The Value of BC's Grasslands:
Exploring Ecosystem Values and Incentives for Conservation

Photo by Chris Harris

Final Report

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1 Introduction

1.1 Why is Natural Capital Important?

Natural capital refers to the earth's land, water, and atmosphere that provide resources and a flow of ecosystem services. Ecosystems such as forests, wetlands, grasslands and rivers provide ecosystem services for local communities as well as regional and global processes. The benefits include the storage of flood waters, water capture and filtration by watersheds, air pollution absorption by plants, and climate regulation resulting from carbon storage in trees, plants and soils. However, as we do not pay directly for these services, they are undervalued in our market economy. They are worth billions of dollars per year, but need to be valued more accurately because their loss has massive economic impacts, threatening health, food production, climate stability, and basic needs such as clean water.

Natural capital is critical to the economic and social well-being of Canadians. While Canadians recognize the importance and value of the environment for their well-being, the conditions and values of Canada's natural capital assets are not accounted for in measures of economic progress like the Gross Domestic Product (GDP) or in Canada's national accounts. Although Statistics Canada has established satellite accounts for marketable products such as timber and potash, Canada's most important assets (natural capital) are generally unmeasured and their full value remains unaccounted for.

Human life itself depends on the continuing ability of the natural environment to function and provide its many benefits. Yet, development generally focuses on what we can take from the environment.[1] One of the main reasons for losses in natural capital is the exclusion of natural capital in our current measures of value and decision-making. Values not reflected in market prices are considered externalities.[2] For example, the value of a forest or grassland in controlling stream-bank erosion and sediment load in a river is not reflected in the market price of land. Nor is the value of a swamp in recharging an aquifer reflected in the price of water. Therefore, the conversion of land for agriculture or urban development does not take into account losses in natural capital.

Similarly, the costs of our impact on the environment, such as losses in or damages to ecosystem services from pollution are not taken into account. As a result, the way in which we measure and count our environmental, social and economic well-being is misleading our economic and social decisions.

[1] White, R.P., Murray, S., and Rohweder, M. 2000. *Pilot Analysis of Global Ecosystems: Grassland Ecosystems*. World Resources Institute. Washington, D.C. (www.wri.org/wr2000)
[2] An externality is a value that is not reflected in that commodity's market price.

The projected impacts of climate change will place additional pressure on our ecosystems in terms of their ability to function and supply regular services such as water supply, flood control and pollination. Communities with low coping ability (i.e. low ecological resilience) will find themselves struggling with diminished green "infrastructure", making them most vulnerable to adverse and costly outcomes.

Given the fundamental importance of biodiversity to human societies, many economists now believe that the loss/degradation of natural areas has an opportunity cost in terms of the provision of such critical ecosystem services.[3] For example, declines in the populations of bees, butterflies and other pollinators as a result of habitat destruction, pesticide use and invasive pests have been estimated to cost farmers millions of dollars each year in reduced crop yields.[4]

1.2 Examples of Natural Capital Assessments

Communities and governments are beginning to recognize the essential services that natural areas provide. The recognition and valuation of ecosystem services are emerging trends at the global, national and regional level. For example, in 2005, the United Nations Millennium Ecosystem Assessment (MA) reported on the condition of the world's ecosystems and their ability to provide services today and in the future.[5] The MA found that over the past 50 years humans have changed the Earth's ecosystems more rapidly and extensively than in any other period in human history. The assessment concluded that approximately 60 per cent (15 out of 24) of the world's ecosystem services are being degraded or used unsustainably, including fresh water, air and water purification, and the regulation of regional and local climate. The full costs of these losses are difficult to measure, but the MA concludes that they are substantial.[6]

> "Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth." [*Millennium Ecosystem Assessment,* 2005]

[3] Perrings et al. 2006. "Biodiversity in agricultural landscapes: saving natural capital without losing interest." *Conservation Biology*. 20:263-264.
[4] Tang, J., Wice, J., Thomas, V.G., and Kevan, P.G. 2007. "Assessment of Canadian federal and provincial legislation's capacity to conserve native and managed pollinators." *International Journal of Biodiversity Science and Management*. 3:46-55.
[5] http://www.millenniumassessment.org/en/Condition.aspx
[6] Millennium Ecosystem Assessment. 2005. "Ecosystems and Human Well-being: Synthesis." Island Press. Washington, DC.

In 1997, a global study estimated the total value of the world's ecosystems goods and services to be worth between $18 and $61 trillion US (2000);[7] an amount similar to the size of the global economy. A follow up study focused on the incremental value of conserving natural capital. The study examined the economic trade-off of conserving a natural area, rather than converting the area for farming or development, in order to protect its ability to supply ecosystem services. This same study concluded that the net value of a hypothetical global reserve network would provide services worth approximately $4,400 billion per year.[8] The study also estimated the average rate of habitat loss globally to be -1.2 per cent per year since 1992, or -11.4 per cent over 10 years, a loss of about $250 billion each year.

More recently, the World Bank published an assessment of the natural capital asset values of world nations.[9] Canada ranked third in terms of the country's per capita market value including timber, oil, gas, cropland, pasture land, non-timber forest products, and protected areas. This result reflects Canada's real advantage in terms of its expansive natural capital. However, this assessment did not include the non-market values of the services provided by Canada's natural capital, nor did it provide an assessment of the costs to natural capital from extraction, production and transportation of these products.

Two Canadian studies have considered the economic value of natural capital for Canada's boreal region. The most recent report assessed the non-market value of the Mackenzie Region's natural capital at an estimated $570 billion per year (an average of $3,426 per hectare), 13.5 times the market value of the region's natural resources.[10] The carbon stored by the Mackenzie watershed was estimated at a value of $339 billion ($820/ha/year), 56 per cent of the total non-market value. An earlier study that assessed the value of Canada's boreal region included a preliminary estimate for pollution costs and public subsidies for natural capital extraction.[11] These costs were an estimated $11 billion per year for the region, of which air pollution costs were the most costly. These costs reduced the estimated market value of the region's natural capital from $62 billion to $51 billion per year.

A two-year study of the economic value of New Jersey's natural capital was undertaken by the Gund Institute for Ecological Economics for the New Jersey Department of

[7] Costanza, R. et al. 1997. "The value of the world's ecosystem services and natural capital." *Nature*. 387:253-259.
[8] Balmford, A. et al. 2002. "Economic Reasons for Conserving Wild Nature." *Science*. 297: 950-953.
[9] The World Bank. 2006. *Where is the Wealth of Nations?* World Bank. Washington, D.C.
[10] Anielski, M., and Wilson, S. 2007. *The Real Wealth of the Mackenzie Region: Assessing the Natural Capital Values of a Northern Boreal Ecosystem*. (2009 Update). Canadian Boreal Initiative. Ottawa, Canada.
[11] Anielski, M. and Wilson, S.J. 2005. *Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems*. (2009 Update). The Pembina Institute and Canadian Boreal Initiative. Ottawa, Canada.

Environmental Protection in 2006. Their study evaluated the state's ecosystem services based on average values from similar studies covering the types of ecosystems present in New Jersey. Their assessment valued New Jersey's ecosystem services between $11.6 billion and $19.4 billion per year. Wetlands provided the largest dollar value for ecosystem services, followed by marine ecosystems and forests.[12]

A similar study on the economic value of ecosystem services in Massachusetts reported that undeveloped land in the state provides more than $6 billion in non-market ecosystem services annually.[13] The findings concluded that permanent protection of undeveloped land makes economic and ecological sense. This was based on the analysis of losses of forests and agricultural land between 1985 and 1999, which have come at an annual cost of $200 million from losses in ecosystem value.

The costs due to the loss of natural areas and the ecosystem services they provide are beginning to be recognized by many jurisdictions. They are taking steps to halt urban sprawl by introducing greenbelt designations, smart growth initiatives, payment for ecosystem services, and new regulations. In New York State, the Catskill/Delaware watershed has provided clean water for New York City since 1915, without the need for filtering. In the early 1990s, the Environmental Protection Agency introduced new requirements for public water systems, which mandated new filtration systems for unfiltered water sources, unless the water quality met specified criteria that exempted filtration.[14] City managers estimated that a new filtration system would cost US$6 to $8 billion and another US$300 million annually to operate.[15] The alternative option was to implement a comprehensive watershed protection program estimated to cost between US$1 billion and US$1.5 billion. This program would include land purchase, pollution reduction and conservation easements enabling the natural ecosystems to purify the water.

New York City chose to invest in the natural ecosystem services of the watershed rather than building new infrastructure based on calculations that determined watershed protection had a better rate of return (90 to 170 per cent) and a shorter payback period of four to seven years.[16] The complex network remains the largest unfiltered surface water supply in the world, supplying 1.3 billion gallons of water each day.[17]

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[12] Costanza, R., Wilson, M., Troy, A., Voinov, A., Liu, S., and D'Agostino, J. 2006. *The Value of New Jersey's Ecosystem Services and Natural Capital*. Gund Institute for Ecological Economics, University of Vermont and New Jersey Department of Environmental Protection, Trenton, New Jersey.
[13] Breunig, K. 2003. Losing Ground: At What Cost? (Third Edition). Massachusetts Audubon Society. Lincoln, Massachusetts. www.massaudubon.org/losingground (accessed March 2008)
[14] NYC Department of Environmental Protection. 2006. *2006 Long-term Watershed Protection Program*. Prepared by the Bureau of Water Supply. NYCDEP.
[15] Richmond, A., Kaufmann, R.K., and Myneni, R.B. 2007. "Valuing ecosystem services: A shadow price for net primary productivity." *Ecological Economics*. 64: 454-462.
[16] Ibid.
[17] NYC Watersheds Water Supply History.
http://nyc.gov/html/dep/html/watershed_protection/html/history.html

Habitat mapping in the Fraser River Delta and Greater Victoria indicates that approximately 70 per cent of the original wetlands have been lost.[18] In the Lower Fraser Valley of British Columbia, the remaining natural wetlands have been estimated to provide ecosystem services worth at a minimum $230 million for waste-cleaning services each year.[19] This doesn't take into account the cost of replacing the wetlands with engineered infrastructure if they were drained. Urban development in the Abbotsford area has resulted in increased rainwater runoff and flooding on both residential and agricultural properties. The City of Abbotsford chose to construct a series of wetlands for water storage in the upper urban tributaries of Fishtrap Creek. The area now stores rainwater runoff from a 3,047 hectare catchment that removes 60 per cent of the suspended solids in the water. The $5 million cost for restoring wetlands was significantly less than the cost of alternative flood-prevention projects.

1.3 Purpose of Report

This report was commissioned by the Grasslands Conservation Council of BC to provide:

- a review of EGS valuation studies regarding grasslands in North America;
- a review of payment for ecosystem services including conservation programs and carbon trading systems related to grasslands and range lands;
- opportunities for further research on conservation incentives and ecosystem services valuation for grassland conservation in BC; and,
- three priority actions ranked according to importance in terms of GCC's future work on natural capital and conservation incentives.

2 Identification of Ecosystem Goods and Services

Ecosystem goods and services are the benefits derived from ecosystems. These benefits are dependent on ecosystem functions, which are the processes (physical, chemical and biological) or attributes that maintain ecosystems and the species that live within them. Humans are reliant on the capacity of natural processes and systems to provide for human and wildlife needs[20]. These include products received from ecosystems (e.g. food, fibre, clean air and water), benefits derived from processes (e.g. nutrient cycling, water purification, climate regulation) and non-material benefits (e.g.

[18] 2007. Green Bylaws Toolkit for Conserving Sensitive Ecosystems and Green Infrastructure. Ducks Unlimited Canada, The Wetlands Stewardship Partnership and the Grasslands Conservation Council of British Columbia.
[19] Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and The Nature Conservancy.
[20] De Groot, R.S. 2002. "A typology for the classification, description and valuation of ecosystem functions, goods and services." *Ecological Economics*. 41: 393-408.

recreation and aesthetic benefits).[21] The following table provides a list of ecosystem function, processes and the corresponding ecosystem services (Table 1).

Table 1: Ecosystem Functions, Processes and Corresponding Ecosystem Services

Functions	**Ecosystem Processes or Components**	**Ecosystem Services**
Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO2/O2 balance, ozone layer)	UVb protection by ozone, maintenance of air quality
Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of a favourable climate, carbon regulation, cloud formation
Disturbance prevention	Influence of ecosystem structure on environmental disturbances	Storm protection, flood control, drought recovery
Water regulation	Role of land cover in regulating runoff and river discharge	Drainage, natural irrigation, transportation
Water supply	Filtering, retention and storage of fresh water	Provision of water by watersheds, reservoirs and aquifers
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
Soil formation	Weathering of rock, accumulation of organic matter	Maintenance of productivity on arable land; maintenance of natural productive soils
Nutrient cycling	Role of biota in storage and re-cycling of nutrients (e.g. nitrogen)	Maintenance of healthy soils and productive ecosystems; nitrogen fixation
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
Pollination	Role of biota in the movement of floral gametes	Pollination of wild plant species and crops
Biological control	Population and pest control	Control of pests and diseases, reduction of herbivory (crop damage)
Habitat	Role of biodiversity to provide suitable living and reproductive space	Biological and genetic diversity, nurseries, refugia, habitat for migratory species
Food production	Conversion of solar energy, and nutrient and water support for	Provision of food (agriculture, range), harvest of wild species

[21] Millennium Ecosystem Assessment. 2003. *Ecosystems and Human Well-being: A Framework for Assessment*. World Resources Institute, Island Press. Washington, D.C.

	food	(e.g. berries, fish, mushrooms)
Raw materials	Conversion of solar energy, nutrient and water support for natural resources	Lumber, fuels, fodder, fertilizer, ornamental resources
Genetic resources	Genetic materials and evolution in wild plants and animals	Improve crop resistance to pathogens and crop pests, health care
Medicinal resources	Biochemical substances in and other medicinal uses of biota	Drugs and pharmaceuticals, chemical models & tools
Recreation	Variety in landscapes	Ecotourism, wildlife viewing, sport fishing, swimming, boating, etc.
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

Source: Wilson, S. 2008. *Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services*. David Suzuki Foundation. Vancouver, Canada.[22]

These processes or functions characterize ecosystems. Using the ecosystem classifications by ecosystem function developed from a number of published sources, the potential ecosystem services for grasslands can be identified.

The Millennium Ecosystem Assessment categorized ecosystem goods and services as: *provisioning services* such as food, fuels and fibres; *regulating services* that affect the climate, disease outbreaks, wastes and pollination; *cultural services* that provide aesthetic, recreational and spiritual value; and *supporting services*, such as nutrient cycling and water purification.[23]

2.1 Valuing Ecosystem Goods and Services

Environmental and ecological economists are developing methodologies and techniques for the valuation of ecosystem services, and more broadly, natural capital accounting. Valuing ecosystem services involves identifying the distribution of land cover types and land use, ascribing the corresponding goods and services based on literature reviews and/or field observations, and the quantification of the market and non-market goods and services provided by the ecosystems based on several different approaches depending on the environmental and economic information. The various

[22] 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.
[23] Anielski, M., and Wilson, S., 2005. *Counting Canada's Natural Capital: Assessing the real value of Canada's boreal ecosystems*. Canadian Boreal Initiative and the Pembina Institute. Ottawa.

elements of value for each of the EG&S can be identified with reference to the Total Economic Value framework. Each of these elements can then be ascertained either by one of several approaches including replacement/damage cost, revealed preference; stated preference or benefit transfer method. Each of these is described below.

2.2 Total Economic Value

In order to determine the value of the environment, the value of nature's services must first be revealed. The UN's Millennium Ecosystem Assessment (MA) poses three main domains as critical for successful policies: the biophysical information about the ecosystem status and process, the socioeconomic information about the context in which and for which the decision will be made and the information about the values, norms and interests of key stakeholders shaping and affected by decisions. The MA identifies the Total Economic Value (TEV) as the most widely used framework to identify and quantify the contribution of ecosystem services to human well-being.

Total economic value distinguishes between use values and non-use values, but these values are incorporated and are defined in monetary terms. There are three main categories of values used to determine the TEV:

- use values
- non-use values
- option values

TEV is composed by use values, option values and non-use components. Often TEV is reported as the sum of use values and non-use values or passive values. Use values can be direct when goods and services are exchanged on the market. Use values that are indirect refer to the life support services provided by the natural environment, which are 'indirectly used'. In the MA report specifically compiled for wetlands, direct use values correspond to the MA's definition of provisioning and cultural services. Indirect use values correspond to the MA's notion of regulating and supporting services. Provisioning, regulating and cultural services may all form part of the option values.

Option values reflect the value people place on a future ability to use the environment and thus the potential future benefits of goods and services. Non-use values include: existence values where the benefit results from knowledge that goods and service exist and will continue to exist, independently of any actual or prospective use by the individual; and bequest value, where the benefit is in ensuring that future generations will be able to inherit the same goods and services of the present generation.

2.3 Non-Market Ecosystem Valuation

Measuring the market value of goods or services is fairly straightforward when they have a market-determined value such as prices for timber. However, non-market values of ecosystem services are much more difficult to quantify because most do not have a market to establish a price.

There are several techniques that have been developed to determine economic values for non-market ecosystem services. These include: economic damages, the willingness of individuals to pay for goods and services or the willingness to accept compensation for losses. Those that focus on economic damages measure losses in productivity, expenditures to offset or replace natural capital services, or potential environmental damages if a service is lost. The willingness to pay or accept compensation is determined by surveys or by observing people's behaviour or choices.

Avoided cost assesses the value for ecosystem services based on what society would have pay if ecosystems and their services are diminished and/or damaged. In other words the value is the avoided cost that would be incurred in the degradation or loss of an ecosystem service. For example, flood control provided by wetlands or water filtration provided by forests and grasslands are very costly to replace with built infrastructure if they can be replaced. In addition, if ecosystem services are diminished due to environmental degradation or land use change, there are also costs in terms of damages to human communities (e.g. flooding damages). Replacement cost is related to avoided cost but focuses on ecosystem services that could be replaced with human-made systems. For example, nutrient cycling waste treatment by wetlands can be replaced with costly treatment systems.

Net factor income valuation refers to the valuation of services that provide for the enhancement of incomes. Some examples include soil erosion improvements due to grass planting on ranchlands that increase incomes for ranchers and water quality improvements that increase commercial fisheries catches and therefore incomes from the fisheries.

Travel cost is a measure of value based on what people pay to travel to experience or recreate in a natural area, the cost of which can reflect the implied value of the service. For example, recreation areas attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it.

Hedonic pricing is the value reflected in the prices people will pay for associated goods or property. This method is often used to estimate how much additional property value is provided by proximity to natural areas or greenspace. For example, housing prices along the coastline tend to exceed the prices of inland homes because of their proximity to water recreation and coastal viewing.

Contingent valuation is a method that determines values by posing hypothetical scenarios in surveys to individuals that involve some valuation of land-use alternatives. This method is often used for less tangible services like wildlife habitat or biodiversity. For example, a survey may be designed to determine how much people would be willing to pay for increased conservation of beaches and shoreline in a certain community.

2.4 Ecosystem Benefit Transfer Approach

If local analysis cannot be undertaken, benefit values can be transferred from other studies. Benefit transfer (also called value transfer) identifies values for an ecosystem service that have been assessed at similar locations. Benefit transfer (BT) involves the adaptation of existing valuation information or data to new policy contexts. In other words, the value determined for an ecosystem service from the original study site is applied to a new "policy" site.[24]

BT is becoming a practical way to inform decisions when primary data for a location is unavailable and primary valuation research is not possible given time and budgetary constraints. The number and quality of empirical economic valuation studies in the peer-reviewed literature is steadily increasing. This provides not only many single service and ecosystem-level studies, but average values from multiple studies.

2.5 Limitations of Ecosystem Service Valuation Research

Limitations in conducting ecosystem service valuation research include: 1) the availability of ecological information, 2) data on the current state of ecosystems and land, and 3) studies documenting the impacts of human land use on ecosystem services.

Valuations of ecosystem services provide an opportunity to rigorously assess the current benefits of an area's natural capital and the potential costs of human impact. Although the methodologies are not yet perfected, it is better to work with approximations than the status quo that essentially assigns a value of zero when designing policy or making land-use planning decisions. Based on thorough literature review and the application of economic valuation methods, representative and meaningful estimates can be developed. In fact, estimated values for non-market ecosystem services are generally conservative estimates due to an incomplete understanding of *all* the benefits provided by nature, the intrinsic value of nature itself and the likely increase in ecosystem service value over time, as services such as water supply become increasingly scarce due to global warming, urban sprawl and population growth, for example.

[24] Desvouges W.H., Johnson, F.R., and Banzhaf, H.S. 1998. Environmental Policy Analsys with Limited Information: Principles and Applications of the Transfer Method. Edward Elgar.Northhampton, MA, cited by Costanza, R., Wilson, M., Troy, A., Voinov, A., Liu, S., and D'Agostino, J. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Gund Institute for Ecological Economics, University of Vermont and New Jersey Department of Environmental Protection, Trenton, New Jersey.

3 British Columbia's Grassland Ecosystems

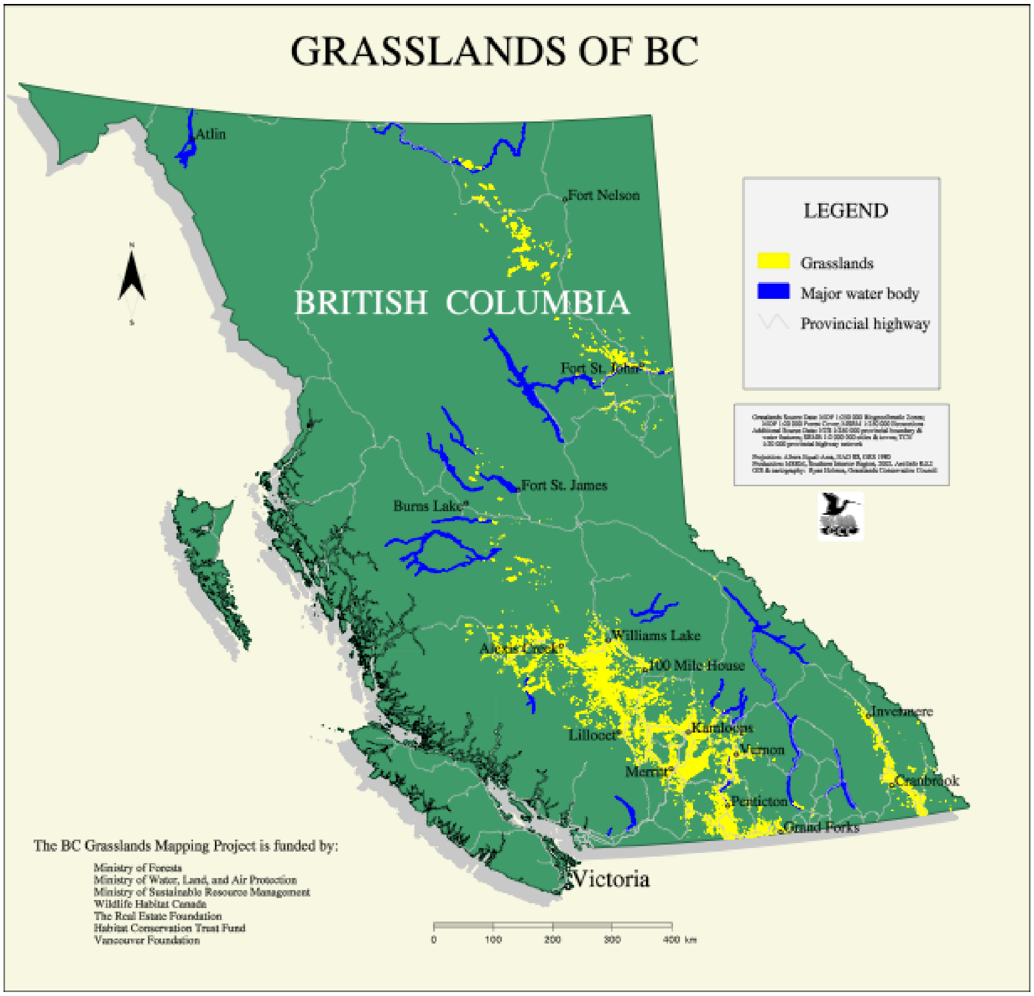
Grasslands cover about 40 percent of the earth's surface and are found in every region of the world. The five countries with the largest grassland area are Australia, the Russian Federation, China, the United States and Canada.[25] A significant proportion of the earth's grasslands have been converted to alternate land uses, such as intensive agriculture and urban development. The remaining grasslands are subject to intensive grazing practices and, in many cases, are overgrazed, degraded and prone to desertification and invasive plants.

Grassland ecosystem services are often overlooked, yet they provide several vital services such as climate regulation, genetic biodiversity, wildlife habitat, pollination, animal forage, and soil conservation. In addition, grasslands have provided many domesticated food plants and hold the potential for new sources of plants that have unique genetic features such as resistance to disease.

In British Columbia, grasslands cover less than one percent (0.8 percent) of the province's land base and most are east of the Coast and Cascade Mountains and south of Williams Lake. Although grasslands cover a small percentage of the province, they are home to a large proportion of the species at risk in B.C. BC's grasslands can be separated into ten, relatively distinct ecological regions. These include the East Kootenay Trench, Okanagan, Thompson-Pavilion, Southern Thompson Upland, Cariboo-Chilcotin, Peace, Muskwa Foothills-Liard Highland, Bulkley Basin, East Vancouver Island-Gulf Islands, and Northern Boreal Mountains-Plateaus (Figure 1).[26]

[25] White, R., Murray, S., and Rohweder, M. 2000. Pilot Analysis of Global Ecosystems: Grassland ecosystems. World Resources Institute. Washington, D.C. (www. wri.org/publication/pilot-analysis-global-ecosystems-grassland-ecosystems)
[26] Grasslands Conservation Council of British Columbia. 2004. BC Grasslands Mapping Project: A Conservation Risk Assessment. Final Report. http://www.bcgrasslands.org/projects/conservation/mapping.htm

Figure 1: Distribution of Grasslands in British Columbia



Grasslands not only provide habitat for a wide variety of species, but they also provide a significant forage base for BC's ranching industry. Domestic livestock grazes about 90 per cent of BC's grasslands, either through private rangelands, grazing tenures on provincial crown land or grazing regimes on First Nations land.

A variety of factors such as urban expansion and development, agricultural conversion, irresponsible recreation, inappropriate land management practices, and non-native invasive plants have resulted in losses of grasslands, and continue to threaten the remaining grasslands.[27] For example, grasslands in the Okanagan and Thompson valleys and the Rocky Mountain trench have been fragmented or lost to urban

[27] Ibid.

development, highways and railway lines, orchards, vineyards and other land uses.[28] The majority of BC's grasslands have been grazed by livestock for over 150 years and have been influenced by recreation for over 50 years.[29] Increasingly, one of the greatest threats to BC native grasslands is invasive non-native plants.

3.1 Review of Grassland and Grassland-related Valuation Studies

This section reviews studies undertaken in North America that have evaluated grassland ecosystem services and/or components of the ecosystem goods and services (EGS) that grasslands provide.

3.1.1 Pilot Analysis of Global Ecosystems: Grasslands (World Resources Institute)

The Pilot Analysis of Global Ecosystems (PAGE), undertaken by the World Resources Institute, analyzes information and develops indicators of the condition of the world's freshwater, coastal, forests, grassland and agroecosystems.[30] The PAGE: Grassland Ecosystems focuses on a select set of grassland goods and services based on the availability of data and the consultation of grassland experts. The report assesses the current status, trends over time and modifications that have changed the condition for the following goods and services:

- food, forage and livestock
- biodiversity
- carbon storage, and
- tourism and recreation.

Overall, the PAGE results demonstrate that the major goods and services provided by grasslands are in good to fair condition. However, the capacity for grassland ecosystems to continue to provide ecosystem goods and services is declining.[31] The PAGE analysis found that:

- the extent of grasslands, especially in the temperate zones of North American and Europe has declined due to cultivation and urbanization.
- Indicators of soil condition show that more half of the grasslands in the study have some degree of soil degradation.
- Indicators of grassland biodiversity show marked declines in grassland birds of North America with negative effects from fragmentation and non-native species.

[28] Grasslands Conservation Council of British Columbia. http://bcgrasslands.org/grasslands/grasslanddisturbances.htm (accessed October 20, 2008)
[29] Ibid.
[30] White, R., Murray, S., and Rohweder, M. 2000. Pilot Analysis of Global Ecosystems: Grassland ecosystems. World Resources Institute. Washington, D.C. (www. wri.org/publication/pilot-analysis-global-ecosystems-grassland-ecosystems)
[31] Ibid.

- Tourism and recreational activities in grasslands provide increasingly important economic contributions, however overuse and declines in wildlife populations decrease the capacity of grassland areas to provide these services.

Analysis of carbon storage found that grasslands store approximately 34 per cent of the global stock of carbon in terrestrial ecosystems (forests store about 39 per cent and agro-ecosystems about 17 per cent). Most of the carbon stocks in grassland are stored in the soil. Therefore, soil greatly impacts the storage potential of grasslands and as a result detailed soil data is needed to fully assess grassland carbon storage potential.

Temperate grasslands, savannas and shrublands have experienced intense conversion to agricultural use. Cultivation and urbanization of grasslands and other modifications (e.g. livestock grazing, desertification) can cause significant carbon emissions. As a result, carbon storage estimates need to reflect the influence of different vegetation and soil types and management practices. This report found that grassland carbon storage potential ranges from 100 to 300 metric tons per hectare. However, higher carbon stores are found in high- and low-latitude grasslands than in mid-latitude grasslands.

In terms of biodiversity, grasslands provide key habitat for birds and many other species. Grasslands are biologically diverse and our home to many endemic species. However, population trend data show a constant decrease in the number of grassland species in North America, over the past 30 years.

Grasslands have also provided the seeds for the major cereal crops grown and consumed worldwide, including wheat, rice, rye, barley, sorghum and millet. They continue to provide genetic material for cultivated varieties that have resistance to crop diseases. The introduction of non-native species negatively affects grassland ecosystems through species competition and can eventually lead to decreases in biodiversity. For example, many types of grassland in North America contain 10 to 20 per cent non-native plant species.[32]

3.1.2 Pimachiowin Aki World Heritage Project Area Ecosystem Services Valuation Assessment

The International Institute for Sustainable Development (IISD) reported on the economic value of ecosystem services provided by the natural environment within the Pimachiowin Aki World Heritage Project Area, in Eastern Manitoba and Northwestern Ontario. The study findings show that residents of the area receive $32 million in direct benefits, whereas non-residents or visitors receive about $12 million in benefits, and shared benefits range from $75 to $85 million. Together the total benefits are estimated to range from $121 to $130 million.

[32] Ibid.

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.

In addition, some ecosystem service values were calculated and omitted from the site's overall ecosystem service value because they were based on studies from areas with greater populations. However, a summary of these other potential ecosystem service values is provided in the report. These values include services such as water supply, air filtration, flood prevention and cultural values. The carbon stored within the forests and peatlands of the study area was also estimated but it too was not included in the annual overall total because it was not considered as annual revenue. The value was estimated to be approximately CDN$2.70 to $17.51 billion. These values were not ascribed by ecosystem type such as dollars per hectare for forests or grasslands.

3.1.3 Ecosystem Services Derived from Wetland Conservation Practices in the United States Prairie Pothole Region[33]

Implementation of the USDA Conservation Reserve Program and Wetlands Reserve Program has resulted in the restoration of approximately 2.2 million hectares of wetland and grassland habitat in the Prairie Pothole Region. These restored habitats provide ecosystem services. This report evaluates eco-services in restored wetlands and grasslands relative to cropland and native prairie baselines. They compared changes in restored catchments to cropland and native prairie catchments in terms of:

- plant community richness
- carbon sequestration
- floodwater storage
- sediment and nutrient reduction, and
- potential wildlife habitat suitability.

[33] Gleason, R.A., Laubhan, M.K., and Euliss, N.H. Jr. (eds). 2008. *Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs*. U.S. Geological Professional Paper 1745. Reston, Virginia.

Biodiversity
Restoration practices improved upland floristic quality and native species richness relative to cropped catchments, but native species richness of restored catchments did not approach the full site potential as defined by native prairie catchments.

Carbon
Catchments with a history of cultivation had less soil organic carbon (SOC) in upper soil profiles than native prairie. The difference varied from 12 to 26 per cent, with an average difference in SOC between restored and native prairie catchments of 15 Mg/ha. However, significant increases in SOC stocks in restored catchments were not evident relative to cropland baselines. Using published SOC sequestration rates, program lands were estimated to sequester 0.5 Mg/ha/year. In addition 1.6 Mg SOC/HA of carbon may be stored in plant biomass on program lands.

Floodwater storage
Wetland catchments intercept precipitation across 444,574 hectares, storing approximately 56,513 ha-m (458,151 acre-ft) of water if wetlands are filled to capacity. Perennial cover in upland catchments reduces the amount of water received by wetlands by enhancing evapotranspiration and soil water holding capacity and infiltration. Therefore lands with cover will have greater potential flood storage services than the flood storage capacity of wetlands. Flood water storage service is significant because otherwise water can cause downstream flooding.

Reduction of sedimentation and nutrient loading
The conversion of cultivated cropland to herbaceous perennial cover reduced total soil loss from uplands (276,021 ha) by an estimated average 1,760,666 Mg/yr (6.4 Mg/ha/yr). The primary benefit of reduced soil erosion is avoided wetland filling – which is critical to maintaining ecosystem services from wetlands. It also reduces the delivery of sediments to sensitive offsite ecosystems such as lakes, streams and rivers

Potential wildlife habitat suitability
The effects of conservation programs increased the number of grassland areas that exceeded published nesting area requirements for the five area-sensitive grassland bird species evaluated.

3.1.4 South Africa grassland values

Although this study was not undertaken in North America, this study for the South African National Biodiversity Institute provides an example of the values of grassland ecosystem services. The value of the flow of ecosystem services in grasslands was conservatively estimated in the order of 9.7 billion rand per year or 29,000 rand per square kilometre.[34] Consumptive uses were worth 1,589 million rand, non-consumptive uses were valued at 233 million rand, indirect use values were estimated at 7,939 million rand, and non-use values were not valued.

3.1.5 Southern Ontario Greenbelt Study

Southern Ontario's Greenbelt surrounds the Golden Horseshoe - extending about 325 kilometres from the eastern end of the Oak Ridges Moraine to the Niagara River in the west, covering 1.8 million acres. Its area consists of protected green spaces, farmlands, communities, forests, wetlands, and watersheds.

This report quantifies the value of the ecosystem services provided by the Greenbelt's natural capital. The annual value of the region's non-market ecosystem services is estimated at $2.6 billion annually; an average value of $3,487 per hectare. An assessment of the non-market values for ecosystem services provided by southern Ontario's Greenbelt were reported by land cover and service type. The report identified the following list of grassland ecosystem goods and services:

- Carbon storage in soils;
- Carbon sequestration;
- Soil formation;
- Soil conservation/ prevention of soil erosion;
- Water regulation (infiltration);
- Nutrient cycling;
- Waste treatment;
- Biological control;
- Pollination services;
- Recreation;
- Aesthetics;
- Domesticated food plants; and,
- Genetic resources for new plants and pharmaceuticals.

Carbon

Grasslands store more carbon than cultivated lands because they provide a complete vegetative cover and because plants grow for seven to eight months of the year.[35] When grasslands are ploughed or converted to agricultural lands, carbon is rapidly released to the atmosphere, and even when grassland is restored, carbon recovery is slow. Carbon stored in Greenbelt grassland soils was estimated at 105

[34] De Wit, M.P. and Blignaut, J.N. *Using monetary valuation results with specific reference to grasslands in South Africa*. South African National Biodiversity Institute. Background Information Report No. 5. South Africa.
[35] Sala, O.E., and Paruelo, J.M. 1997. "Ecosystem services in grasslands." In: *Nature's Services: Societal Dependence on Natural Ecosystems*. G.C. Daily (ed.) Island Press. Washington, D.C.

tonnes of carbon per hectare based on experimental findings from another study.[36] Soil organic carbon for other land cover types was extracted from the Soil Organic Carbon Database of Canada.

Land in permanent cover sequesters more carbon annually than tilled land because of lower decomposition rates and a higher input of plant residue back into the soil.[37] Although the rate of sequestration depends on the type of cover, the change from conventional crop tillage to permanent cover is estimated to increase sequestered carbon by 0.5 tonnes of carbon (1.8 tonnes CO2) per hectare per year compared with conventional crop cover.[38]

All carbon values were based on the average damage cost of carbon emissions reported by the Intergovernmental Panel on Climate Change (IPCC; $52/tC in Cdn 2005 dollars). The value of carbon stored in soils is worth an annual value of $438 per hectare, and the value of annual carbon uptake is worth an estimated $28.46 per hectare.

Pollination

Pollination services provided by natural land cover types including grasslands were estimated to be worth $1,109/ha/year based on the proxy value of the food production that relies on pollination (30%) and the total area of natural cover. Natural cover provides habitat, nesting and forage for pollinators.

Other values that were included in the assessment of grasslands were transferred from other studies:

- Water regulation $7/ha/year
- Erosion control $50/ha/year
- Soil formation $10/ha/year
- Waste treatment $146/ha/year
- Biological control $40/ha/year
- Recreation and aesthetics $3/ha/year

3.1.6 Economic Benefits of Grassland Protected Areas in Nebraska

The Grassland Foundation in Nebraska reported that tourism is Nebraska's third largest earner of revenue from outside the state, generating close to $3 billion in annual revenue.[39] Wildlife-related recreation generated about $475 million in 2001; about $130

[36] Smith, W.N., Desjardins, R.L., and Grant, B. 2001. "Estimated changes in soil carbon associated with agricultural practices in Canada." *Canadian Journal of Soil Science*. 81:221-227.
[37] Ibid.
[38] Smith, W.N., Desjardins, R.L., and Grant, B. 2001. "Estimated changes in soil carbon associated with agricultural practices in Canada." *Canadian Journal of Soil Science*. 81:221-227.
[39] Grassland Foundation. 2005. *Economic Benefits of Grassland Protected Areas*. Grassland Foundation. Lincoln, Nebraska. www.grasslandfoundation.org

million for wildlife viewing, and the remaining balance for hunting and fishing. In comparison, in Colorado, a state with significantly more public land and protected areas than Nebraska, more than $600 million is spent on wildlife viewing alone, with a total economic impact of $1.3 billion.

Travelers spent more than $2.8 billion in Nebraska during 2003 on trips away from home. For example, wildlife watching along the Middle Platte River in Nebraska was worth $27.9 to $57.5 million.

3.1.7 The Value of Natural Capital in Settled Areas of Canada

Olewiler (2004) studied the ecological goods and services provided by the natural capital within settled areas using case studies from various regions across Canada. According to the author, the case studies in this paper illustrate that governments may be making inefficient choices in allocating land to uses that destroy or degrade natural capital.[40]

This report presents four case studies from different agricultural regions of Canada. The cases present the threats to natural capital in each region, provide estimates of the value of natural capital, and illustrate that there are cases where it might be in society's interest to change farming practices to protect natural areas. The cases also repeatedly show that good data measuring the physical amount of natural capital is lacking. These fundamental data are necessary for estimating the value of conserving natural capital and are needed to help make informed public policies about land use.

The author reports that agricultural lands produce ecosystem benefits to society, but because farmers typically receive no payment for the ecosystem benefits generated by their lands and farming techniques, they have little incentive or ability to protect nature. In addition, there is often poor understanding of how changes in farm management might increase natural capital while also providing private benefits to the farm. An example would be allowing natural areas to persist and provide habitat for pollinators, predators for pest species, or water retention. When the value of natural capital on a portion of land exceeds the value of that land used for agriculture, it would be economically efficient to convert that land to some form of permanent vegetative cover (i.e. conservation cover).

The study reports on four case studies including:

- The Lower Fraser Valley, which encompasses approximately 16,225 square kilometres and contains some of Canada's best agricultural land, sensitive wetlands, forests and other natural areas.
- The Grand River watershed - the largest in southern Ontario covering

[40] Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and The Nature Conservancy of Canada.

approximately 6,800 km2, running from Dundalk in the north to Lake Erie in the south. Of this total area, more than 75 percent of the watershed is agricultural land.

- The Upper Assiniboine River Basin (UARB) - a region dependent predominately on agriculture. The UARB consists of 21,000 km2 in east-central Saskatchewan and western Manitoba. There are 1,024,814 cultivated hectares on 5,800 farms.
- The Mill River watershed is located in western Prince Edward Island and drains into Cascumpec Bay, a large generally shallow estuary. The watershed encompasses 11,270 hectares of which 3.4 percent is wetland, 43.2 percent is agriculture, 46.0 percent is forest and 7.4 percent urban development.

In the case of the Lower Fraser Valley, most benefit values are transferred from other EGS valuation studies to provide estimated values for the region. Values are reported for waste treatment services, flood protection, recreational use, non-timber forest products, carbon sequestration, wildlife viewing, hunting and fishing, as well as global values for total EGS for estuaries, lakes and rivers, temperate forests and grasslands. The latter values are transferred from the Costanza et al. (1997) paper on the global value of nature's services.

The case studies report on the value of conserving or restoring permanent vegetative cover and ecologically sound farming practices are assessed in terms of:

- Improved water quality and decreased water treatment costs;
- Lower dredging costs to remove sediment from water conveyance and storage infrastructure;
- Increased recreational opportunities such as fishing, swimming, hunting and wildlife viewing;
- Decreased net greenhouse gas (GHG) emissions;
- Mitigation of flooding; and
- Protection and enhancement of ecological services.

The net benefits of protecting natural areas or converting tilled lands to natural areas were reported for each case study.[41] The case studies estimated the net value of conserving or restoring natural areas ranged from $65/ha/yr in the Upper Assiniboine River Basin in eastern Saskatchewan and western Manitoba, $126/ha/yr in the Mill River Watershed in P.E.I., to $195/ha/yr in the Grand River Watershed of Ontario. The study also reports that improved water quality due to decreased sediment is worth an estimated $4.62 (range of $1.34 to $9.34/hectare/year) based on reduced erosion costs ($1.15/tonne of sediment).

[41] Olewiler, N. 2004. *The Value of Natural Capital in Settled Areas of Canada*. Ducks Unlimited Canada and The Nature Conservancy of Canada.

3.1.8 The Value of New Jersey's Ecosystem Services and Natural Capital

The Gund Institute for Ecological Economics, an academic centre at the University of Vermont, published a report on the economic value of New Jersey's natural capital for the New Jersey Department of Environmental Protection in 2006. [42] Their study evaluated the state's ecosystem services based on average ecosystem service values from previous studies. Their assessment valued New Jersey's ecosystem services between $11.6 billion and $19.4 billion per year. Wetlands provided the largest dollar value for ecosystem services, followed by marine ecosystems and forests.[43]

An assessment of the value of New Jersey's ecosystems services reported that pastureland had a total value of $77/acre/year (US2004$) including:

- Gas and climate regulation $3/acre/year
- Water regulation $2/acre/year
- Soil formation $3/acre/year
- Waste treatment $44/acre/year
- Pollination $13/acre/year
- Biological control $12/acre/year
- Aesthetic & recreational $1/acre/year

3.1.9 Value of the World's Ecosystem Services and Natural Capital[44]

Costanza et al. (1997) was the first global assessment of the world's ecosystem services by land cover type. In this study, researchers reported that grass/rangeland total values were an estimated $232/ha/year (1994 US$) including:

- Gas regulation $7/ha/year
- Climate regulation (no assigned value)
- Water regulation $3/ha/year
- Erosion control $29/ha/year
- Soil formation $1/ha/year
- Waste treatment $87/ha/year
- Pollination $25/ha/year
- Biological control $23/ha/year
- Food production $67/ha/year
- Genetic resources (no assigned value)
- Recreation $2/ha/year

[42] Costanza, R., Wilson, M. Troy, A., Voinov, A. Liu, S., and D'Agostino, J. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Gund Institute for Ecological Economics and New Jersey Department of Environmental Protection. University of Vermont. Burlington, Vermont.
[43] Ibid.
[44] Costanza, R. et al. 1997. "The value of the world's ecosystem services and natural capital." *Nature*. 387: 253-259.

3.1.10 Ecosystem Services Provided by Restored and Native Lands in the United States

Dodds et al. (2008) compared values for ecosystem goods and services provided by restored and native lands by biome across the United States.[45] They estimated that restored lands offer 31% to 93% of the EGS benefits from native lands within a decade after restoration. Their study reports that 10% of the native grasslands in the Great Plains remain (23 million hectares), with an additional 10 million hectares in restored lands. Their assessment analyzed eight EGS values for each biome. The annual value of non-market EGS per hectare of native grasslands in the Great Plains totalled $1,354 ($5,207/ha/year including commodities such as hay). The annual value of non-market EGS per hectare of restored grasslands totalled $1,275 ($3,765 including commodities such as hay).

3.1.10.1 Carbon Storage

The World Resources Institute PAGE analysis on grasslands reported that grassland carbon storage potential ranges from 100 to 300 metric tonnes per hectare. Soil organic carbon stored by grasslands was on average 105 tonnes of carbon per hectare in the southern Ontario Greenbelt, but this does not include the carbon stored by plant biomass. In B.C., grasslands cover 0.74 million hectares. Using the estimated carbon stored per hectare of grassland, the estimated carbon stored by B.C.'s grasslands ranges from 74 million to 222 million tonnes of carbon. The value of carbon would range from $5,200 to $15,600 per hectare based on the avoided cost of carbon emitted to the atmosphere (from the Intergovernmental Panel on Climate Change – IPCC). The southern Ontario Greenbelt study annualized the benefits of stored carbon over 20 years to estimate the value at an estimated $28.46 per hectare per year. The value for B.C.'s grasslands at this rate would be $21 million per year for carbon storage.

Soil organic carbon stored by native prairie catchments is on average 15 Mg/ha (15 tonnes/hectare) greater than restored areas. This is the marginal difference that the conservation of native grasslands provides in terms of carbon storage. If all of BC's grasslands were native then they would hold 11.1 million more tonnes of carbon than if they were restored lands.

This study and the southern Greenbelt study estimated that restored grassland catchments sequestered an estimated 0.5 tonnes/ha/year and that plant biomass may store an additional 1.6 Mg of carbon. If the rate of carbon uptake is applied to B.C.'s grasslands, the estimated carbon uptake per year is 370,000 tonnes of carbon.

3.1.10.2 Reduction in Soil Loss

[45] Dodds, W.K., Wilson, K.C., Rehmeier, R.L., Knight, G.L., Wiggam, S., Falke, J.A., Dalgleish, H.J., and Bertrand, K.N. 2008. "Comparing ecosystem goods and services provided by restored and native lands." *BioScience*. 58:837-845.

The reduction in total soil loss from uplands resulting from the conversion of cultivated cropland to herbaceous perennial cover occurs at an average rate of 6.4 Mg/ha/year. This service is important for maintaining wetlands and their services such as floodwater storage and water filtering abilities. This can be applied to B.C.'s grasslands, in terms of the soil they retain, which is an estimated 4.736 million Mg (tonnes) per year.

3.1.10.3 Pollination Services

Pollination services by grasslands were estimated at $1,109/ha/year for the southern Ontario Greenbelt based on a proportion of the value of food production in the region. Although the value would differ in B.C., a rough estimate can be applied using this transferred value. This rough estimate would value B.C.'s grasslands at $820.7 million per year for pollination habitat services.

3.1.10.4 Other Grassland EGS

The Greenbelt study also reports values for six other ecosystem services totalling $256 per hectare per year including water regulation, erosion control, soil formation, waste treatment, biological control, and recreation/aesthetics. If these values are applied to B.C.'s grassland area, the value for these six services would be $189.4 million per year.

If the value of pollination and carbon storage in grassland soils is included the total estimated value of services provided by grasslands is $1393.46/ha/year. Applied to the area of grasslands in B.C. (0.74 million hectares) the total value can be estimated at $1.03 billion per year.

The value of grasslands was estimated as significantly less by a study undertaken to assess the value of New Jersey's ecosystem services. This study estimated that pastureland has a total value of $77/acre/year ($190/ha/year). This would provide a much more conservative estimate for B.C.'s grasslands at an estimated $140.6 million per year. However, the values were estimated using averages transferred from other studies.

A study undertaken in South Africa measured the flow of ecosystem services provided by grasslands. They conservatively estimated the annual value of grassland services at 29,000 rand per square kilometre. This converts to C$4,219 per square kilometre or C$42.19 per hectare per year. If we apply this estimate to BC's grasslands, the value of ecosystem services can be estimated at C$31.2 million per year. However, this study included consumptive and non-consumptive uses, as well as indirect use but did not include non-use values.
Further, another study from the United States found that the annual value of EGS per hectare of native grasslands in the Great Plains totalled $1,354/ha/year for non-market values, and $5,207/ha/year including marketed goods such as hay, whereas restored lands provided $1,275/ha/year in non-market values and $3,765 for all EGS. If the value

for native grasslands is applied to B.C.'s grasslands, the value of non-market EGS can be estimated at $1 billion per year. This estimate is comparable to the Ontario Greenbelt study's estimate. If the marketed EGS are included then the estimated value of B.C.'s grasslands is $3.85 billion per year.

Based on these estimates the value for B.C.'s grasslands ecosystem goods and services can be estimated to range from $140.6 million to $3.85 billion per year. However, it is much more likely that the value would range from $1 billion to $4 billion given the detail of work put in to the higher valued estimates.

4 Conservation Incentive Programs and Ecosystem Service Trading

Payments for ecosystem services (PES) compensate individuals or communities for actions that increase the provision of ecosystem services such as water purification, flood mitigation or carbon sequestration. PES policies and trading systems use incentives to induce behavioural change.[46] The most widely known type of ecosystem service that is now paid for in ecosystem markets and through incentive programs is that of carbon.

4.1 Carbon Trading and Offsets

Grass absorbs carbon dioxide in the same way that trees do but on a smaller scale. Plants take carbon from the atmosphere and use it to build more plant matter. When grasses die some of that carbon is released back into the atmosphere, but grass plants also release carbon out of their root tips to fungi in the soil that micro-organisms stabilize as particles in the soil. The best way to maximize the amount of carbon stored underground is to maximize the growth of grasses and to avoid overgrazing.

Because grassland and rangeland store carbon they have the potential to provide carbon offsets. Carbon offsets represent a reduction in greenhouse gas emissions that organizations and individuals can use to counter their own emissions, measured in tonnes of carbon dioxide equivalents. Offsets or carbon savings are generated from actions taken to avoid or absorb carbon dioxide or any of the other main greenhouse gases (i.e. methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride).

There are several characteristics that are measured in the process of verifying good quality offsets. Offsets need to be assessed for additionality, verification, permanence, leakage and counted once.

[46] Jack, B.K., Kousky, C. and Sims, K.R.E. 2008. "Designing payments for ecosystem services: Lessons from previous experience with incentive-based mechanisms." *Proceedings of the National Academy of Sciences*. 105:9465-9470.

There are four potential/emerging markets for agricultural/rangeland offsets in BC:

- The voluntary carbon market: Chicago Climate Exchange and the Montreal Climate Exchange, as well as associated Offset Aggregators
- Pacific Carbon Trust
- Western Climate Initiative; and,
- Federal Offset System.

4.1.1 Chicago Climate Exchange

The Chicago Climate Exchange (CCX) is the world's first and North America's only active voluntary, legally binding integrated trading system to reduce emissions of all six greenhouse gases (GHGs) with offset projects worldwide. The CCX employs independent verification and has been trading GHG emission reductions since 2003. Members can reduce their own emissions by purchasing credits from verified offset projects.

The CCX issues tradable Carbon Financial Instrument (CFI) contracts to owners or aggregators of eligible projects on the basis of sequestration, destruction or displacement of GHG emissions. Eligible projects include agricultural methane, landfill methane, coal mine methane, agricultural and rangeland soil carbon, forestry and renewable energy. The offset programs relevant to grasslands are agricultural and rangeland soil carbon management.

Carbon is removed from the atmosphere and sequestered by soils through the growth of crops and grasses. When left undisturbed in grasses, soil carbon can accumulate over several decades. The CCX allows projects by farmers for rangeland soil carbon management that increases carbon sequestration and for newly-planted permanent grassland projects.

Rangeland Soil Carbon Management Offsets

- Offsets may be issued to landowners who commit to increase carbon stocks realized on managed rangelands in approved geographic areas. Projects include non-degraded rangeland managed to increase carbon sequestration through grazing land management that employs sustainable stocking rates, rotational grazing and seasonal use in eligible locations; and, restoration of previously degraded rangeland through adoption of sustainable stocking rates, rotational grazing and seasonal use grazing practices initiated on or after January 1, 1999. The projects must take place within designated land resource regions and must meet a minimum of a five-year contractual agreement.
- Offsets are issued at standard rates depending on the project type and location. The rates vary from 0.12 to 0.52 metric tons of carbon dioxide (CO_2) per acre per year. The CCX pre-emptively addresses CO_2 storage reversal by placing 20% of the CFI contracts generated into a reserve pool. B.C. is

designated as part of Zone A (northwestern U.S.), where soil offsets earn at a rate of 0.6 metric tonnes of carbon dioxide (CO2) per acre per year for land managers that commit to continuous conservation tillage for a period of 5 years.

Grassland Planting
The CCX also issues Exchange Soil Offsets for permanent grass land plantings. Exchange soil offsets are allowed for landowners in U.S. and Canada that commit to maintain increases in soil carbon stocks realized as a result of permanent grass cover plantings. B.C. is designated as part of Zone A (northwestern U.S.), where soil offsets are earned at a rate of 1 metric tonne of carbon dioxide (CO2) per acre per year.

4.1.2 National Carbon Offset Coalition, Inc. (NCOC)[47]

The NCOC is an aggregating member of the Chicago Climate Exchange (CCX) market. They accept applications for grassland planting and rangeland soil Exchange Soils Offsets (XSO). An Offset Aggregator serves as an administrative representative for offset project owners of multiple offset projects. Offset projects involving less than 10,000 metric tons of CO2 per year should be registered and sold through an Offset Aggregator.

Grassland Planting
The NCOC accepts applications for grassland planting to be placed on the Chicago Climate Exchange (CCX). Exchange Soils Offsets (XSOs) are allowed for U.S. and Canadian landowners that commit to maintain increases in soil carbon stocks realized as a result of permanent grass cover plantings that were undertaken on or after January 1, 1999. Grass cover must be maintained through 2010. Canadian provinces of Manitoba, Saskatchewan, Alberta, and British Columbia are included in Zone A with exchange soil offsets at a rate of 1.0 metric tons of CO2 per acre per year.

Rangeland Soil Carbon Management Offsets
The NCOC accepts applications for rangeland to be placed on the Chicago Climate Exchange (CCX) market. Exchange Soils Offsets (XSO) are issued for projects that commit to increase soil carbon stocks through improved range management practices. Eligible projects include:

- Grazing management that employs sustainable stocking rates, rotational grazing and seasonal use on non-degraded rangelands; and,
- Restoration of previously degraded rangelands through sustainable stocking rates, rotational grazing, and seasonable use grazing initiated on or after January 1, 1999.

[47] Website: http://www.ncoc.us

4.1.3 Pacific Carbon Trust

The Pacific Carbon Trust (PCT) is a Crown Corporation established under the B.C. government's Climate Action Plan. Their mandate is to deliver BC-based greenhouse gas offsets to help clients meet their carbon reduction goals and to support growth of the offsets industry in BC. By 2011, PCT is placed to purchase between 700,000 and 1 million tonnes of carbon dioxide equivalent offsets each year.[48] A large part of the offsets will be purchased on behalf of the BC government and the public sector to meet the province's legislated target of carbon neutrality for government activity by 2010. The BC Ministry of Environment has developed a provincial Emissions Offsets Regulation based on international criteria and standards. PCT offsets will be located in B.C., start on or after November 29, 2007 and meet the criteria outlined in the provincial Emission Offsets Regulation. The first offsets purchases include energy efficiency, cleaner energy and fuel switching projects. In addition, renewable energy generation and forest-based offsets will also be purchased.

4.1.4 Western Climate Initiative

The WCI is a collaboration of eleven U.S. states and Canadian provinces including BC that is developing a market-based cap-and-trade system. The system is scheduled to begin operating in 2012. Offsets will be used in the system to reduce the compliance costs for the cap-and-trade program. They have identified a list of project types as priority areas for investigation and development, which include:

- Soil sequestration and manure management; and,
- Afforestation, forest management and forest preservation/conservation.[49]

4.1.5 Federal Offset System

At the federal level, emission-intensity reduction targets for major industrial sectors will be established in 2010. The *Turning the Corner* program will utilize offsets from non-regulated sectors as one option for meeting requirements.[50] Carbon credits may include soil carbon management.

4.2 Conservation Banking

In the U.S., conservation banking has been established since 2003, when the US Fish and Wildlife Service (USFWS) released official federal guidance for the establishment, use and operation of conservation banks. This was modeled on the California conservation banking program, which has been operating since 1995. "Conservation Banking Agreements" are the standardized mechanism for creating bankable

[48] www.pacificcarbontrust.ca
[49] Design Recommendations for the WCI Regional Cap-and-Trade Program. September 23, 2008.
[50] Canada's Offset Program for Greenhouse Gases. http://ec.gc.ca/doc/virage-corner/2008-03/526_eng.htm

endangered species credits, however, other traded units include wetland banking agreements, and habitat conservation plans. Credits are based on species conservation outcomes rather than management (i.e. a bank must demonstrate that the species is being conserved).

Conservation banks are generally created to provide endangered species mitigation credits for one of three uses: internal mitigation, sales to credit purchasers, or both. Buyers can include government agencies or private firms. The Ecosystem Marketplace Network is a non-profit coalition of organizations that is tracking all conservation banking transactions in the United States. The transactions are being tracked on-line at www.speciesbanking.com.

4.3 Conservation and Environmental Protection Programs

4.3.1 Canadian Programs

4.3.1.1 The Canada-British Columbia Environmental Farm Plan Program

A voluntary program led by the British Columbia Agriculture Council (BCAC) (with Ducks Unlimited Canada as a partner) whereby producers undergo a process to identify environmental strengths and any potential risks on their farms. Producers attend a workshop, conduct a risk assessment of their farm/ranch, develop a plan to mitigate any identified risks and have the plan approved. Once the EFP is approved, producers are eligible to apply for cost-shared incentives under the National Farm Stewardship Program and Greencover Canada. This cost-shared funding will help implement the BMPs (Beneficial Management Practices) that address the environmental risks identified in each plan. There are several categories that apply to grassland and rangeland including:

Riparian Area Management (GREENCOVER);

- Land Management for Soils at Risk;
- Enhancing Wildlife Habitat and Biodiversity;
- Species at Risk;
- Grazing Management Planning (GREENCOVER); and,
- Biodiversity Enhancement Planning.

4.3.1.2 Ducks Unlimited Canada

Ducks Unlimited Canada has conservation easement in Alberta and Saskatchewan, as well as conservation agreements in Manitoba for the protection of natural lands on privately owned lands. They also offer forage and rangeland incentive programs in Alberta. The forage incentive program encourages the planting of native and tame grass through a discount on the price of seed, and the rangeland program offers cost-sharing funding and financial assistance to help landowners secure and improve upland native rangeland habitat. In Manitoba, they offer a hay program that helps convert cropland to forage whereby producers receive $20/acre to seed forages that are taken late in the nesting season. In British Columbia, DUC is a partner with the British Columbia Agriculture Council (BCAC) where they contribute to provincial-federal funding through the Environmental Farm Plan (see EFP program above).

4.3.1.3 Plains CO2 Reduction (PCOR) Partnership

The PCOR Partnership is a collaborative effort of 77 public and private stakeholders working on the economic feasibility of capturing and storing carbon from the central interior of North America (including the Prairie Pothole Region). They are undertaking a verification program to develop practical and environmentally sound carbon sequestration operations in the region.[51]

Under the program, Ducks Unlimited has created a partnership with the Eco-Product Fund to finance conservation in the Prairie Pothole Region through the sale of Grassland Carbon Credits. The Eco-Products Fund is a private equity fund that specializes in using innovative financial structures to bring environmental assets such as carbon and biodiversity to the marketplace. They will provide financial support to assist DU in securing grassland easements and carbon credits in the PCOR region and in the marketing of carbon credits to potential investors.

- **USDA Natural Resources Conservation Service**
    a. Conservation of Private Grazing Land Program (Farm Bill 2002)
    This is a voluntary program that helps owners and managers of private grazing land address natural resource concerns. It provides technical assistance for conservation or enhancement of resources to meet ecological, economic and social demands in all 50 states.

    b. Wildlife Habitat Incentives Program (Farm Bill 2002)
    A voluntary program that provides technical and financial assistance to landowners and others to develop upland, wetland, riparian and aquatic areas on their property. Most efforts have concentrated on improving upland habitat such as native prairie.

    c. Grassland Reserve Program (Farm Bill 2002)
    A voluntary program that helps landowners and operators restore and protect grasslands including rangeland, pastureland, shrubland and certain other lands while maintaining them as grazing lands. Participants voluntarily limit future development and cropping uses of the land while retaining the right to conduct grazing practices. Enrolment options include: permanent easement, 30-year easement, rental agreement, and restoration agreement. Contracts and easements prohibit the production of crops (other than hay), fruit trees, and vineyards that require breaking the soil surface and any other activity that

[51] http://www.ducks.org/Conservation/EcoAssets/2530/PCORPartnership.html

would permanently disturb the surface of the land, except for appropriate land management activities included in a grassland conservation plan.

- **U.S. Fish and Wildlife Service**

  d. Grassland Easement Program

  A voluntary program that pays landowners to permanently keep land in grass through legal agreements (easements) with the U.S. Fish and Wildlife Service. Mowing, haying and grass seed harvesting must be delayed until after July 15 each year to help grassland nesting species to complete their nesting before the grass is disturbed. Grazing is allowed.

- **Forest Trends and Conservation International**

  e. Business and Biodiversity Offsets Program[52]

  The BBOP is a partnership of companies, scientists, NGOs, government agencies, research institutes, and financial institutions. Partners involved in the program are working towards a goal of "no net loss" of biodiversity in the context of development projects through support for conservation activities that will protect threatened habitat, contribute to national biodiversity strategies and address local communities' livelihood priorities. The BBOP is managed by two non-profit organizations: Forest Trends and Conservation International. Under a pilot program, companies are quantifying their impacts on biodiversity and offsetting them through activities that advance conservation goals at the landscape-level.

4.4 Discussion: Case Study for BC

In B.C., conservation projects have not sold credits in an established voluntary or compliance market. However, there are some case studies of pilot projects that have been highlighted in a recent report for the Land Trust Alliance of BC. One of the projects, pending validation, is a first in terms of selling carbon credits in the voluntary carbon market. The Community Ecosystem Restoration Project of Maple Ridge is set to sell 100 year carbon credits, pending CCB Standards validation to Zerofootprint and Air Canada customers, at $15 per tonne of carbon dioxide for the planting of over 25,000 indigenous trees on an area of 83 hectares developed over 200,000 tonnes of credits. The project is undertaking restoration of degraded logged forestland in urban areas.

4.5 Potential Grassland Conservation Incentives for Landowners and Conservation Organizations that can be developed in British Columbia.

In terms of conservation incentive programs, the Environmental Farm Plan, available through the BC Agricultural Council is the most readily available program for landowners interested in grassland conservation in BC. Ducks Unlimited Canada is a

[52] www.forest-trends.org/biodiversityoffsettprogram

financial partner is this program, and they also offer an On-Farm Planning cost-sharing program targeted at grass management, nutrient management soil drainage and other environmental enhancements for the Georgia Basin region.

Four potential/emerging carbon offset systems were presented in the preceding section. The Chicago Climate Exchange is the only fully active system of these four. The CCX issues tradable Carbon Financial Instrument contracts for rangeland soil carbon management offsets and grassland planting. I was not able to find an offset aggregator operating in British Columbia. However, the National Carbon Offset Coalition accepts applications for permanent grassland plantings in several Canadian provinces including BC, with an exchange soil offset rate of 1.0 metric tons of carbon dioxide per acre per year. Because there are no obvious offset aggregator operators in BC, there is the potential for development of a company or non-profit entity that could provide offset aggregation services as a member of the CCX. In Alberta, Flatlander Environmental Services Ltd. and C-Green Aggregators Ltd. in Saskatchewan offer agriculture carbon offsets regarding minimum till practices.

The other three potential systems that will be offering markets for carbon offsets include the provincial Pacific Carbon Trust, the regional Western Climate Initiative, and the national Federal Offset System. The specific types of offsets within each offset program have not yet been fully defined, so opportunities exist for the promotion and advocacy of grassland soil carbon conservation and rangeland soil management offsets.

5 Identification of Research Opportunities

5.1 Information gaps for specific grassland types, grassland ecological goods and services, and regions.

There are few studies that have examined a full suite of ecosystem services and their non-market economic values for grasslands in North America, except for the global assessment of natural capital by Costanza et al (1997). However, there are several studies that could be used as input for an economic assessment of the ecosystem services provided by BC's grasslands.

Firstly, several studies can provide information on the ecosystem services provided by grasslands, their condition and measurements for the annual service provided. For example:

a) The World Resources Institute has undertaken a global pilot analysis that identifies a selected set of ecosystem goods and services and evaluates their condition but does not assess their economic value.
b) The USDA studied the ecosystem services provided by restored prairie and wetland habitat providing quantified changes in services. For example they estimated that restored grasslands could sequester 0.5 Mg C/ha/year, perennial

cover in uplands of wetland catchments increase the potential flood storage services, and perennial cover reduces total soil loss from uplands by an estimated average of 6.4 Mg per hectare per year.[53]

Secondly, there are studies that have examined selected grassland ecosystem service values that can be incorporated and/or considered for a BC assessment. Values from the following studies could be used:

a) A study of the ecosystem services provided by the U.S. National Wildlife Refuge System estimated the value of grasslands at $71.2 million per year or $51.40/acre/year. This study only applied a value for three services (wastewater dilution/purification, habitat provision, and erosion control) from one study (Loomis et al. 2000).[54]
b) An assessment of the ecosystem goods and services provided by restored and native lands in the U.S. estimated that native grasslands provide an estimated value of $1,354 (including only non-market services) per hectare per year (2004 US dollars). The value of restored grasslands is estimated at $1,275 per hectare per year for non-market ecosystem services. The largest value was ascribed to recreation after marketed commodities, at $1,003/ha/year. Other ecosystem values included are gas regulation, disturbance regulation, water supply, nutrient cycling, soil erosion control, biodiversity and recreation.

Thirdly, studies that examine a particular service that is related to grasslands can provide ecological measurements, baseline data and/or economic values. The following studies can provide useful input for a BC study:

a) Sala and Paruelo (1997) report on the value of conserving grasslands using a number of sources.[55] They report that:

- Carbon losses as a result of cultivated soils in the Great Plains range between 0.8 and 2 kg/m2, with soils containing an average carbon content ranging from 2 and 5 kg/m2.
- Carbon accumulation after fifty years of abandonment of croplands did not reach the levels of native grassland soils, increasing very slowly at about 60 kg/ha/year/
- Fields uptake only half the methane that native grasslands can (2.6 g C/ha/day as methane).
- Croplands emit nitrous oxide at a higher rate than native grasslands

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[53] Gleason, R.A., Laubhan, M.K., and Euliss, N.H., Jr., eds. 2008. *Ecosystem Services from Wetland Conservation Practices in the United States Prairie Pothole Region with an Emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs*. U.S. Geological Professional Paper 1745. U.S. Geological Survey. Virginia, USA.
[54] Ingraham, M.W., and Foster, S.G. 2008. "The value of ecosystem services provided by the U.S. National Wildlife Refuge System in the contiguous U.S." *Ecological Economics*. 67:608-618.

[55] Sala, O.E., and Paruelo, J.M. 1997. "Ecosystem Services in Grasslands." In: Daily, G.C. (ed.) *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press. Washington, D.C.

- Importance of grasslands genetic resources, in particular the majority of domesticated plants and animals are from grassland regions.
- Heavily grazed areas show double the erosion rates of moderately grazed or ungrazed areas.
- In the United States the average erosion rate is 17 tons/ha/year with off-site costs of $17 billion per year (1992 dollars) and $27 billion for on-site costs; a total cost of about $100/ha of cropland or pasture.

b) Several studies document the importance of conserving natural cover for pollination services:
    - Grazing systems that depend on livestock obtaining their feed from native vegetation may have a strong dependence on pollinators for forb and browse species that are eaten by grazing animals.[56]
    - In canola seed production in northern Canada, fields near uncultivated areas have greater yields due to a more diverse and abundant wild bee community. Yield and profit were maximized with 30% of uncultivated land within 750 m of field edges.[57]

c) Insects provide many services including pollination, pest control and dung burial. Dung beetles decompose dung waste which increases forage availability, nutrient cycling and reduces pest habitat. In the U.S, dung burial by dung beetles is worth an estimated $380 million annually in losses averted.[58]

d) A case study for an area of the Central Platte River in Nebraska's Mixedgrass Prairie Ecoregion provides a range of estimates for the annual net carbon fluxes by restored prairie/grassland cover types in the United States from an extensive literature review.[59] For example, restored grassland in the Great Plains sequesters 0.57 tC/ha/year, whereas restored Conservation Reserve Program grassland in Wisconsin sequesters between 0.25 and 0.88 tC/ha/year depending on the length of time since restoration began.[60]

e) A study that examined the effects of grassland buffers on the levels of total suspended solids (TSS), phosphorus, and the herbicide atrazine found that such buffers reduce levels of these substances in a watershed by 14 percent, 17 percent, and 27 percent, respectively.[61]

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[56] FAO. 2007. *Pollinators: Neglected Biodiversity of Importance to Food and Agriculture*. Commission on Genetic Resources for Food and Agriculture. Rome, 11-15 June. http://www.fao.org/ag/cgrfa/cgrfa11.htm

[57] Morandin, L.A., and Winston, M..L. 2006. "Pollinators provide economic incentive to preserve natural land in agroecosystems." *Agriculture, Ecosystems and Environment.* 116:289-292.

[58] Losey, J.E., and Vaughan, M. 2006. "The economic value of ecological services provided by insects." *BioScience.* 56: 311-323.

[59] Kroeger, T., and McMurray, A. 2008.*Economic Benefits of Conserving Natural Lands: Case Study: Central Platte Biologically Unique Landscape, Nebraska*. Prepared for the Doris Kuke Charitable Foundation. Defenders of Wildlife. Washington, D.C.

[60] ibid.

[61] Franti, T.G., Eisenhauer, D.E., McCullough, M..C., Stahr, L.M., Dosskey, M.G., Snow, D.D., Spalding, R.F., and Boldt, A.L. 2004. *Watershed Scale Impacts of Buffers and Upland Conservation Practices on*

f) Riparian buffers in agricultural areas immobilize nitrogen in vegetation biomass at a rate of 16-37 kg/ha/year, preventing its release to the atmosphere and to ground and surface waters.[62]

Lastly, economic benefit studies on grasslands from regions outside North America may also provide useful information South Africa and China are two countries where studies on grassland values have been undertaken.[63]

5.2 Preliminary framework for developing grassland EGS values for British Columbia

Grasslands are often overlooked in terms of their value for providing ecosystem goods and services. The Pilot Study of Grassland Ecosystems by the World Resources Institute focuses on a selected set of ecosystem goods and services including food, forage and livestock; biodiversity; carbon storage; and, tourism and recreation. These are a generalized set of EGS that can be expanded upon. The USDA Forest Service identifies ecosystem services as the processes by which the environment produces resources such as clean water, forage, habitat for wildlife, and pollination of native and agricultural plants.[64] They report that grassland ecosystems provide the following services:

- Dispersal of seeds;
- Mitigation of drought and floods;
- Cycling and movement of nutrients;
- Detoxification and decomposition of waste;
- Control of agricultural pests;
- Maintenance of biodiversity;
- Generation and preservation of soils and their fertility;
- Contribution to climate stability;
- Regulation of disease-carrying organisms;
- Soil erosion control;
- Water flow regulation in watersheds and stream and river channels;
- Pollination of crops and natural vegetation;
- Provision of aesthetic beauty, wildlife habitat; and,
- Provision of recreational and research opportunities.

Agrochemical Delivery to Streams. Proceedings, American Society of Agricultural Engineers 2004 Conference, 12-15 September. St. Paul, Minnesota.

[62] Tufekcioglu, A., Raich, J.W., Isenhart, T.M., and Schultz, R.C. 2003. "Biomass, carbon and nitrogen dynamics of multi-species riparian buffers within an agricultural watershed in Iowa, USA." *Agroforestry Systems*. 57:187-198.

[63] De Wit, M.P., and Blignaut, J.N. 2006. *Using Monetary Valuation Results with Specific Reference to Grasslands in South Africa*. Background Information Report No. 5. National Grassland Biodiversity Programme. South African National Biodiversity Institute.

[64] USDA Forest Service. http://www.fs.fed.us/grasslands/ecoservices/index.shtml (accessed Jan 2009)

The UN Millennium Ecosystem Assessment (MA) ascribed ecosystem services by global eco-region types including wetlands, forests, dryland systems, and cultivated systems. The assessment identified the following ecosystem services for Dryland Systems:[65]

Supporting Services

a) soil development: formation and conservation
   - o soil properties determine how much of the rainfall will be stored and subsequently become available during dry periods
   - o availability of moisture in soil is an important factor in nutrient cycling

b) nutrient cycling
   - o supports the services of soil development and primary production through the breakdown of dead plant parts that enrich the soil with organic matter, and the regeneration of mineral plant nutrients

c) primary production
   - o net primary production for global drylands was 703 (+/-44) grams per square meter (significantly lower than the values for the MA's cultivated lands 1,098 grams and forest/woodland 869 grams)

Regulating Services

a) Water regulation
   - o Regulation determines allocation of rainfall for primary production, irrigation, livestock watering and domestic uses (i.e. storage in groundwater and surface reservoirs) and for the occurrence of flash floods and their associated damages (soil erosion, reduced groundwater recharge, excessive clay and silt loads in downstream water bodies)
   - o Vegetation cover modulates water regulation service and its efficiency in intercepting rainfall determines the fraction available for human use
   - o In rangelands, vegetation removal and livestock trampling can increase soil water erosion

b) Climate regulation

- Drylands regulate their own local climate to some extent as vegetation cover determines the surface reflectance of solar radiation as well as water evaporation rates
- Also regulate global climate through local carbon sequestration by vegetation which enhance the soil organic carbon pool
- Plant biomass per unit area is lower than forests but the large surface area of drylands gives dryland carbon sequestration a global significance

c) Pollination and Seed Dispersal

- Tight associations between dryland plants and pollinators

[65] Safriel, U., and Adeel, Z. 2005. "Dryland Systems." In: *Ecosystems and Human Well-being: Current State and Trends*. Millennium Ecosystem Assessment.

Provisioning Services

a) Food & fibber
b) Wood fuel
c) Biochemicals
d) Freshwater

- Vegetation cover and its structural diversity control much of water provisioning service
- Resultant water supports rangeland, cropland, livestock and domestic use
- Also critical for maintaining wetlands within drylands

Cultural Services

a) Cultural identity and diversity
b) Cultural landscapes and heritage values
c) Servicing knowledge systems
d) Spiritual services
e) Aesthetic and inspirational services
f) Recreation & tourism

Based on the general typology of ecosystem function and services from several sources, I suggest that a preliminary framework for the identification and valuation of the ecosystem goods and services provided by British Columbia's grasslands include a wide range of ecosystem goods and services that can be explored further for valuation (Table 2).

Table 2: Preliminary Framework for Grassland Ecosystem Goods and Services in British Columbia

EGS Category	Functions	Ecosystem Processes or Components	Ecosystem Services
Regulating Services	Gas regulation	Maintenance of the composition of the atmosphere	1. Absorption of air pollutants by plants
	Climate regulation	Influence of land cover and biological mediated processes on climate	2. Carbon sequestration by plants and soils 3. Carbon storage by soils
	Disturbance prevention	Influence of ecosystem structure on environmental disturbances	4. Storm protection 5. Drought recovery
	Water regulation	Role of land cover in regulating runoff and river discharge	6. Water regulation and drainage
	Pollination	Role of biota in the movement of floral gametes	7. Pollination of wild plant species and crops 8. Pollinator habitat and

			forage
	Biological control	Population and pest control	9. Control of pests and diseases 10. Reduction of herbivory (i.e. crop damage)
Supporting Services	Soil retention	Role of the vegetation root matrix and soil biota in soil retention	11. Prevention of soil loss/damage from erosion 12. Maintenance of arable land
	Soil formation	Weathering of rock, accumulation of organic matter	13. Maintenance of productivity on arable land 14. Maintenance of natural productive soils
	Nutrient cycling	Role of biota in storage and re-cycling of nutrients (e.g. nitrogen)	15. Maintenance of healthy soils and productive ecosystems 16. Nitrogen fixation
	Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutrients and compounds	17. Pollution control/ detoxification, filtering of dust particles
Provisioning Services	Water supply	Filtering, retention and storage of fresh water	18. Provision of water by watersheds, reservoirs and aquifers
	Habitat	Role of biodiversity to provide suitable living and reproductive space	19. Suitable space for refuge, reproduction, and habitat for wild animals and plants
	Food production	Conversion of solar energy, and nutrient and water support for food	20. Provision of food (i.e. crops and livestock)
	Raw materials	Conversion of solar energy, nutrient and water support for natural resources	21. Provision of raw materials such as fibber (i.e. market goods)
	Genetic & medicinal resources	Genetic materials and evolution in wild plants and animals	22. Genetic diversity bank provides options for Improved crop resistance to pathogens and crop pests 23. Drugs and pharmaceuticals for health care
Information & Cultural Services	Recreation	Variety of natural and semi-natural areas with recreational potential	24. Ecotourism and outdoor activities
	Science	Variety in natural	25. Provides opportunities for

	and Education	landscapes, natural features and nature	cognitive development: 26. Scientific knowledge and environmental education
	Aesthetic information	Landscape features	27. Enjoyment of scenery 28. Artistic and commercial use of nature 29. Religious and historic use of nature 30. Aboriginal sites

Source: 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; Wilson, S. 2008. *Ontario's Wealth, Canada's Future*. The Greenbelt Foundation and David Suzuki Foundation. Vancouver, BC.

However, the main non-market services that have been identified in the literature include carbon storage services, soil development services, sediment, and nutrient runoff reduction, tourism and recreation, wildlife habitat, water regulation, and pollination

5.3 Potential Analysis Methods & Tools

The first step for undertaking an economic assessment of the value of B.C.'s grasslands is to assess the availability of spatial geo-referenced data that is available for grassland regions. Spatial land cover and land use data sets will be necessary for much of the analysis. Using this data the following analyses could be undertaken:

a) GIS applications for land-use planning and policy-making can be used to calculate the quantity and monetary benefits for some ecosystem services based on specific site conditions. CITYgreen software calculates carbon sequestration, air pollutant absorption, and water runoff control. It is generally used for urban and peri-urban tree cover but could possibly be adapted for other land cover types.
b) The quantity and value of carbon storage can be assessed using land cover/land use analysis, carbon content estimates from experimental sources and values from a range of sources including regulated carbon market prices (i.e. European Union) and avoided damage costs (i.e. IPCC).
c) The value of water filtration services as the avoided costs of additional losses in natural land cover (i.e. based on the current condition of grassland watersheds).
d) The quantity of organic carbon stored in soils from the Soil Organic Carbon Database of Canada for wetlands, grasslands, and agricultural soils.[66]
e) The estimated quantity of soil loss averted by different grassland cover types and the value based on estimates of on-site and off-site costs from literature sources.

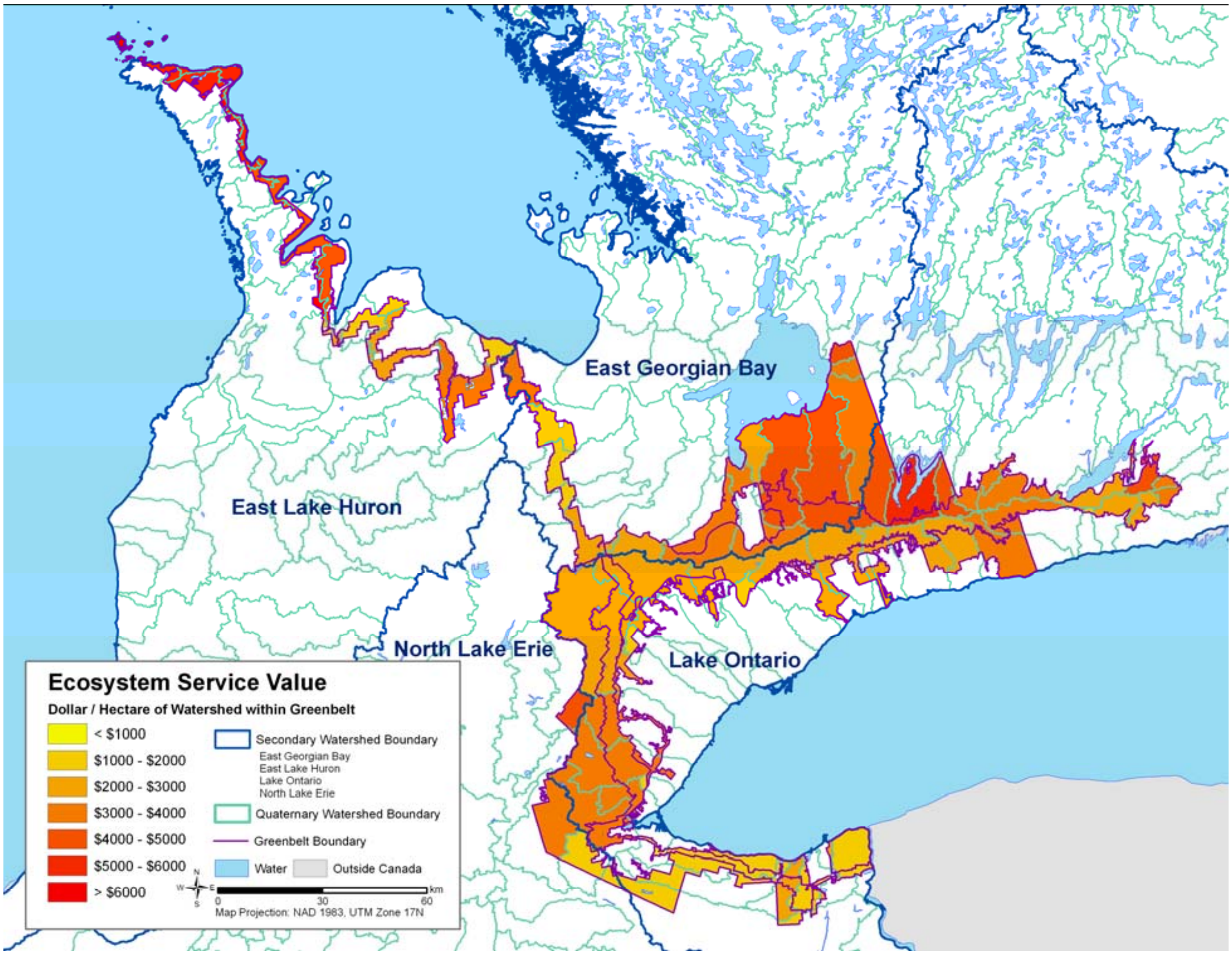
[66] Tarnocai, C. and B. Lacelle. 1996. *Soil Organic Carbon Database of Canada*. Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Canada.

f) The availability and value of pollinator habitat (i.e. valued as an avoided cost or as a proportion of the current value of agricultural production dependent on pollination).
g) Recreation and tourism from local, regional and national studies on the economic impact of nature-based recreation and tourism.
h) Cultural values as the value communities place on the scenery of grasslands such as the willingness to pay for grassland conservation.

The Grasslands Conservation Council (GCC) has a comprehensive data base of geographically-referenced data for spatial analysis of grassland data. In 2004, the GCC completed mapping the location of grasslands in B.C. (1995 data). This data was updated in 2006 to show to show the extent and change in grassland cover between 1995 and 2004 including aerial photography interpretation. In addition, the GCC Priority Grasslands Initiative has delineated priority areas for conservation in several of BC's grassland regions. Data is also available for habitat potential modeling, soils and geological analysis as well as hydrological data for modeling water retention, slope, and soils.

The distribution of ecosystem services and their values can then be mapped. Figure 2 shows a map of the values of non-market ecosystem values by watershed for southern Ontario's Greenbelt. In addition, a pilot version of InVEST software that models and maps natural capital including the distribution and value of ecosystem services is now available. This could potentially be used to illustrate the distribution of key ecosystem services across B.C.'s grasslands.

Figure 2: Ontario Greenbelt Ecosystem Service Average Values per Hectare by Watershed (Dollars/hectare)



Additional information and research that will need to be undertaken to assess: the on-site and off-site costs for BC's grasslands or similar estimates from a similar region; information of the role of grassland cover in regulating the flows of water through watersheds; rates of waste treatment in grassland ecosystems; and, information on the rate of soil formation and nutrient cycling by grassland ecosystems.

6 Synthesis

Habitat mapping in B.C. shows that significant habitat across the province is being lost to land development. Losses include 70 percent of the original wetlands in the Fraser River Delta and Greater Victoria, over 50 percent of wetlands in the Nanaimo and Cowichan estuaries, 85 percent of the natural wetlands in the South Okanagan and the antelope-brush grasslands now represent less than one percent of the B.C.'s land base and are one of the top four most endangered ecosystems in Canada.

The identification of natural capital and ecosystem valuation is vital in order to stimulate a growing dialogue in British Columbia and Canada regarding the importance of natural capital, environmental stewardship and how to account for nature's wealth in economic policy development and land use planning. By demonstrating comprehensive values of conserving natural capital and protecting ecosystems for current and future benefits, decision-makers (municipal, federal, provincial, and First Nations) will make better-informed stewardship decisions that balance broader ecosystem and cultural values with sustainable economics.

Efforts to conserve biodiversity in B.C.'s grasslands have the potential to provide many economic benefits for communities. It is important to identify areas where conservation will benefit both biodiversity and the provision of ecosystem services. However, in order to do so, ecosystem services need to be mapped, quantified and valued.

Grasslands in BC are key ecosystems that provide numerous ecosystem services that benefit local communities, as well as regional and global processes. These services include annual carbon uptake as well as long term carbon storage that help stabilize the earth's climate, soil formation and soil erosion prevention, grazing for cattle, and water regulation.

Accounting for the natural capital provided by B.C.'s grasslands will provide invaluable information on the ecosystem services provided as well as estimates of their socio-economic value for communities. In addition, such information will be essential to prepare and take advantage of the emerging markets for carbon and biodiversity offsets.

The Grasslands Conservation Council is well placed to undertake an assessment of the ecosystem goods and services provided by grasslands in B.C. They have developed their own geographically-referenced data specifically for grassland data analysis. Access to high quality ecological data that can be used for spatial analysis is often the largest hurdle to overcome in terms of an assessment of natural capital and ecosystem services.

The identification and valuation of the ecosystem services provided by B.C.'s grasslands will also provide other opportunities for promoting the "green infrastructure" in which grasslands play a part. The Green Bylaws Toolkit for Conserving Sensitive Ecosystems and Green Infrastructure identify sensitive ecosystems as any fragile and/or rare portion of a landscape with relatively uniform dominant vegetation including wetlands, riparian areas, grasslands and older forests.[67] This B.C. toolkit has been developed to identify the economic, social and environmental benefits that are provided by conserving sensitive ecosystems and green infrastructure, as well as to provide local governments and the public with practical tools for protecting their green infrastructure. The handbook identifies various legal approaches for conserving green infrastructure or natural capital. Several bylaws that can protect these areas and their services such as regional growth strategies, official community plans, tax exemptions, as well as legislative opportunities for ecosystem protection including the Agricultural Land Commission Act and Forest and Range Practices Act are assessed as options for protection green infrastructure or natural capital. The assessment of B.C.'s grassland ecosystem services will enable the GCC to participate in these legal processes and opportunities armed with detailed information on the types of services grasslands are providing and their estimated values.

[67] 2007. *Green Bylaws Toolkit for Conserving Sensitive Ecosystems and Green Infrastructure*. Prepared by Environmental Law Clinic, University Of Victoria Faculty Of Law, And Deborah Curran & Company, for the Wetland Stewardship Partnership, Ducks Unlimited Canada, Grasslands Conservation Council Of British Columbia,
Environment Canada, and the Province Of British Columbia.
http://www.toolkit.bc.ca/sites/default/files/GreenBylaws_toolkit.pdf

6.1 Three Priority Actions for the Grasslands Conservation Council Natural Capital Project

Based on the information compiled in this first phase of the GCC's Natural Capital project, I suggest that the organization focus on the following three priority actions in future grassland natural capital and incentives work:

1) **Natural Capital Value of BC's Grassland**: An ecosystem services assessment for British Columbia's grasslands that identifies ecosystem services provided, as well and the valuation and mapping of grassland market and non-market values. This study will serve as a showcase piece and communications tool for the socio-economic values of grasslands. In addition, the results of this study can be mapped and used as an interactive web-based tool for exploring the types of services provided by grasslands and their values.
2) **Emerging Markets for Soil Carbon Offsets**: Develop policy/outreach brief on the importance of soil carbon management for the maintenance of carbon stores in grasslands and rangelands to ensure that they are included as offsets for provincial and regional initiatives such as the Pacific Carbon Trust (BC) and the Western Climate Initiative (US/Canada). Secondly, identify offset aggregators that can represent offset projects from Canada's grassland and rangeland.

3) **Information on Payment for Ecosystem Services**: Development of handbooks and a series of workshops on ecosystem service trading and incentive opportunities for landowners and grassland-related agencies in British Columbia. This handbook will include steps that landowners/agencies will need to take to develop offset projects.