Prioritizing catchments for stewardship activity in the Lake Simcoe watershed
Introduction
Lake Simcoe Region Conservation Authority staff have been developing the Stewardship Priorities and Opportunities Tool (SPOT) as part of the implementation of subwatershed plans developed for the Lake Simcoe watershed. The SPOT is a tool designed to compare and prioritize opportunities to complete stewardship projects in the Lake Simcoe watershed, based on their ability to contribute to the priorities identified in the Lake Simcoe Protection Plan (LSPP) and the local subwatershed plans. When prioritized, this information is presented in a GIS format to allow the user to easily navigate through the results, and either present them visually, or query the data in more detail.

The SPOT tool consists of three components, a prioritization of opportunities to improve fish habitat (LSRCA 2013a), a prioritization of opportunities to improve terrestrial habitat (LSRCA 2015) and a prioritization of opportunities to complete stormwater management retrofits using low impact development technologies (Drewette 2014). A fourth component, as described in this report, now prioritizes catchments around the watershed for stewardship focus.

The advantages of prioritizing catchments as well as the project sites themselves is that it promotes rapid screening of project opportunities, by allowing the user to identify catchments (or neighbourhoods) throughout the watershed on which to focus action, rather than needing to scan through all of the thousand individual projects that have been identified in each of the component tools of SPOT. An additional advantage of prioritizing at the catchment scale is that it would also promote the “clustering” of activities, to allow stewardship staff to develop more comprehensive stewardship programs, rather than one-off projects, allow them to build relationships with local communities, write more attractive funding proposals, and potentially achieve measurable improvements to watershed health. Prioritizing at a catchment level also provide a new way of summarizing LSRCA’s stewardship opportunities databases and watershed monitoring data, by identifying priority issues at a local scale, which may be of particular interest to local community groups and neighbourhood organizations.

Methods
The catchment-level prioritization was initially developed as part of the prioritization of opportunities to improve aquatic habitats (LSRCA 2013a); this prioritization follows the approach taken in that study.

As with the aquatic habitat prioritization, this prioritization was based on the delineated ‘750 ha catchment’ layer, as an initial survey of the data indicated that 77% of catchments at that scale had monitoring data which described either their fish or benthic communities, or both, and because community groups have historically coalesced around watersheds of this scale, and in the case of a number of high priority ones (e.g. Scanlon Creek, Burls Creek, Bluffs Creek, Bogart Creek) community interest has driven the development of restoration plans specific to those subwatersheds.

However, in the case of the Barrie, Lovers, and Hewitt’s Creeks subwatersheds, the analysis was also done at the 125 ha scale. Biological data was somewhat more available in the Barrie area, and given the interest in the Lake Simcoe Conservation Foundation in focusing fundraising and programming efforts in the Barrie Creeks area, an additional level of analysis was felt to be useful.

An initial attempt to simply add both terrestrial habitat and stormwater management priorities to the fish habitat prioritization tended to identify most of the catchments around the watershed as being
priorities for action, as benefits could be realized for at least one of these components. While realistic, those results did not support the intent of the tool to promote multi-level project screening, and obscured the importance of each individual component for each catchment. Instead, the three components (aquatic habitat, terrestrial habitat, and stormwater management) have been prioritized separately, but remain in an integrated GIS tool to allow the user to either visually examine the results of each component individually, or to complete more detailed queries of the integrated results.

The approach used in prioritizing catchments is a simplified version of the approach taken to prioritize site-level stewardship opportunities. This approach is based on an assessment of the relative ability of each catchment to contribute to a range of targets and objectives of the LSPP (called “benefits”), and the relative “importance” of that aspect of watershed health to the local subwatershed, as identified in the local subwatershed plan (Table 1). The “importance” of each aspect of watershed health represent, in part, the potential for the catchment or subwatershed to achieve the target (e.g. providing habitat for cold water fish communities), while the “benefit” is estimated based on published research relating watershed structure (e.g. forest cover) to watershed function (e.g. diversity in the fish community). In all cases, benefit scores have been converted to a score of 1-10, to allow comparison of potential benefits to a wide range of watershed function on a commensurate scale. The final “priority” of each catchment has been calculated as:

\[
\text{Catchment level priority} = \Sigma (\text{Importance} \times \text{Benefit}) \times \text{Probability of success} \quad \text{(Equation 1)}
\]
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<th>Fish passage</th>
<th>Aquatic communities</th>
<th>Phosphorus loading</th>
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Prioritizing opportunities to improve terrestrial habitat at the catchment level

Like the site-level terrestrial habitat component of SPOT (LSRCA 2015), this tool prioritizes catchments based on their abilities to contribute to the landscape-level objectives and targets of the Lake Simcoe protection plan, namely:

- Increasing overall natural heritage cover
- Increasing large high quality blocks of natural cover
- Decreasing landscape fragmentation
- Improving the watershed’s capacity to adapt to climate change

Increasing overall natural heritage cover

The LSPP sets a target of 40% natural heritage cover for the watershed, based on the concept that some ‘thresholds’ exist in landscape-level forest cover, above which persistence of native species is much more likely (as summarized in Environment Canada 2013). This school of thought would tend to suggest that reforestation efforts should be focused on catchments which, with stewardship effort, could be pulled above the threshold, thus greatly improving the ability of native species to persist on the landscape (Fahrig 2001; Thompson 2010). As such, catchments were prioritized using Equation 2:

\[
\text{Benefit} = \frac{40}{41 - \text{percent natural heritage cover}}
\]

(Equation 2)

Any catchments resulting in a score of less 1 (i.e. those currently over the threshold), were re-attributed with a score of 1. Any catchments scoring more than 10 (i.e. those catchments vanishingly close to the 40% target), were re-attributed with a score of 10.

Increasing large high quality blocks of natural cover

The ability of catchments to contribute to the goal of high quality natural cover was defined as the percentage of the catchment that has the potential to become a high quality natural area (divided by ten to convert the score to a range of 0-10). Areas that had the potential to become high quality natural areas were defined as those that are available for reforestation (i.e. they aren’t currently a natural heritage feature, a road, or a building) are within 100 m of existing High Quality Natural Areas (MNR 2011), and outside areas having more than 25% urban land use within a one kilometer radius (in recognition of the additional stresses on natural areas associated with urban land use; LSRCA 2013b).

Decreasing landscape fragmentation

The ability of catchments to contribute to an increase to landscape-level connectivity was defined as the percentage of the catchment that has been identified as a potential connectivity area, divided by ten (to convert the score to a range of 0-10). Potential connectivity areas have been previously identified (LSRCA 2015), based on a least-cost-path approach to identifying important linkages between the designated high quality natural areas.
Improving the watershed’s capacity to adapt to climate change
Laganiere et al (2010) conducted a meta-analysis of the ability of reforestation projects to sequester carbon, and found that reforestation on sites with high-clay soils sequestered, on average, three times the amount of carbon as on sites with low clay content soil. As such, the potential for each catchment to contribute to climate change mitigation was assessed as being proportional to the percentage of the catchment which consists of high clay content soils (such as clay, clay loam, or silty clay loam soils).

Prioritizing opportunities to improve aquatic habitat at the catchment level
Like the site-level aquatic habitat component of SPOT (LSRCA 2013a), this tool prioritizes catchments based on their abilities to contribute to the landscape-level objectives and targets of the Lake Simcoe protection plan, namely:

- Protecting cold water fish communities
- Removing barriers to fish migration
- Improving in-stream fish habitat
- Reducing phosphorus loads to Lake Simcoe and its tributaries

Protecting cold water fish communities
To determine the potential benefits of improving in-stream thermal regime at the catchment scale, a simple ranking scheme was developed, based on the characteristics of watersheds which supported stable, declining, and extirpated brook trout populations in the eastern US (Hudy et al, 2008). Under this ranking scheme, catchments were ranked such that catchments with cold water fish (i.e. brook trout, mottled sculpin, or rainbow darter), but warm water conditions, were given the greatest benefit (8 out of 10). Sites which had historically supported cold water fish communities, but no longer do, were assessed as having secondary benefits (5 out of 10), and catchments with either no historic records of supporting cold water fish, or where cold water fish were currently living in cold water communities, were assessed as having the least benefit (1 out of 10).

Removing barriers to fish migration
To calculate the benefits to fish passage at a catchment scale, the Dendritic Connectivity Index (DCI; Cote et al, 2009) was calculated for each catchment in the Lake Simcoe watershed. The DCI is intended as a measure of the fragmentation of dendritic riverine networks. At its simplest, it measures the ability of fish to move between patches in the network, and assumes that any barrier on the network fully restricts passage. At that simplest derivation, the DCI equation becomes:

$$DCI = \sum \frac{(\text{length of individual stream segments})^2}{\text{Length of stream network}^2} \times 100$$  \hspace{1cm} (Equation 3)

The end result is an index value which ranges from 1 (fully connected) to 0 (fully fragmented). The benefit score for each catchment was then calculated as:

$$\text{Benefit to fish passage} = 10 - (\text{DCI} \times 10)$$  \hspace{1cm} (Equation 4)

Catchments which do not support brook trout had their scores halved.
Improving in-stream fish habitat
At a catchment scale, Steedman (1988) found a linear relationship between riparian forest cover and mean Index of biotic integrity (IBI) score. Similarly, Rios and Bailey (2006) and Johnson et al (2007) predict a linear response of Hilsenhoff biotic index (HBI) to catchment scale forest cover. As such, the potential benefit to fish or benthic communities at a catchment scale was assessed based on the relative position of the average IBI or HBI index in each catchment to the overall average of IBI and HBI indices over all catchments. Catchments which were estimated as having high potential benefits to fish habitat were those which had both depressed benthic and fish communities.

Reducing phosphorus loads to Lake Simcoe and its tributaries
The Louis Berger Group (2010) has previously established catchment-level targets for phosphorus loading to meet the LSPP target of 44 T/yr from the watershed to Lake Simcoe, as well as estimating the current phosphorus export from each catchment. The potential benefit to P-reduction, at a catchment scale, was simply based on the gap between current phosphorus loading and the established target for that catchment.

Prioritizing opportunities to promote low impact development at the catchment level
The relative priority of LID implementation at a catchment-level is based on the current rate of phosphorus export, and the current level of stormwater management, with the intent of identifying catchments which are contributing significantly to phosphorus loads, and in which stormwater controls are not up to contemporary standards.

The potential benefits to phosphorus reduction was based on the gap between current phosphorus loading and the established target for that catchment (Louis Berger Group 2010), with a current stormwater management factor (Table 2), based on the stormwatersheds within each catchment (LSRCA 2007). In cases where more than one stormwatershed exists in a catchment, the factor for the least controlled stormwatershed was used in calculating catchment-level scores.

Table 2. Predicting benefits to stormwater management from LID retrofits

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<th>Stormwater management pond manages to:</th>
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<tr>
<td>Levels 2 to 4 quality control</td>
<td>3</td>
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<tr>
<td>Quantity control only</td>
<td>5</td>
</tr>
<tr>
<td>No stormwater pond, stormwater is uncontrolled</td>
<td>10</td>
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</table>

Estimating the probability of project success
Clusters of past projects may be indicative of a local community that is supportive of stewardship or interested in watershed health, and in many cases also provide a suite of demonstration sites to future engage the local community and build further partnerships with landowners. As such, catchments within which the LSRCA LEAP program has a history of success, or where an active community group
(such as a Friends group) has a presence, have been prioritized higher, reflective of this social component of stewardship.

The history of project implementation was developed as a score ranging from 1-10, by calculating the Z-score of the number of projects completed within each catchment. An additional score representing the presence or absence of environmental community groups was created by scoring catchments with a value of 2 or 1, respectively. The final ‘probability of success’ score was the sum of these two values.

**Results**

This analysis resulted in the categorization of the ability of each of the 302 catchments to contribute to improving aquatic habitat, terrestrial habitat, and low impact development approaches to stormwater management (Table 3).
Table 3. Catchment-level priority classification

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<th>Low</th>
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<th>Medium</th>
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<td>19.8 – 33</td>
<td>81</td>
<td>33 – 41</td>
<td>23</td>
<td>&gt; 41</td>
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Figure 1. Catchment-level priorities for terrestrial habitat stewardship projects
Figure 2. Catchment-level priorities for aquatic habitat stewardship projects
Figure 3. Catchment-level priorities for stormwater retrofit projects
Works cited


Lake Simcoe Region Conservation Authority. 2007. Lake Simcoe basin stormwater management and retrofit opportunities.

Lake Simcoe Region Conservation Authority. 2013a. Prioritizing aquatic habitat stewardship opportunities in the Lake Simcoe watershed.

Lake Simcoe Region Conservation Authority. 2013b. LSRCA Lands natural heritage summary.

Lake Simcoe Region Conservation Authority. 2015. Prioritizing terrestrial stewardship opportunities in the Lake Simcoe watershed.


Ministry of Natural Resources. 2011. Identifying and mapping areas of high quality natural cover that are 25 hectares or greater in the Lake Simcoe watershed.

