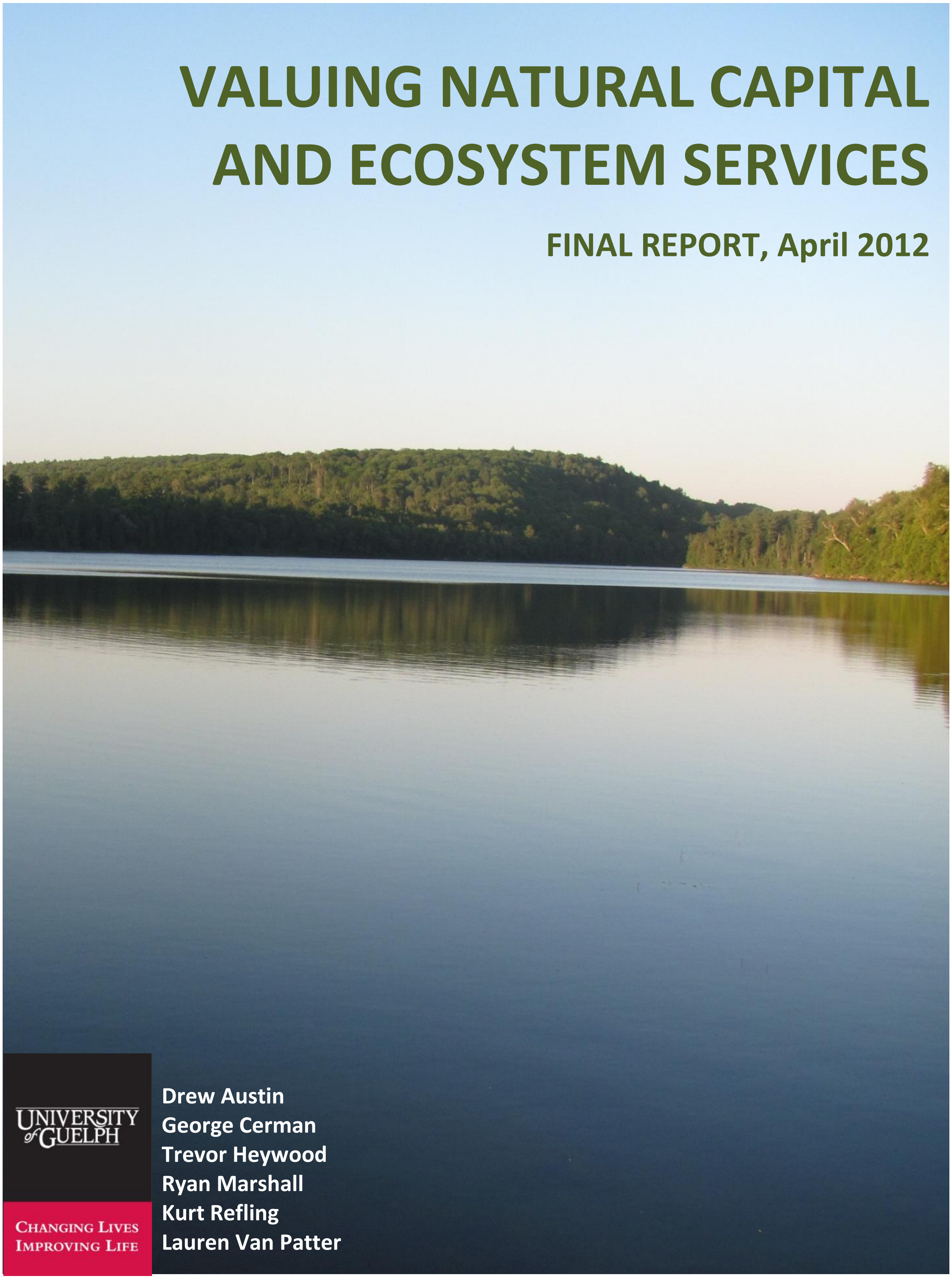

VALUING NATURAL CAPITAL AND ECOSYSTEM SERVICES

FINAL REPORT, April 2012

UNIVERSITY of GUELPH
CHANGING LIVES IMPROVING LIFE

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VALUING NATURAL CAPITAL AND ECOSYSTEM SERVICES

FINAL REPORT

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Prepared for:

Muskoka Watershed Council

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Muskoka Watershed Council
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Bracebridge, Ontario, Canada

Dear Mr. Milligan and Ms. Brouse,

Subject: Valuing Natural Capital and Ecosystem Services Proposal

The Environmental Sciences Ecosystem Valuation Group is proud to present our final report on the valuation of natural capital and ecosystem services in the Muskoka River Watershed and northern portion of the Black River – Lake Simcoe Watershed.

The 20 sub-watersheds that make up Muskoka River Watershed and northern portion of the Black River – Lake Simcoe Watershed have a permanent population of 55,000 and seasonal population of 100,000. It is therefore important to properly assess the economic value of the natural capital and ecosystem services that this area supplies.

While we have undertaken valuation work specifically, we also discussed the application of our valuations to policy and planning work that the Muskoka Watershed Council could undertake in the future. We hope you find this information helpful in providing guidance.

It was a pleasure to conduct this research for you. We trust this report meets your needs.

Sincerely,

Environmental Sciences Ecosystem Valuation Group

Drew Austin	George Cerman	Trevor Heywood
Ryan Marshall	Kurt Refling	Lauren Van Patter

ACKNOWLEDGEMENTS

First and foremost, we wish to thank Rob Milligan and Judi Brouse of the Muskoka Watershed Council for providing us with valuable feedback and resources throughout this project. Without this assistance, much of the project would not have been possible. Secondly, we wish to recognize Dr. Shelley Hunt, course coordinator, in providing us with guidance on conducting this research project. This is a first time experience for most of us, so her instruction was crucial to completing the necessary material, and properly organizing our time. Lastly, we wish to thank Adam Bonnycastle for providing us with guidance on using ArcGIS.

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1.0 EXECUTIVE SUMMARY

This report provides information and details the process used in the valuation of natural capital and ecosystem services in the Muskoka River Watershed and the northern portion of the Black River–Lake Simcoe Watershed. This region is home to many permanent and seasonal residents, and is supported by recreation and tourism industries. The natural environment is recognized as the biggest draw to the region, so the understanding of natural capital and ecosystem services is vital.

In Section 4.0 of our report, background information that informed our understanding of this area and assisted in the development of our study methods is presented in a literature review. This literature review also discusses the importance of environmental valuation, and provided a clear understanding of what is required to obtain values. It further addresses the value paradigm of marginal versus absolute valuation, discusses intermediate goods in environmental valuation, provides examples of frameworks and related case studies, and summarises several criticisms of commonly-used valuation methods. In Section 6.0, the methods used to generate values for a select number of ecosystem services in Muskoka are discussed, and justified. The decisions for the types of land-cover, as well as the selected ecosystem services are explained. The use of a value transfer technique through a literature review is also discussed.

In Section 7.0, our results are presented with the assistance of many tables and figures. Ecosystem service values were applied with the aid of Geographic Information System (GIS) to visually display the total monetary benefits of ecosystem services for different land-cover types per annum in the Muskoka River Watershed and the northern part of the Black River–Lake Simcoe Watershed. Finally, in Section 8.0, our results are discussed in the context of their applicability to the Muskoka region. The limitations of this study are identified, as well as recommendations for future research initiatives outlined. The use of these results or the results of future studies are framed in the context of a biodiversity strategy, contribution to existing research conducted in the region, and the priorities of Muskoka in general.

2.0 INTRODUCTION

The District Municipality of Muskoka is located two hours north of Toronto in what is considered central Ontario. The landscape of Muskoka consists of lakes surrounded by rocky shoreline as well as forested landscapes. The landscape of the region is characterised by 94% vegetation cover. This high percentage of natural landscapes, along with the close proximity to southern Ontario, makes it an extremely popular location for outdoor recreation. Presently, The Muskoka River Watershed and the northern portion of the Black River–Lake Simcoe Watershed is home to approximately 55,000 permanent residents and approximately 100,000 seasonal residents. As a result of Muskoka's environment, tourism and recreation serve as primary contributors to the regional economy. Consequently, the maintenance of the natural environment is important for intrinsic as well as economic benefits.

The economic benefits provided by ecosystems are difficult to capture for several reasons, including their inherent difficulties associated with defining the values, as well as ascertaining values after a definition has been agreed upon. The primary reason ecosystem services are difficult to define is due to evolving views on the environment over time. In 1997, Costanza *et al*. provided the following definition of ecosystem services: the interaction of human capital (machinery, various technologies) with natural resources. Consequently, the final value of ecosystem services equates to the amount of money it would take to replace the services provided by the natural biosphere with an artificial biosphere (Costanza *et al.*, 1997). This definition largely operates on a marginal basis. That is, the value of a service is looked at in a traditional economic sense: the change in value associated with increasing or decreasing a specific variable. In the context of this report, this would mean the value of a specific ecosystem service, such as erosion prevention, is conceptualized as the value associated with increasing or decreasing a unit-area of a particular ecosystem which provides that service, such as wetlands. Furthermore, in classical economic theory, marginal values tend to be diminishing. That is, each additional hectare of wetland will yield less benefit than the previous. Establishing such a value, however, is extremely difficult to accomplish in both novel research and the value transfer methodology we employed in this study. Value transfer will be discussed in more depth in Sections 6.0, Materials and Methods, and 8.0, Discussion.

In 2007, Boyd and Banzaf challenged the above-stated definition of ecosystem services. Instead of the marginal view provided by Costanza *et al.* (1997), Boyd and Banzaf argued that ecosystem services should be valued as absolutes, and not on a margin. To this end, Boyd and Banzaf (2007) provided the following definition: "components of nature, directly enjoyed, consumed, or used to yield human well-being". This particular definition estimates ecosystem service values based on what is present and does not attempt to assign marginal values for services. That is, increasing the area of a wetland from one to two hectares will increase the value by the same proportion as increasing the area from one-hundred to two-hundred hectares.

For this report, the definition provided by Boyd and Banzaf (2007) is used to determine values for various ecosystem services. The above-stated definition was specifically chosen for this report for several reasons. Firstly, from a theoretical point of view, computing marginal values for ecosystem services is immensely difficult for novel research and practically impossible from a value transfer approach as most studies *do not* report marginal values. Secondly, from a practical point of view, it was much more efficient to treat the dollar values we obtained as constants for the purposes of generating final values as well as using ArcGIS to generate a dollars per hectare ($/ha) map (see Figure 2). For a graphical representation of diminishing marginal values and constant values, see Figure 1 below.

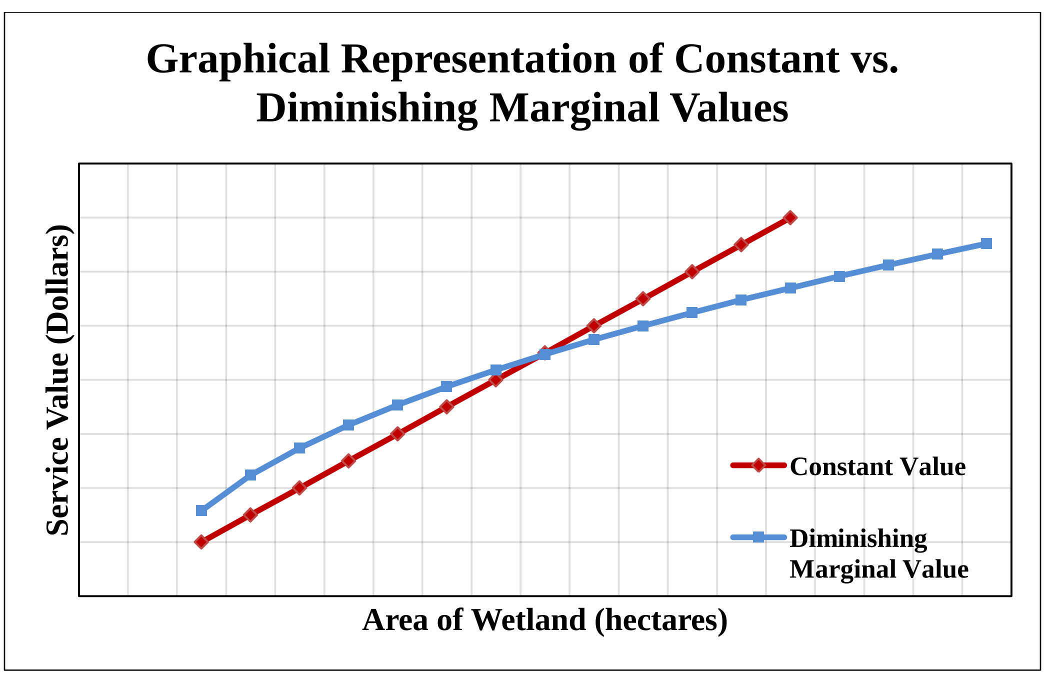

Figure 1: Graphical representation of constant versus diminishing marginal values.

The difficulty in obtaining specific values for ecosystem services is primarily a methodological problem. Carpenter and Wilson (1999) provide several methods that can be used to obtain novel values: travel cost, hedonic pricing, and contingent valuation, which will be discussed more in-depth in Sections 4.0, Literature Review, and 8.0, Discussion, of the report. Travel cost and hedonic pricing assign economic values based on market prices of related private goods (i.e. water filtration is valued based on prices of bottled water), while contingent valuation relies on an honest completion of willingness to pay (or willingness to accept) surveys (Carpenter and Wilson, 1999). Our report, however, does not rely on using the above methods to obtain novel values. This is due to issues of high financial and temporal resources required to undertake these types of research, which were outside of the scope of our study. In contrast, we used an in-depth literature review to obtain values of various ecosystem services, and transfer them to Muskoka. The limitations of the value transfer methodology, as well as recommendations for future analysis are provided in Section 8.0, Discussion, of the report.

3.0 REPORT ORGANIZATION

The report begins with an extensive literature review which provides background information pertaining to various studies that explore ecosystems valuations. There is then a discussion of the goals and objectives of our research and a comprehensive discussion of our materials and methods. Following the presentation of our results, there is an in-depth discussion which explores the following topics: data limitations, areas of future studies, and potential areas of data application. The conclusion summarises our findings and provides final considerations.

4.0 LITERATURE REVIEW

4.1 Value Paradigm: Marginal versus Absolute Valuation

While ecosystem goods often have market value, ecosystem services are traditionally hard to define. A definition provided by Costanza *et al.* (1997), discussed in the introduction, states the following: ecosystem services are defined by the interaction of human capital (machinery, various technologies) with natural resources. The value of the ecosystem service, according to Costanza *et al.*, is the amount of money it would take to replace the services provided by the natural biosphere with an artificial analog. Due to the inherent difficulties of quantifying the replacement costs of these services, they assert that asking for an absolute value of a specific ecosystem service is fundamentally flawed. Alternatively, they suggest that a more relevant question is what impact a change in quality and/or quantity of a specific ecosystem would have on human welfare. This idea of measuring change in value is referred to as marginal valuation, and is one of the two opposing ideas about the role that valuation should play. Costanza *et al.* (1997) went on to synthesize several studies and presented a (rough) starting estimate for the total value of all ecosystem services present on earth.

In a paper by Boyd and Banzaf (2007), the definition of ecosystem goods and services proposed by Costanza *et al.* was opposed. They argued that the examining the marginal value of the change in quantity or quality of an ecosystem services is flawed, and that in order to be considered in valuation, values must be absolute, much like GDP (gross domestic product; a measure of the total value of final goods and services in a country), which is a metric that ecosystem services should attempt to emulate. This valuation role, referred to as absolute valuation, is the antithesis to the marginal approach. To demonstrate this point, Boyd and Banzaf (2007) define ecosystem services as “components of nature, directly enjoyed, consumed, or used to yield human well-being”. This, they assert, has several implications: ecosystem services must be final, non-market products. In this way, the aggregate of ecosystem services can be summed with GDP (market values) to create a metric for a “green GDP”. Mirroring the precedent set in standard GDP calculation, intermediate goods must not be included in calculations of ecosystem services, as this would present the risk of redundant values. As an example, if the value of wood and the chair it is used to make are both counted in GDP, the wood is counted twice: once in the transaction to the furniture manufacturer, and once in the cost of the chair being sold at the furniture store. The difficulties surrounding this distinction as it applies to ecosystem services are discussed in the following subsection.

While our report finds the criticisms of Costanza *et al.* (1997) valid, attempting to procure a marginal value for the change in the value of ecosystem services is rarely done. Because of this, our process of reviewing studies in order to identify values would be difficult, if not impossible, if we took a marginal valuation approach. As a result, we have opted to use an absolute valuation approach.

4.2 Intermediate Goods in Environmental Valuation

The specification that GDP must be a tally of final, not intermediate goods and services is something which has similarly large impacts for ecosystem values, but in a much more complex manner. To illustrate this, Boyd and Banzaf (2007) use the following example which pertains to angling: fishing itself is a final product of an ecosystem, composed of market and nonmarket goods and services. Scenic vistas near bodies of water could be considered intermediate, but are ecosystem services, as are the resident fish and the body of water. The boat, angling materials, and fishing license are not ecosystem services, having market value, but would be erroneously tallied if fishing itself was seen as an ecosystem service. This specification, they assert, is key in differentiating between intermediate goods and final non-market "products", all of which hinges on what qualifies as an ecosystem service. If this appears convoluted or difficult, that is because it is: the struggle over what to include in trying to measure the value of natural areas often contradicts itself. While Boyd and Banzaf (2007) specify the importance of mirroring GDP, their attempt to find the total value purposefully targets intermediate values, ignoring the final market-based products of the non-market ecosystem services.

In response to these contradictory concerns over ecosystem valuation, our analysis has opted to consider both market-based recreational vectors of the value of ecosystem services (ex. hunting, fishing) *and* the more direct measures of non-market services (ex. climate regulation, water filtration), calculated separately in order to get a more clear idea of what values surround Muskoka's environment. Comparing these results also granted a perspective of the discrepancies between recreational embodiments of *in-action* valuation and the more abstract methods by which ecosystem services are tallied: as we see in later sections, market-based recreational values are insignificant compared to the non-market ecosystem service values of the same area.

4.3 Examples of Frameworks and Related Case Studies

Our framework for determining the value of ecosystem services is by no means the only one which has been used. This subsection aims to show some alternative frameworks that have been used in evaluation as a means of establishing the practices in the field.

Kremen (2005) concedes the importance of Costanza *et al.*'s view that trying to establish an absolute value for a given ecosystem service is difficult by demonstrating the complexity of such a task. As a result, Kremen establishes a framework which recommends the compartmentalization of systems. An in-depth four step system is presented:

- Determine which components of ecosystems are key service providers and develop their functional relationships.
- Establish community structures and their influence on services.
- Determine key environmental aspects which influence the provision of services.
- Attempt to establish a spatiotemporal understanding at which specific service providers operate.

It would be challenging to apply this framework on a global scale, because it requires the knowledge of surrounding communities and their interactions with the ecosystems being examined. This model would be much simpler to apply locally, and has been by the case that follows.

An example of the above process is demonstrated by Brauman *et al.* (2007) with respect to the value of hydrologic systems, which they define as the surface and groundwater within the same drainage basin. Brauman *et al.* (2007) highlight the important fact that water—and therefore its economic valuation—is contingent on the ecosystem. That is, the value of fresh systems (i.e. freshwater systems) is a function of the ecosystem through which the water flows. Consider water flowing through a large amount of vegetation: in this context the value derived from the hydrologic system can be estimated through active flood prevention and an increase in water quality due to filtration effects of root systems. Conversely, if one's aim is to greatly increase the quantity of water flowing through an area, the surrounding vegetation would be less valuable as it slows down water flow. In another demonstration of this context-specific valuation idea, Brauman *et al.* (2007) discussed the concept of diminishing marginal values of ecosystem services. That is, the value provided by an additional litre of water at low levels is significantly higher than an additional litre of water at high levels. To some degree, this corroborates criticisms made in Boyd and Banzaf (2007): marginal valuation is difficult, if not impossible to apply to gain an understanding of value in ecosystems. These stipulations of the importance of context became very relevant to the synthesis of the report, and reinforced the need to clearly define and bear in mind objectives.

Because ecosystem services are not traded and sold in markets, there are significant questions raised as to how to best identify their values. Carpenter and Wilson (1999) identified three separate methods of valuation in their framework for analysis: travel cost, hedonic pricing, and contingent valuation. Travel cost and hedonic pricing methods assign economic value based on market prices of related private goods (i.e. value of water filtration services is estimated by prices of bottled water), while contingent valuation relies on communities honestly filling out "willingness to pay surveys": intuitively, these are questionnaires which ask how much a consumer would be willing to pay for that service. These "non-use" values, taken from data that doesn't come from markets, are more difficult to capture because they rely on potential future uses of the resource. Daily *et al.* (2009) state that the value of ecosystem services is generally greatly underestimated, and mirroring old adages, natural capital is generally only recognized after it's gone, as seen in the case of the after-effects of Hurricane Katrina. These issues of primary valuation methods are more thoroughly discussed in our Recommendations for Future Studies section.

Complexity of ecosystem valuations is further touched upon by Turner and Daily (2008). In their paper, several constraints of current valuation frameworks are identified. Namely, Turner and Daily acknowledge that in addition to the lack of information on ecosystem benefits, there also exists what economists refer to as an *externalization* of benefits. That is, the people who receive the greatest benefit from ecosystem services are often at odds with and, or far away from, the people who would stand to benefit from development. Furthermore, Turner and Daily bring up an interesting problem with large scale conservation efforts. Although large scale prevention of ecosystem destruction has net benefits, it also has large scale costs (Turner and Daily, 2008). The costs, however, are incurred locally (say, within a nation, refraining from clear-cutting a section of rainforest for farming purposes) while producing a global benefit. That is, a small portion of the world is paying a large price for the benefit of everyone, leading to equity and rent-seeking concerns. While the net benefit is great, for both the present and the future, there is very little to no incentive to forgo the present day revenue generated for ecosystem alteration by local governments that generally govern land use.

One can attempt to resolve these issues of temporal and spatial benefit disconnects by emphasizing the need for compromise (Farber *et al*., 2006). Farber *et al.* (2006) begin their attempt at a resolution by acknowledging the need for additional information on the trade-offs people are willing to make. Additionally, they establish another framework, by presenting two ways to analyze ecosystem services: costs of management options (the traditional economic approach) and sustainability analysis, which takes on more of the ethical argument. These approaches are not necessarily at odds. In fact, Farber *et al.* (2006) argue the two methods should be used in tandem; they advocate one should use management methods while using sustainability and other ethical considerations as constraints in the model. That is, use conventional economics which satisfy any moral obligations towards the future.

In a framework very relevant for the literature review process which we have used, Troy and Bagstad (2009) provide a method of using established values and applying them in local policy decisions. This method, known as spatial value transfer, takes values established from the several of the aforementioned methods and uses them to value local ecosystem services with similar contextual factors. In an analysis of integrating the valuation of ecosystem services into public policy, Cowling *et al.* (2008) establish that the analysis must be done in three stages:

1. Social assessments must be done. This consists of an examination of the local human population likely to be affected by any policy changes, in addition to the value in use or non-use of the ecosystem services.

2. The biophysical environment has to be characterised in order to determine the nature, quantity, and quality of ecosystem services being provided.

3. These are later converted into values and summed in the third and final part of the analysis, value assessment.

This step-by-step process mirrors the proposed approach to cost-benefits analysis outlined by Boardman *et al.* (2011): first, standing must be established. This is analogous to the social context which Cowling *et al.* (2008) assert has to be defined. Boardman *et al.* (2011) go on to detail a nine-step process by which a cost-benefit analysis may be conducted. Converted to apply to valuing a single non-market service, the approach advocates determining values, discounting future benefits to reflect human time preference, summing the values, and performing a sensitivity analysis to assure (or criticize) the validity of the values chosen based on uncertainty.

4.4 Criticisms of Valuation Methods

In light of the contradictions and challenges which come with the valuation process, many researchers have presented criticisms. Chee (2004) expresses concerns for many of the methods advocated by the papers in the preceding literature review. Fungibility, or the ability to substitute between different kinds of benefits, is an assumption fundamentally made by translating ecosystem services into monetary values. This substitution assumption, or valuing at the cost of replicating a service as proposed by Costanza *et al.* (1997), fails to account for the interconnectedness of ecosystem services. If the value of wetland-filtered water is equivalent to the price it would require to process water for quality, all other benefits dependent on this water would be unaccounted for and ignored. Indeed, irreversibility is an issue of high concern: if an ecosystem's values are complex and entwined such that it cannot be replaced or replicated after the death of the ecosystem, how can a value be assigned? Chee (2004) further proposes that values dependent on consumer awareness are fundamentally flawed as well. This is because the amount a consumer is willing to pay for an ecosystem can be based on a lack of awareness of the functions that ecosystem performs. The cost an individual spends travelling to a national park is not a good metric for determining value either, as psychological reports suggest it is unlikely they have factored the inherent and complicated benefits ecosystems provide into their decision. Regardless of these concerns, Chee (2004) maintains that valuing ecosystem services can present valuable uses in policy decisions. Farber and Howarth (2002) reach a similar conclusion: while the steps that have been taken non-market valuation particularly in the methods used by Costanza *et al.* (1997), are open to criticism, the concept for valuation of ecosystem services is strong, and the need for it is great. Faced with a world in which concrete values are more and more necessary in bringing about change, we are inclined to agree.

5.0 PROJECT OBJECTIVES

Natural ecosystem processes provide many benefits to individuals and communities. However, due to the difficulty in obtaining true values—as discussed above—ecosystem services are generally undervalued or omitted entirely from decision-making processes. This can lead to insufficient protection of natural ecosystems and the erosion of ecosystem service provision. In order to prevent this slow degradation, the Muskoka Watershed Council (MWC) seeks to develop regional natural capital and ecosystem values. To this end, the objective of our project was to conduct an extensive literature review and obtain 2012 Canadian dollars values per hectare for several ecosystem services including, but not limited to, erosion prevention, flood prevention, atmospheric gas regulation, as well as recreational and tourism benefits of forests, open water, wetlands and pasture ecosystems. Subsequently, we were able to use the per hectare values in tandem with ArcGIS to determine a total value of non-recreational ecosystem services. Furthermore, through tourism data provided by the MWC, we were able to obtain the recreational values Muskoka's ecosystem services.

6.0 MATERIALS AND METHODS

Time and resources were serious limitations for this study. Therefore conducting original research in order to generate ecosystem service values was outside of the scope of this study. Gathering these data would have involved methods such as investigating replacement or avoidance costs, conducting surveys in a stated-preference approach, such as contingent valuation, or compiling data in a revealed preference approach, such as hedonic methods (Farber *et al.*, 2006). Each of these approaches would have been extremely costly and time consuming, and therefore were not possible in our study. In place of conducting original research, we used a value transfer approach to complete as in depth of an investigation as is possible over our study period. Value transfers are conducted through the execution of a literature review to quantify values that can be applied to an area based on valuation studies carried out elsewhere, and are a very common technique in this field (Brouwer, 2000; Kennedy and Wilson, 2009; Troy and Bagstad, 2009). Although there are issues with the applicability of values generated elsewhere to a new study area, value transfer was really the only option for a study with our constraints (Spash and Vatn, 2006).

As a result of the limited time available for this study, we also could not examine all ecosystem goods and services present within the watershed. Our first step was therefore a determination of the highest priority ecosystem goods and services. This was accomplished through communications with the client, as well as reviews of documents from The MWC, such as The Muskoka Watershed Report Card (MWC, 2007), and Strategic Priorities (The District Municipality of Muskoka, 2008). Through this research, we concluded that The MWC placed highest priority on several ecosystem services. These focus mostly on values other than direct-use values, which are defined as values associated with the direct use or consumption of a resource, such as timber or animal products (Kennedy and Wilson, 2009). It was determined that high water quality, atmospheric gas regulation, and habitat provision were some of the areas of highest importance. As a result, we decided to investigate the following eleven ecosystem services:

- Wildlife habitat;
- Freshwater supply (Filtration, retention & storage);
- Climate regulation (regional & local);

- Atmospheric gas regulation;
- Flood prevention;
- Erosion prevention;
- Pollination;
- Nutrient sequestration;
- Nutrient cycling;
- Aesthetic value; and
- Recreation/tourism.

The ecosystem goods and services that are provided by some discrete land area are a function of the type of ecosystem of which this land unit is comprised. Therefore, our study began by using ArcGIS software to determine land cover types so that we could begin associating the corresponding goods and services that each ecosystem type provided. These ArcGIS Land Cover files were obtained from the client, and were originally created by the Ministry of Natural Resources. The vegetative classification of the land cover data were divided into the following categories:

- Bedrock;
- Burns;
- Coniferous Forest;
- Cuts;
- Deciduous Forest;
- Mixed Forest;
- Open Bog;
- Pasture;
- Sand/Gravel/Mine;
- Settlement/Infrastructure;
- Sparse Forest;
- Treed Bog; and
- Water – Deep or Clear.

Out of these 13 categories, we first eliminated Bedrock, Burns, Cuts, Sand/Gravel/Mine, and Settlement/Infrastructure, as we considered these as either insignificant providers of our selected ecosystem services, or too difficult to locate relevant literature estimating the value of services provided by them. Furthermore, these uses only represented 3.39% of the total land cover examined, and therefore their exclusion would be insignificant. With the remaining seven, we decided that it was not realistic within the scope of this study to examine Coniferous, Deciduous, and Mixed Forest types separately, so we combined these three categories into one Forest category. We also merged Open Bog and Treed Bog into a Wetland category, as there are few studies in the literature which separate wetland types in quantifying ecosystem service values. We were therefore left with five categories:

- Forest;
- Sparse Forest;
- Water – Deep or Clear;
- Wetland; and
- Pasture.

Our next step was to associate the land cover types with the ecosystem services they provide. We did this through reviewing current literature, especially case studies of projects similar to this. We produced Table 1, which was modified from a paper by Vihervaara *et al.* (2010). We quantified each land cover type with respect to its capacity to provide ecosystem services as 0, 1, or 2, meaning not important, somewhat important, and very important, respectively. Our goal in doing this categorization was to determine how much effort to expend in locating ecosystem service values for that land cover type in the literature. We decided to expend a lot of time and effort searching for applicable values for any land cover type quantified as a “2” for a service, less time for a “1”, and did not search for values for relationships quantified as “0”. The outcome of this analysis is presented in Table 1 below. We also reviewed value transfer methods in order to ensure we minimized potential transfer errors.

Table 1: Capacity of the five selected land-cover types to provide the eleven selected ecosystem services; 0 = not important provider; 1 = somewhat important provider; 2 = very important provider. Modified from Vihervaara *et al.* (2010).

Service Type	Service	Forest	Sparse Forest	Open water – deep/clear	Wetland	Pasture
Provisional	Wildlife habitat	2	1	1	1	1
	Freshwater Supply	1	0	2	2	0
Regulating	Climate regulation	2	1	2	2	0
	Atmospheric gas regulation	2	1	1	2	1
	Flood prevention	1	0	2	2	0
	Erosion Prevention	2	1	0	0	0
	Pollination	1	0	0	2	2
	Nutrient Sequestration	1	0	1	2	2
Supporting	Nutrient Cycling	2	1	1	1	2
Cultural	Aesthetic value	2	1	2	0	0
	Recreation & Tourism	2	1	2	0	0

In reviewing the transfer literature, we determined that we should treat the value of direct use recreational services, such as nature parks, boating, fishing and hunting, as separate from the provisional, regulating, and supporting service values. This was for several reasons. Firstly, there were time limitations that constrained us, and original research of firms that provide recreation in Muskoka would have been very time consuming. Secondly, ecosystem valuation of recreation and tourism services could be easily taken from analysis of Statistics Canada data provided to us by the Muskoka Watershed Council. This microdata was collected from the Travel Survey of Residents of Canada and the International Travel Survey, and subsequently prepared for the Ontario Ministry of Tourism and Culture (2010). While this was not in an area based format, it was considered to be more relevant since it was specific data for the Muskoka region, and tourism and recreation is not spread equally over the land cover area examined. Our cultural values were derived from spending on recreation within Muskoka. This data is presented in Table 3.

Our value transfer approach through a literature review was largely based on the methods used in two similar studies from Ontario. These studies are Kennedy and Wilson's (2009) "Natural Credit: Estimating the Value of Natural Capital in the Credit River Watershed" and Troy and Bagstad's (2009) "Estimating Ecosystem Services in Southern Ontario". In order to gather research that was most applicable to our study area, we used the Environmental Valuation Reference Inventory™ (EVRI™). EVRI™ is an online database of peer reviewed articles from around the globe that pertain to environmental benefits transfer (DeCivita *et al.*, 2011). The database was created by Environment Canada in conjunction with the United States Environmental Protection Agency, and enables researchers to locate studies that are similar in terms of study area and environmental focus in order to create value transfers that are as applicable as possible (DeCivita *et al.*, 2011). We also used other scientific literature internet search tools, such as Google Scholar.

All group members reviewed the literature separately to find ecosystem service values identified in Table 1, and many values were located from a broad range of current scholarship. We aggregated all values we located separately onto one Excel spreadsheet. Often there were multiple values that had been identified for some of these services. We deliberated as a group to determine which value would be most relevant, depending on the conditions identified in the literature. For example, values that were applicable to southern Ontario were given preference over values for US or global forests. Many of our values were transferred from a study by Wilson (2008) in the Lake Simcoe basin, which is immediately southwest of Muskoka, and therefore very similar ecologically. Some of our other values had to be transferred from studies in New Jersey (Costanza *et al.*, 2006), Southern Ontario (Troy and Bagstad, 2009), or even, in a few circumstance, globally (Costanza *et al*., 1997.)

In aggregating these values in the spreadsheet, we employed several transfer decision rules adapted from the study by Kennedy and Wilson (2009). In summary, the following protocols were followed: ensuring the original unit-values of estimates were maintained, ensuring original ecological context of the value estimate were maintained, adjusting values from other countries to Canadian dollars based on the exchange rate of the year of the study, and adjusting all values for inflation to 2012 Canadian dollar values. By following all of the above-described methods, we ensured that the values generated through value transfer are as applicable to the Muskoka region as possible. In order to make adjustments to measure ecosystem values in 2012 Canadian dollars, the most relevant unit for this project, conversions were undertaken in a systematic manner. First, one value was converted from dollars per acre to dollars per hectare, the common unit used for all ecosystem service values. Second, any values in United States dollars were converted to Canadian dollars before being adjusted for inflation. This captured the present value of the ecosystem service to Canadians in the year that the literature review was conducted. Third, the values were adjusted for inflation using measures of the 'core' Consumer Price Index (CPI) in Canada, as measured by Statistics Canada (2012). 'Core CPI' (CPIX) is the CPI that disregards the measure of eight of the most volatile components (fruit, vegetables, gasoline, fuel oil, natural gas, mortgage interest, inter-city transportation and tobacco products), and the effects of changing indirect taxes on the remaining components. The Bank of Canada uses CPIX to "look through" temporary changes in inflation and focus on underlying trends (Bank of Canada, 2012).

The exchange rates used were annual averages measured by the United States Department of the Treasury, or the Bank of Canada. CPIX data from 1995 to 2011 was retrieved from a customized version of CANSIM table 326-0021, which was manipulated on the website for Statistics Canada (2012). This merely required the manual selection of different items as follows:

Step 1: Geography – Canada

Step 2: Commodities and commodity groups – "All-items CPI excluding eight of the most volatile components (Bank of Canada definition)"

Step 3: Time Frame – January 1994 – January 2012

Step 4: Output (not relevant)

All values for unit conversions, currency Exchange rates, and inflation rates are summarized in Table 2. The currency conversion rates for 1994, used to calculate an average annual rate, are presented in Table 3. The finalized ecosystem service values, in 2012 Canadian dollars per hectare, were then applied to GIS data provided to us by The MWC. A table containing data on land cover and area was retrieved using ArcGIS, and subsequently exported to Excel for easier manipulation and analysis, due to the technical limitations of the group members. After adding up the total land area in hectares for each type of land cover, it was multiplied by the ecosystem value per hectare (if applicable) to calculate the total value each type of land cover contributed. This was tallied on the recreation and tourism values, to give aggregate valuations of ecosystem services in the Muskoka River and Black River–Lake Simcoe watersheds.

Table 2: Conversion rates for ecosystem values.

Unit Conversions[a]			
Unit	**Acres**		**Hectares**
Value	1	=	0.404685642
Exchange rates			
Year	**CAD**		**USD**
1994[b]	1.366427092	=	1
2004[c]	1.30152024	=	1
Inflation Rates[d]			
Date	**CPI (2002=100)**	**% Change from Previous**	**% Change to 2012**
Jan-94	86.1	-	36.93%
Jan-95	87.8	1.97%	34.28%
Jan-96	89.3	1.71%	32.03%
Jan-97	91.2	2.13%	29.28%
Jan-98	92.6	1.54%	27.32%
Jan-99	93.4	0.86%	26.23%
Jan-00	94.6	1.28%	24.63%
Jan-01	96.3	1.80%	22.43%
Jan-02	98.1	1.87%	20.18%
Jan-03	101.3	3.26%	16.39%
Jan-04	102.8	1.48%	14.69%
Jan-05	104.5	1.65%	12.82%
Jan-06	106.2	1.63%	11.02%
Jan-07	108	1.69%	9.17%
Jan-08	108.9	0.83%	8.26%
Jan-09	110.8	1.74%	6.41%
Jan-10	113	1.99%	4.34%
Jan-11	115.3	2.04%	2.25%
Jan-12	117.9	2.25%	-

[a] According to Google Calculator, February 2012
[b] Calculated as an average of all daily exchange rates in 1994. US Department of the Treasury.
[c] Bank of Canada.
[d] Based on "All-items CPI excluding eight of the most volatile components (Bank of Canada definition)". Statistics Canada CANSIM Table 326-0020

Table 3: Canada to U.S. dollar conversion rates, 1994.[a]

Date	Rate	Date	Rate	Date	Rate	Date	Rate	Date	Rate	Date	Rate
3-Jan-94	1.3155	8-Mar-94	1.3573	11-May-94	1.3781	14-Jul-94	1.382	16-Sep-94	1.3515	21-Nov-94	1.3669
4-Jan-94	1.3173	9-Mar-94	1.3522	12-May-94	1.3808	15-Jul-94	1.379	19-Sep-94	1.3517	22-Nov-94	1.3762
5-Jan-94	1.318	10-Mar-94	1.3577	13-May-94	1.3785	18-Jul-94	1.378	20-Sep-94	1.3443	23-Nov-94	1.3735
6-Jan-94	1.3215	11-Mar-94	1.3617	16-May-94	1.3756	19-Jul-94	1.38	21-Sep-94	1.343	24-Nov-94	ND
7-Jan-94	1.3235	14-Mar-94	1.36	17-May-94	1.379	20-Jul-94	1.3815	22-Sep-94	1.3433	25-Nov-94	1.3761
10-Jan-94	1.3181	15-Mar-94	1.364	18-May-94	1.3778	21-Jul-94	1.3785	23-Sep-94	1.3458	28-Nov-94	1.3785
11-Jan-94	1.3219	16-Mar-94	1.3623	19-May-94	1.3738	22-Jul-94	1.378	26-Sep-94	1.3473	29-Nov-94	1.3777
12-Jan-94	1.3208	17-Mar-94	1.3656	20-May-94	1.3768	25-Jul-94	1.3787	27-Sep-94	1.3478	30-Nov-94	1.3752
13-Jan-94	1.3209	18-Mar-94	1.3695	23-May-94	1.379	26-Jul-94	1.3807	28-Sep-94	1.341	1-Dec-94	1.3754
14-Jan-94	1.3205	21-Mar-94	1.3642	24-May-94	1.3786	27-Jul-94	1.3797	29-Sep-94	1.3425	2-Dec-94	1.372
17-Jan-94	ND	22-Mar-94	1.3665	25-May-94	1.3825	28-Jul-94	1.3808	30-Sep-94	1.341	5-Dec-94	1.3732
18-Jan-94	1.3157	23-Mar-94	1.364	26-May-94	1.3865	29-Jul-94	1.3835	3-Oct-94	1.3457	6-Dec-94	1.3732
19-Jan-94	1.311	24-Mar-94	1.3726	27-May-94	1.3864	1-Aug-94	1.3885	4-Oct-94	1.345	7-Dec-94	1.3799
20-Jan-94	1.3103	25-Mar-94	1.3753	30-May-94	ND	2-Aug-94	1.3896	5-Oct-94	1.3472	8-Dec-94	1.3835
21-Jan-94	1.3115	28-Mar-94	1.3748	31-May-94	1.3845	3-Aug-94	1.3883	6-Oct-94	1.3477	9-Dec-94	1.3848
24-Jan-94	1.311	29-Mar-94	1.3775	1-Jun-94	1.386	4-Aug-94	1.3869	7-Oct-94	1.3485	12-Dec-94	1.386
25-Jan-94	1.3117	30-Mar-94	1.3794	2-Jun-94	1.3855	5-Aug-94	1.3882	10-Oct-94	ND	13-Dec-94	1.3872
26-Jan-94	1.3133	31-Mar-94	1.3838	3-Jun-94	1.3831	8-Aug-94	1.38	11-Oct-94	1.3438	14-Dec-94	1.3875
27-Jan-94	1.3115	1-Apr-94	1.389	6-Jun-94	1.3745	9-Aug-94	1.3747	12-Oct-94	1.3477	15-Dec-94	1.3875
28-Jan-94	1.324	4-Apr-94	1.3954	7-Jun-94	1.371	10-Aug-94	1.3753	13-Oct-94	1.3488	16-Dec-94	1.3885
31-Jan-94	1.327	5-Apr-94	1.3841	8-Jun-94	1.3756	11-Aug-94	1.378	14-Oct-94	1.354	19-Dec-94	1.3941
1-Feb-94	1.3308	6-Apr-94	1.384	9-Jun-94	1.374	12-Aug-94	1.3819	17-Oct-94	1.3565	20-Dec-94	1.3946
2-Feb-94	1.3277	7-Apr-94	1.3865	10-Jun-94	1.3745	15-Aug-94	1.3802	18-Oct-94	1.355	21-Dec-94	1.3945
3-Feb-94	1.3278	8-Apr-94	1.3817	13-Jun-94	1.3812	16-Aug-94	1.3796	19-Oct-94	1.3548	22-Dec-94	1.3985
4-Feb-94	1.3343	11-Apr-94	1.388	14-Jun-94	1.386	17-Aug-94	1.3768	20-Oct-94	1.355	23-Dec-94	1.3991
7-Feb-94	1.3418	12-Apr-94	1.3795	15-Jun-94	1.3882	18-Aug-94	1.3792	21-Oct-94	1.3543	26-Dec-94	ND
8-Feb-94	1.3423	13-Apr-94	1.3763	16-Jun-94	1.3928	19-Aug-94	1.3757	24-Oct-94	1.3525	27-Dec-94	1.4005
9-Feb-94	1.3447	14-Apr-94	1.3797	17-Jun-94	1.3925	22-Aug-94	1.3755	25-Oct-94	1.3495	28-Dec-94	1.4035
10-Feb-94	1.3416	15-Apr-94	1.3851	20-Jun-94	1.394	23-Aug-94	1.3775	26-Oct-94	1.3475	29-Dec-94	1.4078
11-Feb-94	1.343	18-Apr-94	1.3887	21-Jun-94	1.3805	24-Aug-94	1.3746	27-Oct-94	1.349	30-Dec-94	1.403
14-Feb-94	1.3536	19-Apr-94	1.3865	22-Jun-94	1.385	25-Aug-94	1.373	28-Oct-94	1.3502		
15-Feb-94	1.3546	20-Apr-94	1.3858	23-Jun-94	1.3853	26-Aug-94	1.37	31-Oct-94	1.3527		
16-Feb-94	1.3508	21-Apr-94	1.3812	24-Jun-94	1.3898	29-Aug-94	1.3693	1-Nov-94	1.3545		
17-Feb-94	1.3406	22-Apr-94	1.3785	27-Jun-94	1.3875	30-Aug-94	1.3673	2-Nov-94	1.3555		
18-Feb-94	1.3387	25-Apr-94	1.3815	28-Jun-94	1.3864	31-Aug-94	1.3712	3-Nov-94	1.3573		
21-Feb-94	ND	26-Apr-94	1.3733	29-Jun-94	1.384	1-Sep-94	1.3682	4-Nov-94	1.3576		
22-Feb-94	1.3425	27-Apr-94	1.3753	30-Jun-94	1.3825	2-Sep-94	1.3665	7-Nov-94	1.3556		
23-Feb-94	1.34	28-Apr-94	1.3805	1-Jul-94	1.3822	5-Sep-94	ND	8-Nov-94	1.3575		
24-Feb-94	1.3475	29-Apr-94	1.3818	4-Jul-94	ND	6-Sep-94	1.368	9-Nov-94	1.3535		
25-Feb-94	1.3516	2-May-94	1.383	5-Jul-94	1.3891	7-Sep-94	1.3685	10-Nov-94	1.3588		
28-Feb-94	1.3522	3-May-94	1.384	6-Jul-94	1.3849	8-Sep-94	1.371	11-Nov-94	ND		
1-Mar-94	1.3498	4-May-94	1.3863	7-Jul-94	1.3885	9-Sep-94	1.3674	14-Nov-94	1.3578		
2-Mar-94	1.3534	5-May-94	1.3847	8-Jul-94	1.3903	12-Sep-94	1.3662	15-Nov-94	1.3632		
3-Mar-94	1.3561	6-May-94	1.3836	11-Jul-94	1.391	13-Sep-94	1.3537	16-Nov-94	1.365		
4-Mar-94	1.3575	9-May-94	1.3797	12-Jul-94	1.3837	14-Sep-94	1.3516	17-Nov-94	1.3654		
7-Mar-94	1.3569	10-May-94	1.3784	13-Jul-94	1.3814	15-Sep-94	1.354	18-Nov-94	1.3675		

Average: 1.36642709163347

[a] US Department of the Treasury.

7.0 RESULTS

As was discussed in Section 6.0, Materials and Methods, our study was comprised of two separate analyses: calculating the recreational, use value of the ecosystems in Muskoka, and assessing the non-use values of ecosystem services. In our first analysis, focusing on recreational goods and services, values were surmised from tourism data collected in the Muskoka Regional Tourism Profile. Table 4 below shows the number of persons who visited the Muskoka region in 2009. Average spending per person who visited was also found from the Muskoka Regional Tourism Profile and is illustrated in Table 5 below. Total tourism revenue was calculated by multiplying total number of trips in Table 4 by the average spending found in Table 5. This lead to Table 6 below, which demonstrates the total estimated recreational value of the 20 sub-watersheds in the Muskoka River Watershed and the northern portion of the Black River–Lake Simcoe Watershed. Total value was determined, after adjustment for inflation, to be $311,283,758.55 (2012 CA).

Table 4: Person visits in Muskoka: trip activities (total).[a]

	Overnight				**Non-Overnight**			
	Ontario	**Other Canada**	**U.S.**	**Overseas**	**Ontario**	**Other Canada**	**U.S.**	**Overseas**
Nature Parks	153000	5000	10000	24000	1000	0	1000	2000
Boating	713000	11000	30000	13000	11000	0	51000	5000
Fishing	270000	5000	8000	3000	28000	0	0	0
Hunting	15000	0	0	0	0	0	0	0

[a] Muskoka Regional Tourism Profile, Table 1.8

Table 5: Average visitor spending.[b]

	Overnight				**Non-Overnight**			
	Ontario	**Other Canada**	**U.S.**	**Overseas**	**Ontario**	**Other Canada**	**U.S.**	**Overseas**
Average $/person	$186	$234	$440	$483	$154	$367	$394	$456

[b] Muskoka Regional Tourism Profile, Table 1.12

Table 6: Total recreational ecosystem spending (in thousands).[ac]

	Overnight				Non-Overnight			
	Ontario	**Other Canada**	**U.S.**	**Overseas**	**Ontario**	**Other Canada**	**U.S.**	**Overseas**
Nature Parks	$28,458	$1,170	$4,400	$11,592	$154	$0	$394	$912
Boating	$132,618	$2,574	$13,200	$6,279	$1,694	$0	$20,094	$2,280
Fishing	$50,220	$1,170	$3,520	$1,449	$4,312	$0	$0	$0
Hunting	$2,790	$0	$0	$0	$0	$0	$0	$0
Total Spending (CAD$ 2009)	$289,280							
Total Spending (CAD$ 2012)[d]	$311,283.76							

[a] Muskoka Regional Tourism Profile, Table 1.8
[c] Number of Trips in Table 3.1 were multiplied by average spending in Table 3.2 to derive these values.
[d] Inflation values from Table 4 Were used to adjust this value.

Our second analysis focused on the non-use ecosystem service values in Muskoka. Table 7 presents ecosystem service values that were located for the five land-cover categories that were analysed. The value of each of the ecosystem services associated with each land-cover type were added together to determine the dollar per hectare value of each of the five land-cover types. These simplified, aggregated data are provided in Tables 8 and 9.

Table 7: Ecosystem service values by type and land cover.

SERVICES		FORESTS					SPARSE FOREST				
Type	**Description**	**Source**	**Priority**	**Value**	**Unit**	**Present Value**	**Source**	**Priority**	**Value**	**Unit**	**Present Value**
Provisional	Wildlife habitat	a	2	$923.00	2004 US	$557.56	e	1	$133.00	2008 CA	$143.99
	Freshwater supply	b	2	$209.86	2005 CA	$236.77					
Regulating	Climate regulation	b	2	$958.11	2005 CA	$1,080.97	-	1	-	-	-
	Atmospheric gas regulation	b	2	$377.14	2005 CA	$425.50	e	1	$992.00	2008 CA	$1,073.98
	Flood prevention	b	1	$459.00	2005 CA	$517.86		0			
	Erosion prevention	d	2	$17.00	2005 CA	$19.18	e	2	$779.00	2008 CA	$843.38
	Pollination	b	1	$951.00	2005 CA	$1,072.95		0			
	Nutrient sequestration	d	1	$58.00	2005 CA	$65.44		0			
Supporting	Nutrient cycling	c	2	$361.00	1994 US	$675.47	e	1	$513.00	2008 CA	$555.40
	Photosynthesis	-	2	-	-	-	-	1	-	-	-
Total						**$4,651.69**					**$2,616.75**

OPEN WATER					SWAMP/BOG					PASTURE				
Source	**Priority**	**Value**	**Unit**	**Present Value**	**Source**	**Priority**	**Value**	**Unit**	**Present Value**	**Source**	**Priority**	**Value**	**Unit**	**Present Value**
e	1	$10.00	2008 CA	$10.83	b	1	$5,830.88	2005 CA	$6,578.57	e	1	$95.00	2008 CA	$102.85
b	2	$197.00	2005 CA	$222.26	b	2	$406.74	2005 CA	$458.90		0			
-	2	-	-	-	b	2	$536.86	2005 CA	$605.70		0			
d	1	$676.59	2006 CA	$751.13	d	2	$429.41	2005 CA	$484.47	b	1	$492.70	2005 CA	$555.88
c	2	$5,445.00	1994 US	$10,188.14	b	2	$4,038.51	2005 CA	$4,556.37		0			
	0					0					0			
	0				-	2	-	-	-	b	2	$951.00	2005 CA	$1,072.95
c	1	$665.00	1994 US	$1,244.28	d	2	$2,017.00	2005 CA	$2,275.64	d	2	$25.00	2008 CA	$27.07
e	1	$612.00	2008 CA	$662.58	e	1	$2,779.00	2008 CA	$3,008.67	b	2	$23.50	2005 CA	$26.51
-	1	-	-	-	-	1	-	-	-	-	2	-	-	-
				$13,079.22					**$17,968.32**					**$1,785.26**

* All values have units of $ per hectare per year, unless otherwise noted
* All converted values are in 2012 Canadian dollars
[a] Costanza *et al.* (2006).
[b] Wilson (2008a).
[c] Costanza *et al.* (1997).
[d] Wilson (2008b).
[e] Troy and Bagstad (2009).

Table 8: Land-cover values breakdown.

Land-Cover Type	Area (ha)	%/Total Area	$/ha	Total Value	%/Total Value
Bedrock	10,499.71	1.51%	-	-	-
Burns	103.34	0.01%	-	-	-
Cloud and Shadow	2,020.58	0.29%	-	-	-
Coniferous Forest	30,925.34	4.44%	$4,651.69	$143,855,002.90	3.35%
Cuts	37.50	0.01%	-	-	-
Deciduous Forest	222,640.12	31.93%	$4,651.69	$1,035,652,064.64	24.15%
Mixed Forest	208,792.44	29.94%	$4,651.69	$971,237,026.48	22.64%
Open Bog	228.33	0.03%	$17,968.32	$4,102,738.54	0.10%
Pasture	17,210.75	2.47%	$1,785.26	$30,725,596.12	0.72%
Sand/Gravel/Mine Tailings	124.69	0.02%	-	-	-
Settlement/Infrastructure	10,839.96	1.55%	-	-	-
Sparse Forest	75,807.84	10.87%	$2,616.75	$198,370,326.81	4.62%
Treed Bog	10,175.73	1.46%	$17,968.32	$182,840,713.04	4.26%
Water - Deep or Clear	107,884.39	15.47%	$13,079.22	$1,411,043,655.42	32.90%
Recreation and Tourism	-	-	-	$311,283,758.55	7.26%
Total	**697,290.72**	100.00%		**$4,289,110,882.49**	100.00%

Table 9: Aggregated land-cover valuation.

Land-Cover Type	Area (ha)	%/Total Area	$/ha	Total Value	%/Total Value
Forest	462,357.91	66.31%	$4,651.69	$2,150,744,094.02	50.14%
Wetland	10,404.06	1.49%	$17,968.32	$186,943,451.58	4.36%
Pasture	17,210.75	2.47%	$1,785.26	$30,725,596.12	0.72%
Sparse Forest	75,807.84	10.87%	$2,616.75	$198,370,326.81	4.62%
Water - Deep or Clear	107,884.39	15.47%	$13,079.22	$1,411,043,655.42	32.90%
Recreation and Tourism	-	-	-	$311,283,758.55	7.26%
Total	**697,290.72**	96.61%		**$4,289,110,882.49**	100.00%

The total present values of each of the five categories were then multiplied by the number of hectares each category represented in the region. Tables 8 and 9 show the number of hectares each category represents and the total value of each category. The overall total value of non-use services provided by the 20 sub-watersheds in the Muskoka River Watershed and northern portion of the Black River–Lake Simcoe Watershed was determined to be $3,977,827,123.95 (2012 CA). It is worth noting, however, that although certain land types had a larger proportion of land-cover, it may not have had the same proportion of land value. Table 9 demonstrates that this is particularly true for the land type Forest, which represented 66.31% of land cover but only represented 50.14% of value. The opposite occurred for Water – Deep or Clear. It represented only 15.47% of land cover but produced 32.90% of total value. However, Wetlands were found to be the most valuable land type. As Table 9 demonstrates, Wetlands were found to have the highest value per area at $17,968.32 per hectare. Wetlands represent only 1.46% land cover but 4.36% of the total ecosystem service value.

In our analysis, there were often many values for the same ecosystem service provided by a land-cover type from different studies. As is outlined in Section 6.0, Materials and Methods, we attempted to select the value that applied best to Muskoka, meaning the one from the study that is as ecologically similar to Muskoka as possible. Table 10 presents the low and high values located from various studies, in order to see the ranges of estimates that can be found for various services. From Table 10, we can see that many of the lower-bound estimates are from the study by Costanza *et al.*, which was carried out in 1997, and many of the higher-bound estimates are from more recent studies. This could be the result of two changes that have been occurring over the last several decades: our ecological knowledge of the importance of ecosystem services has been increasing, and our societal awareness of the importance of the environment has been growing.

The distribution of value in the 20 sub-watersheds can be seen in Figure 2. It is a gradient colour scale of the ecosystem value for the land cover, based on dollars per hectare. It ranges from white ($0/ha) to full green (GRB 255, 0, 0; $20,000). Combining the two analyses that were undertaken, of recreational value and non-use value, it was determined that the total value of the 20 sub-watersheds in the Muskoka River Watershed and the northern portion of the Black River–Lake Simcoe Watershed is approximately $4,298,110,882.49 (2012 CA).

Table 10: Ranges of values located for several ecosystem services.

SERVICES		FOREST								
			Low Value				High Value			
Type	Description	Priority	Value	Source	Unit	Present Value	Value	Source	Unit	Present Value
Provisional	Freshwater supply	2	$22.24	a	2004 US	$33.20	$209.86	b	2005 CA	$236.77
Regulating	Climate regulation	2	$88.00	c	1994 US	$161.47	$958.11	b	2005 CA	$1,080.97
	Atmospheric gas regulation	2	$148.26	a	2004 US	$221.31	$328.00	h	2007 Euro	$425.50
	Pollination	1	$400.31	a	2004 US	$597.55	$951.00	b	2005 CA	$1,072.95
		OPEN WATER								
			Low Value				High Value			
Type	Description	Priority	Value	Source	Unit	Present Value	Value	Source	Unit	Present Value
Provisional	Wildlife habitat	1	$10.00	e	2008 CA	$10.83	$533.00	f	2002 US	$807.39
	Freshwater supply	2	$197.00	b	2005 CA	$222.26	$9,226.00	f	2002 US	$13,975.54
Regulating	Atmospheric gas regulation	1	$322.00	f	2002 US	$487.77	$676.59	d	2006 CA	$751.13
	Flood prevention	2	$5,445.00	c	1994 US	$10,188.14	$8,789.00	f	2002 US	$13,313.58
	Nutrient sequestration	1	$665.00	c	1994 US	$1,220.19	$2,014.00	f	2002 US	$3,050.81
		WETLAND								
			Low Value				High Value			
Type	Description	Priority	Value	Source	Unit	Present Value	Value	Source	Unit	Present Value
	Freshwater supply	2	$406.74	b	2005 CA	$458.90	$7,000.00	g	1995 US	$12,844.10
Regulating	Atmospheric gas regulation	2	$133.00	c	1994 US	$244.04	$429.41	d	2005 CA	$484.47
		PASTURE								
			Low Value				High Value			
Type	Description	Priority	Value	Source	Unit	Present Value	Value	Source	Unit	Present Value
Regulating	Pollination	2	$14.00	c	1994 US	$25.69	$951.00	b	2005 CA	$1,072.95

* All values have units of $ per hectare per year; * All converted values are in 2012 Canadian dollars

[a] Costanza *et al.* (2006); [b] Wilson (2008a); [c] Costanza *et al.* (1997); [d] Wilson (2008b); [e] Troy and Bagstad (2009); [f] Kroeger (2005); [g] Brander *et al.* (2006); [h] Chiabai *et al.* (2009)

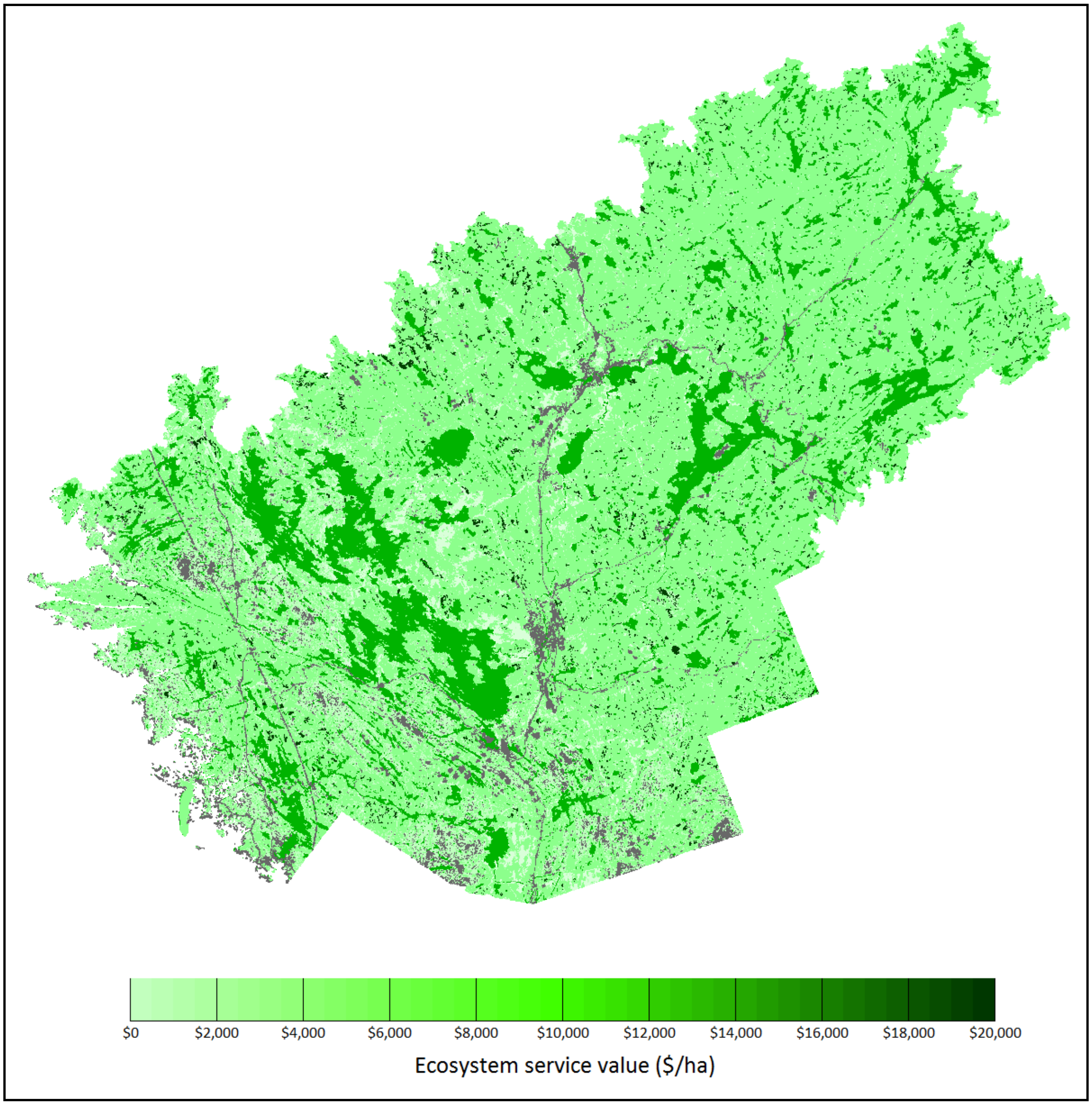

Figure 2: Value of ecosystem services in dollars per hectare.

8.0 DISCUSSION

8.1 Study limitations

Our research consisted primarily of a literature review under a heavy time constraint. There are several limitations associated with using a value transfer method (from a literature review) that are important to recognize. Spash and Vatn (2006) identify two primary constraints. Firstly, the results of value transfer methods are dependent on the quality of the primary research upon which they are based, which could be seriously flawed in terms of survey design, data collection, economic methods, empirical techniques, explanatory power, and reliability and validity tests. Secondly, this accuracy concern is compounded by the transfer: errors can result from applying the results of one study to another geographic area due to differences in environmental, socio-economic and policy contexts (Spash and Vatn, 2006). To illustrate, a simultaneous study conducted on two similar Norwegian lakes produced two different value functions (Spash and Vatn, 2006). Value functions are mathematical representations, in the form of equations, of the ecosystem services provided by a specific area (in this case the two lakes). Upon producing both value functions, the researchers applied Lake One's value function to Lake Two, and vice versa, in order to compare results. The value transfer experiment resulted in 20-40 percent variation between predicted values (the value of Lake Two predicted by the value function of Lake One, and vice-versa) versus the actual value (Spash and Vatn, 2006). This example demonstrates the way in which the value transfer methodology can produce large variations in final values on both the national (value transfer *within* a country) as well as international (value transfer *between* countries) levels. For these reasons, the reliability and applicability of results generated through value transfer methods must be examined critically and used carefully.

We attempted to locate and transfer values that were as ecologically applicable to Muskoka as we could, but this was not always possible. We searched for values from areas that were geographically proximate, such as the Lake Simcoe Basin, from which we were able to locate many applicable values. For this reason, we do not expect as large of a variance in our final values as was found in the aforementioned study from Norway. However, there will inevitably be some variance due to the differences in environmental, socio-economic and policy contexts outline by Spash and Vatn (2006). We also searched extensively for values from

Scandinavia in order to locate ecosystem service values for a shield system similar to Muskoka. However, we were unable to locate applicable research from this region at the time our study was undertaken due to concerns of ill applicability.

Although there has been great headway in the field of ecosystem service valuation over the last decade, some values are still very difficult to obtain or locate any examples of in the current literature. As an example, pollination values could only be obtained for forests and pasture. Additionally, climate regulation values were only obtained for forest and wetland ecosystems, even though open water systems such as lakes are often cited as important components of the global carbon balance (Dean and Gorham, 1998). Similarly, we were unable to locate any values for photosynthesis, and were therefore forced to omit this valuable but unquantifiable service from our calculations altogether. It is also important to recognize that a literature review reflects only past values. This is particularly important in our research because past values do not reflect changes in environmental views. As a result, old values from the review may be over or underemphasized based on changes in societal values.

8.2 Recommendations for Future Studies

8.2.1 Traditional Economic Methods

We recommend that future studies be undertaken in order to synthesise data that more accurately represents the unique context of Muskoka. A valuation protocol, or framework, should be created that will effectively provide the information needed to make the desired types of environmental management decisions in Muskoka in the future. An increasing number of protocols are being advanced to develop valuation strategies. As an example, Daily (2000) presents an Ecosystem Services Framework containing the following four steps:

1. Identify ecosystem services,
2. Characterize the services,
3. Establish safeguards, and
4. Monitor the services by evaluating the safeguards.

In the context of this framework, establishing safeguards simply means ensuring that key ecosystem services will be protected. This is through determining the desired mix of service provision, and ensuring the institutional capacity exists to protect these services (Daily, 2000). Similarly, Brouwer (2000) writes that ecosystem service valuation best practices should follow seven steps:

1. Define ecosystem goods and services,
2. Identify stakeholders in ecosystem goods and services,
3. Identify the values held by different stakeholders,
4. Involve stakeholders in determining validity of monetary ecosystem service valuation,
5. Study selection,
6. Account for effects of selected value procurement technique, and
7. Stakeholder involvement in value aggregation.

In this framework, by study selection Brouwer (2000) means deciding which type or types of valuation techniques will be most appropriate in a certain context (see Table 11 for descriptions of the most common valuation techniques).

Both of these frameworks illustrate that there are two separate components of ecosystem service valuation: the *supply side,* which is a function of how much of an ecosystem service can be provided by the ecosystem, and the *demand side*, which is a function of how much society wants an ecosystem service to be provided. Together, the supply and demand for an ecosystem service determines its value. For example, a small wetland area within a large residential subdivision may not be physically capable of providing a large amount of flood and runoff control. However, the amount of flooding and surface water flow that occurs within the residential subdivision may lead its residents to desire a higher amount of flood and runoff control. This demonstrates a low supply and high demand, which results in the ecosystem service of flood and runoff control to yield a high value. This value would be higher than what one would find in an area with a large wetland and a small residential subdivision; conditions where there is a higher supply and a lower demand for the ecosystem service.

In terms of the supply side of the Muskoka region's value function, estimates were made through our value transfer approach, but further studies with different methods could more accurately portray the provision of services in the region. In our study, the ability of certain areas to provide a variety of services were generalised through the transfer of values from similar land-cover types. In reality, all areas of land classified as having the same land-cover type will rarely have identical abilities to provide ecosystem services in terms of both service quantity and quality. Rather, this ability will be based on a whole suite of other characteristics, including, but not limited to: fragmentation (geographic dispersion or connectedness of the ecosystem), total biomass, human impact, etc. (Daily, 2000). For these reasons, we recommend that firsthand studies of the characteristics of ecosystems providing these services should be undertaken. De Groot *et al.* (2010) suggest that the efficiency of these studies could be augmented by focusing on a select number of key indicators of the quality of services. The starting point for these studies, then, would be to identify the highest priority services for examination, and then the selection of key indicators of these services in order to best illustrate their value. While it is financially unfeasible to conduct independent value analyses on *all* ecosystem services, the valuation of the Muskoka region would significantly benefit from primary studies conducted on higher priority ecosystem services, and those conspicuously missing from potential value transfer sources.

In terms of the demand side of the Muskoka region's value function, we have concluded that the ideal manner to generate such values would be through a novel study that undertakes primary valuation methods to discover the value that residents and visitors of the Muskoka region place on the provision of ecosystem services. Although there are issues with relying solely on the demand of residents of the region, as some services provided by Muskoka may be valued domestically *and* internationally, using the values and preferences of local residents is both the most practical and equitable approach: this is largely due to political feasibility. There are many methods that are commonly used in environmental valuations in general, several of which are touched upon in the literature review found earlier in this document. In terms of ecosystem services, direct valuation through market-based techniques is only applicable for a select few services: those that are subject to market transactions. This presents the difficulty of quantifying the value of services which are not traded in the market. Table 11 (below) provides brief descriptions and limitations of several of the most commonly used methods in estimating the value of non-market ecosystem services.

Table 11: A brief description and explanation of the limitations associated with several common environmental valuation techniques; based on information from Turner *et al.* (2010) and Farber *et al.* (2002).

METHOD	DESCRIPTION	LIMITATIONS
Travel Cost	Survey-based; uses information on travel and time expenditures, relating them to the amount people are willing to pay to visit an area.	-Not always applicable; -Only for use values; -Complex & requires a lot of data.
Hedonic Pricing	Assumes prices individuals will pay for associated goods (such as housing) will reflect service demand.	-Needs a lot of data; -Only for use values -Sensitive to Specification.
Replacement Cost	Based on the cost of replacing ecosystem service with manufactured substitute.	-Can overestimate; -Only for use values; -Not well validated.
Contingent Valuation	Stated preference method; people are asked directly how much they are willing to pay for something in a hypothetical market.	-Very time intensive -Nontrivial information lost; -High chance of bias.

The issues associated with the validity and accuracy of the valuation techniques found in Table 11 are widely discussed in the literature, and make selection of the best approach challenging (e.g. Brouwer, 2000; Chee, 2004; Farber *et al.*, 2002; Turner *et al.*, 2010). To further complicate matters, often the preferable valuation technique varies by ecosystem service type. Table 12 below, taken from Farber *et al.* (2006), illustrates this. This means that different services may have to be valued through the use of different valuation techniques, or a combination of techniques. This would increase the time and cost of potential future studies. Further, as is evident from an examination of Table 12, few of the values that would be characterized as “non-use” values have high amenability to traditional methods used for generating environmental values. Some of these “non-use” services are of high priority to Muskoka, such as gas regulation, climate regulation, soil retention, and nutrient regulation. In order to cope with this reality, more than one of these valuation techniques may need to be combined, or else these techniques could be combined with non-traditional methods, such as those described in the following section.

Table 12: Descriptions of: the amenability to valuation in general, most appropriate forms of valuation, and geographic transferability of values, for a variety of ecosystem services; from Farber *et al.* (2006).

Ecosystem Service	**Amenability To Economic Valuation**	**Most Appropriate Method for Valuation**	**Transferability Across Sites**
Gas regulation	Medium	CV, AC, RC	High
Climate regulation	Low	CV	High
Disturbance Regulation	High	AC	Medium
Biological Regulation	Medium	AC, P	High
Water Regulation	High	M, AC, RC, H, P, CV	Medium
Soil Retention	Medium	AC, RC, H	Medium
Waste Regulation	High	RC, AC, CV	Medium to High
Nutrient Regulation	Medium	AC, CV	Medium
Water supply	High	AC, RC, M, TC	Medium
Food	High	M, P	High
Raw materials	High	M, P	High
Genetic resources	Low	M, AC	Low
Medicinal resources	High	AC, RC, P	High
Ornamental resources	High	AC, RC, H	Medium
Recreation	High	TC, CV, Ranking	Low
Aesthetics	High	H, CV, TC, Ranking	Low
Science/education	Low	Ranking	High
Spiritual/historic	Low	CV, ranking	Low

Legend
AC: avoided cost; CV: contingent valuation; H: hedonic pricing; M: market pricing;
P: production approach; RC: replacement cost; TC: travel cost

8.2.2 Non-Traditional Methods

As the adequacy of traditional economic valuation methods are increasingly criticized, alternate valuation techniques are beginning to be discussed and suggested in the literature (e.g. de Groot *et al.*, 2010; Farber *et al.*, 2002; Turner *et al.*, 2010). Many of these techniques can be seen in Table 13, alongside traditional valuation methods. The most promising of these methods are the deliberative and participatory approaches, or discursive methods. For example, deliberative monetary valuation techniques combine stated preference approaches with discursive models borrowed from the field of political sciences. This means that groups gather to undertake contingent valuation or choice modelling together to generate a monetary value (Farber *et al.*, 2002).

Discursive methods are founded on the principle that rather than making environmental management decisions based on the aggregation of individual preferences gathered separately through a variety of techniques, we should instead be encouraging approaches of deliberate democracy and open discourse (Farber *et al.*, 2002). There are many benefits associated with this model. Firstly, in individual valuation exercises, the values can be seriously impacted by the level of knowledge of the participant. In these open discursive models, education, and knowledge-sharing between experts and individuals possessing local environmental knowledge can work together to make value-judgements. This type of knowledge-sharing is often advocated as a best practice in other fields relating to environmental management and decision-making, such as Environmental Impact Assessments (EIA) (Noble, 2010). These methods further allow for the incorporation of preference construction as part of the valuation process. Preference construction is the process by which individuals develop the values they place on various environmental goods or services, and relies on the acquisition of information about these goods and services, and their significance to that individual. The process of informed preference construction can result in more stable value judgements (Turner *et al.*, 2010). Secondly, when groups make decisions together, as opposed to individually, there is more opportunity to focus on outcomes that will benefit society as a whole instead of being based solely on personal preferences, which can lead to more equitable decisions (Farber *et al.*, 2002). Some of the limitations that have been addressed for discursive methods include high time and cost requirements, issues with biases in the recruitment process, issues with small groups representing wider populations, and difficulties in generating a monetary estimate (Turner *et al.*, 2010).

Despite these issues, the many benefits of discursive methods lead us to suggest that some mode of deliberative or discursive valuation be employed, potentially alongside individual valuation techniques.

Table 13: List of economic and non-economic techniques used in environmental valuation; modified from de Groot *et al.* (2010)

Economic Techniques	**Non-economic Techniques**
Market price approach	Consultative methods
Replacement cost approach	Questionnaires
Revealed preference methods	In-depth interviews
Travel cost method	Deliberative & participatory approaches
Hedonic pricing methods	Focus groups, in-depth groups
Stated preference methods	Citizen juries
Choice modelling	Delphi surveys
Contingent valuation	Rapid rural appraisal
Participatory approaches to valuation	Participatory action research
Deliberative valuation	Methods for reviewing information
Benefits transfer	Systematic reviews

The benefits of discursive methods can be illustrated by recognizing that the preferences of individuals can be both intrinsic and instrumental in nature. Intrinsic values can include subjective social or moral judgements that an individual holds about a society or the environment, while instrumental values represent preferences an individual expresses in a competitive market in light of different tradeoffs in benefits and costs.

Methods exist to attempt representing intrinsic values amongst a community of individuals in terms of economic prices, which is described as “welfare economics”. However, describing intrinsic ideals as a monetary economic valuation, according to Sagoff (2008), may be improper. Instead, Sagoff (2008) advocates keeping intrinsic and instrumental value judgements as separate environmental governance frameworks. Intrinsic frameworks pose political or ethical questions that a community must answer, such as what moral obligations they have to the environment, and to what degree those obligations truly represent the beliefs of that community. These questions involve the support or opposition towards ideas, settled through argument and debate. Instrumental frameworks deal with judgements as to the both the benefits and costs of particular action, and how they satisfy the collective preferences of that community. These questions involve settling interests and tradeoffs through competitive monetary exchange.

Environmental Impact Assessments (EIA) could represent forums where both of these frameworks could operate. On one hand, an EIA could examine the social intrinsic beliefs and values of a community, expressed through some of the non-economic techniques outlined in Table 13. On the other hand, the EIA can examine the benefits and costs of a proposed project, which are directly borne by a community and taxpayers. In either case, there is still the expressing and sharing of values to overcome knowledge sharing barriers outlined by Noble (2010).

While Sagoff (2008) is presenting a philosophical approach to environmental governance in general, the principle of his argument in terms of valuating ecosystem services is that the ideals and the preferences of residents and visitors of the Muskoka region need to be kept in separate tracts of thought. A commercial development on a waterfront location in Muskoka could be used as an example. The development could pose intrinsic questions to be debated by the local community, such as whether it is aesthetically detrimental to the waterfront view, or it incorporates the natural environment into commercial activity, and which of these is preferred by the community at large. Instrumentally, it could pose questions as to whether the economic activity the development generates outweighs the cost of reducing the ecosystem services provided by the land, or whether it would be beneficial to require the developer to undertake certain design requirements to preserve some ecosystem services. An EIA could examine both lines of questioning, but they must be kept separate according to Sagoff (2008).

8.3 Applications of Ecosystem Service Values in Muskoka

Our research provides two primary functions: the presentation of generated values and the basis of further research. Should the MWC decide to use the values generated through this study, they could apply the results to cost benefit analyses. Cost benefit analysis (CBA) is a process which analyzes the costs and benefits of a project and serves as a guideline for decision-making. It is used to compare the potential future benefits of a project against other projects or the status quo (Boardman *et al.*, 2011). Consider a hypothetical development of a wetland. According to our findings, wetlands are valued at nearly $18,000 per hectare. Consequently, any project where benefits are less than development cost plus the $18,000 per hectare of wetland eliminated would not proceed. It is important to note that this is a highly stylized example, and there are many caveats that come with conducting a CBA, such as decision criteria (net present value versus benefit-cost ratio) as well as moral considerations (Boardman *et al.*, 2011). The results of our study could also be used as comparison tools for any values generated through novel research. Additionally, due to our extensive literature review, a large amount of peer reviewed literature concerning the ecological and economic considerations associated with ecosystem service valuation has been obtained. This is a useful starting point for designing future research. The subsequent sections outline some possible suggestions for the application of ecosystem service values that may be generated in the future.

8.3.1 In Designing a Biodiversity Strategy

There are a variety of future land management decisions in Muskoka that could be influenced as a result of the findings of our study, and future studies based on the groundwork laid in this report. One such application would be a Biodiversity Strategy. Biodiversity can be defined as “an attribute of a site or area that consists of the variety within and among biotic communities, whether influenced by humans or not, at any spatial scale from microsites and habitat patches to the entire biosphere” (DeLong, 1996). The relationship between biodiversity and ecosystem services has long been debated in the scientific literature. For instance, Turner and Daily (2007) argue that biodiversity is both an intermediate and final ecosystem service. This means that biodiversity assists with certain ecosystem operations categorized as services, such as soil retention, pollination, water purification, and climate change mitigation, and also has a final service role related to cultural and spiritual values (Thompson *et al.*, 2011). Contrary to this, many argue that if biodiversity assists in the provision of ecosystem services, it cannot be an ecosystem service itself, or this would be a circular relationship (Srivastava and Vellend, 2005). Despite these conflicting ideas, it is generally accepted that biodiversity is important to the provision of ecosystem services. For instance, Balvanera *et al.* (2006) conducted a review of experimental work in this field from the preceding 50 years, and concluded that there was clear evidence of a positive effect of biodiversity on most ecosystem services. For this reason, protecting biodiversity through carefully planned protected areas, and a carefully synthesised

Biodiversity Strategy, could assist in ensuring the continued provision of valuable ecosystem services.

Based on the above-described relationship between biodiversity and ecosystem service provision, it may be tempting to design conservation initiatives for biodiversity, and assume that the protection of ecosystem service-provisioning areas will necessarily follow. This is, however, not a sound strategy. In a recent study, Chan *et al.* (2006) analysed and compared areas with high levels of biodiversity to areas with high levels of provision of a variety of ecosystem goods and services. The authors concluded that there were some “hotspots” where high values of both of these factors coincided, but there was not a universally strong correlation between them. Similarly, Nelson *et al.* (2008) found that the protection of areas for the goal of maintaining the provision of ecosystem services can increase species conservation, but does not always. For instance, within their study area, they found that future conservation measures that focused on the maintenance of rare habitats would ultimately reduce potential for future carbon sequestration. For instance, the Eastern Wolf (*Canis lupus lycaon*) is a species of Special Concern within Muskoka, and requires large areas of intact forest (Georgian Bay Biosphere Reserve, n.d.). If conservation actions were planned around the protection of this species alone, it may successfully ensure the continued provision of ecosystem services generated by forests. However, important ecosystem types required for the provision of a variety of other critical services, such as the provision of flood prevention and nutrient cycling and sequestration services by wetlands, may not be afforded sufficient protection. Similarly, affording protection only to wetlands, as the ecosystem services they provide were calculated as being the greatest per hectare in this study, would not afford protection to species that depend on habitat types other than wetlands.

For all of the reasons previously listed, it is commonly recommended that biodiversity and ecosystem services be examined separately, and then areas that are high in both can be prioritized for conservation (Chan *et al.*, 2006; Nelson *et al.*, 2008; Kremen and Ostfeld, 2005). This also allows land-managers to ensure that areas that provide ecosystem services that are not clearly linked to high levels of biodiversity are afforded protection as well as those that are. Further, an in-depth examination of tradeoffs involved in a variety of future land use decisions, in terms of both different ecosystem services, and biodiversity, could generate the best policy decisions.

Another issue with diversity planning and ecosystem services is that when diversity is investigated and mapped within a region, the most common metric used is species richness. Species richness is defined as the number of biological groups (such as species, or genera) within a certain area (DeLong, 1996). Although values for species richness can be important, the functioning of an ecosystem and the subsequent services it provides can also depend on: biological identities and densities, biomass, interactions between populations, number of and relationships between functional groups, and spatial and temporal variations of all of these factors (Kremen and Ostfeld, 2005). Since gathering all of the data necessary to understand these complex ecosystem components would require time, financial, and human resources outside of the scope of most regional planning bodies, Kremen and Ostfeld (2005) recommend the cataloguing of various functional groups represented in an area, known as a "functional inventory". This would permit decisions based on knowledge of the key species necessary for ecosystem functioning, and the prediction of ecosystem functional effects based on future management decisions.

The relationship between, and protection of, biodiversity and ecosystem services is of particular importance as concerns over the impacts of global climate change mount. Many authors have concluded that diversity can promote stability in ecosystems, both through increasing resistance and resilience. Resistance is the ability of a system to retain function in the face of perturbations, and resilience is the ability of a system to recover after a major disturbance (Thompson *et al.*, 2011). The maintenance of high levels of biodiversity could stabilize the response of systems to gradual increases in temperature, as well as the increased prevalence of natural disturbances which are thought to accompany climatic changes (Dale *et al.*, 2001).

Climate change could have numerous effects on natural systems in Muskoka, including positive feedback loops in forest carbon storage, and serious risks to the hydrological cycle (Yao, 2009). These risks include altered water levels in lakes, risks to biodiversity, and increased extreme events, such as droughts and flooding (Yao, 2009). Additionally, areas in which the Precambrian Shield underlies the surface, such as Muskoka, can be at a higher risk of compromised water quality as a result of human actions (Schindler and Lee, 2010). The importance of freshwater to the study area can be clearly found in the Strategic Priorities document created by the District Municipality of Muskoka (2008), which include several strategies that focus on maintaining the quality of surface water. Our study results also reflected these values, as the two ecosystem types with the highest estimated values for ecosystem service provision per hectare are wetlands, at $17,968.32/ha, and open water, at $13,079.219/ha. For these reasons, we suggest that future conservation strategies emphasise ensuring there is sufficient protection for areas important for water-related ecosystem service provision.

8.3.2 As an Addition to The Muskoka River Watershed Inventory Project

Another potential use of our research is to combine the results of our study with the findings of The Muskoka River Watershed Inventory Project Final Report (Tran, 2007). This report identified areas of high ecological importance based on: size of discrete terrestrial ecosystems; presence of old growth forests; interior size of discrete terrestrial ecosystems; presence of wetlands, riparian of rivers and streams, inland lakes, and the Great Lakes shoreline; highly permeable areas; habitat diversity; species and vegetation community occurrences; and important habitat areas. By adding the values found in this study to the above-listed criteria generated in The Muskoka River Watershed Inventory Project, conservation priorities within Muskoka could be prioritized for more precise focus in conservation efforts. Additionally, if future studies yield more complete biodiversity information, or a functional inventory is completed, it could be added as another criterion. This process can be thought of as adding additional layers in a geospatial analysis in order to generate decisions that best reflect conservation values and priorities.

8.3.3 In Modelling Future Scenarios

A further suggestion for future use of this study's results is its application for scenario development through knowledge of future land use projects. Ecosystem service values can be an important part of informing decisions about land use and development. Future scenario development can be used to assist with decision-making by using the value of land cover types as rough prioritization for areas where ecosystem service provision would be more or less adversely affected by various human land uses. One potential tool that could assist in this work is the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) tool. InVEST is a computer model developed by The Natural Capital Project, which is a collaboration between Stanford University, The Nature Conservancy, and World Wildlife Fund, in conjunction with other institutions (Daily et al., 2009). InVEST uses land use and land cover data to generate economic values of ecosystem services provided by these systems (Tallis and Polasky, 2009). In practical terms, it functions as an ArcGIS toolbox that can be downloaded for free from The Natural Capital Project website (http://www.naturalcapitalproject.org/).

The supply side of the ecosystem service value is generated through ecological modelling based on previously gathered knowledge, and the demand side is generated based on the data that is provided with respect to settlement proximity, density, etc (Tallis and Polasky, 2009). Values that can be generated through InVEST that would be applicable to this study include: "climate regulation through carbon sequestration...water quality control for regulatory compliance...storm peak flow mitigation, recreation & tourism...nontimber forest product production, provision of cultural values & nonuse values...[and] terrestrial biodiversity as an attribute of natural systems..." (Tallis and Polasky, 2009). InVEST can be a very useful tool for decision-makers, as one can project the provision of ecosystem services in the future based on different future land cover types or land uses (Nelson *et al.*, 2009). As a result, InVEST may assist in informing decision about where to site future developments, conservation initiatives, etc., as it allows you to model the changes in the provision of certain ecosystem services, so decisions can be made based on what strategy minimizes service losses.

9.0 CONCLUSIONS

The Muskoka River Watershed and the northern portion of the Black River–Lake Simcoe Watershed is home to 55,000 permanent and 100,000 seasonal residents. As the population continues to increase, demand for land will increase as well. It is therefore vital that decision-makers have an accurate understanding of the economic value of the natural capital and ecosystem services provided by this area. This report provides important information on ecosystem service valuation, and can serve as a building-block for future studies that could help influence local decision-making and policy governing biodiversity, ecosystem management, and land development in Muskoka.

The valuation of natural capital and ecosystem services will consist of developing a valuation framework that is appropriate for the context of Muskoka. The valuation technique, or combination of several techniques, that best meet the needs of decision-makers in Muskoka must be decided upon. The importance of stakeholder participation in the valuation process should be recognized. Muskoka will have unique challenges in this respect, given the large population of seasonal residents that should also be considered as stakeholders. The environment means different things to different people. Individuals and groups conceive of the value of ecosystems in different ways, and this will be reflected in any attempt to value ecosystem services. The various interests of stakeholders and residents must be balanced, and well-designed environmental valuation techniques can contribute to the balancing of these interests by decision-makers. Future projects based on the principles outlined in this document have the potential to ensure the continued enjoyment of the natural landscape of Muskoka by all, and ensure sustainable environmental management of this unique region in the future.

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