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A Valuation Of Ecological Services In The Great Lakes Basin Ecosystem to Sustain Healthy Communities and a Dynamic Economy

Prepared for the

Ontario Ministry of Natural Resources

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Economic Valuation of the Great Lakes

PREAMBLE

This analysis of the value of the Great Lakes to the health of people, communities and the economy in Ontario has been designed to provide the Ontario Ministry of Natural Resources (MNR) with a credible assessment of the contributions made by the Great Lakes and to the local, provincial, regional, and national economies. For non-traditional benefits assessment, we provide methods for valuation of natural resources and options for MNR to more thoroughly quantify benefits that we can only estimate by extrapolation from existing literature.

This document first characterizes the major uses of the Great Lakes for which economic value can be calculated either directly or indirectly. It then portrays a subset of the major stressors many of which have not historically been addressed through COA and/or the Great Lakes Water Quality Agreement (GLWQA). After a brief review of valuation methods, the document describes different categories of benefits ascribable to different aspects of the Great Lakes economy. A short number of case histories are then provided for studies that have calculated values of some Great Lakes attributes that go beyond direct market values. The document concludes with recommendations as to what methods and studies could be undertaken to more fully valuate particularly difficult attributes that have inherent, but not market value.

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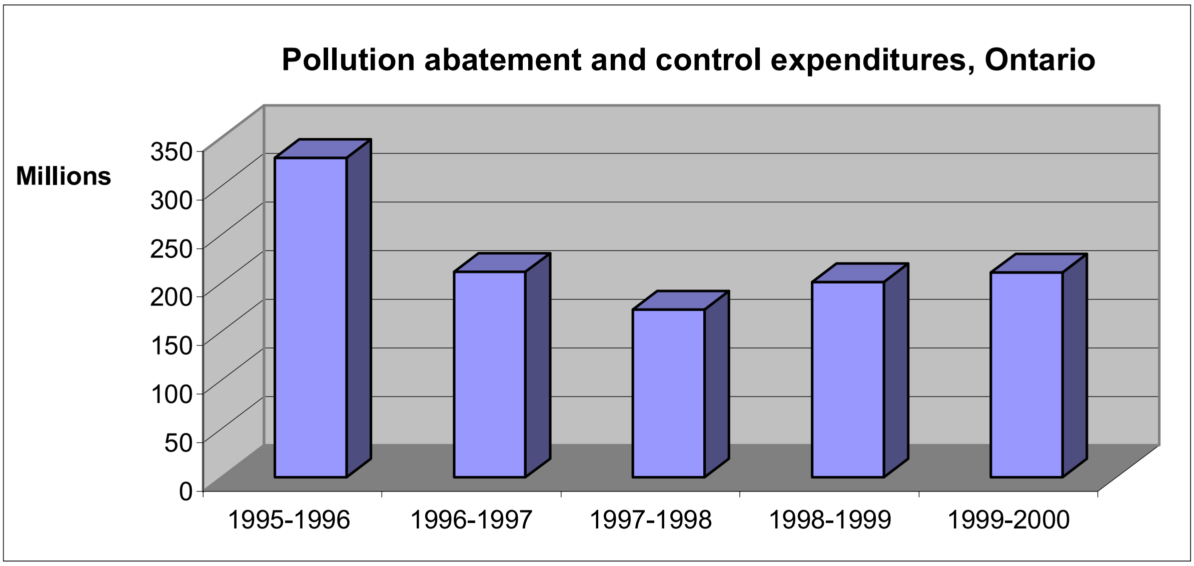
Executive Summary

More than 8 million Canadian and 35 million U.S. residents live, work, and recreate in, on or by the waters of the Great Lakes basin (GLRC 2005). The amount of water in the Great Lakes is estimated to be 6 quadrillion gallons (22.8 quadrillion liters, EPA). These waters are also the foundation of a diverse and unique basin-wide ecosystem.

Industries in the Laurentian Great Lakes region account for more than a third of the combined Canadian and U.S. gross national product (Martin Associates 2001). The area generates two-thirds of Canada's manufacturing output. The Non-Farm Economy of the Great Lakes is $3.7 trillion GDP, representing 30% of the value of the GDP in the US and Canada combined, with an employment base of 43.4 million (Marker 2005). Agriculture contributes $53.4 billion GDP generated from 577,500 farms in Canada and the US (Marker 2005). Gross production in the Great Lakes is third only to the US and Japan economies, notwithstanding its population ranking 12th after China, India, United States, and other nations, and GDP in Ontario is on a steady rise (Statistics Canada).

The area within the Great Lakes basin watersheds is 580,430 km2. Human activity in the same region requires eight times the land and water area to be sustainable (The Sustainability Report accessed 03/06). Sustainable management policies for the future will be impossible to formulate without understanding how management decisions, and on-going transformations in the landscape ecosystems of the Great Lakes Watershed, affect the productivity of species targeted by Great Lakes fisheries (NOAA accessed 03/06).

Statistics Canada estimates the Government of Ontario’s provincial expenditures for environmental improvements in excess of $200 Million per year bearing in mind that over 75% of Ontarians reside in the Great Lakes region.



Source: Statistics Canada

In addition to the quantified values that follow, there are numerous values that cannot be quantified, and should be made explicit in any policy considerations. Clearly, some of the environmental amenities or services that flow from natural resources are more difficult to quantify than others. The difficulty is particularly evident for those resources that are not traded in markets. For example, the value of preserving a species (or the cost of its extinction) is difficult to estimate because there is no way to predict the potential market value the species might have had for future generations. Likewise, the value of preventing further climate change is difficult to gauge because we cannot be sure of all the potential outcomes of no action until they are upon us, and it is no longer possible to prevent them.

Since the intention of this paper is to ascertain the economic value of such an ecologically important (and irreplaceable) resource as the Great Lakes, it is important to be ever-mindful of the major criticism of GDP as a measure of wealth (Rees, Costanza 1997: 253-60) This increasingly prevalent criticism says that GDP has yet to account for the non renewable resource depletion and general entropy and pollution that is often associated with economic growth and traditional measures of societal wealth. The focus on the inadequacy of GDP and its narrow interpretation of economic wealth (frequently gained at the expense of ecological health) continues. It is increasingly the subject of many criticisms and proposals for a more inclusive measure of wealth especially in the discipline of "ecological economics" (Daly, Costanza, Rees, Waring, Brown, Cobb, Green, Hawking, etc.). This distinction is particularly important for natural resources and is a contentious issue, especially in relation to the overexploitation of natural resources. This convention can result in misleading evaluations of resources such as fisheries or recreational "assets" since they rely on natural resources for which no account is made of their depletion. This means that even though a given year's harvesting activity may have over-exploited the stock (even to the point of irreversible depletion), it will still show up as a positive gain for the economy. If the depletion of the resource were also included in national accounts (as they are with inventories of "produced assets") the apparent benefits for the over-exploitation of natural resource assets would be substantially reduced (Ferguson and Krantzberg, 2006).

Protected areas, and nature conservation generally, provide many benefits to society, including preservation of biodiversity, or maintenance of watersheds, for example. Some of these benefits are intangible, but can be can be estimated using environmental economics for valuation of passive uses. The loss of open land and functioning ecosystems is essentially an irreversible process, and little insight is available to those making land-use change decisions as to what tangible and intangible values are being lost. To understand what sustainable development means in a practical sense, it will be necessary to preserve natural capital, or at least articulate and understand the value of the lost natural capital. Such capital is what natural systems provide in the current and future flows of service, such as resources, flora, fauna, and ecosystems that provide human beings with tangible and intangible goods and services that have real use and non-use economic value (Jaffe 2006).

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Economic information should serve as one consideration in a broader decision-making process incorporating all relevant information of environmental, social, and economic factors (Cangelosi 2002). We offer MNR an economic profile of the Great Lakes that should be linked to its environmental and social values in determining policy and program priorities.

Summary of Quantified Economic Attributes of Great Lakes Resources

Sector	Value per annum (except where noted)	Notes	Where value is counted	Relevance to Great Lakes Ecosystem Quality and Water Quantity
Commercial Fishing	$35 million	Landed value of fish only (before processing)	Ontario, Canada	❖ Quality of water in the Great Lakes directly related to prosperity of industry ❖ Contaminant levels in fish are a measure of effectiveness of harmful pollutant management regionally, nationally, internationally ❖ Contaminant levels in fish can also reflect how changes in food web effect contaminant tropho-dynamics; ❖ Contaminant levels that exceed guidelines and regulations for safe consumption, export represent a lost economic, cultural use opportunities) ❖ Lower water levels reduce spawning and breeding areas for native fish
	$91.4 million including indirect sales, employment income and taxes + 1136 person years of work	Direct and indirect sales value		❖ As above
Aquaculture	$23-$24 million	Landed value of fish only	Ontario, Canada	❖ Quality of water in the Great Lakes directly related to prosperity of industry ❖ Lower water levels or changes to nearshore currents could exacerbate waste assimilation from net cultures
	$65 million + 500 person years of work	Total Value added to the economy	Ontario, Canada	
Transportation	$2.2 - $3 billion + 17/18,000 jobs	Value added to provincial GDP through activities generated by transport industry	Great Lakes and St. Lawrence	❖ Lower water levels reduce the transportation/navigation abilities of commercial boats in the Great Lakes, decreases value of maritime transport
Sport Fishing	$7.5 billion	Value of total industry – including money spent on trips, boats, travel, tourism, etc.	Canada and US	❖ Quality of water in the Great Lakes directly related to prosperity of industry ❖ Lower water levels reduce spawning and breeding areas for native fish ❖ Polluted water reduces recreational enjoyment and willingness to participate in industry
	$500 million	Direct Spending on trips only, no secondary effects	Ontario, Canada	

Sector	Value per annum (except where noted)	Notes	Where value is counted	Relevance to Great Lakes Ecosystem Quality and Water Quantity
Recreational Boating	$2.2 billion	Value to the overall economy	Canada (no study available for Canada and interpolated from US values)	❖ Polluted water reduces recreational enjoyment and willingness to participate in industry ❖ Lower water levels reduce navigable pathways for leisure trips
Beaches	$200-$250 million	As valued by beach-goers in terms of what they would be willing to spend and what they do spend to recreate at the beach	Ontario (no study available for Canada and so interpolations made from US values)	❖ Polluted water reduces recreational enjoyment and willingness to participate in industry ❖ Too high/too low water levels reduce aesthetic value/ recreational abilities of beaches
Wetlands and Biodiversity	$70 billion	Includes values of nutrient cycling, flood control, climate control, soil productivity, forest health, genetic vigour, pollination and natural pest control	Canada (unable to separate values by provincial lines – inextricably linked)	❖ Polluted water can negatively affect the health and prosperity of all creatures whose habitat lies within the wetland. ❖ Unhealthy wetlands reduce the positive benefits that humans receive from them such as air and water filtration, biotic enjoyment and useful medicines, etc. ❖ Wildlife viewing is a significant sector and its economic impact in Ontario needs to be included in the report

Summary of Economic Threats to the Attributes of Great Lakes Resources

Threat	Potential Loss Value	Notes	Geographic Area of Reporting
Aquatic Invasive Species	4% loss of native North American freshwater species per decade	Over next century the entrance of AIS could cause the loss of these species through predation, overcrowding, food web alterations, etc.	Both Canada and the US
	$134 billion ($9 billion per AIS expected) 15 most recent invaders could cause this much economic damage by 2050	Zebra mussel – $5 billion/yr (control costs and damages) however no estimation of health effects Sea Lamprey -$12 million/yr in control costs - $6 million studying effects of lampricide Asian Carp – over $9 million on protective barrier and over $450, 000/yr in maintenance of barrier	US (similar effects are expected to be seen on Canadian side)
	$500 million	Control Costs spent by Canada every year on current AIS in Great Lakes (no estimation of environmental impacts)	Ontario mainly, Canada
	$6 million	Preventative Costs for Ocean ships	Both Canada and US
	$4 million	Monitoring, reporting, and public dissemination of all ballasting activities	Both Canada and US
	$2.5 million	To determine immediate prevention measures	Both Canada and US
Infrastructure	$18 billion	Needed over next 15 years to provide drinking water to Great Lakes population due to inefficient pricing of water in the past	Ontario, Canada
Sprawl	$5,300 per unit of housing (1995 dollars)	Additional public and private costs of infrastructure	Applicable to Canada
	$11,000 per unit of housing over a 75 year period	Infrastructure replacement, and operating and maintenance costs	Applicable to Canada
	$700 million - $1 billion	Excess infrastructure, operating, maintenance, emissions, health care, traffic policing, etc. costs	Greater Toronto Area
Social /Lifetime Costs	$93-$250 million	Reduced productivity and increased social costs due to mercury exposure to children in the womb	Ontario, Canada
	$5 billion +	Increased mortality rates due to pollution carried in the Great Lakes region (death rates and increased sickness and hospital stays)	Ontario, Canada
Loss of Transoceanic Vessels	$54.9 million/yr	The reduction in the transport industry if the oceanic vessels were restricted due to concerns over introduction of AIS.	Ontario, Canada

Recommendation For Further Quantification:

- *A study into the direct and indirect benefits of aquaculture in the Great Lakes to Ontario and Canada be performed in order to better understand how to best include these practices into the management of the Lakes. A survey of aquaculture industries has been done by Statistics Canada, however the numbers available should be separated into the different regions where they are seen. This would begin to allow a more accurate assessment of how the aquaculture industry would be affected by different stressors on the Great Lakes.*

Recommendation for Further Quantification

- *A survey of Great Lakes fisheries would be valuable to ascertain precisely their fish markets to help determine where the effects of the methyl mercury contamination would most likely to be seen and could consequently be monitored.*

Recommendation for Further Quantification

- *The extraction of the Canadian portion of the value of wetlands has not been determined, and while the value of maintaining Canada's vast resource of wetlands should be obvious with respect to its provision of the basic necessities of life non-use value methods could be developed to valuate these resources.*

Introduction

Underlined text indicates a hyperlink in the electronic version of this document.

When North America is photographed from space, the Great Lakes are one of the few recognizable surface features. By surface area, Lake Superior, the Ojibwas' "Gichigami" is the largest freshwater lake in the world. Some 1370 kilometers to the east, Lake Ontario's average annual flow rate of 240,000 cubic feet per second or 6,800 cubic meters per second gives birth to the St. Lawrence River—the connection to the Atlantic Ocean. In between, more than 8 million Canadian and 35 million U.S. residents live, work, and recreate in, on or by the waters of the Great Lakes basin (GLRC 2005). The amount of water in the Great Lakes is estimated to be 6 quadrillion gallons (22.8 quadrillion liters). These waters are also the foundation of a diverse and unique basin-wide ecosystem.

The non-farm economy of the Great Lakes is \$3.7 trillion GDP, representing 30% of the value of the GDP in the US and Canada combined, with an employment base of 43.4 million (Marker 2005). Agriculture contributes \$53.4 billion GDP generated from 577,500 farms in Canada and the US (Marker 2005). Gross production in the Great Lakes is third only to the US and Japan economies, notwithstanding its population ranking 12th after China, India, United States, and other nations.

The Great Lakes have provided resources to humans since the arrival of the first aboriginal North Americans. Europeans that penetrated into the continental interior from settlements along the St. Lawrence River relied on Great Lakes services both as a transportation waterway and source of sustenance. As communities settled along its shores, fishing was established as a commercial activity.

Great Lakes commercial fishing, including aboriginal activity is almost entirely a Canadian economy, having been severely restricted and in some cases eliminated from US waters. The historical reasons for this situation are related to some extent to the severe stresses placed on Great Lakes ecosystems in the mid-20th century. The depleted states of some once-abundant stocks and public perception of the Great Lakes as polluted combined to make commercial fishing precarious in the U.S. Former staples of the industry were in short supply and those that remained were perceived to be unfit for human consumption (Meisenheimer 2006).

Nevertheless, the value of the Great Lakes to Canada and Ontario is immense. The Great Lakes provide drinking water for the millions of residents. One in three Canadians and on in 10 U.S. residents depend on the great Lakes for their water (Great Lakes Commission). They support an abundance of recreational opportunities, and provide a marine transportation system for industries and businesses. Combined with the St. Lawrence Seaway, the Great Lakes link to markets around the world.

Industries in the Great Lakes region account for more than a third of the combined Canadian and U.S. gross national product (Martin Associates 2001). The area generates two-thirds of Canada's manufacturing output.

U.S. and Canadian Great Lakes bulk carriers called "lakers" (75 US and 90 Canadian) move cargo among Great Lakes ports, with both nations' laws reserving domestic commerce to their own flag carriers. Ocean ships called "salties" flagged by their respective countries connect the Great Lakes with the rest of the world. One thousand St. Lawrence Seaway salties arrive per year, and about 50,000 barges connect with the rivers. The Great Lakes are also linked to the U.S. inland river navigation system, via barge traffic through Chicago Sanitary and Shipping Canal, connecting the Illinois Waterway to the Mississippi River (Martin Associates 2001).

The Great Lakes are an unmatched recreational asset. The lakes host millions of Canadian and U.S. registered boats. The Great Lakes sport fishery alone contributes billions annually to the regional economy. An estimated 1.2 million recreational boats are registered in Ontario's portion of the Great Lakes.

Resource-based tourism is an important part of Ontario's economy. It includes segments of the tourism industry that depend on traditional resource-based activities such as hunting and fishing, as well as newer economic opportunities based on ecotourism and adventure travel (MNR 2005). The Great Lakes Coastal Areas and the Lake Nipigon Basin have highly significant ecological values with extremely significant tourism and recreation potential. The Heritage Coast provides habitat for numerous significant plant and animal communities, and has fisheries habitat crucial to the ecosystem of the Great Lakes. The Great Lakes Enhanced Management Area policies apply to all Crown lands, waters, lakebeds, Crown islands, and intervening coastal areas along the Great Lakes shoreline from Port Severn in Georgian Bay, through the North Channel of Lake Huron, to the international border south of Thunder Bay on Lake Superior (MNR 2005).

The five National Parks on the Great Lakes include Bruce Peninsula, Georgian Bay Islands, Point Pelee, Pukaskwa, and the St. Lawrence Islands. These ecosystems and the biological diversity they support are natural assets that contribute to the economy. Wetlands are particularly important to biodiversity. Methods to measure the sociological and economic benefits of wetlands show promise and are beginning to demonstrate the returns on investment from actions to sustain wetlands and the benefits that may be lost if they are degraded.

Some form of cost-benefit analysis has been part of water resources management decision making for most of the twentieth century. Although the methodology has varied significantly over time, advocates for cost-benefit analysis have always asserted that this tool, though imperfect, makes a contribution to the public debate about allocating budget funds or making regulatory decisions. During much of the history of benefit cost analysis for water development projects, such as infrastructure expansion or upgrades, and more recently in evaluation of regulations, environmental services were not recognized or were treated as intangibles that should not be subject to quantitative benefit measurement. Instead, benefit analysis was reserved for services that had market analogs. For example, navigation benefits were likened to rail and pipeline transportation. Flood damage reduction benefits were related to avoided costs of making repairs to a building or making up for lost income in a business. After the 1960s, economists refined the theoretical foundation for monetary valuation and then developed databases and empirical tools to estimate monetary values for environmental services. The profession now has refined it approaches for measuring the benefits of direct use of the environment (e.g., the value of a day of salmon fishing) and passive benefits (e.g., the value of simply knowing that a salmon population exists in a river) (Shabman and Stephenson 2000)

Quantitative information on the benefits derived from environmental remediation is generally insufficient to specifically assess the economic and biological benefits of remediation. Only a qualitative description of the potential benefits resulting from improvements in ecosystem health as a result of implementing remedial measures is possible because of: (1) the complexity and diversity of the aquatic systems, and the diversity of ecological receptors for various stressors; (2) stress and exposure conditions; (3) the complexity of ecosystem structure and function, and uncertainty in the interaction between factors involved in ecosystem recovery and responses; and (4) uncertainty regarding the extent to which remediation will result appreciable changes in ecosystem health (California Environmental Protection Agency accessed 3/06). Opportunity cost of paying for remediation could be used as a surrogate.

The aquatic ecosystems of the Great Lakes include food webs of phytoplankton, invertebrates, fish, birds, mammals, and other organisms that interact with each other through a complex flow of matter and energy. When remediation takes place, the aquatic system should improve and biota respond.

An improved perception of water quality will also have a positive impact on the other non-consumptive water-associated uses of a particular location (Hanna, pers. comm.).

Opportunities and Challenges under the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem

Recognizing the need for shared action to protect the Great Lakes, Canada and the U.S signed the Great Lakes Water Quality Agreement (GLWQA) of 1972, revised in 1978, and amended by protocol in 1987. The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA) is a federal-provincial agreement aimed at the enhancing and protecting the Great Lakes Basin Ecosystem. The Agreement outlines how the two governments will cooperate and coordinate their efforts regarding Great Lakes basin management, and how Ontario will assist Canada in meetings it commitments under the GLWQA.

The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem

Accord Canada-Ontario concernant l'écosystème du bassin des Grands Lacs

COA was first signed in 1971 in anticipation of the Canada-United States GLWQA. There have been six COA's since 1971. Through the 1970s and 1980s, COA served as a cost share arrangement directed principally at sewage treatment plant upgrades and monitoring and surveillance. More recent COAs were based on existing government programs and funding projections, in efforts to coordinate and complement activities between Canada and Ontario. In anticipation of the 2002 COA, Ontario received $50 million over five years, and the federal Great Lakes Action Plan was renewed at a level of $40 Million for five years, the latter with an emphasis on implementing Remedial Action Plans. Eight federal departments and three provincial ministries signed the most recent COA in 2002 and it expires in 2007.

COA has achieved many successes, and continues to face challenges. The technical and fiscal resources essential to implement the commitments have been limited. Ongoing serious threats remain absent under COA (see below for further detail). For example, the number of introductions of exotic species has soared to approximately two new invaders per year. Such introductions are among the most significant threats to biodiversity in the Great Lakes, and programs for prevention, mitigation or adaptation are absent from COA. The economic impact of such introductions is direct, when it affects the vitality of fisheries and the intakes pipes of industry and municipalities. It is indirect when it injures biodiversity, for example, of biologically rich systems. Further signs of distress in the lakes are the lack of appreciable natural reproduction of lake trout in the lower lakes, while other desirable fish population levels remain severely depressed.

While phosphorus reductions at wastewater treatment plants in the 1970s and 1980s led to successful algae reduction, cladophora again fouls some beaches and near-shore habitats posing a costly challenge to COA partners both in terms of benefits lost (such as tourism revenue linked to recreation) and remedial investments required to upgrade aging infrastructure. Municipal wastewater treatment infrastructure is old and deteriorating, and sewage and combined sewers overflow during storm events allow untreated wastes to enter the Great Lakes. Contaminated sediment continues to be a source of pollutants into the food chain, resulting in elevated concentrations of PCBs and mercury in fish, wildlife, and humans along with associated health costs and lost opportunities for economic development. Tributary flows and habitats, essential to the fish of the Great Lakes, have been negatively altered by local watershed activities that change hydrology. Wetlands that provide habitat and serve as pollution filters continue to be lost.

A sustainable approach to achieving balance between economic, societal, and ecological needs should be integrated into the use, development, rehabilitation, and conservation of Great Lakes resources. Individuals, private enterprises and local communities can generate sustainability through their actions and decisions. Provincial and federal governments play important roles in promoting sustainable behaviour through guidance, outreach, and support to enhance the capacity of local communities, as well as through policy and funding decisions under COA or otherwise. Illuminating the economic value of the Great Lakes that is dependent upon healthy ecosystems, and central to societal well-being could help mobilize movement towards a sustainable Great Lakes Basin Ecosystem.

An evaluation of current and future human activities in the Great Lakes Basin highlights trends that continue to threaten ecosystem services which have economic value, and direct economic competitiveness including:

- Loss of natural and agricultural lands to development at rates exceeding population growth;
- Increased demands on ecosystems for recreation;
- An aged water and wastewater infrastructure unable to handle current demands;
- Ongoing threats to biodiversity and ecological services due to alien invasive species and climate change;
- Increasing demands on ecosystems for aquaculture production;
- Disconnected programs for planning and management of ecosystem services;
- Sprawl and the increase of impervious surfaces, exacerbating nonpoint source pollution, which is likely to increase in response to climate change.

Great Lakes Stressors

Land Use and Urban Sprawl

Land use and water resources are unequivocally linked. The type of land and the intensity of its use will have a strong influence on the receiving water resource. The impact of land use practice on either the quantity or quality of water can be substantial.

Although there are many definitions of sprawl, a central component of most definitions and of most people's understanding of sprawl is this:

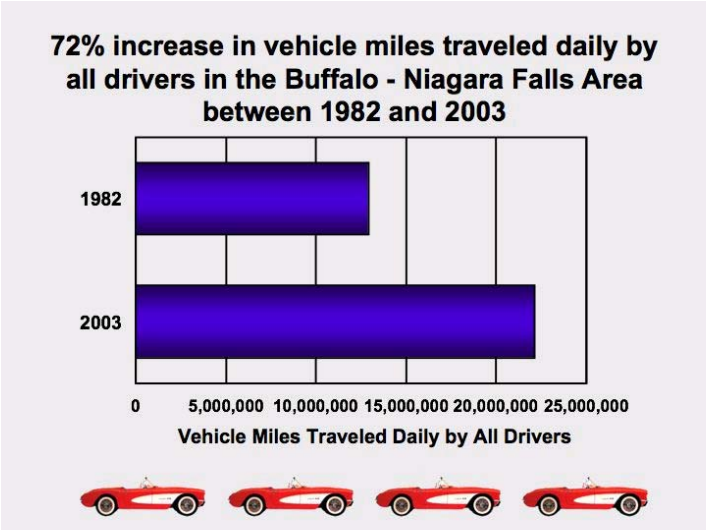
> Sprawl is the spreading out of a city and its suburbs over more and more rural land at the periphery of an urban area. This involves the conversion of open space into built-up, developed land over time.

Ontario's major urban centres are growing rapidly. Without careful planning and compact development the region will lose more open, pervious space and exacerbate air and water quality problems.

Poor water quality remains a persistent problem across the basin. Sprawl adds to this in several ways. Rain and snowmelt move across highways, roads, parking lots and yards, washing contaminants into storm drains, rivers and lakes. As land in the watershed is converted to hard surfaces that are impervious to water, the area loses its ability to absorb and store rainfall. Roads and parking lots accumulate oil, solvents and other contaminants that are discharged untreated into the receiving water during storm events. Research suggests that when impervious surfaces cover more than 10 percent of a watershed, the water bodies they surround become degraded (e.g. Smart Growth America). This clearly characterizes all of the major cities in Ontario on the Great Lakes (Nirupama and Simonovic 2004).

Low-density, automobile-dependent development is a leading cause of the increase in imperviousness. Transportation-related hard surfaces account for over 60% of the total imperviousness in suburban areas. For instance, a half-hectare parking lot produces 16 times more runoff than an undeveloped meadow (Natural Resources Defence Council 2002).

With the proliferation of impervious surfaces and extreme storm events, precipitation causes flash flooding. There is less recharge with subsequent decreases in groundwater flows.



As development spreads farther into wild lands and watersheds, fish and wildlife habitat becomes fragmented. Fragmentation results in species loss and presents a threat to biodiversity. An increasing population, developmental pressures, absence of land use planning, and competition for water resources, continually contribute to the degradation of water resources (Institute of Water Research accessed 03/06 2006). Managing water resources on a watershed basis will help address potential impacts including:

- Changes in water flow and storage which may lead to floods, drought, or changes in microclimate
- Deterioration of water resources due to lack of soil conservation and increased input of pollutants
- Decline in water resources due to excessive use (overexploitation)
- Increases in soil erosion and salinization due to poor land use practices

Coastal communities in the Great Lakes are sensitive to changes in water levels, which occur due to extremes in the balance of precipitation and evaporation. High water levels lead to shoreline erosion and the loss of houses constructed too close to the lakes. Low water levels reduce beach access, the use of docks and can make navigation hazardous, all with quantifiable economic implications.

Sprawling regions generate more pollutants from mobile sources, as more people drive longer distances more often. Gridlock affects our economic well-being (MMAH accessed 03/06). Congestion in the GTA and Hamilton is estimated to cost the economy $2 billion per year because it delays the movement of goods. MMAH points out that if Ontario continues to grow in the same way, it is estimated that the time needed to travel from Toronto to Hamilton will nearly double from an hour and a half in 2000 to about three hours in 2021.

Exhaust from vehicles that idle in gridlock contributes to poor air quality and smog. Carbon dioxide emissions double when speeds drop from 55 to 30 km per hour. The number of smog advisories in the Toronto area has increased from a total of one in 1993 to 20 in 2001. Poor air quality causes 5,000 hospital admissions in the central zone each year. As Ontario grows in a sprawling fashion, people use cars more frequently than in the past. Between 1964 and 1996, the number of vehicle trips per day has increased from 3 million to 10 million – an increase of 333 per cent.

Other pollutants emitted by cars, such as benzene and particulate matter are associated with increased risk of lung and other cancers, particularly for those who live near major roadways (MOE accessed 03/06 2006).

The high cost of providing and maintaining infrastructure for sprawling development hurts taxpayers and contributes to the fiscal crises facing many local governments. Sprawling development does not generate enough tax revenue to cover the costs to local municipalities for new infrastructure and public services.

Research by Colorado State University found that in Colorado, "dispersed rural residential development costs county governments and schools $1.65 in service expenditures for every dollar of tax revenue generated." (Environment Colorado Research and Policy Center 2003). Whether the developer, the new homebuyer, or the local government pays the costs for new sewer and water hook-ups, water and sewer services constitute a large portion of the capital costs of new communities. However, sprawl can inflate the costs of this new infrastructure by 20 to 40 percent (ibid). Additionally, the cost to provide public infrastructure and services for a specific population in new sprawling development is higher than to service that same population in a smart growth or infill development. Sprawling communities require longer public roads and water and sewer lines to provide services.

Climate Change

In general, climate change models applied to the Great Lakes region predict warmer and probably drier weather during the twenty-first century. While annual average precipitation levels are unlikely to change, the seasonal distribution is likely to, increasing in winter and decreasing in summer. Increases in rain or snow are not predicted to compensate for the increased evaporation and transpiration in a warmer climate, including evaporation during winter months when ice cover on the lakes is absent or transient. Declines in the duration of winter ice are expected to continue. This will affect surface and groundwater levels, and soil moisture is projected to decrease by 30 percent in summer (Union of Concerned Scientists 2005).

The distribution of many fish and other organisms in lakes and streams will change as will the economic value associated with these species. Coldwater species such as lake trout, brook trout, and whitefish and cool-water species such as northern pike and walleye could decline in the southern parts of the region, while warm-water species such as smallmouth bass and bluegill could expand northward. Warmer waters in the region's lakes and streams would reduce the size of favourable habitat for trout, whitefish, and other cold-water fish species. A recent EPA study found that a warming of 4.5°F over the next 70 years could cut the habitat of brook, rainbow, cutthroat, and brown trout by one-fourth to one-third throughout the U.S. A 4.5°F warming is slightly below the midpoint of the 2-8°F range predicted by climate models for the year 2100; the actual temperature change that occurs could be smaller or greater. Chum, Chinook, pink, and Coho salmon would experience similar habitat losses. These observations are applicable to Ontario's portion of the Laurentian Great Lakes region.

Indigenous species currently found just to the south of the region and warmwater non-native species such as common carp are predicted to expand their ranges, increasing competition with native plant and animal populations in the region and exacerbating the costs associated with invasive species (see elsewhere in this document). With the warming trend, the duration of summer stratification should increase, adding to the risk of oxygen depletion and formation of hypolimnetic anoxia. Prolonged warmer water temperatures signal potentially adverse conditions for the survival of aquatic organisms. For example, outbreaks of type E botulism occurred in the eastern basin of Lake Erie between 1999 and 2002, a period of high lake-water temperatures (e.g. 25.0 to 25.7 ^{o}C maximum) (Alben et al. 2006). Warmer temperatures and shorter cold seasons could allow disease-carrying hosts to survive at locations further north than at present. Mosquito-borne diseases such as malaria and encephalitis could expand into Canada, presenting a challenge for our health care system. Changes in ecosystems may allow different species of plants to flourish, possibly causing problems for asthma and allergy sufferers (Environment Canada accessed 03/06).

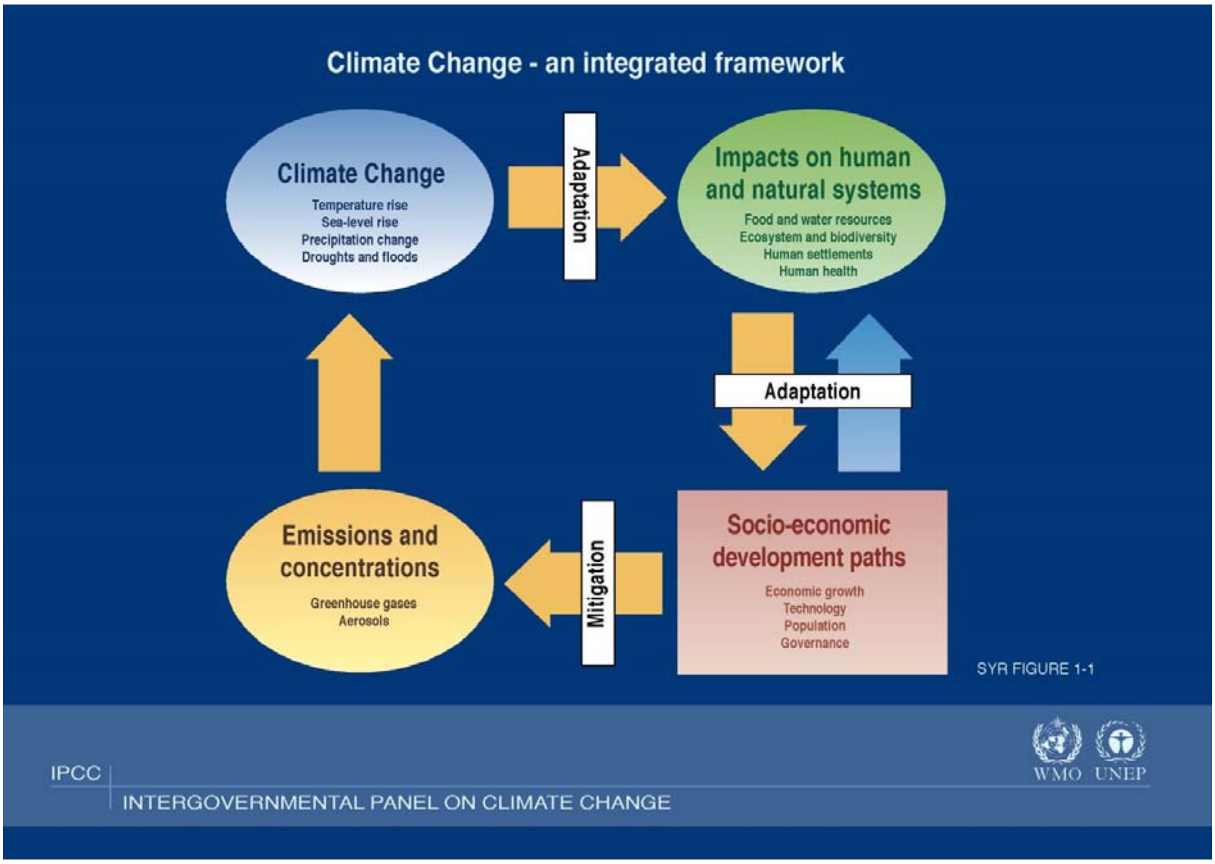
Earlier ice break-up and earlier peaks in spring runoff will change the timing of stream flows. Changes in the timing and severity of flood pulses are likely to reduce safe breeding sites, especially for amphibians, migratory shorebirds, and waterfowl, and may cause many northern migratory species such as Canada geese to winter further north. Insect-eating migratory birds might have trouble finding food. Similarly, birds that lay their eggs earlier might have poor nesting success if their young hatch before favoured prey species become available (USEPA accessed 03/06).

Reduced summer water levels would diminish the recharge of groundwater supplies, cause small streams to dry up, and reduce the area of wetlands, resulting in poorer water quality and less habitat for wildlife. As lake levels drop, costs to shipping in the Great Lakes are likely to increase, along with costs of dredging harbours and channels and of adjusting docks, water intake pipes, and other infrastructure. Ingram et al (2006) used wetland vegetation and bird community predictive models to estimate impacts on community structure due to reductions in mean annual water levels for Lakes Ontario and Erie. They concluded that shoreline alteration and coastal geomorphology would inhibit the ability of current wetland communities to persist under declining water level scenarios. Existing wetland conservation projects and future Great Lakes coastal wetland conservation programs will need to factor in climate change scenarios to ensure that actions taken in the next 10 years remain good conservation decisions into the future.

River flooding may become more common and extreme because of more frequent rainstorms onto more impervious surfaces. This will degrade the natural capital associated with the flood-absorbing capacities of wetlands and floodplains. The result could be increased erosion, additional water quality deterioration from higher loads of nutrients, pesticides, and other contaminants with concomitant societal and economic costs.

Water withdrawals from the Great Lakes are already the subject of contentious debate, and pressures for more water for irrigation, drinking, and other human uses may intensify the conflicts as water shortages develop.

The Intergovernmental Panel on Climate Change presents the complex set of responses in the integrated framework below.



Exotic invasive species

The flow of invasive species to the Great Lakes continues. In 2001, scientists estimated that 162 invasive species had entered the lakes from all pathways (IJC 2004). Today, some scientists have raised that estimate to more than 180 non-indigenous fish, invertebrates, plants, algae, protozoa and parasites, and predict that one new non-indigenous species will be discovered in the lakes about every six months.

A new international convention to prevent the potentially devastating effects of the spread of harmful aquatic organisms carried by ships' ballast water has been adopted by the International Maritime Organization (IMO), the United Nations agency responsible for the safety and security of shipping and the prevention of marine pollution from ships. The instrument was adopted at an international conference held in February 2004 at IMO's London Headquarters.

The Convention will require all ships to implement a Ballast Water and Sediments Management Plan. All ships will have to carry a Ballast Water Record Book and will be required to carry out ballast water management procedures to a given standard. Existing ships will be required to do the same, but after a phase-in period.

Parties to the Convention are given the option to take additional measures that are subject to criteria set out in the Convention and to IMO guidelines yet to be developed. Provisions of the International Maritime Organization Convention on standards for ballast water discharge could take at least five to eight years to come into full force. Given the current rate of introductions, the Great Lakes could be at risk from eight to 12 additional non-indigenous species during that time. Any one of these new invaders could prove to be as ecologically and economically destructive as those already in the system, if not more so.

New introductions of aquatic species could add to the serious economic costs and ecological damage in Great Lakes, affecting both countries (Pimentel et al 2000). As emphasized by the IJC (2004) a binational, regional plan is essential to stop this influx. There are limited points where controls are needed to halt aquatic alien invasive species from entering the Great Lakes. For instance, sea-going ships gain access by a single gateway, the St. Lawrence River Seaway, which the United States and Canada share. The numbers and classes of foreign ships that ply the waters of the lakes — as well as the cargoes they carry — are well documented, and are significantly more manageable than those found throughout the entire international maritime shipping industry.

Toxic Chemicals

Toxicity problems emerged in the Great Lakes earlier than in other regions because most of the pollutants entering the lakes are retained. The residence time of Lake Superior, for example, is some 200 years. Concentrations of persistent toxic substances remain high in some locations and several top predator species. Atmospheric deposition, release from sediment, and diffuse runoff continue to hamper recovery of the Great Lakes ecosystem causing economic damage to the provision of valued services the lakes could support.

Recent data analyses and modeling efforts have highlighted that changes in the structure of the foodweb (e.g. presence of exotic species such as zebra mussel) can have dramatic effects on contaminant concentration levels in fish and wildlife higher up the food chain (Jackson 1996). Understanding these processes could result in more effective abatement and monitoring programs. It would also promote better public awareness of the effectiveness and complexities of clean-up efforts. This is particularly so, if decreases in contaminant loadings happen concurrent with to increases in contaminant levels in fish and wildlife caused by changing foodwebs, not more pollution (Science Advisory Board, 1997).

The global cycling of chemicals is affecting and will continue to affect the Great Lakes. Of transboundary consequence is the continued use or generation of persistent toxic substances such as mercury, DDT, PCBs, PAHs, mirex, dioxin and furan, to name a few. While banned from use in Canada and the United States, DDT continues to be sold and used in other jurisdictions. These compounds are found in the Basin, and result in impaired fish, wildlife, and human health. Neither local nor basin-wide restoration programs can fully address these chemicals when atmospheric deposition from long-range transport is the dominant loading pathway.

New Human Health and Chemical Effects

Research in the Great Lakes region provides evidence linking air pollutants such as ground-level ozone, sulphates, and airborne particles, to adverse effects on respiratory health. These include reduced lung function in children, and increased hospital admissions for respiratory ailments.

Endocrine disruption caused by gender bender chemicals is emerging as a major issue for the residents in the Basin due to the significant human health implications. Human health effects due to endocrine disruption remain controversial, and the substances that may be responsible for health risks are not well defined. However, some pesticides, certain chemicals used in the manufacture of plastics, some other industrial chemicals as well as some naturally occurring substances have been shown to mimic the action of estrogen in tissue cultures and laboratory animal studies (Health Canada 1997). Analyses of historical data indicate a decline in sperm quality and quantity of men in developed countries. Limited evidence suggests an increase in bladder and colon cancer risk associated with long term exposure to high levels of chlorination by-products (Marrett and King 1995).

Increasingly, jurisdictions and organizations such as the IJC are raising the potential for human health effects resulting from proximity to the Great Lakes Basin. The concentrations of such contaminants in the tissues of people eating large amounts of Great Lakes fish continue to be several fold higher than in people who do not eat such fish.

At – risk populations continue to be exposed to persistent toxic substances. Some highly exposed groups have body burden levels 3-4 times higher than the background level despite reductions in discharge to the aquatic environment (Asplund et al. 1999), which calls into question the effectiveness of risk communication.

Postulated human health effects linked to exposure from the Great Lakes Basin ecosystem include a reduction in IQ for the children exposed in utero to PCBs (Chen et al. 1992) and mercury (Commission for Environmental Cooperation 2004, International Joint Commission 2004). There is evidence among the various studies that PCBs/dioxins or a specific subset of these chemicals are the agents responsible for at least part of the observed difference in neurobehavioural outcomes for the infants exposed to these teratogenic agents in utero.

There has been a major increase since the late 1990s in the measurement and detection of organic chemicals that are not presently classified as persistent organic pollutants (Krantzberg et al. 2006). These chemicals include:

- Polybrominated diphenyl ether flame retardants (PBDEs) widely used in polymers and textiles;
- Fluorinated surfactants used to make hundreds of everyday products from non-stick cookware and water- and stain repellent coatings for carpets and raincoats to cosmetics, paper products, and polymers for electronics;
- Chlorinated naphthalenes (PCNs) used in cable insulation, wood preservation, electronics manufacturing, and dye production;
- Chlorinated alkanes (also known as chlorinated paraffins) found in paints and adhesives as well as fluids used in cutting and machining metals; and
- Pesticides currently in use such as endosulfan and lindane.

Despite the limits and weaknesses of individual pieces of research, the collective weight of evidence is compelling: people are continuing to be exposed, and there are health consequences and associated health care and societal costs resulting from these exposures.

Methods for Valuation of Natural Resources:

Literature Review

The valuation of any natural resource can be performed in a number of ways depending on the particular nature of that resource. The following literature review outlines the methods used commonly today in order to determine the total economic value of the Great Lakes. Value generally, consists of three elements (Tietenberg 2006).

- Use Value – direct use of the environmental resource – fish harvested from sea, timber from forest, water extracted from a stream for irrigation
- Option Value – willingness to preserve an option to use the environment in the future even if one is not currently using it
- Non Use Value (existence value) – willingness to pay for improving or preserving resources that one will never use

Total Willingness to Pay is the sum of these three values.

Tietenberg suggests that these values can be determined by methods contained in one, some or all of the following valuation method classifications: Direct Observation, Direct Hypothetical, Indirect Observable and Indirect Hypothetical.

Valuation Methods by Classification

- *Direct Observation Methods*

For a number of natural resources, actual resource values can be inferred for certain aspects of their total overall value. (Tietenberg, 2006) A clear example of this is the value of the fish harvested from the Great Lakes. These resources have a clear financial value, as they are part of a market on which they are traded. This value is then calculated as the number of fish harvested multiplied by the market price for the particular variety of fish.

The Northeast-Midwest (NEMW) Institute and the National Oceanic and Atmospheric Administration (NOAA) describe direct observation methods as

> "For goods traded in markets, economists estimate changes in producer and consumer surpluses to determine the change in economic value associated with environmental interventions" (NEMW 2001)

They also include Defensive Expenditures as the expense of the work, technology, remediation, etc. that would be required to bring the natural resource back to its current level of productivity. This amount can be used to help to determine the lower bound of what the value of conservation of the natural resource is. In general these methods are relatively standard and well accepted due to the explicit value of the goods and services being traded in the marketplace (NEMW 2001).

- *Direct Hypothetical Methods (Contingent Valuation)*

In contrast to Direct Observable values, the Direct Hypothetical valuation methods can be used where there is no specific market price for the resource. In this type of valuation, non-use values can be elicited by a survey of what people would be willing to pay to preserve the species, services, or ecosystem (Tietenberg, 2006).

Caution should be used with direct hypothetical methods as the answers and results can be biased by the nature of the questionnaire or survey method. Tietenberg categorizes the four types of bias as:

1. Strategic Bias – the desire of the respondent to alter results of the survey to influence a particular outcome more so than their individual response would allow.
2. Information Bias – where the respondents are ignorant of the necessary information that would allow them to accurately valuate the natural resource.
3. Starting Point Bias – predefined answers that do not allow the respondent to correctly value the natural resource and that skew the results by artificially defining the range of possible answers.
4. Hypothetical Bias – the knowledge that the respondent will never actually have to pay for the natural resource may cause them to enter into the survey too casually and not provide an accurate response.

The more meaningful and well defined are the choices placed before participants, the more their responses will reveal about the choices they would make if the situation were real. This type of valuation could be appropriate for many applications to Great Lakes resources including fisheries, remediation of contaminant sediment, wetland and fish habitat restoration, marina development, and redevelopment of harbours and other coastal areas (NEWM 2001).

This method can be comprehensive in the range of applicable value types (use and non-use) that can be included, and is flexible. Contingent Valuation (CV) is a means of estimating total values, including passive use values. CV is less demanding in terms of data and statistical procedures than other methods. Revealed preference methods (discussed below) depend on statistical techniques to unravel economic values implicit in choices that people actually make. (NEWM 2001)

Decision-makers who base choices on CV results should expect to be able to defend the validity of the method or of the individual studies on which they are deriving valuation results. CV studies vary greatly in quality such that the results of any given study probably should be carefully reviewed. The merits of each study need to be considered on a case-by-case basis. (NEWM 2001)

- *Indirect Observable Methods*

Indirect Observable methods are used when the resource is not part of the market economy – either the resource is free or it is not traded but the value can be inferred by other methods. There are two methods mainly used in this category; the Travel-Cost and Hedonic Value and Wage Methods.

By way of illustration, if the entrance to sport fishery is free, one can infer its value to its users by the time and money (including foregone income and opportunity costs) that they are willing to spend in order to use it. This is known as the travel cost method (Tietenberg, 2006). These values can help determine the effects of changes to the natural resource in respect for the customers “willingness to pay” for it. In order to use the travel-cost method to value an intervention, behaviour must be linked to the effects the intervention has on the resource (NEMW 2001).

The two main types of travel-cost models are single-site and multiple-site models. The two approaches differ in how explicitly they account for the availability of substitutes. The single site travel cost method does not take allow for substitutes on the value of the resource whereas the multiple-site method does with the use of a random utility model (RUM) (NEMW 2001). In other word, the value of a particular park or reserve will be valued more highly in the single-site method since there is no accommodation for substitutes. The value, or willingness to pay for a commodity is directly linked to the availability of substitutes for that commodity. In the multi-site method, the availability of other sites to act as substitutes for each other, devalues the individuals willingness to pay for any one site in particular.

The Travel-Cost method mimics empirical techniques used elsewhere by economists and is based on actual behaviour compared to verbal responses about a hypothetical situation. Travel-Cost methods cannot be used when there is not observable behaviour to reveal values and so non-use values must be determined by other methods. Also, there must be a relationship between the trips to the resource that corresponds to the quality of the resource and the variances in market outlays and time costs amongst individuals must be considered (NEMW 2001).

Multiple regression analysis can be used to infer the value of being close to natural resources or to avoid environmental risks from changes in the price of housing. This is the Hedonic Value and Wage Method. It can also be used to infer the value of wages needed to convince an individual to take on exposure to the risk (Tietenberg, 2006). A leading strength of the hedonic valuation method is its use of actual market transactions. The values derived are not merely hypothetical or expressions of intent; they reflect real commitments of consumers to achieve specific environmental quality improvements through the choice of residences or jobs. Data availability often limits what can be included in a hedonic study and, more generally, the types of environmental quality that can be analyzed. Price, attribute, and socioeconomic data are needed for a large number of individual transactions, and such detailed data are routinely available for only a few goods and services. Hedonic valuation only provides a partial estimate of the value of environmental changes and non-use values are not recognized (NEMW, 2001).

- Indirect Hypothetical Methods

Using this method, a set of choices is given and the respondents select among alternate states of the world (instead of willingness to pay). Researchers try to derive marginal willingness to pay from the choices of the respondents.

Notes for Implementation of Valuation Methods:

Environmental projects often generate primary and secondary effects. These should be explicitly described. Their inclusion in the valuation process can be counted where the secondary effects would otherwise go uncounted (Tietenberg, 2006).

Intangible benefits should be detailed at least qualitatively since they are much harder to quantify. Sensitivity analysis of the estimated benefit values derived from less than perfectly reliable data will help in defining the importance of that benefit (Tietenberg, 2006).

Benefits transfer is the application of the results from any of the above studies to another natural resource intervention or geography and can be a useful alternative to repeating studies. The resource or the interventions must be adequately similar for the transfer of knowledge to be valuable (NEMW 2001).

Valuation Estimates by Category

Commerce and trade: value of, including employment

Fishing and Aquaculture

Commercial fishing was once a large industry in the Great Lakes, however only pockets still remain mainly because the more valuable, larger fish have given way to small and relatively low-value species (Great Lakes Information Network). Nevertheless remains one of the largest fresh water fisheries in the world. While landings over the past decade are declining, at approximately 1/5 of historic maximums, the landed value is increasing. In 2005, Ontario's Great Lakes landings (29.5 M lbs) by the commercial fishing industry were worth approximately $35 million Cdn./yr (MNR Harvest Statistics for the Province of Ontario, 2005). The Lake Erie commercial fishing industry is socially and economically important to the province. There are 211 commercial fishing licenses on Lake Erie. Commercial fishers operate out of 11 communities along the Lake Erie shoreline. In 2004, a total of 12.3 million kg (27 million lbs.) of fish were caught with a landed value of $23.7 million (before processing). Lake Erie's harvest represents 80 per cent of the total value of Ontario's commercial fishery and 76 per cent of the province's total catch. Of that total, 1.3 million kg (2.9 million lbs.) of walleye were caught with a landed value of $6.5 million. 2.4 million kg (5.3 million lbs.) of yellow perch were caught with a landed value of $10 million.

In 2000, an initial expenditure of $40.4 million from commercial fishing generated income, employment and tax benefits in Ontario. This initial expenditure generated an estimated total of $96.1 million in direct plus indirect sales volume. In terms of Gross Provincial Income, the estimated impact of commercial fishing amounted to $43.6 million or 45.4% of total gross output (MNR, pers. comm.).

The impact in terms of employment was 1136.1 person years of full-time job equivalents. A total of $26.2 million of labour income is paid to persons employed in jobs associated to commercial fishing, $11.6 million of which is paid to persons directly involved in commercial fishing activities. Taxes generated as a result of commercial fishing activities amounted to a total of $15 million. The federal, provincial and local governments collected $7.4 million, $4.8 million and $2.3 million respectively (MNR, pers. comm.). The next highest yield is the invasive species smelt. In totality, then, this amounts to $91.4 million direct and indirect benefits of the commercial fishery in that year.

In addition to the value of the open fisheries, there are an increasing number of aquaculture operations in the Great Lakes. Statistics Canada (2005) defines aquaculture as an industry comprised of establishments primarily engaged in farm-raising finfish, shellfish or any other kind of aquatic animal. Statistics Canada valued the aquaculture industry in Ontario in 2004 as having a gross output of $22.7 million consisting of the sales value of products and services (whole fish dressed, fish eggs and live fish, finfish and molluscs, etc).

Similarly Sippel and Muschett (1999) determined that the farm gate value of the industry was worth $24 million Cdn. in 1997 ($23 million trout and $1 million other species). In addition, an estimated $65 million was contributed to the provincial economy through the creation of over 500 person years of employment and their spin-off investments.

These numbers represent aquaculture in Ontario, not just from the Great Lakes however the majority of aquaculture in Ontario occurs in Lake Huron (University of Manitoba, 2003). The economic contribution of $65 Million estimated above, is comparable to that reported by the University of Guelph, below.

Ontario Aquaculture Production Summary

	Annual Production			Farm-gate Wholesale Value			Employment			Economic
Year	Rainbow trout (tonnes)	Other fish (tonnes)	TOTAL (tonnes)	Rainbow trout (million $)	Other fish (million $)	TOTAL (million $)	Full-time (person-years)	Part-time (person-years)	TOTAL (person-years)	Contribution (million $)
1999	3,850	125	3,975	15.5	1.3	16.8	176	64	240	50 – 60
2000	4,000	225	4,225	16.5	1.3	17.8	164	66	230	60 – 65
2001	4,135	225	4,360	16.1	1.3	17.4	160	60	220	60 – 65
2002	4,550	225	4,775	18.2	1.3	19.5	165	75	240	60 – 65
(2003)	4,200	150	4,350	16.4	0.9	17.3	160	60	220	60 – 65
2010 estimate	*5,000*	*500*	*5,500*	*22.0*	*3.0*	*25.0*	*175*	*50*	*225*	*70*

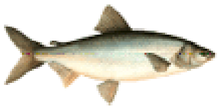
Note: preliminary estimate for 2003

Data Collected and Provided by Aquaculture Centre, University of Guelph, 2004

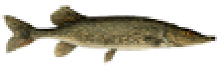
Recommendation For Further Quantification:

- *A study into the direct and indirect benefits of aquaculture in the Great Lakes to Ontario and Canada is performed in order to better understand how to best include aquaculture practice into the management of the lakes. A survey of aquaculture industries has been done by Statistics Canada, however the numbers available should be separated into the different regions according to operation. This would begin to allow a more accurate assessment of how the aquaculture industry would be affected by different stressors on the Great Lakes.*

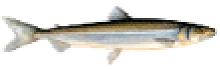
Freshwater Fish



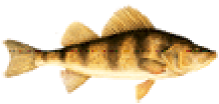
55Lake Whitefish (Coregonus clupeaformis)



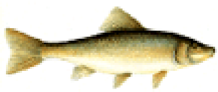
56Northern Pike (Esox lucius)



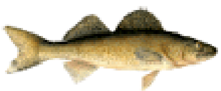
57Rainbow Smelt (Osmerus mordax)



58Yellow Perch (Perca flavescens)



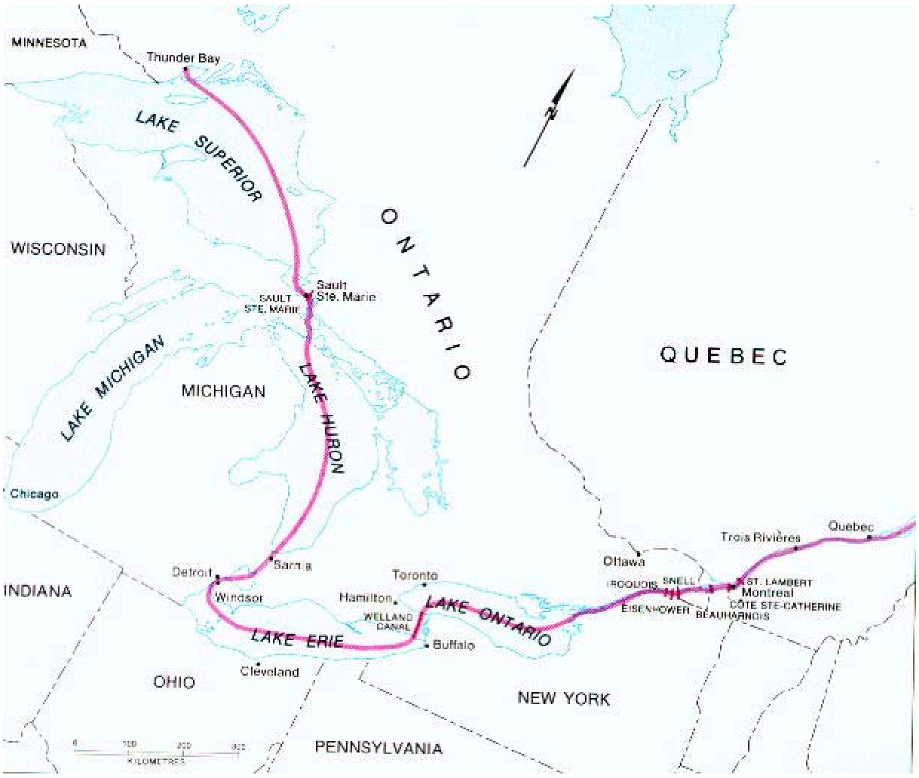
59Mullet (Catostomus commersoni)



61Walleye-Pickerel (Stizostedion vitreum vitreum)

Source OMAFRA

Transport for bulk goods used in the steel and other industries



The Great Lakes and St Lawrence Seaway benefit Ontario as a shipping route for many domestic and international businesses. Martin Associates (2001) assessed the economic impacts of the cargo and shipping industry through each of the 16 major US ports on the Great Lakes. The study was intended to develop a realistic assessment of the contributions made by the Great Lakes St. Lawrence Seaway System and the 16 major individual ports to the local, state, regional, and national economies located on the US side of the border. The bulk of the information gathered was by way of a comprehensive telephone interview program of more than 380 individual firms providing maritime services at the ports.

The US estimates for the economic value are as follows:

- Maritime activity on the U.S. Great Lakes St. Lawrence Seaway System generated $3.4 billion of business revenue to firms providing transportation and cargo handling services (excludes the value of the commodities moving on the Great Lakes St. Lawrence Seaway System).
- The 43,968 directly employed residents of the U.S. Great Lakes region received $1.6 billion of direct wages and salaries.
- As the result of purchases by these directly employed workers, an additional $1.9 million of local purchases and consumption expenditures were created, supporting the 27,392 induced jobs.

- The firms providing the cargo handling and transportation services spent $1.3 billion on purchases for supplies, business services and maintenance and repair services, utilities, etc.
- These local purchases supported the 26,757 indirect jobs.

Although a study of the Canadian side of the waters was not included, it was stated that the industry located along the Canadian portion of the Great Lakes St. Lawrence Seaway System represents a significant portion of total Canadian industrial output. While not as detailed, Transport and Environment Canada (Environment Canada Action Plan 2000-2005) estimate that the Great Lakes & St. Lawrence Waterway adds $3 billion annually and approximately 17 000 jobs to the Canadian economy (Environment Canada, 2004).

The Canadian non-profit St. Lawrence Seaway Management Corporation (SLSMC accessed 03/06) extrapolated the following numbers from the SLSDC Report. The Seaway is responsible for approximately 36,000 direct and indirect jobs in Canada and 150,000 in the United States. Maritime commerce on the Great Lakes/St. Lawrence Seaway System annually generates more than $4.3 billion in personal income, $3.4 billion in transportation-related business revenue, and $1.3 billion in federal, state and local taxes.

Although they did not venture to determine the effect on Canadian economies directly, they did estimate that the jobs created were just over one fifth of those in the US. Pro-rated to the personal income and business revenue, the Canadian numbers are $1.03 billion in personal income, $777 million in transportation-related business revenue. It would require further study to further verify the pro-rated estimate of $312 million in taxes due to the differences in tax systems in Canada and the United States.

LECG (2004) also found the economic impact of the Canadian Marine Transportation Industry to be substantial. The "extensive array of activities generated by the Great Lakes /St Lawrence waterway provided over $2.2 billion of provincial GDP in 2003 (or 0.45% of total Ontario GDP) and over 18,000 jobs. This estimate is only a measure of what the industry contributed as a 'producer'; no doubt massive amounts of industrial and commercial activity in Ontario would not have been possible without marine transport to carry in raw materials and carry away finished goods, but how much this activity was is not possible to estimate with any precision."

LECG (2004) describe the Marine Transport Industry as passenger and freight transport, ferry transport, marine towing, ship chartering, marine cargo handling, harbour and port operations, marine salvage, piloting services, and marine shipping agencies. Obvious omissions (among others) are cruise ships and storage and warehousing associated with the industry.

According to LECG, the breakdown of the $2.2 billion provincial benefits of Marine Transport was as follows for the year 2000

Final Expenditure – Sales by Marine Transport = $984 Million
Direct GDP (at Factor Cost) = $394 Million
Direct Plus Indirect GDP at Market Prices = $757 Million

Total Impact on GDP at Market Prices = $2.04 Billion (0.42%of GDP)

Employment statistics are as follows

Direct Employment from Input/Output Estimates = 4,364
Direct plus Indirect Employment = 9,913
Total Impact on Employment = 17,932 (0.31% of Total Employment)

Although the industry may not be particularly reliant on the water quality in the Great Lakes, it is heavily dependent upon water levels. If the water levels of the lakes were to be lowered as predicted by climate change models (up to 5 feet) and/or by water diversions, this could substantially inhibit the ability of this business to continue. For each inch of carrying capacity lost to lower water levels, a thousand-foot-long ship can carry 270 fewer tons. The ship owners are paid on the basis of the tonnage they carry, but their operating costs are fixed, so they face decreased revenues if they have to off-load freight

Taylor and Roach (2005) examined the economic consequence of shutting the seaway to transoceanic vessels or "salties", and using other modes of transportation to move goods. They concluded that a cessation of ocean shipping on the Great Lakes would result in a transportation cost penalty of US$54.9 million per year. The relatively small transportation cost penalty of US$54.9 million is because no more than12.3 million metric tons of ocean vessel cargo moving into and out of the Lakes via the Montreal – Lake Ontario section of the St. Lawrence Seaway (in 2002), or some 6.8% of total Great Lakes –St. Lawrence Seaway System tonnage. It is also due to the fact that the costs of the alternative modes, for lakers, rail and barge primarily, are not substantially higher than the cost for the ocean direct routings into and out of Great Lakes ports. While these other modes have some potential capacity constraints, Taylor and Roach believe laker and rail capacity would be able to accommodate the extra volume. Overall, their conclusion is that ocean vessels, or salties, on the lakes make only a modest contribution to transportation cost savings for users of the System. The calculated cost penalty represents a 5.9% increase in the current door-to-door transportation cost for the goods currently moving via ocean shipping in the Great Lakes. The study findings are highly relevant to the growing debate over whether or not ocean ships in the Lakes provide sufficient benefits to society, given the estimates of the costs of existing invasive species range from $200 million to as high as $5 billion per year, with the predominant vector being the ballast tanks of ocean vessels (IJC 2004).

Mud harbouring resting stages of potential invasive species in the ballast tank of a vessel declaring no ballast on board

Alien Invasive Species

A serious threat to the sustainability of the Great Lakes is the ongoing introductions of aquatic invasive species (AIS). Although there are voluntary guidelines with regard to ballast water treatment, AIS are often brought into the Great Lakes in the ballast water (or sludge at the bottom of empty ballasts which is unregulated) of commercial ships; the regulations are only 3 to 17% effective (Office of the Auditor General of Canada, 2001) because more than 80% of vessels entering the seaway declare no ballast on board (NOBOB) (IJC 2004). Other vectors for introduction include intentional introductions, aquaculture, aquarium trade, horticulture, live fish to market, bait fish trade and canals and diversions (Commissioner of the Environment and Sustainable Development 2001).

AIS that enter the Great Lakes threaten the diversity and abundance of native species, the ecological stability of infested waters, the commercial, agricultural, aquacultural and most recreational activities (http://www.anstaskforce.gov/ansimpact.htm). These invaders have been causing irreparable damage for many years. Damages will increase in the absence of aggressive measures to prevent their continued introduction.

Expected costs

Ricciardi and Rasmussen (1999) predict that alien aquatic species will, in part, contribute to the extinction of native freshwater species in North America at a rate of 4% over the next century. Freshwater organisms are predicted to go extinct five times faster than terrestrial organisms and three times faster than coastal species.

Keeping non-native species from entering the basin can save millions of dollars in control costs beyond the cost of damage they would do to the ecosystem (Office of the Auditor General of Canada, 2001).

Costs of damage are almost impossible to predict, given the uncertainty as to which species will enter the Great Lakes next. The general rule is that "about 10% of all introduced nonindigenous species actually become established, and about 10% of those that become established also become invasive and harmful" (International Association for Great Lakes Research, 2002). The Aquatic Nuisance Species (ANS) Task Force estimates that the 15 most recent introductions of these invaders could cost the U.S. $134 billion by 2050 (ANS Task Force). Per species this is approximately $9 billion US. Direct Canadian estimations have not been established from these predictions however it is logical to estimate that preventing AIS from entering the Great Lakes could easily save Canadians billions of dollars over the next few decades.

The future of AIS in the Great Lakes has enormous potential to seriously devalue almost all aspects of the Great Lakes. Society must also grapple with the ongoing costs and continued control of species that have already made their way into the lakes. In Canada, it is estimated that $500 million is spent annually on alien species control efforts in the Great Lakes (Commissioner of the Environment and Sustainable Development 2001). This $500 million Canadian does not include the economic impact of AIS on the ecological services and species that they have disrupted.

The sea lamprey and the zebra mussel have been the most publicized AIS in the Great Lakes, however they are just two of over 170 invasive aquatic species that are known to have entered the Great Lakes Basin (Office of the Auditor General of Canada, 2001).

The Great Lakes Regional Collaboration estimated the cost for preventative measures, including to require, verify, and enforce best performing ship-board ballast water treatment and hull management methods for ocean-going vessels at $6 million per year. They further estimated that $4 million/yr would be required for monitoring, reporting, and public dissemination of all ballasting activities, prevention practices, and outcomes such that progress toward the prevention goal is measurable and enforcement practical. $2.5 million/yr was estimated to immediately and significantly expand research, testing, and evaluation of policies and technologies as alternatives to on-board treatment. Alternatives to be investigated should include (but not be limited to) cargo transfer, shore-based treatment, use of discharge permits, and state/regional actions. This is above and beyond over $50 million over three years to make the barriers to invasive species migration at the Chicago Sanitary and Shipping canal permanent (see below: Asian Carp).

The Zebra Mussel

The zebra mussel, having entered the Great Lakes via ships that have traveled from Europe, has now spread outwards into Canada and the U.S. (Benson and Boydstun 1995). The presence of the zebra mussel in the Great Lakes greatly reduces the food and oxygen available in the water for native fauna and threatens the survival of other native species such as mussels, clams and snails by over colonization (Benson and Boydstun 1995; Keniry and Marsden 1995). Additionally they directly increase human costs as they invade and clog water intake pipes, water filtration and electric generating plants. Khlanski (1997) estimated that they could be causing $5 billion/yr in damages to these facilities. Breaking down the costs by sector affected municipalities and industries, using large volumes of Great Lakes water, expend approximately $360,000 per year on zebra mussel control; small municipalities average

$20,000. Nuclear power plants average an additional $825,000 of additional costs per year for zebra mussel control. As the zebra mussel spreads to inland lakes and rivers across North America, such as the Mississippi River Basin and Lake Champlain, so do the costs to water users (ANS Task Force). A large potion of this $5 billion cost is also attributed to the effects on the fishing industries in the Great Lakes because significant natural food web alterations caused by zebra mussel.

The human health implications of the zebra mussel are related predominantly to the fact that by filtering vast amounts of water, concentrations of organic pollutants within their tissues are extremely elevated, and are then passed up the food chain to fish and wildlife that can be consumed by humans (Protect Your Waters, 2006).

Sea Lamprey

The Sea Lamprey is an eel-like fish normally present in the Atlantic Ocean. The sea lamprey is an aggressive parasite. While attacking its prey the lamprey attaches itself to the flesh and bores a hole into the body. "An anticoagulant in the lamprey's saliva keeps the wound open for hours or weeks, until the lamprey is satiated or the host fish dies" (Wisconsin Sea Grant, 2006). Since their introduction in 1921 through the Welland Canal, they have contributed greatly to the decline of the whitefish and lake trout in the Great Lakes. The Great Lakes Fishery Commission's Sea Lamprey control program consists mainly of population reductions through chemical introduction into the waters. This program has been successful in reducing populations by 90% and has costs Canada and the United States more than $12 million annually for more than a decade. Despite these efforts however, the populations have been increasing in recent years (ANS Task Force, 2006).

Since 1988, Canada and the United States have spent more than $6 million studying the effects of long-term exposure to Lampricide TFM (the chemical used to exterminate the Sea Lamprey larvae). Health Canada and the EPA have established few if any health effects of Lampricide although they suggest using caution in residential use as with any type of pesticide (GLFC, 2004).

Asian Carp

Catfish farmers imported two species of Asian carp –the bighead and silver – in the 1970s to remove algae and suspended matter out of their ponds. During large floods in the early 1990s, many of the catfish farm ponds overflowed their banks, and the Asian carp were released into local waterways in the Mississippi River basin. The carp have steadily made their way northward up the Mississippi, becoming the most abundant species in some areas of the River. They out-compete native fish, and have caused severe hardship to the people who fish there (USEPA 2003).

The Chicago Sanitary and Ship Canal connects the Mississippi River to the Great Lakes via the Illinois River. Recent monitoring shows the carp to be in the Illinois River within 50 miles of Lake Michigan. Asian carp have been found in the Illinois River, which connects the Mississippi River to Lake Michigan. Due to their large size and rapid rate of reproduction, these fish pose a significant risk to the Great Lakes ecosystem.

A temporary barrier had been built at a cost of $2.2 million to help prevent goby from entering the Mississippi River. It also serves to repel Asian carp from entering the Great Lakes. Another $5 million is needed to make this barrier permanent. That structure, originally intended to be temporary is wearing out. At least one tagged common carp has breached the barrier. Though construction of Barrier II is progressing, the U.S. Army Corps of Engineers did not receive funding to continue operation of Barrier I beyond May 2006 and received no funding for operation of Barrier II once construction and safety tests are complete. At this point as the local sponsor for the project, the State of Illinois will have responsibility for operating the barrier.

Authorization language for the Corps to operate Barrier II and continued operation of Barrier I is in the Water Resources Development Act (WRDA) and the National Aquatic Invasive Species Act (NAISA) however, neither of these bills have passed Congress. The State of Illinois will need to run the barrier until the Corps or other Federal agency receives authorization and appropriations to operate the system. This cost of this barrier is $9.1 million however it also requires $250,000 to operate per year, ten times that of the temporary barrier (University of Wisconsin Sea Grant accessed 03/06).

A Rapid Response Committee has developed a Rapid Response Plan to address the presence of Asian carp in the Chicago Sanitary and Ship Canal if they begin to congregate below the existing barrier before the second barrier is operational. The Asian Carp Rapid Response Plan would involve eliminating Asian carp from 5.5 miles of the Sanitary and Ship Canal. Current estimates for implementation of the plan place the cost at about $450,000. There are 18 agencies involved in the response planning effort but none of them has the funds to enact the plan if it is needed. Funding for the plan is not covered in any Congressional Act or other agency mission. The response plan is a vital action that must be used if the carp appear in the Canal before Barrier II is in place.

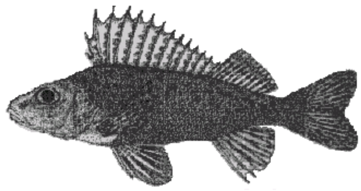
The reason for the urgency regarding preventing the Asian carp entry to the lakes is that they could decimate the fishery, which is a multi-billion dollar industry in the Great Lakes.

Round goby

The goby is a bottom-dwelling fish that has great potential for causing impacts on Great Lakes fisheries. Originally the round goby and the tubenose goby were introduced into the St. Clair River in 1990, probably via contaminated ballast water of transoceanic ships.

Round goby are thriving in the Great Lakes Basin because they are aggressive, voracious competitors for food and that forage in total darkness. The round goby takes over prime spawning sites traditionally used by native species, competing with native fish for habitat. They out-compete native bottom dwelling fish such as sculpins and log perch, forcing them out of their living spaces and spawning sites. Gobies also consume eggs of other fish that broadcast their eggs or build nests in the cobble substrate. These fish include walleye, sunfish, lake trout and other salmonids.

Gobies can reproduce up to six times a summer, allowing their populations to expand rapidly. As they become abundant in near shore areas they may be a nuisance to anglers fishing with worms or other invertebrates. The round goby is already causing problems for other bottom-dwelling Great Lakes native fish like mottled sculpin, logperch and darters. They have shown a rapid range of expansion through the Great Lakes (GLIN accessed 03/06).

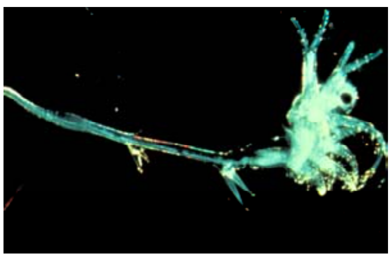


The Ruffe

The ruffe (Gymnocephalus cernuus), a small spiny perch capable of explosive population growth, also threatens the Great Lakes fishery. Native to lakes and rivers in Eurasia, the ruffe was introduced to Duluth Harbor on Lake Superior via ballast water of an ocean going vessel and first collected in fish surveys in 1986.

The ruffe competes with native fish for food and habitat. Its ability to displace other species in newly invaded areas is due to its high reproductive rate, its feeding efficiency across a wide range of environmental conditions, and characteristics that may discourage would-be predators such as walleye and pike.

Ruffe grow rapidly and can reproduce in their first year. In the St. Louis River, near Duluth, Minnesota, females can lay between 45,000 and 90,000 eggs a year. Ruffe are primarily bottom feeders, preferring dark environments where they can hide from predators. The sharp spines on their gill covers, dorsal and anal fins make them difficult for larger fish to eat.



The spiny water flea

The spiny water flea (Bythotrephes cederstroemi) is a crustacean with a long, sharp, barbed tail spine. A native of Great Britain and northern Europe east to the Caspian Sea, Bythotrephes was first found in Lake Huron in 1984–probably imported in the ballast water of a trans-oceanic freighter. Since then, populations have exploded and the invertebrate can now be found throughout the Great Lakes.

Resource managers are concerned about this invasive species because they may compete directly with young perch and other small fish for food, such as Daphnia. Spiny water fleas also reproduce rapidly. During warm summer conditions each female can produce up to 10 offspring every two weeks. As temperatures drop in the fall, eggs are produced that can lie dormant all winter.

Its sharp spine makes it extremely hard for small fish to eat, leaving only some large fish to feed on them. As a result, spiny water flea populations remain high while populations of plankton have declined, with as of yet, unproven impacts on biodiversity in the Great Lakes.

Purple Loosestrife

Purple Loosestrife (Lythrum salicaria) is a wetland plant from Europe and Asia. It was introduced into the east coast of North America in the 1800s. Loosestrife forms dense, impenetrable stands that are unsuitable as cover, food or nesting sites for a wide range of native wetland animals, including ducks, geese, rails, bitterns, muskrats, frogs, toads and turtles (GLIN accessed 03/06). Many rare and endangered wetland plants and animals also are at risk, resulting in economic costs associated both with control programs, and with loss of species richness in wetland and riparian zones.

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Water and Infrastructure

The main source of drinking water for Ontario's major cities is the surface water of the Great Lakes (Pollution Probe 2001). As these cities continue to grow, the burden that these water withdrawals will have on the health of the Great Lakes will increase accordingly unless measures are put in place to reduce per capita consumption and increase the degree to which the water is treated prior to being re-introduced into the lakes.

In 1991 due to mounting concerns over water availability and management procedures, Environment Canada commissioned a report entitled "Municipal Water Rates in Canada: Current Practices and Prices, 1991". One important conclusion was:

> "In terms of sustainability, current municipal water pricing practices give cause for concern. A brief consideration of financial, economic and physical viability, as well as environmental and public health, leads to the conclusion that municipal water systems are unsustainable under current pricing practices".

In the 2004 OECD Environmental Performance reviews, Canada was seen as follows with respect to its water management:

> "In a country where the public often regards water as a limitless resource and a gift of nature, the notion that water is also an economic good with social and ecological functions is not yet readily accepted. Therefore, water management often lacks an economic information and analytic base. Many price signals are inappropriate and subsidization is pervasive." (OECD, 2004)

The OECD based this opinion primarily on their findings regarding the prevailing price structures in place in Canadian municipalities. They found that 43% of households with municipal water services paid for their domestic water with a flat rate structure plan. Not only are these flat rates completely lacking in their ability to place any value on the conservation of water, they are set so low that most municipalities are unable to recover their capital and operating costs and require government subsidies to continue operations.

The effects of inefficient pricing policies have led to serious debts and infrastructure issues within the water and wastewater service systems in Ontario. A large portion of the cash cost of water service is externalized to provincial taxpayers through capital facility grants due to the insufficient amount of funds collected from the consumers. The effects of the externalized costs are also observed through the polluting wastewater emissions that affect all members of the community (Adams, 2001) and will eventually lead to an increase in the overall charge to treat that water for safe consumption. As the source water becomes increasingly contaminated with new classes of chemicals, new technologies must be incorporated in order to service safe drinking water quality.

Externalizations and the associated under-pricing of water have been unable to curb excess consumption (Adams, 2001). The OECD quotes figures for Ontario showing that the gap between marginal cost and prices for municipal water supply has led to consumption exceeding efficient levels by an average of 50% (OECD 2000). In an analysis of fresh water issues conducted for the UN Commission on Sustainable Development, the federal government notes that each Canadian consumes on average 326 litres per day, twice the European average (Government of Canada, 1998).

Inefficient water pricing structures have left municipalities with insufficient funds to properly maintain water services. Watertight, a document prepared for the Minister of Public Infrastructure Renewal projects that, “unless the rate of capital investment increases sharply from the levels of the recent past, Ontario will face a gap of roughly $18 billion between what systems need and what they receive in funding over the next 15 years” (Swain et. al. 2005). This gap should not be met with increased grants through upper levels of government since this would exacerbate the situation and lead to an even greater problem in the future as population and consumption levels continue to increase.




Urban sprawl is particularly inefficient in the delivery of water infrastructure to residents of sprawling regions. If communities continue to develop in this same inefficient manner, the cost to the communities (both urban and sprawl towns) will be significantly higher than if a more thought out and alternative approach is used. The CMHC (Canada Mortgage and Housing Corporation) performed a study which compared conventional suburban development with a mixed use, more compact development in accordance with the principles of New Urbanism and found that these alternative methods could "lower public and private capital costs of infrastructure by 16 per cent, or approximately $5,300 (1995 dollars) per unit" (Gurin, 2003). Common development standards have infrastructure replacement, and operating and maintenance costs that are 9 per cent or almost $11,000 per unit (over a 75-year period) higher than these more "smartly" built communities (Gurin, 2003).

Blais (1995) suggests "more compact and efficient urbanization in the Greater Toronto Area would save (in 1995 dollars) about $10 billion to $16 billion in infrastructure costs and about $2.5 billion to $4 billion in operating and maintenance costs over 25 years". She further states that "if external costs (for emissions, health care, traffic policing, etc.) are considered as well as capital and maintenance, then approximately $700 million to $1 billion per year could be saved by a more efficient pattern of development" (Blais, 1995).

In addition, the sewage infrastructure costs, (rarely fully incorporated into the water pricing of Ontarians) partially treated sewage discharged into the Great Lakes adversely impacts receiving water quality. When the municipalities allow minimally treated sewage to enter the receiving waters there are few initial direct costs to the municipality, however, there are external costs to the environment. The effects of polluted water on the health system are evidenced in increased hospital admittances; the private sector in terms of more sick days and lower productivity; and affect the general well being of society. The recreational value of the beaches is affected and the value as a recreation facility is lost (actual value lost located elsewhere is the document).

Source water itself can also be considered a commodity with value that needs to be included in the basic inventory of infrastructure assets. The existence value of a safe supply of clean water is viewed by most Canadians as a fundamental prerequisite and, "in the long-term planning of a system, consideration must be given to the conservation and protection of the water resource upon which the system is based" (Pollution Probe, 2001).

The effects and high costs of urban sprawl can also be incorporated into the infrastructure valuation. The more spread out people become; infrastructure costs of providing safe and adequate water and sewage systems increase dramatically. As cities cover more and more land area, there is less of that area available for wetlands and the services that these provide. The value of wetlands and biodiversity that are dealt with in this paper are thus at risk as urban sprawl continues to infiltrate natural areas.

Health: Biodiversity Impacts

Episodic die-offs of bottom-feeding fish and fish-eating birds from botulism poisoning are being reported, mainly in the eastern basin of Lake Erie, with lesser outbreaks noted in the western and central basins as well as in lakes Huron and Ontario. During and after the die-offs, rotting fish and bird carcasses litter beaches and shorelines (International Joint Commission 2004). Toxins from the bacterium Clostridium botulism and specifically Type E botulism, which is found in fish-eating birds in the Great Lakes, cause these die-offs. The last substantial Type E botulism outbreak occurred in Lake Michigan during the 1960s. The neurotoxin is produced in the absence of oxygen and with suitable temperature and nutrient conditions. It remains unclear which factors trigger the bacterium to produce the neurotoxin and the ensuing fish and wildlife die-offs. However, Type E botulism outbreaks have occurred as the round goby population, another invasive species, has increased. Researchers are looking for clues that triggered the botulism outbreak in Lake Erie, the source of the toxin, and its transfer among fish and other aquatic organisms, waterfowl, and fly maggots on carcasses (Domske and Obert 2001).

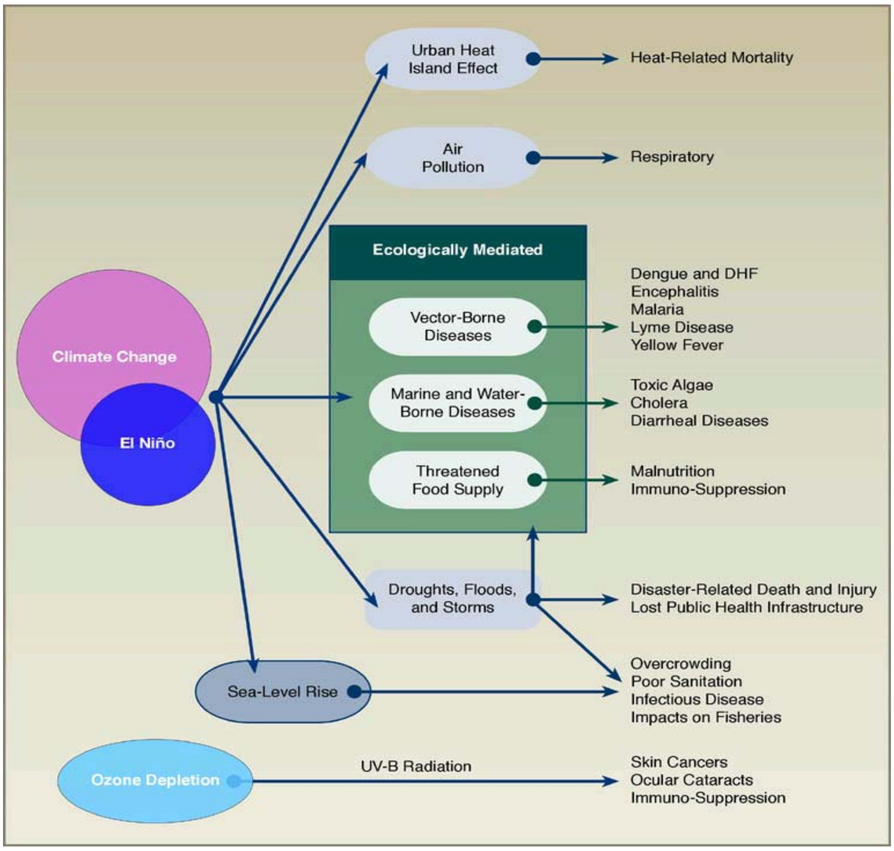
Human Health Effects Due to Introduction of a Foreign Virulent Pathogen

Through the same mode of transport used by AIS to enter the Great Lakes region, it is entirely possible that a future invader could be a virulent pathogen. Such an outcome would have severe human and economic costs. Consider by way of illustration, that the recent outbreak of SARS in Canada cost the Ontario and Toronto economies $2 billion. In Toronto in 2003, there were 252 people infected, 15,000 people in quarantine, and 44 people suffered fatally. Another example is that of the avian flu. This particular outbreak would likely be global, however an estimation of its impact on Canada reveals that between $6 and 14 billion could be expected as economic losses and as well it could infect as many as 6.2 million Canadians, killing about 133,000. (CBC News, 2006)

Health Effects due to Climate Change

"The effects of global climate change include heat waves, disruption of previously stable weather systems, more frequent violent weather events, increased risks of infectious diseases, and threats to food supplies. Over time, additional and far-reaching impacts are likely to arise from rising sea-levels caused by the melting of polar ice-caps and alpine glaciers, and thermal expansion of the sea-water mass." (David Suzuki Foundation, 1998)

As detailed elsewhere in this report, numerous activities are directly related to the quality and quantity of the water in the Great Lakes. As climate change occurs it can exacerbate the health effects that are currently being seen due to pollution in the area. Currently, there are approximately 70 heat-related deaths in Montreal, and 20 in Toronto every year. It is estimated that by 2020 annual heat-related deaths could increase to 460 in Montreal and 290 in Toronto (David Suzuki Foundation, 1998).



Fish safe for consumption and associated avoided health costs

Most health care practitioners recommend consumption of fish as a source of protein and healthy fatty acids. Human health effects caused by contaminants in fish however, are tempering the health benefits of consumption. Mercury is of particular concern in the Great Lakes and numerous studies have been or are being done to attempt to understand its full impacts on human, animal and ecosystem health (International Joint Commission 2004).

Although the concern is greatest for vulnerable segments of the population, (pregnant women, children and certain ethnic communities who consume large amounts of seafood) there is a risk that children born to mothers who have consumed mercury-contaminated fish during the pregnancy are at greater risk of having neurological development problems (as many as 475,000 children born each year in the US alone are at risk, 4 million born in total). The Commission for Environmental Cooperation (2004) found economic costs due to increased education and health costs, and reduced productivity. They estimated cumulative health care costs at the billions of dollars level in the Great Lakes regions. Accurate quantification is limited due to inadequate information on mercury levels in sport fish and consumption data (Mercury Recovery Fund, 2004).

Trasande, et al. (2005) also attempted to quantify the costs associated with exposure to methyl mercury. Methyl mercury exposure is principally from consumption by pregnant women of seafood contaminated by mercury from anthropogenic (70%) and natural (30%) sources. Power plants account for 41% of anthropogenic emissions. Using national blood mercury prevalence data from the Centers for Disease Control and Prevention, Trasande et al. (2005) found that between 316,588 and 637,233 U.S. children each year have cord blood mercury levels greater than 5.8 µg/L, a concentration associated with loss of IQ. The resulting loss of intelligence causes diminished economic productivity that persists over the entire lifetime of those affected. The lost productivity due to methyl mercury toxicity amounts to an estimated $8.7 billion annually (range, $2.2-43.8 billion; all costs are in 2000 US$). Of this total, $1.3 billion (range, $0.1-6.5 billion) each year was attributable to mercury emissions from American power plants.

Using the CEC estimate of 475,000 children at risk, the results are an approximate cost of $18,315 per child who is affected by methyl mercury through exposure during fetal development ($8.7 billion/475,000 children).

It is possible to estimate the effects of mercury-contaminated fish for the Great Lakes region using a number of assumptions. First, assume that the 475,000 at risk children are located evenly throughout the United States. If this is true, since 10% of the

American population lies in the Great Lakes basin (Environmental Protection Agency, 2006), there are approximately 47,500 children at risk in the US Great Lakes region. Also, because more than 60 percent of the $7 billion worth of the fish and shellfish consumed in the US is imported (New York Sea Grant), assumed that 40% of these at risk children are attributed to domestic fish consumption. Further assume that all of the domestic fish consumed within the Great Lakes region are from within the Great Lakes. This results in 19,000 at risk children of the American Great Lakes population directly attributable to mercury contaminated fish. The 34 million people in the Great Lakes Basin are divided approximately 80/20 US/Canada (NOAA, 2004) and so it can be estimated that approximately 4,750 Canadian Great Lakes children are at risk during development. If costs per child are estimated at about $18,315 per child (as above) this then amounts to $87 million US dollars, or $93 million Cdn. lost due to lost productivity due to lower IQs on the Canadian side of the Great Lakes, Adding these to the number of at risk children in the US gives a total of 23,750 at risk, with a total Great Lakes region cost of $435 million US.

Given that exposure is mainly through the consumption of fish that contain the methyl mercury, the extent to which these enormous social and economic costs are attributable to the Great Lakes condition depends on the degree to which fish consumed in the region originate from the Great Lakes. Unfortunately, data regarding the primary markets for Great Lakes fish are not readily available and are not in general separated from other fishing sources in Canada.

Due to the severity of effects due to exposure to methyl mercury for infants and to others through ingestion it would be recommended that a more thorough study be performed on the short and long term effects of mercury-contaminated fish in the Great Lakes. A survey of hospitals and employers in order to estimate the costs would help to determine the overall economic effects of the contaminated fish. In addition to this, the social costs of having children born with lower IQs should be considered in terms of future prosperity of the population.

In other words, for Canadians, consuming contaminated fish from the Great Lakes would have a $93 million cost avoided if mercury contamination was remediated.

Another approach can be used to estimate the costs of methyl mercury exposure to fetuses. Over 4.7 million people consume Great Lakes fish from sport fishing annually (Agency for Toxic Substances and Disease Registry, 1999). The average sports fisherman consumes 2-3 times more fish than the general U.S. population and the portion of consumers of these fish who are women is 43.9% (Agency for Toxic Substances and Disease Registry, 1999). The average American Birth rate is 14.14 births per 1000 population (CIA World Fact Book, 2005). This suggests then that 66,458 children are at risk, which would then cost $1.2 billion in societal costs to the Great Lakes Region, based on the average expected cost of $18,315 per affected child. Again taking 25% of this gives a rough estimate of Canadian effects in the Great Lakes region; this amounts to over $250 million.

Based on the above two studies, $93 - $250 million in costs would be avoided by eliminated this pathway of exposure in Canada alone. Mercury is just one of the known PBTs present in the Great Lakes Basin. It can be used as an example for the extent of damages and costs that are possible.

Recommendation for Further Quantification

- *A survey of Great Lakes fisheries would be valuable to ascertain their fish markets and their contribution to diets in populations at risk (e.g. Asians, Aboriginal, pregnant women and children, those living in close proximity to GL coastal areas or AOCs such as Hamilton Harbour) to help determine where the effects of methyl mercury contamination would most likely be seen and could consequently be monitored.*

Gilbertson and Brophy (2001) report on a Health Canada study that provided data on the hospitalization and mortality records of the Windsor area through the period from 1986 to 1992. They examined the possibility that pollution in fact lead to declining human health. The study found that throughout the period studied, people in the Windsor Area of Concern died at "significantly higher rates (males: 8% higher, 613 excess deaths; females: 5% higher, 366 excess deaths) than in the rest of Ontario Province". The number of cases of people in the Windsor Area of Concern being hospitalized for all causes during the 7-year period between 1986 and 1992 was

122,776 cases, or 21% higher in males (20,987 excess cases of morbidity), and 165,344 cases, or 15% higher for females (21,567 excess cases of morbidity). Although there is no evidence directly linking the amount of pollution seen in these areas to these mortality and hospitalization rates, the relationships described in the study are troubling.

Using the average statistical value of a life of $5 million dollars (Burtraw & Krupnick, 1999), the deaths associated with the pollution in the Great Lakes Region is $5 billion dollars plus the excess hospitalizations costs which could not be quantified (1,000 excess deaths attributable to pollution in the Windsor area). So, the cost avoided by curtailing pollution could have been as high as $5 billion over the six year period examined.

Recreation: value of, including employment

Recreational fishing

Sport fishers have enjoyed the Great Lakes as an abundant source of fish varieties for generations. An estimated 469,128 anglers fished on the Great Lakes in 2000, of which 336,632 were residents of Ontario and 132,496 were visitors to Ontario, primarily from the United States (Fisheries and Oceans Canada, 2000). Of this amount, $201 million (52%) was attributed to recreational fishing activities on the Great Lakes system, with anglers spending $214 million on goods and services directly related to their fishing activities, averaging $455 per angler

The Great Lakes sport fishery alone contributes some $7.5 billion (U.S.) annually to the regional economy (Great Lakes Waterways Management Forum, 2000). In 2001 Great Lakes anglers spent $1.3 billion on fishing trips and equipment on the U.S. side of the border or entire basin? (2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation). In 2002, the estimated 1,746 Great Lakes charter firms made more than 93,000 charter trips, on the U.S. side. In the Great Lakes region (U.S.), these charter-fishing firms brought in estimated total sales of $34.5 million (Sea Grant – Fisheries Extension Enhancement Economics).

Statistics Canada (2000) reported that Great Lakes anglers in Canada spent an estimated $390 million on durable goods used in whole or in part for recreational fishing, allocated on the basis of their Great Lakes fishing activity. They also spent $214 million on goods and services directly related to their fishing activities, averaging $455 per angler. This totals to over $500 million direct spending on Great Lakes recreational fishing in Canada alone, not including the value of the time spent getting to these areas, or the secondary economic benefits to the service industry.

Recreational boating

The Great Lakes are home to 25% of the Canadian population and serve as a major recreational area for a large number of those residents. The aesthetic beauty and abundant wildlife have made it a prime destination for boaters and tourists, and despite a relatively short boating season compared to the rest of the country, Great Lakes boaters log many hours on the water. Recreational boating provides over 125,000 jobs and contributes approximately $9 billion (U.S.) annually to the U.S. Great Lakes economy (Great Lakes Waterways Management Forum, 2000). The Canadian Great Lakes economic value of boating can be estimated as $2.2 billion, using a proportionate population assumption. This assumption is tested again below.

The Great Lakes Regional Collaboration describes a typical Great Lakes marina. "[At] Tower Marine in Saugatuck, Michigan, the 395 boats renting slips spent $2.85 million on annual craft expenses and another $2.85 million on boating trips, accounting for 15,000 days of boating in 2004. The direct economic impacts of trip spending was $1.8 million in sales, $661,00 in wages and salaries and $952,000 in value added to the local economy, supporting 37 jobs. Annual craft expenses directly supported an additional 44 jobs from $2.6 million in direct sales, $834.000 in wages and salaries and $1.5 million in value added."

Bathing Beaches

Boating is not the only non-fishing recreation activity reliant on Great Lakes water quantity and quality. Shaikh (2004) estimates that the average day at the beach is worth approximately $35 to the individual with a total seasonal value of $800 million to $1 billion US for US population using Great Lakes beaches. Proportionally this is $200 to $250 million of value for Canadian Great Lakes beach goers (Shaikh, 2004)

Wetlands, biodiversity and passive recreation

The abstractness of the valuation process for wetlands causes difficulty when attempting to provide the economic value of these features. The lack of an open market for wetland services and provisions, such as water purification, maintenance of biodiversity, and flood control, necessitates the use of indirect methods.

The wetlands surrounding the Great Lakes are valuable for almost innumerable reasons. Some of these have already been discussed with the corresponding direct benefits to the Great Lakes economy. Their intrinsic values are harder to define because they are much more intangible. Our inability to reproduce their functions due to physical, scientific, and economic limitations only increases the strength of the argument for preservation.

The economic benefits (both direct and indirect) of preserving these wetlands as healthily functioning ecological services include nutrient cycling, flood control, climate control, soil productivity, forest health, genetic vigour, pollination and natural pest control. The benefits of maintaining and restoring the Great Lakes wetlands extend outside of the region; wild unprocessed biodiversity in Canada has been valued at approximately $70 billion (NRTEE accessed 03/06). Although this value is not contained solely within Ontario, the gross Canadian value is dependent on the viability of the individual ecosystems located in the different provinces. Many species that depends on them are migratory and in fact travel from wetland to wetland. This natural migration sustains a healthy level of biodiversity in Great Lakes wetlands. When human development impedes this by separating the natural corridors between the wetlands, it weakens the strength and value of the entire network of ecosystems.

The value of the biodiversity contained in wetlands has both intrinsic value and direct economic value. The intrinsic value of biodiversity exists regardless of its direct value to humans or if there is an ecologically equivalent species (Redpath Museum). The ecological services that biodiversity provides have economic, aesthetic, scientific and recreational value and are more easily discussed than the intrinsic value due to the transparency of the monetary system on which the values are based. The preservation of wetlands also provides some insurance for future generations because there may be medicines available in the flora and fauna (Redpath Museum).

The Eastern Habitat Joint Venture (EHJV) has identified the Lake St. Clair area as one of Ontario's top priorities for migratory waterfowl habitat conservation. The primary goal of the restoration project is to increase the availability of waterfowl staging habitat within
approximately 8 km of the Canadian shoreline of Lake St. Clair. In this context, the EHJV note the potential to significantly augment local biodiversity and greatly increase the socio-economic benefits of the project.

"Additional recreation opportunities including birding and nature viewing and hunting, will be provided by the restoration of wetland habitat. The proposed basic wetland design alone will draw visitors, but incremental increases in biodiversity through the creation of additional
habitat (e.g. mud flats to attract shore birds or grasslands) will likely increase visitation. The local consensus is that there are too few sites to satisfy local demand for hunting; therefore, the proposed wetland is welcomed as a development that will help meet this demand. The restored wetland would add approximately 500 hunter days per season."

The total economic effect from new recreation expenditures associated with the restored wetland is estimated to be $200,000 to $430,000, annually. Total recreational user value (based on a "Willingness to Pay" approach) for the restored wetland is estimated to be $130,000 to $330,000, annually."

"The combined environmental, economic, and social effects of the proposed project are positive and significant. The restored wetland will:

- Increase waterfowl staging habitat
- Increase local biodiversity
- Increase local hunting opportunities
- Increase local recreational opportunities
- Have a negligible economic effect
- Have positive public benefits
- Enhance local tourism potential
- Provide education and research opportunities
- Contribute to local cultural heritage
- Restore critical habitat within the Great Lakes ecosystem"

As an illustrative tool, Environment Canada compiled the following table to highlight the values of a wetland.

Examples of Economic Wetland Benefits. (Environment Canada, 2004)

USE BENEFITS			**NON-USE BENEFITS**
Direct Use Benefits	**Indirect Use Benefits**	**Option Benefits**	**Existence Benefits**
• recreation - boating - birding - wildlife viewing - walking - fishing • trapping- hunting • commercial harvest - nuts - berries - grains - fish - peat - forestry	• nutrient retention • water filtration • flood control • shoreline protection • groundwater recharge • external ecosystem support • micro-climate stabilization • erosion control • associated expenditures, e.g., travel, guides, gear, etc.	• potential future uses (as per direct and indirect uses) • future value of information, e.g., pharmaceuticals, education	• biodiversity • culture • heritage • bequest value

Although there have been no studies on the overall economic value of Great Lakes wetlands, case studies have been developed looking at particular recreational or scenic areas. One specific case is that of Long Point, Lake Erie. Long Point Park is part of a 40-kilometre-long sand spit in Lake Erie recognized as a biosphere reserve by the United Nations. It is a world-renowned refuge and stopover for migrating birds in fall and spring. Waterfowl viewing is excellent in March. Its delicate dunes and marshes also teem with songbirds, spawning fish, turtles and frogs (Ontario Parks, 2006).

Contingent valuation was used to measure the annual net recreational benefits of this area to Canadians in 1981 (Kreutzwiser, 1981). Kreutzwiser calculated the total expenditures made by recreational users of the wetlands and found that recreational users spent $119,000 ($215,906 in 1999 Cdn. dollars) in total to receive wetland benefits that were estimated to have a contingent value of $213,000 ($386,000 in 1999 Cdn dollars) per year. This means that for every dollar users spent, the user received $1.79 in benefits, a return of 179 percent" (Environment Canada, 2000). If Long Point is representative of the other four national parks in Ontario's Great Lakes, users will spend more than $1 million/yr with a contingent value of more than $1.5 million/yr. These figures are compelling, and do not even include the intrinsic value of wildlife production and protection, biodiversity, nutrient retention or groundwater recharge or discharge.

van Vuuren and Roy (Cited in Balmford et al. 2002) reported that draining freshwater marshes in one of Canada's most productive agricultural areas in the Great Lakes region yielded net private benefits, in large part because of substantial drainage subsidies. However, social benefits of retaining wetlands, arising from sustainable hunting, angling, and trapping, greatly exceeded agricultural gains. Consequently, for all three-marsh types considered, present economic values were higher when the wetlands remained intact, exceeding figures for conversion by a mean of around 60% ($8800 compared with $3700/ha).

Costanza et al. (1997) attempted to value the world's ecosystem services and natural capital. They produced a median value of $33 trillion considered to be a minimum because the study was the first of its kind and was relatively simplified compared to the scope of the task. It would be economically and physically impossible to replace the services that were included in this valuation.

Recommendation for Further Quantification

- *The extraction of the Canadian portion of the value of wetlands has not been determined, and while the value of maintaining Canada's vast resource of wetlands should be obvious with respect to its provision of the basic necessities of life non-use value methods could be developed to valuate these resources.*

Riparian Zones: Value and Avoided Costs

Stream Stability

Urban retrofits and stormwater management technology are investments required when urbanization or agricultural land use disrupts normal hydrologic regimes. Studies indicate that urban stream systems may fail to function if the watershed is at 10 – 15 percent or greater impervious surface, resulting in streams that silt downstream areas and increase flood potential. Trees, shrubs and under-story serve to retain stream integrity. When lost, stormwater treatment options that integrate natural systems, such as grass swales and bioengineered buffer strips provide improved environmental quality and stream stability, at a cost. Costs of engineered stormwater best management practices range from $200 to $4,000 per hectare, and will cost that much again over 20 to 25 years (Palone and Todd 1998). A valid argument then is that natural riparian buffers provide this service and have this estimated value at a minimum.

Flood Prevention

When storm events generate flooding conditions, the presence of a forested stream corridor or flood plain enables the roughness of the vegetation to reduce the energy of the water flow, thereby reducing damage to riverbanks and the effects of downstream flooding. Retaining forest area and buffers can reduce storm water on the order of tens of millions of dollars (Palone and Todd 1998). In addition to monetary losses, floods also lead to increased losses of life.

"According to the Federal Emergency Management Agency (FEMA), the government entity responsible for disaster response and prevention, the number of floods, flood deaths and property losses caused by flooding is increasing. Nationwide, floods killed 892 people between 1988-97, and cost an average of $4.3 billion each year during the same time period. FEMA believes a principle cause for this increased flooding is poor planning and unwise development that destroys the wetlands and open space that protect communities". (Sierra Club, 1998)

Further services associated with vegetated riparian zones include recreation, property values, recreation and tourism opportunities, and intangible benefits discussed elsewhere in this document.

Economic Benefits to Restoring Beneficial Uses in the Great Lakes Areas of Concern

Extracted from the Sediment Priority Action Committee 2000 (SedPAC)

The 1987 GLWQA commits the two governments to develop Remedial Action Plans (RAPs) at Areas of Concern (42 in total at that time, 15 remaining in Ontario) where ecosystem deterioration is particularly pronounced. A RAP is an instrument that enables governments and concerned citizens to restore and protect "beneficial uses" (14 of which are specified in the Agreement). According to Annex 2, the two federal governments are to work in cooperation with state and provincial governments and with local communities to jointly develop and implement the RAPs. Krantzberg (2003) discusses the process for developing and implementing RAPs in greater detail.

In some cases uses are activities or thing that cannot be evaluated directly by economic analysis, such as improved aesthetics of the water, although contingent valuation could be used in this case. In other cases the beneficial use is associated with or leads to some other activity that may be subject to economic analysis, such as reductions in fish advisories, which leads to more enjoyment of recreational fishing. For each use impairment, SedPAC (2000) identified one or more categories of economic benefit that could be measured and evaluated.

Restrictions on fish and wildlife consumption

In many AOCs, the fish and/or wildlife have concentrations of pollutants in their flesh that may cause harm to humans. This leads to advisories recommending the limitation of consumption of those species. If prevention or remediation reduces the concentration of pollutants in the fish, the human health risk is reduced, and advisories can be relaxed or eliminated. This may increase the enjoyment of those who wish to consume the fish and wildlife, which may be seen through an increase in fishing and hunting for sport, for commercial ends, or for sustenance. In the case of native communities, the harm caused to the social structure as a result of banning a traditional food source that is central to the traditional way of life may be quite great, and the benefits of restoring that food source should be correspondingly great.

Economic benefits: Human health; Recreation (fishing & hunting); Commercial fishing & hunting; Social-Cultural (aboriginal).

Degradation of fish and wildlife populations

Restoring populations may improve the quality or quantity of fishing and hunting for sport, for commercial ends, or for sustenance. It may also contribute to a more complex and robust aquatic and terrestrial ecosystems. This, in turn, might lead to increased human enjoyment of the area for recreational purposes including fishing, hunting, and viewing. There remains the question of how to value such an ecosystem restoration beyond these active uses. If some individuals value the existence of a healthy ecosystem in itself, apart from their use of it, there are added benefits from enhancing ecosystem integrity.

Economic benefits: Recreation (fishing, hunting, viewing); Commercial fishing & hunting; Social-cultural (aboriginal); Ecosystem integrity.

Degradation of fish and wildlife habitat

Remediation and protection can help to restore populations suffering from lack of habitat quantity and quality, leading to benefits similar to those listed above for populations.

Economic benefits: Recreation (fishing, hunting, viewing); Commercial fishing & hunting; Social-cultural (aboriginal); Ecosystem integrity.

Fish tumours and other deformities

Active intervention or pollution prevention that reduced the incidents should make the fish more attractive and should increase the quantity of fish consumed. The benefits are therefore similar to those for improved fish populations, but also include the increase in the health of the birds and animals, as well as their numbers.

Economic benefits: Recreation (fishing & hunting); Commercial fishing & hunting; Social-cultural (aboriginal); Ecosystem integrity.

Bird and animal deformities and reproductive problems

Active intervention or pollution prevention that reduced these incidents should make them more attractive and should increase the quantity of wildlife caught. It could also improve the value of wildlife for observation. The benefits are therefore similar to those for improved wildlife populations, but also include the increase in quality.

Economic benefits: Recreation (fishing, hunting, viewing); Commercial fishing & hunting; Social-cultural (aboriginal); Ecosystem integrity.

Degradation of benthos

Actions that enable the recovery of benthos could in turn lead to improvements in the aquatic ecosystem in general and hence to improved fish and wildlife populations, for which the benefits could be measured.

Economic benefits: Recreation (fishing, hunting, viewing); Ecosystem Integrity; Economic Development.

Eutrophication or undesirable algae

Eutrophication can reduce the quality of water for fish and wildlife, and for human recreation. The benefits from remediation and prevention could be measured as benefits to fish and wildlife populations, as direct benefits to recreational activity, and as benefits to ecosystem integrity.

Economic benefits: Recreation (fishing, hunting, swimming); Commercial fishing & hunting; Social-cultural (aboriginal); Ecosystem integrity.

Degradation of phytoplankton or zooplankton

The degradation of phytoplankton or zooplankton can have an impact on the quality and quantity of both fish and wildlife. The benefits of reduced degradation could be measured by estimating the benefits of improving the fish and wildlife populations.

Economic benefits: Recreation (fishing & hunting); Commercial fishing & hunting; Social-cultural (aboriginal); Ecosystem integrity.

Added cost to agriculture or industry

The presence of contaminants can cause the water to be unsatisfactory for agricultural or industrial use. Contamination may result in the need for pre-treatment of water supplies, remediation may reduce those treatment costs.

Economic Benefits: Avoided costs to agriculture and/or industry.

Restrictions on dredging

The presence of contaminated sediment may lead to restrictions on dredging. The physical effect of the restrictions is that channels become silted up, interfering with navigation of commercial and recreational vessels thereby increasing shipping costs, sometimes substantially. The economic effect may also be due to the increased cost of shipping with reduced loads, or the higher cost of employing environmentally protective dredging. Dredging and disposal costs for contaminated sediment is three to five times that of unrestricted materials, from $3-10 per cubic yard to $10-50 per cubic yard.

Economic benefits: Avoided costs for navigation.

Case Studies

The case studies provided below were selected due to their relevance to Ontario's Great Lakes and were among the few available to illustrate the magnitude of economic values.

Waukegan Harbour and related sediment studies

According to the IJC (2003) as of 2003, Canada and the U.S. spent upwards of $33 million Cdn. and $160 million US, respectively, on remedial projects at the Great Lakes Areas of Concern. Alternately, SedPAC (2000) reported that $580 million had been spent. Regardless, the governments estimate $7.4 billion will be needed to restore beneficial uses in AOCs over the next decade at least (IJC 2003). Waukegan Harbor, Illinois is among the AOC where partial cleanup has occurred (IJC 2002).

Between 1948 and 1971,Outboard Marine Corporation discharged millions of gallons of hydraulic fluid containing PCBs into the harbour through floor drains. The resulting PCB concentrations in sediment exceeded 25,000 ppm in some areas, orders of magnitude greater than sediment guidelines in the US or Canada. The estimated price tag for sediment remediation was approximately $21 million US. Braden et al. (2004) estimated the value to the local community of cleaning-up the area using techniques that draw inference from residential property choices about the benefits accruing to homeowners. The study combined survey and market data. The flexibility of the survey approach complements the fact that property value data reflect real behaviours and financial commitments. As an influence on respondent's housing choices, the results indicating homeowners' willingness to pay, for full arbour cleanup, at approximately $400 million in Waukegan and $7 billion to $12 billion elsewhere in Lake County. The estimates are equivalent

to between 16 and 19 percent of the total value of Waukegan's owner-occupied housing stock and between 15 and 26 percent of home values elsewhere in the County.

Another study of sediment remediation in the Lower Fox River of Green Bay, Wisconsin, indicated average annual benefits of $100 to $300 per household (Environment Canada Sustainability Fund). In addition to benefiting property owners, remediation also increases the community's tax base. In the Hamilton Harbour Area of Concern, it is estimated that approximately 18.5% of the residential property values in the study area were attributable to improvements in water quality and the establishment of the Pier 4 and Bayfront Parks (Environment Canada Sustainability Fund).

Artificial Reef Project, Lake Erie, Ohio: Case Study, Lipton et al. 1995

Studies indicate that when artificial reefs are constructed with proper materials, placed in the right locations, and developed with a specific purpose and plan, they can enhance sustainable fisheries. In many areas, new aquatic communities created by the artificial reefs draw increased numbers of recreational and commercial fishers and scuba divers. Travel and tourism dollars brought into the region by visiting anglers and their families, results in positive economic impacts to local communities.

Unlike the western basin of Lake Erie, the central basin is deeper and larger. It also lacks the productive bottom structures that provide habitat for fish. These features, combined with the fact that schools of walleye are often located further from shore, make walleye more difficult to locate in the central basin. Access for boat anglers is another difficulty: the rocky bluff and high bank terrain of the central basin impedes the construction of marinas and launch ramps, which are readily available to boat anglers in the western basin. While there are many excellent fishing areas in the central basin, not all are within safe running distance for smaller boats. Fishery managers have recognized that construction of artificial reefs strategically located in areas easily accessible to boat anglers could attract greater numbers of anglers in the central basin. Furthermore, if the artificial reefs yield the expected results — attracting fish and thus increasing angler participation and catch rates — the fishery's role in helping develop a recreational economy in the Central Basin communities could be enhanced. Total costs for the construction of these reefs, while difficult to estimate due to substantial in kind contributions, ranged from $84,000 - $210,000.

One rationale for undertaking the Ohio Artificial Reef project was to improve the integrity of the central basin area. In the past, eastern Ohio waters have been plagued by heavy pollution. At one time the situation was so bad that the surface of the Cuyahoga River ignited. Since then, environmental enhancement measures have significantly improved water quality. Residents of the central Lake Erie region wanted assurance that the central basin could provide water-related recreational pleasures similar to those available in the western basin. The construction of artificial reefs has been perceived as an effective strategy to improve the area's character. Additional gains to local small boat anglers are also expected: anglers should experience increases in recreational fishing value as a result of the new, productive, quality fishing sites within close proximity to sheltered ports. Communities as a whole should benefit from some increases in tourist-related activities resulting from improved sport fishing opportunities.

Nipigon River Conservation Reserve Resource Management Plan

In 1990, research demonstrated that fluctuating water levels on the Nipigon River and excessive draw down was killing developing brook trout in the spawning beds. Following a series of flow tests, an agreement established a minimum flow of 270m3/s on the Nipigon River from October 1 to May 15. By 1994, the province, Ontario Power Generation, and stakeholders developed a long-term Nipigon River Water Management Strategy cooperatively after extensive field studies, computer modeling and thorough public consultation process.

This strategy met the goals of the study by establishing guidelines for addressing water levels needs for lake and river fish as well as the water levels needs of all users, including the provision of safe drinking water. The recommended flow seeks to minimize the negative impacts on fish and all users of both the river and lake. The intent of the new Operating Plan is to (1) significantly improve water level conditions for fish on the Nipigon River and Lake Nipigon, (2) have only a marginal (1%) impact on the value of hydroelectric power generation (relative to the estimated total average annual value of approximately 30 million dollars in 1994), and (3) improve conditions for other users.

Ontario Power Generation (OPG) operates all three of the Nipigon River generating stations. Alexander Dam has a capacity of 67.5 mega watts (MW) and in 2000 produced 522 giga watt hours (GWh) valued at $21 million. Cameron Falls Dam has a capacity of 75 MW and in 2000 produced 643 GWh valued at $26 million. Pine Portage Dam has a capacity of 128.7 MW and in 2000 generated 979 GWh, valued at $39 million. In 2000, total value of the Nipigon River production was $86 million.

Critical Asian carp barrier at risk

http://www.glc.org/announce/06/05carp.html

Media Release of the Great Lakes Commission

Congress urged to act against Great Lakes invaders

“After a close call in which the Great Lakes could have lost one of its major protections against invasive species, especially the Asian carp, the Great Lakes Commission is urging Congress to take action to ensure that it doesn’t happen again.

The Commission is calling for Congress to pass the long-delayed Water Resources Development Act that, in addition to addressing other Great Lakes needs, provides for the permanent operation of an Asian carp barrier in the Chicago Sanitary and Shipping Canal.

The barrier faced being shut down before the U.S. Senate approved emergency legislation Thursday morning authorizing the U.S. Army Corps of Engineers to operate the facility on a temporary basis. The barrier had been schedule to cease operation on Monday, May 8, due to a lack of funds and limits on the funding authority.

“In order to provide authority for a permanent, effective barrier against Asian carp through the Chicago Sanitary and Shipping Canal, Congress must swiftly pass the Water Resources Development Act,” said Tom Huntley, chair of the Great Lakes Commission. “We can’t keep relying on stopgap measures to protect the Great Lakes against an invader that could wreak vast ecological damage and devastate our sportfishing industry.”

The barrier uses an electric field to prevent Asian carp and other invasive species from reaching the Great Lakes via the Mississippi River system, where they have become established. The Water Resources Development Act would provide permanent authority for the Corps of Engineers to operate the barrier and authorize funding to cover the cost.

The Asian carp is feared because its voracious appetite could devastate the food chain and sport- and commercial fishing if it should ever become established in the Great Lakes. Originally brought in to control algae in southern fish farms from which it escaped, these “aquatic vacuum cleaners” can grow to several feet in length and nearly 100 pounds.

“Our price tag for combating invasive species in the Great Lakes, such as the sea lamprey and zebra mussel, is already millions of dollars a year,” said Leslie Sgro, deputy director of the Illinois Department of Natural Resources.

“It’s simply short-sighted not to make the relatively modest investment we need to protect ourselves against this new invader, particularly with our $4.5 billion Great Lakes sport fishing industry at risk.”

The Chicago Sanitary and Ship Canal barrier consists of two units, a temporary demonstration barrier and a more powerful permanent barrier that is partially completed. The stopgap measure authorizes the Corps to take over operation of the temporary barrier, but using funds originally designated for completion of the permanent barrier. The Water Resources Development Act would authorize both the completion of the more powerful barrier and permanent operation of both that barrier and the demonstration barrier as additional protection.

The Senate legislation now goes to a conference committee to be reconciled with the House supplemental bill, H.R. 4939, which did not include funding for the barrier[1]."
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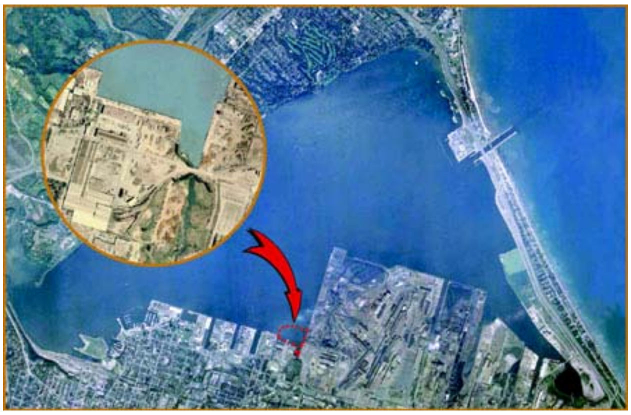
BENSIM: A Dynamic Simulation Benefits Assessment Model Applied to Hamilton Harbour Remediation

Edward Hanna, Tatiana Koveshnikova, Elizabeth Kuruzc, Eric Miller, Peter Victor



Benefits of Environmental Clean-up Projects: A Stakeholder-driven Model

This BENSIM model identifies each major stakeholder/beneficiary involved in harbour remediation. Benefits necessarily differ greatly according to beneficiary perspectives. The beneficiaries include:

- Government (federal, provincial, municipal)
- Industry (Stelco, Dofasco, local businesses)
- Hamilton Port Authority
- Public (Harbour users, unemployed, property owners)

Benefits are sorted into monetary, social, and environmental categories, and span:

- Reputation
- Expenditures
- Revenues
- Property development
- Employment
- Increased use and enjoyment

Point estimates provided below by the authors are shown for each benefit type. The authors note that in many instances the range for each point estimate is quite large;

[1] Operation of the barrier is estimated at $250,000 US per annum

BENSIM is being used to explore the ranges for important point estimates. Further, not all benefits have been expressed in economic terms; therefore, these economic benefits underestimate the full benefit of Hamilton Harbour remediation. The values reported here include the remediation of contaminated sediment at Randle Reef, and all other remediation predicted as required for delisting Hamilton Harbour as an Area of Concern. For the federal government, direct (federal income and sales taxes collected from all remediation spending), indirect revenues (federal income and sales taxes collected from increased spending generated by spin-off activities that generate income) and cost avoidance with full-scale remediation of the harbour amount to $338 Million. Figures for the province are $279 Million. Property tax collected on improved property values plus land development tax collected on new properties, and avoided infrastructure spending on developments near to the harbour bring a benefit to the municipalities of $60 Million. For local businesses, increased sales of goods and services from increased income generated by spending on the projects and spin-offs amount to $592 Million in benefits. Appreciation of existing residential property assets, and new residential property assets have a value of $124 Million to local property owners. Boating, swimming, angling, and passive use increase in value by $496 Million with Harbour restoration. These values give an order of magnitude synopsis of the benefits associated with natural resource damage mitigation.

Natural Resource Damage Assessment: Case Study, US Environmental Protection Agency

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) addresses any release, or threatened release, of hazardous substances, pollutants, or contaminants that could endanger human health and/or the environment. CERCLA's response provisions focus on the protection of human health and the environment. The statute also provides authority for assessment and restoration of natural resources that have been injured by a hazardous substance release or response. CERCLA define "natural resources" broadly to include "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources"…" One of the primary responsibilities under CERCLA is to assess the extent of injury to a natural resource and determine appropriate ways of restoring and compensating for that injury. A natural resource damage assessment (NRDA) is the process of collecting, compiling, and analyzing information to make these determinations.

Using valuation methods, such as contingent valuation, averting behaviour analysis, hedonic analysis, and travel cost analysis, reasonably accurate case specific estimates of NRDAs can be generated, however, they are time consuming, since a study must be conducted to evaluate the exact magnitude and nature of the injury to natural resources, and then additional analysis must be carried out in order to ascertain the value of the injured resources to society.

Damage estimates are likely to be higher in cases where the injured resources are of relatively great value. There are many places where judgments of relative values are implicitly being made; four examples can be readily identified. Consider a chemical or oil spill. First, spill vulnerability scores are higher in marine and estuarine areas if species of special importance (such as those thought to be endangered) are likely to have been affected. Second, spill vulnerability scores are higher in freshwater areas if the water system in question is important for benefits such as municipal water supply, recreation, or wildlife habitat. The scores are also higher if the water system is relatively pristine. Third, the index of recreation vulnerability includes factors relevant to the social value of the damaged resource, since recreation vulnerability is a function of how many people participate in recreational activities in the area affected by a spill. Fourth, spill vulnerability scores are higher for freshwater wetlands that are important (for example, those that harbour endangered species) or unusual. However, there is no unified, transparent mechanism through which the value to society of damaged resources is brought into the calculations (Ando et al. 2004).

Extra Intangible Benefits

Consideration of passive-use value in an economic analysis is due to Krutilla's (cited by Carson 2000) seminal observation that many people value natural wonders simply for their existence. Krutilla argued that people obtain value through vicarious enjoyment of natural areas and, as a result, had a positive willingness to pay government to exercise good stewardship of the land. These values have been variously called bequest value, look-existence value, intrinsic value, inherent value, passive-use value, stewardship value, and non-use value. Without the inclusion of passive-use considerations, pure public goods, including overall level of air and water quality, and remote wilderness areas, have little or no measured economic value.

Pure public goods are those for which it is impossible to exclude people from enjoying the good and from which enjoyment by one person does not degrade another person's enjoyment of the good.

Government typically, but not always, provides pure public goods. The value of pure public goods cannot be assessed by traditional economic techniques because these techniques measure differences in quantities of a good consumed as a function of differences in prices. For a pure public good, all people experience the same level of the good.

Harris et al. (1989) remind us that natural areas and wildlife are often viewed as:

> Either priceless or beyond market-like transactions because of spiritual or other facts, including perceptions that moral rights rather than exchangeable property rights should predominate.

Cost-benefit analysis however, has several shortcomings, Cost-benefit analysis rests on a series of assumptions and value judgments that cannot remotely be described as objective. Moreover, the highly complex, resource-intensive, and expert-driven nature of this method makes it extremely difficult for the public to understand and participate in the process. Thus, in practice, cost-benefit analysis is anything but transparent

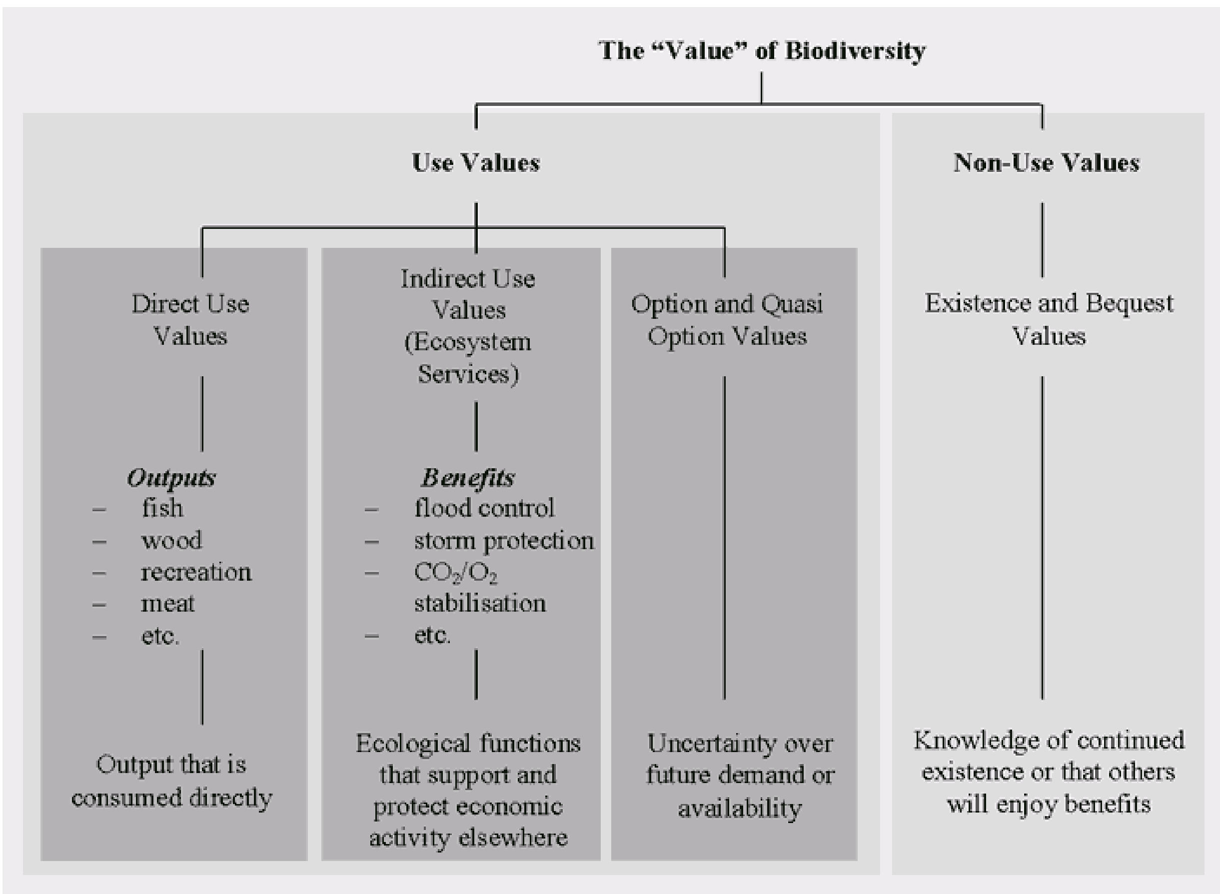
(Ackerman and Heinzerling 2005). Many benefits of public health and environmental protection have not been quantified and cannot easily be quantified given the limits on time and resources. Even when the data gaps and limitations are explicitly stated, policy debate tends to emphasize numeric values produced by cost-benefit analysis while relevant but non-monetized factors are ignored or forgotten.

It is, however, becoming an increasingly common environmental policy decision tool. Legislators and the public are calling for more careful evaluation of the costs and benefits of government actions to improve the environment (Cangelosi 1996). Increasingly, cost-benefit analysis is required to measure the cost-efficiency of environmental protection interventions or regulations. Cost-benefit comparisons also are being applied in cleanup projects to select among competing environmental recovery scenarios. However, while numerous researchers have evaluated pollution impacts, little has been done to estimate the economic benefits that would result from environmental improvements. Several shortcomings in the art and science of cost-benefit analysis make the procedure problematic and controversial. Little is known about ways to assess the costs of not acting to protect the environment, or the benefits of action. Many costs of pollution and most benefits of a clean environment are intangible or difficult to track. For example, the value of a healthy eagle population to basin residents may not be quantifiable. Similarly, we lack the technical know-how to assess the improvements in public health (and therefore savings) that could accrue from increased pollution controls or a cleanup. Finally, we need tools to assess the value to future generations of preserving environmental amenities (Cangelosi 1996).

Clearly, some of the environmental amenities or services that flow from natural resources are more difficult to quantify than others. The difficulty is particularly evident for those resources that are not traded in markets. For example, the value of preserving a species (or the cost of its extinction) is difficult to estimate because there is no way to predict the potential value the species might have had for future generations. Likewise, the value of preventing further global climate change is difficult to gauge because we cannot be sure of all the potential outcomes of no action until they are upon us, and it is no longer possible to prevent them.

Protected areas, and nature conservation generally, provide many benefits to society, including preservation of biodiversity, maintenance of watersheds, and so on. Many of these benefits are intangible. The loss of open land and functioning ecosystems is essentially an irreversible process, and little insight is available to those making land-use change decisions as to what tangible and intangible values are being lost. To understand what sustainable development means in a practical sense, it will be necessary to preserve natural capital, or at least articulate and understand the value of the lost natural capital. Such capital is what natural systems provide in the current and future flows of service, such as resources, flora, fauna, and ecosystems that provide human beings with tangible and intangible goods and services that have real use and non-use economic value (Jaffe 2006).

The different categories of value of different elements and functions of biodiversity



Reproduced from Organisation of Economic Cooperation and Development (1999)

There are very few studies that synthesize a broad a range of interdependent ecological functions, uses and values at a given site; or that track site changes in values across different states of ecological disturbance (Turner et al. 2003). Such studies would be of great relevance to decision makers faced with the complex trade-off between protection and conservation net benefits and development (requiring land use change) net benefits. There is an inarguable need for more research studies of this type to complement and extend the current environmental valuation knowledge stock. This data can then be combined with socio-political and socio-cultural knowledge to better inform sustainable development projects, policies and programs.

Summary

Summary of Quantified Economic Values

Sector	Value per annum (except where noted)	Notes	Where value is counted	Relevance to Great Lakes Ecosystem Quality and Water Quantity
Commercial Fishing	$35 million	Landed value of fish only (before processing)	Ontario, Canada	❖ Quality of water in the Great Lakes directly related to prosperity of industry ❖ Contaminant levels in fish are a measure of effectiveness of harmful pollutant management regionally, nationally, internationally ❖ Contaminant levels in fish can also reflect how changes in food web effect contaminant tropho-dynamics; ❖ Contaminant levels that exceed guidelines and regulations for safe consumption, export represent a lost economic, cultural use opportunities) ❖ Lower water levels reduce spawning and breeding areas for native fish
	$91.4 million including indirect sales, employment income and taxes + 1136 person years of work			❖ As above
Aquaculture	$23-$24 million	Landed value of fish only	Ontario, Canada	❖ Quality of water in the Great Lakes directly related to prosperity of industry ❖ Lower water levels or changes to nearshore currents could exacerbate waste assimilation from net cultures
	$65 million + 500 person years of work	Total Value added to the economy	Ontario, Canada	
Transportation	$2.2 - $3 billion + 17/18,000 jobs	Value added to provincial GDP through activities generated by transport industry	Great Lakes and St. Lawrence	❖ Lower water levels reduce the transportation/navigation abilities of commercial boats in the Great Lakes, decreases value of maritime transport
Sport Fishing	$7.5 billion	Value of total industry – including money spent on trips, boats, travel, tourism, etc.	Canada and US	❖ Quality of water in the Great Lakes directly related to prosperity of industry ❖ Lower water levels reduce spawning and breeding areas for native fish ❖ Polluted water reduces recreational enjoyment and willingness to participate in industry

Sector	Value per annum (except where noted)	Notes	Where value is counted	Relevance to Great Lakes Ecosystem Quality and Water Quantity
	$500 million	Direct Spending on trips only, no secondary effects	Ontario, Canada	
Recreational Boating	$2.2 billion	Value to the overall economy	Canada (no study available for Canada and interpolated from US values)	❖ Polluted water reduces recreational enjoyment and willingness to participate in industry ❖ Lower water levels reduce navigable pathways for leisure trips
Beaches	$200-$250 million	As valued by beach-goers in terms of what they would be willing to spend and what they do spend to recreate at the beach	Ontario (no study available for Canada and so interpolations made from US values)	❖ Polluted water reduces recreational enjoyment and willingness to participate in industry ❖ Too high/too low water levels reduce aesthetic value/ recreational abilities of beaches
Wetlands and Biodiversity	$70 billion	Includes values of nutrient cycling, flood control, climate control, soil productivity, forest health, genetic vigour, pollination and natural pest control	Canada (unable to separate values by provincial lines – inextricably linked)	❖ Polluted water can negatively affect the health and prosperity of all creatures whose habitat lies within the wetland. ❖ Unhealthy wetlands reduce the positive benefits that humans receive from them such as air and water filtration, biotic enjoyment and useful medicines, etc. ❖ Wildlife viewing is a significant sector and its economic impact in Ontario needs to be included in the report

Summary of Economic Threats to the Value of the Lakes

Threat	Potential Loss Value	Notes	Geographic Area of Reporting
Aquatic Invasive Species	4% loss of native freshwater species	Over next century the entrance of AIS could cause the loss of these species through predation, overcrowding, food web alterations, etc.	Both Canada and the US
	$134 billion ($9 billion per AIS expected) - 15 most recent invaders could cause this much economic damage by 2050	Zebra mussel – $5 billion/yr (control costs and damages) however no estimation of health effects Sea Lamprey -$12 million/yr in control costs - $6 million studying effects of lampricide Asian Carp – over $9 million on protective barrier and over $450, 000/yr in maintenance of barrier	US (similar effects are expected to be seen on Canadian side)
	$500 million	Control Costs spent by Canada every year on current AIS in Great Lakes (no estimation of environmental impacts)	Ontario mainly, Canada
	$6 million	Preventative Costs for Ocean ships	Both Canada and US
	$4 million	Monitoring, reporting, and public dissemination of all ballasting activities	Both Canada and US
	$2.5 million	To determine immediate prevention measures	Both Canada and US
Infrastructure	$18 billion	Needed over next 15 years to provide effective drinking water to Great Lakes population due to inefficient pricing of water in the past	Ontario, Canada
Water Power (tribs)	-while not examined in this study—loss of access to critical habitat by a significant number of Great Lakes species		
Agricultural Practices	-while not examined here—irrigation (water extraction from tribs; nutrient and contaminant loading; riparian habitat loss; increased costs to water treatment…..		

Threat	Potential Loss Value	Notes	Geographic Area of Reporting
Sprawl	$5,300 per unit of housing (1995 dollars)	Additional public and private costs of infrastructure	Applicable to Canada
	$11,000 per unit of housing over a 75 year period	Infrastructure replacement, and operating and maintenance costs	Applicable to Canada
	$700 million - $1 billion	Excess infrastructure, operating, maintenance, emissions, health care, traffic policing, etc. costs	Greater Toronto Area
Social /Lifetime Costs	$93-$250 million	Reduced productivity and increased social costs due to mercury exposure to children in the womb	Ontario, Canada
	$5 billion +	Increased mortality rates due to pollution carried in the Great Lakes region (death rates and increased sickness and hospital stays)	Ontario, Canada
Loss of Transoceanic Vessels	$54.9 million/yr	The reduction in the transport industry if the oceanic vessels were restricted due to concerns over introduction of AIS.	Ontario, Canada

Recommendation For Further Quantification:

- *A study into the direct and indirect benefits of aquaculture in the Great Lakes to Ontario and Canada be performed in order to better understand how to best include these practices into the management of the Lakes. A survey of aquaculture industries has been done by Statistics Canada, however the numbers available should be separated into the different regions where they are seen. This would begin to allow a more accurate assessment of how the aquaculture industry would be affected by different stressors on the Great Lakes.*

Recommendation for Further Quantification

- *A survey of Great Lakes fisheries would be valuable to ascertain precisely their fish markets to help determine where the effects of the methyl mercury contamination would most likely to be seen and could consequently be monitored.*

Recommendation for Further Quantification

- *The extraction of the Canadian portion of the value of wetlands has not been determined, and while the value of maintaining Canada's vast resource of wetlands should be obvious with respect to its provision of the basic necessities of life non-use value methods could be developed to valuate these resources.*

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