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Pimachiowin Aki World Heritage Project Area Ecosystem Services Valuation Assessment

By Vivek Voora and Stephan Barg

November 2008

Prepared for the Pimachiowin Aki Corporation

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Published by the International Institute for Sustainable Development

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International Institute for Sustainable Development
161 Portage Avenue East, 6th Floor
Winnipeg, Manitoba
Canada R3B 0Y4
Tel: +1 (204) 958–7700
Fax: +1 (204) 958–7710
E-mail: info@iisd.ca
Web site: http://www.iisd.org/

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Executive Summary

Pimachiowin Aki, "the land that gives life" in Ojibwe, is a non-profit corporation striving to achieve international recognition for an Anishinabe cultural landscape as a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site (Province of Manitoba, 2007). This landscape consists of 40,000 km^2 of intact natural environments located across Eastern Manitoba and Northwestern Ontario. A detailed document outlining the site's cultural and natural attributes, potential development paths and strategies for its preservation must be devised and presented as part of the nomination process for World Heritage inscription (Roy, 2007).

This report estimates the economic value of the ecosystem services provided by natural environments to people, which will be useful background for the nomination document. In general, ecosystem services are made up of the many natural processes by which ecosystems, and the species that make them up, sustain and fulfil human life (Daily, 1997). Of course, there are many aspects of the World Heritage Project (WHP) area, for example spiritual and cultural aspects, that cannot be valued in economic terms. However, other ecosystem services do indeed have economic value, such as the sequestration of carbon, the preservation of endangered species and the provision of pure water and air. Estimating the monetary value of these helps demonstrate that the value of the area in its current state is far higher than just the current level of economic activity would suggest.

The economic value of the area's ecosystem services was estimated by mapping its land covers and using valuation studies from similar environments such as Ecoregion 90. Ecosystem service values were derived for the resident and non-resident populations of the site. This distinction is important, as people who live and work within the site will derive different values from it than will people who visit the site to experience its special natural and cultural characteristics. The ecosystem services evaluated were organized into four main categories: provisioning, regulating, cultural and supporting. This categorization is based on the one developed for the Millennium Ecosystem Assessment, and is a widely accepted international framework for categorizing ecosystem services (see Appendix B).

The overall ecosystem service value provided by the Pimachiowin Aki was estimated to be approximately CDN$121.35 to $130.30 million per year. The largest components of this estimate are fishing (at $35 million/year), pure water ($32 million/year) and carbon sequestration (between $12 and $21 million/year). This estimate is conservative, as a number of the ecosystem services identified were not valued due to a lack of information. The table below provides a breakdown of the overall ecosystem service value derived for the area.

Conservative ecosystem service economic values provided by the World Heritage Site (all values are in CDN$ million/year)			
Ecosystem Service	Resident	Non-resident	Total[a]
Provisioning	32.22	7.03	59.42
Regulating	0.02	-	47.52–56.47
Cultural	-	5.33	5.33
Supporting	-	-	9.08
Totals	32.24	12.36	121.35–130.30

[a]Some ecosystem services are valued equally between resident and non-resident populations therefore the ecosystem service values can only be added along each column.

Potential ecosystem service values, which are shown in the table below, were also calculated but omitted from the site's overall conservative ecosystem service value. The water from the WHP area's major rivers has a potential economic value of CDN$0.27 to $5.55 billion per year. The potential air filtration service provided by trees and flood prevention provided by wetlands was estimated to be worth CDN$350 to $600 million per year and CDN$380 million per year respectively. These numbers are based on studies in more populated areas, and thus cannot be considered representative of the reality in the WHP area. The spiritual value of the WHP area was conservatively assumed to be worth approximately CDN$160,000 per year to the residents of the Pimachiowin Aki based on compensating traditional healers for their services.

Potential ecosystem service economic values provided by the World Heritage Site (all values in CDN$ million/year)			
Ecosystem Service	Resident	Non-resident	Total[a]
Provisioning	-	-	270–5,550
Regulating	-	-	730–980
Cultural	0.16	-	0.16
Totals	0.16	-	1,000.16–6,530.16

[a]Some ecosystem services are valued equally between resident and non-resident populations therefore the ecosystem service values can only be added along each column.

The carbon stored within the forests and peat lands of the WHP area was estimated to be worth approximately CDN$2.7 to $17.5 billion. This estimate is not included as it is not annual revenue. Nevertheless, it was calculated to draw attention to the significant economic value of the area's carbon stock.

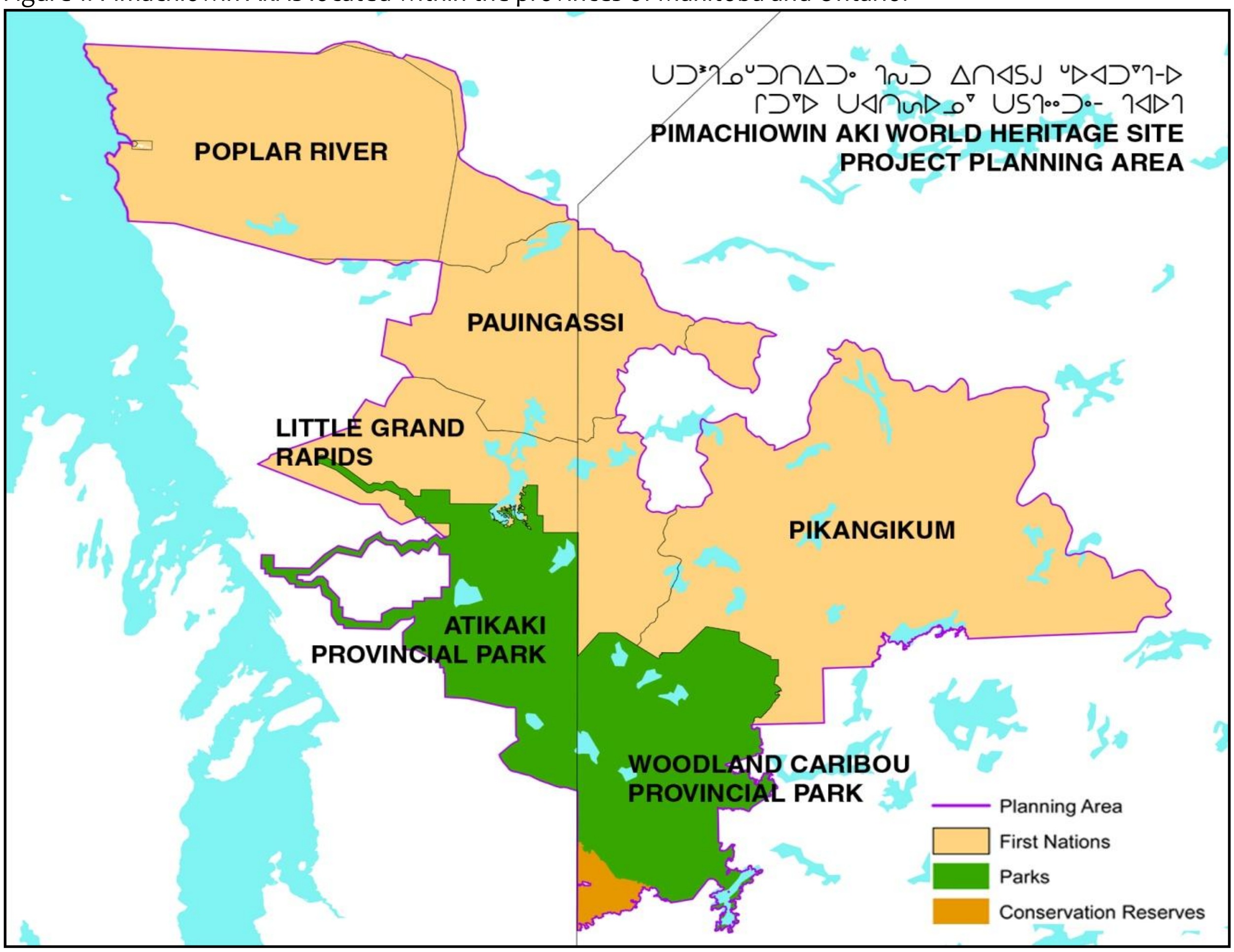
This analysis also took account of various public expenditures to protect and manage natural resources and provide visitor services in the Pimachiowin Aki area. More specifically, annual provincial expenditures on parks and forest fire management were estimated to be approximately CDN$4.48 million. The ecosystem service benefits received from the Pimachiowin Aki area, as estimated in this study, are about 28 times greater than the estimated public expenditures.

The results obtained provide a conservative estimate of the WHP area's ecosystem services values based on available information. It is important to note that the ecosystem service values generated should not be viewed as being perfectly accurate. They are meant to initiate discussion with local, national and international stakeholders on the valuable benefits we receive from the natural environments of the WHP area. Ecosystem service valuation studies are subject to a variety of challenges (including the interconnectedness of ecosystems and evolving valuation methods). For example, in this study, many of the values for ecosystem services are taken from studies done elsewhere, and those values may not represent the actual situation in Pimachiowin Aki very well. However, the results do provide useful information. They enable the comparative analyses to similar studies and most importantly, they draw attention to the valuable services that we receive from natural environments even when they do not generate market-based economic activity.

1.0 Introduction

Pimachiowin Aki, "the land that gives life" in Ojibwe, is a non-profit corporation striving to achieve international recognition for an Anishinabe cultural landscape as a United Nations Educational, Scientific and Cultural Organization UNESCO World Heritage Site (Province of Manitoba, 2007). The goal of the Pimachiowin Aki Corporation is: "To safeguard the Anishinabe cultural landscape and boreal forest as one living system to ensure the well-being of the Anishinabe who live there and for the benefit and enjoyment of all humanity" (Pimachiowin Aki Corporation, 2008). To establish the World Heritage Site, the corporation is striving to develop sustainable land management practices that will preserve the land and the Anishinabe culture (Pimachiowin Aki Corporation, 2008).

Figure 1: Pimachiowin Aki is located within the provinces of Manitoba and Ontario.



The area under consideration consists of 40,000 km^2 of intact natural environments spanning across Eastern Manitoba and Northwestern Ontario (Province of Manitoba, 2007) (see Figure 1). The area includes Atikaki and Woodland Caribou Provincial Parks and the traditional lands of the Poplar River, Little Grand Rapids, Pauingassi and Pikangikum Fist Nations. The Anishinabe communities living in this area have co-existed harmoniously with their natural surroundings for 5,000 years (Province of Manitoba, 2007). Establishing this World Heritage Site will facilitate the preservation of their culture, which is intimately interwoven with their natural landscape, in perpetuity.

To establish a World Heritage Site, its outstanding universal value must be demonstrated (Roy, 2007). The World Heritage Convention defines "outstanding universal value" as follows:

> *Outstanding universal value means cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole. (The World Conservation Union, 2006)*

A detailed document outlining the site's cultural and natural attributes is required to demonstrate the cultural and natural significance of the site. In addition, potential development paths and strategies for conserving and protecting the cultural and natural qualities of the site must also be devised and presented (Roy, 2007).

The natural environments of the Pimachiowin Aki site provide a number of important ecosystem services to people residing within and outside the site. Ecosystem services flow from natural environments. For instance, the natural environment in the form of flowers, pollen and pollinators are required to perform the ecosystem service of pollination (Binning et al., 2001). Natural environments must be interconnected, healthy and whole to provide ecosystem services. Their ability to provide services is compromised when degraded, exploited, disturbed or fragmented and is improved when preserved, enhanced or reconnected.

In addition to acquiring an understanding of some important aspects of the site, there is another reason for estimating the economic value of the ecosystem services provided by the natural environments of the Pimachiowin Aki. Payments for ecosystem service schemes are gaining importance as an economically effective way to preserve natural environments and they could provide financial returns for protecting and maintaining the Pimachiowin Aki area, through public or private agreements (World Wildlife Foundation, 2006). Furthermore, Huberman (2007) contends that the World Heritage Convention provides a suitable model for developing an International Payments for Ecosystem Services framework. The first step in establishing payments for ecosystem services schemes is to identify the ecosystem's biophysical functions that are providing people with beneficial services. The next step is to quantify the beneficial services provided by the ecosystems. The last step is to determine how these services are economically valued by people so that people who maintain these services can be compensated accordingly. What about the market mechanisms?

This report provides an economic value estimate for the ecosystem services provided by the Pimachiowin Aki World Heritage Project (WHP) area. A land cover map was first compiled to assess the general biophysical characteristics of the land. Ecosystem services were then identified, quantified and valued. A number of approaches and proxies were used to derive ecosystem service values for the communities residing within and outside the site. Valuation data from existing studies were used to quantify and value the ecosystems services provided by the Pimachiowin Aki site. The results obtained provide a conservative estimate of the WHP area's ecosystem services values based on available information. It is important to note that the ecosystem service values generated should not be viewed as being highly accurate. They are meant to initiate discussion with all stakeholders on the valuable benefits we receive from the natural environments of the WHP area. Important points of clarification are first presented to explain the concepts that are referred to in the report and the rationale for the valuation approach used for the analysis.

The report first discusses the conceptual basis for ecosystem service valuation and the methodologies used to assess them. The next section presents the data, assumptions and calculations used to derive economic values for the ecosystem services provided by the WHP area. Finally, the major findings are presented in the conclusion section. Three appendices, one relating to valuation methods and the others relating to the categorization of ecosystem services and land cover typology are also included in the report.

2.0 Valuation Elements

The term "value" can be interpreted in a number of ways. In this working paper, the term "value" is used to refer to the site's "economic and non-economic value." The terms "economic value" and "non-economic value" will be used to specifically designate the site's features that are respectively measured in monetary or non-monetary terms. Economic values are typically determined by tracking the amount of money people pay for a particular good or service. Where this information is not available, economic values are determined by using a number of valuation techniques such as asking people how much they would be willing to pay for a particular good or service (see Appendix A). There are also non-economic values, which can be assessed by gathering information and thoughts from people on the importance, meaning and utility of a particular good or service.

Economic values are likely to differ between residents living within and outside the Pimachiowin Aki site. For instance, First Nations people who have lived and worked on the land over generations will perceive the site differently than people who live elsewhere and may travel to the site to enjoy pristine natural environments. This distinction is important as cultural influences, worldviews and experiences will greatly affect the value one attaches to natural environments and their ecosystem services. In this report, the economic value estimates are made for both the residents of the WHP area, and for non-residents. This is a somewhat uncommon approach as most ecosystem goods and services studies do not make this distinction.

Valuing ecosystem services is subject to a variety of challenges. Conceptually, economically valuing natural environments is not truly possible with current economic valuation methodologies because ecosystem services emerge from interconnected, healthy and resilient ecosystems (Straton, 2006). Distinguishing one ecosystem service from another contradicts this reality. Furthermore, cultural ecosystem services cannot be translated into monetary terms in representative ways. Nevertheless, estimating the monetary value of ecosystem services helps clarify the economic and other benefits we receive from them. In addition, economically valuing the contribution of natural environments to the preservation of a culture (cultural ecosystem services) provides insights as to how they are perceived.

Most ecosystem services are not economically valued through revealed preference methods, which are characterized by an actual monetary exchange for products or services (see Appendix A). Services and products that are not monetarily exchanged can be economically valued using stated preference methods that are based on what people say they are willing to pay for something. Stated preference methods are not considered as rigorous as revealed preference methods due to the numerous influences that can impact people's answers. The wording used to compile survey questions and respondent moods are among the factors that can greatly influence the valuation data collected from stated preference methods. Stated preference information can also be time-consuming and expensive to collect.

The transfer of valuation information from existing studies conducted elsewhere to an area of interest using the benefit transfer approach was devised to compile valuation assessments costeffectively. Transferring valuation data inherently introduces error in a valuation assessment, as all spatial and temporal contexts will be different from one another. In addition to the shortcomings of stated preference methods, the errors introduced by using the benefit transfer approach compound the inaccuracies of ecosystem service estimates.

Despite all of the limitations of ecosystem service valuation studies, they still provide very useful information. First, by using methodologies consistent with other studies, valuation estimates can be compared across studies. These comparative studies can reveal the distinctive aspects of a particular area. Thus, the benefit of this work relates in part to its usefulness in comparing it to other studies, rather than on the absolute accuracy of the results. Second, economic valuation estimates also help refute the idea that natural environments are valueless if they do not generate market-based economic activity. Trees that are not harvested and rivers that are not dammed still generate important economic values regionally and globally. It is important to invest in the Pimachiowin Aki to maintain the ecosystem services it provides, and a valuation assessment can help support that argument. Moreover, as Payments for Ecosytem Services are more broadly implemented this creates an opportunity to help finance the long-term operation and management of the area.

3.0 Valuation Approach

A spatially based ecosystem services valuation approach provides a means to efficiently value the Pimachiowin Aki site. Measuring and establishing the surface areas of various different land covers is the basis for an estimate of the types and amounts of ecosystem services that could potentially flow from them. Estimating the ecosystem service flows from the land covers requires reliable and suitable biophysical data. In this study, ecosystem service economic values were derived for people living within and outside the site and were aggregated to provide an overall economic value for the site. Detailed descriptions of each step used in the valuation approach are provided in the following subsections.

3.1 Land cover mapping

A land cover map was compiled to determine the spatial extents of the various land covers that make up the Pimachiowin Aki site. Different land covers provide varying ecosystem services. For instance, water bodies provide a means for transportation and habitat for fish, which can offer communities a source of food. Forests sequester carbon via vegetation growth and provide habitat for wildlife, which supports hunting and trapping activities. GIS land cover data was acquired from Natural Resource Canada to create a comprehensive land cover map of the area. The data, which were classified into 20 land cover classes, were derived from 2000 Landsat imagery with a 25-metre resolution.

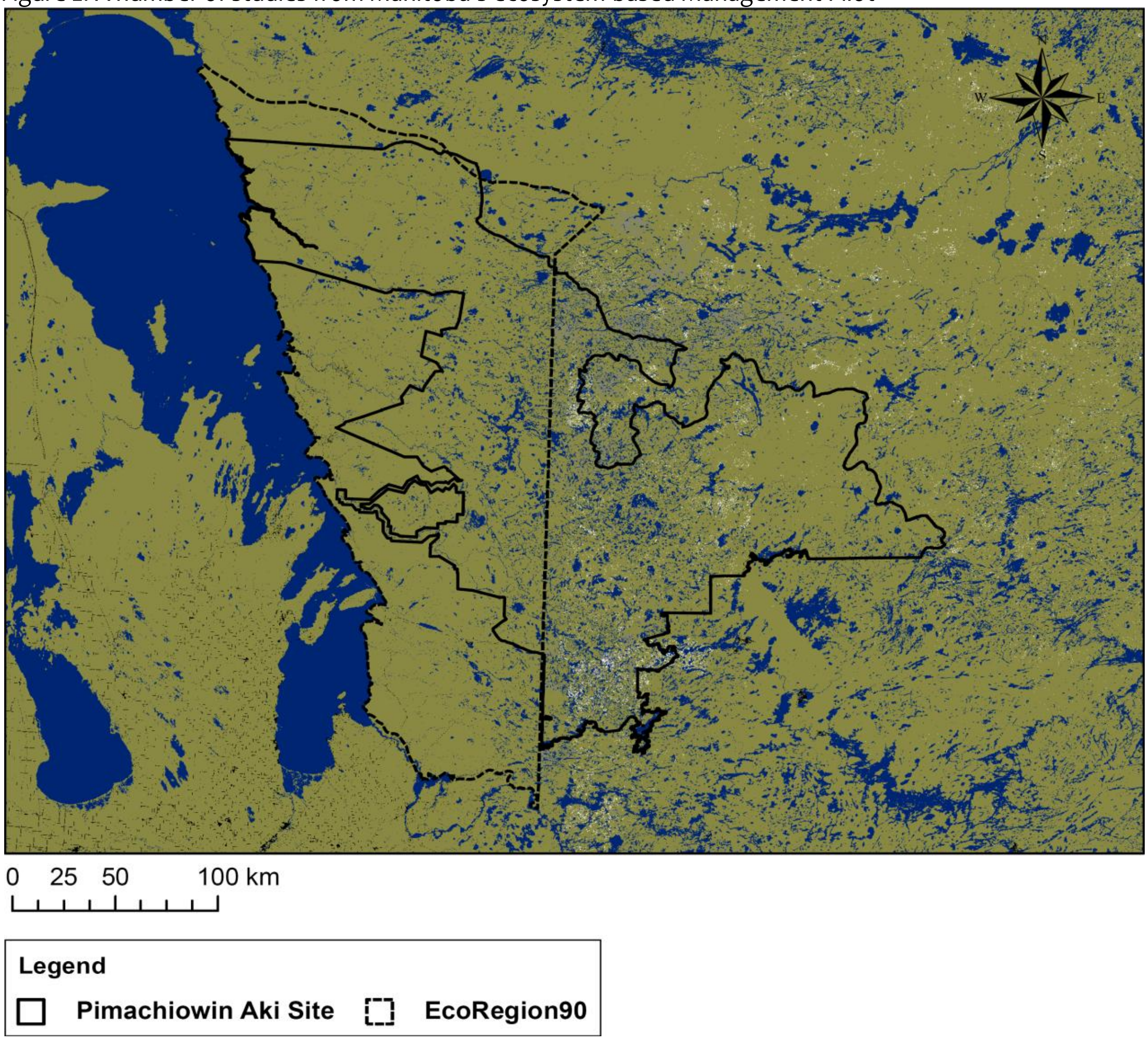
3.2 Ecosystem service identification

A number of ecosystem services were identified and grouped into provisioning, regulating, cultural and supporting services to structure the analysis. This categorization was done in accordance with the Millennium Ecosystem Assessment framework, which is widely accepted and recognized internationally (see Appendix B). An emphasis was placed on identifying the ecosystem services relevant to the communities living within the site but services that are of regional and global relevance were also included. For instance, food provisions provided by hunting and fishing, as well as spiritual and educational opportunities, were ecosystem services identified as being directly relevant to local communities. Water treatment and carbon sequestration were identified as being services that have economic value of regional and global relevance. The ecosystem services that did not have economic values were discussed qualitatively.

3.3 Ecosystem service quantification and valuation

The ecosystem services provided by the site are quantified and valued based on relevant data obtained from a number of studies that have either been conducted in parts of the WHP area or in similar locations. For instance, the total populations of furbearing animals caught for trapping was estimated based on studies conducted within Ecoregion 90 (ER90), which encompasses a portion of the WHP area (see Figure 2).

Figure 2: A number of studies from Manitoba's ecosystem-based Management Pilot



Projections for Ecoregion 90, which overlaps the WHP area, were used to estimate the ecosystem service values provided by the site.

Two sets of economic values were derived from the ecosystem services identified and quantified for people living within and outside the site. In some instances the ecosystem service economic values were similar. For instance, the economic values of carbon sequestration are assumed to be the same regardless of one's location or cultural background. In contrast, hunting was economically valued differently between communities living within and outside the site. Some ecosystem services are not amenable to being economically valued as they may be viewed as having infinite value. For instance, the ecosystem service associated with spirituality is beyond economic value to the people who have spiritual beliefs closely interwoven with the site's natural environments. The sets of ecosystem service economic values derived for people living within and outside the site were aggregated to provide an overall economic value for the WHP area.

All the ecosystem service values derived for this study were based on valuation studies conducted in other areas. Transferring valuation information from existing studies to the study site introduces error into the analysis. The inaccuracies associated with transferring valuation data from one context to another was minimized by using valuation studies conducted in similar environments as the WHP area. In addition, the ecosystem services values transferred were adjusted for inflation and currency differences.

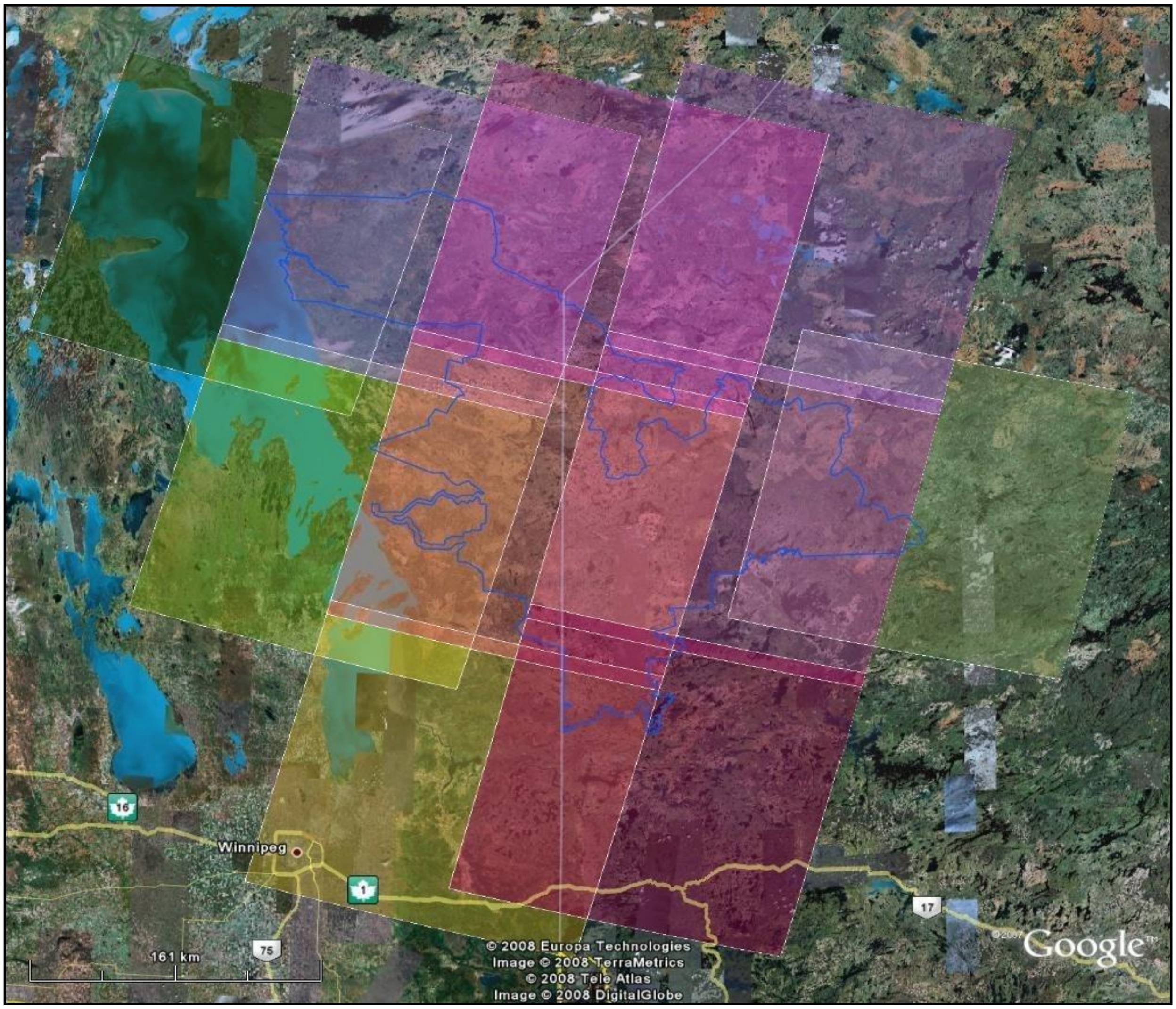
Most of the values derived for the ecosystem services evaluated were estimated based on valuation studies that have been conducted in other areas. Transferring valuation information from existing studies to the study site invariably introduces errors in the analysis. Nevertheless, the inaccuracy associated with transferring valuation data from one context to another was minimized by using valuation studies that were conducted in similar environments as the WHP area. In addition, the values transferred were adjusted for inflation and currency differences. A brief discussion is included on the relevance of the valuation transfer for each economic value derived in the assessment. In several cases the economic values calculated were not included in the overall results due to the context differences between the source of the estimate and the Pimachiowin Aki.

In general, there is a lack of ecosystem service values in the literature for the multitude of benefits we receive from the natural environment (Decaens et al., 2006). A number of the identified ecosystem services provided by the WHP area were not valued due to a lack of information. Thus, the overall ecosystem service value derived for the site is conservative.

4.0 Land Cover Mapping

Information on the composition of the natural environments of the WHP area was first required to estimate the value of the ecosystem services provided by the site. The various land covers that make up the WHP area were mapped using land cover data derived from 2000 Landsat Enhance Thematic Mapper images with a 25-metre resolution (see Figure 3).

Figure 3: The Landsat Enhanced Thematic Mapper image coverage used to determine the land covers of the WHP area.



The land cover data used to produce the land cover map shown in Figure 4 is comprised of 20 land cover classes (see Appendix C). The land cover classification was completed by two different parties, which resulted in discrepancies between the Manitoba and Ontario sides of the WHP area. The surface areas of the various land covers within the WHP area were calculated based on pixel counts (each pixel representing 625 m^2). The land cover areas listed in Table 1 were used to quantify and value the ecosystem services of the WHP area. The accuracy of the land cover information affects the ecosystem service values calculated based on land cover surface areas. To rectify the land cover classification discrepancies, certain imagery sections of the map would have to be reclassified.

Figure 4: The Pimachiowin Aki land cover map with 20 land cover classes (see Table 1).

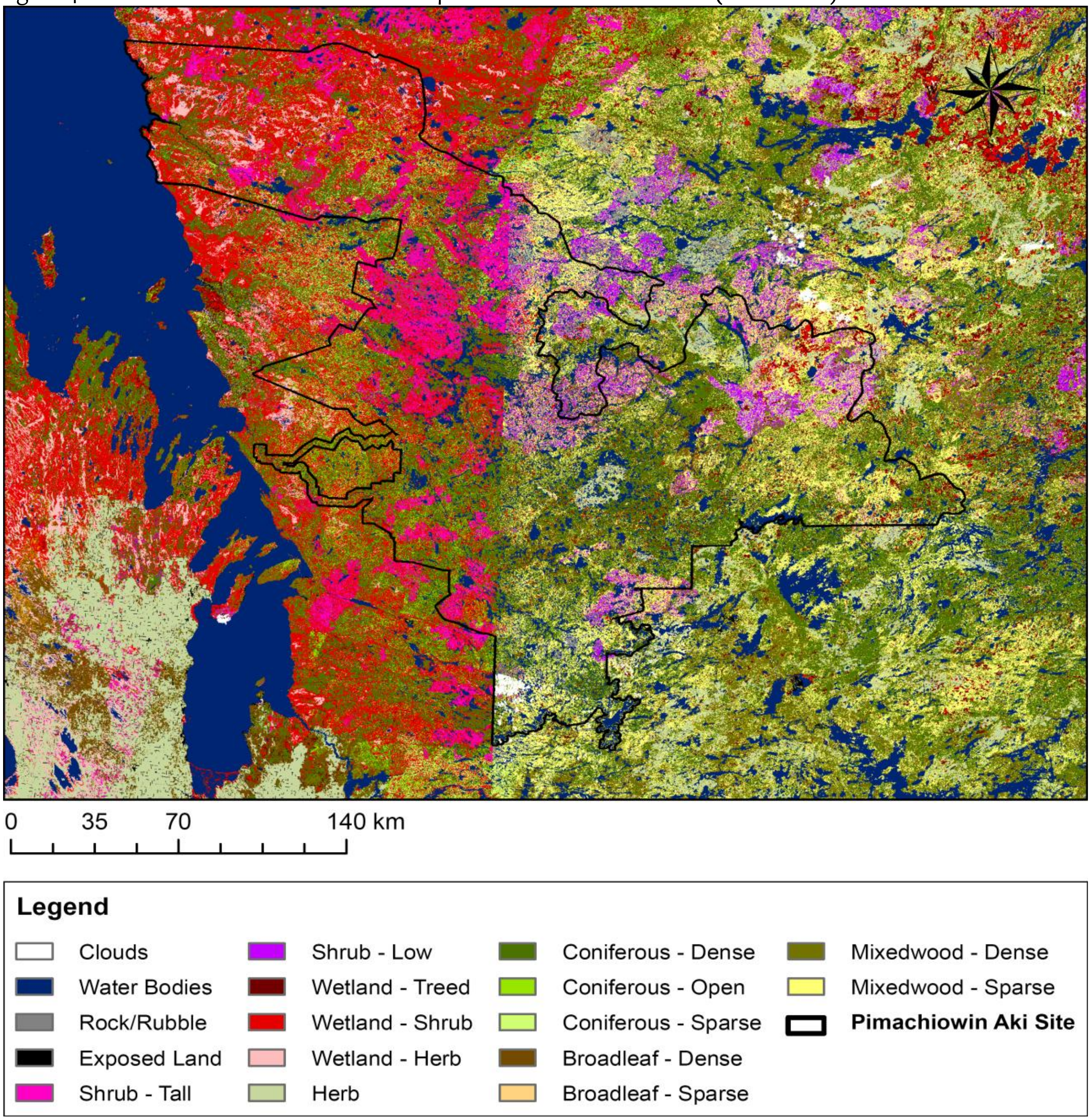


Table 1: Land cover areas of Pimachiowin Aki		
Land Cover	Area in Square Kilometres	Area in Hectares
Cloud	133.14	13,314
Shadow	0.00	0
Water Bodies	5,133.52	513,352
Rock/Rubble	418.67	41,867
Exposed Land	16.19	1,619
Shrub – Tall	2,506.60	250,660
Shrub – Low	1,270.10	127,010
Wetland – Treed	1,037.21	103,721
Wetland – Shrub	7,110.66	711,066
Wetland – Herb	888.07	88,807
Herb	568.66	56,866
Coniferous – Dense	9,150.72	915,072
Coniferous – Open	1,230.42	123,042
Coniferous – Sparse	610.51	61,051
Broadleaf – Dense	912.64	91,264
Broadleaf – Open	0.00	0
Broadleaf – Sparse	21.86	2,186
Mixed Wood – Dense	2,638.89	263,889
Mixed Wood – Open	0.00	0
Mixed Wood – Sparse	5,670.14	567,014
Total	39,317.99	3,931,799

5.0 Ecosystem Services Identified

A number of ecosystem services provided by the WHP area were identified and categorized into provisioning, regulating, cultural and supporting services in accordance with the Millennium Ecosystem Assessment framework (see Table 2 and Appendix C).

Table 2: Ecosystem services provided by the proposed World Heritage Site

Ecosystem Service	Description[a]
Provisioning	Basic requirements for well-being.
Hunting activities	Food harvested from hunting activities.
Fishing activities	Food harvested from fishing activities.
Wild rice harvesting	Food harvested from wild rice cultivation.
Water supply	Clean drinking water supplied by natural ecosystems.
Trapping activities	Fur harvested from trapping activities.
Medicinal plants	Plants harvested to treat ailments.
Hydro-power	Water supply for producing electricity
Regulating	Maintain a habitable environment.
Carbon sequestration and storage	Regulation of carbon dioxide concentrations through the appropriation and storing of carbon.
Air filtration	Filtration of air pollutants by vegetation.
Micro-climates	Ecosystem influences on micro-climates.
Water treatment	Removal and breakdown of water pollutants.
Erosion control	Lower soil losses leading to water siltation.
Flood prevention	Prevention or dampening of flood events.
Biological control	Pest control through natural processes.
Cultural	Non-material benefits.
Recreational opportunities	Opportunities for recreation and refreshment.
Spiritual and religious	Spiritual and religious inspirational values.
Cultural heritage	Cultural identity including traditions and landscapes.
Educational experiences	Opportunities for observations in nature and the accumulation of traditional ecological knowledge.
Supporting	Ensure the existence of natural environments.
Pollination	Movement of plant genes for reproduction.
Habitat/refugia	Suitable living space for species to evolve and breed.
Soil formation	Formation of productive soils by rock weathering, decomposition and accumulation of organic matter.

[a]Descriptions obtained from Anielski & Wilson (2007), de Groot (2006), Farber et al. (2006) and Chiesura & de Groot (2003).

6.0 Ecosystem Service Quantification and Valuation

The ecosystem services described in Chapter 5 were evaluated to estimate the benefits resident and non-resident populations receive from them. Table 3 provides a summary of the WHP area's conservative ecosystem service economic values. The following subsections provide detailed explanations on how they were calculated.

Table 3: Conservative ecosystem service economic values provided by the proposed World Heritage Site (all economic values in CDN$ million/year)

Ecosystem Service	Resident	Non-Resident	Total[a]
Provisioning	32.22	7.03	59.42
Hunting activities	2.59	0.98	3.57
Fishing activities	29.05	6.05	35.10
Wild rice harvesting	0.38	0	0.38
Water supply	0.13	0	0.13
Medicinal plants	-	0	-
Trapping	0.07	0	0.07
Hydro-power	-	-	20.17
Regulating	0.02	-	47.52–56.47
Carbon sequestration	-	-	12.32–21.27
Air filtration	0.02	-	0.02
Micro-climates	-	-	-
Water treatment	-	-	31.83
Erosion control	-	-	3.35
Flood prevention	-	-	-
Biological control	-	-	-
Cultural	-	5.33	5.33
Recreational opportunities	0	3.05	3.05
Spiritual and religious	-	-	-
Cultural heritage	-	2.28	2.28
Educational experiences	-	-	-
Supporting	-	-	9.08
Pollination	-	-	-
Habitat/refugia	-	-	9.08
Soil formation	-	-	-
Totals	32.24	12.36	121.35–130.30

[a]Some ecosystem services are valued equally between resident and non-resident populations therefore the ecosystem service values can only be added along each column.

A few potential ecosystem service values were calculated and omitted from the site's overall ecosystem service value. A summary of the WHP area's potential ecosystem service values is provided in Table 4. Detailed explanations of how these values were calculated are provided in the following subsections.

Table 4: Potential ecosystem service economic values provided by the proposed World Heritage Site (all economic values in CDN$ million/year)			
Ecosystem service	Resident	Non-resident	Total
Provisioning	-	-	*270–5,550*
Water supply	-	-	270–5,550
Regulating	-	-	*730–980*
Air filtration	-	-	350–600
Flood prevention	-	-	380
Cultural	*0.16*	-	*0.16*
Spiritual and Religous	0.16	-	0.16
Totals	*0.16*	-	*1,000.16–6,530.16*

The carbon stored within the forests and peatlands of the WHP area, estimated to be worth approximately CDN$2.70 to $17.51 billion, was calculated to draw attention to the significant economic value of the site's carbon stock. This estimate is not included in the conservative or potential ecosystem services value estimates as it is not annual revenue.

6.1 Provisioning services

Provisioning ecosystem services include food, fuel and fibre provided by the natural environment required for human well-being. Valuing provisional services is usually straightforward as they are typically expressed by market values. Food, material and energy provision services were evaluated based on hunting, fishing, wild rice harvesting, water supply, medicinal plants, fur harvesting and hydro-power.

6.1.1 Food Provision

The food provision services of the WHP area were estimated based on the hunting, fishing and wild rice harvesting activities of ER90. The harvesting information dated mid-1990s to present was modified and applied to the WHP area to economically value its food provision ecosystem services. The accuracy of the estimates could be improved with the use of more up-to-date harvest information.

Hunting

Hunting provides the residents of the WHP area with an important source of food. It is especially important for isolated communities cut off from supply networks such as permanent roads. Perhaps more importantly, hunting provides indigenous residents with cultural experiences. Non-resident hunters benefit from an additional source of food, recreational opportunities and perhaps a deepening experience with their natural surroundings.

Hunting's economic value for resident and non-resident populations was estimated by calculating hunting expenditures (hunting licences, supplies, food, hunting and repair gear, lodging and travel) and wild meat replacement costs. Hunting expenditure information was obtained from a socio-economic study conducted in ER90, which found that residents spend CDN$613 per animal and non-residents spend CDN$3,000 per bear, CDN$2,500 per deer and CDN$5,000 per moose (see Tables 5, 6 and 7) (Hristienko, 2008; Peckett, 1999). Wild meat replacement cost was estimated from bear, moose and deer harvest information from ER90, average animal weights, meat-to-total-weight ratios and farmed wild animal meat market values (see Tables 5, 6 and 7). The following assumptions were made to calculate the hunting opportunity economic value:

- The overall hunting opportunity economic value estimated from ER90 information can be transferred directly to the WHP area due to the similarities in surface areas and land covers.
- The approximate average weight of animals harvested is based on the average weights of males and females combined.
- The average meat to carcass weight ratio is 0.5.
- The average cost of game meat is CDN$5.00/lb or CDN$11.02/kg, which is a low estimate (Grande Premium Meats, 2008).

Table 5: Wild game information used to estimate the economic value of hunting for residents of the proposed World Heritage Site.

Animal	Approximate Average Weight[a]	Meat to Weight Ratio[b]	Conservative Cost per kg of Meat[c]	Hunting Expenditures[d]	
				Resident	Non-resident
Bear	153	0.5	$11	$610	$3,000
Deer	65	0.5	$11	$610	$2,500
Moose	386	0.5	$11	$610	$5,000

[a]The animal weights used in the calculations were based on the average weights for males and females: female and male black bears weight ranges are 40 kg to 180 kg and 115 kg to 275 kg respectively (Wikipedia, 2008a); female and male moose weight ranges are 270 kg to 360 kg and 380 kg to 535 kg respectively (Wikipedia, 2008b); and female and male dear weight ranges are 40 kg to 60 kg and 60 kg to 100 kg respectively (Wikipedia, 2008c).
[b]Approximate meat–to-weight ratio will vary but is generally 50 per cent (Grosshans, 2008).
[c]Cost per kg of meat is a low estimate obtained from Grande Premium Meats (2008), a butcher selling farmed wild animal meat online.
[d]Non-resident hunting opportunity expenditure information was obtained from Manitoba Conservation personnel and does not include airfare to and from Manitoba and incidental spending on local goods (for example meat cutting, packing, taxidermists, souvenirs) (Hristienko, 2008). Resident hunting expenditures is a conservative estimate obtained from Peckett (1999) and adjusted for inflation.

Table 6: Ecoregion 90 resident hunting opportunity value (Hristienko, 2008).

Animal	Number of Permits	Number of Animals Harvested	Hunting Opportunity Value	Meat Replacement Cost
Bear	121	37	$73,810	$31,136
Deer	1,279	644	$780,190	$230,230
Moose	1,481	270	$903,410	$573,210
Total	2,881	951	**$1,757,410**	**$834,576**

Table 7: Ecoregion 90 non-resident hunting opportunity value (Hristienko, 2008).				
Animal	Number of Permits	Number of Animals Harvested	Hunting Opportunity Value	Meat Replacement Cost
Bear	184	141	$552,000	$118,652
Deer	30	18	$75,000	$6,435
Moose	37	19	$185,000	$40,337
Total	251	178	**$812,000**	**$165,424**

The overall hunting opportunity economic value of the WHP area is approximately CDN$3.57 million/year (resident = CDN$2.59 million/year, non-resident = $0.98 million/year), which was calculated by adding hunting expenditures and wild meat replacement costs for resident and non-resident populations.

The hunting opportunity economic value estimated for the WHP area is likely conservative. Aboriginal people do not require hunting permits and the animals they harvest annually is not tracked. The harvesting information used to calculate hunting expenditures and wild meat replacement costs is outdated and may not be representative of the current situation. Total harvests will vary from year to year depending on a number of factors. Harvest information was limited to big game, which included black bear, moose and deer. Incorporating hunting opportunity values associated with smaller animals and waterfowl would have enhanced the site's overall hunting economic value. The wild meat replacement costs used in the analysis is conservative as it is likely greater than CDN$11/kg. A number of factors will influence the cost of meat, such as demand for the product, quality, type of cut, transportation and processing costs. For instance, Grande Premium Meats (2008) sell small deer tenderloin for USD$33.00/kg and Exotic Meat USA sells venison medallion filets for USD$45/kg (Exotic Meats USA, 2007; Grande Premium Meats, 2008). In addition, the travel costs required to access the remote areas of the WHP area were not included in the analysis. Hence, the actual economic value offered by the WHP area's hunting opportunities is likely greater than the value calculated in this study.

Fishing

The WHP area supports commercial and recreational fishing activities. Commercial fishing provided employment for approximately 47 people in the communities of Poplar River/Big Back/Neginnan in 1998. The water bodies of the WHP area provide resident and non-resident fishing enthusiasts with subsistence and an enjoyable outdoor activity.

The total landed value of fish harvested from Lake Winnipeg by Poplar River/Big Black/Neginnan's was estimated to be CDN$554,948 in 1998. Adjusting this figure to account for inflation we get for a total commercial fishing value of approximately $680,000/year. It must be noted that the protected area of the Poplar River community extends beyond its coastline and into Lake Winnipeg.

The recreational fishing economic value provided by the WHP area was calculated by estimating fishing expenditures (fishing licenses, supplies, food, fishing and repair gear, lodging and travel) and catch replacement costs for resident and non-resident populations. Fishing expenditure information was obtained from a socio-economic study conducted in ER90 that found that residents spent CDN$16.44 million per year and non-residents spent CDN$4.34 million per year in 1995 (Peckett, 1999). Catch replacement costs were estimated based on the number, species, average weights and market values of fish caught in ER90 in 1995 (Peckett, 1999). The catch distribution between resident and non-resident populations was determined from respective angler days compiled for ER90 in 1995 (see Table 8). The following assumptions were made to calculate the fishing opportunity economic value for the WHP area:

- The fishing opportunity economic value calculated using ER90 information can be applied directly to the WHP area as it has twice the amount of water bodies by surface area and both landscapes share similar characteristics.
- Fishing information for East Central and the Whiteshell/Nopiming represents all of ER90 adequately as they cover a good portion of the area.
- Accessing the WHP fishing areas is similar to the Whiteshell/Nopiming.
- The distribution of the number of angler days can be used to estimate the catch distribution between resident and non-resident populations.
- Fishing harvest information for East Central and the Whiteshell/Nopiming has not changed since 1995.
- The average weights estimated for each fish species is representative of the weights of fish caught in ER90.
- Fish market values reported by Manitoba Conservation in 1999–2000 have not changed over time and can be applied to 2007 by adjusting for inflation.

Adjusting the 1995 East Central and Whiteshell/Nopiming angler expenditures for inflation we get CDN$20.88 million per year for residents and CDN$5.51 million per year for non-residents. The resident and non-resident angler day percentage was first multiplied with the catch information to estimate respective catch distributions (see Tables 8 and 9) in accordance with the following example:

> 646,944 Walleye (East Central Walleye catch) x 90.14 per cent (percentage of total – resident number of angler days – East Central) + 545,454 Walleye (Whiteshell/Nopiming Walleye catch) x 96.20 per cent (percentage of total – resident number of angler days – Whiteshell/Nopiming) = 1,107,869 Walleye (resident Walleye total catch)

Average fish weights and their market values were estimated based on information from Wikipedia and the Manitoba Conservation 1999–2000 Annual Report. The market values were adjusted for inflation to 1995 so they could be multiplied with the 1995 harvest data, and the total economic values where then adjusted for inflation to 2007 (see Table 10). The total economic value of the fish caught in ER90 is estimated to be approximately CDN$8.03 million/year (residents = CDN$7.49 million/year; non-residents = $0.54 million/year).

Table 8: Number of angler days (percentage of total)			
Region	**Resident**	**Non-resident**	**Total**
East Central	213,092 (90.14%)	23,306 (9.86%)	236,398
Whiteshell/ Nopiming	431,833 (96.20%)	17,076 (3.80%)	448,909

Table 9: Catch distribution estimation				
	Total Catch 1995		**Catch Distribution**	
Fish	**East Central**	**Whiteshell/ Nopiming**	**Resident**	**Non-resident**
Walleye	646,944	545,454	1,107,869	84,529
Northern Pike	331,475	454,349	735,862	49,962
Channel Catfish	7,710	0	6,950	760
Smallmouth Bass	26,301	141,576	159,899	7,978
Perch	96,381	275,781	352,170	19,992
Lake Trout	2,590	8,484	10,496	578
Stocked Trout	1,983	71,673	70,734	2,922
Other	133,918	101,648	218,497	17,069
Total Catches	**1,247,303**	**1,598,902**	**2,662,415**	**183,790**

Table 10: Economic value of fish caught in ER90					
Fish	**Weight kg**	**1995 $/kg**	**Resident**	**Non-resident**	**Total Value**
Walleye	0.91	$4.28	$3,916,048	$298,791	$4,214,839
Northern Pike	2.27	$0.82	$1,246,497	$84,633	$1,331,130
Channel Catfish	4.54	$1.00	$28,719	$3,141	$31,860
Smallmouth Bass	0.45	$1.04	$68,982	$3,442	$72,424
Perch	0.23	$4.96	$361,260	$20,508	$381,768
Lake Trout	4.54	$0.89	$38,399	$2,115	$40,513
Stocked Trout	4.54	$0.89	$258,776	$10,689	$269,465
Other	0.45	$0.30	$27,435	$2,143	$29,579
Total Catches			**$5,946,117**	**$425,463**	**$6,371,580**
Adjusted for 2007			**$7,492,108**	**$536,083**	**$8,028,191**

The commercial and recreational fishing opportunity economic value provided by the WHP area amounts to approximately CDN$35.10 million/year.

The fishing opportunity economic value calculated for the site is conservative. Average harvested fish weights can vary significantly from year to year. For this reason, conservative weight estimates were used in the analysis. In addition, other freshwater species such as crayfish and bait fish were not included in the analysis. Live bait fish and leeches harvested as part of the live bait fish production in ER90 was worth approximately CDN$60,000 in 1997 (Peckett, 1999). It must also be pointed out that a direct correlation cannot be made between number of angler days and catch distributions for resident and non-resident populations. For instance, residents may catch more fish per angler day than non-residents due to their familiarity with the area. The actual fishing opportunity economic value of the WHP area is likely greater than the calculated estimate, and the catch distribution between resident and non-resident fishermen may be inaccurate.

Wild rice harvesting

Wild rice harvesting within ER90 is carried out on approximately 100 lakes and is very inconsistent from year to year. Peckett (1999) reports that wild rice yields for ER90 and most of Manitoba were very low in 1998. Wild rice harvest information was collected from ER90 and historical annual averages were obtained from local processing companies. They reported total harvest yields ranging from 250,000 to 600,000 pounds over the years, representing an annual revenue of between CDN$175,000 and $425,000 (Peckett, 1999).

The following assumptions were made to estimate the wild rice harvesting economic value provided by the WHP area:

- Wild rice harvesting yields in the WHP area are similar to the yields in ER90.
- The average yield and annual revenue ($300,000/year) reported by local processing companies is representative due to the variability in annual yields.

The WHP area's wild rice harvesting economic value is estimated to be CDN$380,000 per year, which was calculated by adjusting the average ER90 wild rice harvest annual revenue for inflation.

The wild rice harvesting economic value calculated was based strictly on annual revenues reported by processing plants. Wild rice harvested for subsistence, which could be of significant value, was not captured in the estimate. Nevertheless, due to harvest inconsistencies, which are greatly dependant on environmental conditions, the wild rice harvesting economic value estimated for the WHP area is likely reasonable.

Water supply

A clean and abundant water supply is important for well-being. A number of Canadian studies have been conducted to assess people's willingness to pay for clean drinking water. A study conducted in 1997 aimed to determine the willingness to pay to conserve and protect water resources by asking the following question (Rollins et al., 1997):

> *Would you be willing to support a program to conserve water by repairing water distribution and sewage treatment systems in Canada, if it cost your household an additional X dollars each month?*

The study determined that the average willingness to pay for Manitobans was approximately CDN$28.13/household/month (Rollins et al., 1997). Adjusting the figure for inflation gives a mean willingness to pay CDN$421.95/household/year. Another study estimated that Winnipeg residents would be willing to pay CDN$115.20/household/year in 1999 to improve their drinking water quality (McComb, 2002). Adjusting this figure for inflation (CDN$138.30/household/year) and applying it to the 921 households in the WHP area (Statistics Canada, 2006), we get a total willingness to pay of CDN$130,000 per year for quality drinking water.

Water supply services can also be estimated on a volumetric basis. Gardner and Pinfold Consulting Economists ltd. (2006) estimated that the domestic water use of the Albertan portion of the South Saskatchewan River is worth approximately CDN$0.93/m^3 based on water infrastructure expenditures. The economic value of the Assiniboine Aquifer water supply located in southwestern Manitoba was estimated to range from CDN$30,000/m^3 to $620,000/m^3 (Kulshreshtha, 1994). Using volumetric discharge information from the major rivers of the WHP area, we can coarsely estimate its total potential water supply economic value.

Table 11: Total annual volumetric discharge of the major rivers of the WHP area[a]

Location of Water Flow Gauge	Volumetric Discharge in 1000 m^3/yr
Poplar River at outlet of Weaver Lake	1,031,000
Berens River at outlet of Long Lake	1,931,000
Pigeon River at outlet of Round Lake	2,541,000
Bloodvein River above Bloodvein Bay	1,386,000
Total	**6,889,000**

[a]Volumetric data were obtained from Bulloch et al. (2002) and is based on averaged historic annual flow rates measured on the major rivers of the WHP area (1967–1998 for Poplar River, 1957–1996 for Berens River, 1957–1992 for Pigeon River and 1976–1999 for Bloodvein River).

Adjusting the economic values reported in Kulshreshtha (1994) for inflation (CDN$40,000/m^3 to $800,000/m^3) and applying these figures to the volumetric discharge of the main rivers of ER90 we get a potential economic value of between CDN$0.27 to $5.55 billion/year.

The willingness to pay calculated for the site may not be accurate as it is based on responses from Winnipeg residents. Residents of the WHP area may have a different perspective on their willingness to pay to improve water quality. The total water supply economic value range estimated for the site is conservative as it is based on the water discharge capacity of major rivers and does not include the water supply capacity from lakes and smaller water bodies (streams, creeks and wetlands).

Water is a priceless resource and economically valuing it is a challenge reflected by the range at which water is publicly sold. For instance, bottled water is sold for approximately $1.00/litre while the City of Winnipeg sells water to its residents for $0.001/litre (City of Winnipeg, 2007). It also provides a number of important functions beyond personal consumption as it is used for cooking, cleaning and cooling. Water is irreplaceable and economically valuing this resource is likely to fall short of its true value. Therefore, the water supply economic value estimated for the WHP AREA is conservative.

6.1.2 *Material provision*

Material provision services were economically valued based on medicinal plants used to treat ailments, furs collected from trapping and hydro-power production. Average expenditures on over-the-counter drugs within Canada were used to estimate the economic value of medicinal plants. ER90 trapping information was used to estimate the economic value of furs harvested within the WHP area. Hydro-power was estimated based on the amount of water supplied to Lake Winnipeg, which eventually flows through Manitoba hydro dams.

Medicinal plants

Medicinal plants are often collected by local communities to treat minor or major ailments. According to the Patented Medicine Prices Review Board (1998), Canadians spent 1.1 billion dollars on over-the-counter drugs in 1998. Since Canada's total population was a little over 30.3 million in 1998 the per capita expenditure on over–the-counter drugs was approximately $363.02 per person. Assuming that spending on medicine has not changed over the last ten years we can adjust the per capita expenditure for inflation, which gives $446.52/person/year. If we assume that WHP area residents get 30 per cent of their medicine from medicinal plants then this would save them approximately $133.96/person/year. The total population of the WHP area was 3,891 residents in 2006 (Statistics Canada, 2006). If every resident offset 30 per cent of their expenditures on drugs by using medicinal plants the WHP area communities would collectively save CDN$520,000 million per year. Assuming that medicinal plants found in the WHP area have the potential of offsetting total expenditures on medicines, approximately CDN$1.74 million/year would be saved.

Traditional healers claim that there exists a medicinal plant to treat every ailment (Azur, 2008). It is therefore conceivable that all ailments could be treated with medicinal plants collected from the natural environment. The number of ailments treated with medicinal plants will vary from community to community. To assume that WHP area residents treat 30 per cent of their ailments with medicinal plants is likely reasonable. Nevertheless, since there is no certainty that the residents of the Pimachiowin Aki would offset their medical expenditures with medicinal plants this value is not included in the overall WHP area ecosystem service valuation estimate.

Trapping

Trapping has provided livelihoods for the residents of the WHP area for over a century and it continues to be an important economic activity for the people of the WHP area. Revenues generated from trapping activities vary greatly from year to year depending on a number of factors, such as the types of animals caught and fur market values.

The average economic value of the furs trapped by three communities of the WHP area (Poplar River, Pauingassi and Little Grand Rapids) between 2000 and 2006 was approximately $38,000 (see Table 12) (Berezanski, 2008). The following assumptions were made to calculate the trapping opportunity economic value of the WHP area:

- Trapping is also commonly practiced by the Pikangikum First Nations community and their trapping harvest revenues are equivalent to that of Poplar River due to the similarities in size of their traditional lands.
- Resident populations are the only people involved in trapping activities in ER90 and the WHP area.

Table 12: Trapping production by three communities in the proposed World Heritage Site[a]				
Year	Inflation Rate	Little Grand Rapids	Pauingassi	Poplar River
2000/2001	1.17	$28,445	$10,126	$53,939
2001/2002	1.14	$3,892	$58	$14,681
2002/2003	1.12	$4,953	$429	$10,724
2003/2004	1.07	$2,597	$3,993	$13,562
2004/2005	1.06	$2,723	$124	$75,016
2005/2006	1.04	$1,474	$167	$1,098
Average		**$7,347**	**$2,483**	**$28,170**

[a]Harvest information was obtained from Berezenski (2008) who compiled trapping information tracked by Manitoba Conservation.

The total economic value of trapping for the WHP area was calculated by averaging 2000/2001 to 2005/2006 trapping harvest information, which was then adjusted for inflation. The total value calculated amounts to approximately CDN$70,000 per year.

The amount calculated may be high, as total revenues from trapping activities will fluctuate with the number and types of animals trapped and their market values. Total trapping revenues generated by the Pikangikum First Nations community were not known and were estimated by using the revenues generated by the Poplar River community. Although this may be a reasonable assumption, the overall trapping value calculated for the WHP area is likely inaccurate.

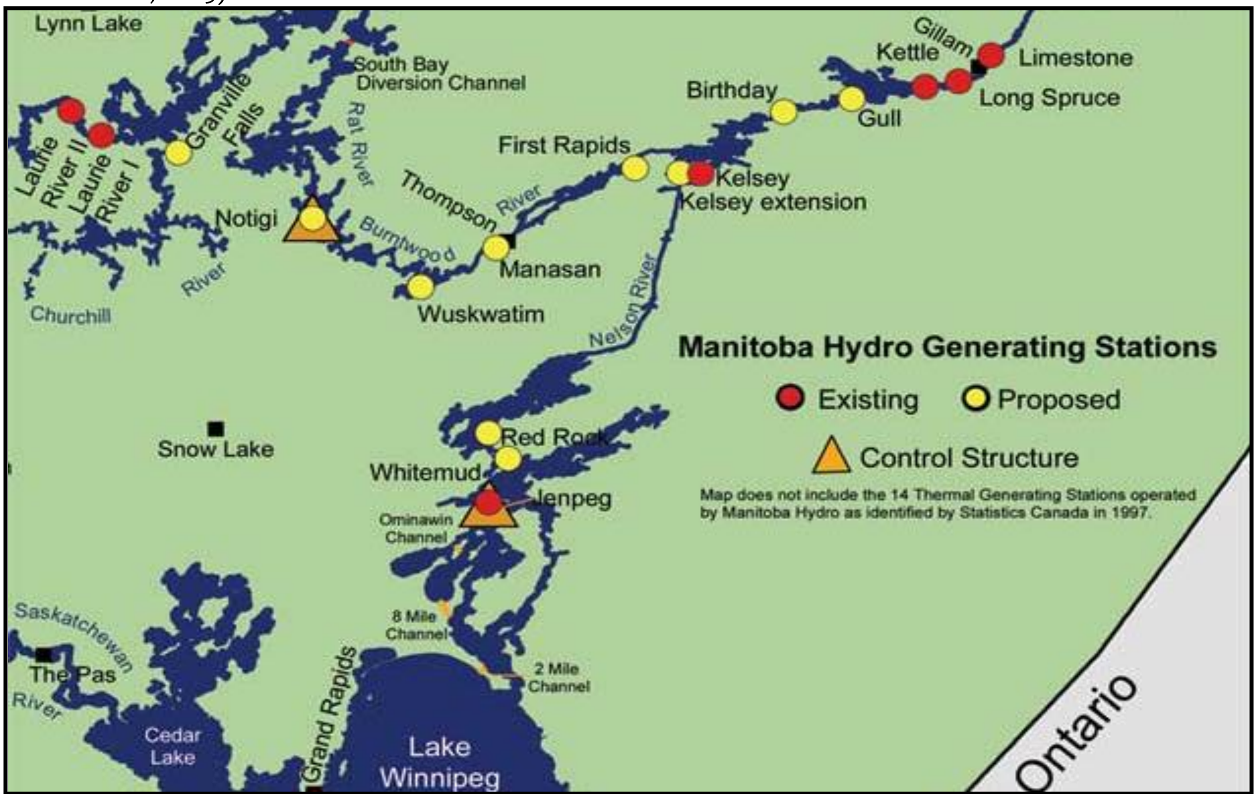
6.1.3 Energy provision

Manitoba produces the vast majority of its electricity by exploiting hydro-power. The hydro-power produced by the clean water of the WHP area is assessed to estimate its contribution to Manitoba Hydro's electricity production.

Hydro-power

The water bodies of the WHP area mostly drain into Lake Winnipeg, which acts as a water reservoir to turn hydro-power into electricity that is then supplied to customers across the province. The water from Lake Winnipeg flows through a series of dams (Jenpeg, Kelsey, Kettle, Long Point, Limestone) located on the Nelson River (see Figure 5).

Figure 5: Manitoba Hydro power generation station locations on the Nelson River (Manitoba Eco-Network, 2005).



The total volumetric flow of the proposed WHP area's major rivers that empty into Lake Winnipeg is approximately 218 m^3/s (see Table 13). Assuming that the water flowing into Lake Winnipeg gets perfectly mixed, we can then calculate the amount of power produced by the WHP area's major rivers.

Table 13: Volumetric flows of the major rivers in the WHP area and at the Nelson River hydro power generating stations

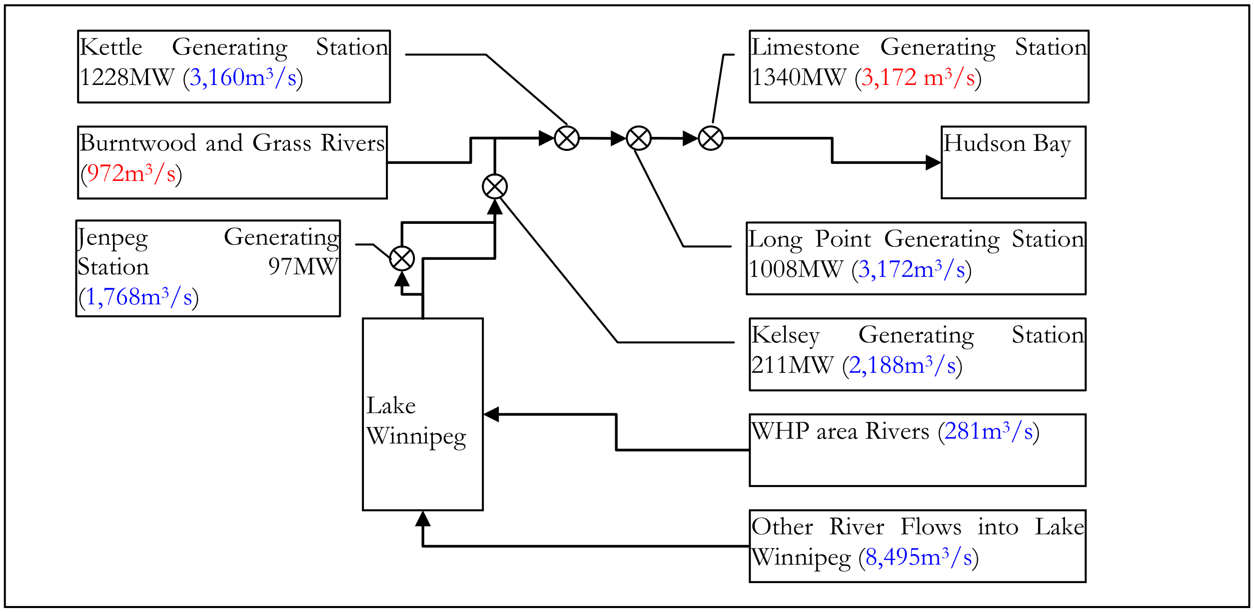
Location of Water Flow Gauge	**Volumetric Discharge in m^3/s**
Poplar River at outlet of Weaver Lake	32.69
Berens River at outlet of Long Lake	61.23
Pigeon River at outlet of Round Lake	80.57
Bloodvein River above Bloodvein Bay	43.94
Total	**218.45**
Nelson River (West Channel) at Jenpeg	1768.33
Nelson River at Kelsey Generating Station	2188.33
Nelson River at Kettle Generating Station	3160.00
Nelson River at Long Spruce Generating Station	3171.67
Nelson River at Limestone Generating Station	3171.67

[a]Volumetric data were obtained from Bulloch et al. (2002) and Environment Canada (2008a; 2008b; 2008c; 2008d). They are based on averaged historic annual flow rates measured on the major rivers of the WHP area

(1967–1998 for Poplar River, 1957–1996 for Berens River, 1957–1992 for Pigeon River and 1976–1999 for Bloodvein River) and the Generating Stations (1967–2006 Jenpeg, 1960–2006 Kelsey, 1987–2006 Kettle, 1987–2006 Long Spruce). The flow at Limestone Generating Station was assumed to be the same as the flows at Long Point Generating Station.

The maximum water volumetric flow into Lake Winnipeg recorded in 2005, an exceptionally wet year, was 8,495 m^3/s (Manitoba Hydro, 2005). Therefore the major rivers of the WHP area contribute approximately 2.57 per cent of the total volumetric flow into Lake Winnipeg. The water eventually leaves Lake Winnipeg and travels the Nelson River where it passes through five hydro dams (Jenpeg, Kelsey, Kettle, Long Point, and Limestone) before joining the waters of the Hudson Bay (see Figure 6). Approximately 2.57 per cent of the water passing through the Jenpeg and Kelsey power generating stations and approximately 1.78 per cent of the water passing through the Kettle, Long Spruce and Limestone power generating stations originates from the WHP area.

Figure 6: Flow rates going through the Manitoba Hydro power generation stations on the Nelson River (Manitoba Eco-Network, 2005). Flows determined using statistical data are in blue and flows calculated and estimated are in red.



The annual average power production from the Manitoba Hydro power generation stations on the Nelson River amounts to 23,220 million kWh/year. Hence, the volumetric flow from the major rivers of the WHP area produces approximately 435 million kWh annually. Manitoba Hydro's average gross revenues from 2000 to 2007 were approximately CDN$460,000/kWh (Manitoba Hydro, 2007). Assuming that Manitoba Hydro generates CDN$460,000 for all the power it produces and sells, the water flows of the WHP area provide a gross revenue stream of CDN$20.17 million/year (see Table 14).

Table 14: Total power production values from the water flows of the WHP area			
Generating Station	Annual Average Power Production in million kWh	WHP area Water Flow Percentage of Total	Estimated Value of Power Produced at $0.04/kWh
Jenpeg (97MW)	910	2.57	$1,085,220.40
Kelsey (211MW)	1800	2.57	$2,146,589.80
Kettle (1228MW)	7070	1.78	$5,839,596.62
Long Spruce (1008MW)	5800	1.78	$4,790,616.75
Limestone (1340MW)	7640	1.78	$6,310,398.61
Total			$20,172,422.17

The economic value of hydro-power production provided by the WHP area was calculated by assuming that all of WHP area's major river flows will eventually flow through the Manitoba Hydro power generation stations on the Nelson River. Although small amounts of water flowing into Lake Winnipeg may be lost to evaporation or groundwater infiltration, most of it will eventually flow through these hydro dams. The share of the power production attributed to the major rivers of the WHP area was based on the maximum flow rate of 2005 (a very wet year with the wettest conditions since 1912) (Manitoba Hydro, 2005). In reality, the power production share of the major rivers of the WHP area may be greater and, for this reason, the hydro-power production value calculated is conservative.

6.2 Regulating services

Regulating services provided by ecosystems ensure that our environments remain habitable. These services are more difficult to quantify and value than provisioning services as they emerge from whole and healthy ecosystems. Ecosystem services that maintain the atmosphere and climate, water and the living biota were examined to estimate the economic and non-economic values of regulating services provided by the WHP area.

6.2.1 Atmospheric and climate regulation

The atmospheric and climate regulation services provided by the WHP area were evaluated based on the carbon sequestration and storage capacity, air filtration capacity and micro-climate influences of its landscape. The ecosystem services were evaluated monetarily and non-monetarily depending on the availability of relevant information.

Carbon sequestration and storage

Natural landscapes regulate atmospheric concentrations of carbon dioxide by sequestering and storing carbon. Carbon dioxide is sequestered during plant photosynthesis and is converted into a variety of carbon compounds that make up our planet's biomass, which eventually decomposes back into the ground (Anielski & Wilson, 2005).

Increasing carbon dioxide concentrations in the atmosphere have led to global warming and climate change impacts that are being felt worldwide (Stern, 2006). Consequently, the carbon storage and sequestration services provided by our natural environments have become increasingly valuable. The

Stern Review on the Economics of Climate Change (2006) states that one of the key international responses to climate change must include taking action to prevent and reduce deforestation.

> *The loss of natural forest around the world contributes more to global emissions each year than the transport sector. Curbing deforestation is a highly cost-effective way to reduce emissions (Stern, 2006, p. xviii).*

There are currently no timber harvesting operations in the WHP area and its natural environments provide carbon sequestration and storage services of significant economic value. For instance, Olewiler (2004) determined that protecting or converting tilled lands to natural environments within the Assiniboine River Basin provides carbon sequestration economic values ranging from CDN$9.80 to $29.40/hectare/year. The forest carbon sequestration economic value of the Canadian Boreal Region was estimated to range from CDN$3.27 to $23.96/hectare/year (Anielski & Wilson, 2005).

Averaging the forest carbon sequestration economic values estimated for the Canadian boreal region and adjusting for inflation gives CDN$14.16/hectare/year. Multiplying this figure to the various forest land covers of the WHP area we get a total forest carbon sequestration economic value ranging from CDN$12.32 to $21.27 million/year (see Table 15).

Table 15: Forest carbon sequestration value of the proposed World Heritage Site

Forest Cover		Crown Closure		Carbon Sequestration Value	
Type	Area (ha)	High	Low	High	Low
Coniferous – Dense	915,072	100.00%	61.00%	$12,961,811	$7,906,705
Coniferous – Open	123,042	60.00%	26.00%	$1,045,715	$453,143
Coniferous – Sparse	61,051	25.00%	10.00%	$216,194	$86,478
Broadleaf – Dense	91,264	100.00%	61.00%	$1,292,730	$788,565
Broadleaf – Open	0	60.00%	26.00%	$0	$0
Broadleaf – Sparse	2,186	25.00%	10.00%	$7,742	$3,097
Mixed Wood – Dense	263,889	100.00%	61.00%	$3,737,930	$2,280,137
Mixed Wood – Open	0	60.00%	26.00%	$0	$0
Mixed Wood – Sparse	567,014	25.00%	10.00%	$2,007,910	$803,164
Total	**2,023,517**			**$21,270,033**	**$12,321,289**

Information collected from "Counting Canada's Natural Capital: Assessing the real value of Canada's Boreal Ecosystems" written by Anielski and Wilson (2005) was used to estimate the total economic value of the carbon stored within the WHP area. The forests of the Boreal Shield, which cover an area of 119.8 million hectares, store approximately 19,234 million tonnes of carbon within its forest soils and standing biomass (Canadian Forest Service, 2001). This gives a total carbon storage estimate of approximately 160.55 tonnes of carbon per hectare of forest. Applying this value to the forest covers within the WHP area we get a range of 241 to 140 million tonnes of carbon stored (see Table 16).

Table 16: Carbon stored in the forests of the proposed World Heritage Site					
Forest Cover		Crown Closure		Tonnes of Carbon	
Type	Area (ha)	High	Low	High	Low
Coniferous – Dense	915,072	100.00%	61.00%	146,915,640	89,618,540
Coniferous – Open	123,042	60.00%	26.00%	11,852,662	5,136,153
Coniferous – Sparse	61,051	25.00%	10.00%	2,450,454	980,181
Broadleaf – Dense	91,264	100.00%	61.00%	14,652,449	8,937,994
Broadleaf – Open	0	60.00%	26.00%	0	0
Broadleaf – Sparse	2,186	25.00%	10.00%	87,754	35,101
Mixed Wood – Dense	263,889	100.00%	61.00%	42,367,561	25,844,212
Mixed Wood – Open	0	60.00%	26.00%	0	0
Mixed Wood – Sparse	567,014	25.00%	10.00%	22,758,657	9,103,463
Total	**2,023,517**			**241,085,175**	**139,655,645**

Anielski and Wilson (2005) provide a range of CDN$7.48 to $55.42 per tonne of carbon for evaluating the carbon storage economic value of the Canadian Boreal Forest. More recently, Anielski and Wilson (2007) derived a global carbon economic value of CDN$38 per tonne of carbon based on the Stern Report. Adjusting the lower estimate from Anielski and Wilson (2005) and the Stern Report's carbon storage economic values for inflation, we get range spanning from CDN$7.68 to $38.60 per tonne of carbon. Applying this range to the forests of the WHP area gives a total carbon storage economic value of CDN$1.07 to $9.31 billion.

Peatlands store a substantial amount of carbon (Canadian Council of Forest Ministers, 2000). The vast majority (up to 90 per cent) of wetlands in the Boreal shield are peatlands that contain approximately 261 tonnes of carbon per hectare (Anielski & Wilson, 2005). The total surface area of treed and shrub wetlands represent approximately 89 per cent of the total wetlands by surface area in the WHP area. Assuming that all treed and shrub wetlands are peatlands is a reasonable assumption. Applying the carbon economic value range used to determine the forest carbon storage economic value (CDN$7.68 to $38.60/tonne of carbon) to the total peatland area and carbon storage capacity of the WHP area we get a carbon storage economic value spanning CDN$1.63 to $8.20 billion.

The total forest carbon sequestration economic value of the WHP area is estimated to range from CDN$12.32 to $21.27 million per year and the total forest and peatland carbon storage economic value is estimated to be CDN$2.70 to $17.51 billion. The overall carbon sequestration and storage economic value of the WHP area is likely greater as grasses and shrubs, which also provide carbon sequestration and storage services, where not included in the analysis.

The dynamic behaviour of natural environments makes it challenging to estimate the total amount of carbon sequestered annually. Older trees may absorb less carbon annually than younger trees as they eventually reach a steady state. Natural and human disturbances such as forest fires and timber harvests can release carbon into the atmosphere and move it into soils and the forest product sector (Kulshreshtha et al., 2000). These disturbances can set the forest to earlier succession stages increasing carbon sequestration capacity. Surface areas within the WHP area classed as grasslands (these were classed inaccurately and are likely shrublands) and shrublands were formerly forests that were likely burned. These areas may sequester carbon at a faster rate than older forests within the site.

The carbon sequestration and carbon storage economic values estimated for the site are likely reasonable. The value ranges calculated reflect variances in forest densities and carbon valuation methods. Anielski and Wilson (2005) report a wide range of carbon values derived using a number of approaches: carbon emission trading in Europe; risk assessment to the global insurance sector; UNEP global climate change damage estimations; replacement cost of afforestation; and estimated cost of timber income foregone. With time, a standard carbon valuation method may be established, which will improve the accuracy of carbon sequestration and storage economic value estimates.

Air Filtration

Besides sequestering carbon dioxide, trees enhance our air quality by capturing a number of airborne pollutants. A modelling study that utilized meteorological and pollution concentration data from across the U. S. estimated that urban trees greatly improve urban air quality by filtering out 711,000 tonnes of air pollutants (O_3, PM_{10}, NO_2, SO_2, CO) (Nowak et al., 2006). This service was economically valued at approximately $USD3.8 billion per year (Nowak et al., 2006). A study conducted in the city of Modesto, California, concluded that the city's 90,000 trees absorbed 154 tonnes of air pollutants per year (or 3.7 lb/tree) corresponding to an economic value of USD$16 per tree (McPherson, et al., 1999). Dwyer et al. (1992) found that 500,000 mature mesquite trees remove 6,500 tons of particulate matter per year, corresponding to an economic value of USD$4.16 per tree.

Air pollution concentrations within the WHP area are low compared to urban settings as there are no major industrial operations or excessive traffic in the area. Nevertheless, towns and communities within and neighbouring the site will benefit from the air cleaning services provided by the trees and vegetation of the WHP area. Assuming that there are 60 trees/km^2 within the 50.42 km^2 of the WHP area's settled areas implies that there are at least 3025 trees located there (Hely, Bergeron, & Flannigan, 2000; Statistics Canada, 2006). Multiplying the total number of trees with the air filtration service economic value reported by Anielski and Wilson (2005) (adjusted for currency exchange and inflation = $6.66/tree) we get a total potential air filtration service economic value of CDN$20,000 million per year for the residents of the WHP area.

We can also estimate the total potential air filtration economic value of the site by assuming that it is located within or near an urbanized area. Hely et al. (2000) report that the tree density variances in different parts of the Canadian boreal forest range from 112 to 7 trees per hectare. Assuming that the average tree density reported by Hely et al. (2000) (60 trees/hectare) is representative the WHP area's dense forests, with 100 per cent crown closure, we can then estimate the total number of trees within the WHP area. Table 17 provides an estimate of the tree density breakdown for the various forested land covers of the WHP area.

Table 17: Number of trees in the proposed World Heritage Site					
		Crown Closure		Number of Trees	
Forest Cover	Total Area	High	Low	High	Low
Coniferous – Dense	915,071.94	100.00%	61.00%	54,904,316	33,491,633
Coniferous – Open	123,041.56	60.00%	26.00%	4,429,496	1,919,448
Coniferous – Sparse	61,051.13	25.00%	10.00%	915,767	366,307
Broadleaf – Dense	91,263.56	100.00%	61.00%	5,475,814	3,340,246
Broadleaf – Open	0.00	60.00%	26.00%	0	0
Broadleaf – Sparse	2,186.31	25.00%	10.00%	32,795	13,118
Mixed Wood – Dense	263,888.63	100.00%	61.00%	15,833,318	9,658,324
Mixed Wood – Open	0.00	60.00%	26.00%	0	0
Mixed Wood – Sparse	567,014.06	25.00%	10.00%	8,505,211	3,402,084
Total	2,023,517.19			90,096,716	52,191,160

Multiplying the total number of trees with the air filtration service economic value reported by Anielski and Wilson (2005) (adjusted for currency exchange and inflation = $6.66/tree), we get a total potential air pollution filtration service economic value of CDN$350 to $600 billion per year for the WHP area. This estimate is not included in the overall economic value of the WHP area's ecosystem services as it is based on valuation information from urbanized areas.

The economic value of the air filtration services provided by the forests of the WHP area are likely inaccurate. The information used to calculate the economic value of air filtration services by the WHP area was based on air filtration services provided by trees in urban settings when, in reality, the four communities of the WHP area are located within a natural landscape. The potential economic value of the WHP area's air filtration services was calculated strictly to demonstrate the valuable services we receive from forests and is not included in the overall WHP area ecosystem service valuation estimate.

Micro-climates

Natural environments influence the climate in a number of ways. Natural vegetation increases ambient humidity by transpiration and emits chemicals that act as nucleation sites for the formation of clouds (Harding, 2006). Precipitation redistributes and resupplies water on the landscape. Trees provide shading by intercepting sunlight and slow wind speeds by breaking up air currents. These ecosystem functions help regulate our climate.

A number of studies estimate the shading and heating economic values provided by trees in residential areas. McPherson et al. (1999) concluded that the 90,000 trees of the city of Modesto, California, provide shading and cooler summer temperatures economically valued at USD$870,000 per year (122 kWh/tree or $10/tree). Wolf (1998) estimates that a 25-foot tree saves an American household an average of USD$10/year in heating and cooling costs. The influence of vegetation on climate within the settled areas of the WHP area cannot be estimated accurately due to a lack of adequate information.

6.2.2 *Water regulation*

The water regulation services provided by the natural environments of the WHP area were estimated based on water treatment, flood prevention and erosion control services. Wetlands provide important water treatment services by filtering and decomposing nutrient loads. They also regulate and retain water flows preventing or attenuating floods. Vegetative covers retain soils and lower their erosion, often leading to increased water siltation.

Water treatment

Water treatment service economic values were estimated based on the nutrient retention and treatment capacities of wetlands and the equivalent costs of treating these nutrients by using wastewater treatment plants. Wetland biological processes (plant growth, insect and wildlife consumption) readily capture and break down nitrogen and phosphorus compounds. The increased concentration of phosphorus and nitrogen in water bodies favours algae growth, which consumes more oxygen threatening aquatic life. Increasing phosphorus and nitrogen concentrations in Lake Winnipeg have led to extensive algal blooms impacting the fishery industry and causing beach closures.

Olewiler (2004) reports that wetland plants such as duckweed and pennywort can remove 116 to 770 kg/ha/year of phosphorus and 350 to 32,000 kg/ha/year of nitrogen and that a quasi-natural bed of reeds can remove 101 kg/ha/year of phosphorus and 1,910 kg/ha/year of nitrogen (Olewiler, 2004). A conservative estimate from a North American database reports that wetlands remove 80 kg/ha/year of phosphorus and 548 kg/ha/year of nitrogen (Olewiler, 2004). Furthermore, Olewiler (2004) states that the equivalent service from a wastewater treatment plant would cost anywhere from CDN$21 to $61/kg for phosphorus and CDN$3 to $8/kg of nitrogen.

The wastewater treatment service provided by the wetlands of the WHP area was determined by using the conservative wetland removal rate of phosphorus and nitrogen and the lower nutrient wastewater treatment cost reported by Olewiler (2004). Modifying the lower wastewater treatment cost estimates for inflation gives CDN$22.26/kg of phosphorus and CDN$3.18/kg of nitrogen. The wetlands of the WHP area, which cover approximately 814,787 hectares, could potentially provide the equivalent phosphorus and nitrogen removal service of a wastewater treatment plant economically valued at CDN$3.18 billion per year.

The WHP area is covered by vegetation and we can expect the nutrient run-off from its landscape to be minimal. Assuming that the total nutrient load is only one per cent of the wetland nutrient capture capacity gives a total wastewater treatment economic value of approximately CDN$31.83 million per year.

This estimate is reasonable, as wastewater plant expenditures for treating phosphorus and nitrogen can be quite high and natural background sources can be substantial. The City of Winnipeg has spent a total of 65 million in capital costs and $85,000 per year in operating costs to treat phosphorus and nitrogen from its wastewater (Borlase, 2008). These expenditures will increase over the period of 2008 to 2014 by CDN$636 million in capital costs and CDN$2.57 million/year in operating costs (Borlase, 2008). In addition, natural sources can provide a substantial amount of nutrient loads to water bodies. The Lake Winnipeg Stewardship Board estimates that 38 per cent of nitrogen sources and 35 per cent of phosphorus sources flowing into Lake Winnipeg come from natural background and undefined sources, which include forests, wildlife and septic fields (Lake Winnipeg Stewardship Board, 2006).

Flood prevention

Wetlands regulate water flows and can retain large volumes of water (Anielski & Wilson, 2005; Olewiler, 2004). The loss of wetlands increases the likelihood and extent of flooding events, which can impact and damage built-up environments. The flood prevention service provided by wetlands in the Lower Fraser Valley is estimated by Olewiler (2004) to be worth CDN$408 to $2,110/hectare/year. Schuyt and Brander (2004) estimate that the economic value of the world's wetlands flood control service amounts to approximately US$464/hectare/year. The economic value of wetland flooding prevention services is a function of a community's vulnerability to flooding impacts.

Settled areas located along waterways within the WHP area may be impacted by flooding events induced by wetland losses. Information on the vulnerability of settled areas to flooding impacts is required to determine the economic value of wetland flooding prevention services. The potential wetland flood prevention service within the WHP area can be estimated assuming that settled areas along waterways substantially increases. Applying the lower estimate provided by Olewiler (2004) to the wetlands of the WHP area, we get a total potential flooding prevention service of approximately CDN$380 million/year. This estimate is not included in the overall economic value of the WHP area's ecosystem services as the flooding vulnerability of the WHP area's communities is unknown.

The economic value of wetland flooding prevention services will be dependent on flooding events and human-built infrastructure prone to flood damage. The WHP area is primarily comprised of natural environments and, aside from the four First Nation communities situated along water bodies, there is no other major human-built infrastructure prone to flooding within the site. Assuming that the site does not provide flood prevention services of significant economic value is plausible.

Erosion Control

Vegetated areas provide important erosion control services by retaining soils from wind and water run-off. Erosion can lead to infrastructure damages, water siltation that can harm fish populations, and a reduction in soil productivity for agriculture (Anielski & Wilson, 2005; Belcher et al., 2001; Olewiler, 2004). Olewiler (2004) reports that the erosion control services provided by conserving natural environments in the Upper Assiniboine River Basin can be estimated by measuring improvements in water quality (CDN$1.34 to $9.34/hectare/year) and reductions in wind erosion (CDN$1.34 to $4.01/hectare/year). Anielski and Wilson (2005) report that logging induced erosion in the United States leading to the sedimentation of water bodies costing US$1.94/tonne of sediment.

Erosion processes in natural environments such as the WHP area are mostly naturally induced.

Consequently, the erosion control services provided by the vegetation of the WHP area cannot be easily quantified and economically valued. To estimate the erosion control economic value of the WHP area we assume that removing its vegetative cover would increase water siltation. Re-establishing a vegetative cover would decrease sedimentation and improve water quality, which would potentially be worth $1.39/hectare/year (the lower amount estimated by Olewiler [2004] and adjusted for inflation). Since there is a total of 2,401,187 hectares of vegetated land cover in the WHP area, their erosion control service economic value amounts to approximately CDN$3.35 million per year.

The economic value calculated for the erosion control services provided by the vegetative covers of the WHP area is conservative. The lower estimate from Olewiler (2004) was used in the calculation, which focused strictly on improved water quality by preventing sedimentation. Degraded water quality will also have an impact on fish populations, which is an important food source for the residents of the WHP area. For these reasons the erosion control services provided by the WHP area is likely more valuable than the estimate calculated.

6.2.3 Biological control

Ecosystem services provide important and valuable biological control services. For example, bird predation on insects is instrumental in limiting their populations. Although insects are an important part of healthy and functioning ecosystems they can inflict irreversible damage to natural environments. For example, it is expected that the mountain pine beetle will decimate 80 per cent of all the merchantable pine of British Columbia's interior forests by 2013 (British Columbia Provincial Government, 2006). This will have a noticeable impact on the economic, social and cultural well-being of the province.

The City of Winnipeg's expenditures on insect control activities in 2007 were considerable: $3.2 million spent on the Dutch elm disease prevention; and $4.1 million spent on mosquito population control programs (City of Winnipeg Public Works Personnel, 2008). If natural insect predators disappeared, the city's insect control expenditures would increase substantially.

Replacing bird biological control services in forests by pesticides or genetic engineering was estimated by the U. S. Forest Service to cost US$7/acre or CDN$21.84 per hectare in 2002 (Anielski & Wilson, 2005). If we adjust this figure for inflation the total biological control service economic value provided by birds would be approximately CDN$24.24/hectare/year. Applying this figure to the forests of the WHP area, we get a potential total economic value ranging from approximately CDN$21.09 to $36.40 million/year (see Table 12).

Table 18: Biological control service of the proposed World Heritage Site					
Forest Cover		Crown Closure		Pest Control Value	
Type	Area (ha)	High	Low	High	Low
Coniferous – Dense	915,072	100.00%	61.00%	$22,183,540	$13,531,959
Coniferous – Open	123,042	60.00%	26.00%	$1,789,694	$775,534
Coniferous – Sparse	61,051	25.00%	10.00%	$370,006	$148,003
Broadleaf – Dense	91,264	100.00%	61.00%	$2,212,448	$1,349,593
Broadleaf – Open	0	60.00%	26.00%	$0	$0
Broadleaf – Sparse	2,186	25.00%	10.00%	$13,250	$5,300
Mixed Wood – Dense	263,889	100.00%	61.00%	$6,397,294	$3,902,349
Mixed Wood – Open	0	60.00%	26.00%	$0	$0
Mixed Wood – Sparse	567,014	25.00%	10.00%	$3,436,445	$1,374,578
Total	**2,023,517**			**$36,402,677**	**$21,087,316**

The potential economic value of the biological control services provided by the birds of the WHP area is not included in the overall ecosystem service value estimate as the direct benefit to the resident population is unknown. Nevertheless, the potential biological control value calculated is likely conservative due to the devastating impacts that species could have on ecosystems if they proliferate unimpeded. This has been illustrated a number of times by the introduction of exotic species within natural environments. For instance, the opossum which was introduced in New Zealand for its fur is now considered a pest as they have no natural predators and are devastating the country's forests and biodiversity. If left unchecked, species can greatly disrupt natural cycles and lower the integrity of ecosystems.

6.3 Cultural services

Cultural services are non-material benefits that are provided by our natural environments that are important for enhancing well-being and quality of life (Chiesura & de Groot, 2003). Ecosystems provide us with opportunities for recreation, spiritual and religious enlightenment, educational experiences and cultural heritage values. These cultural services will be evaluated to estimate their contribution to the well-being of the WHP area resident and non-resident populations.

Quantifying and valuing cultural services is often difficult as they are not amenable to economic analysis for individuals or communities. For example, the cultural services provided by the WHP area are of infinite value to the Anishinabe people as their culture is intimately connected with their natural landscape. In contrast, tourists who travel to the WHP area to experience an intact natural environment will value the landscape differently.

A number of proxies can be used to coarsely estimate cultural service economic values. For instance, donations to conservation agencies can be used to estimate the cultural heritage value of a landscape and travel expenditures to visit sites with spiritual meaning can be used to estimate the spiritual and religious value of an environment (Chiesura & de Groot, 2003). Although these approaches do not entirely capture the benefits we gain from cultural ecosystem services they highlight their importance for maintaining our quality of life and well-being.

6.3.1 *Recreational opportunities*

Natural environments provide recreational opportunities that can be important for maintaining mental health, emotional development, aesthetic enjoyment and freedom (Chiesura & de Groot, 2003). Distinguishing between recreational and regular activities for resident communities is challenging. For this reason, recreational service economic values were estimated strictly for non-resident populations.

Information on non-consumptive wildlife activities, canoeing and camping expenditures from the ER90 was gathered to estimate the recreational economic values of the WHP area. Environment Canada studies conducted between 1981 and 1991 showed that expenditures for non-consumptive wildlife activities were approximately double the expenditures on recreational hunting (Environment Canada, 1987; 1993). Assuming that this ratio is accurate for the WHP area, expenditures on non-consumptive wildlife activities by non-residents would amount to approximately CDN$2 million/year (which is double non-resident expenditures on recreational hunting). Eight hundred canoeists spent approximately $800,000 in 1998 to paddle the various water bodies of ER90 (Peckett, 1999). Assuming that expenditures on paddling activities within the WHP area are similar to ER90 is reasonable as it has twice the water body surface area. Therefore, the total recreational economic value of canoeing within the WHP area when adjusted for inflation is approximately CDN$980,000 million per year. Camping user fees generated by Atikaki (no camping fees) and Woodland Caribou (camping fees) Provincial Parks was $69,400 in 2007. The overall recreational opportunity economic value of the WHP area is estimated to be worth approximately CDN$3.05 million per year.

The recreational value estimated for the WHP area is reasonable as it could have included additional recreational expenditures such as retreats to remote lodges, winter sports (snowmobiling, ice fishing, backcountry skiing), and artistic activities (painting and photography). Recreational opportunities provided by natural environments are valuable for human well-being and the economic value calculated for the WHP area is conservative.

6.3.2 *Spiritual and Religious*

The spiritual and religious services provided by the WHP area are invaluable to the Anishinabe people as their culture is interlinked with their spiritual beliefs. A study conducted by the Northern Lights Heritage Services (2000) interviewed 293 members of the ER90 Anishinabe community. The interviewees referred to a number of sacred sites within their traditional lands, which included pictographs, petroforms and good hunting rocks. Land and water were referred to as sacred as the land "provides all the needs of the people" and water "supports life and therefore must be respected and protected" (Northern Lights Heritage Services, 2000, pp. 48, 60). In addition, certain bird, animal and fish species are greatly revered by the Anishinabe people. For instance, the bald eagle and the sturgeon are considered sacred. The sturgeon is especially important as it is considered to be an elder amongst fish populations:

> *The sturgeon totem is one of the oldest in Ojibwe mythology and social organization. Numa (sturgeon) as a*

> *member of the family clan of fishes, claimed to be one of the first to emerge from the great water. (Northern Lights Heritage Services, 2000, p. 63)*

Furthermore, the Anishinabe people believe that the Creator made all things for a purpose (Fenton et al., 2001): "The creator made these things for us to enjoy but not to interrupt the cycle" (Fenton et al., 2001, pp. IV-91).

Monetarily valuing the spiritual and religious services provided by the WHP area to the Anishinabe people would not adequately represent their value. Nevertheless, a number of proxies could be used to estimate the spiritual and religious benefits of the natural environment. For instance, the economic value of traditional healing (which is often closely interlinked with spiritual beliefs) can be economically valued by estimating equivalent service costs provided by a psychologist or a social worker. Traditional healers typically do not charge communities for their services. Assuming they charged the same rate as a professional in the medical field (approximately CDN$750/day plus expenses) is reasonable (Azur, 2008). If a traditional healer visited the four communities of the WHP area once a week for the entire year this would represent a value of approximately CDN$160,000 per year. This estimation is not included in the overall ecosystem service economic value of the WHP area project area, as the spiritual and religious value of the Pimachiowin Aki is beyond monetary value to the Anishinabe.

The value estimated is conservative as it is the natural landscape that sustains the spiritual, mental and physical well-being of the Anishinabe peoples. Ray Rabliauskus, an Anishinabe elder who sits on the Pimachiowin Aki board, states "without our environment the people feel physically sick" (Rabliauskus, 2008). The major sense of loss felt by Anishinabe communities associated with the disappearance of the Pimachiowin Aki would lead to illnesses. Physical and mental health is invaluable and the public costs borne by the medical system to treat these communities would likely be significant.

People's willingness to pay (travel costs and entrance fees) to visit culturally significant areas (such as burial grounds, traditional meeting grounds, and spiritual locations) to better understand the Anishinabe culture could be used to estimate their economic value. Boxall et al. (2003) estimate that tourists would be willing to pay an additional CDN$61.31 to CDN$77.26 per trip to visit the pictographs on the Segrium and Manitogotan canoe routes located on the east side of Lake Winnipeg. On the other hand, these sites may not be amenable to tourism as the increased number of visitors could impact their sanctity, alter the landscape, and degrade their cultural value. Boxall et al. confirm this possibility by stating: "A discovered pictograph that is subsequently defaced, however, is worth about 6–10 per cent of the value of the painting in its pristine states" (Boxall et al., 2003, p. 227). The spiritual and religious values provided by the WHP area for non-residents were not evaluated due to a lack of adequate information.

6.3.3 Educational experiences

Natural environments provide us with a number of educational opportunities to build our ecological knowledge. Learning through experimentation and observation leads us to discoveries such us new medicines and materials and better environmental management approaches (Benyus, 1997; Canadian

Boreal Initiative, 2005; Chiesura & de Groot, 2003). Biomimicry, which means "the imitation of life," encourages learning from nature's infinite pool of innovative solutions to solve human problems in a way that is conducive to life (Benyus, 1997). Sustaining natural environments like the WHP area ensures that we maintain opportunities for learning, discovery, gaining ecological knowledge and solving our problems by imitating and being inspired by nature.

The Anishinabe have lived in harmony with their natural landscape for many generations. Their intimate relationship with the landscape has lead to the accumulation of valuable traditional ecological knowledge that has been passed down from generation to generation. Preserving this knowledge is closely related to preserving the Anishinabe's cultural values and way of life. For instance, hunting provides the Anishinabe people with a way to meet their food requirements and gain important ecological knowledge (Northern Lights Heritage Services, 2000). An Anishinabe's first moose kill is a hunter's rite of passage and is celebrated by sharing the meat with friends and family (Northern Lights Heritage Services, 2000). The Boreal Forest Initiative highlights the importance of traditional ecological knowledge for the management and conservation of the Canadian boreal region (Canadian Boreal Initiative, 2005). They recommend the "incorporation of Traditional Knowledge into land use planning and resource management decisions with the informed consent of aboriginal people" (Canadian Boreal Initiative, 2005, p. 54). Maintaining and preserving traditional ecological knowledge is imperative to manage and sustain our natural environments.

Educational experiences are often invaluable. Estimating their economic value can be accomplished by using a number of proxies. Chiesura and de Groot (2003) suggest gathering information on the cost of nature inspired books and films, investments in ecological research, tourism revenue from naturalist interpretive centres and the economic value of new scientific discoveries as proxies for evaluating the educational experience economic value provided by natural environments. For instance, a graphic novel series pitched by Michael Stewart to Rubicon Publishing will draw from Anishinabe cultural knowledge to impart insights for the conservation of the environment (Stewart, 2008). If accepted, this graphic novel series will generate revenue in the United States and Canada. Educational experiences provided by the WHP area were not evaluated due to a lack of information.

6.3.4 Cultural heritage

The cultural heritage services provided by the WHP area is of infinite value to the Ainishinabe people as their culture and way of life is intimately interwoven with the natural environment in which they reside. In essence the Anishinabe culture cannot survive without natural landscapes like the Pimachiowin Aki. Hence, the cultural heritage services provided by the WHP area's natural environments to the Anishinabe people cannot be economically valued. Estimates can be derived from expenditures on cultural tourism, local products and traditional handicrafts as a proxy to estimate the cultural heritage economic value of the WHP area. This would greatly undervalue the important cultural heritage value of the site.

Residents living outside the site may economically value the cultural heritage provided by the WHP area for reasons that may be different from the Anishinabe people. Numerous donations are provided annually to conserve natural environments by Canadians. For example, a study that tracked environmental conservation donations in the Prairie Provinces (Alberta, Saskatchewan and Manitoba) concluded that approximately 10 per cent of 13,572 individuals made a donation averaging $77.70 for environmental conservation (Yen, et al., 1997). Applying this figure to Manitoba's current population (which was 1,180,004 in 2007) gives a total provincial donation of CDN$9 million for conserving natural environments (Statistics Canada, 2007). Although this donated amount is directed to all natural environments within Canada it highlights the importance Manitobans place on natural environments.

A valuation study conducted by a team of researchers at the University of Winnipeg concluded that most people surveyed favoured environmental protection over economic development, which indicates the importance Manitobans place on protected environments and natural habitats. "As a preliminary estimate we see that the average Manitoban household would be willing to make a one-time payment of $440 to double the size of the protected wilderness of ER90 (this corresponds to approximately $132 million or about $146 per hectare protected)" (Fenton et al., 2001, pp. IV-42).

Assuming that the willingness to pay per household to double ER90 can be used to estimate the willingness to pay to establish the WHP area is reasonable since the WHP area and ER90 are approximately equivalent in surface area. There were 448,765 households in Manitoba in 2006 and the donation is estimated to be approximately CDN$503/household (adjusted for inflation). Therefore, Manitobans would be willing to pay approximately CDN$228 million as a one-time donation to establish a conservation area the size of the WHP area. At a discount rate of 1 per cent, we can estimate that Manitobans would be willing to donate CDN$2.28 million per year to establish and maintain the WHP area.

The estimated cultural heritage economic value calculated for this study is reasonable. The donation estimate is accurate as it was based on people's willingness to pay for establishing a conservation area the size of the WHP area. In addition, a discount rate of one per cent was used in the calculation when rates of two to ten per cent are typically used to convert investments into annual flows (Whitehead, 2005).

6.4 Supporting service

Supporting services are crucial as they perpetuate the existence of natural environments. Economically valuing these services is misleading as they are irreplaceable. Pollination, habitat/refugia and soil formation services will be examined to estimate the invaluable supporting service values provided by natural environments. Pollination perpetuates life and is greatly economically valued for agriculture. Suitable and diverse habitat and refugia facilitate the conservation and enhancement of our planet's biodiversity. The formation of healthy soils through physical and biological processes is invaluable for plants and organisms to thrive.

6.4.1 Pollination

The pollination services we receive from our natural environments are indispensible to maintaining and proliferating life. There are over 1,000 species of pollinating insects in Canada and approximately 70 per cent of our food crops are dependent on insects for pollination (Dyer, 2006).

It is estimated that nature's pollination services provide Canadians with over a billion dollars worth of fruits and vegetables per year (Seeds of Diversity and Ecological Monitoring and Assessment Network, n.d.). The US agricultural sector estimates that pollinators provide benefits amounting to USD$4 to $7 billion per year (Anielski & Wilson, 2005). Increased agricultural yields and quality in the United States from the pollination services of honey bees was estimated by Morse and Calderone (2000) to be worth approximately USD$14.6 billion per year.

Aside from agriculture, pollination services also benefit natural environments that are dependent on pollinators to proliferate plant life. Pollinator diversity is of great importance to maintain biodiversity (Eardley et al.,2006). Furthermore, some pollinators are keystone species within their ecosystems as their pollination services are important for maintaining their integrity.

> *In natural ecosystems, the visual clues of insufficient pollination are more subtle than in agriculture, but the consequences can be as severe as the local extinction of a plant species, a noticeable decline in fruit and seed eating animals, the loss of vegetation cover and ultimately, if keystone species are involved, the demise of healthy ecosystems and their services. (Eardley et al., 2006, p. xii)*

Due to a lack of adequate information, valuing the pollination services in monetary terms provided by the WHP area was not possible. Nevertheless, the variety of suitable natural habitats for pollinators (dry wood, bare ground, vegetation-free embankments, carrion, host plants and caves) within the WHP area supports pollinator diversity. The conservation of pollinator diversity is imperative for maintaining biodiversity within natural environments and the long-term viability of agricultural productivity (Eardley et al., 2006).

6.4.2 *Habitat/refugia*

The WHP area provides a variety of habitats and refugia for insects, fish, plants and animals species. Suitable and varied habitats are imperative for maintaining biodiversity, which is an indicator of ecosystem integrity. The WHP area consists of a variety of water bodies, forests, grasslands, shrublands, wetlands and rocky areas.

The forests of the WHP area is dominated by jack pine and black spruce (Bulloch et al., 2002). Other common tree species found in the WHP area include tamarack, white fir, willow and aspen (Bulloch et al., 2002). The tree density of the WHP area's forests is also varied and ranges from densely to sparsely treed. Shrublands also cover a good portion of the WHP area landscape. Their presence is likely the result of regenerating forests, which are depleted due primarily to forest fires (Bulloch et al., 2002).

Wetlands are especially important for maintaining biodiversity and represent approximately 23 per cent of the WHP area by surface area. Over one third of the world's wetlands (including 40 per cent of wetlands of international importance) are located in Canada's Boreal region. Approximately 65 per cent of major wetland types have been lost and converted within Canada to give way to human activities and built-up environments (Anielski & Wilson, 2005). For instance, the pothole region has lost 40 to 50 per cent of its wetlands due to agriculture (van Kooten, 1993). The WHP area has a variety of wetland environments characterized by herbaceous plants, shrubs and trees.

These varied environments provide habitat for a range of wildlife species. Bulloch et al. (2002) estimate that there is approximately 376 vertebrate species that reside, migrate and breed within ER90. This estimate is likely similar for the WHP area. Table 13 was reproduced directly from Bulloch et al. (2002) and lists the species at risk (according to the Committee on the Status of Endangered Wildlife in Canada [COSEWIC], Manitoba Endangered Species Act [MESA] and the Manitoba Conservation Data Centre [MCDC]) within ER90, which will likely be similar for the WHP area.

Table 19: Species at risk within ER90 and the WHP area[a]

Life Form	COSEWIC Listing[b] and Trend[e]	MESA Listing[c] and Trend[e]	MCDC Listing[d] and Trend[e]
Amphibians	Leopard Frog (v) (t=n/a)	Nil	Green Frog (S2) (t=n/a)
Reptiles	Nil	Nil	
Birds	Ferrugious hawk (v) (t=d) Peregrine falcon (v) (t=i) Loggerhead shrike (t) (t=d) Baird's sparrow (t) (t=d) Caspian tern (v) (t=d) Barn owl (v) (t=n/a) Short-eared owl (v) (t=n/a) Red-headed woodpecker (v) (t=n/a) Cerulean warbler (v) (t=n/a) Yellow breasted chat (v) (t=n/a) Least bittern (v) (t=n/a) King rail (e) (t=n/a)	Ferrugious hawk (v) (t=d) Peregrine falcon (e) (t=i) Loggerhead shrike (e) (t=d) Baird's sparrow (e) (t=d) Piping plover (e) (t=d) Burrowing owl (e) (t=d)	Ferrugious hawk (S2) (t=d) Peregrine falcon (S1) (t=i) Loggerhead shrike (S2S3) (t=d) Baird's sparrow (S2S3) (t=d) Piping plover (S2) (t=d) Burrowing owl (S1) (t=d) Green heron (S1S2) (t=n/a) Great egret (S2) (t=n/a) Ross' goose (S2) (t=n/a) Grasshopper sparrow (S2S3) (t=n/a) Sprague's pipit (S2S3) (t=n/a) Eastern towhee (S2S3) (t=n/a)
Mammals	Grey fox (v (t=d,s) Wolverine (v) (t=s) Woodland Caribou (t) (t=d,s) Mountain lion (e) (t=d,s)	Nil	Little brown myotis (S2) (t=s) Woodland jumping mouse (S2) (t=d,s) Mountain lion (S2) (t=d,s)
Total	**18**	**6**	**15**

[a]This table was reproduced from Bulloch et al. (2002).
[b]Committee On the Status of Endangered Wildlife in Canada (COSEWIC) includes the status of vulnerable (v), threatened (t) and endangered (e).
[c]Manitoba Endangered Species Act (MESA) includes the status of vulnerable (v), threatened (t) and endangered (e).
[d]Manitoba Conservation Data Centre (MCDC) includes the states of critically (S1) imperilled and imperilled (S2).
[e]Trend (t) includes stable (s), increasing (i) or decreasing (d) or not available (n/a).

The WHP area offers a variety of aquatic habitats for fish. The eastern part of the WHP area is dominated by deeper and cooler lakes and rivers, while the western side offers an aquatic environment that is more turbid and warmer (Bulloch et al., 2002). Overall, the water bodies of the WHP area are very productive and offer good habitat for a variety of fish to thrive in. There are only two fish species in the WHP area that are under threat. The Chestnut Lamprey is considered vulnerable and the Lake Sturgeon is considered threatened according to the COSWIC.

Natural landscapes such as the WHP area are greatly valued by Canadians as they provide a variety of natural habitat and refugia which are imperative for maintaining biodiversity (Gardner Pinfold Consulting Economists Limited, 2006; Yen et al., 1997).
A study conducted in Saskatchewan in 1993 found that the willingness to pay for preserving woodland caribou habitat for an estimated 3,600 animals, amounted to an average of CDN$14.66/household/year (Tanguay et al., 1993). Woodland caribou are indigenous to Manitoba's Boreal Forest and the province was home to approximately 2,500 in the mid-1990s (Bulloch et al., 2002). Adjusting the willingness to pay information obtained from Saskatchewan households for inflation (CDN$20.23/household/year) and applying it the Manitoba households (448,765 households in 2006) gives a total of CDN$9.08 million per year.

This estimate greatly undervalues the important habitat and refugia services provided by the WHP area, as it represents strictly people's willingness to pay for preserving the woodland caribou habitat. Economically valuing all the various wildlife and aquatic habitats of the WHP area was not possible due to a lack of information.

6.4.3 Soil formation

Soil formation is the product of abiotic (climate, mineral substrate) and biotic (vegetation and soil biota) activity (Decaens et al., 2006; Feller et al., 2003). Climate-driven processes such as freeze-thaw and precipitation events influence the formation of soils. Geological processes and bedrock composition define the mineral content of the soils likely to form in a given environment. Plant root structures break up rock, retain soil and extract soil minerals required for growth. Soil fauna provide important services in forming and shaping soils and are appropriately referred to as ecosystem engineers (Decaens et al., 2006; Feller et al., 2003). The soil formation services provided by the soil biota of the WHP area is discussed qualitatively.

Soil biota, which represents 23 per cent of all known species (360,000 known species), play an important role in organic matter dynamics, nutrient cycling, carbon storage, energy flow and water infiltration and storage in soil (Decaens et al., 2006). All these processes are important for maintaining the integrity of ecosystems. Organic matter decomposition is especially important as 60 to 90 per cent of all terrestrial primary production is decomposed in the soil (Decaens et al., 2006). Without the important functions carried out by soil biota, terrestrial ecosystems would collapse: "Evidence suggests that the destruction of soil and its biota would result in cascading effects on ecosystem biodiversity and functioning, thus impairing their capacity at maintaining ecosystem services" (Decaens et al., 2006, p. S34). Furthermore, biodiversity can be linked to soil biota populations. A study conducted by Cesarz et al. (2007) found that there was a positive correlation between earthworm populations and tree species diversity. For these reasons, soil animals can be good indicators of soil health (Decaens et al., 2006; Doran & Zeiss, 2000).

Due to a lack of adequate information, the soil formation services provided by soil biota within the WHP area was not economically valued. Nevertheless, we can safely state that these services are fundamental to the integrity and health of its ecosystems.

6.5 Public expenditures

Canadians contribute to the preservation of natural environments in a number of ways. Existing public expenditures for the preservation of natural environments include costs associated with establishing and conserving them.

Ontario Parks and Manitoba Conservation spent \$304,000 and \$24,000 in 2007 to respectively maintain woodland cariboo and Atikaki Provincial Parks having a total surface area of 8,862 km^2. This represents an annual expenditure per surface area of approximately \$37.01/km^2/year. Applying this value to the surface area of the Pimachiowin Aki gives CDN\$1.48 million per year.

The value calculated is conservative compared to Parks Canada expenditures, which has budgeted approximately CDN\$212 million in 2008–2009 to maintain and restore the ecological integrity of our national parks and marine conservation areas and the commemorative integrity of national historic sites (Parks Canada Agency, 2008). Assuming that half the budget will be spent to conserve the ecological integrity of national parks which cover 224 466 km^2 gives an annual expenditure per surface area of CDN\$472/km^2 /year (Natural Resources Canada, 2004).

In addition, provinces spend considerable sums of money on forest fire management personnel and equipment. The Province of Manitoba has spent approximately CDN\$39 million per year in forest fire management between 2000 and 2007 to protect 26.3 million hectares of forests (Manitoba Conservation – Forestry Branch, n.d.; McTavish, 2008). Breaking this value down on a per-hectare basis gives approximately CDN\$1.48 /ha/year. The province of Ontario spends approximately CDN\$1.16 million per year in forest fire management to manage fires in the Woodland Caribou Park, which covers a surface area of 450,000 hectares. Breaking this value down on a per-hectare basis gives CDN\$2.58/ha/year (Crofts, 2008; Ontario Parks, 2008). Applying the more conservative forest fire management value calculated for Manitoba to the Pimachiowin Aki's 2 million hectares of forested area gives approximately CDN\$3 million.

The total amount of money currently spent on preserving natural environments the size of the Pimachiowin Aki amounts to CDN\$4.48 million. The ecosystem service benefits received from the Pimachiowin Aki estimated is approximately 28 times greater than the public expenditure estimated to conserve the natural environments.

7.0 Results and Discussion

This report presents an ecosystem service value assessment of the Pimachiowin Aki, a 40,000 km^2 Anishinabe landscape located across Eastern Manitoba and Northwestern Ontario. The site's ecosystem services were valued by mapping its land covers and using valuation studies from similar environments. Ecosystem service values were derived for the resident and non-resident populations of the site. This distinction is important, as people who live and work within the site will value it differently from people who visit the site to experience an intact natural environment. The ecosystem services evaluated were organized into four main categories: provisioning, regulating, cultural and supporting.

The overall ecosystem service value provided by the Pimachiowin Aki site was estimated to range from CDN$121.51 to 130.46 million per year. This estimate is conservative, as a number of the ecosystem services identified were not valued due to a lack of adequate data. The table below provides a breakdown of the overall ecosystem service value derived for the site.

Table 20: Conservative ecosystem service economic values provided by the proposed World Heritage Site (all economic values are in CDN$ million/year)

Ecosystem Service	Resident	Non-Resident	Total[a]
Provisional	32.22	7.03	59.42
Regulating	0.02	-	47.52–56.47
Cultural	-	5.33	5.33
Supporting	-	-	9.08
Totals	**32.24**	**12.36**	**121.35–130.30**

[a]Some ecosystem services are valued equally between resident and non-resident populations therefore the ecosystem service values can only be added along each column.

The top five ecosystem service values, along with the assumptions and the valuation sources used to derive the numbers, provided by the World Heritage Project (WHP) area are presented in Table 21.

Table 21: Top five ecosystem service values provided by the proposed World Heritage Site (all economic values are in CDN$ million/year)			
Ecosystem Service	Value Calculated	Assumptions	Sources
Fishing Activities	35.10	The fishing opportunity economic value calculated using ER90 information can be applied directly to the WHP area as it has twice the amount of water bodies by surface area. Fishing information for East Central and the Whiteshell/Nopiming represents all of ER90 adequately as they cover a good portion of the area. Accessing the WHP area fishing areas is similar to the Whiteshell/Nopiming. The distribution of the number of angler days can be used to estimate the catch distribution between resident and non-resident populations. Fishing harvest information for East Central and the Whiteshell/Nopiming has not changed since 1995. The average weights estimated for each fish species is representative of the weights of fish caught in ER90. Fish market values reported by Manitoba Conservation in 1999–2000 have not changed over time and can be applied to 2007 by adjusting for inflation.	Peckett, (1999); Manitoba Conservation, (2000); Wikipedia (2008)

Water Treatment	31.83	Wetland nutrient removal rate was assumed to be 80 kg/ha/yr of phosphorus and 548 kg/ha/yr of nitrogen. Wastewater treatment costs are assumed to be CDN$22.26/kg of phosphorus and CDN$3.18/kg of nitrogen. The nutrient load is assumed to be only 1 per cent of the wetland nutrient capture capacity.	Olewiler (2004)
Ecosystem Service	Value Calculated	Assumptions	Sources
Hydro power	20.17	The WHP area major rivers contribute 2.57 per cent of the volumetric flow into Lake Winnipeg. All the water originating from the WHP area major rivers flow through Manitoba Hydro's power generation stations at the outlet of Lake Winnipeg and the Nelson River. Gross revenues from hydro power production is $0.046/kWh.	Bulloch et al. (2002); Manitoba Hydro, (2005; 2007)
Carbon Sequestration	12.32–21.27	Forest carbon sequestration economic values are CDN$14.16/hectare/year. EOSD Land covers information adequately represents the forest density of the WHP area.	Anielski and Wilson (2005)
Habitat/ Refugia	9.08	Households in Manitoba are Willing to pay the same amount as households in Saskatchewan to preserve woodland caribou habitat.	(Tanguay et al. (1993)

Potential ecosystem service values, which are shown in the table below, were also calculated but omitted from the site's overall conservative ecosystem service value. The water supply from the WHP area's major rivers have a potential economic value of between CDN$0.27 and $5.55 billion per year. The potential air filtration service provided by trees and flood prevention provided by wetlands was estimated to be worth between CDN$350 and $600 million per year and CDN$380 million per year respectively. The spiritual value of the WHP area was conservatively assumed to be worth approximately CDN$160,000 per year to the residents of the Pimachiowin Aki based on compensating traditional healers for their services.

Table 22: Potential ecosystem service economic values provided by the proposed World Heritage Site (all economic values in CDN$ million/year)			
Ecosystem Service	**Resident**	**Non-Resident**	**Total**
Provisioning	-	-	270–5,550
Regulating	-	-	730–980
Cultural	0.16	-	0.16
Totals	***0.16***	-	***1,000.16–6,530.16***

The carbon stored within the forests and peatlands of the WHP area was estimated to be worth approximately CDN$2.7 to $17.5 billion. This estimate is not included as it is not annual revenue. Nevertheless, it was calculated to draw attention to the significant economic value of the WHP area's carbon stock.

The analysis also examined current public expenditures on the management and conservation of natural environments. Canadians spent approximately CDN$4.48 million in 2007 on provincial parks and forest fire management to preserve natural environments in an area the size of the Pimachiowin Aki. The ecosystem service benefits received from the Pimachiowin Aki estimated is approximately 28 times greater than the public expenditure estimated to conserve the natural environments.

The results obtained provide a conservative estimate of the WHP area's ecosystem services values based on available information. It is important to note that the ecosystem service values generated should not be viewed as being highly accurate. They are meant to initiate discussion on the valuable benefits we receive from the natural environments of the WHP area. Although ecosystem service valuation studies are subject to a variety of challenges (including the interconnectedness of ecosystems and valuation data inaccuracies due to inconsistent and evolving valuation methods), they provide useful information. They enable the comparative analyses to similar studies, and most importantly, they draw attention to the valuable services that we receive from natural environments even when they do not generate market-based economic activity.

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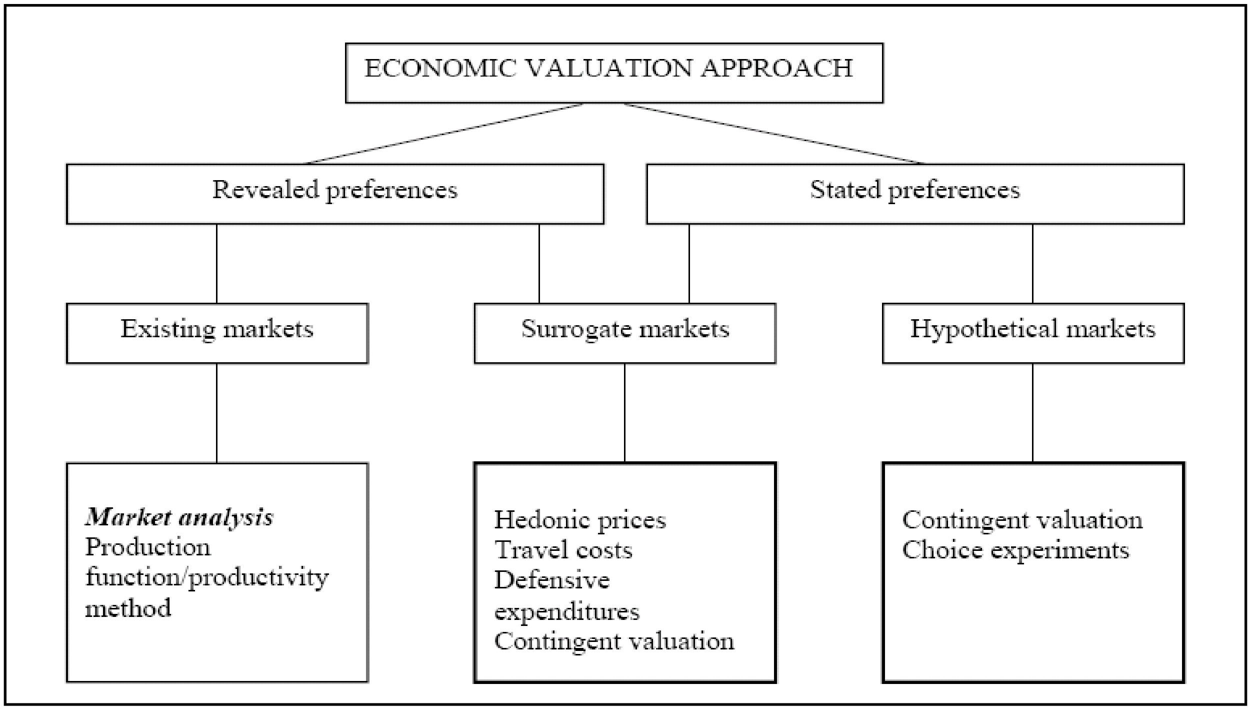

9.0 Appendix A – Valuation Methods

Figure 7: **Valuation methodologies (Source: United Nations Economic and Social Council, 2006, p. 31)**

Valuation methods can be organized into revealed and stated preferences methods. Revealed methods use data on actual behaviour and consumption patterns while stated preference methods rely on responses to queries to estimate the willingness to pay for goods and services. The values of environmental assets traded in existing markets are determined by market prices driven by supply and demand and production costs. The productivity method is used to evaluate environmental quality impacts on a good's production costs. For example, water purification costs are compared to the cost of eliminating agricultural runoff. Revealed and stated preference methods within surrogate and hypothetical markets are used to capture values of ecosystem services that are not market traded. The hedonic price method is used to determine the value of environmental assets via market traded goods. For instance houses in quiet or non-polluted environments are in more demand. The travel cost method determines the value of environmental assets via travel expenditures for recreation. Defensive expenditures are estimated by evaluating the cost of avoiding damages as a result of adverse environmental impacts such as air pollution or flooding by maintaining or restoring environmental assets.

The contingent valuation method uses willingness to pay (WTP) questions on hypothetical situations to determine the value of NC and ecosystem services. It is the most widely used method for estimating non-use values. For example, people might be asked their WTP for better air quality, biodiversity or aesthetically pleasing landscapes. The information collected using the contingent valuation method can easily be questioned as it consists of stated preferences based on hypothetical situations. Choice experiments involve ranking and scoring selected ecosystem services and their estimated values allowing the analysis of preferred environmental policy options. Comparing and ranking natural environment restoration programs leading to different outcomes is an example of a choice experiment.

10.0 Appendix B – Ecosystem Services

The Millennium Ecosystem Assessment (2003) organizes ecosystem services by grouping them into four categories: **provisioning services** include the basic necessities we consume and require for our survival and well-being; **regulating services** provide us with a habitable environment; **cultural ecosystem services** benefit people in a nonmaterial manner; **supporting ecosystem services** are necessary for the continuation of the other three types of ecosystem services.

Figure 8: Ecosystem services are the benefits people obtain from ecosystems (Millennium Ecosystem Assessment, 2003, p. 57).

Provisioning Services

Products obtained from ecosystems

- Food
- Fresh water
- Fuelwood
- Fiber
- Biochemicals
- Genetic resources

Regulating Services

Benefits obtained from regulation of ecosystem processes

- Climate regulation
- Disease regulation
- Water regulation
- Water purification
- Pollination

Cultural Services

Nonmaterial benefits obtained from ecosystems

- Spiritual and religious
- Recreation and ecotourism
- Aesthetic
- Inspirational
- Educational
- Sense of place
- Cultural heritage

Supporting Services

Services necessary for the production of all other ecosystem services

- Soil formation
- Nutrient cycling
- Primary production

11.0 Appendix C – Land Cover Typology

Land Cover	Description
No Data	
Cloud	
Snow/Ice	Glacier/snow
Rock/Rubble	Bedrock, rubble, talus, blockfield, rubbley mine spoils or lava beds
Exposed Land	River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking, or other non-vegetated surfaces
Water	Lakes, reservoirs, rivers, streams, or salt water
Shrub – Tall	At least 20 per cent ground cover which is at least one third shrub; average shrub height greater than or equal to 2 metres.
Shrub – Low	At least 20 per cent ground cover which is at least one third shrub; average shrub height less than 2 metres.
Herb	Vascular plant without woody stem (grasses, crops, forbs, gramminoids); minimum of 20 per cent ground cover or one-third of total vegetation must be herb.
Bryoids	Bryophytes (mosses, liverworts, and hornworts) and lichen (foliose or fruticose; not crustose); minimum of 20 per cent ground cover or one-third of total must be a bryophyte or lichen.
Wetland – Treed	Land with a water table near/at /above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is coniferous, broadleaf, or mixed wood.
Wetland – Shrub	Land with a water table near/at /above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is tall, low, or a mixture of tall and low shrub.
Wetland – Herb	Land with a water table near/at /above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is herb.
Coniferous – Dense	Greater than 60 per cent crown closure; coniferous trees are 75 per cent or more of total basal area.
Coniferous – Open	26-60 per cent crown closure; coniferous trees are 75 per cent or more of total basal area.
Coniferous – Sparse	10-25 per cent crown closure; coniferous trees are 75 per cent or more of total basal area.
Broadleaf – Dense	Greater than 60 per cent crown closure; broadleaf trees are 75 per cent or more of total basal area.
Broadleaf – Open	26-60 per cent crown closure; broadleaf trees are 75 per cent or more of total basal area.
Broadleaf – Sparse	10-25 per cent crown closure; broadleaf trees are 75 per cent or more of total basal area.
Mixed Wood – Dense	Greater than 60 per cent crown closure; neither coniferous nor broadleaf trees account for 75 per cent or more of total basal area.
Mixed Wood – Open	26-60 per cent crown closure; neither coniferous nor broadleaf trees account for 75 per cent or more of total basal area.
Mixed Wood – Sparse	10-25 per cent crown closure; neither coniferous nor broadleaf trees account for 75 per cent or more of total basal area.