Credit Valley Conservation

The Credit River Watershed

Property Value Appreciation: Impacts of Natural Features

DSS

CVC
CREDIT VALLEY CONSERVATION

Final Report

The Credit Watershed:
Social, Economic and Environmental Services Provided to the Watershed Community

The Impact of Natural Features on Property Values

Submitted to
Credit Valley Conservation

Prepared by
DSS Management Consultants Inc.

March, 2009

CREDIT VALLEY CONSERVATION

DSS Management Consultants Inc.
Designers of Decision Support Systems

March 12, 2009
Sent by e-mail

Credit Valley Conservation
1255 Old Derry Road
Mississauga, Ontario
L5N 6R4

Attention: Mike Puddister, Manager Lands & Stewardship

Re: Final Report - The Credit Watershed: Natural Features Impact on Property Values – Our file no. 339

Dear Mr. Puddister:

Following is our final report regarding the above study. This report describes the results of our analysis, their interpretation and potential application in detail. The report has benefited from the comments that you and others provided on the draft report.

The economic values that have been estimated provide an important basis for guiding future management decisions. That being said, these are the first estimates of the economic value of the Credit watershed natural features that have been produced. For this reason, these estimates can be improved over time by refining and expanding the methodology set out in this report. Recommendations for future analysis are included.

On behalf of the project team, thank you for the opportunity to undertake this interesting work on your behalf. We hope that you will find these results useful for securing funds to conserve and enhance the natural features of the Credit River watershed.

Sincerely

Edward Hanna, Principal

c.c.: Jeffery Wilson, CVC
Scott Milne, MPAC
DSS Project Team

Executive Summary

This study is part of a long-term initiative by Credit Valley Conservation (CVC). The analytical results presented in this report are intended to assist CVC in making management decisions affecting the Credit River watershed and the quality and quantity of ecological goods and services (EGS), particularly those associated with certain types of natural features (i.e., ravines and upland green space). More specifically, this study focuses on the increase in the value of properties proximal to natural features. This appreciation of nearby properties represents a portion of the total value of these natural areas. These property value impacts need to be combined with other measures of the economic value of EGS to arrive at an estimate of the total value of natural features.

A hedonic analysis methodology was used to derive the impact of natural features on nearby residential properties. Hedonic models are a form of revealed preference valuation which relies on actual real estate market behaviour to deduce the value of individual components or characteristics of purchased properties. The hedonic methodology is widely used in property assessment.

Residential properties are valued in Ontario by the Municipal Property Assessment Corporation (MPAC) using a type of hedonic modelling called the Sales Comparison approach. These MPAC models include hedonic price coefficients (i.e., property adjustment factors) for a wide range of characteristics including:

- location (e.g., MPAC has identified over one hundred unique market areas and created hedonic regression equations for each of these markets),
- lot characteristics (e.g., lot size, frontage),
- buildings (e.g., number, size, year of construction, quality measures), and,
- local factors (e.g., neighbourhood character, proximity to positive and negative land uses including natural features).

MPAC has access to all land title documents. These documents contain information such as property location, sale amount, sale date, etc. MPAC agreed to use their Sales Comparison approach to produce property value models for each market area in the Credit River watershed. As well, MPAC provided digital maps of the market areas and the homogeneous neighbourhoods within each market area.

Following are the specific steps which were followed in this analysis.

1. MPAC market models for each of the eight market areas within the Credit River watershed were obtained.
2. Two market areas were selected for detailed application of the methodology (i.e., south and north Mississauga).
3. A typology for the four MPAC natural feature classes was developed by examining a sample of properties whose value had been adjusted by MPAC appraisers due to the presence of a certain type of natural feature.
4. A comprehensive geo-spatial inventory of natural features classified according to the MPAC natural feature classes was prepared for each market area.

5. A property database was compiled for these properties which included information on the homogeneous neighbourhood, lot size and proximity to a specific class of natural feature.
6. An adjusted value for each property was calculated using the corresponding MPAC model and lot size and homogeneous neighbourhood adjustment factors.
7. The hedonic modeling literature was reviewed and a distance decay function was derived based on reported results.
8. The increase in the adjusted value attributable to proximity to a natural feature was calculated using the corresponding MPAC adjustment factor, the separation distance between the natural feature and the property boundary and the generic distance decay function.
9. The results for individual properties were aggregated to produce summary results for various combinations of market areas and natural feature types.

Abutting a natural feature can increase property value from 1% to 5% depending on the type of natural feature. MPAC has developed four classes of green space adjustment factors. These four classes of green space were used by the CVC GIS department to produce the natural features and property inventories that were used in this analysis. The boundary of each natural area plus its classification code was included in a GIS layer. A 100 m zone of influence around the boundary of each natural feature was added. The natural feature layer was overlaid on a property boundary GIS layer. All properties for which a portion of their boundary was within the 100 m zone of influence of a natural feature were included in the database. In total 28,377 individual properties were included in the analysis.

The impact of the nearest natural feature was estimated for each of these properties. The unadjusted value of each property was estimated based on lot size and location. The price was then adjusted to account for the average value of buildings. This adjusted value was then used to determine the increase in value associated with the nearby natural feature. A final adjustment was made for proximity effects. The value of properties abutting directly on a natural feature is typically impacted more than properties more distant from the natural feature. A distance decay function was estimated from the results of other hedonic analyses.

The results of the hedonic analysis indicate that on average natural features in south Mississauga increase property values by about $8,010 per property. This increase in value is equal to about 2.4% of the base value of these properties. In north Mississauga, property values are increased by about $10,273 per property or about 3.6% of the base value.

Overall natural features increase property values in south Mississauga by a total of $127,636,079 and in north Mississauga by a total of $127,810,876. Of this total, the majority of the increase (i.e., over 75%) is accounted for by the green space category.

Uncertainty ranges for these estimates were produced. The error ranges for the hedonic price coefficients were used to estimate these uncertainty ranges. The uncertainty range for the aggregate impact on property values is ±3%.

The natural feature values estimated in this analysis capture only a small subset of the EGS that the natural features in the Credit River watershed produce. These economic value estimates capture primarily the amenity values enjoyed by property owners living nearby a natural feature. The amenity values enjoyed by people living more than 100 m from the natural feature are not included. Likewise, these estimates do not include any other EGS that a natural feature might provide.

These economic value estimates are driven by current consumer preferences. As consumer preferences change over time, the value assigned to being proximal to natural features will change as well. These changes in consumer preferences could result in the value of natural features increasing or decreasing. However, the expectation is that environmental conservation will remain a high public priority as local and global environmental pressures increase. For this reason, the value of being proximal to natural features can be expected to increase over time.

These results provide compelling evidence of the large economic importance of natural features in the Credit River watershed even when only a subset of the values of natural features is included. In this respect these results provide a strong basis for investing greater attention in the conservation and management of these features.

The hedonic modeling methodology used in this study provides estimates of the economic value for individual properties of specific natural features. This information could be valuable for estimating the compensation that is due to individual homeowners in the event that a local natural feature is damaged or destroyed and it is deemed that local property owners have some legal right to seek damages for such losses.

These results provide a solid foundation for making decisions on budget allocations. The overall value of the capital stock on hand is commonly used as a rule of thumb for arriving at operating and maintenance budgets for that capital. While other considerations must play a role, the results of this study will provide a solid starting point for making these difficult budgeting decisions.

MPAC has provided hedonic model coefficients for all market areas in the watershed. These model results could be used to produce comparable economic value estimates for the remainder of the watershed provided that a comparable property database was available. Expansion of the analysis should be undertaken as the need arises.

TABLE OF CONTENTS

List of Tables

List of Figures

Acknowledgements

DSS Management Consultants Inc. acknowledges the following contributions to this analysis.

Mike Puddister, Credit Valley Conservation, directed the project and provided critical comments on various drafts of this report and overall guidance on the purpose and context for the study. Mike's ongoing support and patience while the data and analysis on which this report is based were compiled was essential.

Jeff Wilson, Credit Valley Conservation, played an ongoing role in overseeing the technical aspects of the analysis. Jeff's assistance was particularly valuable in coordinating the work of CVC's GIS team.

Brian Morber, Credit Valley Conservation, directed the compilation of the GIS database that was used in this analysis. Brain developed the natural feature typology based on the MPAC sample sites and applied this typology to natural features in the study area.

Scott Milne, Product Development Manager at MPAC, provided market models for the Credit River watershed. As well Scott provided helpful explanations of the MPAC modeling approach as needed.

This project was undertaken with the assistance of an advisory committee. The members of the committee are:

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Most of the cover page photos were obtained from the following source:
http://www.mississauga.ca/portal/

1 Introduction

This section provides the context for this report. The background leading up to the study is reviewed. As well, the scope of the analysis and the structure of this report are set out.

1.1 Background

This study is part of a long-term initiative by Credit Valley Conservation (CVC). CVC has committed to developing ultimately a comprehensive information system which can be used to derive measures of the economic value of ecological goods and services (EGS) provided by the Credit River watershed. This information system will assist CVC in making management decisions affecting the Credit River watershed and the quality and quantity of available EGS.

As a public agency, CVC makes management decisions designed to enhance the public good (i.e., that are designed to yield a positive net social benefit) while ensuring the conservation of the Credit's natural resources. For example, CVC strives to provide the optimal supply of natural features that will yield the greatest benefit to its "shareholders" (i.e., the residents and municipal governments in the watershed). CVC however, does not have absolute control over all factors affecting the supply of natural features and is often faced with pressure to change land and water uses from private land owners who are driven by strong economic forces. The results of CVC's valuation of EGS initiative will assist in evaluating economic trade-offs and in arriving at a mix of natural features and land and water uses that will yield the greatest benefit to the community.

As part of this initiative, CVC issued a request for proposals to prepare several valuation studies for EGS in the Credit River watershed. DSS prepared a technical proposal outlining its proposed valuation methodology which was based on using a hedonic modeling approach to produce estimates of the impact on property values of nearby natural features. The DSS proposal was accepted by CVC in June 2006. This report describes the results of the DSS analysis.

As noted, this study is focused on a subset of the Credit River watershed EGS. The increase in the value of properties proximal to natural features represents a portion of the value of their associated EGS. These property value impacts need to be combined with other measures of the economic value of EGS to arrive at an estimate of their total value. The results of this study provide an initial partial estimate of this total value.

1.2 Scope of Report

This report provides details on the methodology and data used to produce estimates of the property value impacts of natural features in the Credit River watershed. The methodology is generic and has been applied to two real estate market areas[1] in the watershed. The methodology can be expanded to other market areas in the watershed as needed by the CVC. The steps required to do so are set out in this report.

[1] Property values are analysed based on different geographical areas referred to as market areas. See Section 2.3 for further explanation.

The methodology includes only that portion of the economic value of natural features that are capitalized by private landowners through the value of their property. The estimated impacts on property prices of these natural features do not reflect their full societal value. Indeed, these estimates likely capture only a relatively small portion of the total economic value of these natural features.

This analysis is limited by the scope of natural features that the Municipal Property Assessment Corporation (MPAC) includes in its analysis of property values. For this reason, the only natural features included are upland green space (e.g., publicly owned passive use open space like woodlots) and ravines. There are other types of natural features in the Credit River watershed that provide significant benefits (e.g., wetlands); albeit, there is some question whether proximity to wetlands enhance local property values. In any event, the exclusion of these other types of valuable natural features means that the values derived in this analysis are underestimates of the total value of natural features in the watershed.

1.3 Report Organisation

Section 2 of this report explains the economic theory and principles on which the property appreciation impacts have been derived. Basic concepts central to the methodology are introduced and explained. Each of the steps that were taken to derive the property appreciation impacts of natural features is described.

Section 3 presents the results of the analysis.

Section 4 discusses the interpretation of the results and presents some recommendations arising from the analysis. These range from ways to improve the analysis in the future to how best to apply the results for management purposes.

2 Property Appreciation Methodology

This section describes first the economic theory underlying the property appreciation methodology used to value impact of natural features on properties in the Credit River watershed. Next the individual steps and data sources are described for the valuation methodology.

2.1 Hedonic Model Methodology

Two basic types of valuation methodologies are commonly used to value non-market goods and services, namely revealed and stated preference techniques (Young, 2005). Revealed preference techniques rely on the observed behaviour of people to deduce value estimates. Stated preference techniques rely on the responses of people to some form of survey, questionnaire or experimental trade-offs to deduce preferences and values. Hedonic models are a form of revealed preference valuation since they rely on consumption behaviour to deduce the value of individual components or characteristics of purchased goods and services.

According to Colwell and Dilmore (1999), Court (1939) published the first article on hedonic price indexes. However, Waugh (1928) estimated price-characteristic functions for vegetables, and Haas (1922) estimated land price-location functions. Today, the hedonic methodology is now well established and used widely (e.g., Triplett, 2004).

The basic economic principle underlying hedonic models is the idea that a particular good has various components or characteristics that in combination produce the overall value of the good; or conversely, that the value of individual components can be deduced from the overall value of a good or service. For example, a car consists of a body, engine, wheels, etc. By statistically comparing the selling prices for different types of cars with different types and combinations of components, the value of each type of component can be deduced. In brief, hedonic models of cars are based on the idea that the value of a car is equal to the sum total of the value of the parts. The hedonic model methodology is based on two key principles:

1. The value of the good can be reduced to its constituent parts, and
2. The market values of those constituent parts individually are equal to their contribution to the total value of a good.

Of course, the value of a car may be determined by more than the material components. For example, the brand name (e.g., Porsche) alone may increase the price that people are willing to pay for a car. For this reason, the price of a good may consist of material and perceptual characteristics that combined result in the overall price for the good.

Hedonic models are estimated by analyzing the selling prices for a particular class of goods (e.g., cars) and testing different model formulations to see which best predicts observed consumer behaviour. The testing involves testing the inclusion of different components of the good and different coefficients and functional forms. Typically the best model is the one that best forecasts consumer purchasing behaviour associated with different types of a good (i.e., different combinations of components). A hedonic model consists of a set of components (i.e., specific constituents or characteristics of a good), coefficients for each component and the functional form for each coefficient. The hedonic model can then be used to forecast the likely selling price of other goods comprising different combinations of the components.

The coefficients for each component are estimates of their contribution to the total value of a good. In other words, these coefficients are estimates of the value of each component as revealed by consumer behaviour. In theory, these value estimates are comparable to value estimates that one would expect to derive from a well-structured and rigourous stated preference methodology.

Statistical techniques (typically some form of regression analysis) are used to derive and test hedonic model coefficients. As a result, the precision of a hedonic model is strongly influenced by sample size, variability and representativeness. As the complexity and variability of the good being analysed increases, the sample size needed to precisely estimate individual coefficients increases as well.

Hedonic models are used extensively in real estate. Buildings and properties are heterogeneous. As a result, prices vary significantly from one to another. With hedonic models, it is assumed that the value of a property can be separated or decomposed into individual characteristics such as number of bedrooms, size of lot, character of the neighbourhood, etc. A hedonic model treats these characteristics (or bundles of characteristics) as if they were separate goods, and estimates prices for each of them. Hedonic models are commonly used in tax assessment and litigation.

One of the earliest studies using hedonic models to estimate the prices of environmental goods was by Ridker and Henning (1967). That study used census data to examine the impact of air pollution on median house values in different census tracts. Since then, the hedonic method has been widely used to infer the value of environmental amenities that are bundled with real property (Pope, 2008). Considerable research has been undertaken estimating the impact of positive (e.g., natural areas, open space and clean water) and negative (e.g., waste disposal sites, major roadways and industrial development) environmental features on property values (Geoghegan et al, 2003; Smith et al, 2002; Irwin and Bockstael, 2002; Achyarya and Bennet, 2001). For example, hedonic analysis has been used to estimate the amenity value of particular types of open space: golf courses (Talhelm, 2001), neighbourhood parks (Epsey and Owusu, 2001), greenbelts (Curran, 2001; Quayle and Hamilton, 1999), forest areas (Tyrvainen and Miettinen, 2002) and urban wetlands (Mahan et al, 2000; Earnhart, 2001). This research has shown that property prices are affected by their proximity to such environmental features and that the effect generally declines exponentially with separation distance (Anderson and West, 2006; Curran, 2001; Hammer et al, 1974; Quayle and Hamilton, 1999).

Residential properties in Ontario are primarily valued using a type of hedonic modelling called the Sales Comparison approach to value. The Municipal Property Assessment Corporation (MPAC) carries out this approach using multiple regression analysis a statistical technique used commonly in hedonic model development. MPAC has identified over one hundred unique market areas and created regression equations for each of these markets for the purpose of valuing residential property These MPAC models include several adjustment factors to account for proximity to positive and negative environmental features. MPAC is required to produce estimates of value as of a legislated valuation date and to adjust sale prices to reflect any market change over time.

2.2 *Modifications to Methodology*

The original methodology that was proposed by DSS was to construct a customized hedonic model for a sample of properties in the Credit River watershed that were and were not proximal to specific types of natural features. These results were proposed to be extrapolated across the watershed to derive the total economic value of each type of natural feature in terms of enhanced property values. This methodology was modified significantly for a number of reasons.

An unsuccessful attempt was made to secure access to the real estate transaction database for the Credit watershed through the Toronto Real Estate Board (TREB). TREB has proprietary rights to the Multiple Listing Service database. This database contains critical information on specific property characteristics (e.g., age of buildings, type of construction, number and floor area of different types of rooms, lot size and frontage) plus the latest selling price. However, TREB would not provide access to that database for the purposes of this study. No other practical source for these data was available.

Subsequently MPAC was approached to determine if their in-house hedonic models might be adapted for the purposes of this analysis. MPAC receives all land title documents registered at the fifty-four Land Registry Offices across Ontario. These documents contain information such as the: owner's name, mailing address, legal description, sale amount, sale date, etc. These data are entered in MPAC's property database. Only sales that are considered to represent valid market sales are included in MPAC's analysis. MPAC agreed to use their sales comparison approach to produce property value models for each market area in the Credit watershed.[2] As well, MPAC provided digital maps of the market areas and the homogeneous neighbourhoods[3] within each market area (Figures 1 and 2).

MPAC includes adjustment factors for proximity to four classes of green space/natural area, namely, green space (mainly upland woodlots) and ravine types 1, 2 and 3. MPAC provided specific examples for each of these classes of green space.

Once the availability and nature of the MPAC model results were confirmed, the methodology was revised as follows. An inventory for each MPAC class of natural feature type was prepared by the CVC GIS department. This inventory was overlaid on the property parcel layer. All properties within 100 m of a natural feature were entered into a spreadsheet along with key information about the property. This database was combined with the MPAC model coefficients to arrive at the increase in value for each property proximal to a natural feature.

This revised approach had some advantages and limitations relative to the original methodology.

2.2.1 Advantages

There are three major advantages with using the MPAC models. First, the MPAC models are based on a comprehensive analysis of all recent property transactions. The original methodology was based on using a sample of properties due to budgetary constraints. By using all properties the model coefficient estimates were considerably more robust than what might have been achieved with a much smaller sample.

Second, MPAC has tested and compared many different property characteristics and model formulations throughout the province. These models have been tested repeatedly by independent experts through tax appeals and other legal proceedings. As a result, their rigour and credibility is exceptional and far greater than is the case with hedonic models reported in the environmental economics literature which are based on much smaller sample sizes and fewer property characteristics.

[2] All MPAC products (e.g., the market models and the market and homogeneous neighbourhood maps) included in this report are copyrighted and are proprietary to MPAC. None of these products should be sold or reproduced without the written consent of MPAC.

[3] Homogeneous neighbourhoods are geographic areas defined by natural (e.g., ravines, topography, major streets), man-made or political boundaries and are established based on a commonality of land uses and the types and ages of buildings. Every residential property in MPAC's database is identified with a code (e.g., A16) which corresponds to its homogeneous neighbourhood. This ensures MPAC is able to capture this important property characteristic during its valuation of the property.

Finally, MPAC has examined in detail the influence that location plays on property prices and has developed a comprehensive system of market areas and homogeneous neighbourhoods (see Figures 1 and 2). This level of geographic precision is exceptional and results in greatly improved estimates of the impact of natural features on property values and could not have been achieved with the original methodology.

2.2.2 Limitations

Two principal disadvantages are associated with using the MPAC hedonic models. First, the MPAC natural feature classification system is coarse and evolving. A standard typology for the natural feature types was not available from MPAC. Instead, CVC deduced a typology based on a sample of properties for different natural feature classes provided by MPAC. The limitations of the MPAC natural feature classes limited the range and resolution of natural features that could be included in the analysis. For example, different levels of natural feature quality within a category could not be captured.

On the other hand, the natural feature classes that MPAC uses are derived based on observed price variations. In other words, the coarse nature of the natural feature classes largely reflects the coarse nature of consumers' perceptions of natural features when they are making decisions to purchase a property. For this reason, adding greater resolution based on more scientifically-derived classes of natural features would likely not improve the resolution or precision of the value estimates.

The other major disadvantage relates to the methodology that MPAC uses to estimate the impact of natural features on property values. MPAC only includes an adjustment for properties that abut directly onto a natural feature. The original methodology proposed to estimate the impact for properties directly abutting on a natural feature and more distant properties. This disadvantage was overcome by modifying the MPAC natural feature adjustment factors to account for the impact of separation distance.

Further details of the analytical methodology are provided following.

2.3 Methodological Steps

The methodology used for assessing the impact of natural features on property values involves integrating the standard MPAC hedonic models with detailed geographic information on the distribution of individual properties relative to the location of individual natural features.

Following are the specific steps which were followed in this analysis.

1. MPAC market models for each of the eight market areas within the Credit River watershed were obtained.
2. Two market areas were selected for detailed application of the methodology (i.e., south and north Mississauga).
3. A typology for the four MPAC natural feature classes was developed by examining a sample of properties whose value had been adjusted by MPAC appraisers due to the presence of a certain type of natural feature.
4. A comprehensive geo-spatial inventory of natural features classified according to the MPAC natural feature classes was prepared for each market area (Figure 3).

5. A property database was compiled for these properties which included information on the homogeneous neighbourhood, lot size and proximity to a specific class of natural feature.
6. An adjusted value for each property was calculated using the corresponding MPAC model and lot size and homogeneous neighbourhood adjustment factors.
7. The hedonic modeling literature was reviewed and a distance decay function was derived based on reported results.
8. The increase in the adjusted value attributable to proximity to a natural feature was calculated using the corresponding MPAC adjustment factor, the separation distance between the natural feature and the property boundary and the generic distance decay function.
9. The results for individual properties were aggregated to produce summary results for various combinations of market areas and natural feature types.

Further details associated with these steps are discussed following.

2.4 MPAC Market Models

MPAC is an independent, not-for-profit corporation whose main responsibility is to provide municipalities with property assessments for taxation purposes. MPAC's mandate is to accurately classify and value properties in Ontario in compliance with the Assessment Act and regulations established by the Ontario government. Residential properties in Ontario are primarily valued using the sales comparison approach. MPAC regularly analyses recent market transactions to derive hedonic price coefficients for each of over one hundred unique market areas in the province. The basic methodology is common across all market areas.

MPAC has identified using statistical analyses a large number of property characteristics that significantly influence property value. These characteristics include the number, size, type, age and quality of the buildings on the property plus the size and nature of the lot. In addition, MPAC has identified a number of locational factors that influence property values. For example within each market area, a fabric of homogeneous neighbourhoods has been defined (see Figure 2). MPAC derives adjustment factors (i.e., hedonic price coefficients) for each neighbourhood [4].

MPAC also estimates for each market area adjustment factors to account for the proximity of positive and negative environmental features. Proximity to green space has a positive impact on property values. The magnitude of the impact is dependent on the nature of the green space. As noted above, MPAC includes adjustment factors for proximity to four classes of green space/natural area, namely, upland green space and ravine types 1, 2 and 3.

[4] Neighbourhood adjustment factors are derived similar to all other adjustment factors used by MPAC. Locational variables are included in the regression model for a market area and are tested for statistical significance. Only statistically significant locational differences are included to define homogeneous neighbourhoods. In this way, homogeneous neighbourhoods ultimately are defined empirically; although, they also are typically evident from visual inspection as well. These MPAC adjustment factors are the hedonic price coefficients estimated for the regression model for each market area.

Figure 1 – MPAC Market Areas Within Credit River Watershed

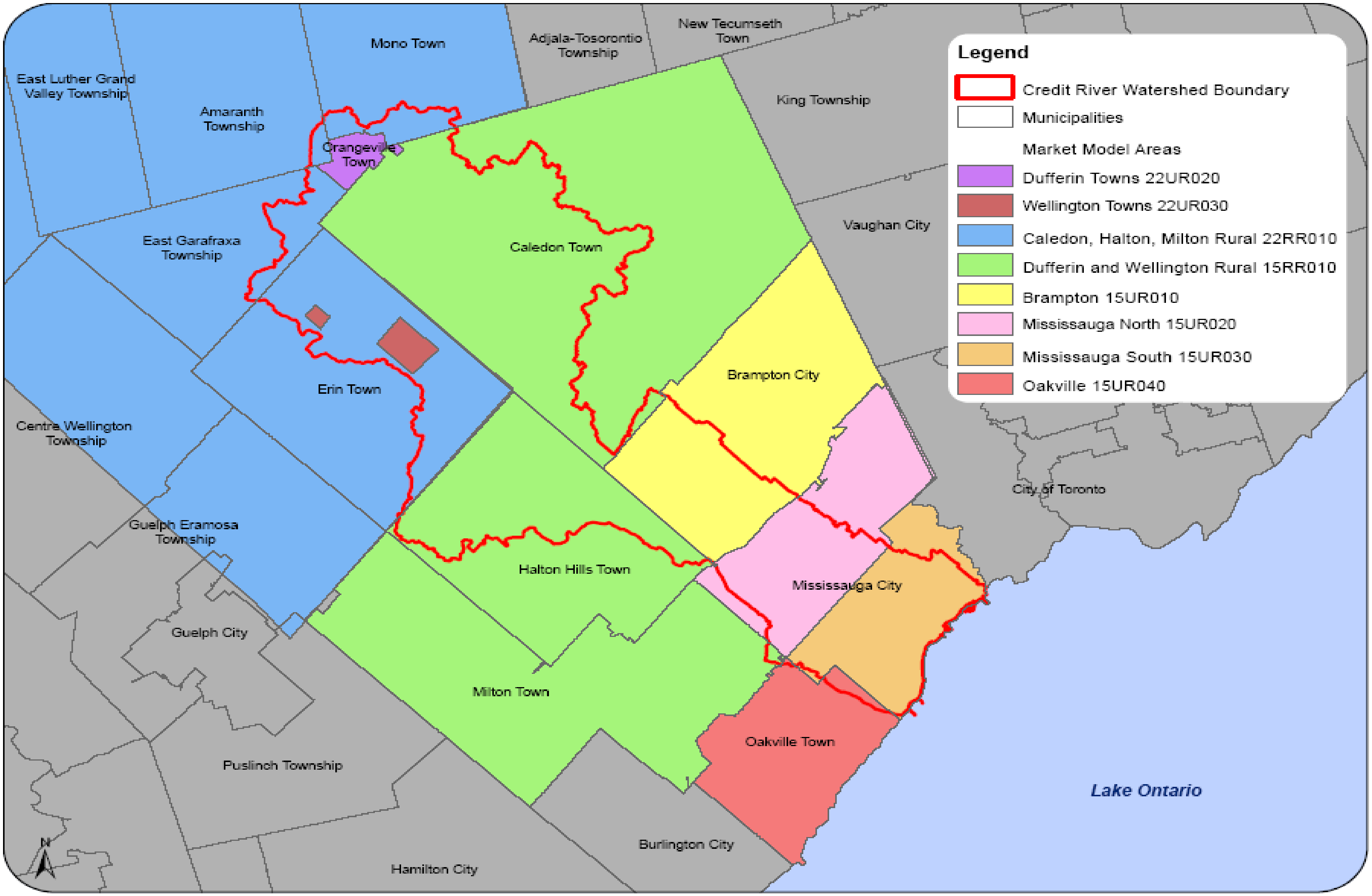


Figure 2 – Homogeneous Neighbourhoods for South and North Mississauga Market Areas

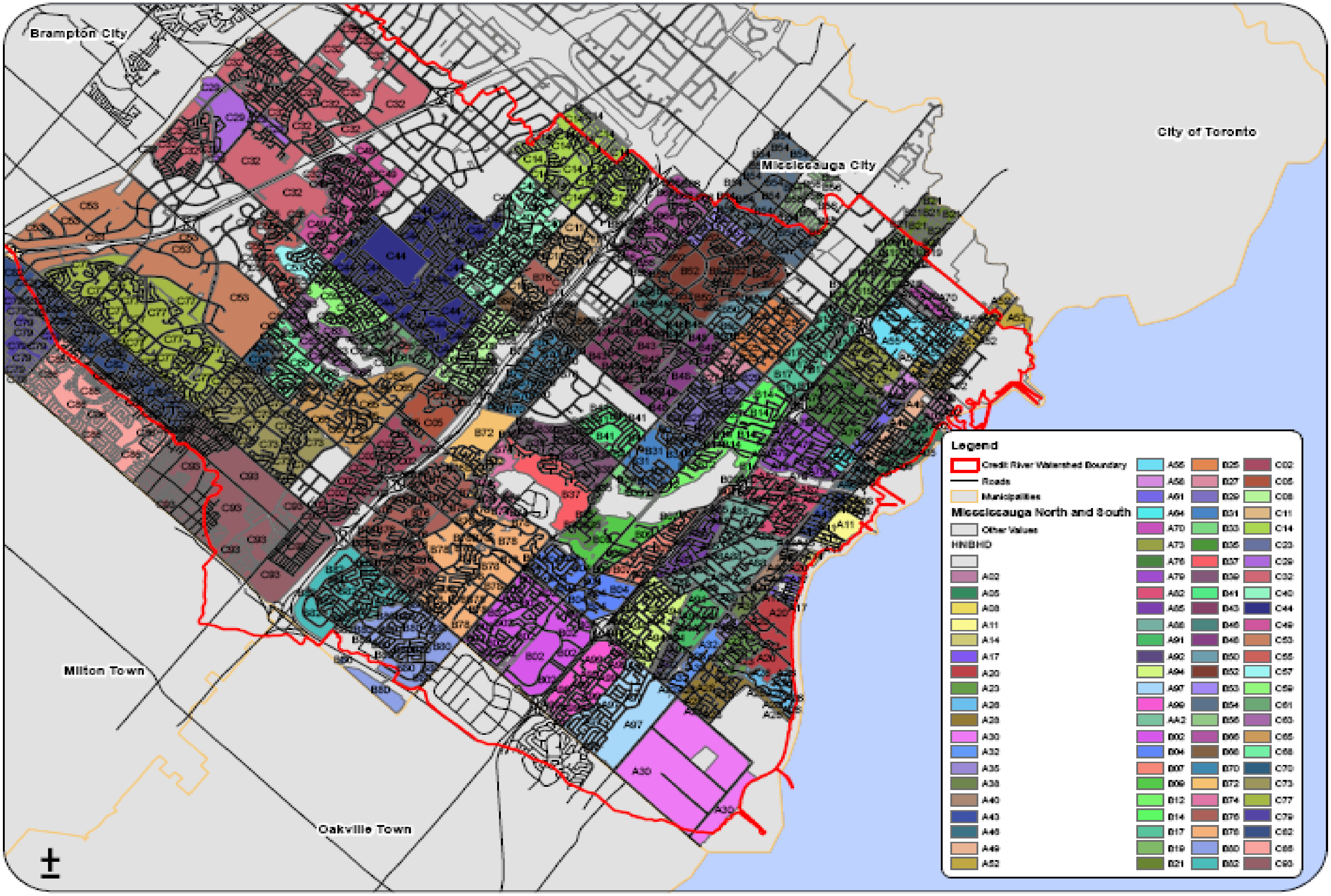
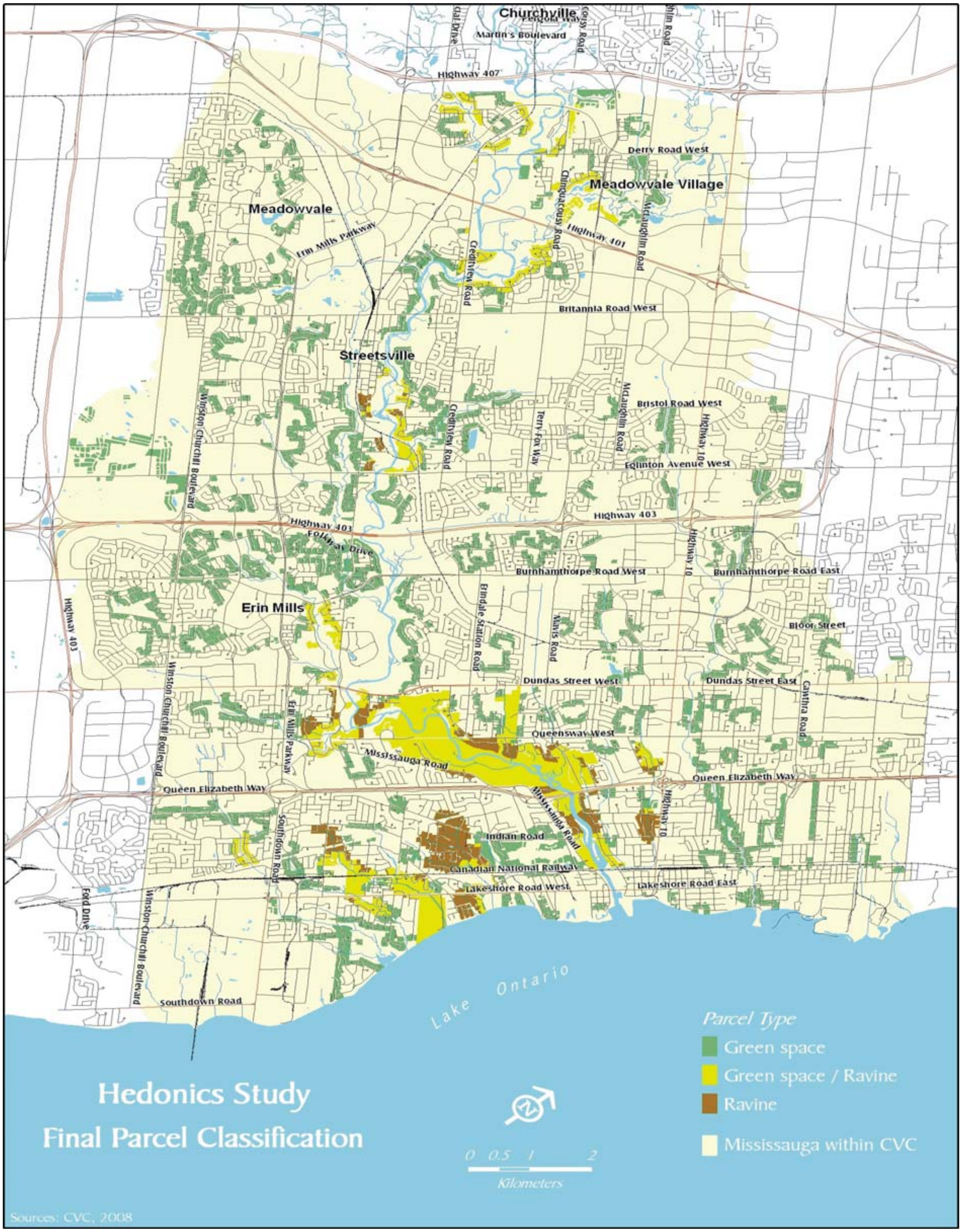


Figure 3 – Map of Natural Features in South and North Mississauga[5]



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[5] This map was produced by the CVC GIS department.

Using recorded sale prices, these adjustment factors are estimated as a percentage of the base value constant[6] for each market model. The adjustment factors may be positive or negative depending on the impact of the moderating characteristic. For example, the value of two comparable properties in different homogeneous neighbourhoods may be different only as a result of their location. The base value constant is the starting value MPAC applies to all properties. The base value constant is not equal to the average sale price value. The base value constant is statistically derived and relates only to the hedonic price coefficients for an individual market model.

MPAC provided for each market area within the Credit River watershed, their 2005 base year market model coefficients with accompanying documentation outlining the details associated with the statistical procedures used to derive these coefficients. The south Mississauga model was based on all market transactions from 2003 to 2005 (i.e., a total of 14,539 sales) with an average sale price of $338,863. The north Mississauga model was based on all market transactions from 2003 to 2005 (i.e., a total of 8,917 sales) with an average sale price of $287,181. Appendix A provides the MPAC model coefficients for each market area that were used in this analysis.

2.5 Market Areas

CVC decided to apply this methodology to a portion of the Credit River watershed. South and north Mississauga were selected since these areas have a diversity of nature feature types and represent a range of property types and pressures in terms of conservation of natural features. Both lie within Peel Region, abutting the City of Toronto on the east and Halton Region on the west. South Mississauga is delineated by the Lake Ontario shoreline north to Hwy 403, north Mississauga stretches from Hwy 403 north to Hwy 407.

As well, considerable time is required to produce the supporting property database for the analysis. The decision was made to focus the analysis within part of the watershed initially. If the results prove useful, the scope of the analysis may be expanded to encompass additional market areas over time.

2.6 Natural Feature Adjustment Factors

MPAC has developed four classes of green space adjustment factors. The values for each natural feature adjustment factor for each market area are shown in Table 1. Abutting a natural feature can increase property value from 1% to 5% depending on the type of natural feature.

These adjustment factors are estimated using the hedonic regression analysis techniques described in Section 2.1. However, the precision of the estimates is influenced by the number of market transactions available for the analysis and that are adjacent to a specific type of natural feature. Where the number of observations is small, the precision of the estimated

[6] The base value constant is the statistically-derived constant for the regression model for each market area. The impact of the relevant adjustment factors for an individual property is added to this constant to generate a unique market value assessment. The methodology used in this study is identical to this market assessment methodology except that detailed information on all of the property adjustment factors were not available and the focus was not on estimating the overall market value of individual properties but instead, on the incremental value attributable to proximity to a natural feature.

adjustment factor is reduced. For this reason, MPAC overrides the estimated values where they are outside the range normally estimated. The columns entitled “Source” in Table 1 indicate whether the adjustment factor is derived from the hedonic regression analysis or the estimate has been overridden and constrained by MPAC to a more reasonable range. These adjustment factors were used in this analysis.

Table 1 - MPAC Natural Feature Adjustment Factors

Natural Feature Type	South Mississauga	Source	North Mississauga	Source
Green Space	2%	model derived	4%	model derived
Ravine Type 1	5%	model derived	3%	constrained
Ravine Type 2	4%	constrained	2%	constrained
Ravine Type 3	3%	model derived	1%	constrained

The adjustment factors are fairly consistent and logical. Ravine type 1 includes the largest and most natural areas whereas ravine type 3 is the least natural. This trend is evident in the adjustment factors for each ravine type in each market area; albeit the magnitude of the effect varies from one to the other.

The behaviour of the green space adjustment factor is less consistent. In south Mississauga, proximity to green space has less impact than ravine type 3 whereas in north Mississauga, the impact is greater than ravine type 1. This inconsistency is likely partly due to the variation in ravine types and green spaces between the two market areas. These results also highlight the potential for significant variations in the impact of natural features from one location to another.

As well, MPAC is in the process of standardizing the use of natural feature adjustment factors by its staff (Milne, 2008). Considerable discretion is assigned to staff when a determination is being made about the impact of a nearby natural feature. MPAC is working to reduce this potential source of variation.

2.7 Natural Feature Categories

For the purposes of this analysis, MPAC provided a sample of properties for the two market areas. In each case the type of natural feature that had been defined by MPAC appraisers was provided. Each of these natural features was examined individually and compared to other natural features in the same class and those in other classes. On the basis of these comparisons, a natural feature typology was derived for the two market areas that could be applied using remote sensing information.

The green space category was separated from the ravine types by topography alone. MPAC designates publicly owned land with public access as green space if it is not planned for development and is designated as Green Space or Open Space by a municipal zoning by-law. Green space does not include active recreational areas (e.g., ball fields, golf courses) but does include passive use parks. All upland natural features (including upland woodlots) were coded as green space as well as other categories of open space meeting these criteria.

The ravine types were distinguished by topography, size, connectivity and tree cover. Ravine type 1 sites were deeper and larger connected ravines with considerable tree cover. Ravine type 3 included isolated shallow ravines often devoid of tree cover. Ravine type 2 was intermediate between these two types.

2.8 Natural Feature and Property Inventory

CVC produced the natural feature and property inventories that were used in this analysis. First, the natural feature typology deduced from the MPAC sample properties was used to assign all natural features in the two market areas to one of the four MPAC categories. The boundary of each natural area plus its classification code was included in a GIS layer (see Figure 3). A 100 m[7] zone of influence around the boundary of each natural feature was added.

The natural feature layer was overlaid on a property boundary GIS layer. The property boundary layer included geo-referenced property lines plus a tax roll identifier. All properties for which a portion of their boundary was within the 100 m zone of influence of a natural feature were included in the database. In total 28,377 individual properties were included in the analysis.

For each eligible property, the following data were included in the database:

- Assessment roll number
- Market area
- Homogeneous neighbourhood
- Lot area
- Type of natural feature
- Nearest distance to natural feature.

In some cases, a property boundary intercepted the zone of influence of more than one natural feature. Where more than one natural feature was present, the feature closest to the property was assumed to have the dominant effect. This simplification underestimates the impact of natural features on property values. Some additivity is likely among the impacts of natural features but no function for combining these impacts was available.

Table 2 provides a summary of the eligible properties in each market area according to the type of natural feature nearby. By far, the majority of the properties in both areas were proximal to green space. The frequencies of the ravine types declined from ravine type 1 to ravine type 3. The total numbers of properties in each market area are similar.

[7] The width of this zone of influence was based on results reported in the literature. Further explanation is provided in Section 2.9.

Table 2 – Summary of CVC Properties Database

Natural Feature Type	Market Area		Totals
	South Mississauga	North Mississauga	
Green Space	13,566	11,304	**24,870**
Ravine Type 1	932	453	**1,385**
Ravine Type 2	1,222	685	**1,222**
Ravine Type 3	215	-	**900**
Total	15,935	12,442	**28,377**

Table 3 provides a summary of the property characteristics associated with each type of natural feature in each market area. Some consistent differences are evident between south and north Mississauga. The average lot size is considerably larger in south Mississauga. Likewise, lot frontages tend to be larger. These differences reflect the development history of these two market areas. South Mississauga was developed earlier than north Mississauga. Lot sizes and frontages have tended to decline over time.

Table 3 – Sample Properties Statistics

Natural Feature Type	Average Lot Size (ha)		Average Lot Frontage (m)	
	South Mississauga	North Mississauga	South Mississauga	North Mississauga
Green Space	0.07	0.06	20.1	17.4
Ravine Type 1	0.23	0.07	38.8	19.9
Ravine Type 2	0.23	0.09	45.7	22.2
Ravine Type 3	0.09	-	21.1	-
Overall	0.09	0.06	23.1	17.8

These differences likely explain some of the differences seen between the two areas in terms of property appreciation impacts. The larger lots and frontages in south Mississauga lead to higher values for individual properties but result in fewer properties being influenced by a given natural feature due to increased separation distances.

2.9 Unadjusted Value Estimation

The initial unadjusted value for each property was calculated according to the following equation.

$$BV_{i,m,n} = \left(MC_m + \sqrt{LA_{i,m,n}} \times LF_{m,n}\right) \times HN_{m,n} \times \left(AP_m \div AE_m\right)$$

Where:

$BV_{i,m,n}$ is the unadjusted value for the i^{th} property in homogeneous neighbourhood n in market area m (dollars)

MC_m is MPAC hedonic regression equation constant for the base value for market area m (dollars)

$LA_{i,m,n}$ is the lot area for the i^{th} property in homogeneous neighbourhood *n* in market area *m* (m^2)[8]

$LF_{m,n}$ is the lot area adjustment factor for homogeneous neighbourhood *n* in market area *m* ($\$/m^2$)

$HN_{m,n}$ is the adjustment factor for homogeneous neighbourhood *n* in market area *m* (%)

AP_m is the average reported sale price for market area *m* (dollars)

AE_m is the average unadjusted estimated property value for market area *m* (dollars)

The rationale for each of the terms in this equation is self evident from their definitions with the exception of the last two terms. The full MPAC models include many variables that take into account the nature of the buildings on the property (see Section 2.2). These types of details could not be provided by MPAC for the properties included in the database. As a result, when the average unadjusted values for the properties in the database were compared to the average selling price for the properties on which the MPAC models were based, the average of the unadjusted values was considerably less than the recorded average selling price. In other words, an adjustment was required to account for the value of the buildings on the properties.

The last term in the base value equation was added for this reason. As a result of this adjustment, the average estimated base value of the properties in the database is equal to the average value of the recorded transactions for the market area. This adjustment is imprecise with respect to individual properties since considerable variation in building number, size and quality among properties is common. However, this imprecision balances out when the results are aggregated and has much less effect on the precision of the aggregate estimates.

That being said, this adjustment likely leads to an underestimate of the total impact of natural features on property values. The properties and buildings adjacent to natural areas tend to be above average due to the increased attractiveness of the location. This adjustment assumes that the buildings on these properties proximal to natural features are of average quality for the market area. No data were available to estimate the difference in average property value for properties proximal to natural features.

2.10 Distance Decay Function

The MPAC green space adjustment factors are applied only to abutting properties. However, research has shown that the value of properties proximal to but not directly abutting an environmental feature may be affected also (Anderson and West, 2006; Curran, 2001). For example, the negative impacts on property values of a nearby heavy industry plant are not limited only to properties abutting such a facility. The width of the impact zone will depend on many factors including visibility, negative publicity and the nature of the operations. Irrespective of these site-specific factors, researchers have consistently shown that the magnitude of the impact declines with distance. The rate of decline tends to be exponential (Hammer et al., 1974; Quayle and Hamilton, 1999).

[8] The hedonic regression analysis tests various forms of each variable to find the form that yields the best fit. In the case of lot area, the square root of the lot area is the form of this variable that yields the best fit. That is why this equation uses the square root of the lot area.

The environmental economics literature was searched for hedonic analyses relating real estate prices to proximity to green space. Table 4 summarises the results of that review. This table shows the type of green space examined and the magnitude of the proximity impact at different separation distances. In many cases, researchers arbitrarily set the zone of influence and then lumped all properties within the zone to derive an estimate of the average proximity impact. However, several researchers explored quantitatively the relationship between separation distance and rate of decline of the proximity impact.

Overall these results reveal a general decline in effect with distance as expected. Likewise the proximity effect varies with the nature of the green space. The magnitude of the impact varies considerably, by as much as over 30%.

Anderson and West (2006) used a hedonic analysis of real estate transactions to estimate the effects of proximity to open space on sales price in the U.S.A. They derived empirically an exponential distance decay function. The mathematical form of the function is asymptotic. Various truncated forms of the function were tested against an approximate function derived by aggregating various results reported for greenways (Figure 4). On the basis of these results, a cut-off distance of 100 m was selected.

Truncating the zone of influence to 100 m will tend to underestimate the full impact of natural features on property values. Certainly the estimated value of the natural features would be increased by expanding the zone of influence. Based on a zone of influence of 350 m, the function suggests that 20% of the impact remains at 100 m. The unlimited nature of this exponential decay function suggests that property values will be affected at even greater distances by a natural feature. However, as the distance increases, the magnitude of the effect declines greatly. As well enlarging the zone of influence would also increase significantly the size of the property database. Using a zone of influence of 100 m is conservative but the magnitude of the underestimate cannot be estimated without more detailed analysis.

2.11 Natural Feature Impacts

The natural feature impact on the value of each property in the database was calculated according to the following equation.

$$NV_{i,m,n,o} = BV_{i,m,n} \times NF_{m,o} \times e^{-(\ln(d) \times c)}$$

Where:

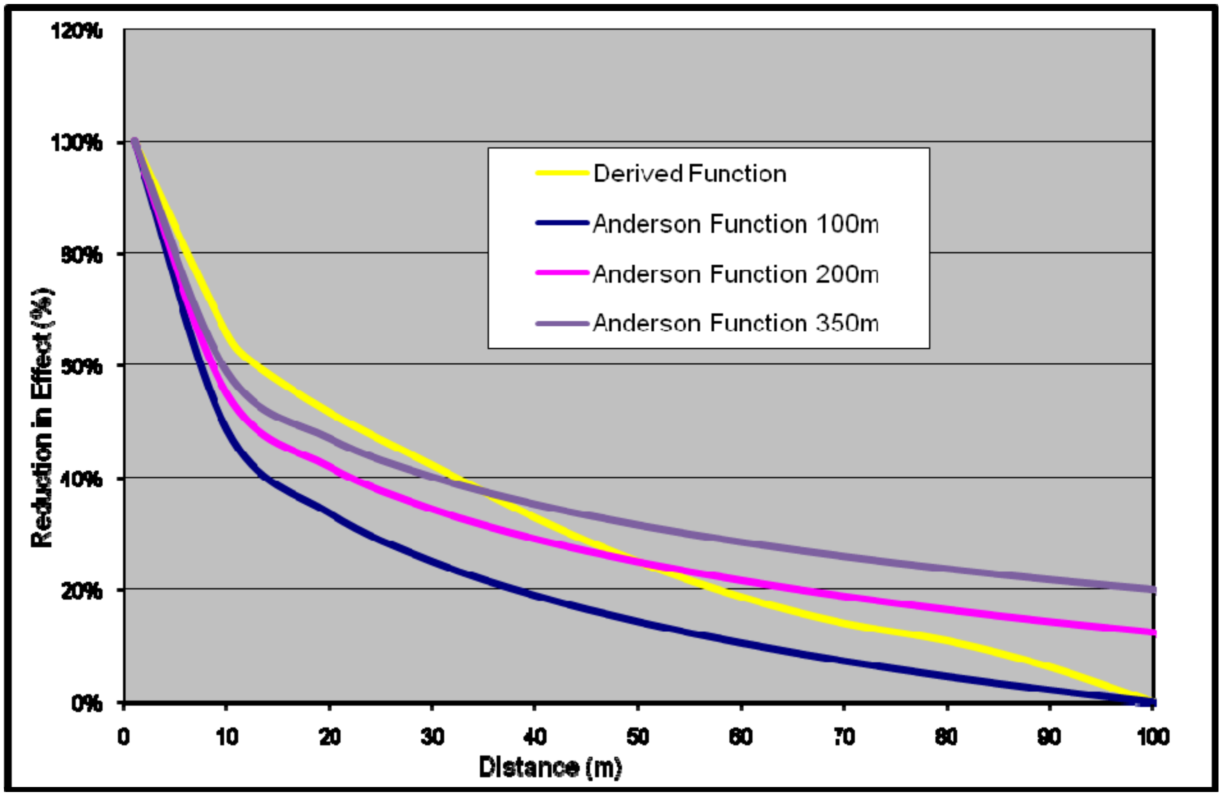
- $NV_{i,m,n,o}$ is the natural feature value for the i^{th} property in homogeneous neighbourhood *n* in market area *m* for nature feature type *o* (dollars)
- $BV_{i,m,n}$ is the base value for the i^{th} property in homogeneous neighbourhood *n* in market area *m* (dollars)
- $NF_{m,o}$ is the natural feature adjustment factor for market area *m* for nature feature type *o* (%)
- *ln (d)* is the natural logarithm of the measured distance between the nearest point of the boundary of the natural feature type *o* and the nearest point on the i^{th} property boundary (m)
- ***c*** is the regression constant (-0.0252) for the distance decay function for proximity to natural feature (1/m)

Table 4 – Proximity Impacts of Green Space on Property Values

Separation Distance (m)	Proximity Impact	Authority	Source
High Use Recreation Area			
NS	0%	Weicher and Zerbst, 1973	Curran, 2001
NS	negative	PKF Consulting, 1994	Curran, 2001
610	negative	More at al, 1982	Curran, 2001
Low Use Recreation Area			
6	negative	More at al, 1982	Curran, 2001
610	0%	More at al, 1982	Curran, 2001
Greenway			
0	7%	Curran and Draeseke, 2000	Curran, 2001
0	13%	Johnston et al, 2002	King et al, 2004
0	15%	Weicher and Zerbst, 1973	Curran, 2001
0	15%	Quayle and Hamilton, 1999	Curran, 2001
0	27%	Thorsnes, 2002	King et al, 2004
0	32%	Correl et al, 1978	Curran, 2001
12	33%	Hammer et al, 1974	Curran, 2001
46	0%	Quayle and Hamilton, 1999	Curran, 2001
46	0%	Johnston et al, 2002	King et al, 2004
46	0%	Thorsnes, 2002	King et al, 2004
50	8%	Curran and Draeseke, 2000	Curran, 2001
100	0%	Curran and Draeseke, 2000	Curran, 2001
137	0%	Quayle and Hamilton, 1999	Curran, 2001
137	0%	Weicher and Zerbst, 1973	Curran, 2001
305	9%	Hammer et al, 1974	Curran, 2001
610	4%	Hammer et al, 1974	Curran, 2001
975	0%	Correl et al, 1978	Curran, 2001
Golf Course			
0	5%	Talhelm, 2002	
0	8%	Do and Grudnitski, 1995	Curran, 2001
46	0%	Do and Grudnitski, 1995	Curran, 2001
46	1%	Talhelm, 2002	
Farmland			
0	2%	Irwin, 2001	King et al, 2004
46	0%	Irwin, 2001	King et al, 2004

The natural feature adjustment factors are shown in Table 1. These factors are derived by MPAC. The regression constant was extracted from the hedonic regression analysis reported by Anderson and West (2006). This coefficient was estimated for special types of parks (i.e., parks not used for active recreation) which corresponded most closely with the natural features in this analysis.

Figure 4 – Distance Decay Functions



2.12 Uncertainty Ranges

MPAC reports standard errors for key variables in their models. These standard errors have been used to generate central, high and low estimates of the impacts of natural features. The high and low ranges have been generated using simple combinations of the standard errors and hence overestimate the actual confidence limits of the estimates. On the other hand these error ranges capture only a subset of the estimation errors in the methodology. Adding error ranges for other variables would increase the confidence limits.

For these reasons the reported confidence intervals should be interpreted as being indicative and not definitive of the uncertainty in the estimates. More robust confidence intervals could be estimated using Monte Carlo sampling routine and a comprehensive set of error ranges.

3 Results

This section presents the results of the property appreciation analysis.

3.1 South Mississauga

The base value of the properties in south Mississauga was strongly correlated with proximity to different types of natural features. The highest value properties tended to be associated with ravine type 1 (Table 5). The lowest value properties were proximal to green space.

Table 5 - Average Value of Property and Natural Features Appreciation Impact

Natural Feature Type	Average Property Base Value	Average Property Appreciation Impact	Increase in Value
	South Mississauga		
Green Space	$317,476	$5,798	1.9%
Ravine Type 1	$605,016	$27,390	4.7%
Ravine Type 2	$478,309	$17,560	3.8%
Ravine Type 3	$355,591	$9,270	2.8%
Average	**$346,873**	**$8,010**	**2.4%**
	North Mississauga		
Green Space	$295,995	$10,618	3.7%
Ravine Type 1	$304,733	$8,350	2.8%
Ravine Type 2	$316.676	$5,855	1.9%
Ravine Type 3	N/A	N/A	N/A
Average	**$297,454**	**$10,273**	**3.6%**

On average natural features in south Mississauga increase property values by about $8,010 per property. This increase in value is equal to about 2.4% of the base value of these properties. Overall natural features increase property values in south Mississauga by a total of $127,636,079 (Table 6). Of this total, the majority (i.e., about 60%) is accounted for by green space. The large contribution by green space is driven the by the great number of properties in proximity to green space relative to other natural feature types (see Table 2). As well, residential densities around green space may be higher and setbacks from green space may generally be less compared to those around higher quality ravine types. This has two results. First the numbers of properties impacted is higher around green space and the impact of the distance decay function on the appreciation value is reduced due to closer proximity. Ravine types 1 and 2 comprise 37% of the property appreciation impact.

3.2 North Mississauga

Some similar patterns are evident for north Mississauga. However, the highest base value properties are associated with ravine type 2, not ravine type 1. This pattern may reflect the more recent and different development history of north and south Mississauga. The lowest value properties were proximal to green space but the overall differences in base value are considerably less than what is evident in south Mississauga.

Table 6 - Aggregate Property Appreciation Impacts

Natural Feature Type	South Mississauga	North Mississauga	Total
Green Space	$78,648,163	$120,012,138	$198,660,301
Ravine Type 1	$25,527,389	$3,782,412	$30,309,802
Ravine Type 2	$21,458,249	$4,016,326	$25,474,575
Ravine Type 3	$2,002,279	-	$2,002,279
Overall	**$127,636,079**	**$127,810,876**	**$255,446,956**

On average natural features in north Mississauga increase property values by about $10,273 per property. This increase in value is equal to about 3.6% of the base value of these properties.

Overall natural features increase property values in north Mississauga by a total of $127,810,876. Of this total, the great majority (i.e., over 90%) is accounted for by green space. Ravine types 1 and 2 account for all of the remainder.

3.3 Combined Impact

In total, natural features in the two market areas increase property values by about $255,446,956. Proximity to green space accounts for about 77% of this total. The three ravine types contribute declining proportions of the total consistent with declining natural qualities. The impacts are distributed fairly evenly between north and south Mississauga.

3.4 Uncertainty Ranges

Table 7 presents the uncertainty ranges for the aggregate property value results. These uncertainty ranges are based on the reported error ranges for the MPAC hedonic model coefficients (see Section 2.12). As discussed previously, these uncertainty ranges do not include allowance for all sources of uncertainty in the estimates. On the other hand, the estimation methodology used to produce these ranges results in maximum uncertainty ranges.

The difference between the central and upper and lower values is in the order of 3%. The variation in error range among market areas and natural feature types is small. If these uncertainty ranges are to be used for decision making, the more precise estimates should be prepared using random sampling methods.

Table 7 – Uncertainty Ranges for Aggregate Property Appreciation Impacts

Natural Feature Type	Low	Central	High
Green Space	$192,978,559	$198,660,301	$204,342,042
Ravine Type 1	$28,529,013	$29,309,802	$30,090,590
Ravine Type 2	$24,750,240	$25,474,575	$26,198,909
Ravine Type 3	$1,924,682	$2,002,279	$2,079,875
Overall	**$248,182,495**	**$255,446,956**	**$262,711,416**

4 Interpretation and Application

This section discusses how these results should be interpreted and applied from a conservation management perspective.

4.1 Interpretation of Values

The purpose of this study is set out in Section 1.2; in short, the purpose is to provide useful economic valuation information to advance conservation management in the Credit River watershed. One of the challenges with the valuation of EGS is that a single natural area typically supplies multiple types, quantities and qualities of EGS. As well, the types, quantities and qualities of EGS supplied vary from one natural area to another as do their value. To a limited extent, some of this variation is captured through the four types of natural features included in this analysis. However, caution must be exercised when interpreting these values.

The methodology only values those EGS that influence purchasers' decisions when purchasing real estate. The great majority of purchasers appear to focus strictly on the amenity values[9] afforded to them individually by a nearby natural feature. This behaviour is consistent with economic theory.

Many EGS provided by natural features are non-market public goods. They are not owned by private individuals. Private landowners cannot normally capitalize on these EGS. For this reason, a market-based methodology like hedonic modeling cannot hope to capture the value of these non-market public goods. Hence, the natural feature values estimated in this analysis capture only a small subset of the EGS that the natural features in the Credit watershed produce. Specifically, the estimated economic values capture primarily the amenity values enjoyed by property owners living nearby a natural feature. The amenity values enjoyed by people living more than 100 m from the natural feature are not included. Likewise, the estimated economic values do not include any other EGS that a natural feature might provide.

[9] Amenity values include aesthetic values including scenic value. As well, proximity to a natural area may provide an opportunity for passive uses (e.g., walking, bird watching).

Related to this point is the nature of the values that have been estimated. The increase in property value from proximity to natural features is realized by the property owner individually, not by the public as a whole[10]. In other words, these estimated economic values of natural features are market values that are owned privately. Most initiatives to value EGS are driven by the need to correct market failures when it comes to non-market values (i.e., underestimation of their value and as a result, sub-optimal allocations and use of these natural features). This type of concern does not apply in the case of the amenity values included in this study.

The amenity values included in this study are part of the real estate market. Their value is established through supply and demand and in theory their allocation within the market will be near optimal, ignoring the influence of various market imperfections. In other words, external management by the CVC through intervention in the supply of these values is not necessary. This feature of these results has important implications for their use in management.

This does not mean that a significant market failure is not present. Clearly, the optimal management and conservation of natural areas will not be achieved strictly through the private market since only a portion of the value of these areas is captured through real estate values. The results of this study provide an estimate of the private value that is captured through the real estate market as a basis to gauge the magnitude of the public benefits that are outside the private market.

These value estimates are capitalized values and not annualized values. Care must be taken when comparing these values with other estimates of the value of EGS which may be expressed as annualized values. These capitalized values can be converted to annualized values if required for a certain application by using a discount rate.

Finally, the economic values estimated in this analysis are driven by current consumer preferences. As consumer preferences change over time, the value assigned to being proximal to natural features will change as well. These changes in consumer preferences could result in the value of natural features increasing or decreasing. However, the expectation is that environmental conservation will remain a high public priority as local and global environmental pressures increase. For this reason, the value of being proximal to natural features can be expected to increase over time.

[10] Some public benefit may be realized through municipal levies charged to developers based on the increased value of lots proximal to natural features. However, this marginal increase in public revenue from this one-time charge is relatively insignificant compared to the value of the annual production of EGS associated with natural areas. Another common misconception about the impact of increased property values on public benefits relates to the idea that this will result in increased tax revenues. The public does not realize increased tax revenues from enhanced property values associated with proximity to natural features. Mill rates are based on the total assessment base of a municipality and its forecast budget. Increasing the assessment base (e.g., through the enhanced market value of properties proximal to natural features) may affect the mill rate for all property owners throughout a municipality (i.e., the distribution of the tax burden may change) but no overall increase in tax revenues will result. Accordingly, it is technically incorrect to claim that natural features increase tax revenues.

4.2 Management Applications

The ultimate purpose of the results of this analysis is to assist CVC make better conservation management decisions. This section examines how these results should be used to assist in conservation management.

4.2.1 Total Economic Value

Many conservation organizations are producing "natural capital" reports for various areas and ecosystems (e.g., Costanza et al., 1998; Olewiler, 2006; Anielski and Wilson, 2005 and 2005; Wilson, 2008; Kennedy and Wilson, 2008). These studies tend to share some common features. Their focus is on estimating the total value of EGS. Many of their unit "prices" are derived using a benefit transfer methodology and these unit prices are average prices not marginal prices. As a result of these and other features, the results of such studies have limited application for conservation management decision making. Their primary purpose is to draw the attention of the public and decision makers to the total economic value of these non-market EGS. As more attention is given to these non-market EGS, the idea is that greater priority will be given to them when management decisions are being made. But the connection is strictly qualitative; in other words, the results themselves are not designed to be used directly in making management decisions.

The results of this study will be useful for similar purposes. This study provides compelling evidence of the large economic importance of natural features in the Credit River watershed even when only a subset of the values of natural features is included. In this respect the results provide a basis for investing greater attention in the conservation and management of these features.

4.2.2 Reliable Benchmark

The results of this study provide a partial estimate of the economic value of the natural features in the two market areas. These estimates are solidly grounded on an empirical analysis of a great number of behavioural observations. The results provide a minimum estimate of the amenity value of these natural features. These results provide a solid benchmark and complement for future studies of the economic values of natural features.

In other words, these results provide a technically robust estimate of the economic values of these amenities. Accordingly these results provide a point of comparison for any future studies that the CVC might undertake. By designing any future studies to produce estimates of the economic values of these amenities as well as those for other EGS, the validity of these alternate methodologies can be partly checked by comparing their results with these results.

4.2.3 Compensation

Local property owners often guard with great vigour, local natural features and with good reason. As this study shows, these natural features have value for them. While this raises a difficult legal issue of ownership and rights, what is clear is that local property owners can suffer real economic loss when local natural features are damaged or destroyed. As well, local property owners stand to gain significantly from the wise management and conservation of proximal natural features. These are important considerations in terms of the fair distribution of costs and benefits.

The hedonic modeling methodology used in this study provides estimates of the economic value for individual properties of specific natural features. This information could be valuable for estimating the compensation that is due to individual homeowners in the event that a local natural feature is damaged or destroyed and it is deemed that local property owners have some legal right to seek damages for such losses.

4.2.4 Investment in Ongoing Management

Natural features require management to sustain their quality over time. The level of management varies from one site to another and is tied to among other things the level of use of the site and its desired future state. The decision on the amount to invest in such management is rarely based on economic decision rules (e.g., maximizing net benefit). Instead, these decisions are largely made *ad hoc* with little forecasting of the net benefit that can be expected, let alone the optimization of that net benefit.

These results provide a solid foundation for making decisions on budget allocations. The overall value of the capital stock is commonly used as a rule of thumb for arriving at operating and maintenance budgets for that capital. While other considerations must play a role, the results of this study will provide a solid starting point for making these difficult budgeting decisions.

4.2.5 Trade-off Decisions

The most difficult management decisions involve arriving at trade-offs among competing options. For example, a manager may face the dilemma of what type and level of management intervention should be prescribed for a certain natural feature. To arrive at such decisions, managers should evaluate all reasonable options and compare the options objectively and consistently using appropriate decision criteria. Economic methods can be valuable for guiding such trade-off decisions.

Unfortunately, the results of this analysis have limited utility for this application. The characterization of the natural features is coarse for the reasons explained. No insight is provided as to the changes in economic value associated with intra-class changes. For example, the results provide little insight into the change in property values that might be expected by degrading a type 1 ravine if the degradation did not cause a change in the class.

Many conservation management decisions involve similar types of marginal changes. Considerable modification to the methodology would be required to produce marginal value estimates that would be useful for trade-off decisions. In particular, much finer resolution regarding natural feature characteristics would be required.

4.3 Further Analysis

These results are for only a portion of the Credit River watershed. Nonetheless, given the relatively high density of residential properties in these two market areas, a significant portion of the economic value of these natural feature amenities has likely been captured by this study.

MPAC has provided hedonic model coefficients for all market areas in the watershed. These model results could be used to produce comparable economic value estimates for the remainder of the watershed provided that a comparable property database was available. Expansion of the analysis should be undertaken as the need arises.

While the results of this analysis are robust from an economic methodology perspective, only a small subset of EGS associated with these natural features is included. Future economic analyses using other valuation methodologies should be designed to be complementary to these results. The specific nature of these additional studies should be determined based on the nature of the management issues and decisions for which the results will be used.

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Appendix A - MPAC Market Model Coefficients

North Mississauga Market Model Final Regression		
Average Sale Price		**$287,181**
Variable	**Unstandardized Coefficient**	**Standard Error**
Constant	**$108,783**	**$1,807**
Neighbourhood C02	$4,399	1475.58
Neighbourhood C05	$4,399	1475.58
Neighbourhood C08	$0	0.00
Neighbourhood C11	$0	0.00
Neighbourhood C14	25069	1113.71
Neighbourhood C17	-11698	1095.81
Neighbourhood C20	-11698	1095.81
Neighbourhood C23	-11698	1095.81
Neighbourhood C29	4171	842.24
Neighbourhood C32	4171	842.24
Neighbourhood C37	7101	803.52
Neighbourhood C40	7101	803.52
Neighbourhood C44	7101	803.52
Neighbourhood C49	4171	842.24
Neighbourhood C55	10027	1516.32
Neighbourhood C57	10027	1516.32
Neighbourhood C59	0	0.00
Neighbourhood C61	0	0.00
Neighbourhood C63	10027	1516.32
Neighbourhood C65	43285	1852.83
Neighbourhood C68	10027	1516.32
Neighbourhood C70	12582	1140.74
Neighbourhood C73	12582	1140.74
Neighbourhood C77	-5469	739.30
Neighbourhood C79	-5469	739.30
Neighbourhood C82	-5469	739.30
Neighbourhood C86	-5469	739.30
Neighbourhood C93	0	
Lot Size Adjustment ($/Sqrt m^2)	1090.26182	25.68

Site Influences	**Adjustment Factor**	**Derivation**
Abuts Green Space	1.04	model derived
Abuts Ravine 1	1.03	constrained
Abuts Ravine 2	1.02	constrained
Abuts Ravine 3	1.01	constrained

South Mississauga Market Model Final Regression		
Average Sale Price		**$338,863**
Variable	**Unstandardized Coefficient**	**Standard Error**
Constant	**$53,185**	**$3,209**
Neighbourhood A02	67535.14107	4544.35
Neighbourhood A05	67535.14107	4544.35
Neighbourhood A08	67535.14107	4544.35
Neighbourhood A11	67535.14107	4544.35
Neighbourhood A14	96034.80141	4672.22
Neighbourhood A17	96034.80141	4672.22
Neighbourhood A20	96034.80141	4672.22
Neighbourhood A23	96034.80141	4672.22
Neighbourhood A26	96034.80141	4672.22
Neighbourhood A28	-12962.96524	2181.62
Neighbourhood A30	-12962.96524	2181.62
Neighbourhood A32	0.00000	0.00
Neighbourhood A35	0.00000	0.00
Neighbourhood A38	0.00000	0.00
Neighbourhood A40	0.00000	0.00
Neighbourhood A43	0.00000	0.00
Neighbourhood A46	11142.53476	3986.30
Neighbourhood A49	11142.53476	3986.30
Neighbourhood A52	11142.53476	3986.30
Neighbourhood A55	-9325.92290	3301.24
Neighbourhood A58	0.00000	0.00
Neighbourhood A61	0.00000	0.00
Neighbourhood A64	11142.53476	3986.30
Neighbourhood A67	-9325.92290	3301.24
Neighbourhood A70	-9325.92290	3301.24
Neighbourhood A73	0.00000	0.00
Neighbourhood A76	0.00000	0.00
Neighbourhood A79	135006.52711	4440.48
Neighbourhood A82	135006.52711	4440.48
Neighbourhood A85	91413.10164	3285.74
Neighbourhood A88	91413.10164	3285.74
Neighbourhood A91	91413.10164	3285.74
Neighbourhood A92	-12962.96524	2181.62
Neighbourhood A94	-12962.96524	2181.62
Neighbourhood A97	-12962.96524	2181.62
Neighbourhood A99	-12962.96524	2181.62
Neighbourhood B02	-16187.23098	3028.40
Neighbourhood B04	-16187.23098	3028.40
Neighbourhood B07	0.00000	0.00
Neighbourhood B09	0.00000	0.00
Neighbourhood B12	0.00000	0.00
Neighbourhood B14	-14817.57762	3000.93
Neighbourhood B17	-9200.42481	3197.67
Neighbourhood B19	-9200.42481	3197.67
Neighbourhood B21	-9200.42481	3197.67

Neighbourhood B23	-9200.42481	3197.67
Neighbourhood B25	0.00000	0.00
Neighbourhood B27	0.00000	0.00
Neighbourhood B29	-14817.57762	3000.93
Neighbourhood B31	-14817.57762	3000.93
Neighbourhood B33	0.00000	0.00
Neighbourhood B35	0.00000	0.00
Neighbourhood B37	0.00000	0.00
Neighbourhood B39	-15242.61929	2697.79
Neighbourhood B41	-15242.61929	2697.79
Neighbourhood B43	-4785.27288	2228.78
Neighbourhood B46	-4785.27288	2228.78
Neighbourhood B48	0.00000	0.00
Neighbourhood B50	0.00000	0.00
Neighbourhood B52	0.00000	0.00
Neighbourhood B53	0.00000	0.00
Neighbourhood B54	0.00000	0.00
Neighbourhood B56	0.00000	0.00
Neighbourhood B58	11045.12247	2842.81
Neighbourhood B60	11045.12247	2842.81
Neighbourhood B62	11045.12247	2842.81
Neighbourhood B64	0.00000	0.00
Neighbourhood B66	0.00000	0.00
Neighbourhood B68	-4785.27288	2228.78
Neighbourhood B70	-4785.27288	2228.78
Neighbourhood B72	0.00000	0.00
Neighbourhood B74	0.00000	0.00
Neighbourhood B76	-25488.41075	1810.53
Neighbourhood B78	-25488.41075	1810.53
Neighbourhood B80	-25488.41075	1810.53
Neighbourhood B82	-25488.41075	1810.53
SQRT_ELS Square Root of Effective Lotsize for Improved Properties	2032.19359	36.12

Site Influences	**Adjustment Factor**	**Additional Comments**
Abuts Green Space	1.02	model derived
Abuts Ravine 1	1.05	model derived
Abuts Ravine 2	1.04	constrained
Abuts Ravine 3	1.03	model derived