The Transect as a basis for understanding Phosphorus Pollution

Abstract

The sub-urban pattern of development has created numerous deleterious impacts for close to a century. The advent of the Rural-Urban Transect has been a powerful tool in analysing such impacts. For example, it has been instructive regarding the differences in CO^2 emissions from differences in development patterns. This study used a similar method to assess differences in phosphorus-loading of a large waterbody across the Transect. It relied on several decades of phosphorus measurements for Lake Simcoe in Ontario, Canada. Public policy has mandated the creation of a remediation plan for this watershed. Anthropogenic phosphorus in this Lake has increased since the clearing of the watershed began for farming and settlement. Recreational fishing is important to the local economy, but the hypoxia resulting from increased phosphorus levels has limited fish populations. Contemporary analyses highlight various sources of P-loading from activities such as agriculture and roads, septic beds and sewage treatment, atmospheric deposition and “urban” runoff. Though this has been useful in guiding environmental remediation, public policy has failed to address the importance of development patterns as a solution. The use of the Transect in this preliminary study reveals: the overwhelming extent of “sub-urban” as the development pattern within the watershed, the disproportionate impact of this pattern for P-loading, the predominant sub-urban contribution to the phosphorus problem on both a watershed and household basis, and urbanism as a possible solution to phosphorus pollution.

Introduction

Research Question

The question addressed below, is whether a rural to urban transect-based analysis can bring clarity to certain impacts (i.e., phosphorus loading of waterbodies) that occur from clearing land for rural and urban uses. Specifically, is there a spectrum of impacts, based on a spectrum of habitats? This is in contrast to the conventional assessment of impacts according to economic sources such as: aggregates, agriculture, roads, sewage plants, settlement areas, etc.

Lake Simcoe Watershed

Lake Simcoe is at the heart of the traditional territory of the Chippewa Tri-Council and home to Georgina Island First Nation. It is the sixth largest lake entirely within the jurisdiction of the Province of Ontario, Canada (World Atlas, 2018), aside from the Great Lakes and other smaller water bodies shared with our American neighbours. It is the largest inland lake in Southern Ontario and lies approximately 45 km (28 mi.) north of Toronto’s city limits (MOE, 2009).

Figure 1: Location of Lake Simcoe Watershed

The Lake Simcoe watershed covers 3,400 km^2 (1313 sq. mi.) and is framed by the Oak Ridges Moraine to the south and the Oro Moraine to the north. There are 18 major river systems, with 4,225 kilometres of creek, stream and tributary channels. It is a habitat for 75 species of fish, 50 of which reside in the lake. The watershed is home to more than 450,000 people and crosses 20 municipal boundaries through the Regions of York and Durham, the County of Simcoe, and the Cities of Kawartha Lakes, Barrie and Orillia. The lake itself covers 20 percent of the area and provides a source of safe drinking water to seven municipalities. (LSRCA, 2018)

Figure 2: Land Base within Lake Simcoe Watershed

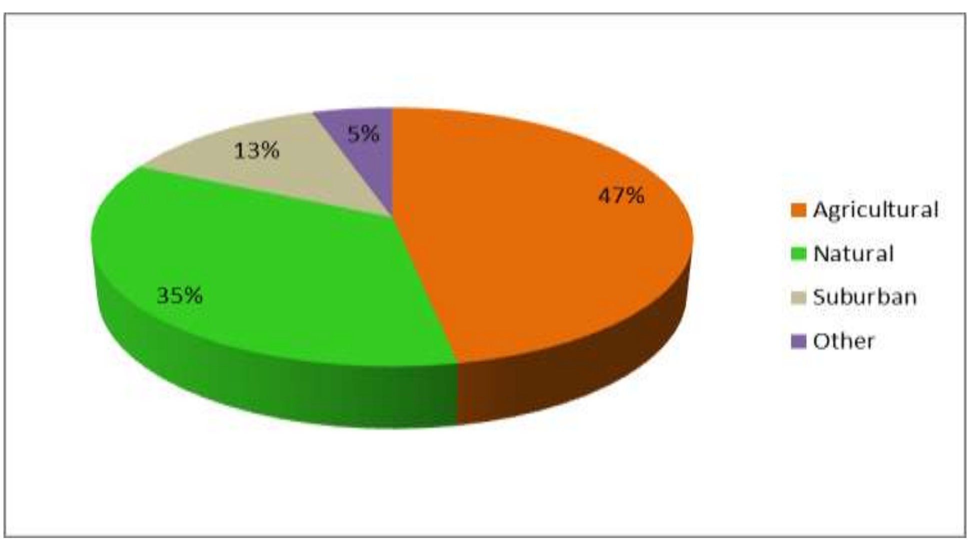
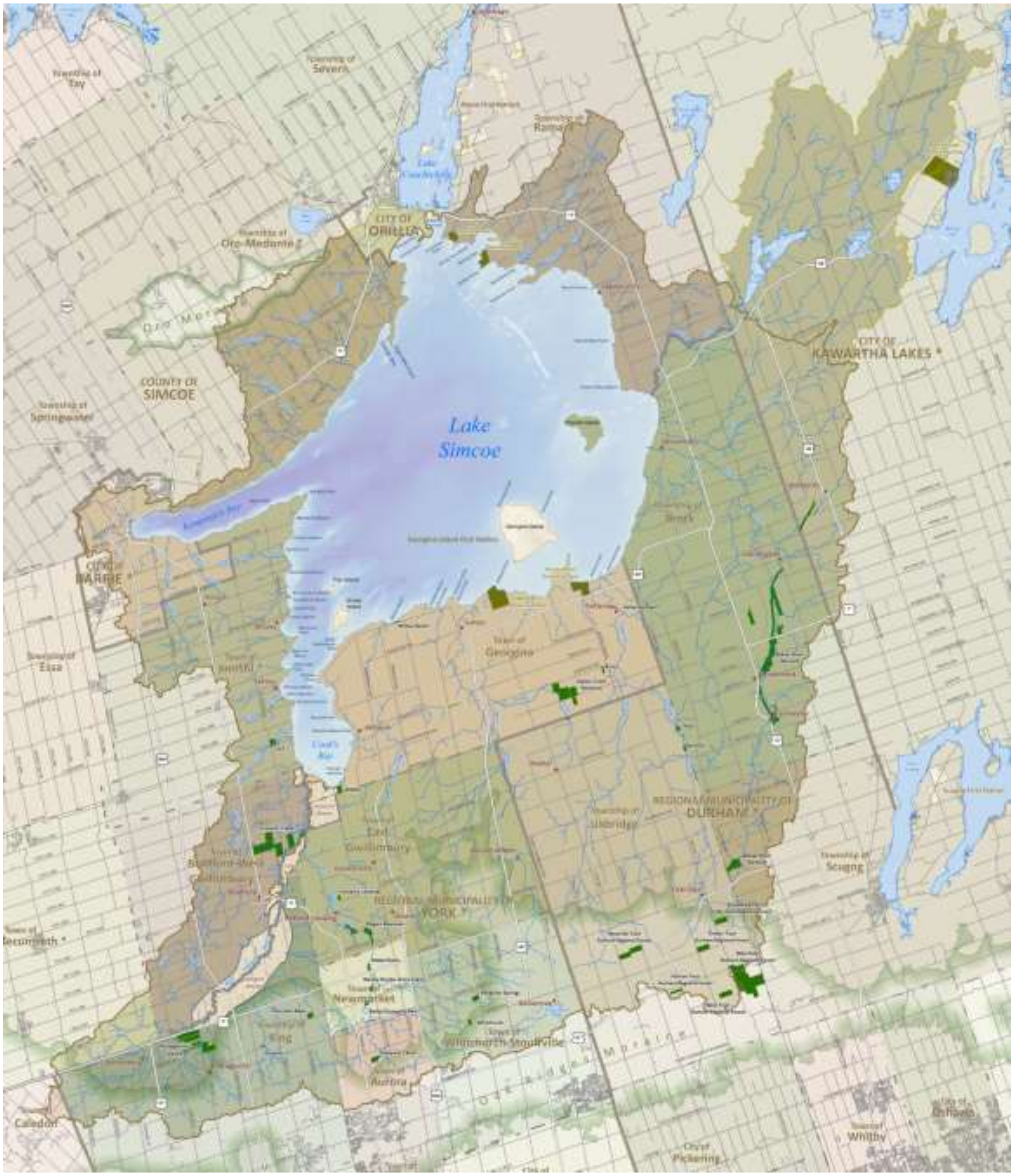


Figure 3: Boundaries of Lake Simcoe Watershed



The remaining 4/5 of the watershed is a varied landscape. Approximately 35% of the land base remains in a natural, albeit fragmented, array of woodlands and wetlands. As a centre for tourism and recreation it generates over $200 million annually for the local economy. Approximately 47% of the land base is in agriculture; producing $300 million a year from 2000 farms. The ecological services provided by the watershed have an estimated monetary value of $975,000,000 per annum. (LSRCA, 2018; MOE, 2009; Wilson, 2008)

BACKGROUND

A decade ago, the Province of Ontario passed the *Lake Simcoe Protection Act, 2008* in December of that year. It provided the Lieutenant Governor in Council (provincial cabinet) the authority to create the Lake Simcoe Protection Plan (LSPP). The LSPP was the first plan of its kind in the province, which aimed at the protection of an entire watershed (MOE, 2010). Its main priority was to improve the health of the ecosystem. This included rehabilitating shorelines, protecting natural heritage, restoring aquatic life, and directing attention to the impacts of recreation, invasive species, and climate change. Of primary importance was the reduction of phosphorus-loading of the Lake (MOE, 2009b). Directly tied to the LSPP was a Phosphorus Reduction Strategy, released in 2010. Its goal was for a phased reduction of phosphorus loadings from 72 down to 44 tonnes per year by 2045. This would approach the presumed pre-contact levels of 38-40 tonnes. At that point, a deep-water concentration of 7 milligrams per litre of dissolved oxygen can be sustained, thus supporting a cold-water fish community. (MOECC, 2017)

The Plan's objectives were largely structured around the improvement of the watershed's ecological health, such as restoring fisheries, reducing pollution, responding to invasive species, and adapting to climate change. However the three targets pertinent to this discussion are:

- Reducing phosphorus
- Ongoing research and monitoring
- Integrating with other Provincial Plans

The province of Ontario has other overlapping land-use plans that the LSPP is expected to build upon. There is the Oak Ridges Moraine Conservation Plan which overlaps 14% of the watershed, the Greenbelt Plan which overlaps 44%, the Growth Plan for the Greater Golden Horseshoe which covers 100%. There is also the Provincial Policy Statement and the applicable municipal Official Plans. Most of these documents contain verbiage related to intensification, efficient infrastructure, density, reducing impacts on the environment, etc. Additionally, the LSPP has a ten year review embedded in its mandate (MOE, 2009b).

Thus, this Transect-analysis was done ahead of the review, in a context of multiple jurisdictions with multiple policies, most of which aspire to protect the earth while serving the people. This preliminary look relied on numbers generated by the Ministry of the Environment and Climate Change (MOECC, 2017). The actual monitoring of phosphorus levels was done by the Lake Simcoe Region Conservation Authority through 19 tributary stations, 7 atmospheric collectors, polder sampling (the Holland Marsh; used for vegetable production via controlled wetland drainage), mathematical modelling of septic systems, and 15 water pollution control plants (WPCP) (Lembcke et al., 2017).

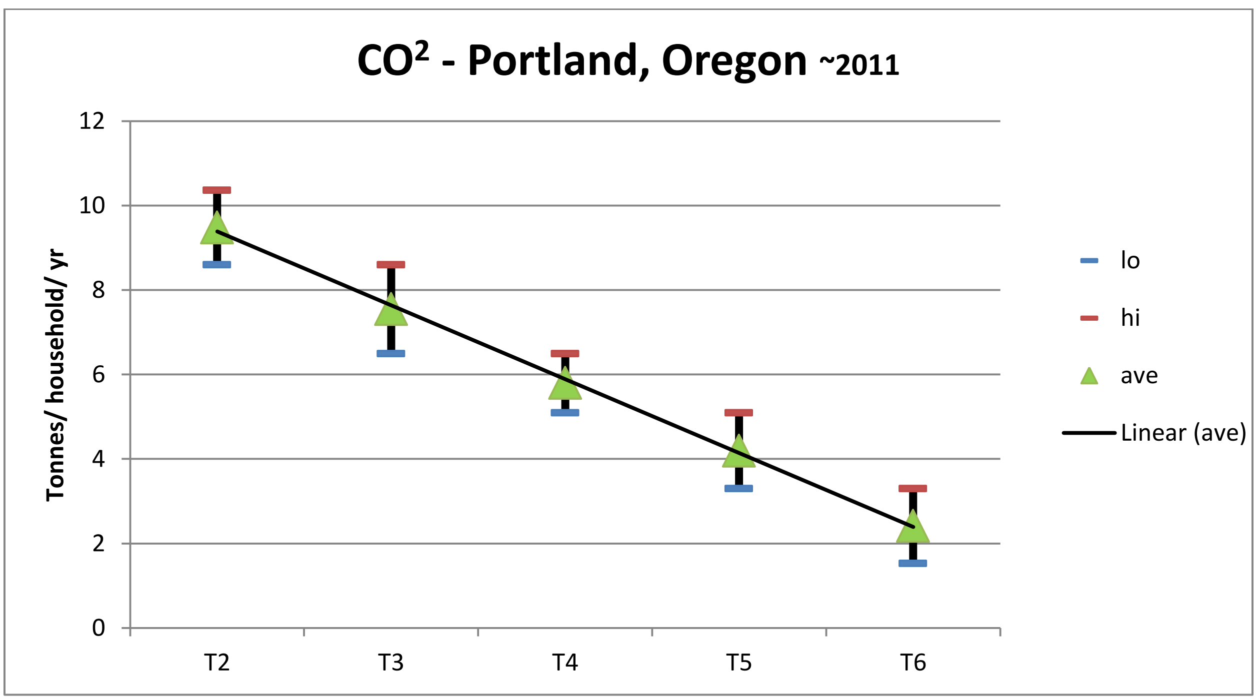
WHY PHOSPHORUS?

Phosphorus (P) was used in this analysis because of the readily available numbers that have been collected over time. The reason for collecting them is to assist in reducing the levels in Lake Simcoe so as to restore the cold water fishery (MOECC, 2017). Though it is an essential nutrient to life, an excess in lakes accelerates plant and algae growth. When these die, they consume oxygen from the water, and thus limit the habitat for fish (LSRCA, 2014).

WHY TRANSECT?

The Transect was used to analyse the phosphorus loading of the lake, due to inspiration from data released by the Center for Neighborhood Technology. It was for the City of Portland, Oregon, and used a different molecule of concern: carbon dioxide. They discovered that the amount of CO^2 released into the atmosphere varied across the landscape depending on the type of urban development revealed by the Transect (Steuteville, 2011). Though it too is an essential nutrient to life, an excess in the atmosphere accelerates the retention of heat. When enough energy is added, the climate becomes unstable, and thus potentially limits the habitat of many species (Robson, 2017). The question is whether a similar difference in the amount of phosphorus released into waterbodies can be detected using the same spectrum model.

Figure 2: Urban impact on CO^2 levels



Why Urban?

The Province has encouraged development in "urban" areas and reinforced such policies with infrastructure funding, e.g., water pollution control plants. Of specific concern is whether the catch-all phrase "urban" serves as an adequate classification when applied to most settlement areas.

Hypothesis:

1. A spectrum model, such as the Rural-Urban Transect, can reasonably be transcribed across an area as large as a major watershed
2. That variations in an environmental input such as phosphorus can be adequately mapped according to the Rural-Urban Transect
3. That differences in environmental impacts can be revealed by the Rural-Urban Transect
4. That the Rural-Urban Transect can thus be used for land-use and environmental policy

The Rural-Urban Transect

Transects, as such, are a tool of environmental science used to analyse ecological variation in the landscape. It reveals "… varying characteristics through different zones such as shores, wetlands, plains, and uplands. Its purpose is to study the many elements that contribute to habitats where certain plants and animals thrive in symbiotic relationship to the minerals and microclimate" (Duany et al, 2012).

The rural-urban transect is an extension of this idea from the natural environment into the built environment. The notion is that as the landscape transitions to the streetscape, habitats (environmental language) or zones (planner language) can still be delineated, analysed, and understood. It is a type of environmental assessment designed to not only be applied to rural settings, but urban ones as well (Talen et al, 2012).

This tool has been instantiated in documents such as the <u>Smart Code</u> that describe *"(t)he rural-to-urban Transect (as) divided into six Transect Zones for application on zoning maps. These six habitats vary by the level and intensity of their physical and social character, providing immersive contexts from rural to urban… at all scales of planning, from region through the community scale and on down to the individual lot and building.*

One of the principles of Transect-based planning is that certain forms and elements belong in certain environments. For example, an apartment building belongs in a more urban setting, a ranch house in a more rural setting… these distinctions and rules don't limit choices; they expand them. This is the antidote for the one-size-fits-all development of today." (Duany et al, 2012)

Table 1: Transect Zone Descriptions. This table provides descriptions of the character of each Transect Zone.

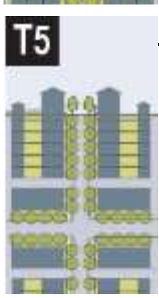
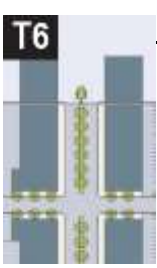
	T-1 NATURAL T-1 Natural Zone consists of lands approximating or reverting to a wilderness condition, including lands unsuitable for settlement due to topography, hydrology or vegetation.	General Character: Building Placement: Frontage Types: Typical Building Height: Type of Civic Space:	Natural landscape with some agricultural use Not applicable Not applicable Not applicable Parks, Greenways
	T-2 RURAL T-2 Rural Zone consists of sparsely settled lands in open or cultivated states. These include woodland, agricultural land, grassland, and irrigable desert. Typical buildings are farmhouses, agricultural buildings, cabins, and villas.	General Character: Building Placement: Frontage Types: Typical Building Height: Type of Civic Space:	Primarily agricultural with woodland & wetland and scattered buildings Variable Setbacks Not applicable 1- to 2-Story Parks, Greenways
	T-3 SUB-URBAN T-3 Sub-Urban Zone consists of low density residential areas, adjacent to higher zones that have some mixed use. Home occupations and outbuildings are allowed. Planting is naturalistic and setbacks are relatively deep. Blocks may be large and the roads irregular to accommodate natural conditions.	General Character: Building Placement: Frontage Types: Typical Building Height: Type of Civic Space:	Lawns and landscaped yards surrounding detached single-family houses; pedestrians occasionally Large and variable front and side yard Setbacks Porches, fences, naturalistic tree planting 1- to 2-Story with some 3-Story Parks, Greenways
	T-4 GENERAL URBAN T-4 General Urban Zone consists of a mixed use but primarily residential urban fabric. It may have a wide range of building types: single, Sideyard, and Rowhouses. Setbacks and landscaping are variable. Streets with curbs and sidewalks define medium-sized Blocks.	General Character: Building Placement: Frontage Types: Typical Building Height: Type of Civic Space:	Mix of Houses, Townhouses and small Apartment buildings with scattered Commercial activity; balance between landscape and buildings; presence of pedestrians Shallow to medium front and side yard Setbacks Porches, fences, Dooryards 2- to 3-Story with a few taller Mixed Use buildings Squares, Greens
	T-5 URBAN CENTER T-5 Urban Center Zone consists of higher density mixed use buildings that accommodate Retail, Offices, Row- houses and Apartments. It has a tight network of streets, with wide sidewalks, steady street tree planting and buildings set close to the sidewalks.	General Character: Building Placement: Frontage Types: Typical Building Height: Type of Civic Space:	Shops mixed with Townhouses, larger Apartment houses, Offices, work place and Civic buildings; predominantly attached buildings; trees within the public right-of-way; substantial pedestrian activity Shallow Setbacks or none; buildings oriented to street defining a street wall Stoops, Shopfronts, Galleries 2- to 5-Story with some variation Parks, Plazas, and Squares, median landscaping
	T-6 URBAN CORE T-6 Urban Core Zone consists of the highest density and height, with the greatest variety of uses, and civic buildings of regional importance. It may have larger Blocks; streets have steady street tree planting and buildings are set close to wide sidewalks. Typically only large towns and cities have an Urban Core Zone.	General Character: Building Placement: Frontage Types: Typical Building Height: Type of Civic Space:	Medium to high-Density Mixed Use buildings, entertainment, Civic and cultural uses. Attached buildings forming a continuous street wall; trees within the public right-of-way; highest pedestrian and transit activity Shallow Setbacks or none; buildings oriented toward the street, defining a street wall Stoops, Dooryards, Forecourts, Shopfronts, Galleries and Arcades 4-plus Story with a few shorter buildings Parks, Plazas and Squares; median landscaping

Table 1: Duany et al, 2012

Methodology

STEP 1

The first step was to consider whether the Transect was applicable to the Lake Simcoe watershed. Generally, T-zones are used within settlement areas. At the regional scale, a “sector” analysis is typically used. However, an overlap exists between the two analyses in terms of the vast areas of field and forest that can exist within a community, but usually range over entire regions (Duany et al, 2012). Guided by the descriptions of the T-zones (see Table 1) landscape features were deemed to be part of a particular zone if it reasonably matched that description.

T-1. Natural features were deemed to fit within the “T-1 Natural” zone. This includes the Lake itself, as the sink for the P-loading, and the 35% of the landscape occupied by forests and wetland. Any phosphorus from these is not anthropogenic and was thus excluded from the calculations.

T-2. Activities such as agriculture, aggregate extraction, unpaved roads, etc. appear to be a good match with the rural landscape, and were thus assigned to the “T-2 Rural” zone.

T-3 to T-6. What remained of the landscape were the settlement areas. These include communities large enough to have a water pollution control plant, and homes that treat sewage via septic beds, such as recreational properties and subdivisions not attached to water pollution control plants. Thus the impacts of settlement could then be assigned to the “T-3 Sub-urban”, “T-4 General Urban”, “T-5 Urban Centre”, and “T-6 Urban Core” zones.

The delineation of these T-zones was again guided by the descriptions found in Table 1. They were compared to personal, on-the-ground knowledge of certain communities, supplemented by Google Maps area & street-view examinations. An estimate was made of the size of each T4, T5, and T6 habitat found in every municipality with a water pollution control plant. The area (km^2) of each T-zone was measured via Google Maps and proportioned against the size of the municipality. T3 was assumed to constitute the rest of the settlement area.

The Cities of Barrie and Orillia have large areas of rural and natural lands. Normally, the Ministry’s data sources would capture any rural P-contributions. Thus, these lands were removed from the size calculation of the T3 zones in those communities to avoid exaggerating their contribution.

STEP 2

The next step was to review the quality of secondary-source data, in terms of its comprehensiveness. The numbers used in this analysis came from the collaboration between the Lake Simcoe Region Conservation Authority and the Ontario Ministry of the Environment. Total phosphorus levels have been recorded since 1980. The contribution of various economic sources to this total were collected since 1990 from tributary streams, water pollution control plants (WPCP), atmospheric contributions, and small-polder vegetable growers in the Holland Marsh. Mathematical estimates of septic system contributions have been done since 1998. Tributaries were split into rural/agriculture (aside from the polders) and urban runoff/storm water beginning in 2002 (Lembcke et al., 2017; MOECC, 2017). More accurate modelling of atmospheric deposition began in 2011 (Haley, 2013).

The estimate of phosphorus for the 2009 start of the LSPP used a baseline period of 2002-2007. This five-year average was 72 tonnes and came from the following sources:

- **Urban** *23 tonnes*
- **Rural** *17 tonnes*
- **WPCP** *5.3 tonnes*
- **Polder** *3 tonnes*
- **Septic** *4.4 tonnes*
- **Atmosphere** *19 tonnes*

(MOECC, 2017)

As these are public agency figures, with data collection and mathematical modelling protocols, it was assumed that these numbers are reasonably accurate.

STEP 3

The next question was whether the data from these six economic sources could be disaggregated, and then reassigned to the six transect zones. Specifically, can sub-urban (T3) contributions be distinguished from genuinely urban sources (T4-T6)? Numbers from settlements and atmospheric contributions needed to be teased apart to be amenable to transect analysis.

Within the watershed, there are fifteen water pollution control plants which provide P-loading figures *(5.3 tonnes, 2009*)*. One is for a rural cheese factory and fourteen are for settlements. These were communities that have become large enough to warrant municipal treatment of sewage. The contribution of phosphorus from each WPCP was proportioned according to the T-zone found in that community.

**the available dataset for community WPCPs started with 2010; the percentage contribution of phosphorus from each community to the total WPCP figure was applied against the 2002-2007 five-year baseline average*

Step 4

Once this was done, the sum of P-loading figures from WPCPs in each T-zone was proportioned against the level of phosphorus from the "Urban" source *(23 tonnes, 2009)*. The result was then added to each T-zone's total.

Step 5

After that, the total amount of atmospheric contribution *(19 tonnes, 2009*)*, was assigned to each T-zone according to the percentage loading from several sources. The categories and their assigned T-zones were:

Agriculture, Aggregates, & Unpaved roads = T2

Construction & Paved roads = T3-T6, proportioned via the “Urban” source into T3, T4, T5, T6

Other = split between T2 & T3-T6

** the percentages derived by the 2011 modelling were used to proportion the 2002-2007 five-year baseline*

STEP 6

What remained were the economic categories that could be allocated directly. The rural *(17 tonnes)* and polder *(3.3 tonnes)* numbers were assigned to the “T-2 Rural” zone. The “T-3 Sub-urban” zone was allotted the septic figure *(4.4 tonnes)*, as it captured cottage or recreational development and home-building outside of settlement areas.

STEP 7

Finally, there was the ascribing of all the distinct P-loading data into the appropriate T-habitats. This was done by summing up the economic source numbers with the proportioned WPCP numbers plus the proportioned atmospheric numbers appropriate to each T-Zone:

Table 2: Phosphorus Sources across the Transect

Land Use Zones	Sources
T2	rural + polder + Silani* + unpaved roads + agriculture + aggregates
T3	septic + % WPCP (suburban) + % “urban” + % paved roads + % construction
T4	% WPCP (general urban) + % “urban” + % paved roads + % construction
T5	% WPCP (urban centre) + % “urban” + % paved roads + % construction
T6	% WPCP (urban core) + % “urban” + % paved roads + % construction

** Rural cheese factory*

The various dates of the available data sets were a concern, but the ones closest together were chosen to keep distortion as small as possible. With this in mind, 2010 is assumed to be the date best reflecting the results. Also, the percentage p-loading of each WPCP for that year was the basis for assessing the contribution from both the “Urban” and sewage plant sources to each T-zone.

STEP 8

To avoid merely testing the relative size of the T-habitats across the landscape, Barrie was chosen for a household-loading analysis. It is a city given its size, density, and population, with a “single-tier” administration. Though not completely within the Lake Simcoe watershed, it is the only municipality with all three urban habitats: T4, T5, &T6. Fortunately, these lie within the watershed boundary.

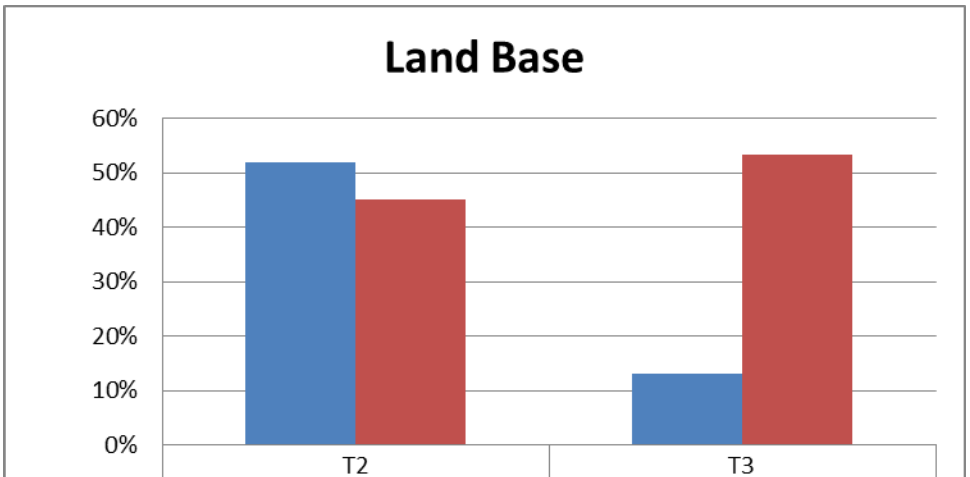
Household estimates were done by counting units from Google maps for the T4, T5, &T6 zones. The T3 estimate used the 2011 census population, divided by Barrie’s average household density of 2.7, and then subtracting the number of units in the T4, T5, & T6 zones. The tonnes of P for a particular T-zone in

Barrie were then divided by the number of households. For convenience, they were converted into grams / household.

Results

What these preliminary results reveal is that two habitats deposit virtually all the phosphorus loading into Lake Simcoe. The second largest is the "T-2 Rural" zone, with approximately two-thirds coming from agriculture and one-third coming from unpaved roads. The largest single contributor to phosphorus loading in Lake Simcoe is the "T-3 Sub-urban" zone. It is worth noting that rural uses represent 52% of the land and 46%* of the impacts within the watershed. On the other hand, suburban uses only represent 13% of the land base but contribute 53% of the impact.

Figure 3: Impact of Transect Habitats



	T2	T3
Area	52%	13%
Impact	45%	53%

**Actual impact = 45.45%*

While this study appears to confirm that the development pattern within the watershed is over 95% suburban, it is also true that urban development contributes less on a per household basis than does sub-urbanism. Using the City of Barrie as a case study, this initial examination shows that, for every household, suburbs contribute more than 6x the amount of phosphorus as does an urban core.

Table 3: Phosphorus loads across Transect ~ 2010

Land Use Zones	tonnes / year	%	tonnes / T3 to T6	%
Total	72*	100	39	100
T2	32.52	45.45		
T3	38.00	53.11		97.44
T4	00.34	0.48		0.87
T5	00.21	0.29		0.54
T6	00.12	0.17		0.31

**Actual total = 71.55 tonnes*

Figure 6: P levels in Lake Simcoe

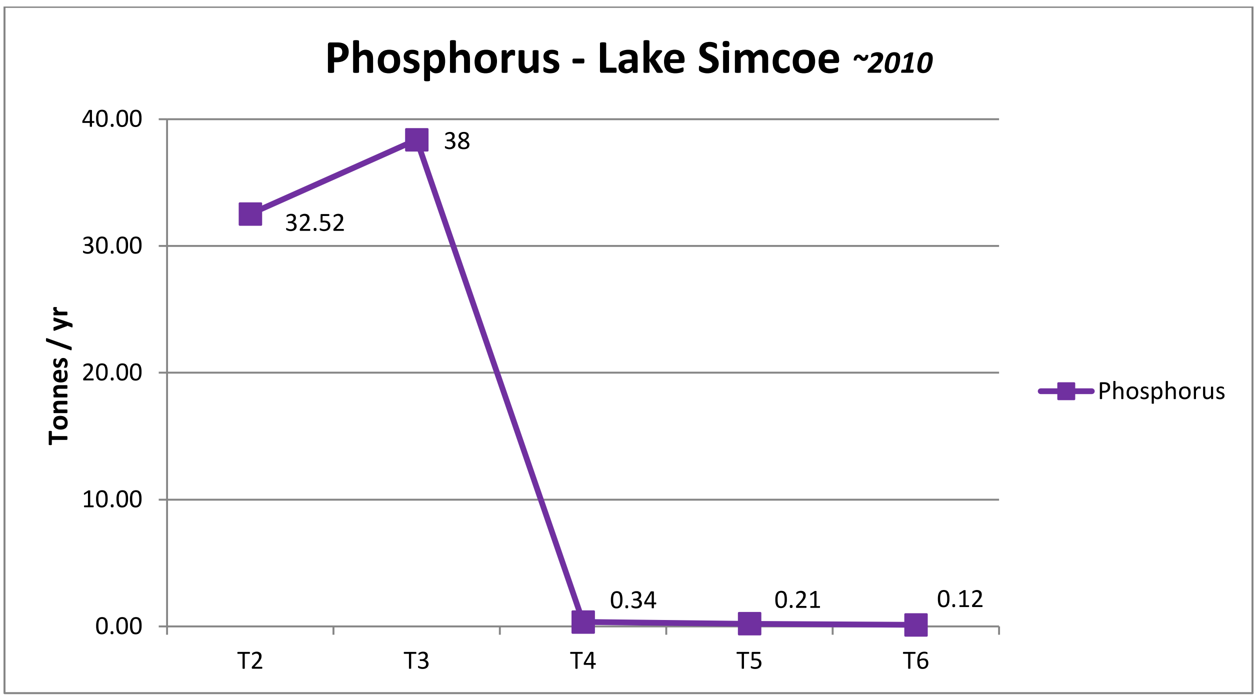


Table 4: Household loads across Transect

Land Use Zones	grams / household
T3	51
T4	35
T5	31
T6	8

Figure 7: Urban impact on Phosphorus levels

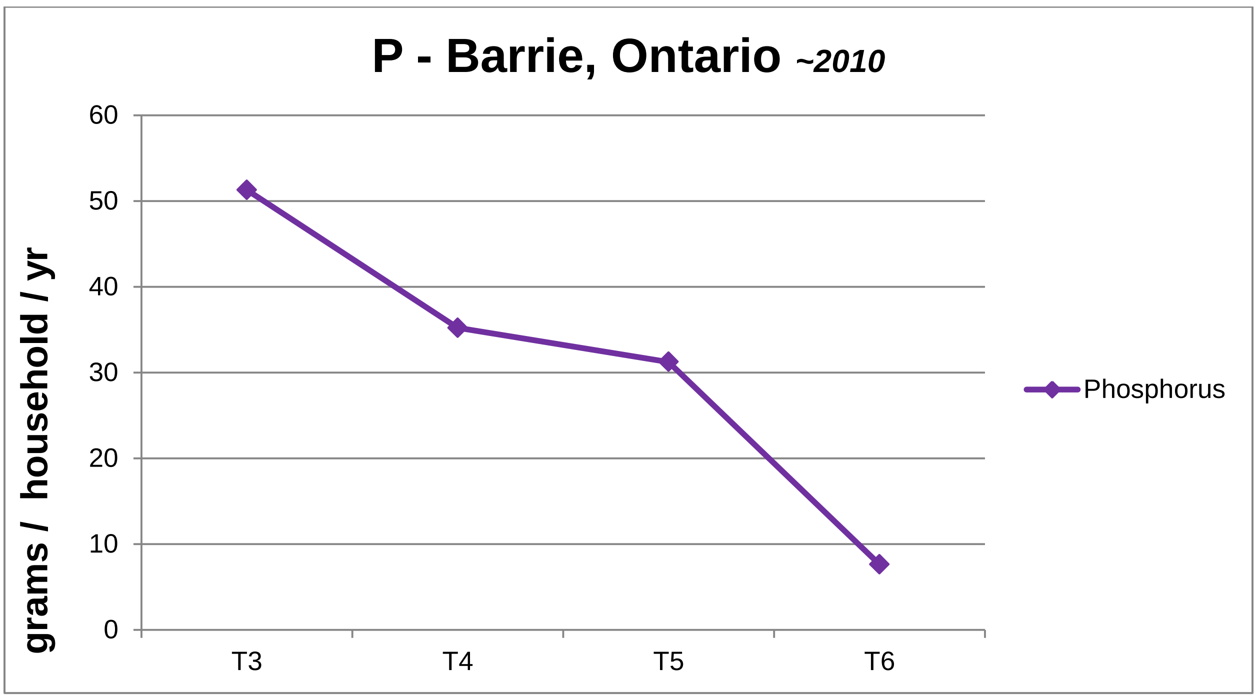


Table 5: Area Estimate

Lake Simcoe	Watershed		Land base	
Area	km^2	%	km^2	%
Total	330,741	100	258,600	100
T1	162,454	49	90,313	35
T2	133,445	40	133,445	52
T3	34,838.9	11	34,838.9	13
T4-T6*	3.1	--	3.1	--

**Includes Aurora & Newmarket* *(Calculations, 2018; Wilson, 2008)*

Discussion

While the deleterious effects of development are generally known, they are often obscured by the fact that development pressure is usually described as "Urban". This examination tested that assumption by using the Transect as an analytic tool. It revealed that not only do urban forms of development produce less phosphorus generally; the phosphorus-loading impact is lower, per unit, than for sub-urban forms of development. Though the Smart Code does make an allowance for healthy T-3 sub-urban patterns, it calibrates the range at 10-30 % area coverage of a municipality (Duany et al, 2012). In the fourteen communities studied, however, it exceeds 90%. Does this surplus constitute sprawl? This preliminary analysis suggests that concentrating growth according to the Transect is better than fostering a conventional development pattern. If so, does the failure to distinguish between urban and suburban undermine policy at its foundation? Perhaps phosphorus loading is simply one of the symptoms.

This distinction is not insubstantial, as the urban contribution to P-loading is essentially nil. It could be argued, of course, that this is because no genuine urbanism is currently being built. Based on the P-loads released from built areas (T3-T6), the urban portion of these areas represents approximately 1.7% of the land coverage for those communities examined. This is in keeping with other assessments of Ontario downtowns as comprising a mere 1-3% of most municipalities (Madi, 2018).

In contrast to these established parts of the watershed's towns and cities, almost all of the remaining development can be described as ***sub***-urban by virtue of its function, character, and structure (Duany et al, 2012). Some of this would be the T3 innate to the traditional patterns of settlement. Conversely, the post-WWII growth displays the "single-use, disconnected… auto-oriented… agglomerations" described as sprawl (Tachieva, 2009). Does this make sub-urban equivalent to sprawl? Perhaps a better question is whether sprawl represents the "shadow side" of T3, which has begun to infect other parts of the Transect. If viewed through a "G5" Sector lens (Tachieva, 2009), the sub-urban form typical within the watershed used to be the rural subdivision (S-3), the industrial park (S-7), the shopping strip and the mall (S-6 & S-8). In response, the Provincial government has encouraged development that is more compact. Yet, the resulting forms are now characterised by the single-family subdivision (S-4), punctuated by an occasional multi-storey building (S-5), the "big-box" shopping centre (S-6), and the academic or commercial campus (S-7); connected by sprawl-type thoroughfares. All more compact, but just as sub-urban.

Such distinctions are easily glossed over. Occasionally, Provincial and municipal plans inadvertently lapse into oxymoronic phrases regarding the need to curb "urban sprawl". This exact phrase was used in the proposed *Growth Plan for the Greater Golden Horseshoe, 2016*, which encompasses the entire watershed. Such usage is unfortunate, since it muddles the policy issue. It ignores built form that is both compact and urban as a primary method of addressing such problems.

Currently, a regional government proposes to construct a sewage treatment plant to cope with development pressure. The local First Nation has objected to the expansion of inevitable environmental impacts that it has not been consulted about. The sewage treatment will be state-of-the-art, and phosphorus-reduction technology will be employed. But this "secondary" approach will, once again, ignore urbanism as "technology" that could solve underlying sub-urban development patterns that foster an expansion of P-loading to begin with.

In recognition of development pressures, the Phosphorus Reduction Strategy (MOECC, 2017) does give weight to "Low-Impact Development"; a suite of "tertiary" interventions such as: green roofs and permeable pavement, perforated pipes and bio-retention, rain harvesting and rain gardens, soak-ways and swales, downspout disconnections, etc. as potential solutions to P-loading (LSRCA, 2018b). These are not dissimilar to the raft of techniques outlined by Tom Low (2009), though not as comprehensive, nor linked to specific T-zones. While such strictures for poorly performing sub-urban design are a necessity, they are not a substitute for a genuine urban structure. In this case, the unabated phosphorus contribution of urban (T4-T6) areas could be increased tenfold and it would still be less than half of the current contribution from the sub-urban (T3) areas of the watershed.

Recently passed legislation, Bill 139, by the Ontario Government (LAO, 2018) is similarly hobbled. Though largely administrative in nature, amending the *Planning Act*, the *Conservation Authorities Act*, *City of Toronto Act*, etc., to help implement the *Local Planning Appeal Tribunal Act, 2017*, it also contains language regarding climate change goals, objectives and actions. It gives priority to municipal plans that emphasize transit areas and density. While this "quaternary" attention to such priorities is noble, without an equal emphasis on urbanism (walkability, connectivity, mixed-use, diversity, quality architecture, etc.; DPZ, 2002) the result may still be characterized as sprawl; high-density sprawl, sprawl serviced by transit, but sprawl nonetheless (Duany, 2008).

Needed Refinements

Improving the methodology would involve ground-truthing the T4-T6 habitats. Aside from personal visits on previous occasions to some locations, no systematic delineation of the T-zones was possible in this preliminary assessment. Thus a conservative approach was used, largely restricting T4-T6 zones to established neighbourhoods. Thorough site-visits may reveal sections of older T3 neighbourhoods that could be assigned to a higher T-zone. Most new areas were considered T3, but might be worthy of inclusion in other transect habitats.

An accurate counting of the population within each T-zone would also allow for the portioning of the data into grams / household across the watershed. Though precise numbers even just for the case study would confirm or falsify the current results.

Another limitation to this approach is that two significant settlements, the Towns of Aurora and Newmarket, have their sewage exported out of the watershed. Since the contribution of phosphorus from each settlement to each T-zone was based on the percentage of every sewage treatment plant within the watershed, this could represent a distortion in the data. While this part of the P-loading generated from within the watershed has been removed, other impacts have not, e.g., surface runoff. In effect, these impacts were assigned to other municipalities. The size and characteristics of the T-habitats of these two communities are also not part of this assessment. That noted; the essential methodology is presumed to remain sound as all known impacts within the watershed are accounted for. It is assumed that while the additional numbers would increase the total phosphorus, the inclusion of the T-zones from these two Towns would not radically alter the distribution across the Transect. It would, however, help confirm or deny these assumptions.

Conclusion

This preliminary work indicates:

1. The Rural-Urban Transect can be transcribed across an area as large as a major watershed if the urban portion is restricted to the community scale.

2. Variations in phosphorus loading can be mapped according to the Rural-Urban Transect.

3. Differences in environmental impacts are revealed by the Rural-Urban Transect.

4. The Rural-Urban Transect could potentially be used to direct land-use and environmental policy.

Though corroborating research should be done, the initial findings strongly suggest that the development patterns we choose do have an impact on the health of ecosystems. The Lake Simcoe watershed is currently being affected by such choices. The legislation undergirding the Lake Simcoe Protection Plan has mandated a ten-year review. It may be wise to include a process to determine whether the land-use plans regulating the watershed are adequately supporting development that is urban rather than sub-urban.

Sources:

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