Economic Activity and Ecosystem Services in the Battle River Basin

Submitted to
Battle River Watershed Alliance
Camrose, Alberta

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March 16, 2011

Executive Summary

In 2007, the gross domestic product (GDP) for Alberta was $256.9 billion. This represents the value of all final goods and services produced within Alberta for that year and are generally considered to be a basic measure of the province's overall economic output and well-being. However, there is increasing recognition that the well-being of a society is based on more than just economic output. Recent studies have demonstrated that society also benefits from various ecological functions or ecosystem services (air, water and land, among others) that are not normally factored into GDP estimates. Furthermore, the ability of ecosystems to provide the full range of goods and services can actually be impaired by economic activities. Thus, there is growing recognition that sustainable development requires balancing the impacts of economic activity with the environment's ability to continue to provide ecosystem services that benefit people.

As part of the process of developing a watershed management plan for the Battle River Basin (BRB), the Battle River Watershed Alliance (BRWA) has expressed interest in determining the economic importance of both economic activity and ecosystem services within the basin. The objective of this study was to provide preliminary estimates of the value of services being provided by ecosystems and the value of economic activity for each of the sub-basins in the BRB. The intent of this report is to provide some initial background information on the relative importance and values of economic activity and ecosystem services in each sub-basin. It is expected that, as the requirements for additional economic studies become apparent, this analysis will provide the foundations for future studies.

Economic Activity

In 2007 the value of economic activity (GDP) in the BRB was estimated to be $9.6 billion, or 3.7% of the Alberta total. Historically, estimates of GDP at a sub-provincial level have been difficult to estimate because the requisite economic information is not collected or analyzed at a regional or local level. However, through use of a new methodology that estimates GDP based on industrial employment profiles and average GDP per job coefficients for the various industries, it was possible to estimate GDP for individual communities or regions. GDP estimates for the various sub-basins were then estimated using the industry employment profiles for the communities and rural areas within each sub-basin at the time of the 2006 census.

The resulting estimates are provided in the following table. It shows that the bulk of economic output is located in the upper part of the BRB, with 54.0% occurring in the Bigstone sub-basin; this sub-basin also accounted for 62.8% of the population. The Paintearth and Iron sub-basins, which are located in the middle of the BRB each accounted for 11.2% of total economic output in the BRB. The other three sub-basins (Sounding, Ribstone and Blackfoot) are located at the downstream end of the BRB and collectively accounted for 23.6% of economic activity in the basin.

Value of Economic Activity and Ecosystem Services in the BRB ($ millions)

Sub-Basin	Economic Activity	Ecosystem Services	Total Value	Percent from Economic Activity
Bigstone	$5,192.2	$1,470.1	$6,662.30	77.9%
Paintearth	$1,073.7	$696.5	$1,770.20	60.7%
Iron	$1,081.5	$477.6	$1,559.10	69.4%
Sounding	$859.5	$1,490.6	$2,350.10	36.6%
Ribstone	$497.3	$483.0	$980.30	50.7%
Blackfoot	$918.5	$435.5	$1,354.00	67.8%
TOTAL	**$9,622.8**	**$5,053.5**	**$14,676.29**	**65.6%**

Ecosystem Services

The value of ecosystem services in the BRB is conservatively estimated to be $5.05 billion, or about $1,408 per hectare for the entire watershed. This estimate was based on the mix of land cover types in the basin and in each of the sub-basins combined with estimates of the value of ecosystem services produced by each land cover type. As there are no studies that have specifically examined the functioning and value of services being produced by ecosystems in the BRB, the study relied on value estimates drawn from similar studies undertaken elsewhere in Canada, particularly recent studies undertaken for the North Saskatchewan Watershed Alliance (Watrecon), the Greenbelt (Ontario) ecoregion study and two watershed valuation studies in Ontario. The study considered 10 types of ecosystem services for 14 land cover types, and found quantifiable values for 74 of the possible combinations. The resulting estimates of the total value of ecosystem services within each sub-basin are also found in the summary table.

The highest annual values of ecological services were attributed to water (rivers, streams, lakes) at $1,604 million per annum (in 2007 dollars), cropland ($844 million/yr., based on stored soil organic carbon and carbon sequestration), wetlands ($834 million/yr., based on stored carbon and carbon sequestration), and deciduous forests ($758 million/yr). The most valuable ecosystem service functions were found to be recreation benefits ($961 million/yr or 19.0% of total EGS values), water regulation by rivers, streams, and wetlands ($861 million/yr. or 17.0% of total EGS values), pollination services by insects ($783 million or 15.5% of total EGS values), and carbon sequestration by all land cover ($430 million/yr or 8.5% of total EGS).

Accordingly, the Sounding sub-basin generated the highest value of ecosystem services at $1,490 million/yr; the only sub-basin where ecosystem values exceeded economic activity values. The Bigstone sub-basin ranked second in terms of ecosystem value at $1,470 million/yr followed by Paintearth at $696 million/yr. Some of the lowest ecosystem values were found in the Iron and Blackfoot sub-basins, which have a high percentage of developed lands. Ribstone sub-basin revealed that economic and ecological values were nearly in balance.

Summary

Based on this assessment, it is concluded the overall well-being of residents of the BRB as measured in economic terms is on the order of $14.7 billion. This represents the value of economic activity ($9.6 billion) generated by residents of the BRB in combination with the value of ecosystem services generated by the landscape ($5.05 billion). Economic activity represents about 65.6% of the combined value of economic activity and ecosystem service values. In only one (Sounding sub-basin) of the 6 sub-basins the value of ecosystem services exceeded the value of economic activity by 1.73 times more.

Overall, the results of the analysis demonstrate the relative importance of ecosystem services throughout the BRB, including on cropland and pasture, which are important carbon sinks.

Table of Contents

List of Tables

List of Figures

1. Introduction

There is increasing recognition that the economic well-being of a society is based on a combination of two factors:

- the employment and incomes resulting from economic production, and
- The benefits that society obtains from various ecological functions or ecosystem services (air, water and land, among others).

Knowledge of these two types of benefits is essential for effective management of water, land, air and other resources. Without considering both, it is possible to pursue economic development that may compromise the provision of ecosystem services, such that, on balance, a society's economic well-being may actually decline. Sustainable development involves attempting to balance the impacts of economic activity with the environment's ability to continue to provide ecosystem services that benefit people, and therefore requires knowledge of each.

The Battle River Watershed Alliance (BRWA) is in the process of developing a watershed management plan for the Battle River Basin (BRB). As background to developing this plan, the BRWA has commissioned various studies to better understand how the basin functions and to assess the potential implications of various watershed management strategies. In 2009, BRWA commissioned Anielski Management Inc. (in partnership with Watrecon Consulting) to undertake an initial assessment of the current levels of economic activity and the provision of ecosystem services in each of the six sub-basins in the Battle River watershed. The objective of the study was to prepare a preliminary estimate of the value of ecosystem services and the value of economic activity for each of the sub-basins.

This study is not intended to represent a rigorous assessment of the benefits of economic activity or of ecosystem services. There is, at present, limited information on the extent and value of economic activity in each of the sub-basins, and there is even less information on the value of ecosystem services associated with the mix of land cover in each sub-basin. Consequently, this report is intended to provide some initial background information on the relative importance and values of economic activity and ecosystem services in each sub-basin. It is expected that, as the requirements for additional economic studies become apparent, this analysis will provide the foundations for future studies.

2. Economic Activity

The conventional measure of the value of economic activity is gross domestic product (GDP) which reports the value of all goods and services produced in a calendar year. The gross domestic product includes only the value of final goods and services that are sold, not goods and services used to make another product. For example, GDP estimates include the value of oil being exported but not the value of oil that is used to produce gasoline or petrochemicals. The governments of Canada and Alberta annually report GDP as measures of the overall health of their respective economies.

2.1 Methodology

The challenge in estimating the value of economic activity within the BRB or any of its sub-basins is that estimates of GDP are simply not reported at this scale. This lack of GDP information at a sub-provincial scale has always been problematic in assessing the economic effects of potential projects or for assessing the contributions of any region or community to the larger provincial economy.

To address the lack of regional GDP information, a new approach was developed by Watrecon Consulting (2010) that estimates GDP based on the employment by industry profile for individual communities or regions. This approach involves combining detailed information on employment in 18 industry categories for communities and rural areas in each sub-basin with estimates of the average GDP and labour income per job in Alberta as indicated by industry multipliers taken from Alberta's provincial Input-Output model (Alberta Finance, Statistics 2009). To confirm the validity of this approach, Watrecon Consulting used the Alberta 2006 employment profile and 2007 employment multipliers to estimate provincial GDP. The resulting estimate ($257.4 billion) was nearly identical to actual GDP for Alberta in 2007 ($256.9 billion), indicating that this approach is accurate at a provincial level.

While this approach has been used to estimate GDP for individual communities and sub-basins in the Battle River Basin, these estimates are likely to be less accurate than the provincial estimates for several reasons:

- The provincial average GDP per job estimates used in the calculations do not account for any variability in output per job in different parts of Alberta.
- People do not always work in the same part of the basin where they live.
- Employment data are rounded and these can lead to inaccuracies, especially for smaller population centres.

Despite these methodological challenges, this approach provides a mechanism by which the economic activity in each of the six sub-basins of the BRB can be quantified and valued. However, the resulting estimates of total GDP for each sub-basin must be considered order-of-magnitude estimates of economic value that can be used to demonstrate the relative economic importance of each of the sub-basins.

Figure 1: Municipal and Sub-basin Boundaries in the Battle River Basin

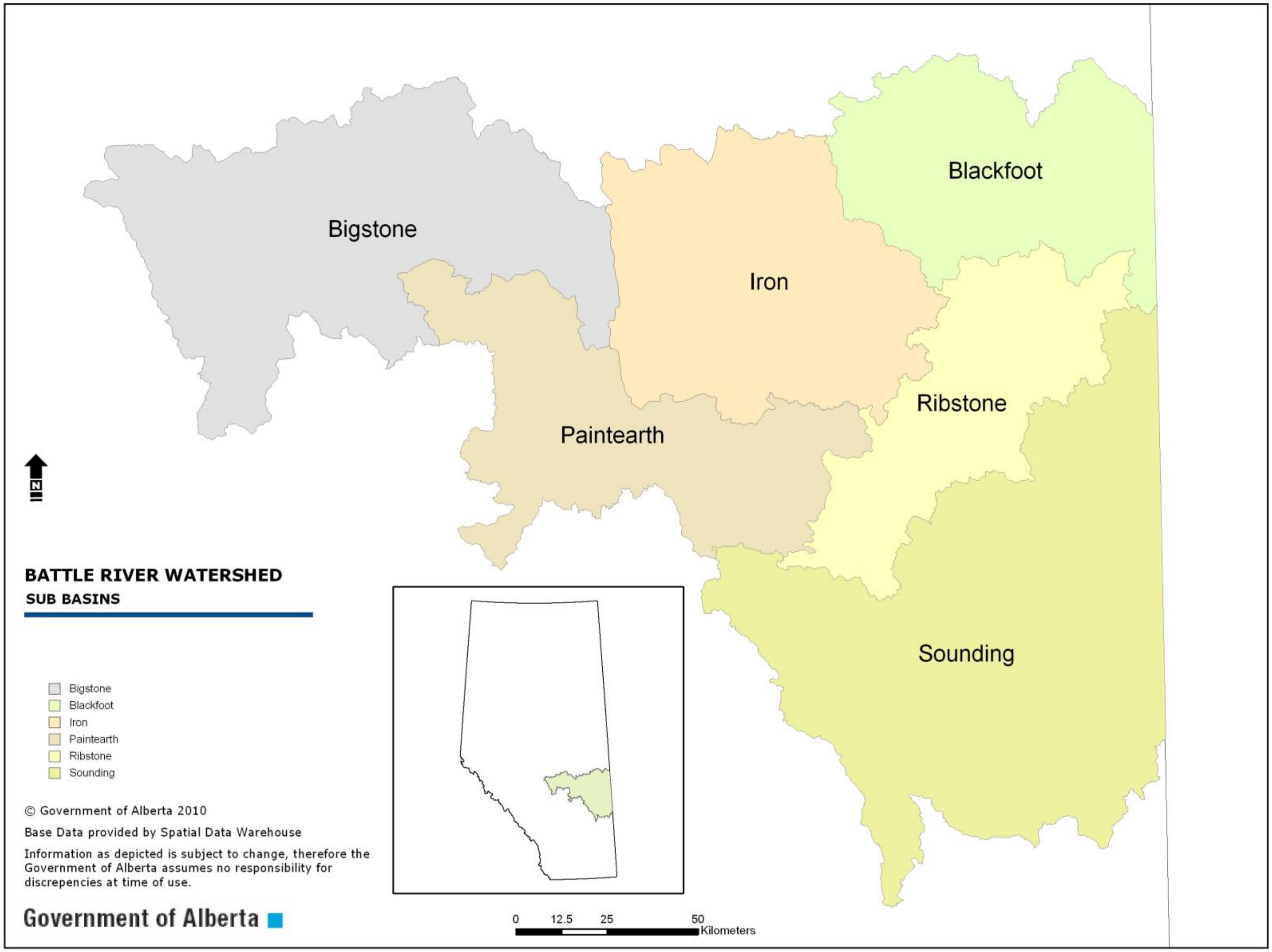


Table 1: Estimates of GDP ($Millions) by Sub-Basin and Industry of Employment

	Bigstone	Paintearth	Iron	Sounding	Ribstone	Blackfoot	Total
Agriculture, forestry, fishing and hunting	$219.4	$79.2	$89.1	$72.2	$43.1	$58.5	$561.5
Mining and oil and gas extraction	$1,937.0	$515.1	$556.7	$539.1	$296.4	$443.8	$4,288.2
Utilities	$143.4	$37.3	$75.3	$29.0	$7.3	$25.0	$317.3
Construction	$365.8	$58.0	$55.6	$31.9	$20.3	$41.6	$573.1
Manufacturing	$329.6	$43.0	$22.3	$10.6	$3.0	$12.6	$421.2
Wholesale Trade	$140.9	$28.7	$17.0	$20.7	$9.7	$21.8	$238.8
Retail Trade	$195.2	$31.0	$17.1	$7.7	$5.8	$23.9	$280.7
Transportation and warehousing	$323.9	$53.3	$45.5	$36.3	$31.9	$54.0	$544.9
Information and cultural industries	$77.0	$14.7	$13.1	$4.3	$1.5	$13.7	$124.2
Finance, insurance, real estate and rental and leasing	$417.0	$79.1	$48.1	$28.2	$20.7	$59.3	$652.4
Professional, scientific and technical services	$111.0	$19.4	$15.7	$7.9	$4.3	$17.1	$175.4
Administrative and support, waste management	$72.0	$8.1	$9.1	$6.0	$4.1	$9.6	$108.9
Educational Services	$100.0	$12.4	$9.9	$8.3	$4.2	$12.9	$147.8
Health care and social assistance	$352.7	$44.9	$47.0	$26.3	$14.9	$35.7	$521.5
Arts, entertainment and recreation	$19.0	$2.5	$1.6	$1.0	$0.9	$1.2	$26.3
Accommodation and food services	$92.5	$12.6	$15.5	$6.9	$5.0	$9.1	$141.6
Other services (except public administration)	$108.0	$17.0	$14.5	$9.1	$5.5	$12.5	$166.7
Public administration	$188.0	$17.5	$28.2	$14.0	$18.6	$66.1	$332.4
TOTAL	$5,192.2	$1,073.7	$1,081.5	$859.5	$497.3	$918.5	$9,622.8
Percent of Total	54.0%	11.2%	11.2%	8.9%	5.2%	9.5%	100.0%

2.2 Value of Economic Activity in the BRB

Based on 2006 employment estimates and the 2007 economic activity coefficients, the BRB generated about $9.6 billion in economic activity. This represents about 3.7% of Alberta's GDP in 2007. Estimates of GDP by sub-basin and industry of employment are provided in Table 2. Figure 1 shows the sub-basin boundaries and the urban and rural communities within each sub-basin.

Figure 2 shows that the bulk of economic output is located in the upper part of the BRB, with 54.0% occurring in the Bigstone sub-basin which accounts for 62.8% of the basin population. The Paintearth and Iron sub-basins are located in the central part of the BRB. They each accounted for 11.2% of GDP in the BRB but were home to 10.0% and 9.2% of the basin population, respectively. The Blackfoot, Ribstone and Sounding sub-basins are located at the downstream end of the BRB. They collectively generate 23.6% of economic activity in the basin but accounted for only 18.0% of the BRB population.

In terms of the allocation of GDP within the BRB, urban areas constituted 60.8% ($5,850.4 million), rural areas 37.5% ($3,603.7 million) and Indian reserves 1.8% ($168.7 million) of GDP. Within the BRB, urban communities accounted for 60.7% of the GDP, with the largest contributors being Camrose (9.9%), Lacombe (8.4%), Wetaskiwin (6.6%), Ponoka (5.3%), Stettler (5.2%) and Wainwright (4.9%). The rural parts of the basin contributed 37.6% of BRB GDP, and the largest generators of economic activity included Wetaskiwin County (6.0%), Camrose County (4.5%), Ponoka County (4.2%), the MD of Wainwright (4.0%), Flagstaff County (3.4%), MD of Provost (2.9%) and Vermilion River County (2.7%). Of the various industrial sectors in the BRB, the mining and oil and gas extraction industries accounted for the largest portion of basin GDP. This sector accounted for 44.6% of basin GDP, with the next largest industry, the finance, insurance, real estate and rental and leasing industry, accounting for 6.8%. Table 2 shows that other industries that made relatively large contributions to basin GDP included construction (6.0%), the agriculture, forestry, fishing and hunting industry (5.8%), transportation and warehousing (5.7%), and health care and social assistance (5.4%).

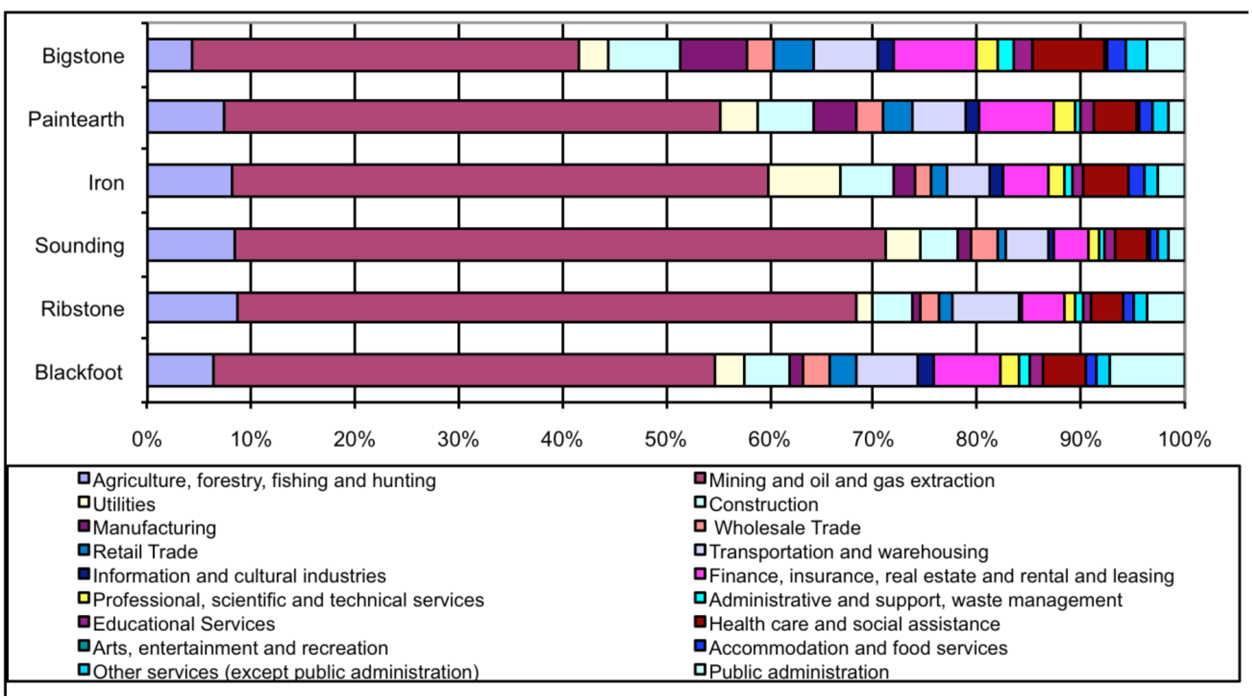
It should be noted that the estimates in Table 1 and Table 2 describe the importance of the various industries in terms of the direct employment (and related GDP) in each industry. However, economic activity in one industry can generate economic activity in other industries (indirect and induced effects), and these spin-off effects show up as direct employment in the other industries. For example, for every 100 direct jobs in construction there are 84 indirect jobs in other supporting industries. In agriculture, there are 81 indirect jobs for every 100 direct jobs. These interactions are not considered in assessing the relative importance of the various industries, as this would represent double counting in calculating total GDP in each sub-basin.

Table 2: Relative Importance of Various Industries to GDP in the Battle River Basin

Industry of Employment	Gross Domestic Product (millions)	Percent of BRB GDP
Mining and oil and gas extraction	$4,288.2	44.6%
Finance, insurance, real estate	$652.4	6.8%
Construction	$573.1	6.0%
Agriculture, forestry, fishing and hunting	$561.5	5.8%
Transportation and warehousing	$544.9	5.7%
Health care and social assistance	$521.5	5.4%
Manufacturing	$421.2	4.4%
Public administration	$332.4	3.5%
Utilities	$317.3	3.3%
Retail Trade	$280.7	2.9%
Wholesale Trade	$238.8	2.5%
Professional, administration	$175.4	1.8%
Other services (except public administration)	$166.7	1.7%
Educational Services	$147.8	1.5%
Accommodation and food services	$141.6	1.5%
Information and cultural industries	$124.2	1.3%
Administrative and support, waste management	$108.9	1.1%
Arts, entertainment and recreation	**$26.3**	**0.3%**

The relative importance of various industries in contributing GDP in each of the sub-basins is described in Figure 2. It shows that the mining and oil and gas extraction industry was the prime driver of economic activity in all sub-basins, and especially in the Sounding Creek sub-basin where it accounted for 62.8% of economic activity.

Figure 2: Importance of Various Industries in Generating GDP in the 6 Sub-basins



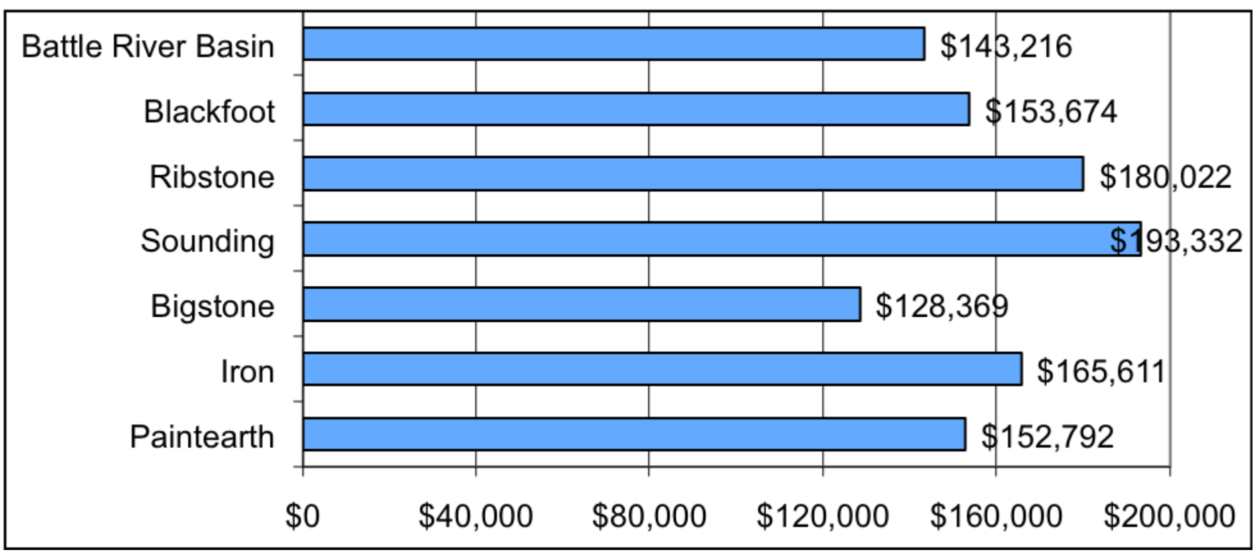
While much of the landscape in the BRB is used for agricultural purposes, the agriculture, forestry, fishing and hunting industry only accounted for 5.8% of basin GDP, although this ranged from 4.2% in the Ribstone sub-basin to 8.7% in the Ribstone sub-basin.

Of all sub-basins, the Bigstone sub-basin received the lowest percentage of its GDP from what are considered to be basic industries, which are goods producing industries such as agriculture, mining and oil and gas, utilities, construction and manufacturing. In the Bigstone sub-basin 42.5% of GDP came from non-basic or service industries and this is because much of the population in this sub-basin lives in one of the larger cities and towns in the BRB and 68.9% of workers in these communities were employed in service industries. In contrast, the Sounding Creek sub-basin obtained 79.5% of its GDP from employment in basic industries. This sub-basin consists primarily of rural residents and less than half the workforce (46.9%) was employed in service industries.

In addition to the pattern of GDP generation being different in each sub-basin, there is some variability within the BRB in terms of the average GDP per capita. This variability is shown in

Figure **3**, with the overall average for the basin being about $143,200 in GDP per worker. The highest per capita economic activity occurred in the Sounding sub-basin, where the average GDP per capita was $193,300, which is nearly 35% higher than the basin average. Average GDP in the Bigstone sub-basin was the lowest ($128,400), being 10% lower than the BRB average, and this reflects the higher percentage of residents employed in service industries which generate less GDP per job than basic or goods-producing industries.

Figure 3: Average GDP per Capita in the 6 Sub-basins



3. Ecosystem Services

Ecosystem services (which are also referred to as ecological goods and services or EG&S) are the benefits that people obtain, either directly or indirectly, from a multitude of resources and processes that are provided by natural ecosystems. Ecosystem services sustain air and water quality, provide clean drinking water, sequester carbon, produce food, decompose wastes, and support and enhance human quality of life. While ecosystem services play a vital role in supporting human well-being, their role and importance is poorly understood and seldom considered in resource management decisions. There is currently an increasing interest in assessing the value of ecosystem services in order to provide communities and resource managers with better information on the importance of natural capital assets. This study provides a preliminary assessment of the scope and value of some of the ecosystem services within the BRB.

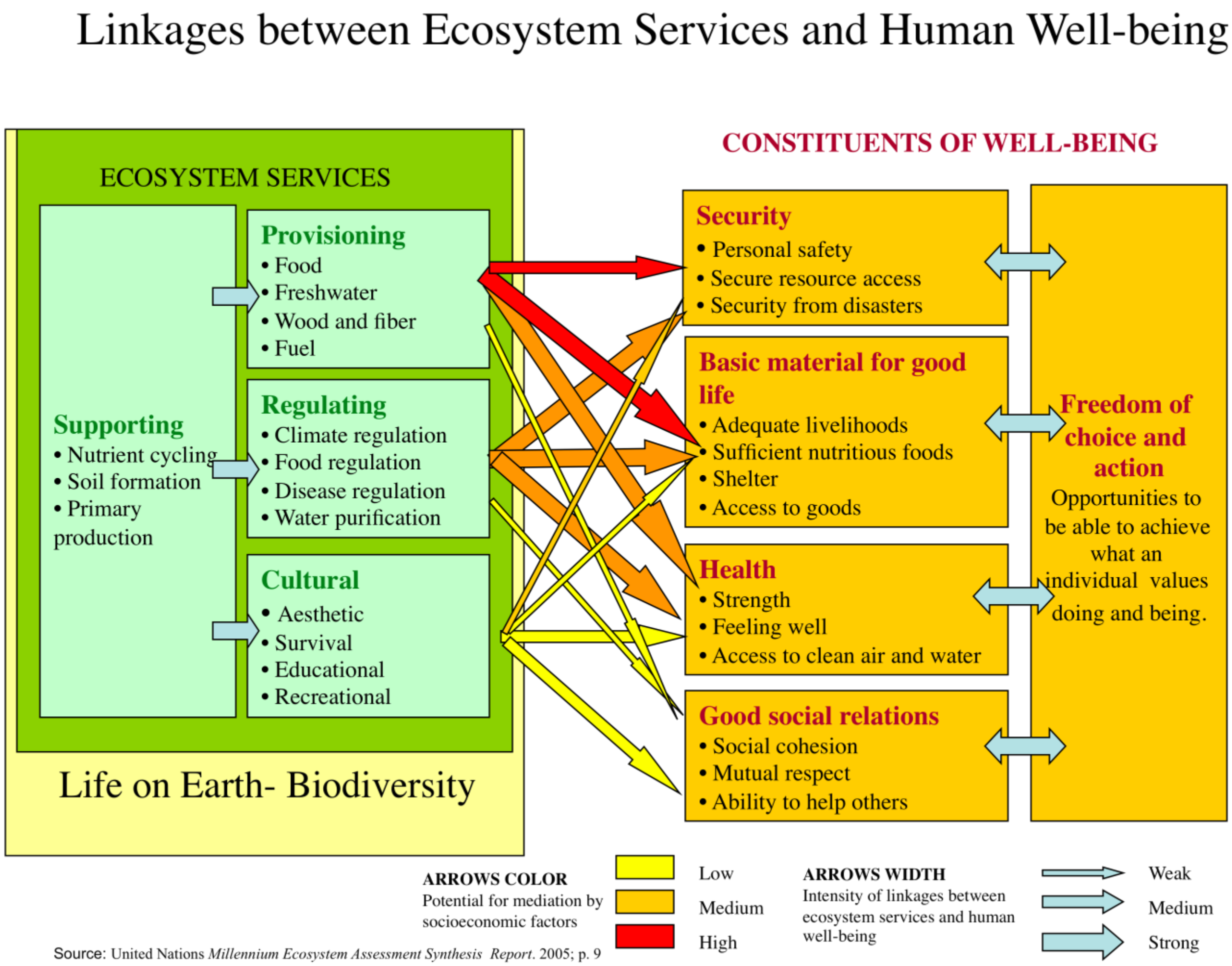
3.1 What are Ecosystem Services?

Ecosystem services can be measured in ecological (biophysical) terms and they can also be translated into economic terms through valuation studies. Ecosystem services directly support human well-being and can represent a significant part of the total economic value of the landscape and economy. Yet, the economic value of ecosystem services is currently not included in economic measures of well-being, like GDP, and are thus assumed to be of 'zero' monetary value[1]. However, as we seek to find a harmonious balance between optimizing economic benefits and maintaining ecosystem services, it is essential that we understand and measure the economic value of the ecosystem services in support of human well-being. With this information we are better able to understand the tradeoffs between conserving ecosystem integrity (thus ecosystem services) and land development.

While scientists and environmentalists have discussed ecosystem services for decades, these services were popularized and their definitions formalized in 2004 by the United Nations Millennium Ecosystem Assessment (MA), a four-year study involving more than 1,300 scientists worldwide.[2] Figure 4 demonstrates the relationship between ecosystem services and human well-being.

[1] Value comes from the Latin *valorum* which means 'to be worthy or strong.'
[2] Millennium Ecosystem Assessment (2005). The Millennium Ecosystem Assessment concluded that about 60 per cent of the world's ecosystems are being used at an unsustainable rate.

Figure 4: Ecosystem Services and Human Well-being



Source: United Nations *Millennium Ecosystem Assessment Synthesis Report*. 2005; p. 9

3.2 What Ecosystem Services are considered for the BRB?

For the purposes of assessing the ecosystem service values for the BRB, we considered a potential 18 ecosystem services which have been considered in previous studies[3]. These are summarized in Table 3.

Table 3: Types of Ecosystem Functions, Goods and Services

Ecosystem Service	Ecosystem Function	Examples of Services
1. Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO2/O2 balance, ozone layer)	UVb protection by ozone, maintenance of air quality
2. Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of a favourable climate, carbon regulation, cloud formation
3. Disturbance prevention	Influence of ecosystem structure on environmental disturbances	Storm protection, flood control, drought recovery
4. Water regulation	Role of land cover in regulating runoff and river discharge	Drainage, natural irrigation, transportation
5. Water supply	Filtering, retention and storage of fresh water	Provision of water by watersheds, reservoirs and aquifers
6. Soil retention	Role of the vegetation root matrix and soil biota in soil retention	Prevention of soil loss/damage from erosion/ siltation; storage of silt in lakes, and wetlands; maintenance of arable land
7. Soil formation	Weathering of rock, accumulation of organic matter	Maintenance of productivity on arable land; maintenance of natural productive soils
8. Nutrient cycling	Role of biota in storage and re-cycling of nutrients (e.g. nitrogen)	Maintenance of healthy soils and productive ecosystems; nitrogen fixation
9. Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutrients and compounds	Pollution control/detoxification, filtering of dust particles, abatement of noise pollution
10. Pollination	Role of biota in the movement of floral Gametes	Pollination of wild plant species and crops
11. Biological control	Population and pest populations	Control of pests and diseases, reduction of herbivory (crop damage)
12. Habitat	Role of biodiversity to provide suitable living and reproductive space	Biological and genetic diversity, nurseries, refugia, habitat for migratory species
13. Food production	Conversion of solar energy, and nutrient and water support for food	Provision of food (agriculture, range), harvest of wild species (e.g. berries, fish, mushrooms)
14. Raw materials	Conversion of solar energy, nutrient and water support for natural resources	Lumber, fuels, fodder, fertilizer, ornamental resources
15. Genetic resources	Genetic materials and evolution in wild plants and animals	Improve crop resistance to pathogens and crop pests, health care
16. Medicinal resources	Biochemical substances in and other medicinal uses of biota	Drugs and pharmaceuticals, chemical models & tools
17. Recreation	Variety in landscapes	Ecotourism, wildlife viewing, sport fishing, swimming, boating, etc.
18. Education, culture & spirituality	Variety in natural landscapes, natural features and nature	Provides opportunities for cognitive development: scenery, cultural motivation, environmental education, spiritual value, scientific knowledge, aboriginal sites

Sources: Adapted from: De Groot, R.S. 2002. "A typology for the classification, description and valuation of ecosystem functions, goods and services." Ecological Economics. 41: 393-408.

[3] Counting Canada's Natural Capital: Assessing the Real Wealth of Canada's Boreal Ecosystem (Anielski and Wilson, 2007a; 2009a); The Real Wealth of the Mackenzie Region (Anielski and Wilson,2007b; 2009b)

Because of data limitations it was not feasible in this preliminary analysis of ecosystem services to estimate the value of all potential ecosystem services with respect to landscape features in the BRB.[4]

In previous studies of the value of ecosystem goods and services, including the recent analysis of for the North Saskatchewan Watershed Alliance (2010)[5] as well as for the boreal ecosystem (Anielski and Wilson, 2009a) and the Mackenzie watershed (Anielski and Wilson, 2009b), the predominate ecosystem service values were found to be water regulation, water supply and climate regulation (i.e. carbon sequestration) that are associated with the most valuable landscapes including open water, wetlands and forests. In the recent study of socio-economic and ecological service values of the North Saskatchewan Watershed, the highest ecological service values were attributed to coniferous forests, rivers and wetlands, while the four most valuable ecosystem service functions were found to be water regulation (by rivers, streams, and wetlands), water supply (by wetlands and urban rivers), disturbance avoidance (by wetlands), and recreation benefits (from a host of land cover types). While the other 14 potential ecosystem functions listed in Table 3 were considered in the valuation, there was no information on their contributions or values in the BRB. For this reason, the true value of the total ecosystem service values in the BRB as described in this analysis tend to be conservative or under-estimate the full potential ecological service values.

3.3 Methodology

The valuation of ecosystem services is a relatively new field of economic analysis. The values derived in this study should be considered conservative estimates of the full potential value of the 18 possible ecosystem functions. It is not feasible or practical in this research study to estimate the value of all ecosystem services in the BRB through direct valuation studies because of the significant costs and time required to do so. Moreover, several other benchmark studies are incomplete in terms of ecological valuation due to data limitations or lack of primary ecological economic valuation research. This was also our experience in a similar study for the North Saskatchewan Watershed Alliance.

Because of these constraints, a 'value transfer' approach is taken whereby ecosystem service values derived from other studies in Canada with potentially similar landscape and ecological features are applied as proxy ecosystem service values for the BRB. This is the most prudent approach given that our valuation work was constrained by the lack of valuation studies applicable to the BRB. Previous ecosystem service values that were considered as suitable benchmarks for value transfer for this study include:

- *Economic Activity and Ecosystem Services in the North Saskatchewan River Basin* (2010) prepared by Watrecon Consulting (John Thompson) and Anielski Management Inc. (Mark Anielski) (April 22, 2010) for the North Saskatchewan Watershed Alliance.

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[4] Many of the ecosystem services identified in the above table have not been valued from other previous studies.
[5] (780) 428-3300

- Wilson, Sara. 2008. *Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services*. Prepared for the Green Belt Foundation. Published by the David Suzuki Foundation.
- *Estimating Ecosystem Services in Southern Ontario* (2009), by Spatial Informatics Group, Austin Troy and Ken Bagstad for Ontario Ministry of Natural Resources (2009).
- *The Real Wealth of the Mackenzie Region* by Mark Anielski and Sara Wilson (2007, revised 2009) for the Canadian Boreal Initiative. *Natural Credit: Estimating the Value of Natural Capital in the Credit River Watershed* by Mike Kennedy and Jeff Wilson, for the Pembina Institute (November 2009)
- *Counting Canada's Natural Capital: Assessing the Real Wealth of Canada's Boreal Ecosystem* by Mark Anielski and Sara Wilson (2007, revised 2009)

These studies are particularly useful and relevant because the value estimates are based on a review of previous research relevant to the respective study areas. For the purposes of this study for the BRB, the previous assessment of the North Saskatchewan Watershed (2010), the work by Sara Wilson in Ontario's Greenbelt[6] region (a 1.8 million acre (728,000 hectare) watershed) and water values from the detailed ecological goods and services valuation benchmark study for Ontario (Troy and Bagstad, 2009) were used. In the case of valuing climate regulatory services (carbon sequestration and storage) we used a custom calculation using carbon sequestration and soil organic carbon inventories for the BRB applied to world carbon market values. The primary source of ecosystem service values drew from Wilson's work in Ontario.[7] Our methodological approach differs somewhat from the approach taken in the North Saskatchewan Watershed study so the respective evaluation results are not directly comparable, at least on an ecological values-per-hectare basis.

3.3.1 Ecological Land Classification and Land Cover

The first step in ecosystem service valuations is to develop a land cover classification data set. Initially, 28 land cover classes were identified, but these were collapsed into the 14 "ecological" land cover classes shown in Table 4 as well as built-up/urban land. Within the BRB (see Table 4) are, which covers 3,589,560 hectares, the majority of land area is annual cropland (1,518,894 hectares or 42.3% of the total area) and perennial crops and pasture (31.7%). The next most important land classification is native grassland comprising 11.1% of the BRB. Roughly 4.6% is water bodies (lakes, rivers, streams and other, both rural and urban areas), 4.4% is coniferous, deciduous and mixed wood forest land, and 3.1% is shrubland.

[6] The Greenbelt, which covers over 1.8 million acres in southern Ontario, is a suitable benchmark for the BRB analysis as the Greenbelt region includes environmentally sensitive land, watersheds, and farmlands that provide essential ecosystem services for quality of life in this densely populated area of Canada.

[7] Wilson's EGS values estimates were the primary source for value coefficients for the BRB study. For details about the methods Wilson applied in deriving the Greenbelt EGS values, please consult her report which can be found at: http://www.davidsuzuki.org/publications/reports/2008/ontarios-wealth-canadas-future-appreciating-the-value-of-the-greenbelts-eco-serv/

Table 4: Battle River Basin Land Cover Area (hectares):

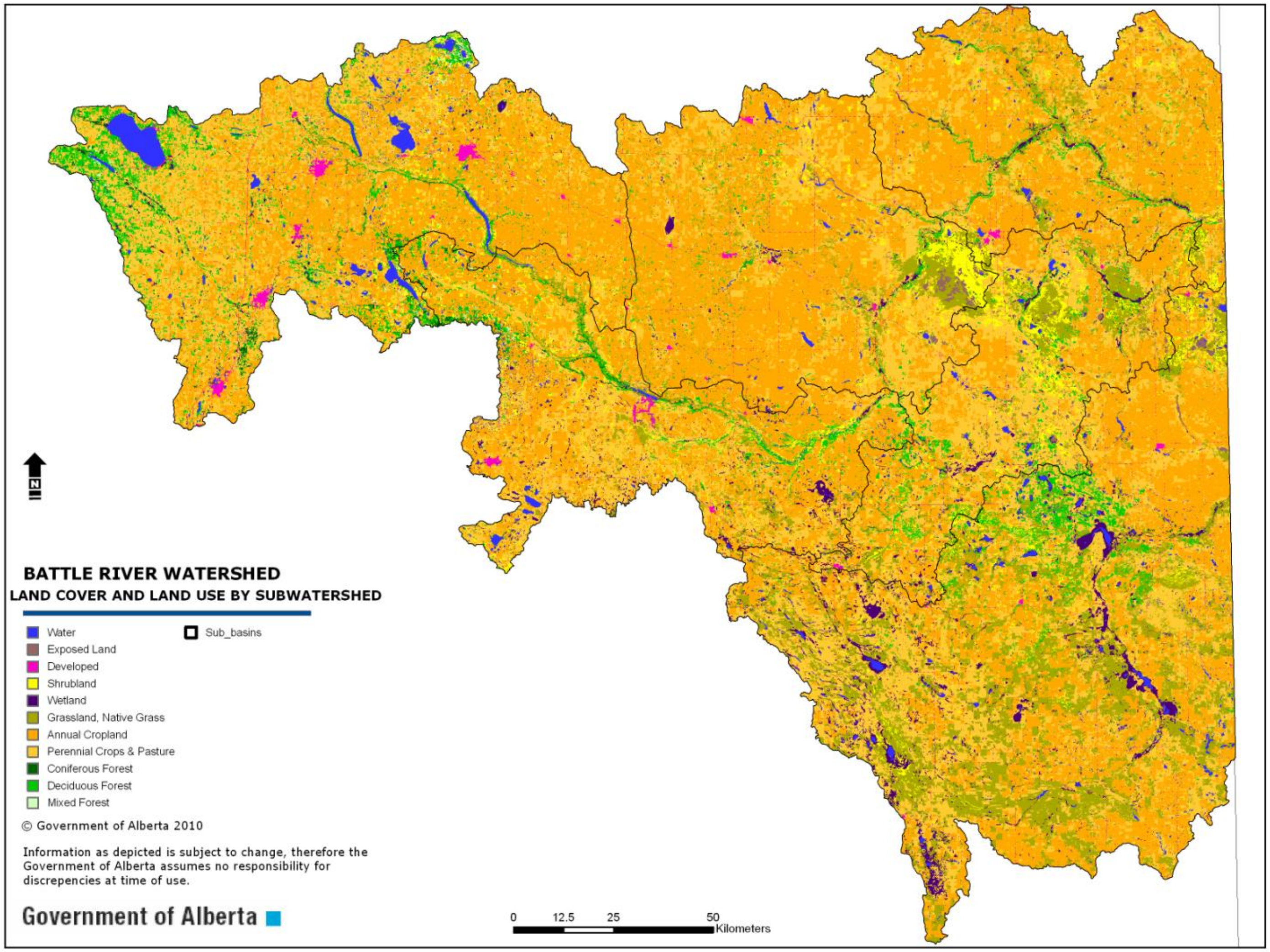
LANDCOVER TYPE	Bigstone	Iron	Paintearth	Ribstone	Blackfoot	Sounding	Total Battle River Watershed
Water							
Urban Water: Lake	29	18	6	3	-	3	**58**
Urban Water: Rivers and Streams	24	2	2	1	1	1	**31**
Urban Water: Other	1	0	0	-	0	-	**2**
Rural Water: Lake	38,132	19,799	11,744	13,786	14,790	47,594	**145,845**
Rural Water: Rivers and Streams	4,050	1,562	3,065	1,207	1,622	3,337	**14,843**
Rural Water: Other	2,421	183	600	297	77	706	**4,283**
Exposed Land	518	4,259	1,042	2,121	832	2,441	11,212
Developed	11,379	3,934	4,010	1,895	3,045	3,752	28,014
Shrubland	15,302	20,065	19,262	24,150	10,609	21,600	110,987
Wetland	4,428	2,811	11,109	6,843	4,006	29,099	58,296
Grassland, native grass	6,811	28,469	28,095	50,609	35,821	249,273	399,077
Annual crop	321,939	312,686	215,476	112,022	231,753	325,017	1,518,894
Perennial crop and pasture	250,614	151,124	150,856	144,610	119,638	322,337	1,139,179
Coniferous forest	8,672	834	4,331	399	529	376	15,141
Deciduous forest	56,321	8,227	20,842	15,832	9,536	25,904	136,661
Mixed forest	5,031	661	1,313	14	18	-	7,037
Ecological lands (sub total)	141,737	86,890	101,411	115,260	77,841	380,334	**903,474**
Built-Up/Urban lands (Subtotal	583,931	467,744	370,342	258,527	354,436	651,106	**2,686,087**
Total Area (ha)	725,669	554,634	471,753	373,788	432,277	1,031,440	3,589,560

Only 0.8 % of the BRB consisted of developed land (includes lands used by municipalities, rural residential, facilities, roads, well sites, pipelines, transmission lines, seismic lines, railways, canals, ditches, mines, feedlots, and golf resorts) compared with 8% in the North Saskatchewan Watershed. The sub-basin with the highest percentage of developed land was the Bigstone sub-basin with 1.6% or 11,379 hectares of this 725,669 hectare sub-basin.

The most dominant land use and land classification throughout the BRB is annual cropland and perennial crops and pasture. The percentage of each sub-basin classified as developed and cropland/pasture land ranged from a high of 84.4% of the Iron sub-basin to a low of 63.1% in the Sounding sub-basin. A relatively small percentage (25.2%) of the BRB remains in an undeveloped or 'ecological lands' integral condition, which includes native grassland, forests, water, wetlands, shrubland, and exposed land.[8] Ecological lands were highest, as a percentage of each sub-basin, in the Sounding sub-basin (36.9%) and lowest in the Iron sub-basin (15.6% of this sub-basin). The Sounding sub-basin had the highest relative percentage of area as water and wetland (7.9%) with the Iron sub-basin having the lowest relative percentage (4.3% of the sub-basin area).

[8] Exposed lands are defined as predominately non-vegetated and non-developed; includes: exposed lands, snow, glacier, rock, sediments, burned areas, rubble, mines, other naturally occurring non-vegetated surfaces. Mines or similar human activity may be mapped by this class, or may be mapped by the developed class; excludes fallow agriculture.

Figure 5: Land Cover in the Battle River Watershed



3.3.2 Valuation of Ecosystem Services

Using the estimated area of land cover (in hectares) we can then attach ecosystem service values (in dollars per hectare) for that land cover type to estimate the total value of ecosystem services for each land cover type. The resulting value estimates are referred to as Ecosystem Service Product (ESP) values. For the most part, we assume that any urban and built-up areas represent formerly undisturbed ecological lands that have been converted for human development purposes and thus have lost most if not all of their former ecological integrity and ecosystem services.[9] For example, in a recent 2009 study for Ontario, it was assumed that any developed (urban) land area and exposed land had no ecosystem service values.

All ESP values are expressed in 2007 Canadian dollars and are based on dollar per hectare by land cover type. It should be noted that the estimates are only relevant for the current 2007 reporting year for comparison with the 2007 economic (GDP) value estimates. While we might assume that ecosystem service values will remain relatively constant, in real dollars, over time, this may not be true due to changes in the stock of natural capital (i.e. depletion) and changes or loss in the integrity of ecosystem services. As natural capital stocks are depleted or ecosystems degraded, their economic value should increase to reflect higher scarcity and their increasing economic value to continue to support human well-being. Thus it is important to continually monitor the relative stock of various land cover types and the ecological integrity (ecosystem functions) of each cover type to adjust the marginal value of ecosystem services over time.

Table 5 shows the possible variety and range of ecosystem service values from recent ecological goods and services valuation studies that were considered for the BRB valuation work. These studies include the work on the Ontario Ministry of Natural Resources EGS benchmark study (Troy and Bagstad, 2009), the Greenbelt, Ontario study (Wilson, 2009), the Mackenzie watershed study (Anielski and S. Wilson, 2007 and 2009), and the Credit River watershed study (Kennedy and J. Wilson, 2009). The table shows the variety and range of values that were derived. The variation in values per hectare reflects differences in ecological conditions and valuation methods or assumptions. In practice, ecological values should be discrete or unique to each respective study area and thus should reveal differences across various watersheds or landscapes.

[9] In the *Real Wealth of the Mackenzie* study (Anielski and Wilson, 2009b), the ecosystem services and respective values for urban and built-up land cover were assumed to be 10% of the optimum ecosystem service value for the original grasslands, water bodies and mixed wood forests that were assumed to be the original undisturbed land features.

Table 5: Comparison of Ecosystem Service Values For Land Cover Types from Previous studies ($ 2007 per Hectare)

Land Cover Type Ecosystem Service Values	Ontario OMNR (Troy & Bagstad)	Greenbelt, Ont. (S. Wilson)	Mackenzie (Anielski &S. Wilson)	Credit River, Ont. (Kennedy & Wilson)
Agriculture/Cropland	291	530	95	687
Grassland/pasture/hayfield*	354	2,034	404	
Forest: non-urban	4,443	5,990	954	6,419
Forest: urban	25,842			9,714
Forest: suburban	14,776			
Forest: adjacent to stream	4,552			18,826
Forest: hedgerow	1,024	1,722	477	
Urban herbaceous greenspace	43,788	220	249	
Open water: river	55,553	13,229*	13,696	13,401
Open water: urban/suburban river	236,391			
Open water: inland lake	5,050			
Open water: great lake nearshore	794			
Open water: estuary/tidal bay	1,852			
Wetlands: non-urban, non-coastal	15,151	14,573	7,336	31,682
Wetlands: urban/suburban	161,419			
Wetlands: Great Lakes coastal	14,761			
Beaches (general)	89,608	2,314		
Urban			126	
Idle Land		1,761		
Orchards		522		
Expose rock/ice[10]				

Table 6 shows the actual ecological service values that were used in the BRB study. For this study, the majority of ecological values for land cover in the BRB were drawn from the Greenbelt, Ontario study by Sara Wilson in 2009. In other words, a transfer-value approach was taken assuming that Wilson's estimates of ecological service values were relevant and transferable to the BRB study area.[11] The exceptions included:

- Valuation of climate regulation services, namely the value of carbon sequestration and carbon storage. Carbon values were determined based on geospatial analysis of carbon volumes related to carbon sequestration (using NBP or net biome productivity data) and soil organic carbon (stored carbon). The physical carbon volume estimates were then

[10] Previous studies of ecological goods and services do not provide estimates of the value of ecosystem services associated with exposed rock and ice though we might speculate that there may be some water supply regulatory services associated with this land cover type. This is an area for future ecosystem service valuation research.
[11] As in similar studies, the challenge is whether and how to assign or transfer values from one study area to another study area in the absence of site or ecosystem-specific values. The test we use is whether we feel that values derived from other studies are relevant and reasonable proxies for ecological services in another study area.

assigned a market value for carbon, based on the most recent (2008) world carbon market values.

- Valuation of water regulation and water filtration services from water bodies (lakes, rivers, streams and other water bodies) were drawn from more detailed ecological service valuation work for Ontario (Troy and Bagstad, 2009).

Table 6 shows the breakdown of ecosystem service values by ecosystem functions for each of the land cover types within the BRB. The table shows that relatively many of the 18 potential ecosystem functions (from the taxonomy of values in Table 3) were not valued either because relevant ecological service values were not available or that a particular ecological service function could not be assigned to a land cover type. This suggests that the ecological value services estimated for the BRB are likely quite conservative.

To calculate the total ESP values for each land cover type, the per hectare ecological service values from Table 6, are multiplied with the area of land cover by land cover type; the only exception is the valuation of climate regulation services (carbon sequestration and storage), as previously noted. The results of the analysis are shown in the following section 3.4 of the report.

Table 6: Value of Ecosystem Services by Ecosystem Function (2007$ per hectare)

Land Cover Type	Annual & Perennial Cropland *	Pasture/grassland *	Grass/Shrub *	Forest-Coniferous *	Forest-Hardwood *	Forest-Mixedwood *	Wetland: Non-urban **	Water: Urban Lakes **	Water: Urban Rivers and Streams **	Water: Urban Other **	Water: Rural Lakes and Other **	Water: Rural Rives and Streams *
Gas regulation/Air Quality		13	13	398	398	398	95					
2a. Climate regulation (stored)	^	^	^	^	^	^	134					
2b. Climate (seq.)	^	^	^	^	^	^	134					
Disturbance regulation							240					
Water regulation		7	7	1,609	1,609	1,609	240	45,768	45,768	45,768	612	33,906
Water supply (filtration)				205	205	205	240	17,690	17,690	17,690		
Erosion control and sediment retention		53	53									
Soil formation	6	11	11	18	18	18						
Nutrient cycling												
Waste treatment		154	154	62	62	62						
Pollination (agri)		1,171	1,171	1,171	1,171.	1,171						
Seed dispersal (birds)				567	567	567						
Biological control		42	42	27	27	27						
Habitat/Refugia											10	
Food production												
Raw materials												
Genetic resources												
Recreation & Aesthetics		4	4	920	920	20		242	242	242	593	
Cultural/Spiritual	146										25	25

Note: The numbers assigned to each of the ecosystem service functions are in accordance with the ecosystem services taxonomy from Table 5.

Value sources:
* Wilson, Sara. 2008. Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services.
** Troy, Austin and Ken Bagstad. 2009. Estimating Ecosystem Services in Southern Ontario (2009). Spatial Informatics Group. Prepared for Ontario Ministry of Natural Resources.
^ Carbon values have been calculated based on for the NBP (carbon sequestration) and SOC (stored soil carbon) volume estimates over the entire land cover and therefore cannot be attributed to discrete land cover types.

3.4 Ecosystem Service Valuation Results

The total value of ecosystem services in each of the sub-basins within the BRB were then estimated using the values for individual land cover types selected from Table 5 and applied to the total area of land cover types. The resulting estimates, termed Ecosystem Service Product values are provided in Table 9 and indicate that ecosystem services within the BRB were conservatively estimated at roughly $5.05 billion in 2007 or roughly $1,408 per hectare per year for the total BRB watershed. Within the BRB, the highest total ESP values were for the Sounding sub-basin at $1,491 million/yr and the Bigstone sub-basin at $1,470 million /yr and the lowest values were for the Blackfoot sub-basin at $435 million/yr.

The highest annual values of ecological services were attributed to water (rivers, streams, lakes) at $1,604 million per annum (in 2007 dollars), cropland ($844 million/yr, based on stored soil organic carbon and carbon sequestration), wetlands ($834 million/yr, based on stored carbon and carbon sequestration), and deciduous forests ($758 million/yr.

The most valuable ecosystem service functions were found to be recreation benefits ($961 million/yr. or 19.0% of total EGS values), water regulation by rivers, streams, and wetlands ($861 million/yr or 17.0% of total EGS values), pollination services by insects ($783 million or 15.5% of total EGS values), and carbon sequestration by all land cover ($430 million/yr or 8.5% of total EGS).

Climate regulation service values are typically the most important services in EGS valuation studies with carbon sequestration and storage provided by forests, wetlands, grasslands, and croplands. In this study of the BRB carbon values played a lesser role with recreation values, water regulation services and pollination services playing a more predominant role in terms of EGS value.

For estimating the value of carbon sequestration by forests, wetlands, grasslands and croplands we relied on analysis of the net biome productivity (NBP). **Net biome productivity** (NBP) is an estimate of the annual net absorption (or release) of carbon by forests and wetlands that were originally developed by Prof. Jing Chen, a geographer, and his research associate Gang Mo at the University of Toronto in the development of carbon cycle account of Canada's forests.[12] The NBP data shows net flux of carbon between 1960 and 2003 for all of Canada. Raw data was then

[12] Prof. Jing M. Chen, a professor at the University of Toronto's Department of Geography, conducts into climate change and biogeochemical cycle modeling. His analysis of Canada's NBP (net biome productivity) estimates for all of Canada's landscapes is unique in Canada and has yet to be discovered. Global Forest Watch Canada was the first organization to access and use Dr. Chen's data as a basis of producing a carbon budget for Canada. Dr. Chen's analysis, which spans the period 1901-2003, is based on estimates of annual Net Primary Productivity (NPP) and then makes adjustments to account for the impacts of land cover changes (e.g. land use impacts, impacts of fire, etc.) on the net carbon balance of ecosystems. NBP is a considered an appropriate for accounting for the net carbon balance of large areas and longer periods of time. The BRB analysis used a custom file of Dr. Chen's original raw NBP data, at the 1 square kilometer resolution, and was analyzed by Global Forest Watch Canada and organized by sub-basin for the BRB.

geospatially mapped at the sub-basin scale for all of Canada by Global Forest Watch Canada.[13] The BRB sub-basin data was clipped from the national NBP data base. NBP data are a useful indicator for valuing carbon and thus climate regulation services, which are generally one of the most significant ecosystem services. To value the annual carbon sequestration estimates for the BRB, we used the 2008 world carbon market average price (converted from US dollars into Canadian dollars applied to 2007).[14]

Table 7 shows that depending on the period of reporting, a sub-basin may be a net carbon sink or become a net source of carbon depending on land use impacts, climatic conditions, the affects of fire or other ecological factors. According to these statistics, the carbon sequestration capacity (based on net biome productivity data) of the BRB watershed has been in decline since 1990 falling from 24,699 tonnes of CO_2 per year for the period 1990-1994 to 15,531 CO_2 per year for the period from 2000-2003 (see Table 7) [15] Previous studies using NBP data show similar trends or fluctuations in in carbon from year to year; from condition of a net carbon storage to a global climate liability (as a net carbon releaser).

Table 7: Net Biome Productivity for the Battle River Basin Watershed by Sub-Basin

	Average tonnes of CO_2 per year		
Sub-Basin	**2000-2003**	**1995-1999**	**1990-1994**
Bigstone (05FA)	14,908	22,618	26,402
Iron (05FB)	455	686	888
Paintearth (05FC)	195	448	532
Ribstone (05FD)	(37)	(334)	(2,958)
Blackfoot (05FE)	n.a.	n.a.	n.a.
Sounding (05GA)	11	(29)	(165)
BRB Total	**15,531**	**23,389**	**24,699**
Note: Negative numbers indicate net releases of carbon while positive numbers indicate the volume of carbon being stored. Blackfoot sub-basin has no NBP data available.			

[13] The results of the analysis of both NBP and soil organic carbon by Global Forest Watch Canada has not been formally released. The analysis served as the basis of the forthcoming (2010) report on the Canadian Index of Well-being that focused on Ecosystem Health originally prepared by Mark Anielski in 2009.

[14] The world carbon market price of carbon is based on the following source:
http://www.environmentalleader.com/2009/01/14/carbon-market-up-83-in-2008-value-hits-125-billion/
http://en.wikipedia.org/wiki/Carbon_finance
In 2008 the price averaged US$26/t C02 or roughly C$27.72/t CO2. We believe this value for carbon to be conservative and reasonable. For example, the Stern report and analysis for the UK estimated a social cost of carbon of roughly US$85/t CO2 while analysis by McKinsey & Co. estimated abatement costs associated with carbon emissions at roughly US$81/tC02. As carbon values, market or social cost of carbon estimates, will vary year-over-year due to changes in market conditions and climate-related environmental impacts and costs, the estimated value of climate regulatory services in the BRB would have to be adjusted accordingly.

[15] The decline in NBP over the study time period may be due to changes in landcover (e.g. tree cover), land use impacts (including natural disturbance such as fire), and other climactic conditions. These fluxes can only be explained by data and analysis completed by Prof. Jing Chen of the University of Toronto and his NBP data set and models.

In addition to measuring the value of annual sequestration of carbon by forests, wetlands, grasslands and croplands, **Soil Organic Carbon** (SOC) – the carbon that is held or stored in the soils of the region -- was measured and evaluated as a basis for measuring the value of stored carbon within the BRB (see Table 8). The original analysis of SOC also came from Global Forest Watch Canada for all of Canada's watersheds at the sub-basin scale. The change in SOC is a useful indicator of general soil health and also serves to estimate how much carbon dioxide is removed from the atmosphere and sequestered in all soils, including agricultural soils. SOC is one of the key indicators used by Agriculture and Agri-Food Canada (AAFC) and is a key component of good soil health and fertility. AAFC has developed an SOC indicator to assess how organic carbon levels are changing over time in Canadian agricultural soils.[16] Stored carbon may be valued based on current market prices of carbon (e.g. in 2008 the average global carbon market value was US$26.00 per tonne of $C0_2$) and valued as an annuity[17]. This method was used to value the stored carbon contained within the Mackenzie region watershed by Anielski and Wilson (2007a, 2009a).

Table 8: Soil Organic Carbon the Battle River Basin Watershed by Sub-Basin, 2006

Sub-Basin	Carbon Mass (million tonnes of C02)
Bigstone (05FA)	38.35
Iron (05FB)	18.36
Paintearth (05FC)	16.27
Ribstone (05FD)	7.81
Blackfoot (05FE)	17.63
Sounding (05GA)	22.95
BRB Total	**121.40**

Assigning market value to carbon stored in soils can be debated. Some would argue that the stored carbon represents a liability to climate change if it were released through poor soil management or other natural disturbances and should not be treated as an asset. Alternatively, the stored carbon might be viewed as an asset, using world carbon market prices as a proxy for its value and applied to an annuity calculation, so long as it remains stored in the ground. We recognize that climate regulation service values will fluctuate depending on whether a unit of land cover is a net absorber or net releaser of carbon and, as a result, climate regulation values may change from a positive benefit in one year to a climate liability the next depending on climatic and other factors. Thus assigning a consistent value for climate regulation is problematic and will most certainly require regular new inventories and revaluation.

[16] The soil organic carbon data used for this indicator comes from the soil organic carbon digital database for Canada for all land cover types developed by C. Tarnocai and B. Lacelle. 1996. Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Canada**.**

[17] An annuity is one of a series of annual payments that would ultimately accumulate to the total value of $86 billion or 3.34 billion tonnes of CO_2 at $26 per tonne.

Notwithstanding these and other valuation challenges, we believe our estimates of the average ESP value of $1,408/ha/yr for entire BRB watershed are relatively conservative given that only half of a potential 18 ecosystem functions have been valued. Moreover, compared with other previous studies our estimated average annual ESP values are lower[18] compared with:

- $3,652/ha/yr from the North Saskatchewan River Basin study (2010).
- $3,758/ha/yr from the Anielski and Wilson study of the Mackenzie watershed (2009)
- $3,775/ha/yr from Wilson's study for Ontario's Greenbelt watershed (2008)
- $3,911/ha/yr from the Kennedy and Wilson's study of the Credit River Watershed in Ontario (2009).

The results of our valuation estimates should be considered as preliminary estimates that will require continuous improvement through improved biophysical inventories and more primary ecological valuation research into values that are relevant to the BRB and to Alberta watersheds, in general. One of the greatest shortcomings in these studies is the lack of a complete biophysical inventory of ecological assets or natural capital and the lack of data on the current state of ecological health or integrity for various land cover types in the watershed.

[18] There are several reasons why the EGS values for the BRB are lower, primarily due to less area of forests, wetlands and water that tend to have higher EGS values than cropland and grasslands which predominate the BRB.

Table 9: Total Value of Ecosystem Services by Land Cover Type and Sub-basin, BRB

Total Estimated EGS Values ($2007 millions per annum)	Bigstone	Iron	Paintearth	Ribstone	Blackfoot	Sounding	Total Battle River Watershed
Gas regulation/Air Quality	$28.18	$4.49	$11.16	$7.43	$4.61	$13.93	**$69.79**
2a. Climate regulation (stored)	$85.31	$40.85	$36.20	$17.38	$39.21	$51.04	**$269.99**
2b. Climate (seq.)	$413.18	$12.61	$5.39	$(1.02)	n.a.[2].	$0.31	**$430.47**
Disturbance regulation	$18.89	$11.99	$47.39	$29.19	$17.09	$124.13	**$248.68**
Water regulation	$279.22	$82.53	$155.82	$76.59	$80.89	$186.57	**$861.60**
Water supply (filtration)	$68.71	$23.17	$47.57	$20.45	$23.93	$54.70	**$238.54**
Erosion control and sediment retention	$1.17	$2.57	$2.50	$3.95	$2.46	$14.33	**$26.98**
Soil formation	$5.17	$3.65	$3.32	$2.72	$2.92	$7.46	**$25.25**
Nutrient cycling							
Waste treatment	$21.83	$17.03	$44.33	$34.32	$20.54	$136.06	**$274.10**
Pollination (agri)	$107.90	$68.22	$86.48	$106.57	$66.18	$347.99	**$783.35**
Seed dispersal (birds)	$39.70	$5.51	$15.02	$9.21	$5.72	$14.90	**$90.05**
Biological control	$2.85	$2.30	$2.72	$3.59	$2.23	$12.10	**$25.78**
Habitat/Refugia	$27.27	$17.31	$68.42	$42.14	$24.68	$179.37	**$359.19**
Food production							
Raw materials							
Genetic resources							
Recreation & Aesthetics	$287.25	$117.74	$116.79	$93.01	$93.83	$253.33	**$961.96**
Cultural/Spiritual	$83.53	$67.66	$53.44	$37.44	$51.26	$94.44	**$387.77**
Total	$1,470.14	$477.65	$696.55	$482.97	$435.54	$1,490.64	$5,053.49

Notes: 1. Water-river ecosystem service values and wetlands ecosystem service values are a combination of values attributed to the urban-suburban portion of river and wetland areas (including a buffer zone) and non-urban river areas. For example, of the estimated 56,496 hectares of area designated as rivers, there are an estimated 17,495 hectares (31.0%) of river area within urban and sub-urban zones. According to the Ontario OMNR 2009 study, the average ecosystem service value of an urban-suburban river is estimated at an average of $236,391/ha compared with a lower value for non-urban river ecosystem services of $13,740/ha we used to value the non-urban river areas (based on Sara Wilson's study of the Greenbelt ecosystem in Ontario). There are only an estimated 11 hectares of urban-suburban wetlands of a total 185,792 hectares of wetlands in the total BRB area. Only urban/suburban rivers and wetlands are assigned a differential value, not other bodies of water 2. There is no NBP (net biome productivity) data available for the Blackfoot sub-basin, hence no ecosystem service values for climate regulation (carbon sequestration) for this sub-basin.* Previous studies of ecological goods and services do not provide estimates of the value of ecosystem services associated with exposed rock and ice though we might speculate that there may be some water supply regulatory services associated with this land cover type. Rock and ice is the predominant land cover in the Cline sub-basin (54.5% of the total sub-basin) and Brazeau (18.4% of the sub-basin).

3.5 Opportunities to Enhance the Estimates of Ecosystem Services

There are many challenges in assessing the relevant ecological values of ecosystem goods and services. The foregoing analysis provides an initial assessment of the value of ecosystem services in the BRB based on readily available information drawn from various other studies that have been completed to date. These estimates should be considered preliminary because the estimates may not adequately reflect potential unique landscape characteristics of the BRB or full knowledge of the range of ecological goods and services being generated by these landscapes.

Various other data sources could be used to improve the quality of the estimates. Possible data sources that could be considered in future studies of the value of ecosystem services in the BRB include the following:

- **Duck Breeding Pairs.** This data, which comes from Ducks Unlimited, provides a potential proxy for the ecological health or integrity of duck habitat, including wetlands and open water bodies. Duck breeding pair data is calculated as a range of the number of duck breeding pairs (from less than 10 to 70-80) per hectare of spatial area. While not formally used in our analysis, this could, in future, serve as a proxy for the relative health and thus the relative range in ecosystem service values of wetlands and water bodies within the watershed based on their ecological condition.

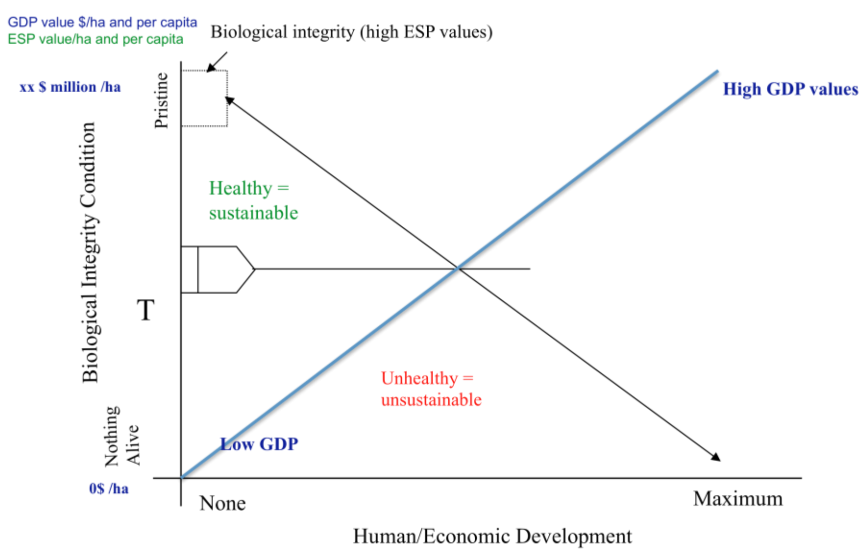
- **Index of Biological Integrity** (IBI) is a scientific tool developed by aquatic biologists used to assess and measure the health of aquatic ecosystems. An IBI associates anthropogenic influences on a water body with biological activity in the water body, and is formulated using data developed from biological surveys of indicator fish populations. An IBI for each of the sub-basins within the BRB would serve as a useful proxy for the integrity of aquatic ecosystems and thus the marginal ecosystem service values associated with water regulation and water supply services as they are impacted by human activity. Unfortunately, IBI statistics of the BRB were not available. However, a benchmark study for the Battle River watershed[19] shows the potential utility of deriving IBI estimates for the BRB that could then be used for developing a range of water regulation and water supply service values based on the relative integrity. The multi-metric IBI has been shown to be highly sensitive to change in cumulative anthropogenic disturbances (particularly road densities). The IBI may provide the single most defensible, easily understood measure of the health of watercourses.
- **Toxic Release Inventory.** Another data layer considered was an indicator of the concentrations of 49 toxic substances released into the environment (air, land, water) that were self-reported by industries as part of the National Pollution Release Inventory for Canada. Using Global Forest Watch Canada geo spatial data we created a toxicity layer

[19] Stevens and Council (2008).

for the BRB that serves as a proxy for the pressures on ecosystem health from pollution. Area-weighted toxicity is calculated at the sub-basin level for the top 17 toxic substances defined in the *Canadian Environmental Protection Act* (CEPA). With an area-weighted measure we have a pollutant toxicity loading indicator that tells us something about the relative toxicity of each of Canada's sub-basin watersheds. This ratio can be compared over time to determine long term trends in toxicity across Canada. This may be useful in future ecosystem valuation studies to estimate the ecosystem service value losses due to pollution pressures. It was not formally used for this study.

These additional data layers provide useful indicators for future assessment of the relative changes in ecosystem health and thus ecosystem service values related to changes in human or economic activity within the BRB. They will serve to derive what economists call 'marginal benefits (or costs)' to ecosystem services associated with activity. The good news is that new proxies for measuring the marginal impacts on ecological integrity are emerging (e.g. duck breeding pairs and the IBI) and should help in analyzing the relative change in ecological service values vis-à-vis changes in the economic development of natural capital opportunities, as Figure 6 suggests. Understanding the marginal impacts to either ecological services and to economic benefits from conventional resource development represents the challenge for future prudent valuation tradeoff analysis.

Figure 6: Relationship between Ecological Integrity Values and Economic Values



Source: Anielski, Mark (2010) and Karr, J. 2000. Health, Integrity, and Biological Assessment: The Importance of Measuring Whole Things. Pp. 209-226 in D. Pimentel, L. Westra and R. Noss, eds., *Ecological Integrity: Integrating Environment, Conservation and Health*. Island Press, Washington, DC.

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Summary and Conclusions

4.1 Summary of Results

The results of this assessment suggest that the overall well-being of residents of the BRB is on the order of $14.7 billion per annum (based on 2007 statistics and estimates). This represents the value of economic activity ($9.6 billion) generated by residents of the BRB in combination with the value of ecosystem services generated by the landscape ($5.05 billion). The assessment suggests that, if the measure of GDP were adjusted to include the value of ecosystem services, the total measure of well being in the BRB would increase by 52%.

The values of economic activity and ecosystem services are summarized by sub-basin in Table 10. In only one (Sounding sub-basin) of the 6 sub-basins the value of ecosystem services exceeded the value of economic activity by 1.73 times more.

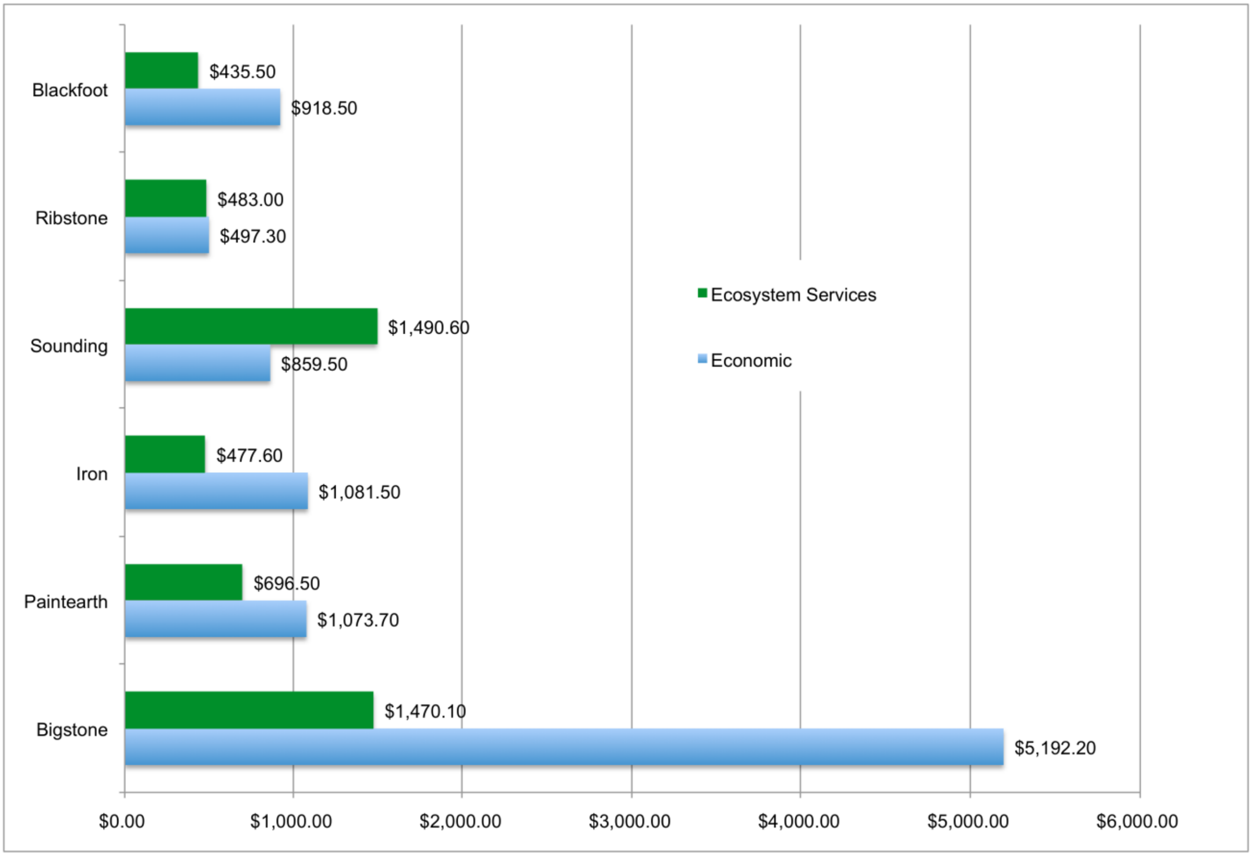
Table 10: Value of Economic Activity and Ecosystem Services in the BRB ($ millions)

Sub-Basin	Economic Activity	Ecosystem Services	Total	Percent from Economic Activity
Bigstone	$5,192.2	$1,470.1	$6,662.30	77.9%
Paintearth	$1,073.7	$696.5	$1,770.20	60.7%
Iron	$1,081.5	$477.6	$1,559.10	69.4%
Sounding	$859.5	$1,490.6	$2,350.10	36.6%
Ribstone	$497.3	$483.0	$980.30	50.7%
Blackfoot	$918.5	$435.5	$1,354.00	67.8%
TOTAL	**$9,622.8**	**$5,053.5**	**$14,676.29**	**65.6%**

Overall, the results of the analysis demonstrate the relative importance of ecosystem services throughout the BRB, including on cropland and pasture, which are important carbon sinks.

Figure 7 shows the magnitude of the value of economic activity and ecosystem services by sub-basin. Overall, the assessment demonstrates the relative importance of ecosystem services in the upper northwest (Bigstone sub-basin), with larger lake areas and water regulation services, and lower southeast (Sounding sub-basin), with large lake area and more native grassland. At the same time Bigstone sub-basin had the highest economic activity in the BRB.

Figure 7: Value of Economic Activity and Ecosystem Services by Sub-Basin, BRB ($ billions)



4.2 Caveats and Conclusions

This is the first estimate of ecosystem service values for the BRB. We believe these are conservative estimates accounting for only a partial number of the 18 potential ecosystem functions evaluated. Further primary valuation research will be required that is relevant to this geographic area of Alberta.

There are several areas of potential improvement including a more accurate accounting of the carbon stocks and flows within the watershed and the relevant economic values attributed to these changes. Second, there is an opportunity to evaluate changes in the biological integrity of aquatic systems (e.g. using the IBI as a proxy indicator) and the relative economic value of these changes as they affect human well-being and costs of adequate and clean water supplies. Third, there is an opportunity to begin to understand the marginal benefits (or costs) of maintaining levels of ecosystem integrity and functions as they translate into economic well-being, as measured by the GDP. These are areas for future improvement in state of watershed measurement and reporting.

There are inherent shortcomings to valuing nature's services. This study, like the other benchmark studies referenced, reveal that ecosystem services valuation remains a young science which will require considerably more primary valuation research and development to ensure the relevance of these values particularly to human well-being. The challenge in ecosystem service valuation is determining how these functions benefit human well-being, which are generally measured in monetary terms, as well as ecological well-being, which may or may not be measured in monetary terms.

Notwithstanding these challenges, the ecosystem services valued at $5.05 billion in 2008 are significant, almost 50% of the relative estimated $9.6 billion in GDP generated in 2007 in the watershed. Ecosystem services represent a significant contribution to both human and ecological well-being. The results demonstrate the need to balance economic benefits for human well-being while maintaining healthy and flourishing ecosystems with integral ecosystem functions that benefit human well-being (in both monetary and non-monetary or quality of life terms) as well as being critical for ecological health. In reality, ecological health can never be adequately valued in money terms. Ecological integrity and resiliency of ecosystems may never find an appropriate price or monetary value but may require measures of resilience and health outside of economic valuation.

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