Investment in Natural Capital by the Federal Government in Canada

by

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I. INTRODUCTION

Concerns about the potential economic effects of global warming, the accelerating rate of environmental degradation in many parts of the world, and greater awareness of the inter-generational effects of economic activity have stimulated research on the concept and measurement of natural capital. This research has led to the realization that while policies directed at the protection of the environment are urgently needed, the development of such policies is hampered by the lack of consistent, comprehensive and reliable data. As pointed out by the National Roundtable on the Environment and the Economy [NRTEE 2003, 2.1] "the national-level macroeconomic indicators currently in use to judge a society's success provide only part of the information needed: they exclude many of the factors on which we depend for continued development as a society, particularly the services provided by a clean environment and by our education system."

The NRTEE [2003, Executive Summary, 2] tried to fill this information gap be developing a set of indicators of natural capital "that would track some of the additional factors that are of importance to Canadians." The NRTEE also recommended an expanded System of National Accounts that would incorporate these new indicators, and more comprehensive and more reliable information on the environment. Efforts in this area are being made by many agencies. For example, several Canadian provinces are developing provincial indicators of environmental quality and sustainable development and a number of federal departments – such as Environment Canada, Natural Resources Canada, and Agriculture and Agri-food Canada - have been working on the development of selective indicators of environmental quality and sustainable development.

One of the areas where information is not only scarce, but partly misleading is that of public investment. Under current practices, only government spending on construction and machinery and equipment is treated as public investment. All other government spending, including spending on environmental quality and on education and skills development, is treated as current consumption. The same narrow definition of investment applies to the private sector where, for example, building a garage is treated as investment while spending on in-house training of workers is treated as consumption. Such a narrow concept of capital cannot be justified in an economic system where growth is driven by human capital, an asset that is inextricably embedded in human beings, where the functioning of markets and the level of living standards are affected by the quality of civic institutions and by the informal networks that facilitate social cohesion [Helliwell 2000], and where the sustainability of human progress rests on our collective capacity and will to protect the environment from the damaging effects of human activity. If future prosperity depends on the stock of productive assets that we bequeath to future generations, we need to measure the stock of these resources accurately in order to develop policies that support sustainable development. Moreover, with respect to natural capital, if we track the health of the environment through selective indicators, we should also track government investment on environmental protection in order to determine the direction and effectiveness of environmental policy.

A new approach to the measurement of public investment in natural capital is presented in this paper, which is part of a larger project aimed at estimating government investment in physical, natural, human, civic and social capital. A distinguishing feature of this approach is the use of criteria that are consistent with the main characteristics of physical

capital, thus maintaining consistency in the measurement of different types of capital. This approach is developed through several steps. The first step (Section II) identifies the main elements of various definitions of natural capital found in the literature and the most common approaches to its measurement. The second step (Section III) identifies the main characteristics of physical capital and selects the criteria for determining which government expenditures may be treated as investment in natural capital. The third step (Section IV) applies those criteria to identify the elements of natural capital. The fourth step (Section V) explains the specific methodology used in the calculation and the last step (Section VI) applies this methodology to the information found in the Public Accounts of Canada for fiscal year 2004-05 to measure the level of federal investment in natural capital. The final section provides some concluding comments.

II. THE CONCEPT AND MEASUREMENT OF NATURAL CAPITAL

This section contains a brief survey of the literature on the concept and measurement of natural capital. It serves as a background to the development of a new approach to the measurement of investment in natural capital which is consistent with the criteria that will be derived from the main properties of physical capital.

Definitions

The concept of natural capital as a component of economic and environmental theory is a recent one. Nonetheless, one can find a long list of definitions in the literature on environmental theory and policy. These definitions contain sufficient differences to allow a breakdown into several categories. Table 1 shows the main elements of seventeen definitions separated into four groups. In this table, instead of reproducing the full

definitions, I separated the main elements on the basis of how the definitions address the following two questions: (a) what are the major components of natural capital, and (b) what is the function of natural capital?

We notice in Table 1 that, as we move from the first to the last group, the number of components of natural capital increases and its function capital expands far beyond the provision of material inputs into the production function. Group A contains two narrow definitions which focus on the stock of natural resources as an extension of the economic concept of capital. The five definitions in Group B expand the components of natural capital to include also environmental or ecosystem services, but maintain a strict connection between natural capital and the production of goods and services. The four definitions in group C acknowledge that natural capital involves both quantity and quality and recognize that the benefits extend beyond the traditional economic ones and include direct utility "through aesthetic and spiritual appreciation of nature." Group D, which contains six definitions, explicitly acknowledges that natural capital "supports life" and "is essential for our survival".

Table 1. Components and Functions of Natural Capital: Selected References.

Author and Year	Components	Functions
Group A		
World Bank [2004]	- stock of natural resources used in production; - renewable and non-renewable.	production.
European Environment Agency [2006]	- environmental goods and services. - extension of the economic notion of capital.	production of goods and services.
Group B		
Costanza, Daly and Bartholomew [1991]	- soil and atmospheric structure; - plants, animals, biomass, etc.	production of ecosystem services, natural resources flow.
Berkes and Folkie [1991]	- non-renewable resources; - renewable resources; - environmental services, maintenance of the quality of the ecosystem.	not specified.
Prugh, Costanza, Cumberland, Daly, Gooland, Norgaard [1995]	- a stock of resources that produces a flow of goods and services.	production of goods and services.
United Nations [1997]	- natural resource stocks; - land; - ecosystems.	provides inputs for economic production.
Hackett [2001]	-stock of resources - living systems; - ecosystem services.	not specified.
Group C		
Pearce [1988]	-supply of natural resource inputs; - a means of assimilating waste from production; - a source of direct human welfare.	serves economic functions.
Gilpin [2000]	- stock of environmentally provided assets; - ecosystems.	provide flow of goods and services, including ecological and spiritual values.
Lantz [2005]	- minerals, plants, animals.	produces oxygen and water, soil, land quality and other services.
Conservation Economy [2006]	- the core and crust of the earth; - the biosphere; - the upper layer of the atmosphere.	provides a wide variety of ecosystem services, including beauty and play.

Group D		
Hawken, Lovins Lovins [1999]	- the sum total of the ecological systems that sustain life.	sustaining life.
NRTEE [2003]	- natural resources; - land; - ecosystems.	- provides materials and services; - is essential for survival.
The Living Planet [2004]	- stock of natural assets.	- resource production; - waste assimilation; - life support.
Olewiler [2004]	- stock of natural resources; - environmental resources; - ecosystem resources; - land.	- input into the production of goods and services; - enjoyment; - essential to sustained health and survival.
Anielsky, Wilson [2005]	- resources; - living systems; - ecosystem services.	supports life.
Government of Canada [2006]	- natural resources; - land - ecosystems.	is essential to sustaining all forms of life.

Table 1 offers the following insights into the scope of natural capital, according to the referenced literature.

First, no distinction is made between renewable and non-renewable resources. Both are treated as a stock of natural capital. The defining criterion in this choice is that both types of resources produce a flow of goods and services.

Second, natural capital includes both tangible assets (renewable and non-renewable resources and land) and intangible assets (environmental or ecosystem services).

Third, natural capital includes intangible "linkages", what some definitions call "living systems." This component suggests that certain "networks" that connect the components of the ecosystem may be treated as capital.

Fourth, natural capital is an input into both market and non-market activity, but it also produces direct utility to individuals.

Finally, as pointed out explicitly in a few definitions, natural capital is unique in the sense that it not only helps produce goods and services and delivers direct utility to individuals, but is essential for the "sustained health and survival" of all forms of life.

In my view, the fundamental shortcoming of these definitions is the absence of a consistent conceptual framework that would provide the required foundation for the treatment of these tangible and intangible assets as "capital." Even when attempts are made to establish conceptual linkages with physical capital, the full extent of the potential linkages is not exploited and one is left with the impression of dealing with ad hoc approaches.

Measurement

Attempts at quantifying the stock of natural capital are fairly recent. In economic theory, the production of goods and services is generally modeled as a function of physical capital (with or without embodied technological change), labour (with or without embodied human capital) and technological change. Natural capital, in the form of land and natural resources, is treated as given. The rapid and non-inflationary growth of the early post-war period supported a view that natural resources did not impose constraints on the continuation of that trend. This view was challenged in 1972 by a group of researchers known as The Club of Rome. Their report, called *The Limits to Growth,* presented the results of simulations derived from a world model designed to evaluate the effects of five major trends: accelerating industrialization, rapid population growth, widespread malnutrition, depletion of non-renewable resources, and a deteriorating environment. Their main findings are that:

1. *if the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth in this planet will be reached sometimes within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity;*

2. it is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his individual human potential.

The authors' general conclusion was that "*on the basis of the present knowledge of the physical constraints of the planet... the growth phase cannot continue for another one hundred years....because of the delays in the system, if the global society waits until those constraints are unmistakably apparent, it will have waited too long.*"

More recently, warnings of the disastrous effects of human activity, this time confined to the specific phenomenon of global warming, were contained in another highly publicized report prepared by Sir Nicholas Stern. This report estimates that "*our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of this century.*" The author estimates that we need to invest one percent of global GDP if we want to avoid these disastrous effects in the future.

Both reports have received negative responses from economists. *The Limits to Growth* was criticized as a Malthusian study which failed to take into account market responses to changes in relative prices as supply constraints begin to appear. *The Stern Review on the Economics of Climate Change* has been challenged on several fronts: (a) the factors that determine changes in the climate system and the channels through which they are translated into economic effects are so complex that they cannot be captured accurately by any model, (b) it uses a near-zero discount rate, and (c) it underestimates the costs of mitigating climate change.

Concerns about the potentially significant long-term economic effects of the over-exploitation of certain natural resources and of the rising trend of environmental degradation have stimulated interest in the measurement of natural capital. A brief survey of the issues associated with the measurement of natural capital is presented in the rest of this section.

A major methodological issue is whether natural capital should be measured in physical or monetary units. The fundamental problem with deriving dollar estimates of the stock of natural capital is that some of its components generate benefits that cannot be valued directly because there is no market exchange. A standing forest is a good example of this situation. It produces lumber, which can be easily valued. But it also serves as a carbon sink, a shelter for wildlife, an erosion control mechanism, and a source of recreation, all services that cannot be directly measured. Researchers have tried to overcome these limitations by developing indirect evaluation methods. The most popular indirect evaluations are:

1. *Contingent Valuation.* This approach uses survey methods to measure natural capital by determining the population's willingness to pay for environmental services or to accept environmental degradation.

2. *Hedonic Pricing.* This is a valuation technique derived from econometric analysis which treats the value of natural capital as an embedded component of the price of a marketable real asset.

3. *Travel Cost Method.* This approach is often used to estimate the value of recreation services, especially when no admission fee is charged. With this approach, the value of a given site is derived from the travel expenses incurred over a given period.

4. *Dose-Response Method.* This technique measures the effect of changes in natural capital on productivity or human well-being. For example, a decrease in the ecosystem's ability to assimilate waste may be partly measured by air quality, which, in turn, affects the incidence of respiratory illnesses, thus increasing health-related absenteeism and reducing labour productivity.

These approaches to the measurement of natural capital raise a number of issues. First, they are indirect measures suitable primarily for environmental services for which a market evaluation is not feasible. Therefore, they serve as a supplement to the measures of tangible natural capital. Second, the required information is largely collected through special surveys, a requirement that makes them an expensive technique. Third, they are most suited to derive estimates for specific areas or regions. The results from one region may be extended to another region with similar characteristics through a technique called 'benefit transfers'. Even when two or more sites are very similar, evaluations using benefit transfers still will involve subjective judgments.

Indirect estimates are not needed in the case of tangible natural resources that have a market valuation. However, as mentioned earlier in the example of a forest, even tangible natural capital may generate a variety of benefits, some of which do not have market prices. If we focus primarily on estimates based on direct market valuations, we may end up underestimating the value of natural capital, a situation that may lead to poor public policy choices. At the political level, this problem was emphasized in 2001 by Paul Martin when he stated that "because we lack the proper measuring tools, we too often fail to take full account of natural capital in the decisions and choices we make."

The complexities encountered in measuring the stock of natural capital have prompted some researchers to identify suitable criteria for such measurement. A detailed approach, which identifies the steps required for the monetary valuation of ecosystem services has been suggested by Kumar [2005]. He starts by separating the valuation of ecosystem services into two categories, namely, use value and non-use value. Use value, in turn, is divided into a direct and an indirect component. While direct valuation has the advantage of market transactions with attached prices, indirect valuation must often rely on special surveys. Non-use values can also be separated into two components: option value and preservation value. The former refers to the value determined by allowing future generations the 'option' of using a particular component of natural capital. The later refers to the value determined on what would be paid to prevent a given component of natural capital to be depleted or degraded for future generations. Kumar notes that the process of evaluation natural capital involves two steps. The first step requires the identification of the component of natural capital being evaluated. The second step involves the evaluation. In this respect, Kumar developed the following list of what to do and what to

avoid when evaluating natural capital: (a) use net not gross benefits, (b) include opportunity cost, (c) do not use replacement costs, (d) do not use benefit transfers, (e) do not extrapolate the results from finite changes, (f) watch for double-counting, (g) do not include global benefits when the analysis is local, (h) avoid spurious precision, and (i) double check your results.

While acknowledging the difficulties encountered in developing reliable estimates of even selected components of natural capital, researchers are pressing for the creation of a comprehensive accounting system for natural capital and have started to produce detailed studies in this area. A study on the ecological value of the boreal forest in Canada was recently prepared by the Pembina Institute [2005] for the Canadian Boreal Initiative. This study is important because the boreal region covers approximately 59 percent of Canada's land mass. According to this study, the net market value of natural capital extraction in the boreal forest - from logging, mining, oil and gas extraction and hydroelectric generation - is $37.8 billion after deducting associated costs such as government subsidies and the human health costs from the air pollution generated by these activities. In contrast, the annual non-market value of this forest amounts to $93.2 billion, allocated as follows: $77.0 billion for flood control and water filtering of peat-lands, $5.4 billion for pest control services by birds, $4.5 billion for nature-related activities, $3.4 billion for flood control, water filtering, and biodiversity value by non-peat-land wetlands, $1.85 billion for carbon sequestration; $575 million in subsistence value for aboriginal people; $79 million in non-timber forest products, and $18 million for watershed services. In addition, the total value of the 67 billion tons of carbon stored in the trees and peat-lands in Canada's boreal forest is valued at $3.7 trillion.

The notion that the value of natural capital may be very large, when properly valued to include both market and non-market valuations, has also been stressed by Olewiler (2004). She developed estimates of natural capital for the Lower Fraser Valley of British Columbia and the Grand River Watershed in Ontario. Her research shows that the valuation of natural capital includes (a) the value of products and services from wetlands, (b) consumer spending on nature-related activities, (c) the value of goods and services from Canadian forests, and (d) the value of the products of agricultural lands.

Concerned about the potential subjectivity in the estimates of the value of the stock of natural capital, some researchers have suggested as an alternative the use of selected indicators that track changes in the stock of natural capital over time without the need for estimating its values. Following a study by Smith, Simard and Sharpe [2001], who suggested the development of a set of separate indicators to measure the different components of natural capital, the National Roundtable on the Environment and the Economy (NRTEE) produced a report entitled *Environmental and Sustainable Development Indicators for Canada [2003].* In this report, the NRTEE proposed five indicators to track movements over time of key components of natural capital. These indicators act as warning devices to alert policymakers of potential risks that would compromise the quantity or quality of the stock of natural resources. These indicators track the changes in (a) air quality, (b) freshwater quality, (c) greenhouse gas emissions, (d) forest cover, and (e) the extent of wetlands. They address major concerns about the effects of changes in ecosystems on the economy and essential supports for life, but focus on what capital does rather than what capital is:

1. *Air Quality Indicator.* This indicator tracks only the level of ground-level ozone. It measures the "average daily eight-hour maximum ozone exposure for the population of an area" (p.4.2.2). The air quality indicator focuses on the maintenance of clean air, a service provided by natural capital which is essential for sustaining life on earth and for reducing the incidence of respiratory and cardiovascular diseases.

2. *Freshwater Quality Indicator.* The purpose of this indicator is to provide a "national measure of the overall state of water quality as measured against objectives related to major water use in Canada" (p. 4.3.1). This is an important indicator because water is an essential element for life in general and serves a variety of uses, such as drinking, washing, recreational use, supporting fish populations, and irrigation.

3. *Greenhouse Gas Emissions.* This indicator will "track Canada's total annual emissions of greenhouse gases" (p. 4.4.1) by measuring the changes over time in the volume of the following gases: (a) carbon dioxide, (b) methane, (c) nitrous oxide, (d) hydro fluorocarbons, (e) perfluorocarbons, and (f) sulphur hexafluoride. The importance of this indicator can hardly be overstated, as can be attested by the increasing concerns for the economic effects of global warming.

4. *Forest Cover Indicator.* This indicator has the objective of tracking "changes in the extent of Canada's forests," (p. 4.5.1) by monitoring the changes in the spread of forest cover for areas that have a 'crown closure' greater than 10 percent. Crown closure is a forest condition where the crowns of trees touch and effectively block sunlight from reaching the forest floor. The rationale for this indicator is the fact that forests serve a variety of vital functions. In addition to providing raw material for industrial purposes, forests play important ecological and recreational roles.

5. *Extent of Wetlands Indicator.* The objective of this indicator is "to measure the overall size of wetlands in Canada and the subsequent change in the extent of these wetlands over time" (p. 4.6.1). The state of wetlands is included in the list of indicators of natural capital because they are considered to be an excellent proxy for the overall health of the ecosystem. Wetlands serve as an important habitat for animals and plant life. They also aid in the purification of water and are able to perform large scale carbon sequestering function. In addition, wetlands help in the prevention of flooding and soil erosion, thus reducing potentially costly environmental and economic damage.

This brief review indicates that developing reliable estimates of the value of the stock of natural capital is a daunting task. Fortunately, most of the issues arising in the valuation of natural capital do not apply to the calculations that will be performed in this paper for two main reasons. First, I focus on the flow of investment in natural capital and not on the value of a given stock of natural capital. Therefore, all I need is the identification of the components of natural capital and not their value to society. Second, my analysis is confined to the federal government's investment in natural capital. Since spending by the federal government in a given fiscal year by department and by selective program is known, all I need to do is identify which spending components can be reasonably allocated to natural capital. Before I move to the identification of federal programs that constitute investment in natural capital, it is necessary to select the appropriate criteria which are derived from an evaluation of the determining features of physical capital, a task that is performed in the next section.

III. THE MAIN FEATURES OF PHYSICAL CAPITAL AND THE CRITERIA FOR INVESTMENT IN NATURAL CAPITAL

Most of the definitions of natural capital reviewed in the previous section seem to have been developed independently of those of physical capital. Some of them even highlight a fundamental difference between physical and natural capital: the former is reproduced by human activity while the latter is not. Even those definitions that are explicitly treated as an extension of the concept of physical capital limit this link to the fact that both types of capital produce a flow of goods and services over time. In my analysis, consistency with the properties of physical capital is a necessary condition for any asset to be treated as capital. This condition is not imposed in order to derive a new definition of natural capital for general use, but is required to ensure comparability in the measurement of government investment in various forms of capital. This paper is part of a broader project that aims at the development of a new classification of government expenditures that separates consumption from investment in physical, natural, human, civic and social capital. Within this framework, methodological consistency is essential and can be achieved by developing criteria based on the properties of physical capital, a form of capital which is grounded in extensive theoretical and methodological research.

The determination of what constitutes investment in natural capital in this section is carried out in two steps. The first step highlights the special features of physical capital while the second step develops a set of criteria for determining which government expenditures can be treated as investment in natural capital.

The Defining Features of Physical Capital

The fundamental building block of the new approach to the measurement of public

investment is a conceptual framework based on physical capital that can serve as a common foundation for all types of capital. To develop this framework I started by asking the following questions: What are its defining features? What are its uses? How is it measured? Which of these aspects of physical capital should be used as criteria for the other types of capital? The information used below in addressing these issues is based on Statistics Canada's publications related to the national Income and Expenditure Accounts.

Defining Features. Four major features define the nature of physical capital. The first feature is that physical capital is a **reproducible** asset which is willfully man-made. It may be produced by a machine, but is willed into existence by economic agents and is produced by using other capital inputs, materials, and labour services. The second feature is that physical capital may be either a **tangible or an intangible asset**. In the National Accounts, spending on physical capital is called fixed investment. Until recently, investment in fixed capital was confined to spending on tangible items such as buildings and equipment. In 2001 this approach was revised when spending on computer software was added to the list investment on fixed capital A third feature of capital goods is their **survivability**. Unlike materials that become incorporated into the final product, capital goods are used in the production process but are not consumed in the process, although their capacity to produce and their value may depreciate over time. They are instrumental in the production of a good, but remain separate from it. A closely related feature is **durability**. Since they are not destroyed in the production process, capital assets can be used repeatedly over an extended period of time.

Uses. Physical capital is acquired by firms for the purpose of producing other goods and services which generate a flow of income for them. That's why physical capital is defined as a factor of production. Its use in the production of goods and services, however, is an intermediate step in the often complex process of creating utility for consumers. Consumers can obtain utility directly or indirectly. Direct utility is obtained from leisure. An example is the enjoyment of a beautiful panorama on a clear day. Indirectly, utility is obtained through the consumption of goods and services. These two forms of acquiring utility sometimes are linked because even the enjoyment of direct utility from leisure often requires the use of goods and services. For example, the site that allows the view of the beautiful panorama may be naturally inaccessible. If a road is built, the site becomes accessible through an investment (the road) which adds to the stock of physical capital. Transportation services then can help facilitate the enjoyment of this particular leisure activity. Thus, while leisure provides the time to enjoy the panorama, the investment in physical capital, which makes the site accessible through the use of transportation services, permits the acquisition of the utility from the viewing.

Whatever the source of utility for the consumer may be, the ultimate purpose of the production and use of physical capital is the generation of utility to consumers. This statement highlights the human foundations of any type of capital. Physical capital as portrayed in economics textbooks appears as a particular object that operates in an impersonal production process where its human connection is limited to the workers that operate it. In fact, both its existence and its uses are dependent on human decisions. Physical capital exists because business owners (human beings acting as economic agents) find it profitable to buy or lease it. It is used to produce goods and services which

are demanded by consumers (also human beings acting as economic agents) because they receive utility from their consumption or use. This human foundation is critical in determining which types of government spending can be treated as investment.

In theory, the distinction between the sources of direct and indirect utility may be used as criteria for distinguishing between investment and consumption. Capital assets generate indirect utility by helping produce goods and services demanded by consumers. In turn, These goods and services, as well as leisure, generate direct utility to the consumers. In practice this distinction is not clear cut in the conventions used in the National Accounts, as will be discussed in more details in the next subsection. For example, a stand alone refrigerator in a residential home is treated as a durable consumer good while a refrigeration unit built into the same house is treated as investment. Yet both units generate the same flow of "refrigeration" services to the homeowner. These special conventions used in the definition and measurement of physical capital must also be taken into consideration in the determination of what constitutes investment in other types of capital.

Measurement

Two separate aspects of the measurement of physical capital may be identified. The first is the list of items included in the definition of capital. The second is the manner in which these items are valued.

What Is Included in Physical Capital. Investment in fixed capital includes three major categories: **residential construction, non-residential construction, and machinery and equipment.** The latter, in turn, includes both tangible and intangible assets (the purchase of computer software). Investment generally refers to the purchase of capital goods by business and government. In the case of residential construction, purchases by individuals

are also treated as business investment by considering the individual as a firm that purchases the asset and rents the housing services to himself/herself as a consumer.

Non-residential construction includes "industrial, commercial and institutional building and engineering works such as roads, dams, transmission lines, oil well drilling and mine development." **Residential construction** includes new housing construction, which is subdivided into "single dwellings, semi-detached dwellings, row housing, apartments, plus cottages, conversions, and mobile homes." For both types of construction, investment in structures is not limited to new construction but includes also "conversions resulting in a structural change and major renovations (together referred to as alterations and improvements)." It is important to note that what determines the investment classification of these alterations and improvements is not an improvement in their function (a change that would increase their productivity), but the structural nature and extent of the change (major versus minor renovations).

Investment in **machinery and equipment** refers to "capital expenditures on durable, tangible goods with an expected service life of one year or more, such as furniture, motor vehicles, office machines and equipment not permanently installed." The above definition of machinery and equipment makes it clear that the classification of a certain item as a consumer good or a capital good is not determined by the nature of the reproduced good, but by the purpose of its use. For example, an automobile purchased by an individual is treated as a durable consumer good because it provides transportation services directly to the owner and is not used in the production of other goods and services. The same automobile purchased by a business is treated as a capital good because it is used to produce other services (it is a factor of production) that are sold to consumers.

Two items in the machinery and equipment category are of particular significance for the identification of other types of capital. They are computers and software. The former is a physical asset while the latter is an intangible asset. Although they are measured separately in the National Accounts, in practice they cannot be used separately as factors of production. Without software, a computer is a useless box. Without hardware, software is inoperable.

Government fixed investment includes all three components mentioned above. Residential construction, such as the construction of a university dormitory, is a very small component of government fixed investment. The largest component is non-residential construction, which includes "schools and hospitals, plus construction of highways, bridges, railway tracks, canals, waterworks, sewage systems, dams, hydro or thermal generating plants, telephone lines, oil and gas facilities, etc." The third component is investment in machinery and equipment and includes "furniture, agricultural machinery, industrial machinery, office machines, automobiles, trucks, other transportation equipment, other machinery and equipment."

Valuation. The manner in which investment in physical capital is valued is crucial in determining which portion of government spending may be treated as investment and which portion as consumption. In that respect, it is important to emphasize the following items:

1. For all expenditures identified as fixed investment in the National Accounts, what is recorded is their selling price, which includes all costs of production and distribution including normal profits (under conditions of perfect competition) and additional profits in the presence of market power. For example, in the case of a company that produces only computers, most of its expenditures would be treated as current spending but the

price of the computer would include all labour compensation, including employees' benefits and management perks, all costs of materials and utilities, and even the costs of snow removal in the winter and landscaping in the summer.

2. Looking at specific components, investment in both residential and non-residential construction includes the costs of site preparation, real estate commissions, and "all capitalized costs such as architectural, legal and engineering fees, capitalized interest and own-account work by firms employing their own labour force." In the case of machinery and equipment, the value of investment includes also "installation and delivery cost."

3. The price of a capital good incorporates costs that are not necessarily related to its function or performance. For example, while site preparation and engineering services become integral components of a structure, legal and real estate expenses are related to the ownership of the structure and not to its form or use. In the case of residential construction, major renovations may include both functional and aesthetic components. While both generate utility for the owner, the latter do not provide shelter services but deliver utility directly to the user of the structure in a manner which is not different from that provided by a piece of furniture. This example highlights the fact that estimates of physical capital found in the National Accounts incorporate special conventions used primarily to facilitate measurement (it is impossible to distinguish between functional and aesthetic spending for a building). It also reminds us that we may not be able to achieve full theoretical consistency and measurement "purity" when we develop estimates of investment in other forms of capital, but we can strive to maintain consistency with the conventions used in the measurement of physical capital. However, we should strive to maintain consistency with the conventions used in the measurement of physical capital.

4. The recorded value of physical capital includes "capitalized interest charges with which capital projects are financed." This component of physical capital has implications for the way in which government loans for the acquisition of other types of capital should be treated.

5. Investment in fixed capital includes both purchases and in-house work. This inclusion is most clearly evident in the case of investment in software, which is divided into three categories: (a) prepackaged software, (b) custom software, and (c) own-account software. Their treatment is described below:

Prepackaged software is software intended for nonspecialized uses and is sold or licensed in standardized form. It typically requires little or no modification for use. It includes both systems software and applications software.... Custom software is software tailored to the specifications of a business enterprise or government unit. Expenditures for custom software include those for the development (analysis, design, and programming) of software tailored to the business enterprise's or government unit's specifications. The expenditures include payments to free-lance computer software writers and to consulting organizations and individuals, who are not employees, who perform programming and systems analysis to support development of software. It also includes expenditures on tailored software that is modified by providers of software or computerized equipment.... Own account software consists of in-house expenditures for new or significantly enhanced software created by business enterprises of government units for their own-use. These expenditures include: wages, salaries and related compensation (such as contributions to pensions and for FICA), materials and supplies consumed, and indirect costs. These indirect costs include depreciation of plant and

equipment, utilities, travel, property and other taxes, maintenance and repair of plant and equipment, and overhead - including personnel, accounting, and procurement. These expenditures are made for analysis, design, programming, and testing of software and may be made by any industry [BEA 1999, pp. 3-4].

Selection of Criteria. The above discussion on the features, uses and measurement of physical capital raises the question of how we should apply this information to determine which components of government spending may be treated as investment. Since each type of capital has specific characteristics, we need a flexible approach that uses the main elements of physical capital as a reference framework.

Starting with **the main features,** we recognize that being a tangible asset is no longer a defining characteristic of physical capital because since 2001 fixed investment includes intangible assets, namely computer software. This recent change highlights the importance of recognizing that our concepts and approaches to measurement of capital must change as economic structures evolve. As we recognize the need to incorporate more than one type of capital in the analysis of economic growth, we must also acknowledge that old concepts and definitions may no longer be useful and must be revised. This means that, as we expand the concept of capital beyond the traditional notion of tangible assets, we can maintain consistency with the revised approach to physical capital by including in the general concept of capital a variety of intangible assets. This conceptual revision must also apply to the property of reproducibility. With respect to this feature, it is important to acknowledge that what matters is that a tangible or intangible asset is reproducible regardless of the source of reproduction. In the case of physical capital, reproduction is by human means while for natural capital reproduction

can be either by human means or by natural forces. Survivability, i.e., the capacity of a capital good to be instrumental in the production of other goods and services without being used up immediately in the production process or becoming incorporated into other goods, and durability, i.e., the capacity to be used repeatedly in the production process, at least a year according to the National Accounts, are also important features of physical capital that will be used as criteria for the determination of investment in natural capital.

With respect to **the use** of physical capital, the general rule is that it is a factor of production because it contributes to the production of other goods and services which generate utility when they are purchased by consumers. This general rule, however, is not applied consistently in the measurement of investment in physical capital. The main exception is the treatment of spending on owner-occupied residences as investment. This investment includes expenditures for aesthetic features of the building, which do not deliver shelter services, but provide direct utility to the owner. Similar cases can be found in other types of construction. For example, the incorporation of a sculpture into a hospital building in order to honour a particular individual serves no health care function, but may deliver direct utility to patients and visitors. Yet, its cost is treated as part of investment in physical capital. These examples should be kept in mind in determining how to treat government spending on national parks.

The approach to **the measurement** of physical capital shows the use of conventions that are not always consistent with the underlying principles. This is particularly true in the case of equipment. Two pieces of equipment that serve the same function are treated differently depending on whether they are incorporated into a structure or not. In the former case, the cost of the equipment is treated as fixed investment while in the latter it

is treated as consumption. This dichotomy is carried through into the tax field where the built-in equipment is treated as real property, and therefore is subject to real property taxes, while the free standing equipment is treated as consumption and is free of tax. Even with these ad hoc conventions, the approach to the measurement of investment in physical capital offers a variety of benchmarks. Among the most important benchmarks is the inclusion in determining the recorded value of a capital asset of (a) services in the production of physical capital, some of which have no relationship to the function of the asset, (b) the cost of financing the production or purchase of a capital asset, and (c) major alterations and improvements, even when they do not affect the function of the capital asset in producing goods and services.

In summary, in my calculations a natural resource or an element of the ecosystem will be treated as capital when it meets the following criteria:

(a) it is either a tangible or an intangible asset,

(b) it is reproducible by man or by nature,

(c) it is not destroyed in production nor is it incorporated into a product,

(d) it can be used repeatedly over an extended period of time (at least one year), and

(e) it generates utility directly or indirectly as a factor in the production of other goods and services.

Once an asset is defined as a capital good, any direct or indirect government expenditure related to its production, sale, installation, and financing will be treated as investment.

A special issue must be addressed at this point, namely, the issue of externalities. When the government uses tax revenues to make an investment, society incurs a cost composed of the sum of the amount spent on the investment and the economic losses from the

efficiency effects of the higher taxation needed to finance that investment. Society also receives an expected return made up of the sum of the direct return and the benefits of positive externalities. If we are interested in cost-benefit analysis of a given investment to determine whether it is profitable for society to undertake the additional investment, we must consider the full costs and benefits. We must also recognize that externalities may be positive or negative. For example, it is well-known that gambling has many negative effects on families. Yet, in the National Accounts the building of a new Casino is recorded as an increase in fixed investment whether it is owned privately or by the government. Accounting for positive and negative externalities is part of the value of the investment to society not of the determination whether an expenditure is consumption or investment. This is not to say that the evaluation of externalities from government activity is a trivial exercise. On the contrary, the broader is our measurement of public investment, the larger potentially are its externalities and the more relevant is their evaluation. This exercise, however, is outside the scope of this paper which focuses on the determination of which portion of federal government spending may be treated as investment in natural capital and not on the value of this investment to society.

In estimating federal investment in natural capital, the selected criteria will be applied in a flexible manner to each item of government spending recorded in the Public Accounts. Before proceeding with the calculations, it is necessary to determine which of the components of natural capital identified in the definitions contained in table 1 meet the above criteria.

IV. A NEW APPROACH TO THE MEASUREMENT OF INVESTMENT IN NATURAL CAPITAL

In this section, the criteria developed from the features, uses and measurement of physical capital are applied to the main components of natural capital identified in the selected definitions: natural resources, air quality, water quality, land, and ecosystems.

Natural Resources. This component can be divided into two main categories: non-renewable and renewable resources. **Non-renewable** resources, which include primarily fossil fuels and minerals, represent a stock of wealth that does not meet the criteria of reproducibility, survivability and durability. Fossil fuels are mostly used to provide energy that is totally expended in the process of producing goods and services while minerals become incorporated into a variety of consumer and producer goods. Therefore, government subsidies for the exploration and exploitation of non-renewable resources will be considered as consumption. **Renewable resources** meet the criterion of reproducibility. Whether they meet the other criteria will be evaluated separately for each component.

Air and Water. These two basic natural resources, which are essential for life, present some complex conceptual challenges. They have properties of non-renewable resources in the sense that more of them cannot be produced on a large scale either by human or by natural means. But they are different than non-renewable resources because their quantity is not depleted through human activity. While their quantity is regenerated through ecological cycles, thus giving them the properties of renewable resources, we cannot invest in these resources in the general sense that we can increase their stock. What human activity influences is not the quantity but the quality of these resources. In this

respect they differ fundamentally from forests. Trees have a natural cycle of birth, growth, death and regeneration. A new seedling, however, is a separate item than the trees that provided the seeds. Air and water do not die and do not provide the seeds for their offspring. Instead, they depreciate rapidly when they are used and then regenerate through natural cycles or human intervention. The properties of air and water as natural capital are discussed separately below.

Air. In its pure form, the air we breathe is a complex mixture of gases and includes 78 percent nitrogen by Volume, 21 percent oxygen and traces of various other gases. It is the vehicle for delivering oxygen to mammals, which makes up 63 percent of a human body and without which life could not be sustained. While a person can remain alive for a certain period of time without drinking and even longer without eating, he/she could not survive without oxygen even for a few minutes. The air that one breathes is returned to the atmosphere with a high degree of depreciation, as the combustion of oxygen in the body generates carbon dioxide that is expelled when breathing out. Then it is regenerated through natural cycles facilitated by forests. How well the air performs this function depends on its quality which, in turn, is affected by human and non-human activity that produces the following pollutants: sulphur dioxide, nitrogen dioxide, ground level ozone, carbon monoxide, particulate matter and lead. In extreme conditions of pollution, air would become unbreathable and incapable of sustaining human life. Air quality meets all the criteria for a capital asset identified earlier: it is a reproducible physical asset with survivability and durability which produces the ultimate service to human beings: the possibility of human survival. While air can perform its "survival task" even when it is polluted, the consequences of its poor quality for human well-being and economic

performance are very serious. The major links between air pollutants and health outcomes are shown in Table 2.

Table 2. Link between Air Quality and Health Outcomes.

Pollutant	Health Effect
Sulphur dioxide	Worsens asthma. Wheezing, chest tightness, shortness of breath.
Nitrogen oxides	Decreased lung function. Cough, chest pain, shortness of breath. Increased hospitalization for asthma.
Carbon monoxide	Reduced capacity of the blood to carry oxygen. Reduced capacity to exercise. Reduced time to onset of angina pain. Neuro-behavioural effects.
Gound level ozone	Lung irritation and inflammation. Reduced lung function. Reduced ability to exercise. Worsens asthma and bronchitis. Increased mortality risk. Increased hospitalization for heart and lung diseases.
Particulate matter	Increased mortality risk. Reduced lung function. Worsens asthma. Increased hospitalization for heart and lung diseases.

The economic costs of polluting the air we breathe are significant. The Ontario Medical Association [2005] estimated that in 2005, asthma alone was responsible for over $500 million in health care costs in Ontario and that by 2026 health care related to asthma will cost Ontario $700 million. Health Canada has estimated that if we do not reduce gas emissions over the next 20 years, we will experience over 11 million new cases of croup and pneumonia, 10,000 new cases of children and adult bronchitis, 9,000 new hospital and emergency room admissions and over 2,000 premature deaths. Not addressing these health effects would cost an estimated $6 billion over the next twenty years. These fiscal costs are compounded by the economic costs generated by increased health-related

absenteeism and lower productivity. While such estimates may incorporate subjective evaluations, there is no disagreement among researchers that the cost to society of air pollution is significant.

The link between air quality and health outcomes is the fundamental reason why the NRTEE chose air quality as one of its five indicators of natural capital. In explaining its rationale for the choice of this indicator, the NRTEE stressed that "the proposed Air Quality Trend Indicator is a measure of an important service provided by natural capital: the provision of air that is clean and does not negatively affect human health" (p. 4.4.3.). For the purpose of measuring government investment in natural capital it is important to remember that what we call air is a specific mixture of gases which provides full support to life on earth when it is maintained free of pollutants. The flow of services that air offers day by day depends on its quality. It is its quality that represents natural capital and any expenditure directed at improving air quality is an investment in natural capital.

The Atmosphere. In addition to supplying the mixture of oxygen and nitrogen that allows human and animal survival, the atmosphere provides a cover that maintains temperatures suitable for human existence and protects us from the harmful effects of ultraviolet light. As pointed out by the NRTEE, "perhaps one of the most important types of ecosystem service is the provision of a stable climate" (p. 4.4.3). This service is particularly important for Canada, a country that, due to its northern latitudes, may experience wider temperature fluctuations than most other regions of the world. The recent debates on global warming and its potentially disastrous effects on the environment and the economy highlights the importance of maintaining a stable climate. As pointed out by the NRTEE "a recent review of potential impacts shows that such changes would have wide-ranging

implications for its economic systems, social well-being including human health, and ecological systems" (p. 4.4.3). The above discussion suggests that the quality of the atmosphere can also be considered a form of natural capital because it meets the suggested criteria in a manner similar to air quality. And its quality, in the sense of preventing global warming and its negative effects (direct plus adjustment costs) is determined by the amount of greenhouse gases in the atmosphere, which include carbon dioxide, methane, nitrous oxides, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride. Any government spending directed at reducing greenhouse gas emissions or sequestering excessive carbon in the atmosphere should be considered an investment in natural capital.

Water. Water is essential not only for human survival, but for the survival of all fauna and flora. Focusing on human survival, it may be helpful to remind ourselves that water constitutes 50 to 77 percent of a human body, depending on age and gender. Its main functions in the metabolic process are (a) to deliver oxygen and nutrients to different parts of the body and (b) to remove toxins and waste from the body. In addition, water (i) regulates body temperature through perspiration, (ii) facilitates movement by reducing friction between joints, (iii) protects organs by acting as a cushion between them, and (iv) facilitates normal body functions.

For the purpose of determining the status of water as natural capital, the evaluation carried out for air can be applied to water. As in the case of air, it is not the amount of available water that represents natural capital, but its quality. While water is essential to our very survival, extremely polluted water would kill us. Water quality is affected by two sources of pollution: point and non-point sources. The first source refers to industrial

and municipal outlets that discharge polluting materials directly into a body of water. The second source refers to activities that lead to water pollution such as run-off from agriculture, forestry, urban and industrial activities, from leaching of landfills and from aiborne pollutants that get mixed with rain and snow. Human activity contaminates water by adding harmful nutrients, heavy metal, pesticides, and a variety of toxins. Some of these contaminants may have short-term effects, but other may have effects that will be noticed after a long period and in a more serious manner. As in the case of air, it not any mixture of liquids that provides life supporting services, but clean water. As it becomes polluted, the flow of those services is impaired. Thus it is the quality of water that represents natural capital and any expenditure that improves the quality of water is an investment in natural capital. A similar conclusion may be deduced from the discussion of the Freshwater Quality Indicator proposed by the NRTEE: "clean water is a crucial ecosystem service that supports natural habitats as well as many economic activities....indeed, good water quality is important to sustain most forms of life" (p. 4.3.1). The stress in the above quotes is on "clean water" and "good water quality."

Large Bodies of Fresh Water. While freshwater is found all over the earth landmass, it tends to collect in large bodies, such as lakes and ponds, and travels through other large bodies, rivers. In these places it offers other services, the most important being waterways for transportation and recreation, and a habitat for fish. As in the case of drinking water, the capacity of water to deliver these services depends on its quality. Excessively polluted lakes and rivers cannot sustain fish and their value for recreational purposes is severely reduced and, depending on the source of pollution, eliminated altogether. Even polluted water may still be used for transportation purposes, and in that sense the body of water

itself is a natural capital. For the other services, what is of value is not the body of water but the quality of the water it contains. With respect to waterways, investment is largely measured by expenditures on harbours and similar physical capital. For the rest, I will treat as investment in natural capital the expenditures directed at improving the quality of the water in rivers and lakes.

Wetlands are special bodies of water that serve as excellent proxies for the overall health of the ecosystem. The importance of wetlands has been emphasized by the NRTEE in selecting its extent as one of the five indicators of natural capital. According to the NRTEE:

> "Wetlands are a significant type of natural capital, rich in productivity and diversity. They provide habitat, food and protection to many species. In Canada, it has been estimated that more than 600 game and non-game species, including one third of Canada's species at risk, are found in wetland ecosystems...Wetlands also provide many essential ecosystem services. The biological activities they support help filter and purify water and to store large quantities of carbon. Through the retention and release of large volumes of water, they help replenish and store groundwater, control floods and storm waters, reduce erosion and protect shorelines. As well, they indirectly support a range of economic activities such as fishing, farming and recreational activities" (p. 4.6.3).

In the case of wetlands, the flow of services they provide is affected by both their size and their quality. Therefore, any government expenditure directed at maintaining or extending the size of wetlands and improving their quality will be treated as an investment in natural capital.

Land. Land has similar characteristics to air and water in the sense that the amount of landmass is largely fixed. Like water, however, its area can change in response to meteorological conditions. For example, global warming that melted part of the arctic ice cap would expand the area covered by water and consequently shrink the land mass as rising ocean levels flood coastal areas. While the landmass may be reduced indirectly

through human activity that leads to global warming, there seem to be minimal opportunities for a man-made increase in the earth's landmass. What can be increased by human activity is the livable space associated with a given landmass through vertical rather than horizontal construction and through reclamation projects.

Land provides a variety of services, which may be divided into three groups: (a) provision of space, (b) medium for the growth of forests, and (c) soil for agricultural production. The first service refers to the land which is used for the construction of roads and buildings. It does not provide a direct benefit, but serves as the basis for the generation of services through a variety of physical investment components. In this manifestation, it generally becomes incorporated into physical capital which in turn generates goods and services. This component cannot be treated as natural capital for two reasons: (a) it is an embedded input, and (b) its value is already included in the value of the physical capital that incorporates it. In the case of forested areas, the land is inextricably linked to the overall forest habitat. Again it provides the basis for other assets which in turn produce foods and services. For this component, therefore, the natural capital resides in the assets that land supports and not the land itself. In this respect, we need to distinguish two separate components: (a) forest land and (b) agricultural land.

Forests provide a flow of a variety of economic and ecosystem services over time. As pointed out by the NRTEE in explaining its choice of Forest Cover as a natural capital indicator, "While forested lands are sometimes viewed mainly as areas of wood production, forests also provide wildlife habitat, recreational opportunities, and ecosystem services such as mechanisms to clean air and water and sequester carbon."

The trees that form a forest may be treated as natural capital only when they are alive and produce forest cover. When they are cut, they cease to generate ecosystem services and become a material input into the production of other goods. As raw material, they meet the reproducibility criterion but fail the survivability and durability criteria because they are either destroyed in the production process (wood used for heating purposes) or become incorporated into other products (paper, furniture). The forest is a component of natural capital only to the extent that it provides recreational and ecosystem services (especially the production of oxygen and the sequestration of carbon) and provides a habitat for animals and plants. Let us consider the example of a tree with respect to its function as a producer of oxygen. In this function, a tree is a piece of natural capital which produces a flow of a good, oxygen, which provides utility. The tree is reproducible naturally or through man-made efforts, and it is neither destroyed in the process of producing oxygen nor is it incorporated into the oxygen.

What represents natural capital, therefore, is not the allowable annual timber cut, or the market value of the standing timber, but the live forest, its extent and its health which, as suggested by the NRTEE, can be approximated by the forest cover. Any government spending on the expansion of the forest cover and the quality of the forest, interpreted as its ability to provide recreational and ecosystem services, therefore, should be treated as investment in natural capital. In this respect, it should be stressed that, based on the treatment of the aesthetic components of buildings as physical capital, any expenditures on parks and forested areas that increase their aesthetic value to potential visitors should also be treated as investment in natural capital. In either case we have a situation where expenditures that provide direct utility to consumers are treated as investment. It seems to

me that either we find a way of separating the functional components of construction from their aesthetic components, therefore treating the latter as consumption for both physical and natural capital or we treat spending on the aesthetic components of the environment also as investment.

Agricultural Land. In the case of the forest, the quality of the soil may not be as crucial to its growth as other factors, such as the various aspects of forest management, including thinning, periodic brush clearing, and species selection. In the case of *agricultural land,* soil quality is crucial. Agricultural land provides the basis for the production of food, either directly in the case of vegetables or indirectly through fruit trees and the production of grass fed to animals. In any case, what provides the services is not sterile land, but fertile land. It is the quality of the soil and not the soil itself that produces goods in the same manner as the skills of a worker produce goods and services and not the limbs of a body devoid of a functioning brain. Therefore, government spending on improving the quality of agricultural land is an investment in natural capital.

Quality, which is essential for agricultural land, is not important in the case of shrubland, natural grassland, marsh land and similar types of land. Although this type of land does not produce food for human consumption, it provides an important habitat for wildlife and serves other ecological functions. While it is difficult to identify direct expenditures for this type of land, it is useful to acknowledge that this land is a form of natural capital and that expenditures on the preservation of wildlife habitat should be treated as investment in natural capital.

Hydro, Solar and Wind Power. These natural sources of power have become important components of the fight against global warming. For the purpose of this paper, the relevant question is: to which extent can these sources of power be considered natural

capital? Let us start with **Hydro** power, its capacity to generate electricity and its similarities and differences with electricity generated from fossil fuels. Fossil fuels generate electricity as they release heat when they are burned, thus generating steam that spins special electricity generating turbines. In this process, the fuel burned is entirely destroyed and is no longer available for other uses. Moreover, as this fuel is burned it discharges a variety of pollutants into the atmosphere, thus degrading the quality of the air we breathe and increasing the level of greenhouse gases (both representing depreciation of natural capital). A similar but simpler process occurs in the case of hydro power as the latent energy in water drives special turbines as it falls down through appropriately designed chutes. Unlike fossil fuels, however, this water releases temporarily its latent energy but is not destroyed in the process and does not change its composition. It is still available for a variety of other uses, including drinking, irrigation and even additional electricity generation if a suitable site exists downstream. Moreover, through natural cycles, the flow of water to the electricity generating site is perpetually renewed, thus making this power a renewable resource. Finally, hydroelectric generation may be viewed as a replacement for fossil fuel generation. As such it performs the task of eliminating the air pollution and greenhouse gases that would be released by fossil fuel generation, thus enhancing two other forms of natural capital. Hydroelectric power, therefore, meets all the criteria for being treated as capital. What constitutes natural capital in this case, however, is the power that is actually converted into electricity. Investment in hydroelectric generation is largely in the form of site preparation, construction and equipment, items that are already included in fixed investment (physical capital). Functionally, however, these investments are directed at natural capital.

A similar analysis applies to **solar and wind power**. In either case we have a renewable source of energy that is harnessed through the use of suitable equipment. All three power sources are renewable resources and therefore meet the criterion of reproducibility, though by nature and not by man. They also meet the criteria of separability and durability because they are not consumed when they are harnessed. The equipment used to harness this renewable power is treated as fixed investment when it is purchased by business or government and even when it is purchased by individuals and is permanently incorporated into a structure.

The research and development expenditures by private firms in the production of solar and wind power equipment are not directly recorded as investment. However, when this equipment is sold, the associated research and development expenditures are incorporated into its selling price and thus become indirectly capital spending. Similarly, government subsidies to industry for research and development in the area of hydro, solar and wind power are not recorded as investment. Moreover, these subsidies would tend to reduce the selling price of the subsidized equipment, thus creating a negative bias on the value of private investment. This bias would be eliminated by treating these subsidies as capital spending. Direct government expenditures on research and development of solar and windpower should also be treated as investment when they do not result in the production of equipment for sale at market prices.

The application of the criteria derived from the properties of physical capital to the major components of what is generally included in the definitions of natural capital is shown in Table 3.

Table 3. The Application of Selected Criteria to Determine the Components of Natural Capital.

Component	Criteria			Utility	Is It Natural
	Reproducibility	Separability	Durability	Generation	Capacity
Non-renewables	No	No	No	Yes	No
Air Quality	Yes	Yes	Yes	Yes	Yes
Water Quality	Yes	Yes	Yes	Yes	Yes
Quality of the Atmosphere	Yes	Yes	Yes	Yes	Yes
Forest Cover	Yes	Yes	Yes	Yes	Yes
Quality of the Forest	Yes	Yes	Yes	Yes	Yes
Timber Resources	Yes	No	No	Yes	No
Size and Quality of Wetlands	Yes	Yes	Yes	Yes	Yes
Quality of Agricultural Land	Yes	Yes	Yes	Yes	Yes
Hydro, Solar and Wind Power	Yes	Yes	Yes	Yes	Yes

In my calculations I will treat as investment in natural capital and government expenditures directed at the items identified as natural capital in Table 3. Details of the allocation procedure are discussed in the next section.

V. METHODOLOGY

As mentioned earlier, this paper is part of a project aimed at measuring government investment in five types of capital: physical, natural, human, civic and social. The first two types of capital have been defined in this paper. Details on the other three types of capital are provided in the papers that evaluate them individually. For the purpose of this paper it will suffice to include general definitions. Investment in human capital includes spending on the creation, acquisition and dissemination of knowledge. Investment in civic capital includes spending on formal organizations that promote public participation

in policy development, while investment in social capital includes spending for formal and informal networks that facilitate action towards a shared goal.

In the context of a broad concept of capital, one is faced with allocation decisions due to potential overlap among the various types of capital. These decisions depend on whether the allocation of a certain amount of investment is based strictly on the structural features of a capital good or it also includes its purpose. Let us consider the following example. The government offers a conditional grant to universities for the purpose of establishing centres for environmental studies. Part of the mandate of these centres is to encourage the formation of groups of citizens devoted to environmental protection. In time, some of these groups organize themselves into advocacy organizations and are successful in obtaining funding from private and government sources to finance their organizations and some capital projects for environmental clean-up. In this process, they are also able to promote the organization of other informal groups of environmentally active people. This entire process touches on all five categories of capital. The grant for the dissemination and acquisition of knowledge by universities is an investment in human capital, the financial support for the advocacy group is an investment in civic capital, the support for the other groups of environmentally active people is an investment in social capital, the expenditures for the capital project are an investment in physical capital, and the expenditure on environmental clean-up by all these groups are an investment in natural capital. All these expenditures, however, are directed at the environment. If we base our allocation on the structural components, we will disaggregate these expenditures into the five types of capital as suggested above. If we focus entirely on the function of these expenditures, we will make a single allocation to natural capital.

In this paper I have used a compromise that combines both approaches. I distinguish between direct and associated investment in natural capital. The direct component includes only the expenditures that I have identified above as investment in natural capital. The other expenditures are listed under the heading "associated investment". The sum of the two components yields the total investment in natural capital.

My calculations are based on the budgetary expenditures of the federal government for fiscal year 2004-05 as recorded in the Public Accounts. Each Ministry or separate Agency breaks down its activities into separate areas, where each area includes a variety of programs aimed at a specified objective. For each area, total budgetary expenditures are divided into three major categories: (a) capital expenditures, (b) operating expenditures, and (c) transfers. Capital expenditures include only spending on fixed capital as defined in the National Accounts. Transfers include grants and other contributions to individuals, private sector organizations, including business and non-profit organizations, and other governments. Transfers to other governments are composed of two major parts: unconditional transfers, such as Equalization payments, and conditional transfers which usually take the form of payments under cost-shared arrangements for selected programs or projects. In my calculations, unconditional transfers are excluded because there is no specific expenditure attached to them since provinces can use these funds according to their spending priorities. Conditional transfers, on the other hand, are for specific spending programs which are clearly identified in the Public Accounts. Some of the transfers are for capital projects, therefore, they are investment in physical capital which is not recorded in the "capital" category of federal spending in the Public Accounts. In my calculations, these expenditures are added

to the portion of capital spending assigned to natural capital in measuring the "associated investment in physical capital."

The category of expenditures called "transfers" provides details on the purpose of those transfers. In some cases this information allows an unambiguous allocation. In other cases, the expenditure may involve investment in more than one type of capital, but the information is not sufficient to determine the relative shares. In these cases, the estimation of the total investment does not involve arbitrary decisions, but the allocation among different types of capital does.

The most difficult task is that of allocating operating expenses. These are Ministry or Agency expenditures, largely in the form of wages and salaries, which may involve direct investment, as in the case of internal training programs, or indirect investment as components of the costs associated with investment already identified under capital spending, but not included in value of that investment because there is not selling price. The question in that case is: which portion of operating expenses should be treated as indirect investment? This adjustment is necessary to maintain consistency with private investment for which all operating costs are included in the sale price of the capital good. The Public Accounts provide a description of the purposes of each "business line", but this information is not sufficiently detailed to allow an unequivocal allocation. To reduce the potential degree of arbitrariness, the information contained in the Public Accounts has been supplemented by information obtained from other publications, such as annual departmental or Agency Reports.

In the Public Accounts, expenditures by "business line" are presented on both a gross and a net basis, where the latter is the difference between gross expenditures and revenues

netted against expenditures. Departments and Agencies are involved both in spending and collecting revenues, separately from the general revenues collected by the Canada Revenue Agency. These revenues are largely in the form of returns on investment and the sale of goods and services. In the Public Accounts, revenues from the latter source are deducted from the gross expenditures to derive the value of net spending. Through this procedure, the activities that generate these revenues are implicitly treated as "private sector" activities and the associated expenditures are not a burden on taxpayers. For example, if the Department of Agriculture and Agri-food performs testing services for livestock and charges a fee that covers the full cost of the services, the net budget for this service is zero and no tax burden is imposed on taxpayers. In the Public Accounts, total spending by Ministry is recorded on a net basis. I will follow that procedure in my calculations. The revenues to be netted against expenditures are recorded for each "business line". Instead of calculating the gross total and then deduct the relevant revenues, I will deduct those revenues directly from operating costs because, in my view, this is the relevant component of expenditures for this adjustment. There is no revenue associated with transfers. Capital items may be involved in the production of some of the goods and services that generate revenues, but it would be impossible to determine their contribution.

Since the efforts to increase accuracy in the allocation require detailed calculations, the details are presented in a separate appendix, which is available on request. Only the summaries by Ministry and Agency are presented and discussed in the next section.

VI. FEDERAL GOVERNMENT INVESTMENT IN CANADA

Estimates of direct and associated federal government expenditures on natural capital are

found in Appendix Table A-1. Summaries of those estimates are presented and discussed in this section.

Table 4 shows the distribution of total federal investment in natural capital (the sum of direct and associated investment) by department. This table indicates that investment in natural capital can be found in nine federal departments and Agencies. In 2004-05, the estimated investment in natural capital amounted to $3.265 billion and represented 2.6 percent of adjusted federal program spending, measured as total spending net of interest on the public debt and unconditional transfers to other levels of government. The largest contribution to this total was made by the Environment Ministry which accounted for 34.6 percent of the total. Other large contributors are the Ministry of Fisheries and Oceans with a share of 28.6 percent and the Ministry of Natural Resources with a share of 22.2 percent. Together, these three Ministries accounted for 85.4 percent of total federal investment in natural capital. Moderate contributions were made by the Ministry of Agriculture and Agri-food (6.2 percent) and the Ministry of Indian Affairs and Northern Development (6.1 percent). The remaining four Ministries made only a marginal contribution.

Table 4. Estimated Investment in Natural Capital by the Federal Government, 2004-05.

Ministry	Total Investment $ Thousands	Percent of Grand Total
Agriculture and Agri-food	201,926	6.18
Environment	1,130,380	34.63
Fisheries	934,188	28.62
Foreign Affairs	19,400	0.59
Indian Affairs and Northern Development	198,039	6.07
Natural Resources	723,530	22.16
Solicitor General	53,891	1.65
Transport	2,235	0.07
Western Economic Diversification	1,122	0.03
Total	3,264,701	100.00
Percent of Adjusted Budgetary Spending	2.72	

Table 5 presents a measure of the intensity of investment in natural capital by Ministry, calculated as the ratio of a Ministry's investment to its total budgetary expenditures. For all nine Ministries combined, total investment in natural capital represented 12.3 percent of budgetary expenditures. Not surprisingly, the Ministries with the largest contribution to investment in natural capital had the highest investment intensities with shares of investment ranging from 77.2 percent for the Ministry of the Environment to 63.4 percent for the Ministry of Fisheries and Oceans and 43.9 percent for the Ministry of Natural Resources. In all other Ministries, the degree of investment intensity was low to negligible.

Table 5. Intensity of Investment in Natural Capital by Department, 2004-05.

Ministry	Total Investment $ Thousands	Total Budgetary Expenditures $ Thousands	Ratio Percent
Agriculture and Agri-food	201,926	3,936,636	5.13
Environment	1,130,380	1,463,265	77.25
Fisheries	934,188	1,472,576	63.44
Foreign Affairs	19,400	5,044,228	0.39
Indian Affairs and Northern Development	198,039	5,602,427	3.53
Natural Resources	723,530	1,647,683	43.91
Solicitor General	53,891	5,457,057	0.99
Transport	2,235	1,636,127	0.13
Western Economic Diversification	1,122	312,131	0.36
Total	3,264,701	26,572,130	12.29

Table 6 shows the components of total investment in natural capital by type of investment for all Ministries combined. According to this table, the split between direct and associated investment in natural capital is about 60/40. The associated investment is largely in the form of investment in human capital, which accounts for 84.1 percent of this subtotal. Investment in physical capital, which is the only component recorded in the National Accounts represents 13.2 percent of associated investment and only 5.2 percent of the total.

Table 6. Components of Investment in Natural Capital by the Federal Government, 2004-05.

Component	**Investment**	**Percent of Total $thousands**
A. Natural Capital (Direct)	1,976,614	60.54
B. Associated Investment		
Physical Capital	170,009	5.21
Human Capital	1,083,482	33.19
Civic Capital	33,445	1.02
Social Capital	1,151	0.04
Subtotal	1,288,087	39.46
Total	3,264,701	100.00

VII. CONCLUSION

This paper introduced a new methodology for measuring public investment in natural capital and applied it to the expenditures of the federal government in Canada for fiscal year 2004-05. In determining which expenditures should be treated as investment, I used a set of criteria based on the main features, uses and measurement of physical capital. Since this paper is part of a larger project aimed at measuring public investment in five types of capital (physical, natural, human, civic and social), I estimated both direct investment in natural capital and the associated investment in the other four types of capital.

My results indicate that in 2004-05 total investment in natural capital by the federal government amounted to 2.6 percent of its net budgetary expenditures (total expenditures minus interest on the debt and unconditional transfers to other levels of government). Sixty percent of this share (1.9 percent of net budgetary expenditures) was in the form of direct investment in natural capital. Five-sixth of the associated investment was in the form of investment in human capital. The physical capital component, the only type of capital included in the National Accounts, represented only five percent of total investment in natural capital.

APPENDIX.

Table A-1. Federal Government Investment in Natural Capital: 2004-05, $thousands.

Ministry	Direct	Associated				Total
		Physical	Human	Civic	Social	
Agriculture and Agri-food	86,127	2,996	112,803			201,926
Environment	603,740	47,289	477,049	1,348	954	1,130,380
Fisheries and Oceans	660,923	106,349	166,719	197		934,188
Foreign Affairs	19,400					19,400
Indian Affairs, Northern Dev.	193,056	4,973	10			198,039
Natural Resources	356,120	8,402	326,911	32,097		723,530
Solicitor General	53,891					53,891
Transportation	2,235					2,235
Western Economic Diversification	1,122					1,122
Total	1,976,614	170,009	1,083,482	33,445	1,151	3,264,701

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