with the *Road Network***
 - select grid cells with a suitCode of > 0[*Query*];
 - select grid squares that intersect *Road network* features [*selectByTheme...INTERSECTS,0...*];
 - change the suitCode of selected cells to 0 [*Calculate*];
12. Negative - **Select and populate grid cells that have a suitability code of greater than 0 and fall within 30 m of the *Miscellaneous Transport*;**
 - select grid cells with a suitCode of > 0[*Query*];
 - select grid squares within a distance of 30 m from *Miscellaneous Transport* features [*selectByTheme...ISWITHINDISTANCEOF,0.03...*];
 - subtract 1 from the suitCode of selected cells[*Calculate*];
- 13, 14 & 15 Negative - **Select and populate grid cells that have a suitability code of greater than 0 and intersect with the *Miscellaneous Transport, Buildings and Railway/Abandoned Railway*** (note: three separate steps)
 - select grid cells with a suitCode of > 0[*Query*];
 - select grid squares that intersect *Miscellaneous Transport, Buildings and Railway/Abandoned Railway* features [*selectByTheme...INTERSECTS,0...*];
 - change the suitCode of selected cells to 0 [*Calculate*];

16., Negative - **Select and populate grid cells that have centres within vegetation polygons;**

- select grid squares that have centres within Vegetation polygons
[*selectByTheme...HASCENTERWITHIN,0...*];
- change the suitCode of selected cells to 0 [*Calculate*];

Once the suitability process is complete, the grid can be classified by suitability code. The highest suitability code is considered most suitable for planting. The suitability grid may require further analysis as some grouped cells will become stranded when transportation criteria are applied (See Example).

TOOLS AND TOOL LISTS

1 ha Grid (Modified User Script)

The *1 ha Grid* tool uses a modified *grid creation* script (Mrak and Starling) which was downloaded from the Internet. It enables the user to create a vector grid with a predefined 1 ha cell size by delineating the desired target area. The output shapefile is a required component for the *planting suitability* button.

© **Forest Stand Update (SSRAP Developed Script)**

The *Forest Stand Update* tool facilitates the creation and updating of a forest restoration layer. The user is provided with input boxes to help identify the target forest stands.

Steps:

1. Find the active themes and get the first theme [*getActiveThemes.Get(0)*].
2. The user selects the features by delineating a rectangle around the target features [*av.run(View.SelectPoint...)*].
3. The area of the selected features is updated to the Area field [*[Shape].returnArea*].
4. Add a landowner field if the field is not found in the attributes table [*field.make*].
5. Provide a text box to allow the user to input the landowner name [*msgBox.Input....*].
6. Populate the selected features with the users input [*calculate*].
7. Carry out steps 4 to 6 for stand description and ID.

Updating restoration sites is useful when updating and analysing the vegetation layer for habitat conditions.

© **Drainage Segment Update (SSRAP Developed Script)**

The *Drainage Segment Update* tool enables the user to quickly update the drainage layer if a definition is required. The ArcView processes involved in updating the drainage segments are

similar to the *Forest Stand Update* tool where the user is provided with a drop down list of common drainage definitions. This tool is used on datasets that don't have drainage descriptions (MNRcodes). A distinction can be made between stream segments and other drainage types such as wetland or lake.

© Stream Order Update (SSRAP Developed Script)

The *Stream Order Update* tool enables the user to quickly classify stream segments by selecting the segment features and choosing the appropriate stream order from a drop down list. The processes used are similar to those used in the *Forest Stand Update* tool. Stream order classification is a key component of the habitat analysis method.

MENU ITEMS



Figure 13: Menu Items found in the Habitat Analysis GUI

30 m Offset Drainage Segment (SSRAP, ArcView sample and system scripts)

The *30 m Offset Drainage Segment* menu activates a series of Avenue scripts that measures the approximate width of vegetation along both sides of a drainage theme.

Steps:

1. Find the *vegetation* and *drainage* themes [*findTheme...*].
2. Get the selected drainage features [*getSelection*].
3. Create a new line theme [*av.run("Habitat2.newLineTheme"...)*].
4. Find the shape field from the *drainage* theme attributes table [*findField*].
5. For each feature (segment) in the attributes table, get the shape [*queryshape...*].
6. Break the shape into approximately 10 m segments [*returnDensified(10)*].
7. Draw each 10 m segment as a graphic line [*GraphicShape.Make(segment coordinates)*].
8. Move on to the next feature in the theme (back to Step 4).
9. Select all 10 m segment graphics [*av.run("Graphic.SelectAll"...)*].
10. Cut all selected graphics [*av.run("View.CutGraphics"...)*].

11. Start editing the new line theme [*SetEditableTheme...*].
12. Paste the 10 m segments into the new line theme [*av.run("View.Paste"...*].
13. Stop editing the new line theme which is now the *10 m segment* theme.
14. Run the offset script.
15. Create a new line theme.
16. Find the shape field from the *10 m segment* theme attributes table [*findField*].
17. For each 10 m segment, establish an increment list [*theIncList={5,10,15,20,29}*].
18. For each increment in theIncList, run the modular offset script [*av.run(habitat3.Offset...*].
19. Offset the 10 m segment by the increment value to the right (positive)of the line [*returnOffset(theIncList value)*].
20. Select the *vegetation* polygon that falls beneath the offset segment [*selectByShapes*].
21. Get the shape extent of the selected vegetation polygon [*theVegTab.QueryShape...*].
22. Test the offset segment to determine if it is contained by the vegetation polygons shape extent [*shape_extent.Contains...*].
23. If the segment is contained by the vegetation polygon the test result is true.
24. Carry out steps 19 to 23 for the left (negative) side of the 10 m segment.
25. Continue on to the next increment and run steps 19 to 24 again.
26. Once theIncList iterations for the 10 m segment are complete, if all offsets are contained within the selected vegetation features, then create a graphic line using the original line segment.
27. If any offsets are not contained by the vegetation polygon, do not create the original graphic line segment.
28. Continue to the next 10 m segment and run steps 18 to 27 again.
29. Continue until all segments have been offset and tested.

The output theme will only include segments that have more than 30 m of adjacent vegetation on both sides. The theme can be summarized and joined to the original drainage theme to repopulate the attributes table.

Upland Habitat for Wetlands (SSRAP, ArcView sample and system scripts)

The *Forest Habitat for Wetlands* menu item provides a measured estimate of forest cover adjacent to wetland boundaries. Similar to the *30 m Offset Drainage Segment* menu item, the *Forest Habitat for Wetlands* scripts involve breaking the wetland polygon into approximately 10 m perimeter segments and offsetting each segment until it is outside the corresponding vegetation polygon. The maximum offset value is assigned to an offset field for the original line segment.

Steps:

1. Find the *vegetation* and *wetland* themes [*findTheme...*].
2. Get the selected *wetland* features [*getSelection*].
3. Create a new line theme [*av.run("Habitat2.newLineTheme"...*].
4. Find the shape field from the *wetland* theme attributes table [*findField*].
5. For each feature (polygon) in the attributes table, get the shape [*queryshape...*].

6. Convert the polygon to a polyline and break the shape into approximately 10 m segments [*asPolyline.returnDensified(10)*].
7. Draw each 10 m segment as a graphic line [*GraphicShape.Make(segment coordinates)*].
8. Move on to the next feature in the theme (back to Step 4).
9. Select all 10 m segment graphics [*av.run("Graphic.SelectAll" ...)*].
10. Cut all selected graphics [*av.run("View.CutGraphics" ...)*].
11. Start editing the new line theme [*SetEditableTheme...*].
12. Paste the 10 m segments into the new line theme [*av.run("View.Paste" ...)*].
13. Stop editing the new line theme which is now the *10 m segment* theme.
14. In the new line attributes table, create an offset field to hold the maximum offset values [*field.make...*].
15. Add a unique wetland ID to corresponding segments [*join...(shapefield)/query/calculate...*].
16. Run the offset script [*av.run("Habitat2.OffsetPolygonSeg2" ...)*].
17. Find the shape field from the *10 m segment wetland perimeter* theme attributes table [*findField*].
18. Start with an offset value of zero and offset the 10 m segment by zero metres to the left (negative/outside polygon) of the line [*returnOffset(0)*].
19. Test the zero offset to determine if it is contained within a vegetation feature.
20. Begin offsetting the segment, if the zero offset is contained by the vegetation feature, with an increment value of - 40 m.
21. Select the *vegetation* polygon that falls beneath the offset segment [*selectByShapes*].
22. Get the shape extent of the selected vegetation polygon [*theVegTab.QueryShape...*].
23. Test the offset segment to determine if it is contained by the vegetation polygons shape extent [*shape_extent.Contains...*].
24. If the segment is contained by the vegetation polygon the test result is true.
25. Continue on to the next increment subtracting 40 m and run steps 20 to 24 again unless the test result is false.
26. Once the test result is false, add 20 m to the offset value and run through steps 20 to 24 using - 20 m as the increment.
27. Once the test result is false after the 20 m increment test, add 15 m to the offset value and run through steps 20 to 24 using - 5 m as the increment.
28. Once the 5 m increment test is false, assign the maximum increment value to the *offset* field in the attributes table for the original.
29. Continue to the next 10 m segment and run steps 18 to 28 again.
30. Continue until all segments have been offset and tested.

The output shapefile will contain all 10 m segments with the attributes table having maximum offset values for the width of adjacent forest cover. A summary shapefile can be generated to attain the maximum, minimum and average adjacent forest width for each wetland.

Grid Count (SSRAP, ArcView sample and system scripts)

The *Grid Count* menu item was developed to handle an anomaly that occurs during the *Planting Suitability* process. Some grouped cells will become stranded when negative selection criteria such as transportation or buildings are applied. To remedy this situation, a thinning process is applied to all grid cells eliminating suitable cells that are isolated.

Steps:

1. Find 1 ha Grid and vegetation themes.
2. Find the suitcode and vegstat fields.
3. Select the grid cells that are adjacent to vegetation polygons and populate their vegstat field with 2.
4. Query for grid cells with a vegstat of zero (not vegetated).
5. From the queried, non-vegetated grid cells, query for the grid cells with a Suitcode > 0 and a SuitCode < 6.
6. Assign the selected cells to a selection bitmap.
7. Find the ID field.
8. For each cell in the bitmap, get the cell ID and add it to a list.
9. For each cell ID in the list query for the cell ID.
10. Select all grid cells that are adjacent to the selected cell.
11. Query from the selected cells, those cells with a SuitCode > 4.
12. Count the selected cells and assign the total to a variable - count2.
13. Query from selected cells, those cells with a SuitCode < 5.
14. Count the selected cells and assign the total to a variable - count3.
15. Select the current cell ID.
16. If the value assigned to count2 < 3 and the value assigned to count3 < 5 then add the cell ID to a list.
17. Continue steps 9 to 16, until all cells have been analysed.
18. Select the cells within the list and populate their suitcode with zero.

The grid can be summarized and compared to the original planting suitability grid to demonstrate the changes that have occurred to the SuitCode.

Extract Parcels By Targeted Stream Segments (SSRAP and ArcView system scripts)

The *Extract Parcels By Targeted Stream Segments* menu item automatically joins a stream segments with, but less than 30 m, adjacent vegetation layer with a parcels (landowner information) layer. The stream lengths with, but less than 30 m, adjacent vegetation are determined for each parcel. Parcels are then ranked by length of stream meeting the criteria. The user is asked to provide the number of parcels to be extracted. The parcels with the highest ranking up to the user defined number are exported to a shapefile.

Steps:

1. Clear the active themes [*.setActive(False)*].
2. Find the “*Intersects but < 30M of Veg*” and the “*Parcels*” themes.
3. Find the “*Shape*” field from both layers and the “*Length*” field from the intersect layer.
4. Join the parcels layer to the intersect layer using the “*Shape*” field as the common field [*.join...*].
5. Ask the user to choose a unique identifier field from the parcels theme (ie property number).
6. Create a summary table summarizing the intersection stream segments by the unique identifier field (Property Number) and include the segment length [*Vtab.make..., Table.makewithGUI..., .SetName...*].
7. Join the summary table to the parcel table using the unique identifier field as the common field.
8. Select parcel with “*Intersects but < 30 m of Veg lengths*” > 0 m.
9. Ask user to enter the number of parcels to extract from the selected parcels.
10. Create a list to hold the unique identifiers of the parcels with the top “number to extract” (Step 9) length of “*stream length with but < 30 m Veg*” [*list.make*].
11. Sort the parcels by “*stream length with but < 30 m Veg*” [*table.sort...*].
12. Add the top “number to extract” values from the unique identifier field from the “*Parcels*” theme to the list (Step 10) [*table.convertRowToRecord..., list.add...*].
13. For each value in the list (Step 10), query for parcels that match the list value (unique identifier) [*table.query...*].
14. Export the selected parcels to a new shapefile [*av.run("View.Export",...)*].

Wetland Complex Suitability Analysis (SSRAP and ArcView system scripts)

The *Wetland Complex Suitability Analysis* menu item ranks wetland complexes by evaluating certain criteria (Refer to Section 1: Wetland Selection for Restoration). The user is prompted by a series of multiple, yes/no and list message boxes, to input appropriate information that will be used in the ranking process. ArcView uses the provided information to calculate a suitability value for each wetland complex polygon. The wetland complexes meeting the most criteria will have the highest suitability value.

Steps:

1. Find the “*Adjacent Veg Width (W Area)*”, “*Wetland Area*”, “*Watershed*”, “*Wetland Complex*”, “*Vegetation*”, “*Wetland Complex (For Offset)*” themes.
2. List the appropriate Polygon or Arc themes for the user to select from if any themes are missing from the previous step.
3. Ask the user if Fractal Dimension will be included as part of the analysis.
4. Ask the user if Land Use will be included as part of the analysis.
5. Ask the user if wetland Complex Classification should be included as part of the analysis.
6. Prompt the user to assign weight values to size / shape and adjacent vegetation (wetland complex if Step 5 = “YES”) components of the analysis.
7. Ask user to assign maximum adjacent forest values for *Wetland Area* and *Wetland Complex* layers.
8. Ask user if clipped wetland coverage is required.
9. Clip wetland complex coverage if clipped version is required [*av.run(“Habitat.clip”...*)].
10. Add required calculation fields to wetland complex coverage [*av.run(“Habitat2.WetlandAddFields”*)].
11. Find the “*Adjacent Veg Width (Complex)*” theme.
12. Perform offset analysis on wetland complex layer if previous step result is “*nil*” [*av.run(“Habitat.Offset Polygon...”*)].
13. **Perform Adjacent Land Use to wetland area analysis if Step 4 = “YES”**
[*av.run(“Habitat2.WetlandLandUse”...*)].
14. Find the *Land Use* theme [*View.findtheme(“Land Use”*)].
15. Allow the user to identify the Land Use theme from a list box if a Land Use coverage is not found [*av.run(“Habitat2.ThemeListSub”...*)].
16. Find the field named “*offset*” in the *wetland area* offset coverage which is referenced back to the originating script [*self.get(1)*].
17. Find the string field named “*land_class*” in the *land use* coverage [*findfield*].
18. Provide the user with a list of string (*land use* coverage) fields to choose from if the “*land_class*” field is not found [*msgbox.listasstring...*].
19. Clone the *land_class* field and add the clone to the *Wetland Area Offset* coverage [*OffsetTable.addFields ({theLandClassField.clone})*].
20. For each segment in the *wetland area offset* theme, offset the segment by the value found in the offset (maximum adjacent forest width) field [*returnoffset*].
21. Select the Land Use parcels that intersect the offset segment [*theLandUseTheme.selectByShapes({theOffsetTheme},#VTAB_SELTYPE_NEW)*].
22. Count the number of land use polygons that are selected [*...getSelection.count*].
23. Assign “UNKNOWN” to the Land Use field in the *Wetland Area Offset* layer if the result from step 21 equalled 0 [*...setValue...*].
24. Assign the selected polygon’s land use description to the *Wetland Area Offset* layer’s land use field for the original segment if the result from step 21 is greater than 0 [*theLandUseTable.returnValue..., theOffsetTable.setValue...*].
25. Move on to the next Wetland Area Offset Segment.

26. **Run Wetland Analysis script (Refer to Wetland Analysis - Section 2)**
[*av.run("Habitat2.WetlandAnalysis"...*].
27. Find the "shape" and calculation fields from the Wetland Complex layer [...*findField...*].
28. Calculate the area of each polygon in the *Wetland Complex* Layer
[*av.run("Habitat2.AddArea", nil)*].
29. If fractal dimension is required, for *Wetland Area* and *Wetland Complex* tables, find the fractal dimension, area and perimeter fields [...*findField...*].
30. Add a perimeter field and calculate the perimeter of each polygon if the perimeter field is not found in the *Wetland Area* or *Wetland Complex* table [...*Field.Make..., expression = "[Shape].returnLength", ...Calculate...*].
31. Calculate the Fractal Dimension of each polygon and add the value to the Fractal Dimension field [*expression = "([Perimeter.Log(10)/[Area.Log(10)]*2"*].
32. Find the Offset fields in the *Wetland Area* and *Wetland Complex* tables.
33. Find the Land Use field in the *Wetland Area Offset* theme if the Land Use component is required (step 4 = "YES").
34. Make a list to hold the land uses occurring at the maximum forest width [*list.make*]
35. For each segment in the *Wetland Area Offset* layer, return the land use value and add it to the list [*theList.Add(theOffsetTable.returnValue(theLandUseField....)*].
36. Remove any duplicate land use descriptions in the list [...*removeDuplicates...*]
37. Count the number of individual land classes and EXIT the script if there are more than 20 (A multiple input box can only handle a maximum of 20 input boxes in ArcView).
38. Find the corresponding field from the *Wetland Complex* table for each unique land class in the *Wetland Areas Offset* table.
39. Create the appropriate field(s) for fields not found in Step 37.
40. Select the *Wetland Area Offset* segments that fall within each Wetland Complex polygon [*selectByPolygon...*].
41. For each unique land class, calculate the percentage of Wetland Area Offset segments that fall within each Wetland Complex polygon and add the value to the appropriate land class field in the *Wetland Complex* Layer.
42. Apply a modified version of the statistics system script to the Wetland Area Offset segments.
43. Count the number of offset segments with an offset value of zero.
44. Count the number of offset segments with an offset greater than the user defined threshold from Step 7.
45. Add the calculated Mean, Minimum, Maximum, Standard Deviation, Zero Offset Count and Greater Than User Defined Threshold to the appropriate attribute fields and records.
46. Repeat steps 35 to 45 using the *Wetland Complex Offset* layer instead of the *Wetland Area Offset* layer (Skips land use steps 40 and 41).
47. Calculate the area of each Wetland Complex polygon.
48. For each Wetland Complex polygon in the *Wetland Complex* Layer, select the Wetland Area polygons that fall within the Complex.
49. Sum the area of Wetland Areas that fall within the Wetland Complex.
50. Calculate the percentage of the Wetland Complex that is covered by Wetland Area.
51. Move on to the next Wetland Complex polygon and repeat steps 48 to 50.

52. **Rank wetlands according to selected criteria and user defined weights**
[*av.run("Habitat2.WetlandRank"...*].
53. Find calculation fields in wetland Complex attribute table and create a list of fields that are present.
54. Create a label list for use in a multiple input box.
55. For each calculation field, calculate the average and maximum values for the entire Wetland Complex (watershed) coverage.
56. Determine which operator to use with the default value (<,= or > is based on the specific criterion)
57. Add the average value and the corresponding operator to a list of default values (order of values corresponds to order of labels) .
58. Add the Maximum value to a list of Maximum values (order of values corresponds to order of labels).
59. Move on to the next calculation field until all fields are accounted for in the Maximum, Average and label lists.
60. Create a new label list by combining each value from the label list with the corresponding values from the maximum list.
61. Ask the user to enter a threshold value for each criterion or accept the default values.
62. Ask the user to identify the field (must be a string field) in the Wetland Complex layer that describes wetland classification (if step5 = "YES").
63. Prompt the user to rank each land use (if step 4 "YES") with a multiple message box containing the list of land classes and an ordered list of default values.
64. Add a land use suitability, problem flag and wetland suitability fields to the wetland layer.
65. Divide the user defined component weight (see step 6)by the number of criteria used in each component (for example, if the user defined component weight = 10 and the number of criteria used to analyse the component = 4, then each criterion will have a suitability value of 4/10 or 2.5).
66. Query the *Wetland Complex* layer on each calculated field using the user defined threshold value and relational operator [*table.query...*].
67. Add the weighted suitability value to the Wetland Suitability field for each criterion.
68. Calculate the suitability value based on the percentage of adjacent vegetation land use that falls within the *Wetland Complex*.
69. Set the flag value to 1 if there are no wetland areas within an individual wetland complex (indicates possible anomalies).
70. Add the weighted land suitability value to the wetland suitability field
71. Rank the wetland classes by adding all values from wetland class to a list, remove the duplicate values and sort the list in ascending order [*list.add..., list.removeduplicates..., list.sort...*].
72. Apply the weight value to the wetland class ranking (refer to step 27).
73. Create a dictionary to hold the wetland class and its corresponding rank [*dictionary.make...*].
74. Apply the suitability weight to the rank value and add the weighted rank to the wetland suitability field (For example, the user has applied a weight value of 6 to the wetland component. The wetland complex layer consists of 3 unique wetland classifications "class

1”, “class 3” and “no class”. Each classification is ranked accumulatively based on the calculated rank. Each class rank will be multiplied by the weight factor which will equal 6/3 or 2 starting. In this example, a non classified wetlands suitability would increase by 0, a class 3 wetlands suitability would increase by 2 and a class 1 wetlands suitability would increase by 4.).

APPENDIX 2

SAMPLE SPREADSHEET FOR CALCULATING HABITAT CONDITIONS

**Severn Sound RAP - Habitat Restoration Strategy
Forest Habitat Targets - ***Watershed*** Year*****

<i>Parameter</i>	<i>Target</i>	<i>Watershed</i>
% Forest Cover	> 30%	+D23
Size of Largest Patch	> 100 ha	+B28
% Forest > 100 m from Edge	> 10%	+D16
% Forest > 200 m from Edge	> 6%	+F16

Overlapping Watershed Boundary

	<i>Total Watershed Area (ha)</i>	<i>100 m Buf Area (ha)</i>	<i>100 m Buf % of Wshed</i>	<i>200 m Buf Area (ha)</i>	<i>200 m Buf % of Wshed</i>
	+B17/10000	+C17/10000	+C16/B16	+E17/10000	+E16/B16
Paste Here (1)	Total Area	100 m Area		200 m Area	

Clipped with Watershed Boundary

	<i>Total Watershed Area (ha)</i>	<i>Vegetation Area (ha) in Wshed</i>	<i>Vegetation Percent of Wshed</i>
	+B24/10000	+C24/10000	+C23/B23
Paste Here (2)	Total Area	Total Vegetation Area	

Largest Patch Size

	<i>Clipped (ha)</i>
	+B29/10000
Paste Here (3)	Largest Patch Size

Severn Sound RAP - Habitat Restoration Strategy
Riparian Habitat Targets - *Watershed*** Year*****

PARAMETER	TARGET	Watershed
% of Natural Veg. Along First to Third Order Streams	75% of stream length should be naturally vegetated	+D31
	75% of stream length should have 30 m wide buffers.	+F31

Includes Arbitrary Stream Lengths through Ponds, Lakes and Wetlands

Stream Order	Stream Length (m)	Stream Length Veg Intersect (m)	Percent Vegetated	Stream Length > 30m Veg(m)	Percent > 30m Buffer
1	+B38	+D38	+C13/B13	+F38	+E13/B13
2	+B39	+D39	+C14/B14	+F39	+E14/B14
3	+B40	+D40	+C15/B15	+F40	+E15/B15
4	+B41	+D41	+C16/B16	+F41	+E16/B16
5	+B42	+D42	+C17/B17	+F42	+E17/B17

1 to 3	@SUM(B13..B15)	@SUM(C13..C15)	+C19/B19	@SUM(E13..E15)	+E19/B19
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Excludes Arbitrary Stream Lengths

Stream Order	Stream Length (m)	Stream Length Veg Intersect (m)	Percent Vegetated	Stream Length > 30m Veg(m)	Percent > 30m Buffer
1	+B50	+D50	+C25/B25	+F50	+E25/B25
2	+B51	+D51	+C26/B26	+F51	+E26/B26
3	+B52	+D52	+C27/B27	+F52	+E27/B27
4	+B53	+D53	+C28/B28	+F53	+E28/B28
5	+B54	+D54	+C29/B29	+F54	+E29/B29

1 to 3	@SUM(B25..B27)	@SUM(C25..C27)	+C31/B31	@SUM(E25..E27)	+E31/B31
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Includes Arbitrary Stream Lengths through Ponds, Lakes and Wetlands

Paste Here Original (4)

Paste Here Clipped (5)

Paste Here Offset (6)

St_order	Sum_Length	St_order	Clipped_Length	ID	Sum_Length
1	0	1	0	1	0
2	0	2	0	2	0
3	0	3	0	3	0
4	0	4	0	4	0
5	0	5	0	5	0

Excludes Arbitrary Stream Lengths

Paste Here Original (7)

Paste Here Clipped(8)

Paste Here Offset (9)

St_order	Sum_Length	St_order	Clipped_Length	ID	Sum_Length
1	0	1	0	1	0
2	0	2	0	2	0
3	0	3	0	3	0
4	0	4	0	4	0
5	0	5	0	5	0

Severn Sound RAP - Habitat Restoration Strategy
Wetland Habitat Targets - *Watershed*** Year*****

PARAMETER	TARGET	Watershed
% Wetlands in Watershed	10% of total watershed or to restore to the original extent of wetlands.	+D16
Amount of Vegetation Adjacent to Wetland	Wetlands should have 240 m of adjacent Forest habitat	Mean Width(m)
		Min Width (m)
		Max. Width (m)
		+C32 +D32 +E32

Percent Clipped Watershed Boundary

Total Watershed Area (ha)	Wetland Area (ha) in Wshed	Wetland Percent of Wshed
+B17/10000	+C17/10000	+C16/B16

Paste Here (10)

Total Area	Total Wetland Area
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Forest Wetland Habitat - Measured Distance from Edge

Wetland ID	Average Distance From Edge (m)	Min. Distance From Edge (m)	Max. Distance From Edge (m)
1	20.7813	0	70
2	0	0	0
3	0	0	0
4	2.3936	0	30
5	13.4047	0	200
6	151.901	0	580
7	2.7381	0	60
8	80	5	310

Paste Here (11)

Mean Min. Distance Max. Distance
@MEAN(C23..C30) **@MIN(D23..D30)** **@MAX(E23..E30)**

Add new rows if needed.

Severn Sound RAP - Habitat Restoration Strategy
Forest, Riparian and Wetland Habitat Targets - *Watershed*** Year*****

Forest TARGETS

<i>PARAMETER</i>	<i>TARGET</i>	<i>Watershed</i>
% Forest Cover	> 30%	0.0%
Size of Largest Patch	> 100 ha	0.00
% Forest > 100 m from Edge	> 10%	0.0%
% Forest > 200 m from Edge	> 6%	0.0%

RIPARIAN TARGETS

<i>PARAMETER</i>	<i>TARGET</i>	<i>Watershed</i>
% of Natural Veg. Along First to Third Order Streams	75% of stream length should be naturally vegetated	0.00%
	75% of stream length should have 30 m wide buffers	0.00%

WETLAND TARGETS

<i>PARAMETER</i>	<i>TARGET</i>	<i>Watershed</i>	
% Wetlands in Watershed	10% of total watershed or to restore to the original extent of wetlands.	0.00%	
Amount of Vegetation Adjacent to Wetland	Wetlands should have 240 m of adjacent Forest habitat.	Mean Width (m)	0.00
		Min Width (m)	0.00
		Max. Width (m)	0.00