GPI Atlantic

INTRODUCTION

To the

GPI NATURAL RESOURCE ACCOUNTS

October, 1999

Summary Previews of GPI Reports to be Released in 1999:

Fisheries
Forests
Soils and Agriculture
Greenhouse Gas Emissions

Report Authors:

Tony Charles, Ph.D, Larry Hughes, Ph.D, Sally Walker, Ph.D,
Ronald Colman, Ph.D, Sara Wilson, M.Sc. (Forestry),
Jennifer Scott, M.E.S., Amanda Lavers, B.Sc.

Introducing

The Genuine Progress Index: Renewable Natural Resource Accounts

Prepared by:

Ronald Colman, Ph.D, Tony Charles, Ph.D, Jennifer Scott, MES, Sara Wilson, M.Sc., Larry Hughes, Ph.D, Sally Walker, Ph.D, Amanda Lavers, B.Sc.

VALUING OUR NATURAL RESOURCES:
THE NOVA SCOTIA GENUINE PROGRESS INDEX

Unfortunately, (GDP figures) are generally used without the caveat that they represent an income that cannot be sustained. Current calculations ignore the degradation of the natural resource base and view the sales of nonrenewable resources entirely as income. A better way must be found to measure the prosperity and progress of mankind.

Barber B. Conable, former president, World Bank

In calculating GNP, natural resources are not depreciated as they are used up. For all practical purposes, GNP treats the rapid and reckless destruction of the environment as a good thing!….The world community led by the United States, should move to change this widely used formulation, and others like it, that badly mislead decision-makers who might otherwise place more appropriate economic values on the protection of the global environment. There is no excuse for not changing the definition of the GNP.

Al Gore, Vice-President, U.S.A.

The UN System of National Accounts, the world's yardstick for measuring economic performance, is a flawed framework for appraising the sustainability of economic growth. While it measures how such man-made assets as factories and equipment depreciate as they are used in current production, it leaves out the effects of resource depletion and degradation. For example, national income accounts record timber output, fish harvest, and crop production as income but ignore the costs of deforestation, overfishing, and soil erosion. A nation's depletion of its natural resources – consumption of natural capital – can therefore masquerade as growth for decades, even though it will clearly reduce income prospects from resource sectors in the future. Just as ignoring the deterioration of man-made assets skews economic assessments, so does overlooking the degradation of natural assets.

James Gustave Speth, President, World Resources Institute

GNP and its cousin GDP (gross domestic product) are parts of a general system of economic accounting, called the System of National Accounts (SNA), that misvalues, undervalues or simply ignores natural capital. Manufactured capital is depreciated in recognition that its value declines each year as it wears out or is used up, but the use or loss of natural capital is not counted as a charge against current income. Natural capital is treated in these accounts as if it had no value.

Thomas Prugh, International Society for Ecological Economics

Since the GNP/GDP measures only the quantity of market activity without accounting for the social and ecological costs involved, it is both inadequate and misleading as a measure of true prosperity….New indicators of progress are urgently needed to guide our society – ones that include the presently unpriced value of natural and social capital in addition to the value of conventionally measured economic production. The GPI is an important step in this direction.

Signed by over 400 prominent economists, including Nobel laureates

We currently measure our progress as a society according to our economic growth rates. If the gross domestic product (the sum total of all goods and services exchanged for money) is growing at a good rate, we describe the economy as "robust," "dynamic," and "healthy," which, we assume, translates into social well-being and prosperity. That assumption guides our policy and even determines what issues make it onto the policy agenda.

According to this measure, the more rapidly we deplete our natural resources and the more fossil fuels we burn, the faster the economy grows and, therefore, the "better off" we think we are. Because we assign no value to our natural capital, we actually count its depreciation as gain, with no regard to the reduced flow of services in the future. Robert Repetto remarks:

> *A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these assets disappeared.*

In Nova Scotia we are constructing an index of sustainable development, the Genuine Progress Index (GPI), that is designed to give us a more accurate picture of our well-being. Unlike the GDP, which values only man-made produced capital, the GPI values natural, social and human capital. Among its 20 social, economic, and environmental components, the Nova Scotia GPI therefore includes four natural resource accounts that assign explicit value to our soils, forests, fisheries, and non-renewable resources, and assess the sustainability of our harvesting practices and consumption habits.

In the Genuine Progress Index, natural resources are valued as finite capital stocks, subject to depreciation like produced capital. Genuine progress is measured by our ability to live off the income or "services" generated by our resources, without depleting the capital stock that is the basis of wealth both for our children and ourselves. "Sustainable" resource use therefore means living within the carrying capacity of the resource base and harvesting in accordance with its regenerative ability. A commitment to *sustainable development* ensures that natural wealth is maintained for the benefit of future generations and that our children will not be worse off than we are as a result of our resource exploitation.

The GPI acknowledges not only directly marketable products, but the full range of ecological and social services provided by these resources, which also have indirect economic value. The GPI forest account, for example, counts not only timber production, but also the value of forests in protecting watersheds, habitat and biodiversity, guarding against soil erosion, regulating climate and sequestering carbon, and providing for recreation and spiritual enjoyment. Healthy soils and the maintenance of multi-species, multi-aged forests in turn provide multiple economic benefits by enhancing timber quality and productivity, increasing the economic value of forest products, protecting against fire, disease and insects, and supporting the burgeoning eco-tourism industry.

Unlike our current measures of progress, based on the illusion of limitless growth, the GPI accounting framework therefore clearly recognizes that finite resource stocks have limited regenerative capacity, and thus points to economic policies modeled on the balance and equilibrium that exist in nature. Scientists have noted that the only biological organism that has unlimited growth as its dogma is the cancer cell, a disturbing analogy for conventional economic growth theory.

Until we apply the same basic accounting logic to our natural capital as we currently do to our produced capital, we are unlikely to cut through the pervasive illusion that "more" is "better", or to deviate from a self-destructive path that has depleted our resources and undermined our natural wealth. Including natural resource values in our core economic accounts and measures of progress is essential if we are to shift our economic system in a profound way to chart a sustainable future for our children.

The following examples illustrate some of the resource valuation methods used in the Nova Scotia GPI. The three renewable resource accounts will be completed in the fall of 1999 after revisions based on expert review. Statistics Canada has designated the Nova Scotia GPI as a pilot project for Canada, so that this work will likely have a significant impact beyond this province, and Nova Scotia can benefit from being in the forefront of this important new development.

Important Note: ***The fisheries account, following, gives a clear overview of the application to one specific resource sector of the basic GPI principles, approach and methodology used in all the natural resource accounts. Therefore, this overview is not repeated in the soils and forests sections, which focus instead on sample preliminary results that have emerged from the research to date.***

The GPI Fisheries Account

Tony Charles, Ph.D and Amanda Lavers, B.Sc.

Media reports on the "State of Nova Scotia's Fishery" traditionally focus on the annual quantity of fish caught, the income of fishers, the level of fish exports, and the total fishery revenue. All of these factors contribute to the Gross Domestic Product, the conventional measuring stick of our fishery's progress.

These measures, however, do not capture all that we value in a fishery system. The goal of the GPI Fisheries Account is to provide a more comprehensive assessment of the state of the fishery, and measure how well it has progressed towards sustainability. This preliminary report highlights some of the major themes that will be addressed in the full report, focusing particularly on the following:

- Measures of natural capital and natural resource depreciation
- Assessments of sustainable catches and sustainable employment
- Development of a system of sustainability indicators.

Natural Capital and Depreciation.

Traditionally, we have assessed the economic performance of Nova Scotia's fishery by adding up all the revenue obtained from catching and selling fish. This practice misses a critical point, in that it does not account for the value of fish remaining in the ocean after the fishery has taken place, or any damage to the natural system which maintains the fishery. The fish in the sea, the quality of the water, the ocean bottom habitat, and all the other elements of the marine environment constitute 'natural capital' – this is what keeps the fishery functioning and as such needs to be recognized as having real value.

We have traditionally placed a value on human-made capital, such as pieces of machinery, by measuring investment costs. What about natural capital? What is its value? Certainly, there are many roles played by elements of the ecosystem that are truly invaluable and which we cannot directly translate into monetary terms. It has proven useful, nonetheless, to look at natural capital partly in monetary terms. When this is done carefully it can help us to recognize:

(1) the intrinsic value of fish stocks in the ocean, analogous to a savings account from which interest may be harvested year after year, and
(2) the folly of large harvests that seem profitable but actually lead to fishery collapse.

Consider a particular fish species such as haddock. Considerable effort is expended each year by government scientists to estimate the total amount (weight) of haddock within a certain region of the ocean – this is called the 'biomass'. If we multiply this estimate of biomass by the price of haddock, we can calculate a monetary value for all the haddock that live in Nova Scotia's waters. The value of haddock stocks, for example, in Nova

Scotia's waters in 1997 was $128 million. This is the value that could theoretically be obtained if every haddock were caught and sold that year. Of course, this is impractical and undesirable – because we want to maintain the fish stock at a healthy level and live off the annual growth. A sensible resource manager should consider fish in our waters to be like the assets of an investment which will yield profit while maintained, or like funds in a savings account whose earnings and interest can sustain people's livelihoods.

We can reconstruct the value of our fish stocks in the past by adjusting for changes in fish stocks, fluctuating prices and for inflation (see Figure 1). If we compare our current stocks to previous ones we can better understand what 'progress' we have made toward a sustainable and healthy fishery.

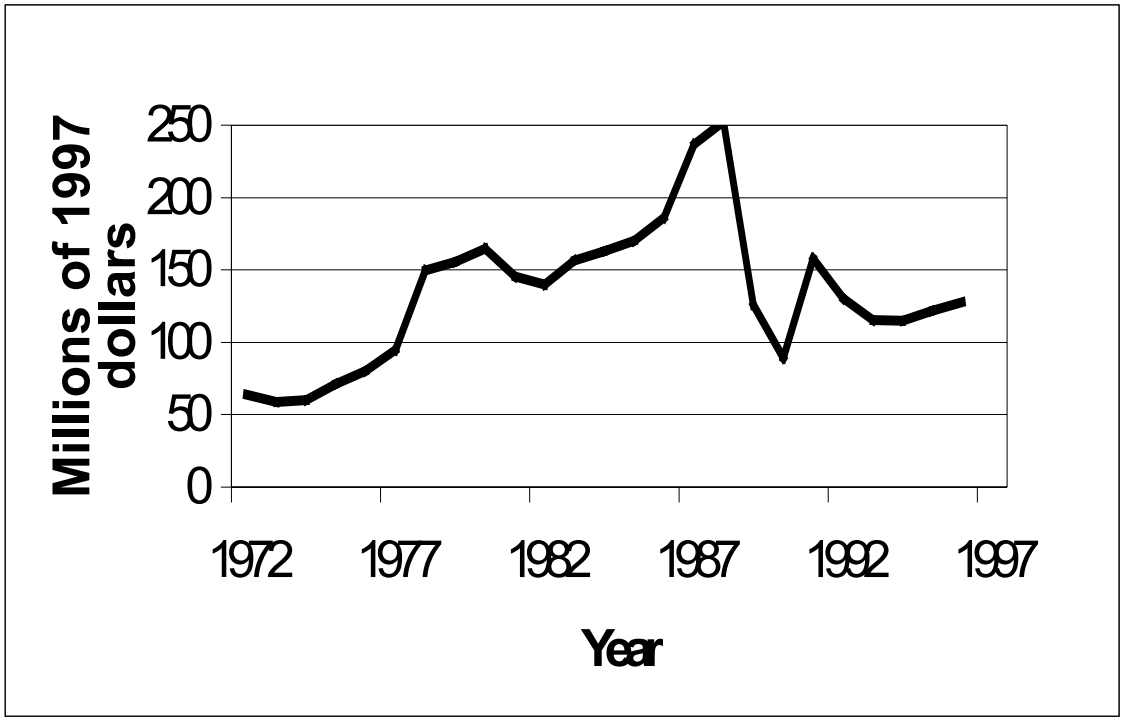


***Figure 1**. The value of Nova Scotia's haddock stocks generally rose between 1972 and 1988 but fell in 1989 and has not yet reached levels as high as those in the 1980's. Unfortunately, data are not available prior to 1972.*

In the late 1980's we had an increasing fisheries GDP, while we were catching, selling and exporting more fish. However, we were simultaneously depleting our natural capital. This is called resource depreciation and is analogous to what happens as a business capital stock (factories, pieces of equipment, etc.) wears out over time. In contrast to a piece of machinery, fish stocks can be self-sustaining and actually appreciate; that is, their economic value as a stock can actually grow naturally. If fish stocks are subjected to over-exploitation or other pressures, however, they will lose economic value.

A clear example of resource depreciation is provided by Nova Scotia's cod stocks. Figure 2 shows the dramatic increase in the gap between the potential value of Nova Scotian cod stocks and the value they actually had. This gap represents the depreciation of our natural assets. We calculated potential value simply in reference to biomass levels in 1982 (the year for which the earliest reliable biomass data are available – earlier data do exist but their consistency and reliability are unclear). Had we been able to estimate biomass of Nova Scotian cod 25, 50, or 100 years ago the resulting graph of depreciation would likely be even more dramatic.

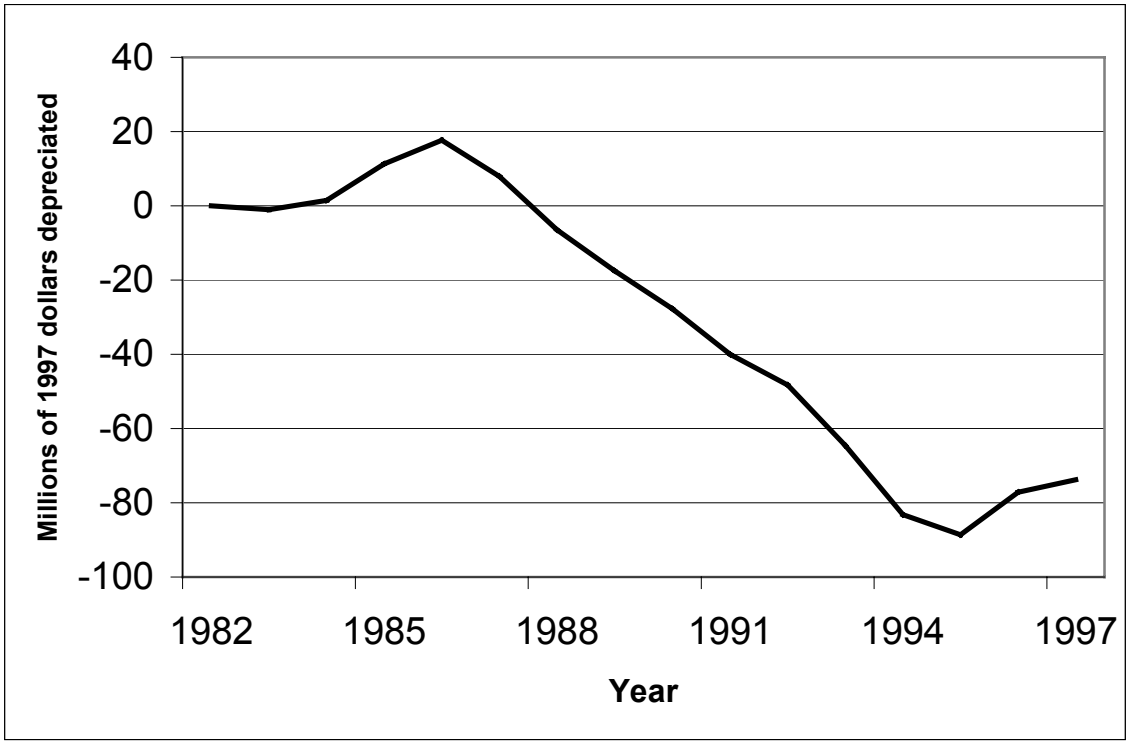


Figure 2. *The value of cod living in Nova Scotia's waters greatly depreciated between 1986 and 1996. By 1996 the loss of natural assets, compared to the level of cod stocks existing in N.S. waters in 1982, amounted to more than $70 million. Note that since depreciation is measured relative to 1982 stock levels (the first year for which reliable data are available), significant depreciation may already have occurred in prior years relative to potential carrying capacity. Earlier data do exist, but their reliability is unclear.*

If a private company allowed this level of depreciation in its produced capital, its factories would soon be falling apart. Yet in the fishery, this depreciation occurred behind the scenes while annual reports of progress told of high profits and a strong industry. The GPI fisheries accounts begin to remedy this flaw by measuring harvests *in relation to* stock values over time.

Sustainable Catches and Employment.

Historical catch levels in Nova Scotia's fishery are available for some major species back to the turn of the century.[1] These records are useful for roughly estimating a 'safe' amount of fish that the ocean has consistently provided to fishers. The Nova Scotian lobster fishery, for example, consistently landed about 10,000 metric tonnes per year for the 50 years between 1920 and 1970. That level may not compare well with recent much higher landings, but that level endured for so long as to reflect what has historically proved to be a truly sustainable level. The GPI fisheries study reviews historical catches for several species, not to illustrate a *maximum* yield that could be taken from the resource, but rather to indicate levels of fishing that have worked and been sustainable in the past. The strong advantage of such a conservative valuation is that, unlike maximum yield estimates, it allows for natural fish stock changes due to environmental fluctuations.

These sustainable catch estimates directly affect employment and pose a key question for policy makers: How many jobs could there be in a sustainable fishery? The answer depends both on the sustainable catch levels discussed above and on what is considered a reasonable average income for a fisher. In fact, the number of sustainable jobs can be calculated as follows, for any particular mix of gear and fleet types:

1. Determine a 'sustainable gross revenue' (or landed value) for each species by multiplying its sustainable catch level by the unit price;
2. Determine a species-specific 'sustainable net revenue' as a fraction of the above, to deduct costs of harvesting (allowing for the mix of fleets involved);
3. Calculate the total net revenue from the fishery by summing the net revenues across all species involved;
4. Obtain the sustainable employment by dividing this total net revenue by an appropriate annual fishing income, based on the average industrial wage in the province.

Note that this calculation does not imply that everyone in the fishery receives the average annual income, but rather that an average fisher receives this income. Matters of income distribution and fairness will be considered elsewhere in the GPI accounts. Note also that here we are calculating 'full-time equivalent' jobs. Many more people can be involved in the fishery if they also work and obtain income in other economic activities, along with their fishing. Finally, note that the calculated level of sustainable employment will vary with the mix of fleets; not surprisingly, using a more capital-intensive fleet results in a lower level of employment.

After adjusting for inflation and changes to the market price of fish products, we have estimated a livelihood carrying capacity for Nova Scotia's fishery, using the above method. Through the 1980s and 1990s, the number of fishers that could be employed full time without over-exploiting Nova Scotia's fish stocks was between 7000 (using an

[1] The historical data actually vary according to species. Data for all major species are available from 1972, and for some species from 1960. For the inshore fishery, records were published from 1920 to 1950. Some of the most consistent records dating to the early part of the century are for the lobster fishery.

industrial average wage) and 11,000 (using a poverty-line income for a 4-person family). Interestingly, Statistics Canada reported between 6000 and 12 000 Nova Scotians were occupied in the fishing industry during the same time period. These numerical ranges are remarkably close. This does not imply that exploitation was sustainable over this time period – at least in the ground fishery. It clearly was not. However, the similar numbers do suggest that employment in a sustainable fishery need not be much lower than it has been in recent years, provided a reasonably fair distribution of income is maintained.

'Genuine Progress' Sustainability Indicators

Assessments of natural capital, sustainable harvests, and sustainable employment provide some key ingredients to a more comprehensive measurement of 'genuine progress' in Nova Scotia's fishery. A full analysis must also include a range of ecological, economic, social, and institutional factors. Such factors are called 'indicators' because they provide indications of how close to or far away from sustainability the fishery is. The GPI fishery report discusses, using current and historical data where possible, a variety of indicators, such as the following:

Ecological Indicators:

- biomass of targeted species and level of resource depreciation
- average size of fish (affected by over-harvesting and environmental stress)
- extent of protected areas, providing fish with refuges from harvesting
- extent of habitat on the ocean floor unaffected by fishing
- level of marine diversity
- level of toxic contamination
- level of discarded waste

Socioeconomic Indicators:

- level of employment versus sustainable livelihood capacity
- level of fleet catching power versus sustainable capacity
- landed value of fish caught
- level of exports
- depreciation of capital assets
- resilience (age structure of fishers, extent of licensing for multiple species)
- concentration of access and wealth (across fleet groups)
- level of debt and bankruptcies
- safety at sea

Institutional Indicators:

- level of resources allocated for science and conservation
- priority placed on sustainability
- cooperation and sharing of power with fishing communities

Note that the first ecological indicator listed, and the first two socioeconomic indicators, are obtained from the results of the calculations discussed earlier in this article. Others are calculated (or assessed qualitatively) using data and information obtained in the course of the GPI research. Details on defining and measuring the indicators, as well as results for each, are provided in full in the report.

What are the implications of the GPI fisheries results?

What we measure is a sign of what we value. Traditional measures, such as fishery revenues, exports and employment, are clearly relevant, but a preoccupation with these measures has misled us in the past. By failing to include such factors as ecosystem health, fishery resilience, and resource depreciation in past calculations, strict economic accounting has given these vital factors an implicit value of zero.

As noted, direct physical and monetary measurements can assist in assessing stock values, depreciation rates, and sustainable catch and employment levels. While not all variables are measurable in these terms, ecological and social variables that enhance sustainability and promote long-term prosperity at least deserve qualitative valuation if we are to preserve our natural wealth, and to maintain a viable fisheries sector and healthy coastal communities into the future.

By not measuring what we value, we have also neglected what we value in the policy arena, producing policy outcomes that have undermined the sustainability of the fisheries sector and depleted our natural wealth – outcomes clearly at variance with our common goals as a society.

A full GPI analysis can help decision-makers distinguish between the real costs and benefits of different options. One option may generate considerable economic activity and positive GDP growth in the short term, but may have such great social and ecological costs, not counted in a typical GDP calculation, as to produce a net negative impact. This was amply demonstrated in the fishery collapse – the devastation associated with a system of valuation that failed to account for its own future well-being.

As Nova Scotia moves into the future, a key goal will be to ensure that its natural resources are used in a sustainable manner that benefits the people of the province, their communities, and the natural environment both now and in the future. Maintaining a system of GPI fisheries indicators may help guide us in this direction.

The GPI Forest Account

Sara Wilson, M.Sc. (Forestry) and Ronald Colman, Ph.D

How can we know with any confidence whether efforts to stem forest decline, are having a positive effect? How can we track what is happening to the forest capital over time? How can we get away from measuring systematic depletion of the forest resource as a net gain in economic growth? If indeed we value forests as an asset, and if ensuring the ability of future generations to meet their own needs is not just rhetoric, it would be useful... to appraise the effectiveness over time of all that we do in relation to sustaining forests. We need a measure for the changing value of the forest capital of the world.
World Commission on Forests and Sustainable Development 1999

In our conventional economic accounts, forests are valued only for their timber values. In other words, forests as natural capital assets are not assigned any economic value, and enter the accounts only when they are cut for timber. Essential life support services provided by forests, - including climate regulation and carbon sequestration, soil erosion control and sediment retention, nutrient and hydrological cycling, preservation of watersheds and habitat, and provision of recreation and social benefits - have remained unvalued, or at best regarded as "free" supports for the market economy. Furthermore, these and other qualitative factors, such as the maintenance of species and age diversity, have not been valued for their vital contribution to long-term timber productivity itself, to the viability and sustainability of forest industries and to future timber market values.

These failings recently led the National Round Table on Environment and Economy to conclude that current harvesting practices on Maritime woodlots were unsustainable, and to warn of a potential collapse equivalent to that in the ground fishery. The Round Table noted that current structures of financial and tax incentives and penalties, based on the conventional economic accounts, actually encouraged and promoted unsustainable harvesting practices. Because we value only what we count in our measures of progress, and because the significant depreciation of the province's natural forest wealth has remained invisible in our standard accounts, potential remedial action and restorative forestry efforts have received insufficient attention in the policy arena.

Fortunately, tremendous progress has been made in recent years by the World Bank, the United Nations, the World Commission on Forests and Sustainable Development, the World Resources Institute, and many others, in developing methods to monitor the health of forests as natural capital assets providing a full range of critical services to society. In fact, the excellent criteria and indicators developed by the Canadian Council of Forest Ministers for the sustainable development of Canada's forests provide the framework for the GPI forest accounts.

The following sections summarize a few preliminary results from the GPI forest accounts, as examples of data that can provide useful information for policy makers and benchmarks for progress in the future. Statistics come primarily from the National Forestry Database and D.N.R. Forest Inventories As we enter the new millennium, these measures can help us protect and enhance our natural forest wealth for the benefit of our children and future generations of Nova Scotians.

Valuing Non-Market Services of Forests

Money is clearly a poor tool for assessing the non-timber values of forests. In an ideal world, qualitative environmental assessments, time use, and other non-market indicators would be considered in their own right in every major policy decision. In reality, however, market statistics and financial structures, such as prices, taxes and monetary incentives, continue to provide the primary cues for the actual behaviour of businesses, consumers and government. As Dr. Andrew Harvey, of the Economics Department at St. Mary's University, remarked, "If it doesn't have a price, it doesn't get attention".

For this reason, and in order to communicate with the world of conventional economics, the GPI does attempt, wherever possible, to assess the economic value of social and environmental assets by imputing market values to services provided by our stock of human, social and environmental capital. Where this is impossible, qualitative valuations are given.

The imputation of market values should not, therefore, be seen as an end in itself, or as a way of reducing profound human, social and environmental values to monetary terms. Rather, it is a necessary and hopefully temporary step to overcome the predominant tendency to undervalue the services provided by our natural resources, unpaid labour, and other "free" assets, to make their contribution to prosperity clearly visible, and to bring them more fully into the policy arena.

There is another reason to impute market values to non-market ecological services and that is to demonstrate the actual linkages and connections between non-market and market factors that do exist. In reality, the depletion of a natural resource, currently invisible in the economic accounts, *will* eventually produce an actual loss of value and jobs in the market economy, as we learned with the collapse of the ground fishery. The ability of healthy forests to protect watersheds, soil quality and habitat directly affects prices, costs and economic values of drinking water, freshwater fisheries, timber productivity, the eco-tourism market, and more. The ability of forests to sequester atmospheric carbon affects economic cost-benefit analyses of alternative greenhouse gas reduction strategies.

In that regard, the GPI effort to assign explicit economic values to non-market functions can be seen as a small step towards "full cost accounting," so that investment decisions and prices might eventually include full social and environmental costs and benefits. Too often, at present, apparently attractive short-term investments are made that carry hidden

long-term costs, like pollution clean-up, that will be paid for by future generations. The GPI method can therefore help to include a more complete range of benefits and costs in the consideration of alternative investment options, and in this way to send more accurate signals to policy-makers and the public alike.

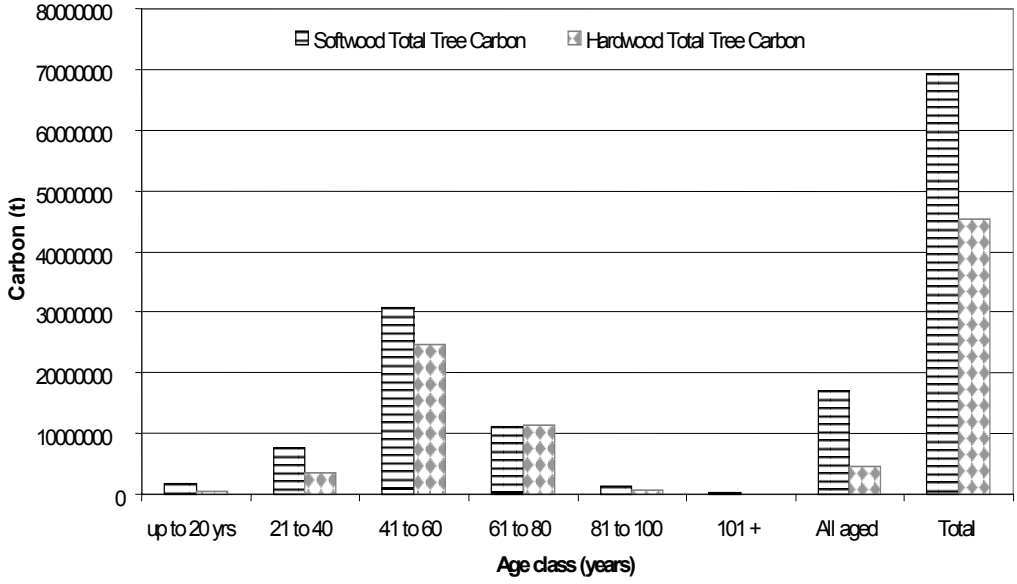
In a world where "everything has its price", monetizing environmental variables actually assigns them greater value in practice, and provides a more accurate measure of their contribution to prosperity, than excluding them from our central wealth accounts and assigning them an arbitrary value of "zero". Our forests are an actual form of "wealth" and, so long as wealth is primarily measured in market terms, the translation effort is required.

Following are a few examples of economic valuations of non-timber forest values that will appear in the GPI forest account:

a) Carbon Sequestration

As concern about global climate change grows, there is increasing appreciation of the vital role forests play in absorbing atmospheric carbon dioxide. Studies show that older forests store larger quantities of carbon than younger ones. Thus even though trees over 80 years old comprise less than 1% of total forest area in Nova Scotia, these trees store as much carbon as the 20% of forest area covered by young trees less than 20 years old (Figure 1).

Figure 1: 1999 Provincial Total Tree Carbon (tonnes) for Softwood and Hardwood Cover Types



Sources: Age class data from the NSDNR 1999 GIS Forest Inventory

This carbon sequestration function has tremendous economic value at a time when Canada has committed itself, under the Kyoto agreement, to a substantial reduction in greenhouse gas emissions. Using conservative and widely accepted monetary values for damage and remediation costs of carbon emissions (US$20 per tonne), the GPI forest account finds that the carbon sink value of Nova Scotia forests, and their older trees in particular, exceeds the total annual contribution of forestry and logging to the GDP. Full references and description of economic valuation methods are given in the complete report.

b) Watershed Protection

Forests provide valuable watershed services that are invisible in the conventional economic accounts. They control soil erosion, prevent sedimentation of streams and coastal waters, maintain stream habitat and microclimate, and maintain and regulate water supply and flows (Myers, 1997). Conversely, deforestation of upland catchments can seriously disrupt natural water systems, increasing water supply costs and erosion, and reducing the value of fisheries. These economic values and costs have been estimated in several studies.

One example used in the GPI forest account is the recent acquisition by New York City of a forest watershed area for the city's water supply. Purchase and restoration of the integrity of that watershed will save the city US$9 billion over 10 years, compared with alternative water filtration costs, for a benefit of $21,718 per ha. (Parlange, 1999). From these and other studies, we have derived an economic value of Nova Scotia forests in protecting the province's watersheds and water supply.

c) Protection of Habitat and Biodiversity

Forest wildlife provides vital ecological services that have significant economic value, including pollination, seed dispersal, nutrient cycling, and protection from pests (Decker and Goff, 1987). Multi-species, multi-aged forests with significant hardwood content have been shown to increase the diversity and populations of birds and parasitoids that are natural predators of the spruce budworm (Su et.al., 1996; Crawford et.al., 1983). In such healthy forests, balsam fir defoliation due to budworm infestation has been substantially less than in even-aged softwood forests with lower proportions of hardwood forest type habitats. The economic value of these savings can be calculated.

The GPI forest account notes that nature tourism is the fastest growing sector of the province's booming tourism industry which, in 1998, yielded revenues of $1.1 billion, 33,000 direct and indirect jobs, and $179 million in tax revenues. A major nature tourism survey conducted for the N.S. Department of Economic Development and Tourism in 1997 found that parks and protected areas rated very highly in importance, that respondents mentioned walking, hiking and wildlife viewing as activities of choice and

that the market increasingly favoured tourism packages that respected the environment. The report concluded that natural settings were critical for the development of the burgeoning nature tourism industry. To assess this economic value for Nova Scotia forests, the GPI report refers to estimates by the Wildlife Advisory Council of the amount actually spent on wildlife-related pursuits.

d) Other Non-Timber Economic Values

Robert Costanza and an international team of scientists have estimated the replacement value of a variety of temperate forest functions, including climate regulation, soil formation, control of erosion, waste treatment, biological control, and food production (Costanza et.al, 1997). Extrapolating from these calculations, the GPI forest account estimates the total economic flow value of services provided by Nova Scotia forests at over $1.2 billion dollars annually, or nearly 15 times the annual contribution to the GDP of timber alone (Table 1).

Table 1: Valuation of Nova Scotia's Forests (1999 Forest area data)

Ecosystem Service	Monetary Value (1994 US$ ha^{-1} yr^{-1})	Total Flow Value for Nova Scotia (1994 US$ yr^{-1} x total forest[2])
Climate regulation	$88	$372,378,160
Soil formation	$10	$42,315,700
Waste treatment	$87	$368,146,590
Biological control	$4	$16,926,280
Food production	$50	$211,578,500
Raw materials	$25	$105,789,250
Recreation	$36	$152,336,520
Cultural	$2	$8,463,140
Total	$302	$1,277,934,140

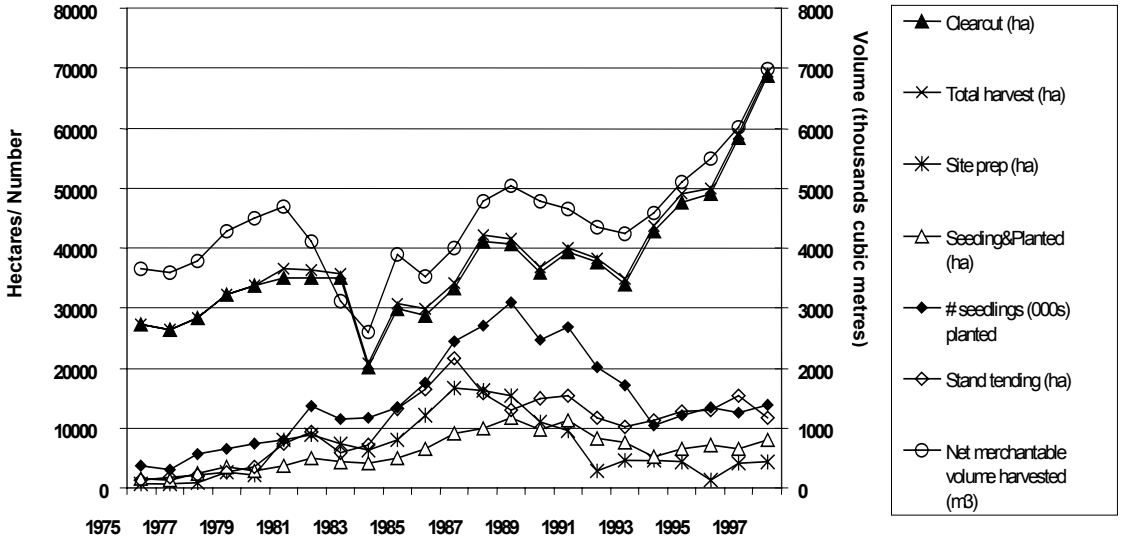
Timber Values: Harvest and Employment Levels

The GPI forest account does not neglect the timber values of Nova Scotia forests, and assesses these in relation to the full range of forest values. The concern is not to make a sharp distinction between timber and non-timber values, but rather to examine the compatibility of timber harvest practices with the preservation and enhancement of the wider range of forest values. The integration of ecological values into the GPI forest accounts reveals quite clearly that their maintenance actually serves to enhance timber productivity and values over time.

[2] Total provincial forest is 4,231,570 ha . This data is from the February 1999 DNR GIS Forest Inventory

What does the historical Nova Scotia evidence reveal? Conventional wisdom, based on use of the GDP as a measure of progress, holds that economic growth creates jobs. However the last 10 years have seen a 24% decline in employment in forest industries even as harvest volumes have increased dramatically. Between 1992 and 1997 in particular, the annual area clearcut doubled from 35,000 ha. to almost 70,000 ha. Partly due to the loss of federal silviculture subsidies, the number of seedlings planted and other silviculture inputs have declined considerably since peaking in 1988 (Figures 2, 3 and 4).

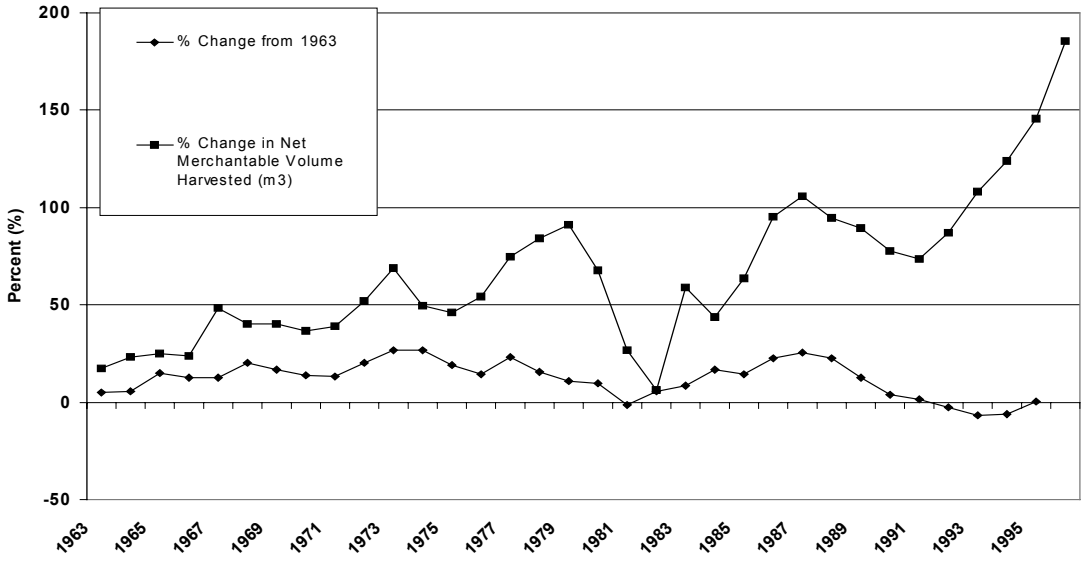
Figure 2: Provincial Area (hectares) of Clearcut Harvest and Silvicultural Activities in Nova Scotia 1975 - 1996



Source: National Forestry Database

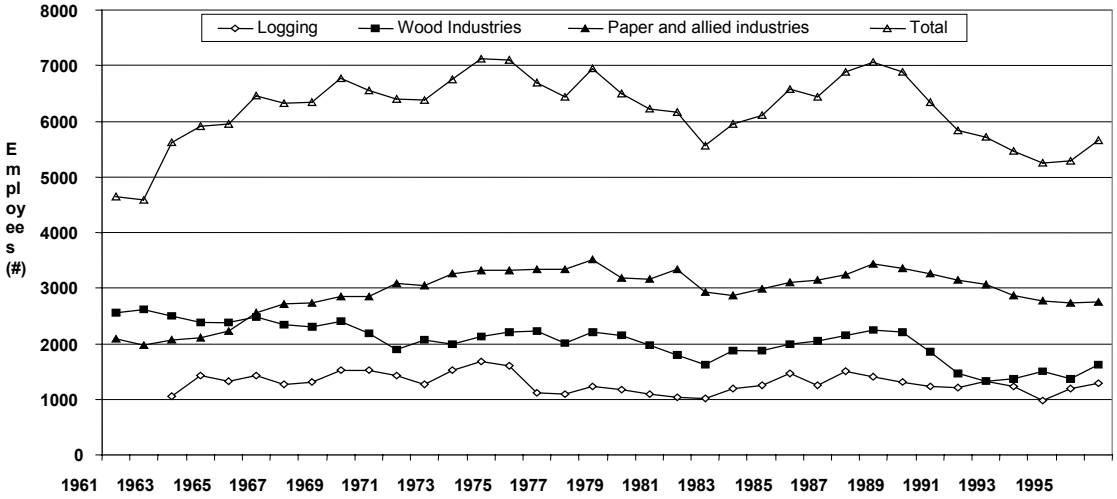
These trends raise serious questions about the sustainability of current harvesting practices. The harvest and employment statistics indicate an increasingly mechanized forest industry with insufficient value-added industries. From the GPI perspective, increasing the number of jobs per unit of resource biomass harvested, through encouragement of value-added industry, is a key to sustainable forestry practices and sustainable local economies.

Figure 3: Percent Change in Number Employed in Forest Industries and Net Merchantable Timber Harvested 1963 to 1997, in comparison to 1963 levels



Sources : Statistics Canada Cat. No. 25-202, National Forestry Database

Figure 4: Number of People Employed by Forest Industries in Nova Scotia 1961-1996



Loss of Species and Age Diversity

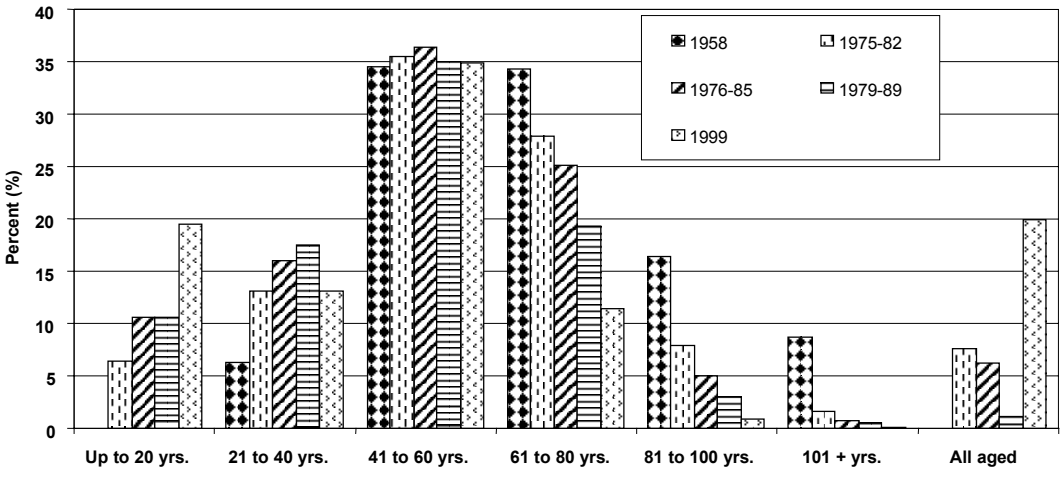
Beyond these simple quantitative statistics, which are also reflected in the conventional economic accounts, the Genuine Progress Index is particularly concerned with qualitative

valuations. For example, the major qualitative differences between multi-aged, multi-species natural forests (i.e. forest gaps foster tree regeneration) and many of the province's even-aged plantations and even-aged naturally regenerated forests (i.e. clear-cutting methods and abandoned old fields convert the forest to even-aged system) are not reflected in the simple quantitative harvesting and regeneration statistics. But Nova Scotia forests today bear little resemblance to those that were originally here, and the changes have major implications for sustainability.

As early as 1912, the first provincial forest survey found that the province's forests had been seriously depleted, and recommended restoration efforts to ensure a healthy, high quality supply for the future. The second forest survey in 1958 noted that the province had lost most of its primary forest, increased the land area covered with non-commercial, low-value species, and suffered greater insect damages than historically. In 1980, the Department of Lands and Forests reported that only 2% of the forest areas cutover were regenerating to tolerant hardwoods. Oak and beech have shown particularly dramatic declines in the last 10 years. Today, less than 1% of old growth forest remains in the province.

By 1958, when the first reliable age-class inventory was taken, older age-class forests were already in serious decline. But in 1958, 59.4% of the forest area was still covered by forests over 60 years in age, and 25.1% was covered by forests over 80 years old. Today only 12.5% of forest area is classified by age classes over 60 years old, and only 2% by forest over 80 years old. In 1958, 8.7% of the forest areas was still covered by trees over 100 years old. Today, these have almost completely disappeared (Figure 5).

Figure 5: Provincial Forest Area by Age Class,Percentage of Total Forest Area 1958 to 1999



Sources: The Forest Resources of Nova Scotia, 1958; DNR Information Report: Nova Scotia Forest Inventory Provincial Summary 1975-1982, 1976-1985, 1979-1989 ; and , DNR GIS February 1999 Inventory Data

What are the economic implications of this loss in species and age diversity? As noted above, studies have found that spruce and balsam fir losses to spruce budworm infestation are significantly less when more hardwoods are present. A New Brunswick study found that balsam fir stands with less than a 40% hardwood component sustained an average of 58%-71% defoliation, whereas stands with greater than 80% hardwood suffered only 12-15% defoliation. The study concluded that mixed balsam fir – hardwood forest stands with greater than 40% hardwoods present could substantially reduce losses during budworm outbreaks (Su et.al., 1996). It is likely that reduced hardwood content and increased even-aged management in Nova Scotia forests have diminished the diversity and population of birds and parasitoids that are natural predators of the spruce budworm and increased susceptibility to infestation and defoliation. From the GPI perspective, this loss in diversity represents a loss in economic value that may manifest directly in increased future costs.

There is also strong evidence that unsustainable harvesting practices and reduced age and species diversity increase the rate of soil erosion. A healthy forest canopy breaks the impact of rain on the soil. When rainwater is captured by leaves, branches and tree trunks, the flow of water to the forest floor, soil and streams is substantially slowed. Myers (1997) found that an undisturbed tropical forest intercepts an average of 35% of rainfall, whereas a logged forest intercepts less than 20%, and a plantation only 12%. Efforts are under way to determine corresponding values for temperate forests. Myers determined that the price of water from a catchment with undisturbed forest doubles after a forest is logged and increases four-fold after uncontrolled logging (i.e. without modifications for riparian zones and adequate protection of stream crossings when building roads).

Hornbeck et. al. (1993) found that intermediate cuttings, thinnings, and herbicide applications doubled the time period in which substantial water flow increases, due to reductions in transpiration and canopy interception, followed forest clearing. Consequent soil erosion negatively impacts future productivity and also carries high potential economic costs.

We have already noted that older trees store substantially more carbon than younger ones. The dramatic loss of older trees in the last 40 years has therefore significantly reduced the carbon storage value of Nova Scotia forests. Habitat and biological diversity loss also has serious implications for the eco-tourism industry. In sum, from the GPI perspective, the loss of age and species diversity, invisible in the conventional economic accounts, and of only minor significance in current assessments of forest sustainability, actually carries major economic costs for the full range of forest values, and has substantially reduced the overall value of Nova Scotia's forests. This represents an actual loss of natural wealth that will continue to impact future generations unless remedial action is taken.

Restoring the Wealth

The GPI forest accounts are designed as a practical, policy-relevant tool that can enhance sustainability and restore the province's natural forest wealth. To that end, the last section of the GPI report recommends concrete policy instruments that can encourage sustainable harvesting practices. It examines existing models of best practices that can maintain the full range of inter-dependent market and non-market forest values. It is clearly demonstrated that by protecting the range of ecological services provided by forests, timber productivity is enhanced, timber market value is increased, jobs are maintained, the nature tourism industry is strengthened, and forest-dependent communities are protected. Above all, future generations will benefit from the restoration of the province's natural wealth.

The GPI Soils and Agriculture Account

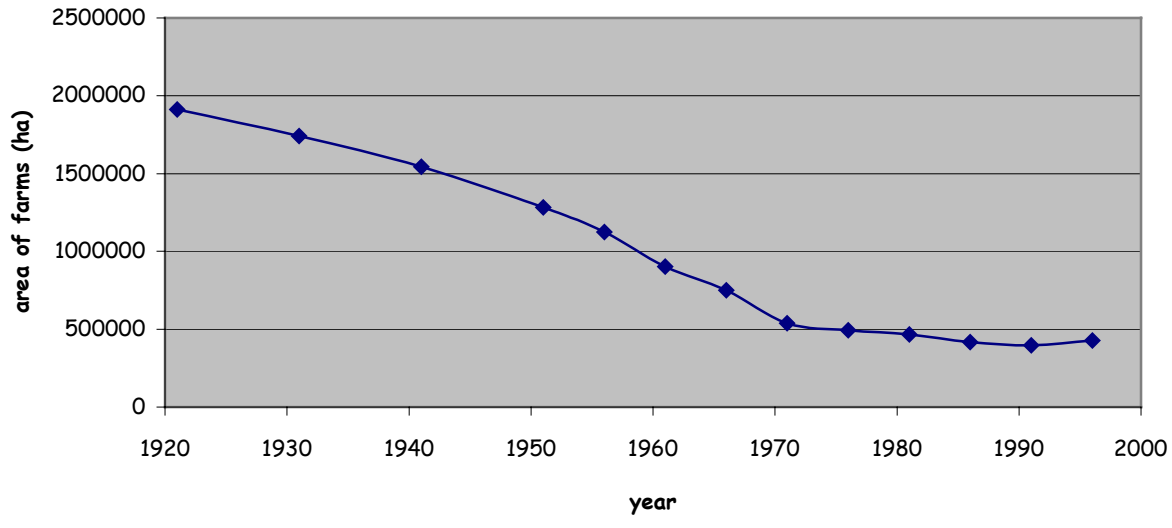
Jennifer Scott, M.E.S.

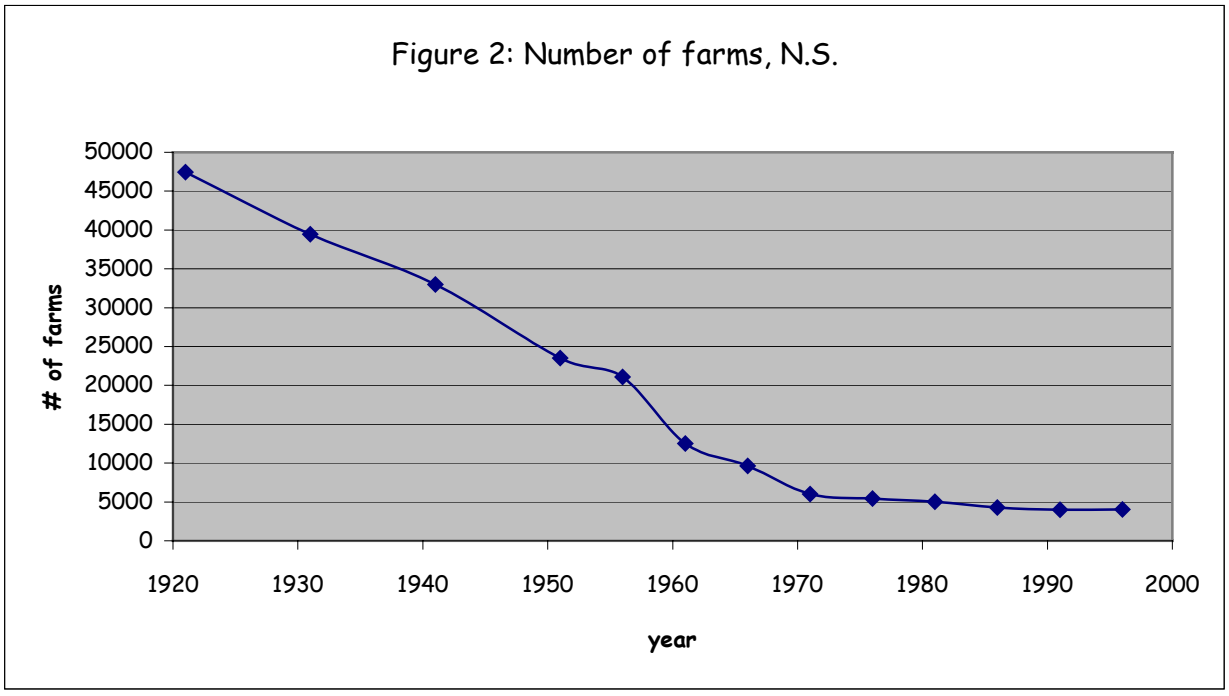
The GPI Soils and Agriculture Account examines a wide range of resource, ecological, social, and economic indicators to assess the sustainability of farming practices in the province. The current crisis faced by Nova Scotia farmers after three years of drought, and a projected $50 million in losses for 1999 alone, makes this work particularly timely, and raises important questions about the political commitment necessary to sustain a viable agricultural sector in the province.

The area of farmland in the province has declined by more than 50% in the last 40 years, and the number of farms has fallen by two-thirds (Figures 1 and 2). There are now less than 4,000 farms left in Nova Scotia, and the Nova Scotia Federation of Agriculture predicts an even more rapid decline following the losses of the last three years. The growing shortage of people willing to take up farming has also made it more difficult to maintain related infrastructure and businesses, which in turn makes it harder for remaining farmers to operate economically.

Still, Nova Scotia farm cash receipts amount to $380 million a year, and agriculture is estimated to provide 16,000 direct jobs and 50,000 indirect jobs for Nova Scotians (Nova Scotia Federation of Agriculture). An integrated set of resource accounts can help provide important information on how this vital economic sector can be viably sustained.

Figure 1: Area of farms (ha) NS





N.S. Agriculture Sector Assets

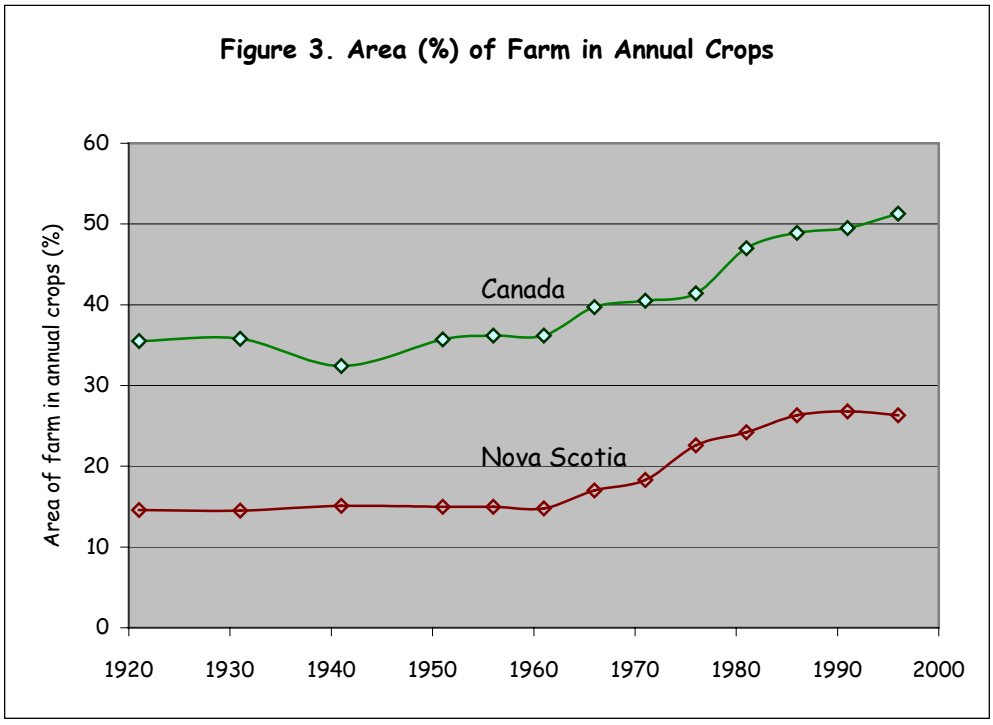
Despite the current farm crisis, there are a number of vital assets that provide a sound basis for a viable and sustainable agriculture sector in Nova Scotia.

- Unlike other agricultural regions of the country like the Prairies, Nova Scotia has a diversified agricultural sector with local, national and international sales, and less dependence on a few potentially volatile export markets. This diversification also has ecological benefits.

- Although some prime agricultural land has been lost to urban encroachment, as reflected in Figure 1 above, Environment Canada estimates that up to 30% of class 2,3 and 4 land in the region is available but not currently being used for farming.

- Nova Scotia farms are not characterized by "horizon-to-horizon" annual crops. Although the per farm area of annual crops is increasing, most Nova Scotia farmland is still in pasture, woodland or other permanent cover, a considerable ecological advantage over other parts of Canada with a higher percentage of farmland in crops (Figure 3).

- Nova Scotia has a highly educated farm population, with surveys indicating a high commitment to good land stewardship, hard work and personal investment, and enjoyment of farming itself. The agriculture sector's "people resource" may be its strongest asset.



Ecological and Resource Indicators

As the forest and fisheries accounts above clearly demonstrate, a healthy resource base is the essential prerequisite for a sustainable and viable economic sector based on that resource. The GPI soils and agriculture accounts develop indicators of sustainable resource use that include the quality and productivity of soils, crops, livestock, and genetic resources, and the impact of agriculture on water quality, environmental quality, and on waste production and recovery. One example will be given here for illustration purposes.

Just as forests provide non-market services with substantial economic value that also affect timber values, so do soils provide a range of vital services that ultimately determine agricultural output. A key indicator of soil quality and thus of "genuine progress" in agriculture, is the maintenance of optimal levels of organic matter in the soil "bank account." Organic matter is the dead and decaying plant and animal material that gives soil its spongy texture and provides a range of economically valuable services.

It holds water in the soil in dry years and allows it to drain in wet years; it helps prevent soil erosion and reduces soil compaction; it breaks down gradually to provide nutrients for plant growth, and is rebuilt with additions of plant residues and manure; it acts as a filter, cleaning air and water; and it exchanges gases with the atmosphere thereby regulating the climate. It is the productive capital of agriculture, subject to appreciation and depreciation.

The appreciation and depreciation of soil quality is currently hidden in the conventional economic accounts and in market statistics, providing few warning signals of impending problems. But substantial resource depreciation over time may significantly increase input costs; reduce agricultural productivity, quality and output; and undermine the long-term sustainability and viability of the economic sector.

Unfortunately, studies indicate that the organic-matter content of Eastern Canada soils has fallen by 30-40% since the 1960's alone. Over the longer term, Agriculture Canada researchers note that "more than 200 years of agriculture in the Atlantic Provinces has resulted in serious soil degradation in some areas of intense row-cropping, seen in the loss of organic matter and fertility, structural degradation, compaction, and erosion."

In 1985, Agriculture Canada estimated the on-farm costs of soil degradation in Nova Scotia at about $11.5 million per year, or $2,685 per farm (20% of average net farm income at the time). Off-farm costs of soil degradation through run-off, sedimentation, and other losses of soil materials, nutrients and pesticides from agricultural lands were estimated at $46 per hectare of conventionally produced row-crops.

Paradoxically, fertilizer use to compensate for soil degradation currently shows up in the GDP as a contribution to economic growth and prosperity, because the GDP simply sums all goods and services exchanged for money. This current accounting mechanism sends misleading signals to policy makers, economists and farmers alike, and blunts incentives for remedial action. By contrast, such losses are counted in the GPI balance sheet as costs rather than gains, and soil degradation are registered as natural capital depreciation.

Economic and Social Indicators

The GPI soils and agriculture accounts also consider farm investment, debt, equity, income and expenses, and market access as indicators of economic viability and sustainability. Social indicators include employment stability, livelihood security, community resilience, health, equity (farm and income distribution, ownership concentration), and knowledge base.

For example, of the $2 billion Nova Scotians spend every year on food, only 2.5% ends up as net income to farmers. Farm margins (the difference between income and expenses) are so narrow for many farmers that even small increases in input prices like feed, fertilizer or machinery, drops in commodity prices, or unpredictable weather like that of the last three years, can threaten farm survival and livelihood. Average net farm income in Nova Scotia ranges from $12,000 to $14,000 per year, and many farmers depend on off-farm job income to keep their farms going. The data contained in the GPI accounts should provide a range of useful information that can assist policy makers in strengthening the economic and social stability of the farm sector.

Restoring the Wealth

The GPI natural resource accounts are not intended as an academic exercise, but as a practical, policy-relevant tool that can improve the well being of Nova Scotians. As such all the resource accounts conclude with specific policy recommendations – for businesses, government, and ordinary citizens – that flow from the assessments of natural capital wealth. Because the conventional market statistics have concealed vital trends in the resource sectors and failed to value our natural wealth, long-term capital depreciation and depletion have undermined sustainability in all three renewable resource sectors.

The good news is that the damage is not yet irreversible, and that measures can be taken to restore the wealth and improve the viability of all renewable resource-based economic sectors. One practical example is given here that demonstrates a win-win strategy capable of improving soil quality, reducing waste, saving input costs, and enhancing long-term productivity and output quality. Recognizing the interdependent linkages between ecological, social and economic sustainability, the GPI recommendations will focus on such strategies that can strengthen our resource base and invest in our natural capital while remaining cognizant of economic realities.

Too often, investments in sustainable harvesting practices are presented as economic trade-offs that are so prohibitive as to prevent farmers' participation. Public demands for environmental stewardship, prevention of soil erosion, protection against nutrient leaching, reduction of pesticide residues and unpleasant smells frequently clash with the extremely narrow margins and low farm incomes already described. By integrating ecological and social variables into the economic accounts, and by recognizing the economic value of investments in natural capital, the GPI can help overcome some traditional barriers to resource protection. The following example provides an illustration.

As shown above, the depletion of soil organic matter can increase farmers' fertilizer input costs, which may temporarily compensate for symptoms of reduced productivity, but may actually exacerbate the underlying problem in the first place. Instead, a variety of long-term and comparison studies have found that soil organic matter can be improved or even *built up* from original levels by two very simple farming methods – growing long-term perennial hay/pasture (forage), and adding manure from livestock that are fed the forage.

For most common soil types in Nova Scotia, growing perennial forage is estimated to increase soil organic matter by 50% from baseline levels over the long term. One research study found that a red clover and timothy forage combination added three tonnes of carbon (organic matter) per hectare per year to the soil.

In addition, long-term studies (lasting 15 years or more) in eastern Canada have found that crop yields are maintained or improved with additions of manure, while they are gradually reduced with additions of synthetic fertilizer. Comparison studies have found that soil organic matter content is higher for manured treatments than for synthetically fertilized ones.

When the two methods are combined and forage is rotated with row crops, manure/forage fertilized row crops have yielded significant long-term advantages over conventional synthetic fertilized systems without forage rotation. Soil fertility is significantly higher, soil carbon (organic matter) is six times higher with manure additions than synthetically fertilized systems, and a significant amount of synthetic fertilizer leaches into groundwater.

What are the economic implications of these findings? Atlantic Canada livestock produces $52.4 million worth of nutrients in its manure every year. This is often treated as a "waste product" and costs are incurred to dispose of it. In addition environmental damage costs are incurred because there is frequently an insufficient land base to dispose of manure properly, and neighbours complain of pungent smells. While this valuable resource is often wasted, Atlantic Canada farmers spend $51 million annually in fertilizers, though much of the nutrient content of these fertilizers is wasted. Nitrogen recovery rates in crops generally range from 30-60% (Table 1).

Table 1: Nitrogen fertilizer recovery levels in relation to application rate

N rate (kg N/ha)	N recovery level (% of N used)
50	83%
100	70%
125	57%
150	49%
200	39%

The long-term benefits of composted manure use are considerable, increasing soil quality and long-term nutrient balance, increasing the ability of soils to withstand stress such as drought and waterlogging, reducing crop losses due to compaction, and improving conditions for legumes which get free nitrogen from the air. The composting process can also reduce fly problems, and use up other waste products such as sawdust or wood shavings. Forage based systems have also been found to require a 50% reduction in energy use, producing further savings, and reducing carbon dioxide emissions accordingly. Each of these functions has an economic value that must be explicitly recognized in our agricultural accounting systems.

From the GPI perspective, there is an additional significant long-term economic benefit in increasing soil organic matter. Besides improving soil quality, soil organic matter acts as a significant carbon sink, removing carbon dioxide from the atmosphere. As noted, the GPI forest account uses a widely accepted value of US$20 per tonne of carbon removed from the atmosphere, though other estimates based on potential climate change damage costs have assigned values as high as $330 and $530 for each tonne of carbon sequestered (equivalent to 21c – 35c per litre of gasoline not burned).[3] Beyond their impact on the agriculture sector, therefore, increases in soil organic matter carry economic benefits to society at large. Conversely, society also pays for declines in soil quality through filled in

[3] Discussion of alternative valuation methods, with full references, is contained in the complete report.

ditches, reduced stream or coastal water quality, and other costs described in the complete report.

Since soil quality improvements also enhance farm viability, some of these costs, savings, and economic benefits have a direct impact on farm livelihood and security. For this reason, restoring natural capital wealth through methods like application of composted manure and rotation of annual crops with perennial forage (hay/pasture) can be very appealing to farmers.

An Ontario study found that growing row crops continuously cost, on average, $150 more per hectare per year in fertilizer costs after 10 years than in the first year. The same comparison study found that organic farms using hay and pasture rotations received one-fifth the subsidies of conventional farms but ended up with over three times the net income, partly due to premium market prices paid for organic products.

That growing demand for organic products presents a potential niche market for Nova Scotia farmers that can repay the transition investment in a relatively short period, while providing a range of other benefits, as demonstrated above. It is an area where targeted government assistance can make investments in sustainability viable for farmers, while reversing the long-term soil quality decline described above and restoring the province's natural wealth.

This example illustrates the potential for the GPI soils and agriculture accounts to demonstrate essential linkages among social, economic, and environmental variables that can assist policy makers in protecting and enhancing the province's natural resources for the benefit of future generations.

The GPI Greenhouse Gas Account

Larry Hughes, Ph.D, Sally Walker, Ph.D, Ronald Colman, Ph.D,
Julia Sable, Jonathan Kay

Introduction

It is understood today that the combustion of fossil fuels produces greenhouse gases, such as carbon dioxide, which may be contributing to climate change.

Many coastal regions, including parts of Nova Scotia, will be particularly vulnerable to some of the predicted effects of climate change, notably sea-level rise. A rise of less than a metre could severely disrupt the lives of many people living in low-lying communities along the Atlantic coast, the Bras d'Or Lakes and the Bay of Fundy.

In December 1997 at the Third Conference of the Parties (COP 3) to the United Nations Framework Convention on Climate Change (UNFCCC) in Kyoto, Japan, the Canadian Federal government agreed that by 2008-2012, greenhouse gas emissions would be reduced to 6 per cent below 1990 levels.

Despite the growing burden of evidence that human induced climate change is under way, the Canadian government has yet to ratify the treaty. Previous Canadian governments have also pledged to meet greenhouse gas reduction targets that have not been attained.

Given the potentially disruptive effects of climate change, GPI Atlantic is now developing a greenhouse gas account that will:

- First, consider the potential effects of climate change on Nova Scotia.
- Second, monitor Nova Scotia's greenhouse gas emissions and establish benchmarks to produce an annual 'report card' showing those sectors of the economy that are improving and those where improvements can be made.
- Third, consider the technological and social changes necessary to permit Nova Scotia either to adapt to or mitigate the effects of climate change.

Unlike the GDP, which always sends the message that "more is better", the GPI recognizes that less pollution and less greenhouse gas emissions are a more accurate indicator of prosperity, well-being, economic sustainability, and "genuine progress", than increased costs or emissions. The GPI goes up when pollution and greenhouse gas emissions decrease. Cost-benefit analysis, as used in the GPI, therefore corresponds far more closely to common-sense perceptions of well-being than a current accounting system like the GDP that simply counts all expenditures as economic benefits.

Potential Effects of Climate Change on Nova Scotia

Global climate change models are not yet regarded as good predictors of particular regional impacts. Nevertheless, the proposed GPI study draws on the best available expert assessments, including Environment Canada's 1997 analysis, *Climate Change and Climate Variability in Atlantic Canada*, to indicate potential impacts of global warming on Nova Scotia. In accord with the aim of the GPI project as a whole, emphasis is placed on possible socioeconomic effects.

At present, it is not scientifically possible to link particular local events with climate change. However, intense floods this summer in Antigonish and in Oxford, Nova Scotia, most recently causing $3 million in damage to roads in Cumberland County alone, may possibly be a sign of things to come, since extreme weather events are predicted to increase with global warming. Similarly, in light of IPCC (Intergovernmental Panel on Climate Change) predictions of an increase in the frequency and intensity of droughts world-wide, it would not be prudent to dismiss the possibility that the three straight years of drought experienced by Nova Scotia farmers may be linked to global warming. Nova Scotia farm losses in 1999 are already $35 million, and are expected to reach $50 million before the end of the year.

The insurance industry has expressed particular concern over the economic costs of climate change, particularly due to an increase in extreme weather events, and is therefore also a source for the GPI study. According to the World Disasters Report, natural disasters were more damaging in 1998 than any other year on record, causing $90 billion of damage worldwide. The Institute for Catastrophic Loss Reduction (ICLR) in Canada has identified hurricanes, erosion, and storm surges as the major climate change concerns for Nova Scotia, resulting in potential coastal flooding, sewer backup, and flooding at the municipal level. Indeed, 13 large insurance companies have already joined to create a new Risk Prediction Initiative, and the ICLR has teamed up with other organizations in a Natural Hazard Risk Assessment Committee to assess potential regional risks due to climate change.

Lower rates of precipitation and milder winters, predicted by climate change models, have already made an impact on the agricultural sector in the province and the Nova Scotia Federation of Agriculture newsletter recently warned that climate change may already be a reality for Nova Scotia farmers. Three of the last five seasons in Atlantic Canada have been the hottest on record, and the other two were the second and fourth warmest ever recorded. The spring of 1999, the warmest on record, was 2.8 degrees above normal, and summer rainfall in the Annapolis Valley was less than half the seasonal average.

Again, it must be emphasized that these floods, heat waves, and drought years may well be natural aberrations. But the precautionary principle, adopted by Nova Scotia in its Environment Act, insists that possible warning signs be taken seriously and that action to forestall potentially catastrophic climate change effects not be delayed.

The proposed GPI study will review existing evidence to assess potential impacts of climate change in Nova Scotia in a number of areas, including:

- ***Temperature and Precipitation:*** Aside from the drought conditions discussed above, there has been a decrease in snow cover in the Atlantic region since 1971, and many rivers are at all-time low levels.
- ***Extreme Weather***. Of greatest concern for Nova Scotia is possible increased hurricane and cyclone activity. Hurricanes have proven among the costliest natural disasters, both to human life and property, and evacuation costs alone have been estimated at $660,000 per mile of coastline in the United States. Since Nova Scotians are also Canadian taxpayers and pay insurance premiums to national insurance companies, they share the economic burden of extreme weather events elsewhere in the country. The Quebec ice storm alone cost $1.5 billion; and government insurers in Canada paid over $2.8 billion in 1998 for claims due to natural disasters. An increase in extreme weather events due to global warming, predicted by the IPCC, will increase premiums and damage costs.
- ***Nova Scotia Coastal Zone***. Low-lying regions around Yarmouth, the Bay of Fundy, and Halifax Harbour have been identified as particularly vulnerable to a combination of sea level rise, higher tides and changes in storm intensity and frequency. The Tantramar Marshes, the Truro flood plain, and sections of the southern and eastern shores are also susceptible to flooding, erosion, or increased coastal instability. Saltwater infiltration of groundwater, threats to communication links, and overtopping of dykes due to storm surges are also predicted in some areas. The construction of new dykes and the raising of existing ones will be costly.
- ***Fisheries***. Climate change is expected to impact the distribution of fish species, migration patterns, arrival times, recruitment success, and growth rates, through physiological effects, and changes in disease, food availability and predator abundance. Paradoxically, global warming is predicted to produce colder, denser, less saline water off Nova Scotia in the long run as Arctic ice caps melt, possibly altering the course of the Gulf Stream, and reducing the population of certain fish species. The GPI fisheries research notes that extremely limited knowledge of ocean response, fish life-cycles, and environmental influences on fish, prohibits definitive predictions of the effects of climate change on the fisheries. The importance of the fisheries both to the Nova Scotia economy and to the viability of coastal communities makes further research in this area imperative.
- ***Agriculture***. Global warming could increase some crop yields, weeds, and pest populations. Higher carbon dioxide levels will help fertilize plants and weeds, and milder winters will allow pests currently eliminated by the cold to survive. Pests of particular concern to Nova Scotia if winters become milder are the gypsy moth, the cereal-leaf beetle, and the tarnish plant bug. Drier weather would increase the need for irrigation, a costly enterprise. The 1998 drought cost between $30 and $50 million in lost crops and livestock, and 1999 farm losses are expected to reach $50 million by year end. A range of estimates for Canada as a whole predicts a decrease in agricultural value of between 0.04% to 0.2% of national GDP annually in the event that atmospheric carbon dioxide concentrations double during the next century as predicted. For Nova Scotia this would mean an annual loss of $5.3 to $26.4 million, less than actual losses incurred by farmers in the last two years.

- ***Ecosystems and Water Resources***. Other studies have summarized potential impacts of an intensified hydrological cycle on Nova Scotia, as predicted by climate change models. Predicted costs include falling lake and groundwater levels, lower levels of dissolved oxygen in rivers and lakes, stresses on freshwater fish populations, and runoff damage to human infrastructure, including dams, bridges and water supply. Predicted benefits include a major reduction in river ice jams. Wetlands, bird migrations patterns, and wildlife habitat are all highly sensitive to climate change.
- ***Forestry***. The IPCC predicts that global warming will increase forest fire losses by 140% globally, with $1.8 billion of annual damages to OECD countries alone. Environment Canada predicts that the Canadian forest industry will suffer, as new northern forest ranges will not mature fast enough to compensate for predicted southern range declines. Soil organic matter, an important carbon dioxide sink, will also decompose faster as temperatures rise, decreasing the carbon sink value of forests and releasing carbon into the atmosphere. Forest productivity in Atlantic Canada is expected to increase by 15-16% under current climate change models, but fire, insect and disease outbreaks are also expected to increase.
- ***Tourism.*** Nova Scotia's billion dollar tourism industry is based, in part, upon Nova Scotia's natural beauty and its relationship to the ocean. The loss of coastline or other features that attract tourists will have a considerable impact upon the tourist industry.

The GPI greenhouse gas study will also consider the predicted climate change impacts on air pollution, energy, and human health in Nova Scotia and on Nova Scotians. This includes an expected increase in vector-borne diseases, air pollutants, and water-borne diseases, with respiratory problems and allergies likely to become more severe.

The cost of climate change to Nova Scotians will not be limited to its impact on Nova Scotia. Climate change is expected to produce up to 150 million environmental refugees world-wide by 2050, forced from their homes by sea-level rise, soil degradation, flooding, erosion, and drought. Just as events such as Kosovo and East Timor produce costs for Canadian taxpayers, so disaster relief, refugees and other overseas impacts of climate change will produce costs here.

Nova Scotia's Contribution to Climate Change

This section of the proposed GPI study, assessing provincial emission trends by sector, is the basis for establishing actual benchmarks of progress for the greenhouse gas component. These benchmarks are set in relation to three standards, beginning with the most relative:

- Any improvement will be gauged by an annual decrease in greenhouse gas emissions from previous years (a decline in emissions makes the GPI go up, and an increase makes it go down).
- Progress will also be assessed in relation to Canada's commitment under the Kyoto Protocol to reduce emissions to 6% below 1990 levels in the period 2008-2012. This translates into a decrease of 13.9% from 1995 levels.

- Even the Kyoto standards will not prevent an increase in atmospheric greenhouse gas concentrations nor turn back global warming trends. An "absolute" or long-term standard of sustainability must therefore be related to the global capacity of forests, soils and oceans to absorb three to four billion tons of carbon annually, about half the current emissions.

Some sample data follow. On a per capita basis, Canadians, including Nova Scotians, are among the highest emitters of greenhouse gases in the world. In 1995, Nova Scotia greenhouse gas emissions were 18,600 kilotonnes of carbon dioxide equivalents, fairly stable since 1990, when emissions were 18,800 kilotonnes. Recent data suggest that emissions are on the rise again. Nova Scotia emissions are currently 19 tonnes per capita, compared to 21 tonnes per capita nationally. Thirty percent of provincial emissions come from mobile sources.

The GPI study will summarize emission trends in various sectors of the Nova Scotian economy. For example, the decline in coal mining has helped reduce provincial emissions, while the popularity of light duty trucks and minivans has increased emissions in the transportation sector. Light duty trucks have a 40% lower fuel efficiency than automobiles, and have almost doubled their market share over the last 15 years. Energy consumption in the residential sector declined significantly until 1996, at which point it began to rise again. Vehicles currently account for about 45% of household greenhouse gas emissions, and space heating for 33%.

Industrial and agricultural sector emissions in Nova Scotia are to be examined in some detail in the GPI study, and tables and graphs will indicate the sectors with significant increases and decreases in emissions over time. The analysis of sectoral trends is important in order identify cost-effective strategies for emission reductions.

Technological and Social Changes

The final section of the GPI greenhouse gas account will look to the future, considering strategies for reducing Nova Scotia greenhouse gas emissions in different sectors, including transportation; agriculture and forestry; and industry. The study also summarizes actions that can be taken within the home, including those recommended by organizations such as Nova Scotia Power. "Best practices" from other jurisdictions will also be examined for their applicability to Nova Scotia and successful strategies noted within the province.

The potential for modal shifts in the transportation sector that can reduce greenhouse gas emissions are discussed in detail, mainly because transportation accounts for such a high proportion of greenhouse gas emissions in the province. Examples from other jurisdictions described in this section include the creation of high occupancy vehicle lanes, van and carpooling, telecommuting, integrated land use-transportation planning, increasing public transit ridership, the cashing out of parking subsidies, and road pricing strategies to reduce automobile use.

This part of the study will also compare the costs of adaptation to climate change to those of possible mitigation. If Nova Scotians and the rest of the world are unable to moderate their energy demands, adaptation strategies will be necessary. These costs will be

compared with the costs of mitigation, reducing our energy demands and creating a sustainable future.

Although Nova Scotia's overall contribution to global climate change is small, a concerted effort on the part of Nova Scotians to reduce their greenhouse gas emissions based upon the GPI recommendations could well attract international interest. If the provincial government can establish such an environment, it is possible that representatives from other jurisdictions will come to Nova Scotia to study the model developed here. This could, in turn, foster the development of industries producing environmentally friendly technologies, creating jobs that at the same time further the stewardship of the environment on which the human economy ultimately depends.