Wetlands and Climate Change
Phase 1

Feasibility Investigation on

The Potential for Crediting Wetland Conservation as Carbon Sinks

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WETLANDS AND CLIMATE CHANGE

The Potential for Crediting Wetlands Conservation as Carbon Sinks

1. INTRODUCTION

Climate change is undoubtedly the most pervasive, complex and challenging of the global environmental issues facing contemporary society. Perceptions of climate change causes, effects, approaches and solutions are diverse, and are often divided on the basis of equitable environmental, social and development opportunities between the industrialized and developing world.

The United Nations Framework Convention on Climate Change (FCCC), adopted at the Rio Earth Summit in 1992, is unique in many respects. It commits all countries to "mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases." The intent of the FCCC is clearly to function as an emissions control convention. However, the requirement for actions to protect and enhance biological sinks underscores the fact that the FCCC is also a sustainable development convention, reflecting the overarching tenet of Rio.

The 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCC) reached a significant milestone in addressing the global threat of climate change. For the first time, industrialized countries agreed to quantified commitments to limit or reduce greenhouse gas emissions by at least 5 per cent below 1990 levels during the first commitment period of 2008-2012.The Kyoto negotiations were protracted and difficult and were only concluded at the last possible moment. Thus, while emission reduction objectives are established for industrialized countries, the means of achieving objectives and extending commitments globally are very much a work in progress. The Protocol is historic in reaching agreement on what to do. However, it represents only the beginning of a process on how to do it.

If one considers the UNFCC to be exclusively a pollution control issue, the Kyoto Protocol would address, through some form of international enforcement regime in developed countries, a limited contribution to global GHG emissions. However, the protocol recognizes that the scope of global solutions must be much more comprehensive and truly incorporate the full dimension of sustainable development.

A major challenge remaining to the Kyoto Protocol is how to engage developing countries in the reduction of greenhouse gas emissions. Since historical emissions are disproportionately from industrialized countries, and development is such a priority for developing countries, equity of both costs and benefits of climate change mitigation and adaptation is of utmost importance.

In addition to the reduction of greenhouse gas emissions by industrialized countries, the Kyoto Protocol provides for: activities which remove CO2 from the atmosphere (carbon sinks); emissions banking, trading and other measures which limit and reduce emissions of GHG; and a joint implementation/clean development mechanism.

The Protocol currently deals only with sinks in the land-use change and forestry activities of afforestation, reforestation and deforestation undertaken since 1990. For the time being, agricultural sinks are not included. However, the Protocol allows for negotiations on what and how additional sinks, including agricultural soils, can be used to meet commitments. As a result of this recognition, activities such as agricultural soils or those pertaining to wetland conservation may be open for consideration.

The key to gaining international acceptance of carbon sequestration for additional land-use, land-use change and forestry activities is to determine a realistic projection, both nationally and internationally, and an agreed methodology for determining “verifiable changes in stock. Some ecologists believe that wetlands can be managed as carbon sinks as part of a mitigative approach to climate change. Should this prove to be correct, then the argument for conserving wetlands and enhancing and sustaining their wide diversity of benefits can be bolstered by an entirely new set of ecological functions and values.

The focus of this study is on the potential role of wetlands in mitigating the impacts of climate change through carbon sequestration. The study takes as its departure point the Kyoto Protocol’s approach to forestry and agriculture as carbon sinks. A key focus will be on human-induced land-use and land-use change brought about by wetland conservation programs, notably the North American Waterfowl Management Plan (NAWMP) Habitat Joint Ventures in agriculture and forest working landscapes.

The feasibility study was separated into two phases: 1) Phase 1 - the science and policy foundations and criteria for wetland conservation as GHG sinks and sources; and 2) Phase 2 - the measurement and verification of wetland sinks. This discussion paper reports on the science and policy components of Phase 1.

2. INTERNATIONAL SINKS POLICY

2.1 The Rio Foundation

The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992 at the Rio Earth Summit, states that "*Each party shall… limit its anthropogenic emissions of greenhouse gases and protect and enhance its greenhouse gas sinks and reservoirs".* While this statement is interpreted in many ways, it is clear that sinks are an integral component of the Convention. The UNFCCC defines a sink as "*any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere."*

The UNFCCC further defines a source as *"any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere".* Reservoirs are defined as *"a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored".*

The term "anthropogenic" has yet to be clearly defined. While the term "human induced" has been has been used as a substitute for anthropogenic and has found widespread acceptance for emissions from industrial processes and fossil fuel combustion, there is some difficulty in applying it to land-use and land-use change activities, that can have both a source and sink term. Because of the natural dynamics and cyclical nature of ecosystems, the time frames for recognizing and measuring greenhouse gas sinks are highly variable. Because of the dominating influence of naturally and anthropogenically variable ecosystems in Canada, such as forests, wetlands and agricultural systems, the sinks issue is of particular national significance and relevance.

2.2 The Sinks Issue from Rio to Kyoto

The Kyoto Protocol was the result of two and a half years of negotiations initiated by the first Conference of the Parties (COP) to the UNFCCC in 1995. The negotiations dragged on to the last minute, culminated after 48 hours of non-stop talks with 160 nations, including Canada, finally agreeing.

Prior to Kyoto, there were two opposite positions on sinks: include them all (that is to allow countries to use sinks to net their gross emissions), or not include them at all. Added to this impasse was the fact that there was no agreement on how they would be included, if in fact they were. If included, they could either count in both the base year (1990) and in the commitment period (the 'net/net" approach), or be counted only in the commitment period (the "gross/net" approach).

The arguments for including sinks were that the UNFCCC includes then (but is unclear on whether they are to be subtracted from emissions, i.e. netted out) and that the best incentive to enhance them is to include them in legally binding commitments. The arguments for excluding sinks were that they constitute a loophole from emissions reductions, and that because of the large uncertainties, they are unverifiable. Canada's view on the uncertainty argument has been that uncertainties could and should be dealt with, as they would be with sources. The onus would be on the reporting party to ensure that what is reported would meet the agreed criteria for verification and compliance. The exclusion of sinks would have removed much of the incentive to undertake protection and enhancement of sinks. In particular, by excluding forestry (and soils and wetlands), we would have failed to foster the sustainability of forests (and agricultural and wetland systems) and would have contradicted the aims of the convention and other international agreements.

A modified middle ground (based in large part on Canada's submission) was adopted in Kyoto after protracted last minute negotiations. The negotiated compromise, with its inherent imperfections, was an agreement to include some land-use change and forestry activities, undertaken after 1990, that affects sinks, namely afforestation, deforestation and reforestation (RAD). These would be added to or subtracted from Parties gross emissions when assessing compliance over 2008-2012, and would be measured as a verifiable change in carbon stocks (Article 3.3). The approach taken therefore was the "gross/net" approach.

When applied, if there is an increase in carbon stock between 2008 and 2012 as a result of RAD activities undertaken since 1990, then the average amount of carbon removal during the commitment period will be subtracted from Canada's average emissions in the 2008-2012 period. If the carbon stock declines (i.e., net carbon emission) as a result of these three post-1990 activities between 2008 and 2012, then the amount will be added to Canada's emissions in the period.

2.3 The Sinks Issue in the Kyoto Protocol

As a major step in meeting the objectives of the UNFCCC, the Kyoto Protocol was adopted in December 1997. The Protocol requires Annex 1 Parties to reduce their average emissions of six greenhouse gases [carbon dioxide (CO2), methane (CH4), nitrous oxide (N20), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6)] in the period 2008-2012, the "first commitment period" by at least 5 per cent below 1990 levels (Article 3.1). Canada's commitment as specified in Annex B is for a 6 per cent reduction.

Three provisions of the Protocol are of particular relevance to using sinks and sources in the “land-use change and forestry” categories of activities to meet the commitments of industrialized countries:

- Under Article 3.1, sources and sinks resulting from land-use change and forestry activities since 1990 are counted if they result from the specific direct human-induced activities of “afforestation, reforestation and deforestation”.

- In addition, under Article 3.4, the COP can decide to include additional human-induced activities related to “agricultural soils” and “land-use change and forestry” in the accounting of assigned amounts.

- Joint implementation of measures among Annex B countries addressed in Article 6 enables such countries to transfer or acquire emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy.

As mentioned previously, a gross/net approach to setting assigned amounts was agreed to by Parties in Kyoto on the basis that this was the most appropriate manner in which to deal with sinks. However, by limiting activities, by including activities that do not have a sink term (deforestation), and by specifying how the changes would be measured, the Protocol is not quite consistent in its treatment of sources and sinks. Furthermore, it does not fully account for what enters the atmosphere, nor does it credit and thereby provide incentives for good management practices for forests, farm and ranchlands, and wetlands that ensure the sustainability and wise use of these ecosystems.

By limiting human-induced actions that can be taken to enhance sinks to two activities undertaken since 1990 in two distinct categories, land-use and land-use change, the Kyoto Protocol has fundamentally changed the accounting system and the way we look at forests and land-use changes. The protocol has functionally produced what can pragmatically be called the Kyoto Forest. For many Parties, the Kyoto Forest represents a small fraction of their forested land, let alone their managed forests. As a result of dealing with only a small portion of forested landscapes and not addressing other managed landscapes, the Kyoto Protocol falls far short of providing the appropriate incentives to meet the goal of the UNFCCC – “*to protect and enhance sinks”.*

In spite of these limitations, the Kyoto Protocol does provide an opportunity to define the current sinks activities and the yet to be defined terms in such a way as to maximize the potential to reduce emissions and enhance sinks. There is an opportunity to work towards definitions that encompass a broad, but realistic, ecosystem/landscape approach to sinks. Such an approach would, in fact, acknowledge the substantial move towards sustainable forestry and agriculture, and the conservation and wise use of wetlands and water resources. A policy imperative is to integrate Kyoto implementation with other international environmental agreements, so as to directly contribute to sustainable development and ensure that the protection and enhancement of sinks is maximized.

2.4 Agriculture Soils and Other Sinks

Agricultural soil sinks are not currently included in the Kyoto protocol. However Article 3.4 allows for negotiations on which and how additional sinks activities (other than RAD), including agricultural soils, can be used to meet commitments. From a source point of view, agricultural soils are specifically recognized in the list of potential sources of greenhouse gases, which Parties must identify in their base year emissions and attempt to reduce. Thus, conservation farming practices, such as minimum, or no till, which have reduced the amount of CO2 emissions since 1990, will contribute to achieving our target.

Wetland sinks are not referenced in the Protocol. However, when forest soils are included, peatlands constitute the largest carbon store in Canadian forest landscapes. Wetlands are also prominent components of Canadian farmland. In the strong movement towards sustainable agriculture in the past decade, wetland conservation has become an important component of broader agricultural landscape soil and water conservation initiatives, including the enhancement of carbon sinks. Although wetlands have not been widely studied, any change in their carbon content may need to be included when we consider the sink capacity of agricultural soils.

Article 3.4 allows for negotiations on what and how additional sinks activities, including agricultural soils, can be used to meet commitments. The COP will decide upon modalities, rules and guidelines as to how carbon removals in agricultural soils, and any additional land-use change and forestry activity, shall be taken into account. The key to gaining international acceptance of carbon is to have a confident projection of the potential, both nationally and internationally, and an agreed methodology for determining “verifiable changes in stock”. Canada and some other countries believe that while these methodological issues are recognized, uncertainties should not be seen as being a reason to exclude agricultural soils.

The Intergovernmental Panel on Climate Change (IPCC) has been tasked to prepare a Special Report on Land-use, Land-use Change and Forestry that will examine the implications of dealing with sinks in a limited fashion and any additional activities including agricultural soils for completion by May 2000. (Foundation Paper, 1998).

2.5 Carbon Stock Measurement and Monitoring

The inclusion of a carbon sink offset in a future COP agreement will depend on the ability of countries to demonstrate their ability to measure, in a reliable, transparent and verifiable manner, the changes in carbon stocks associated with those land-use activities and practices.

The National Sinks Table developed terms of reference for the Measurement of Verifiable Changes in C Stocks in Agricultural Soils, which provide a concise description of measurement and monitoring requirements for soil sinks:

Objectives:

- Define the measurement needs to measure carbon stocks and flows from the soils of agricultural landscapes.
- Identify and assess the various options for measurement, monitoring and verification of changes in carbon stocks in the soils of agricultural landscapes.

Tasks:

- Identify what information/data/methodologies would be required to report on changes in soil carbon…
- Review, describe, and assess the various options for measurement, verification and monitoring over time of changes in carbon stocks within the soils of agricultural landscapes, including the quantification and verification framework described in Bruce et al. 1998. This should include assessments of the adequacy of:

(a) Soil carbon modeling capability,
(b) Input databases for estimates of soil carbon
(c) Data for estimation of land-use and land-use changes within agricultural landscapes, including crop land, range land, the wetland fringe, and afforestation lands,
(d) Monitoring data for model audit and validation,
(e) Methodologies for upscaling to regional and national levels of assessment,
(f) Current research projects being conducted to provide input to the development of a soil carbon measurement tool.

- Assess the uncertainty associated with soil carbon measurement…including a definition of how the term “verifiable” could be defined.
- Assess advantages, weaknesses and costs of various options.

2.6 Carbon Sequestration Markets

When the Kyoto protocol was concluded in late 19997, there was much media coverage and speculation on the potential value of carbon credits in the emerging post-Kyoto marketplace. This lead to concerns that carbon sink credit markets were being established that would provide cheep, developing world alternatives to emission reductions in industrialized countries. An additional concern was that bargain sink credits, particularly in the developing world, would lead to land management decisions designed exclusively for carbon sequestration. It was feared that broader values and benefits such as sustainable development and biodiversity would be compromised.

In discussing agriculture soil sinks, the Sinks Table notes that the ultimate value of a tonne of CO2 for trading is unknown at this time. There have been proposals to sell CO2 at anywhere from a few cents per tonne to tens of dollars per tonne (Foundation Paper 1998). Anderson et al. (1999) notes that the US administration argues that it can achieve compliance with the Kyoto requirements for less than US$25 per ton of carbon avoided, assuming an idealized system of international participation in carbon control through emissions trading. Other estimates go much higher, into the range of US$300 a ton.

The value of credits for carbon sequestration in developing countries through the Clean Development Mechanism is even more uncertain. However, draft guidelines for the GEF establish their financing threshold for short-term carbon sequestration at US$10 per tonne of carbon mitigated.

By and large, land management activities that result in enhanced carbon sequestration, provide other benefits such as soil and water and biodiversity conservation, increased productivity and more sustainable community support systems. Carbon sequestration initiatives then, will most often be value-added components of broader sustainable land-use programs. Actual carbon sequestration investments will be a function of the incremental costs required to justify a project and the market-determined value of the carbon credits. Pilot projects under Credit for Early Action and the CDM will be very important components of this evolving value-added cost-sustainbable benefit dynamic.

3. WETLAND CONSERVATION

3.1 Wetlands Background

Wetlands are among the world’s most biologically productive and diverse ecosystems. Ecologically situated at the interface between land and water, they optimize the attributes of both terrestrial and aquatic ecosystems. However, this transitional status contributes to wetlands being among the most threatened of the Earth's natural environments. Traditionally perceived as wastelands, wetlands have a long history of being drained and converted to other "productive" uses.

Natural wetlands are a collective term for a number of habitats, which have come about through different processes, The Ramsar Convention on Wetlands provides the most universally comprehensive definition of wetlands as: "*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters"* (Ramsar 1998).

Wetlands occur in every country, from tundra to the tropics. While the global extent of wetlands is not known exactly, the World Conservation Monitoring Centre has suggested an estimate of about 570 million ha, roughly 6 per cent of the Earth's land surface. Of that total estimate, 2 per cent are lakes, 30 per cent bogs, 26 per cent fens, 20 per cent swamps and 15 per cent floodplains. Mangroves cover some 24 million ha of coastal area, and an estimated 60 million ha of coral reefs remain worldwide. The largest areas of wetlands are in the high latitudes and the tropics. This is partly a function of high rates of wetland loss in temperate regions due to agricultural expansion and other developments (Ramsar 1998).

Over 24 per cent of the world's wetlands occur in Canada, where 15.9 per cent, or 148 million ha of the landscape is classified as wetlands. Of the terrestrial ecozones of Canada, wetland areas are highest in the north, covering 81 per cent of the Hudson Plains, 41 per cent of the Boreal Plains and 38 per cent of the Taiga Plains. Wetlands are least numerous in the high arctic and mountain regions. In the landscapes of southern Canada, wetlands cover 11.4 per cent of the prairies, 5.1 per cent of the Atlantic Maritime, and 7.5 per cent of the Mixedwood Plains of southern Ontario and Quebec (Ballard 1998). The distribution and abundance of wetlands in Canada is summarized in Figure 1.

3.2 Wetland Status

The majority of the world's wetlands are utilized by people for some purpose. Many of these uses are sustainable and are compatible with the concept of conservation and wise use of wetlands. Many other activities associated with economic, urban and water resources developments characteristically lead to permanent loss of wetland area and degradation of wetland quality and function.

Moser et al. (1996) report on a 1996 OECD overview that states*: "Some estimates show that the world may have lost 50% of the wetlands that existed since 1900; whilst much of this occurred in the northern countries during the first*

50 years of the century, increasing pressure for conversion to alternative land use has been put on tropical and sub-tropical wetlands since the 1950s.

No figures are available for the extent of wetland loss worldwide, but drainage for agricultural production is the principle cause; by 1985 it was estimated that 56-65% of the available wetland had been drained for intensive agriculture in Europe and North America; the figures for tropical and sub-tropical regions were 27% for Asia, 6% for South America and 2% for Africa, making a total of 26% worldwide. Future predictions show the pressure to drain land for agriculture intensifying in these regions."

Figure 2 illustrates the degree of land-use pressures on wetlands in Canada. For the most part the vast wetland areas of the north are not affected by direct human influence or land management activities. Exceptions are site-specific hydro, mining and non-renewable energy developments. The areas of moderate land-use pressure shown in Figure 2 correspond to areas of potential large-scale hydro developments, forestry harvesting practices and peat extraction.

Land-use pressures are highest in the working landscapes of southern Canada, where population, agriculture and development activities are greatest. The status of wetlands in these areas is governed by land-use practices on lands that are primarily owned and/or managed for other purposes. Agricultural expansion has been the major wetland impact in Canada. Regional studies estimate that 65 per cent of Atlantic tidal and salt marshes, 70 per cent of the lower Great Lakes-St. Lawrence River shoreline marshes and swamps, up to 71 per cent of prairie potholes and sloughs, and 80 per cent of Pacific coast estuarine wetlands have been converted to other uses. Primarily this is due to agricultural drainage and diking, to urban and industrial expansion, to construction of port, road and hydroelectric facilities, and to increased demands for recreational properties. Examples of high rates of wetland losses are extensive in the St. Lawrence lowlands, St. John River valley and the Annapolis valley. Furthermore, 80 per cent to 90 per cent of the wetlands surrounding many major urban centers have disappeared (Bond et al. 1992).

The status of wetlands in the working landscapes of southern Canada is considered to be under the influence of human-induced land-uses or land-use changes. For the most part they are affected either by commercial land-use practices or some form of direct or indirect conservation measures.

Information on the status of Canadian wetlands is derived from many different regional sources and disciplines. There is no systematic national inventory of wetlands, nor is there a remote sensing program for wetlands in place or planned. The state of the art Canadian wetland inventory is their remote sensing of prairie-parkland wetlands. In the absence of departments or ministries of wetlands, no national monitoring programs are foreseen.

3.3 Wetland Values and Benefits

There is a broad and growing recognition that wetlands are critically important ecosystems that provide globally significant environmental, social and economic benefits. Among the most biologically productive of ecosystems, they support exceptional levels of biodiversity, purify and moderate water resources and provide food, fiber and water security for local communities. The functions and values of wetland ecosystems, that have impacts far beyond their boundaries, afford them a disproportionately important role as an underpinning of sustainable development.

In addition, wetlands are important, and sometimes essential, for the health, welfare and safety of people who live in or near them. Among the world's most productive and biologically and functionally diverse environments, they provide a wide array of benefits.

(a) Functions

The interaction of physical, chemical and biological components of wetlands, which optimizes the attributes of both terrestrial and aquatic ecosystems, enables wetlands to perform many ecosystem functions, for example (Ramsar, 1997):

- Water storage;
- Storm protection and flood mitigation;
- shoreline stabilization and erosion control;
- groundwater recharge (the movement of water from the wetland down into the underground aquifer);
- groundwater discharge (the movement of water upward to become surface water in a wetland);
- water purification;
- retention of nutrients;
- retention of sediments;
- retention of pollutants;
- stabilization of local climate conditions, particularly rainfall and temperature.

(b) Values

Wetlands provide tremendous economic benefits, for example:

- Water supply (quantity and quality);
- Fisheries (over two thirds of the world's fish harvest is linked to the health of wetland areas);
- Agriculture, through the maintenance of water tables;
- Timber production;

- Energy resources, such as peat and plant matter;
- Wildlife resources;
- Transport
- Recreation and tourism opportunities.

Costanza et al. (1997) estimated the current economic value of 17 ecosystem services (goods and services) for 16 biomes. For the entire biosphere, the value (most of which is outside the market) was estimated to be in the range of US $ 16-54 trillion per year, with an average of US $ 33 trillion per year. Of all of the biomes, the total value per ha of marine and freshwater wetlands were the highest by far. On both a per unit area basis and a total global flow value, wetlands far exceeded the combined values of all forests, grass/rangelands and croplands. Of particular significance to this discussion is that wetlands were ranked highest for gas regulation, the ecosystem function of the regulation of atmospheric chemical composition such as CO2/O2 balance.

3.4 Wetland Conservation

North American wildlife management provided the foundation for the environmental movement near the turn of the Century. The regulation, or prohibition, of harvest and the protection of important habitats were the cornerstones of 20th Century natural resource management. This approach remains central to wildlife management today.

The *Environmental Decade* of the 1960s was launched in response to the concerted reactions of environmentalists, politicians and the public at large to environmental contamination and degradation, and threats to human safety. Awareness of the impacts of persistent toxic chemicals in aquatic and other ecosystems and their bioaccumulation in dependent fish and wildlife populations was instrumental in establishing the modern environmental agenda. Through scientific identification, documentation and public awareness, governments are pressured to enact strong and enforceable environmental regulation and protection legislation. This command and control *pollution control* approach has been, and continues to be very successful in mitigating and preventing the impacts of specific toxic chemicals and point source pollutants. Pollution control is a very effective means of dealing with single factor, or site specific environmental issues.

Prior to the mid-1980s, wetland conservation was, except in name, synonymous with the approach to pollution control. Important wetland sites were secured and managed exclusively for the benefit of wildlife. Key wetlands were designated for protection through legislation on public lands and for market-value acquisition or donation on private lands. Waterfowl represented the common and shared currency that motivated nations to cooperate in protecting wetlands throughout the migratory ranges. The 1971 Ramsar Convention on *Wetlands of International Importance Especially for Waterfowl* was launched on this principle. Member countries designate internationally significant wetlands and pledge to promote the conservation and wise use of wetland resources.

The United States is unique in enacting federal legislation to regulate the protection of both public and privately owned wetlands. In addition, many hundreds of millions of dollars have been expended to acquire and manage wetlands, primarily for the conservation of waterfowl.

The Canadian government is not in the business of legislating the protection of wetlands on private land. Rather, it provides leadership through policies and programs for voluntary, non-regulatory conservation partnerships to sustain wetlands and their wise use. By the late 1970s, it was recognized that financial realities and/or landowner backlash would preclude the acquisition of anything beyond the few national crown wetland jewels that were of international significance. Through the cooperative development of the North American Waterfowl Management Plan (NAWMP) and the Wildlife Habitat Canada Foundation (WHC) it was clearly recognized that to have any meaningful conservation impact, a new approach to conserving wetlands on privately owned and managed lands was required.

The scope of contemporary wetland conservation in Canada goes far beyond securing and protecting important sites. In the past decade and a half, a voluntary, incentive-based approach to the wise and sustainable use of landscape resources has become the cornerstone of an ever-growing partnership effort between government conservation agencies, non-government conservation organizations, private landowners and resource-based industries. Sustainable agriculture and forestry partnerships are positively influencing wetland conservation and economic opportunities across the working landscapes of the country. These partnerships with the agents of wetland conservation, the private landowners and managers, are the hallmark of a successful, voluntary, non-regulatory approach.

Wetland conservation in Canada takes an ecosystem approach to the sustainable development of working landscapes. The NAWMP Habitat Joint Ventures (JVs) deal not only with wetland basins, but include riparian zones and associated uplands. Wetland conservation then, is an integral component of a landscape approach to sustainable agriculture and sustainable forestry. The common element in this approach is to optimize water retention in basins and enhance permanent vegetative cover on riparian zones and fragile uplands. These are the fundamental reasons that this report addresses wetland conservation in this ecologically broad sense and not just wetland basins per se.

For the purpose of this investigation report there are several important highlights to be made regarding environmental and wetland conservation:

- There is a profound difference between the command and control, regulation and protection *Pollution Control* approach and the voluntary, non-regulatory *Sustainable Development* approach to environmental conservation. Wetland conservation in Canada and internationally is primarily a voluntary, multi-sector partnership approach to sustainable development;

- Wetland conservation includes the maintenance, restoration, creation and sustainable use of wetland basins, riparian margins and associated uplands.

- The focus of this work is on landscape-scale wetland conservation activities, not wetland basins per se;

- Wetland conservation in the southern working landscapes of Canada is an integral part of sustainable agricultural and forestry land-use;

- Wetland conservation in developing countries is an integral component of international sustainable development and the Ramsar and Biological Diversity Conventions.

- In the Prairie-Parkland region of Canada, where millions of wetland basins are semi-permanent as a result of natural, or climate change-induced wet-dry cycles, a most cost effective land-use or land-use change option for carbon sink conservation, is simply to leave the basin alone and not cultivate.

3.5 Wetland Carbon Stocks

Wetlands cover 6 per cent of the world's land surface but contain 14 per cent of the terrestrial biosphere carbon pool. In addition, coastal salt marshes and mangroves are considered the most important marine ecosystems for carbon sequestration. When peatlands are included, as is the case in the Ramsar wetland definition, wetlands represent the largest component of the terrestrial biosphere carbon pool (Dixon and Krankina, 1995).

The terrestrial biosphere is estimated to contain a carbon pool of 1943 Gt (Table 2). Wetlands constitute a large global C reservoir at 230 Gt, exceeding agroecosystems (150 Gt) and temperate forests (159 Gt). Significant peat deposits are co-located with forests at high latitudes and are accounted for in the forests/tundra total of 559 Gt (Dixon and Krankina, 1995). According to Zoltai and Martikainen (1996), peatlands hold soil carbon stocks of 541 Gt, which accounts for 34.6 per cent of total terrestrial carbon. When peatlands are segregated, they account for three to three and one half times more carbon than tropical rainforests (Immirizi and Maltby, 1992). Per unit area, wetlands have the largest soil carbon stocks in the world (WBGU, 1998).

The share of tropical wetlands in global wetland area is estimated between 30 per cent and 50 per cent if rice-growing areas are included. Excluding rice farmland, the proportion of tropical wetlands ranges between 10 per cent and 30 per cent. Despite their small share in total wetland area, the carbon stocks of tropical wetlands are of a magnitude similar to those of wetlands of the Northern Hemisphere. This is because their stocks per unit area are several times larger, both in the biomass and the soil compartment. The carbon stocks of tropical wetlands are seriously endangered, especially by land-use changes to rice cultivation (WBGU, 1998).

Information on Canadian wetland carbon stocks and GHG fluxes is almost exclusively confined to peatlands. Wetlands are estimated to cover ~16 per cent of Canada's land surface and contain a carbon reservoir of ~150 Gt C, equivalent to about 60 per cent of Canada's carbon stock. However, since the 150 Gt C represents the total carbon stock of Canadian peatlands, this estimate would not include the carbon sock of all other wetlands. Peatlands represent a long-term sink of between 20 and 30 g C m2/yr and sequester approximately 0.025 – 0.037 Gt C/yr (Hengeveld and Beaulieu, 1999). The carbon stocks in Canadian peatlands is equivalent to about 100 years of current fossil-fuel combustion and represents a reduction in atmospheric CO2 concentration of about 40 ppm (Roulet *et al*., 1997 *In* Clair *et al*., 1997).

Of the total carbon stock of Canadian forests, the carbon in forest peatlands is over 100 Gt, exceeding the combined total carbon stocks in forest trees (14 Gt) and forest soils (71 Gt) (Apps, 1998).

3.6 Wetlands as Sinks and Sources

An ecosystem represents a sink for carbon dioxide if its assimilation of carbon through photosynthesis (gross production – P) exceeds its loss of carbon through respiration (community respiration – R) and harvest. In aquatic ecosystems, R is scaled as the approximate two-thirds power of P, implying that role of aquatic biota as carbon dioxide sources or sinks depends on their productivity. Thus, productive aquatic ecosystems (P>R) tend to function as sinks and unproductive aquatic ecosystems (R>P) tend to function as sources (Duarte and Agusti, 1998).

This generalization does not directly apply to two extremes of the classification continuum of freshwater wetlands: peatlands and rice paddies. As illustrated in Figure 3, the domains which determine the carbon storage in peatlands are: the extent to which the hydrology allows water to flow through the system; the nutrient status of the wetland; and the proportion of time which the wetland is under anaerobic conditions (its seasonality). Thus, carbon storage is maximized in these nutrient poor, closed basins that are permanently inundated. At the other end of the spectrum, created wetlands such as rice paddies, which are nutrient rich (naturally and with fertilizer treatment), with seasonal flow through of water, allow no significant carbon accumulation. Moreover, the anaerobic conditions of rice paddies contribute to substantial methane emissions, which are globally in the order of 100mt/yr (Adger, 1995).

While wetlands constitute a major carbon reservoir, they can function as either greenhouse gas sinks or sources depending on their type, their use and ambient conditions. Some wetlands are characteristically sources and others are sinks. Some have a different role at different times as determined by hydrology. In some wetland types there is a tradeoff between being a carbon sink and a methane source.

Northern peatlands are the best-understood wetlands from a climate change perspective. Due to prevailing anaerobic conditions and the generally low availability of nutrients, the decomposition of organic material is greatly constrained, so that despite a low net primary productivity, carbon stocks continuously grow. Undrained histosols (a soil type typically associated with wetlands) store 0.14 Gt C/yr (Armentano, 1980). In Finland, Silvola (1986) has shown that bogs, with a removal of 0.25 t C/ha/yr, are sinks. Gorham (1991) states an annual increase in stocks of 0.29 t C/ha/yr for the peat-forming wetlands of the northern latitudes. Globally, he estimates these wetlands to be a sink with a carbon flux of –0.1 Gt C/yr.

Conversely, if peat-forming wetlands are drained and converted into utilized areas, the mineralization of carbon stocks generates high carbon flux. Bouwman (1990) reports losses of 10 t C/ha/yr in the initial years. In Great Britain, losses resulting from converting bogs to cultivation are estimated at 5 t C/ha/yr. (Adger, 1994). For Finland, Silvola *et al*. (1996) reports loss rates of approximately 2.5 y C/ha/yr after drainage. On a global scale, Immirzi and Maltby (1992) estimate losses through conversion to agricultural lands to figure 0.063-0.085 Gt C/yr in temperate regions, and 0.053-0.114 Gt C/yr in the tropics.

Presently, there are no complete carbon balance studies including net ecosystem production and respiration on southern Canadian wetlands. However, Hengeveld and Beaulieu (1999) note that lakes and open water bodies (potholes, beaver ponds) have the potential to act as carbon sinks (~8 to 16 g C/m2). In the agricultural working landscape, wetlands are threatened by conversion and/or loss whenever drought or economics provide the land-use change opportunities to motivate farm operators. The result of drying and/or tillage is the release of a significant proportion of the stored carbon. Prairie farmers even refer to the “champagne effect” when greenhouse gases are released upon reflooding Vaughan, 1998).

Arctic carbon stocks are at risk of being released through climate change. Melting of permafrost could alter the regime of wetlands and promote the mineralization of peat. Both the drainage of peatlands and their inundation from hydro developments generate high carbon flux.

To assess the source and sink potentials associated with converting wetlands to agriculture, the flows of methane and nitrous oxide must be taken into consideration. Results from a few studies of methane emissions from temperate and low boreal swamps in Canada indicate a flux range from 0.1 to 4.8 g CH4/m2/yr (equivalent to 0.004 – 0.18 t C/ha/yr) (Waddington, 1998).

CH4 emissions from wetlands are controlled by water table position and soil (peat or sediment) temperature. A drop in water table position decreases CH4 production and increases CH4 oxidation, thereby decreasing emissions. Depending on water table position, emission of CH4 from peatlands is between 0.5 and 50 g CH4-C/m2/yr. In tidal salt marshes, high salt and sulphate concentrations control the production of CH4. CH4 emissions decline with increasing salinity. There is little information on the abiotic controls and processes controlling N2O fluxes from wetlands (Hengeveld and Beaulieu, 1999).

Natural peat-forming wetlands store carbon, release small amounts of nitrous oxide and larger amounts of methane. However, when they are drained and converted to other uses, large amounts of carbon dioxide and nitrous oxide are released, while methane emissions drop or are removed (WBGU, 1998).

Freshwater marshes and beaver ponds are characteristically carbon sinks, but methane sources. However, sinks/sources characteristics can change in response to hydrological regimes. The role of coastal wetlands is related to vegetative composition. The majority serve as a C sink and methane emissions are low as a result of high sulfate concentrations (Murkin, 1998).

Clair *et al*. (1997) noted that there are still major gaps in our understanding of wetlands and their likely responses to climate change. Wetlands lag behind other ecosystems in being adequately modelled and are often excluded from global models of the effects of climate change.

The wide range of wetland types and their different characteristics for different greenhouse gases makes it challenging to determine each wetland’s role. Much research on the magnitude of sources and sinks and the processes controlling them needs to be undertaken.

3.7 Contribution of Wetland Losses to Atmospheric CO2

If global estimates of wetland losses are considered to be somewhat tentative, then the estimates of the contribution of wetland losses to atmospheric CO2 are, at best, speculative. Peatland carbon fluxes are by far the best understood of all wetland types. The enormous volume of peat deposits in the world's wetlands has the potential to contribute significantly to worldwide atmospheric carbon dioxide levels, depending on the balance between draining and oxidation of the peat deposits and their formation in active wetlands (Mitsch and Wu, 1995). Armentano and Menges, 1986 estimated that before recent disturbance of wetlands, net global retention of carbon in wetland peats was 0.057-0.083 Pg-C/yr, most in boreal peatlands. Gorham (1991) estimated an accumulation of 0.076 Pg-C/yr of carbon in northern peatlands.

About one-fourth of the carbon sequestered by wetlands is re-released by methane emissions. For all wetlands in the world, there is an estimated release of 0.09 Pg-C/yr of methane from wetlands and 0.08 Pg-C/yr from rice paddies, out of a total release of about 0.4 Pg-C/yr of methane from all sources (Mitsch and Wu, 1995).

There are indications that the global carbon balance of wetlands has shifted, primarily because of agricultural conversion of peatlands. By 1980 the total carbon shift due to agricultural drainage was estimated by Armentano and Menges (1986) to be 0.063-0.085 Pg-C/yr, with a further 0.032-0.039 Pg-C/yr released from peat combustion.

As is the case with tropical rainforests, wetlands may be close to having shifted from being a net sink to a net source of carbon to the atmosphere during the past 100 years, if the effects of draining, peat combustion and methane emissions from natural and managed wetlands are included. Currently wetlands are estimated to be a sink of about 0.08 Pg-C/yr and a source of 0055 Pg-C/yr. To put these numbers in perspective, the burning of fossil fuel contributes an estimated 5.6 Pg-C/yr and deforestation of tropical rain forests an additional 0.4-2.8 Pg-C/yr of carbon to the atmosphere (Mitsch and Wu, 1995).

Immirizi and Maltby (1992) caution that tropical swamp forests are under considerable pressures from agricultural development agencies. As a worst case scenario, a doubling of such tropical source areas to 7.6 million hectares would release 40 t/ha/yr of carbon.

Meaningful data on the losses of Canadian wetland CO2 to the atmosphere are not available.

3.8 Conservation/Management to Enhance Wetland Carbon Sinks

Any land-use or land-use change that was recognized for carbon credit under the Kyoto protocol would be accountable for the net difference between sources and sinks. For Canadian wetlands, it would be axiomatic then, that all public, private and NGO interests in wetland conservation would have to commit to a realistic projection of a net gain in wetlands and the accomplishment of human-induced management activities that would produce a verifiable increase in carbon stocks resulting from these activities.

The 1995 NATO publication *Carbon Sequestration in the Biosphere: Processes and Prospects* deals with the science, mechanisms and management dimensions of carbon sinks. The working Group report on Carbon Mineralization (Ingram and Thingstad, 1995) concluded that the main options for enhanced carbon sequestration are:

- Management of quality of primary production to retard decomposition in forests and agricultural systems.
- Management of the physico-chemical environment, particularly in agricultural systems, to enhance primary production and increase soil organic matter.
- Conservation and possibly extension of wetlands, including coastal margins, to maintain anaerobic conditions and protect resistant organic residues.

In a discussion of carbon conservation and sequestration, Dixon and Krankina (1995) concluded that strategies for maintaining, restoring and enlarging agroecosystem C pools include:

1. Enhancement of soil fertility and maintenance of neutral pH;
2. Concentration of agriculture rather than expansion;
3. Preservation of wetlands (high in soil C);
4. Minimize site disturbance and retain organic matter in soil;
5. Agro-afforestation; and
6. Conservation tillage practices to reduce soil aeration, heating and drying.

The *Report of the Carbon Flux Process Experts Meeting* (Hengeveld and Beaulieu, 1999) suggested that to include wetlands as biotic sinks, a “Kyoto Wetland” concept be adopted to account for wetland restoration (R), wetland creation (C), and wetland degradation (D) land-use change activities. This RCD is an important concept that has the value-added utility of being easily recognized as an analogue of the forestry RAD activities.

Another activity that is of critical importance to both wetland conservation and the protection and enhancement of sinks is that of sustaining, or protecting wetland basins and margins. Many intact wetland basins in the Canadian agricultural landscape, particularly in the Great Plains region, dry out during periods of drought. When dry, many of the millions of such basins are cultivated and cropped, thereby releasing large amounts of CO2 and N2O and reducing the source of CH4.

From a wetland sink perspective then, an important human-induced land-use option is to do nothing by not disturbing the basins or margins. This is a very cost and labour-effective activity for farm operators. Furthermore, this activity may represent the largest potential activity in Canada for enhancing wetland carbon sinks.

A further benefit of the " do not disturb wetlands" or "sustaining wetlands" option is that riparian vegetation (emergents, grasses, shrubs and trees) can be established and/or maintained on the wetland margins. Apart from their high biomass and soil carbon content, riparian vegetation traps blowing snow, thereby increasing water retention in the basins and stimulating sink enhancement. In consideration of this activity, the "Kyoto Wetland" may be expanded to include sustaining (S) and become RCDS.

As mentioned previously. Any consideration of Kyoto wetland conservation would have to be predicated on a realistic net gain in wetlands that are subject to human-induced land-use or land-use change.

4. ANALYSES OF SCIENCE AND POLICY ISSUES

4.1 Sinks in Context

The Kyoto Protocol is truly a landmark step in the evolution of international environmental agreements. It endeavors to address head on, the root cause of global climate change, that is to control and reduce the emissions of greenhouse gases to the atmosphere. For the first time, the Protocol establishes quantified, legally binding commitments for industrialized (Annex 1) countries to limit or reduce greenhouse gas emissions.

Bearing in mind the genesis of the UNFCCC at the 1992 Rio Earth Summit, the Kyoto Protocol endeavors to capture at least the spirit of the environmental, social and economic dimensions of sustainable development, and take into account Party's commitments under relevant international environmental agreements. At the level of principle, the Kyoto Protocol strives to be all things to all people. It is no wonder that the two and a half years of negotiations that was initiated by the first COP to the FCCC in 1995 concluded only after 48 hours of non-stop talks at the last minute.

As a result, the Kyoto Protocol is the most ambitious, the most complex, and at the same time, the most tentative of any of international environmental agreement. At the close of the 1990s, the Protocol exemplifies the challenges and opportunities of what was to have been the paramount international issue of the decade – trade and environment. It is actually difficult to objectively categorize Kyoto as either an environmental or trade agreement. Perhaps the unheralded genius of Kyoto is that it is both. It boldly, if not yet clearly, launches a process that will have profound impacts on all levels of the world's economy and to all reaches of the biosphere. As such, it will have major impacts on people and communities, and have a major influence on environmental security and social equity between the developed and developing world.

The core element of the Kyoto Protocol is a command and control, environmental protection approach to GHG emission reductions. At the same time, the Protocol makes an up front commitment to promote sustainable development, and in particular the protection and enhancement of sinks and reservoirs, taking into account its commitments under relevant international environmental agreements. The promotion of sustainable forest management practices and sustainable forms of agriculture are also called for (Article 2.1). Furthermore, the Protocol contains three "flexibility mechanisms": carbon sinks; the Clean Development Mechanism: and emissions trading which provide potential opportunities for countries to cooperate in finding the low cost complimentary options to meet their targets.

It is not disrespectful to say that the Kyoto Protocol does not fulfill all expectations and dimensions of mitigating global climate change. Rather, the Protocol represents a significant achievement in that countries actually agreed to bite the climate change bullet in face of major uncertainties, and set in place a course of action to work towards dealing with the myriad of details, approaches and tradeoffs that will be the pragmatic reality of an effective convention. The protocol is only a beginning, and is very much a work in progress.

The commitments of industrial countries to reduce emissions by specified levels are precise, but the means of doing so are yet to be developed and agreed to. At the same time the extent of emission reductions are increasing each year. In Canada, for example, total emissions have increased within a range of 10 per cent to 13 per cent from 1990 to 1996 and are projected to keep rising under a business as usual scenario. Thus the actual reductions in GHG emissions will grow to 21 per cent to 25 per cent by the end of the first 2008-2012 commitment period.

Implementing the emission reduction measures will have profound economic and social implications to Annex 1 countries. If reductions are to have a meaningful impact on global climate, then developing counties must become part of the solution. Command and control environmental protection measures are simply not on in the developing world. Voluntary, non-regulatory measures, driven by incentives and not regulations are the only option available.

The environmental protection side of the Protocol provides a concrete underpinning for industrialized countries to reduce GHG emissions. However, it is the sustainable development side, as provided by the flexibility mechanisms of sinks, emissions trading and the Clean Development Mechanism, that represent the beginning of extending voluntary participation to the level of a global solution.

The way in which the issue of carbon sinks is addressed is really at the crux of the inherent conceptual dichotomy of Kyoto. The current language, if not the intent, is strictly an environmental protection/ pollution control approach. By restricting sinks to the land-use change and forestry RAD activities, the broader issue of protecting and enhancing sinks, let alone dealing with GHG fluxes in forest ecosystems, managed forests, or other ecosystems are ignored. By recognizing sinks, even in the ecologically artificial and limited manner that it does, the Kyoto Protocol initiates a major step towards sustainable development. Having done so implementation measures have a long way to go to get beyond the proverbial no-man's land between pollution control and environmental conservation.

At its June 1998 meeting, SBSTA made a key advance in the acknowledgement that the land-use change and forestry category is really three categories: land-use, land-use change and forestry, thus acknowledging activities such as agricultural and forest soils and potentially wetlands. At the request of SBSTA, IPCC will prepare a Special Report on Land-Use, Land-Use Change and Forestry that will examine the implications of dealing with sinks.

4.2 Perceptions of Sinks - Progressive or Perverse

(a) Science and Policy Perspectives – German Advisory Council on Global Change

The inclusion of GHG sinks and reservoirs in the FCCC and the Kyoto Protocol is of fundamental importance from an ecological and sustainable development perspective. However, the limited treatment of sinks and reservoirs in the Protocol leaves the issue in somewhat of a no man's land, satisfying neither the objectives of pollution control or of sustainable development.

FCCC Parties are sharply divided on the question of whether sinks should be included in the Protocol at all. Canada and other Parties like the US, Australia and New Zealand are strong proponents, having argued that there no limit should be placed on anthropogenic forest sinks. On the other hand, the arguments for excluding sinks were that they constitute an emission reduction loophole, and that because of the large uncertainties, they are unverifiable. The European position has been against sinks for these and other reasons. One argument, or perception, is that sinks are new world (primarily North American) issue that would give unfair advantage in crediting sinks from their vast forest, agricultural and wetland landscapes.

The German Advisory Council on Global Change published a Special Report on *The Accounting of Biological Sinks and Sources Under the Kyoto Protocol – A Step Forwards or Backwards for Global Environmental Protection?* (WBGU, 1998), This most comprehensive treatment of sinks, raises a series of provocative and well-defined questions on the appropriateness of Kyoto sinks. In principle, the Council supports the idea of linking climate protection and the conservation of sinks. However, the Council considers the form in which "land-use change and forestry" activities are accounted for under the Kyoto Protocol to be inadequate and in need of improvement if the objectives of climate protection and biodiversity conservation are both to be served. They believe that the present accounting approach can lead to incentives with negative impacts upon climate protection, biodiversity conservation and soil protection.

The Council notes that terrestrial sinks are by no means constant. Even slight climate changes can lead to sinks becoming sources. Over the long run, fossil fuel emissions can not be compensated for by the terrestrial biosphere.

The WGBU poses a number of serious questions/concerns regarding Kyoto sinks. Several that are of direct relevance to this study are summarized as follows:

- The accounting approach only considers sinks within the commitment period 2008-20012, but does not consider them for the 1990 baseline emissions.

- The accountable RAD activities are not adequately defined. The conversion of primary forests to secondary forests could be indirectly promoted if accountable activities are defined accordingly.

- By not accounting for harvesting, resulting GHG emissions are not taken into account, and become an incentive to clear-cut primary forests

- The protection of primary forests, wetlands and soils as natural carbon reservoirs and sinks is not positively promoted.

- Accounting of changes in carbon stocks during the 5-year commitment period could create an incentive to establish rapidly growing plantations without sustained carbon sequestration.

- The inclusion of additional sink activities would further exacerbate accounting difficulties and would further diminish the verifiability of reduction commitments.

The Council recommends using the guidelines yet to be adopted to combat and minimize the impending undermining of climate protection and impairment of terrestrial ecosystems. At the same time, the opportunities given to conserve sinks should be safeguarded and expanded. Specifically, the Council recommends the following:

- No additional sinks should be accounted, because this exacerbates the uncertainties in verification and further diminishes the reduction commitments for emissions from fossil fuels.

- JI measures should not permit an accounting of sinks that would be domestically prohibited.

- Commitment periods must follow each other without interruption, in order that no incentives are given to clear-cut forests.

- If biological sources and sinks are accounted, then so too must be the destruction of important biological reservoirs (primary forests, wetlands).

- The calculation of carbon stocks of terrestrial ecosystems must, in addition to aboveground biomass, also include the carbon stocks in soils and underground biomass.

- The offsetting of commitments of industrialized countries against projects aimed at enhancing sinks in developing countries should be abstained from for at least as long as the developing countries have not assumed emission limitation or reduction commitments, and as long as the existing uncertainties concerning verification of the impacts of sinks upon developing countries have not been clarified.

The WBGU very credibly identifies and documents some of the unintended or perverse effects of sinks as they are currently addressed in the Kyoto Protocol. By and large, their recommended course of action is to restrict the implementation and promulgation of sinks as much as possible, so as to prevent or curtail additional perverse effects.

An alternative approach would be to proceed cautiously and pragmatically in developing and expanding sink policy and practice in a broader ecological context. In other words, launch programs on a “no regrets” basis to do the best job possible, monitor and assess the results, and take corrective actions when required. A prerequisite of such an approach would be the recognition that:

1. The mitigation of GHG emissions to the atmospheric by biological sinks are real and can be positively managed;

2. Carbon sequestration can be a value-added benefit of ongoing sustainable land-use practices to conserve soil, water, wetlands and biodiversity

3. The effects of sink enhancement are compatible with, and should positively contribute to, sustainable development and the objectives of other international environmental agreements; and

4. Voluntary public, private and NGO partnerships for sink enhancement initiatives provide a unique opportunity to begin implementing the Kyoto Protocol in developing countries.

The Council supports incentives for the conservation of sinks in developing countries, but is against the notion of crediting sinks, at least for as long as the developing countries have not assumed emission limitation or reduction commitments. They recommend that the present financial mechanism, the Global Environment Facility (GEF), should focus more strongly on funding projects aimed at conserving natural reservoirs and sinks, in particular primary forests and wetlands (WBGU, 1998).

In summarizing, the Council strongly underscores the inadequate coordination in global environmental protection. They recommend working towards improved cooperation among the institutions of the "Rio conventions" (climate change, biological diversity, desertification), and other programs in the environmental and development policy arena into a single UN "Organization for Sustainable Development"

Such a framework could go a long way in fostering the environmental, social and economic acceptance of the climate change agenda in developing countries and provide the basis of a "no regrets" approach to influencing sinks policy. The evolving framework may also lead to some form of a sustainable development "oversight function" that could guard against potential perverse effects of sinks programs.

(b) The Environment and Development Perspective - GEF

The GEF is in the early stages of developing a position paper on Elements for a GEF Operational Program on Carbon Sequestration: *"Promoting sustainable enhancement of carbon sinks".* The program objective is: "Strategically promoting viable carbon sequestration opportunities that help to reduce the risk of climate change by sustainably enhancing carbon sinks." The GEF intends to make resources available to meet the incremental costs of sink enhancement. Proposed annual funding by the end of the next decade is about $200 Million US, resulting in annual carbon offsets that would exceed 100 Million tonnes. Since GEF conservation objectives are currently addressed in biodiversity operational programs, the natural entry point for assessing ecosystem carbon sequestration proposals would be criteria for GEF support in the biodiversity area.

The single most important factor for GEF support will be medium and long-term impact on sequestration trends at the least incremental cost. GEF's financing threshold for short-term carbon sequestration interventions is $10 per tonne of carbon mitigated.

Biodiversity conservation is a high GEF priority, so that carbon sequestration projects should also support the achievement of biodiversity objectives wherever feasible and cost effective. GEF supports holistic approaches to promote multiple program objectives and to avoid adverse impacts between programs. To accomplish these objectives GEF aims at strategic partnerships with interested public and private entities to enhance the likelihood of long-term success.

GEF is of the view that carbon sequestration opportunities have not been utilized to the desirable extent, given the relative costs and potential local benefits. They feel that local public benefits such as watershed protection, erosion control or wasteland rehabilitation and possible economic gains are often not taken into account or underestimated in relevant business and/or policy decision making.

From the wetlands focus of this study, a very important GEF perspective is that any activity that may help to achieve a sustainable sequestration impact at a high cost effectiveness may benefit from GEF support. UNEP is aware of and interested in this feasibility study on wetlands. As a result, they have asked WI-A to submit a GEF concept proposal for wetland carbon sequestration studies in selected developing countries. The proposal has been submitted and productive discussions are ongoing.

(c) Public Policy Perspectives - Canadian NGOs

The whole issue of GHG sinks and reservoirs has received little in the way of public policy debate in Canada outside of the "Kyoto Circle" of directly affected interests. The National Sinks Table brings a high level of Canadian sinks policy and science experts to identify the state of knowledge, the gaps and the challenges surrounding the sinks issue. In particular, it provides some preliminary estimates of the forestry and agricultural sinks potential in Canada. It also strives to ensure a clear understanding of the sinks issue among stakeholders and policy makers in Canada by providing technical background and analytical information. The Sinks Table places much more emphasis on technical and analytical aspects than on public policy perceptions of potential stakeholders.

The renewable resource sectors such as forestry and agriculture are obvious and prominent proponents of carbon sinks. However, their interests are not restricted to all sinks for credit, or sinks at all cost. For example, the National Agriculture Environment Committee (NAEC) takes a landscape approach to sinks that recognizes the potential role of wetland sinks as part of the agricultural land-use (Forsyth, 1998). Speaking for NAEC, Daynard, 1999 minimizes the issue of cash value for individual farm soil carbon credits. He indicates far more interest in how we can link the objective of enhancing soil carbon levels with long-term agricultural goals of rebuilding soils organic levels, and reducing input usage in agriculture in a way that is both economically and ecologically beneficial to Canadian farms.

There is a general lack of awareness of the science and policy aspects of carbon sequestration in the conservation and environmental communities. However, this knowledge gap does not preclude strongly held beliefs about carbon sinks, which are often based on anecdotal accounts or ideology. Although public policy is not a specific mandate of this project, it is important to note the range of Canadian ENGO perceptions on the subject.

At one end of the opinion spectrum are environmental advocacy groups who promote a strong regulation/protection or pollution control approach to GHG emissions. They do not trust industry's motives or voluntary initiatives, which they see as emission reduction avoidance or delay. Sinks are considered to be loopholes or stopgap measures at best.

At the other end of the spectrum are organizations actively involved in habitat conservation, such as participating partners in NAWMP Joint Ventures. They have a direct stake in sustainable agriculture and forestry and recognize carbon sink enhancement as an opportunity for value-added funding and benefits for habitat conservation. As proponents of free-market, incentive-based conservation, they are strongly supportive of sink programs.

In the middle ground are those groups who take a wait and see approach. Some are skeptical but will take an objective look at whether sinks are real or not. Others in this general grouping support voluntary incentives, but are concerned about perverse sink activities that would distort land-use decisions and impair landscape integrity.

The question of what sinks are included in Kyoto and how they will be credited will be dealt with by the formal FCCC science, policy and international negotiation processes and not public opinion. However, an informed public policy debate can be an important and healthy element of developing a Canadian approach that optimizes the sustainable development benefits of sink programs and removes or minimizes any perverse effects. This is not only important domestically, but is essential if win-win sink protection and enhancement initiatives in developing counties are to be part of the CDM.

5. INFORMATION REQUIREMENTS

5.1 Wetland Sinks Information Status and Gaps

The Wetlands Research Group (WWG) of the Carbon Experts Meeting (Hengeveld and Beaulieu, 1999) has conducted the most comprehensive Canadian review of wetland sinks issues to date. They addressed wetland ecosystem greenhouse gas stocks and flows processes, protection, measurement and sink enhancement.

The WWG noted that if sinks are included in Kyoto then wetlands, as the largest store, should also be included. However, they concluded that we are not at the point that we can estimate the sink and source strengths of Canadian wetlands. While forests and agriculture systems have federal departments and provincial ministries that are responsible for research into these two land types, there are unfortunately no departments or agencies responsible for wetlands. Thus, there is a lack of co-ordination on wetlands research and database development in Canada. From a global perspective, Adger, 1995 also states that one reason why wetland areas are not well documented is because the focus of government agencies has traditionally been on economically valuable and productive resources.

The Canadian wetland research community, largely based in universities, has an internationally recognized expertise in the role of peatlands in the global carbon budget, including peatlands as sources of CH4 and N20, and the potential impact of climate change and variability on peatland ecosystems. Despite this the WWG could see little about other wetlands in Canada (Hengeveld and Beaulieu, 1999).

The WWG recommended that the Climate Change Action Fund provide funding to hold an expanded wetlands experts workshop in the near future. Its objectives would be to assess our current state of knowledge of the policy relevant science to address the issues raised when considering wetlands as potential sinks for inclusion in subsequent modifications to the Kyoto Protocol. Short-term research objectives include the identification of research groups to focus research on:

1. Carbon stocks and flows (contemporary),
2. Carbon processes (contemporary, variability),
3. Sensitivity and vulnerability of stocks/flows to natural and land-use perturbations, and
4. Economics of wetlands carbon sequestration.

The “Kyoto Wetland” concept advanced by the WWG accounts for the land-use changes of wetland restoration (R), wetland creation (C), and wetland degradation (D). To be policy relevant, wetland research will need to focus on these three RCD activities, including research on stocks, verifiable methodology, baseline levels, and processes. Moreover, research will be needed in natural systems to both gain a better understanding of the major processes and to calibrate/verify and develop wetland greenhouse gas exchange models.

5.2 Wetland Sinks Costs and Benefits

The Sinks Table notes that at present, there is very limited information about the economic costs and benefits of the Kyoto Provisions related to sinks. However, the costs of measuring, tracking and reporting C stock changes in the Kyoto Forest will be significant (Foundation Paper 1998).

Human-induced land-use, land-use change and forestry are the activities recognized by Kyoto and SBSTA as potential sinks. Thus, ecosystems per se are not addressed, whether they are forest or agricultural landscapes. It follows that any potential consideration of wetlands as sinks would be associated with land-use or land-use changes affecting wetland sinks – the results of wetland conservation programs. In the managed, working landscapes of Canada, the NAWMP wetland conservation activities are cooperative partnerships with sustainable agriculture and forestry programs. The upper limit of costs for wetland carbon sequestration in these landscapes would be those costs required for wetland conservation within the broader context of a sustainable landscape approach.

In the decade ending in 1997-98, the NAWMP has conserved an impressive amount of wetland and associated riparian and upland habitat in Canada. To date, 1,696,443 ha have been secured, 5,558,802 ha have been influenced, 440,695 ha have been enhanced and 582,517 ha have been managed.

In the Prairie Habitat Joint Venture, the total costs of conservation activities are $195/ha for securement, $260/ha for enhancement and $42/ha for management. Since all these conservation activities can positively enhance carbon sequestration it is assumed that these costs represent the upper limit for carbon sink investment. Actual costs would be less as they would represent the incremental costs required to justify a carbon sink program.

5.3 Related Wetland Sinks Events

In the Kyoto Protocol’s treatment of sinks, the potential role of wetland conservation was not considered. Furthermore, any discussion of wetlands in climate change circles tended to reflect anecdotal accounts and conclusions of wetlands being noxious wastelands that were major sources of CH4 and CO2.

Since this work began in 1998, several key events have been initiated that raise the awareness and scientific/policy scrutiny of the sink potential wetlands. The author, a member of the National Sinks Table, wrote the section on Wetland Conservation for the *National Sinks Table Foundation Paper* Final Report, released on November 17, 1998. This has contributed to raising the level of Canadian debate on wetlands, both pro and con.

At Wetlands 98, a September international wetlands symposium in St. Louis, Missouri, the author's presentation of these concepts led to a strategic alliance between Wetlands International – Americas, the Association of State Wetland Managers and the Institute for Wetland Science and Public Policy. The first product of this alliance has been a draft white paper on *Wetlands and Climate Change: Scientific Knowledge and Management Options* (Kusler et al., 1999), which provided the background for the February 3-4, 1999 *Wetlands and Climate Change: Scientific Knowledge and Management Options* conference at Laurel, Maryland.

WI-A and ASWM have subsequently been invited to organize and chair an INTECOL VI Conference symposium on *Wetlands as Carbon Sinks and Role in Climate Change* at the Millennium Wetland Event in August 2000 at Quebec City.

In association with COP6 of the Ramsar Convention in San Jose, Costa Rica, the Global Biodiversity Forum 13 will hold an international workshop on "*The Global Carbon Issue: Peatlands, Wise use and Management"*.

At the invitation of UNEP, WI-A and ASWM has submitted a wetlands and climate change concept proposal for potential GEF funding. This work would focus on several case studies in developing counties as pilot projects for GEF-sponsored Clean Development Mechanism initiatives.

A direct output of this feasibility study will be the April 18-20, 1999 *Wetlands and Carbon Sequestration Workshop* at Oak Hammock Marsh, Manitoba. IISD and DUC are the primary lead for this prairie/parkland-focused event, which will bring wetlands and climate change science and policy experts from across Canada.

The Technical Committee on Science and Adaptation Tasks hosted a Carbon Flux Process Experts Meeting at Downsview, Ontario on January 18-19, 1999 (Hengeveld and Beaulieu, 1999). They propose following up with an extended wetlands experts workshop in May 1999.

6. CONCLUSIONS

1. Wetlands contain the largest reservoirs of carbon in the terrestrial biosphere. However, different types of wetlands under varying environmental, climate and land-use conditions can function as both sinks and/or sources for CO_2, CH_4 and N_2O.

2. On a macro-ecological, or global scale, science indicates that anthropogenic land-use and land-use changes can enhance the function of wetlands as

carbon sinks. Although the fluxes of CO2, CH4 and N2O are often a tradeoff with one another, sources of all three can be reduced through management treatment.

3. Vast carbon reservoirs that are not subject to direct anthropogenic influence, such as northern peatlands, have a high potential of shifting from carbon sinks to sources under projected global warming. The southern-most permafrost peatlands are particularly vulnerable from melting. Large-scale water/hydro developments can cause inundated peatlands to become large GHG sources.

4. Anthropogenic land-use changes such as drainage and conversion of wetlands to other uses have profound impacts on GHG fluxes. Not only is wetland sink capability lost, but the carbon reservoirs are released to the atmosphere.

5. The Kyoto Protocol provides no incentive to protect and enhance carbon sinks. This omission somehow needs to be addressed. Canada can demonstrate leadership by advocating progressive change with like-minded Parties within the COP, SBSTA and IPCC.

6. The current, ecologically artificial restriction of sinks to RAD forestry activities, can result in perverse incentives to exploit ecosystem sinks such as old growth forests and wetlands. Again, Canada can demonstrate leadership by advocating the integration of the Kyoto Protocol with the conservation objectives of other international environmental agreements such as Biological Diversity, Desertification and Ramsar, under a more comprehensive sustainable development umbrella.

7. The current state of scientific knowledge does not warrant considering wetlands as distinct carbon sinks under the Kyoto Protocol at this point in time.

8. The upcoming wetlands and carbon sequestration workshops by IISD and DUC, the CCAF, and WI-A and ASWM are essential to defining research gaps and priorities, a research plan and schedule and the formation of coalitions of critical mass to coordinate work and serve as wetlands champions in the climate change policy arena.

9. Both forestry and agriculture are globally dominant renewable resource industries with vast public, private, academic and NGO research and development infrastructures. Because soil organic matter dynamics, as a fundamental factor in site productivity and management, has been a priority R&D activity for many decades, forest and agricultural carbon sequestration is a relatively well understood phenomenon. Research on wetlands, which do

not produce market commodities, do not have this R&D infrestructure. There are no departments or ministries of wetlands

10. Much of the world's lowland forests are associated with wetlands. Peatlands contain by far the largest proportion of carbon in boreal and tropical peat forests. Should the "Kyoto Forest" be expanded to a more ecologically meaningful level and include soils, wetlands would automatically be included.

11. Wetlands are prominent features of agricultural landscapes. About 85 per cent of wetland losses in Canada and the US have been a result of conversion to agricultural uses. Furthermore, millions of temporary wetland basins are tilled and cropped when they are accessible during periods of drought. Since the majority of wetland basins in agricultural landscapes are utilized as agricultural soils, it seems inconceivable to differentiate one from the other. The Kyoto Protocol currently includes agriculture as 1990 sources, thus "utilized" wetland basins are already a part of the Kyoto accounting system. It makes ecological, land-use and land-use change sense to include wetland basins, margins and associated uplands, and their conservation, as an integral part of agricultural soils for carbon credit purposes.

12. In the majority of cases, carbon sequestration can be enhanced by, or be a by-product of, the adoption of sustainable land-use practices that also promote the conservation of ecological goods and services such as soil, water and biodiversity. Thus, the costs and benefits of sink protection and enhancement are characteristically value-added to those of management practices that by themselves are in the best long-term interests of mankind. This is an important consideration in the evolution of market values for carbon and the conceptual design and ecological/ethical assessment of carbon sequestration initiatives.

13. In many cases, the economic value of carbon sequestration would not justify a stand alone, single benefit investment, but represent good business as a value-added transaction. This can be seen as a market-responsive incentive for a more integrated sustainable development approach to sinks, and as a barrier to some of the more perverse single-benefit sink scenarios. It also provides a conceptual basis and investment rationale for a voluntary, early action, no regrets approach by interested public and private sector partners.

14. Wetland conservation in Canada and internationally exemplifies the voluntary, non-regulatory, multi-sector partnership approach to sustainable landscape development. Both costs and benefits are shared between private landowners and managers, local communities, and public, private and NGO interests. This cooperative approach provides a time-tested model for delivering sink enhancement programs in forestry and agriculture, and in developing countries through the Clean Development mechanism.

15. Canadian business, notably the agriculture and forest sectors, are currently active in wetland conservation through the NAWMP Habitat Joint Ventures. Through Credit for Early Action initiatives, the NAWMP provides cost-effective opportunities to become involved in voluntary wetland carbon sink pilot projects in agricultural and forest landscapes.

16. The Clean Development Mechanism provides Canadian International Development and business opportunities for Canadian participation in GEF-sponsored pilot wetland sequestration projects. Wetlands International and the Ramsar Convention are key organizations for program planning, coordination and management.

7. SUMMARY

The Kyoto Protocol represents a major step forward by industrialized countries in addressing the global threat of climate change. The UNFCCC is characterized as being an international environmental agreement, one of the *Rio Conventions*, along with Biological Diversity and Desertification. It is undoubtedly the most complex and challenging of any international environmental agreement, and as such is very much a work in progress. Proceeding towards implementation will take many years of open-minded and equitable, but very thorough and pragmatic negotiations that above all deliver on the environmental bottom line – reducing GHGs in the atmosphere. The challenge is to be flexible and equitable enough to encourage the meaningful participation of developing countries, while ensuring that global GHG emission reduction commitments are met.

As it now stands, it is hard to categorize what type of an agreement the Kyoto Protocol really is. As a function of the participation, sector priorities and time-constraints of the Kyoto negotiations, the final document resembles a hybrid between an environmental regulation/pollution control convention and an international trade agreement. At the same time the Protocol seeks to promote sustainable development and support other international environmental agreements. The flexibility mechanisms are critical in that they may contribute to a broader, more ecologically appropriate climate change mitigation program, and provide value-added stimulation of sustainable development benefits in developing countries. Conversely, if they are not applied prudently, flexibility mechanisms could provide for potential loopholes for emission reduction commitments or inadvertently result in perverse and unsustainable ecosystem effects.

These comments are not intended as a criticism, but rather an acknowledgement of how complex and conceptually bold and inclusive the Kyoto Protocol sets out to be, and how much work will have to be accomplished before the first commitment period begins in 2008. These ambiguities can be seen as either a weakness or a strength. To those who view the world through the bottom line of the written word, the Kyoto Protocol contains many traps and possible pitfalls. To those who look beyond the constraints of the written text, it may provide the beginnings of an opportunity to come to grips with global climate change in yet to be known or imagined ways. At the same time, confronting the profound environmental, social and economic implications of Kyoto may help transform sustainable development from a global concept to a global reality.

There are two major dichotomies of principle and practice that affect virtually all aspects of the Kyoto Protocol:

- A regulation and protection / pollution control approach versus that of sustainable development / environmental conservation.
- Legally binding emission reductions versus voluntary, non-regulated approaches.

In order to address the issues of honest commitment, fairness, equity, and the immense economic implications of the protocol, particularly as it affects the developing world, a healthy dose of "can do" and "no regrets" spirit and practice will be required by all.

Concerns expressed regarding the appropriateness and efficacy of biological sinks should be taken seriously and addressed in a forthright manner. The bottom line of judgement should be the scientific verification that sinks do contribute a net reduction of GHG emissions to the atmosphere, and the potentially large sustainable development benefits their management can provide. To preclude sinks on ideological grounds would remove incentives for sink protection and enhancement, an area of the Kyoto Protocol that needs further development. The loss of sinks would not only remove their GHG buffering capacity, but also release large amounts to the atmosphere.

Conversely, a single-value treatment of sinks could result in inadvertent or perverse environmental effects. For example, old-growth forests or wetlands could be clear-cut or drained and planted to fast-growing tree plantations, if only the carbon sequestered during the commitment period was credited. Sinks should be evaluated from a broader sustainable development perspective, ensuring compatibility with other international environmental agreements such as biodiversity and wetlands.

A concern of some European and developing countries is that North America has an unfair natural sink advantage that will provide emission reduction loopholes. A different perspective might be that because of vast sink resources, they have an inordinate stewardship responsibility for their protection and enhancement.

Perhaps the most significant and potentially most valuable long-term opportunities for sink protection and enhancement are in developing countries. In many areas, single purpose developments have impacted natural systems and degraded the life support functions of soil and water resources, forests, wetlands and agriculture. Restoration of these systems and functions is costly and is often seen as anti-development. Sink protection and enhancement through such methods as the CDM may provide the diversity of costs and benefits that will bring both the concept and reality of sustainability to such developments.

In the Kyoto Protocol's treatment of biological sinks, only LUCF was included, agricultural soils were alluded to and wetlands were not mentioned at all. When the author tabled a discussion paper on Wetlands and Climate Change at the first ad hoc meeting of the National Sinks Table in April 1998 (Patterson 1998), a reaction was that wetlands were not even on the Kyoto radar screen. Since then, this and related work in Canada and the US has begun to focus attention on the issue of wetlands as sinks.

Clearly, the quality and quantity of wetland sinks science, monitoring, verification and reporting do not warrant the consideration of wetlands as unique ecosystems under the Kyoto Protocol. Unlike the economically and politically driven forest and agriculture sectors, the status of wetlands has tended to exist outside of the market economy. It is not surprising that there are no departments or ministries of wetlands, or national conservation coordination entity. In the past decade, however, wetland conservation has become an important component of the sustainable use and stewardship of agricultural and forested landscapes. On ecological, economic and conservation grounds, it is logical to consider wetland sinks as part of forest and agricultural soils.

The current issues, perceptions and approaches to the sinks issue are in many ways similar to those that faced waterfowl and wetland conservation during the late 1970's, when a regulation and protection approach to management prevailed. Regulating the shared harvest of waterfowl between nations, as the management priority was affected by competitive and distrustful perceptions of fair allocations. The object of wetland habitat conservation was to acquire and manage sites for the benefit of waterfowl, protect them from other uses in order to maximize harvest opportunity. However, the development and implementation of the North American Waterfowl Management Plan (NAWMP) by the mid-1980s fundamentally transformed the approach to one of conservation being the first priority and harvest being a shared benefit of conservation efforts.

The NAWMP recognized that to compete for habitat on privately owned and managed working landscapes was not a viable approach to conservation. Rather, It set out to foster a more sustainable and cooperative approach to land-use, where the environmental, social and economic costs and benefits of sustainable agriculture and forestry are shared. Through partnerships and incentives for conservation land-use practices, wetland conservation became a value-added component of renewable resource-based business. This fundamental change in approach spawned the largest voluntary, non-regulatory, partnership approach to natural resources management in history. The NAWMP, through its Habitat Joint Ventures is now recognized as a world-leading demonstration of the sustainable development of landscape resources.

In the 1970's, the predictive status of wetlands-waterfowl science and policy was at a similar level of sophistication as that of wetlands-sinks science and policy today. A policy level assessment of science was strongly supportive of taking a sustainable landscape approach, but adequate cause and effect models, predictions and verification measures were not yet available. However, the NAWMP was cooperatively developed, negotiated and implemented by Canada and the US, and then Mexico, on the basis of a "No Regrets" approach to sustaining shared resources and benefits. Pilot projects provided the first step opportunities to implement, evaluate and refine new approaches. At a global scale, both the Ramsar Convention on Wetlands, and Wetlands International made a similar transition from limited wetland site protection to a broader landscape approach to the sustainable and wise use of wetlands and their resources. Thus, the history of wetland conservation is not only an important precedent for climate change from a sink management perspective, but also as a potential model for evolving sinks policies and programs.

Wetland sinks are currently in a catch 22 situation. They are the largest carbon reservoirs in the world. However, not enough is known about their dynamics, fluxes and responses to management to justify their inclusion in a competitive, distrusting and regulatory international negotiating process. The WBGU, 1998 favours preventing additional sinks activities until it is certain that all effects are positive. However, to permanently preclude wetlands from further consideration now could have serious implications to the protection and enhancement of carbon sinks, and to the promotion of sustainable development and biodiversity conservation opportunities in the developing world.

Given the recent developments and achievements of wetland and waterfowl conservation, that have exceeded any quantitative expectations, it makes sense to pursue a similar "No Regrets" approach to biological sinks. An international negotiating priority for Canada would be towards some form of emissions control-sustainable development bottom line that would protect against unsustainable or perverse effects from sink management, and guard against sinks being used as artificial means of avoiding emission reductions. The "Organization for Sustainable Development" of the United Nations as proposed by the WBGU, 1998 is worth considering as such a model.

Canada's Kyoto position is that forest and agricultural soils should be included as sinks. This study strongly suggests that such a treatment of sinks would logically include wetlands since they are such integral components of those landscapes. Should such a position prevail, wetland sinks could become part of Canada's national forestry and agricultural sinks programs. Canadian wetland science could better organize and focus on the measurement of carbon stocks and flows, as will be discussed at the upcoming Oak Hammock Marsh and Science Experts Meetings. Verification and monitoring, which would include modeling of soil carbon and remote sensing of land-use and land-use change, would best be undertaken by the national forestry and agricultural systems currently under development by those sectors.

To accomplish this will require a major effort to organize, coordinate and catalyze Canadian wetland sink science and policy, a task for which there is no obvious government entity. If wetlands are included in agricultural and forest soils, the responsibility of the wetlands sector would be to provide the wetland science, land-use conservation and policy components to the lead sectors of agriculture and forestry. The cooperative efforts of IISD, DUC, WI-A and NAWCC, together with the Science Experts Wetlands Working Group provide a core of expertise and commitment that can be expanded and built upon.

The NAWMP Habitat Joint Ventures provide a proven delivery system for wetland sink related management programs in both agricultural and forestry lands across Canada. Regional and provincial steering committees currently include representation from the renewable resource sectors and could be expanded as required.

The Canadian business community has been involved in wetland conservation through the NAWMP Habitat Joint Ventures.
In the early months of 1998, following Kyoto, there was a sense of urgency that sinks issues would have to be fast tracked to meet deadlines such as the November 1998 COP 4 in Buenos Aires. Certainly there are important milestones, such as the National Climate Change in late 1999, the IPCC Panel in 2000 and COP 6, amongst others. However there is growing recognition that the implications of climate change mitigation and adaptation are extremely complex and will lead to unprecedented environmental social and economic impacts. From the perspective of sinks science and policy, it is becoming more apparent that it is better to do it right than quick. Sinks are of such potential importance to how we address climate change that it would be a serious consequence to preclude their full assessment and consideration on the basis of artificial deadlines.

Canada has been a world leader in advancing the sinks issue at Kyoto and beyond. Well thought out, scientifically defensible and policy relevant positions have had significant impacts on negotiations. One of Canada's unique strengths in the forest and agriculture sinks deliberations is that government and industry have spoken with a single voice. In the case of agricultural soils, the energy sector has been particularly proactive in promoting and supporting pioneering work in carbon sequestration in agricultural soils.

The potential crediting of wetland conservation as carbon sinks is uncertain at best. However, the whole sinks issue, including LULUCF, is underlain by uncertainly. This has not prevented Canada from taking an aggressive, but reasoned position, one that is having a substantial and positive impact on negotiations. We believe that Canada has a unique opportunity to further develop the science and policy of wetland conservation as components of agricultural and forest soils and be in a position of steering deliberations.

There is a definite role for the Canadian conservation sector and industry in wetland sinks. Beyond the essential research and policy development requirements, there is a need and opportunity to initiate pilot sink enhancement projects domestically and internationally. Through Credit for Early Action and the Clean Development Mechanism Canadian conservation organizations and industry could participate in pilot wetland projects on a “No Regrets” basis. Costs would be those incremental costs in association with wetland conservation funding available to launch the project.

In Canada, the US and Mexico, the NAWMP Joint Ventures would provide the coordinating and implementation infrastructures for pilot project design, delivery and evaluation. Internationally, Wetlands International and the Ramsar Convention would provide these functions and the link to the GEF.

The future status of wetland carbon sinks is uncertain. The global climate change implications of wetland carbon sinks are profound. For Canada to extend its global leadership role to considering wetland carbon sinks as part of agriculture and forest soils is a unique opportunity to advance the climate change agenda and strengthen global sustainable development.

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March 31, 1999

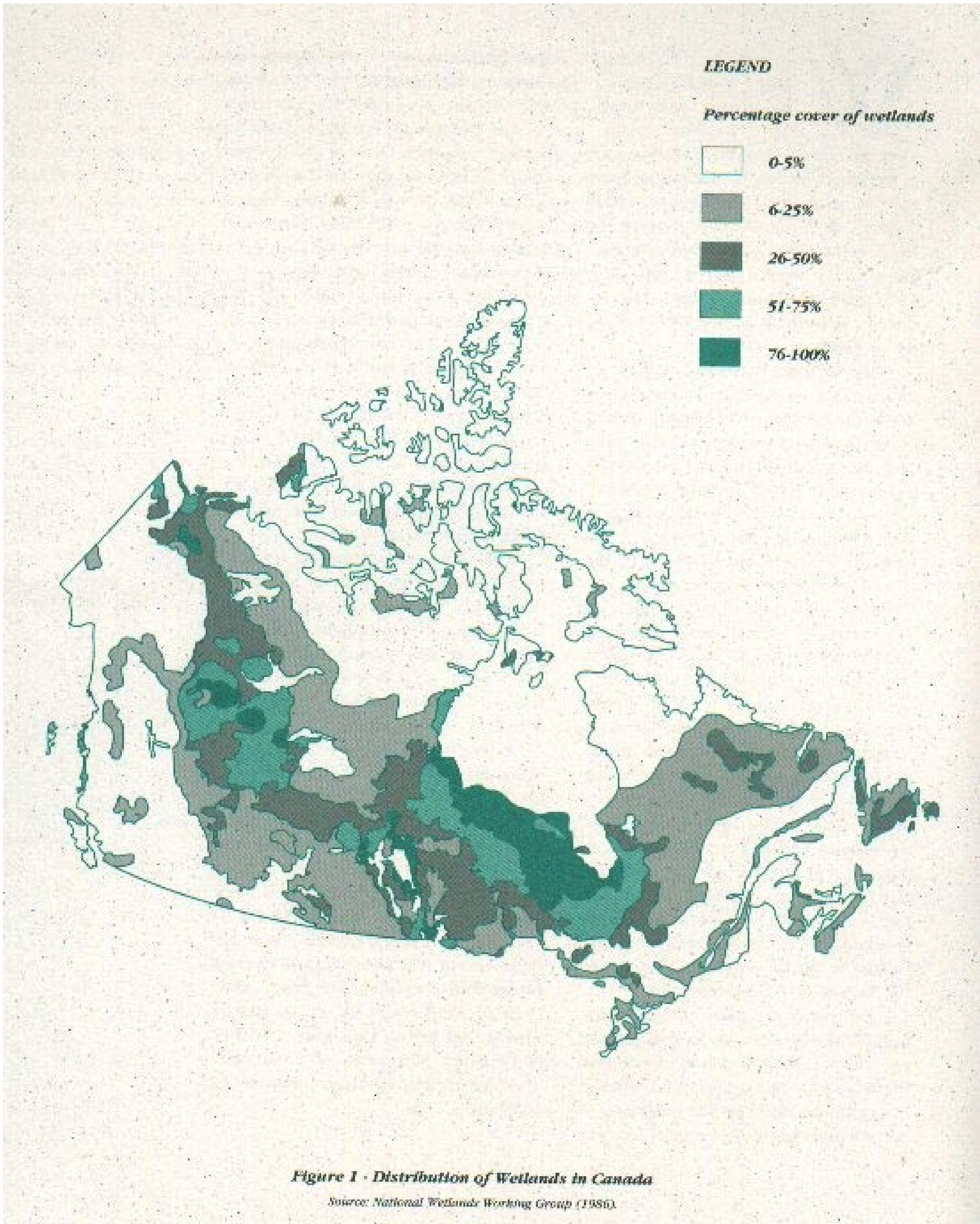

Figure 1. Distribution of wetlands in Canada. From Bond *et al.* 1992.

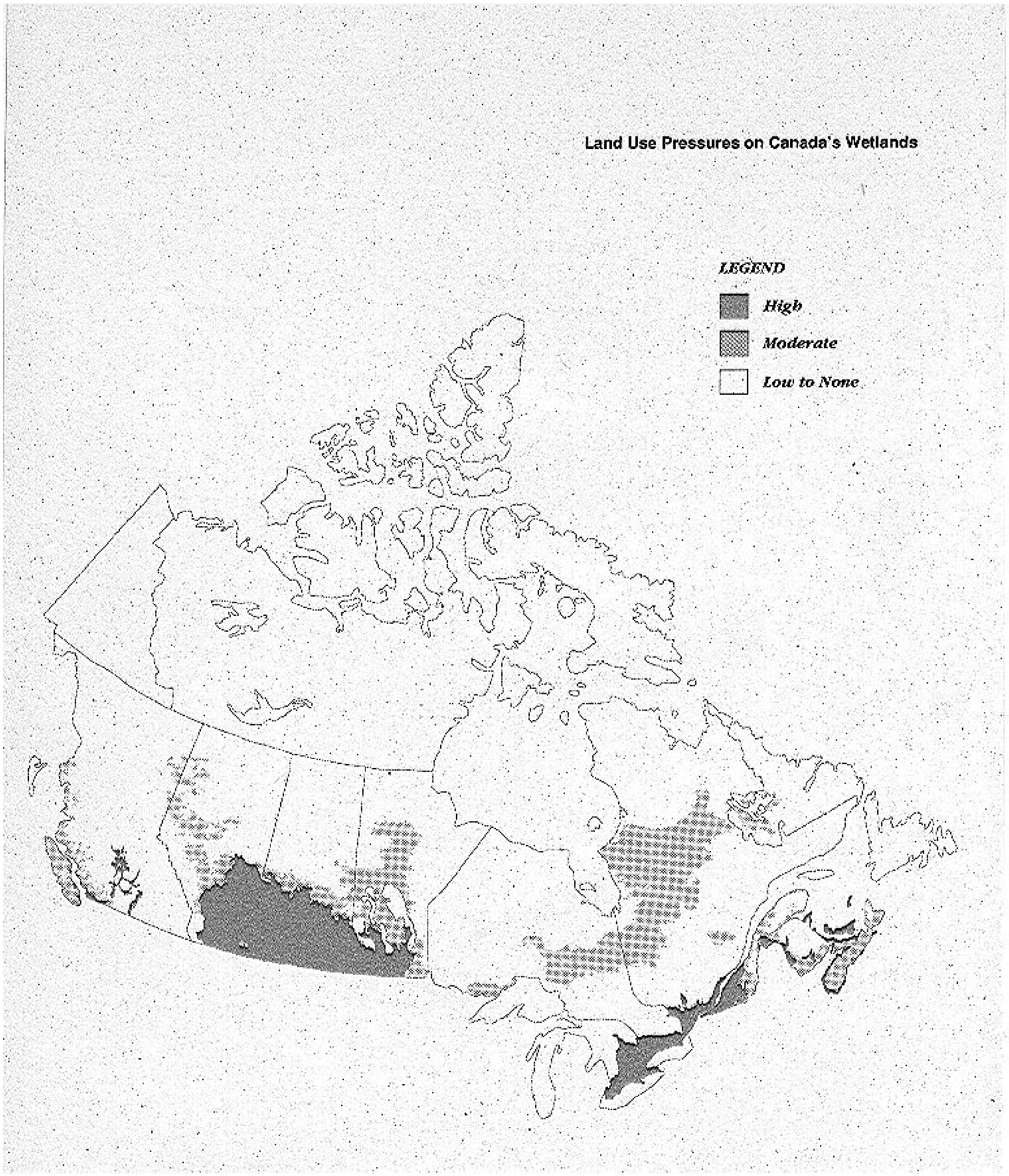

Figure 2. Land use pressures on Canada's Wetlands. From Sheehy, 1993.

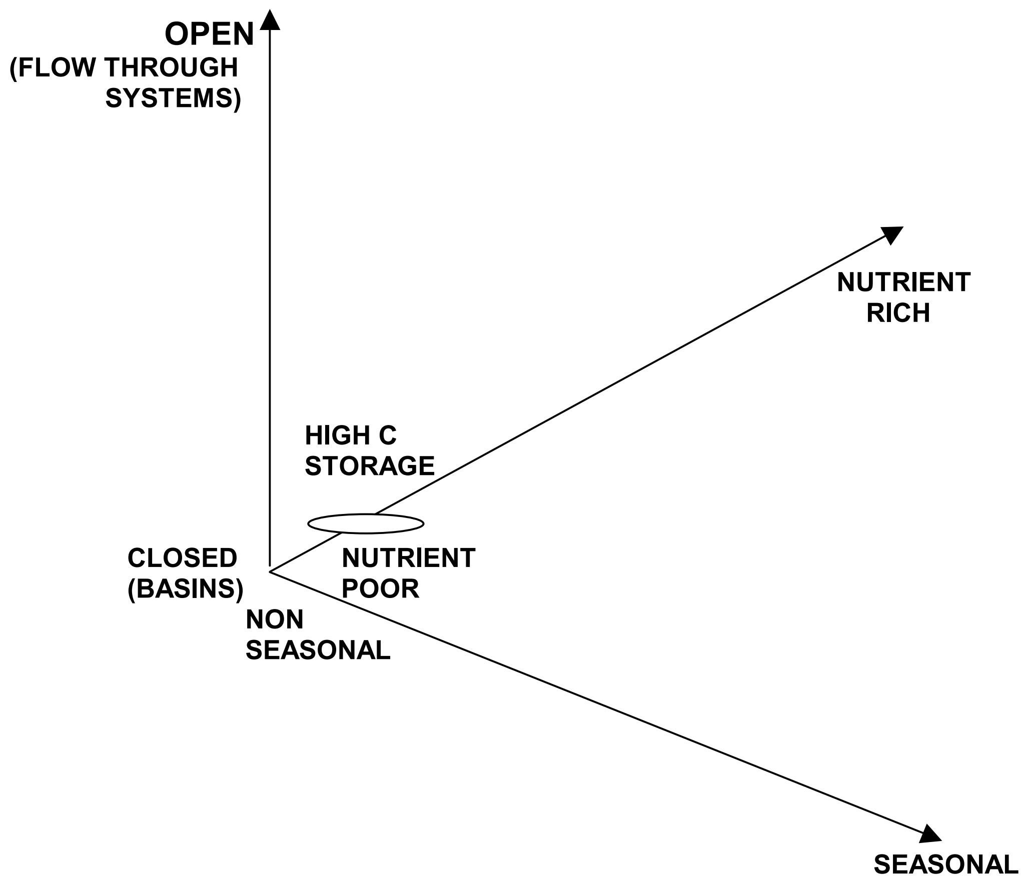

Figure 3. Factors affecting carbon storage in wetlands (from Adger, 1995)

Table 1. Area of wetlands in Canadian ecozones.

Ecozone Name	Percent Organic Bog	Percent Organic Fen	Percent Organic Marsh	Percent Mineral Marsh	*Percent Organic* Swamp	Percent Mineral Swamp	Percent Total	Total Area (Hectares)	Wetland Area (Hectares)
CANADA							15.9112	9294115.1	1478804.6
Arctic Cordillera	0.0610	0	0	0.0632	0	0	0.1242	222866.6	276.8
Northern Arctic	1.8522	0.1159	0	0.5686	0	0	2.5367	1441886.4	36576.6
Southern Arctic	5.4592	0.4363	0.0031	0.1307	0	0	6.0313	796092.6	48014.7
Taiga Plain	28.4859	9.5767	0.0685	0.1440	0.2040	0	38.4921	589737.6	227002.4
Taiga Shield	7.5458	4.6331	0.0166	0.0030	0.0101	0	12.4086	1266209.9	157118.9
Boreal Shield	12.6781	5.1611	0.2994	0.0077	0.3479	0.0003	18.7145	1748530.2	327226.7
Atlantic Maritime	4.1120	0.7524	0.1181	0	0.1161	0	5.1006	19923.3	10162.1
MixedWood Plain	1.9259	0.9597	1.8197	0.3792	1.8197	0.6347	7.5489	111154.1	8390.8
Boreal Plain	13.8698	22.3801	1.7200	2.6886	0.7492	0.0751	41.4828	679074.2	261699.0
Prairie	0.0007	3.6666	1.5139	5.5833	0.6691	0.0011	11.4147	456441.8	52101.5
Taiga Cordillera	1.9309	0.8996	0	0	0	0	2.8305	265118.9	7504.2
Boreal Cordillera	1.1998	0.2835	0	0	0	0	1.4633	462744.6	6863.9
Pacific Maritime	1.6582	0.1403	0.0043	0.0219	0.0043	0.0084	1.6374	206069.3	3786.3
Montane Cordillera	0.6407	1.9906	0.0045	0.0165	0.0006	0	2.6529	479424.5	12718.7
Hudson Plain	45.2716	35.6753	0.0684	0	0	0	81.0133	369519.4	299359.9

Table 2. Current estimates of terrestrial biosphere carbon pools and flux by biotic systems

Biotic System	C Pools (Pg)	C Flux (Pg)
Boreal forests/tundra	559	+0.4 to +0.8
Temperate forests	159	+0.2 to +0.4
Tropical forests	428	-2.0 to +1.2
Agroecosystems	150	-0.1 to +0.1
Grasslands/Savanna/Deserts	417	0 to +0.6
Wetlands	230	0 to +0.2
Total	1,943	-1.5 to +0.2

Table 3. Main Options for Enhanced Carbon Sequestration.

- **Management of quality of primary production to retard decomposition in forests and agricultural systems.**
- **Management of the physico-chemical environment, particularly in agricultural systems, to enhance primary production and increase soil organic matter.**
- **Conservation and possibly extension of wetlands, including coastal margins, to maintain anaerobic conditions and protect resistant organic residues.**

Table 4. Strategies for Maintaining, Restoring and Enlarging Agroecosystem Carbon Pools

1. **Enhancement of soil fertility and maintenance of neutral pH**
2. **Concentration of agriculture rather than expansion**
3. **Preservation of wetlands (high in soil C)**
4. **Minimize site disturbance and retain organic matter in soil**
5. **Agro-afforestation**
6. **Conservation tillage practices to reduce soil aeration, heating and drying**

8. REFERENCES CITED

Adger, W. N. 1995. *Working Group Reports - Management in Wetland Ecosystems.* In Carbon Sequestration in the Biosphere: Processes and Prospects. NATO ASI Series. Series 1. Global Environmental Change: Vol.33: 217-226. Springer-Verlag Berlin Heidelberg.

Anderson, J. W., Morgenstern, R, and M. Toman. 1999. At Buenos Aires and Beyond. Weathervane. http://www.weathervane.rff.org/features/feature061.html

Apps, M. 1998. *Accounting for the Carbon Budget.* Solutions: The Canadian Forest Service Newsletter. Natural Resources Canada. Spring, 1998.

Armentano, T. V. 1980. Drainage of organic soils as a factor in the world carbon cycle. BioScience 30, 825-830.

Ballard, M. 1998. Personal communication. PoleStar Geomatics unpublished data.

Bouwman, A. F. 1990. Exchange of greenhouse gases between terrestrial ecosystems and the atmosphere. In Nouwman, A. F. (ed.). Soils and the greenhouse effect. Proceedings of the international conference "Soils and the Greenhouse Effect". Chichester, New York: Wiley. Cited from WBGU 1998.

Bond, W. K., K. W. Cox, T. Heberlein, E. W. Manning, D. R. Witty and D. A. Young. 1992. *Wetland Evaluation Guide: Final Report of the Wetlands Are Not Wastelands Project.* Sustaining Wetlands Issues Paper, No. 1992-1. North American Wetlands Conservation Council (Canada). Ottawa, Ontario.

Bruce, J., Frome, M., Haites, E., Janzen, H., Lal, R. and K. Paustian. 1998. Carbon Sequestration in Soils. Proceedings of the Soil and Water Conservation Society's Carbon Sequestration in Soils Workshop. Calgary, May 21-22, 1998.

Clair, T. A., Warner, B. G., Robarts, R., Murkin, H., Lilley, J., Mortsch, L. and C. Rubec. 1997. Executive Summary. Impacts of Climate Change to Inland Wetlands: a Canadian Perspective. Oak Hammock Marsh Conservation Centre, Stonewall, Manitoba.

Daynard, T. 1999. Personal Communication.

Costanza, R., d'Arge, R., de Groots, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P. and M. van den Belt. 1997. *The value of the world's ecosystem services and natural capital.* Nature 387: 253-260.

Dixon, R. K. and O. N. Krankina 1995. *Can the Terrestrial Biosphere be Managed to Conserve and Sequester Carbon?* In Carbon Sequestration in the Biosphere: Processes and Prospects. NATO ASI Series. Series 1. Global Environmental Change: Vol. 33: 153-179. Springer-Verlag Berlin Heidelberg.
Duarte, C. M. and S. Agusti. 1998. *The CO2 Balance of Unproductive Aquatic Ecosystems*. Science 281: 234-236.

Forsyth, S. 1998. Personal Communication.

Gorham, E. 1991. Northern peatlands: Role in the carbon cycle and probable responses to climatic warming. Ecological Applications 1, 182-195.

Hengeveld, H. and P. Beaulieu. 1999. Report of the Carbon Flux Experts Meeting, Downsview, 18-19 April 1999.

Immirizi, C. P. and E. Maltby 1992. *The Global Status of Peatlands and their Role in Carbon Cycling.* A Report for Friends of the Earth by the Wetlands Ecosystem Research Group, Department of Geography, University of Exeter. Friends of the Earth, London.

Ingram, J. and F. Thingstad. 1995. Working Group Reports – Mechanisms. Carbon Mineralisation. In Carbon Sequestration in the Biosphere: Processes and Prospects. NATO ASI Series. Series 1. Global Environmental Change: Vol.33: 217-226. Springer-Verlag Berlin Heidelberg.

Kusler, J., Brinson, M., Niering, W., Patterson, J., Burkett, V. and D. Willard. 1999. *Wetlands and Climate Change: Scientific Knowledge and Management Options*. Draft White Paper.

Kyoto Protocol to the United Nations Framework Convention on Climate Change. Source: www.unfcc.de.

Mitsch, W.J. and X. Wu. 1995. Wetlands and Global Change. In Lal, W., Kimble, J., Levine, E. and Stewart, B. E. (eds): Soil management and greenhouse effects. Boca Raton: CRC Press, 205-230.

Moser, M., Prentice, C. and S. Frazier. (1996). A Global Overview of Wetland Loss and Degradation. Technical Session B of the 6th Ramsar COP. Brisbane, Auatralia.

Murkin, H. R. 1998. Personal Communication.

National Sinks Table. 1998. Foundation Paper. Final Report. November 17, 1998.

NATO. 1995. Edited by Max A. Beran. *Carbon Sequestration in the Biosphere: Processes and Prospects.* NATO ASI Series 1. Global Environmental Change: Vol. 33. Springer-Verlag Berlin Heidelberg.

Patterson, J. H. 1998. Discussion Paper on Wetlands and Climate Change. The Potential for Crediting Wetlands as Carbon Sinks. Wetlands International - Americas.

Patterson, J. H. and C. Mrena. 1998. Wetlands and Climate Change: Possible Roles in Mitigative and Adaptive Strategies. The Potential for Crediting Wetland Conservation as Carbon Sinks.

Ramsar. 1998. *About the Ramsar Convention on Wetlands.* http://iucn.org/themes/ramsar/about_why_conserve.htm.

Roulet, N., Bhardwaj, A., Comer, N., Letts, M., Moore, T. and C. Roehm. 1997. Modelling biospheric-climatic feedbacks in peatland ecosystems. In Clair et al. 1997.

Sheehy, G. 1993. *Conserving Wetlands in Managed Forests.* Sustaining Wetlands Issues Paper, No. 1993-2. North American Wetlands Conservation Council (Canada). Ottawa, Ontario.

Silvola, J. 1986. Carbon dioxide dynamics in mires reclaimed for forestry in Eastern Finland. Annales Botanici Fennici 23, 59-67. Cited from WBGU, 1998.

Silvola, J., Alm, J., Ahlholm, U., Nykanen, H. and P. Martikainen. 1996. The contribution of plant roots to CO2 fluxes from organic soils. Biology and fertility of soils 23, 126-131. Cited from WBGU, 1998.

United Nations Framework Convention on Climate Change. Source: www.unfcc.de.

Vaughan, H.H. 1998. Personal Communication.

WBGU (German Advisory Council on Global Change). 1998. The Accounting of Biological Sinks and Sources under the Kyoto Protocol - A Step Forward or Backwards for Global Environmental Protection? Special Report. 75 pp.

Waddington, J.M. 1998. *Southern Canadian Wetland Greenhouse Gas Sources and Sinks*, Abstract of a presentation at PERD Workshop, Downsview, Ontario, May 1998.

Zoltai, S.C. and P. J. Martikainen. 1996. Estimated Extent of Forested Peatlands and Their Role in the Global Carbon Cycle. In Apps, M. J. and Price,

D. T. (eds.). Forest Ecosystems, Forest Management and the Global Carbon Cycle. Band 40. Berlin, heidelberg, New York: Springer, 47-58.