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# The Natural Capital Approach
## A Concept Paper

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**The Natural Capital Approach: A Concept Paper**

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With written contributions from Patti Adye and Mileva Spasic on Ducks Unlimited Canada and the Canadian Boreal Forest Initiative in Chapter 3 – Natural Capital Implementation Initiatives.

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# FOREWORD

Natural capital is the spectrum of physical assets within the natural environment that deliver economic value through ecosystem services. Like a savings account, natural capital can pay interest or be liquidated. If a tree is chopped down for firewood, the capital has been spent. However, if the tree is retained and preserved, it can deliver (perhaps much higher) value through the ecosystem services of shade, air filtration, carbon sequestration and erosion control. Many forms of natural capital provide multiple benefits. Wetlands, for example, provide water treatment and purification services; prevent floods by retaining surface runoff; and provide wildlife habitat.

The concept of natural capital has the potential to reconcile economic and environmental interests by integrating the value of natural capital in decision-making. It makes it possible, for example, to develop a cost-benefit analysis of a new water treatment plant, versus the restoration or preservation of a wetland for the clean water filtration service it provides.

Natural environments are increasingly recognized as essential to human well-being. This paper sets out the framework to develop a natural capital approach to better manage and value natural environments by reviewing the conceptual foundations of the natural capital concept, and charting a roadmap for its application in Canada.

**Henry David (Hank) Venema, Director**
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# EXECUTIVE SUMMARY

The Natural Capital Approach (NCA) is a means for identifying and quantifying natural resources and associated ecosystem goods and services that can help integrate ecosystem-oriented management with economic decision-making and development. By integrating economic and environmental imperatives, NCA operationalizes the ecosystem approach and facilitates policy-making for sustainable development. Environment Canada is exploring the concept to develop effective environmental policies.

Born out of theoretical advancements in ecological economics, the NC concept is gaining considerable interest for devising policies that reconcile economic and environmental imperatives. Integrating the concept within economic and environmental management systems is best achieved by treating the natural environment similarly to other forms of valued capital and adopting the ecosystem approach which is compatible with a wide range of contexts.

NC implementation initiatives are being carried out internationally and domestically as the value of preserving and restoring ecosystems it is being increasingly recognized and linked to human well-being. There is a demand and a need in Canada for developing NC assessment and valuation methodologies. NC research and implementation efforts for the preservation and restoration of natural environments will benefit greatly from a comprehensive NC framework.

Accounting frameworks such as the UN's System of Environmental and Economics Accounts (SEEA 2003) and the Canadian System of Environmental and Resource Accounts (CSERA), offer a comprehensive measure of the state of natural environments. Efforts are ongoing to expand these accounts and include ecosystem integrity measures and ecosystem service values which would further enhance their utility. The European Environment Agency's spatial application of the SEEA 2003 demonstrates the potential for developing a NC informatics architecture based on a comprehensive set of NC accounts that includes ecosystem integrity and ecosystem services values. Integrating the NCA within governance and policy development is best achieved by adopting jurisdictions delineated by watersheds, trade-off assessments based on sound environmental statistics and economic models, incentive programs such as payments for ecosystems and stakeholder partnerships.

The Environment Canada NC framework is a broad and comprehensive outline that lacks an implementation strategy. This void can be filled by Statistics Canada's CSERA which provides a foundation for building a NC informatics architecture. Environment Canada has the expertise to enhance and shape the CSERA by designing ecosystem integrity measures (Canadian Wildlife Service – biodiversity and environmental indicators work) and ecosystem service value estimates (the Ecosystem Valuation Reference Inventory). A NC based pilot study led by Environment Canada will be invaluable to gain experience applying the CSERA and designing NC preservation and restoration policies. These insights can then be used to enhance the current Environment Canada NC framework.

We recommend an Environment Canada piloted ecosystem-scale application of ecological goods and services valuation for policy analysis and design. The ecosystem-scale pilot study will help demonstrate:

- the utility of the CSERA for environmental policy analysis and development;
- the policy saliency of a NC and ecosystem services valuation exercise; and

- the relevance of NC and ecological services valuation for analyzing and justifying NC stewardship and restoration programming in economic terms to key agencies such as the Treasury Board.

The Red and Assiniboine River system in Southern Manitoba—a sub-basin within the Lake Winnipeg watershed—is a suitable location to carry out a NC-based analysis. The transformation of the landscape in Southern Manitoba is marked by a dramatic loss of prairie, forest and wetland covers that have been converted into croplands. NC losses are partly responsible for the degradation of Lake Winnipeg, which has become the most eutrophic large lake in the world. The preservation and restoration of NC such as wetlands, which provide nutrient mitigation and absorption services, would greatly help improve the lake's condition. An IISD-Environment Canada joint NC pilot study in the Red-Assiniboine River system will have the synergistic effect of demonstrating the relevance of the NCA for effective environmental policy-making and NC preservation and restoration for recovering Lake Winnipeg.

The Environment Canada and Statistics Canada NC work would benefit greatly from pilot applications to real-world ecosystem management issues. We regard the Lake Winnipeg Watershed as an excellent candidate for an ecosystem-scale case study to demonstrate the policy utility of ecosystem service valuation and further federal NC research and policy development capacity.

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# 1. INTRODUCTION

Natural Capital (NC) is the natural environment from which emanates the goods and services that sustain life (Envisioning a Sustainable and Desirable America Network, 2001). Furthermore, it is the basis for human activity and well-being. NC can be broadly described as renewable or non-renewable (Costanza & Daly, 1992). Renewable or active NC is self-maintaining due to its ability to harness solar energy. Ecosystems are forms of renewable NC as they can maintain and replicate themselves. Non-renewable or inactive NC—such as fossil fuels or mineral deposits—is formed over long geological time periods and is passive.

Produced and human capitals have traditionally been measured to gauge economic performance while NC has been neglected. This has lead to a depletion of natural environments and the loss of valuable ecosystem services. The Natural Capital Approach (NCA) is a means for identifying, quantifying and valuing ecosystem services leading to better decision-making for managing, preserving and restoring natural environments. Identifying and quantifying NC and its ecosystem services provides additional economic rationale for effective environmental planning and management. If properly designed, the NCA can translate the principles of the Ecosystem Approach, a decentralized environmental planning and management model, to protect native ecosystem integrity in perpetuity and facilitate sustainable development.

Commissioned by Environment Canada, IISD is developing a suitable framework for the application of an NCA within Canada. This concept paper explores the conceptual underpinnings of the NCA in order to provide a foundation for Environment Canada to continue this work. Specifically, this initiative is meant to assist the development and analysis of ecosystem policy based on NC principles. The long term objective of this project will be to apply the framework within a watershed to evaluate its effectiveness by monitoring the watershed's NC.

The NCA is defined by investigating the evolution of the concept and is evaluated against other environmental management approaches. International and Canadian NC implementation and research initiatives followed by the elements required for its implementation are discussed. Environment Canada's NC framework is then presented and the policy development implications of adopting it as an environmental management approach are finally expounded. The conclusions and recommendations provide considerations for further research.

# 2. DEFINING THE NATURAL CAPITAL APPROACH

The Natural Capital concept was popularized in 1990 and was born out of theoretical advances to bridge the gaps between economics and ecology. These advances are succinctly described leading up to current NC state-of-the-art research that is being pursued by the Gund Institute and Stanford University.

The key elements and underpinnings of what constitutes a Natural Capital Approach (NCA) are explored to formulate a Natural Capital Approach working definition. The articulation of the working definition is preceded by NC and Ecosystem Services descriptions. The NCA bridges the disciplines of economics and ecology to facilitate better decision-making for managing, preserving and restoring NC.

The concept is further examined by comparing it to other environmental planning and management approaches. The Economic Growth, Media-based and Ecological Approaches to environmental planning and management are used to compare and contrast the NCA and identify its innovative and challenging aspects. The NCA is established as a means to operationalize the ecosystem approach for sustainable development practice.

Integrating and implementing the NCA within economic and environmental systems is explored. Treating NC similarly to other types of capital will ensure its integration within economic systems and the NCA's compatibility with a plurality of contexts is required for it to be an effective environmental management tool. Efforts to move the concept from theory to practice are discussed.

## 2.1. Conceptual Evolution

The evolution of the NC concept is presented to develop a working definition for the NCA. The NCA concept is the product of important advances in sciences and economics. These advances laid the foundation for the establishment of the International Society for Ecological Economics, Resources for the Future work on green accounting and key recommendations from the Millennium Ecosystem Assessment for watershed-based payments for ecosystem and human well-being. NC "state-of-the-art" research at the Gund Institute and Stanford University is moving the concept from theory to practice.

The importance of NC to the production of goods and services has been acknowledged by prominent economists since the mid-twentieth century. Alfred Marshall, the father of neo-classical economics, was keenly aware of the contribution of nature to the production of goods and services and viewed distinctions between land and capital as trivial (El Serafy, 1991). John Hicks, 1972 Nobel laureate of economics, describes a factor of production as "a contribution to production, in the sense that if it were removed production (or output) would be diminished (El Serafy, 1991, p. 169)." Furthermore, Hicks stated that factors of production do not necessarily need to be appropriable, tradable or have a market.

Equipped with John Hicks's work, Georgescu-Roegen contributed directly to the development of the NC concept by developing a new approach to understanding economic, social and biophysical constraints which he called "bioeconomics" (Gowdy & Mesner, 1998). He highlighted the need for economists to understand the interrelated aspects between resource constraints, social stability and organization, and economic activity (Gowdy & Mesner, 1998). Kenneth Boulding also contributed to meshing the disciplines of ecology and economics by pointing out the limits to exponential growth

within a finite system (Boulding, 1966). Meadows further explored these inter-relations by developing the World 3 model to forecast growth and associated resource depletion rates (Costanza, 2003; Meadows, Meadows, & Randers, 1992).

These concepts inspired the organization of the "Integrating Ecology and Economics" symposium in 1982 where ecologists and economists discussed how to bridge the gap between their respective disciplines. As a result of this symposium, ecologist Robert Costanza teamed up with economist Herman Daly and established the new discipline of Ecological Economics by creating the Ecological Economics journal and the International Society for Ecological Economics in the late eighties (Costanza, 2003). Ecological Economics repositions the natural environment from being a factor of production to being the foundation of production, well-being and existence. Furthermore, it professes that the natural environment cannot be substituted and must be preserved and enhanced. Shortly after, Pearce and Turner popularized the term "natural capital" in their book *Economics of Natural Resources and the Environment* published in 1990 (Smith & Smith, 2006).

Other research initiatives and consortiums are confirming the theoretical advancements in Ecological Economics. Resources for the Future, the first research institute devoted to natural resources and environmental issues founded in 1952, has provided since its inception, substantial rigorous research on a number of fronts for rethinking the exploitation of NC to feed a growing and unsustainable economy (Resources for the Future, Undated). Its recent publications on ecosystem services and green accounting lay a foundation for developing new economic tools that capture the importance of maintaining NC (Banzhaf & Boyd, 2005, 2006; J. Boyd, 2006). The Millennium Ecosystem Assessment (MA), a landmark study released in 2003 conducted by 1,300 experts from 95 countries, revealed that approximately 60 per cent of the ecosystem services that support life on Earth are being degraded or used unsustainably (Millennium Ecosystem Assessment, 2005). In order to prevent the erosion of our ecosystems the MA recommended that significant investments must be directed towards the preservation and restoration of NC. "Increasingly, ecological resources are seen as being crucial to the current and future productive capacity of economic systems with economic sustainability requiring ecosystems to be maintained in certain states of health and functionality (Straton, 2006, p. 403)."

Research efforts on devising strategies for the preservation and enhancement of NC are being spearheaded by the Gund Institute at the University of Vermont, and the Woods Institute at the University of Stanford. The Gund Institute focuses on research initiatives related to "science in economic decision-making; the intrinsic value of ecosystems and the services they provide; integrated community participation in economic design and development; and the development of accurate measurements of system health and sustainability (Gund Institute, 2006b)." The "Natural Capital Project" is a research partnership between Stanford University, The Nature Conservancy and the World Wildlife Fund which aims to: "develop compelling and accessible tools that capture the value of ecosystem services in decision-making, establish an international network of projects that incorporate natural assets and ecosystem services into land-use, build constituencies to magnify the impact of these on-the-ground projects by informing and engaging decision-makers of all types (Stanford University, The Nature Conservancy, & World Wildlife Fund, 2006)." The lessons learned, tools developed and knowledge gained from these research efforts will assist Environment Canada develop effective environmental planning and management strategies.

## 2.2. Working Definition

Defining the NCA requires a proper understanding of what is meant by NC and ecosystems services. NC is the natural environment from which emanates the goods and services that sustains life (Envisioning a Sustainable and Desirable America Network, 2001). More specifically, it is the basis

for human activity and well-being (Brown & Ulgiati, 1999; Carpenter et al., 2006; Fenech, Foster, Hamilton, & Hansell, 2003; Gund Institute, 2006a; Hawken, Lovins, & Lovins, 1999a; Markandya, Mason, Perelet, & Taylor, 2002; Naidoo, 2004). Therefore, human activity and well-being is closely coupled with the state of NC and its services (Carpenter et al., 2006). NC can be broadly described as renewable or non-renewable (Costanza & Daly, 1992). Renewable or active NC is self-maintaining due to its ability to harness solar energy. Non-renewable or inactive NC are formed over long geological time periods and are passive. "NC includes both mineral and biological raw materials, renewable (solar and tidal) energy and fossil fuels, waste assimilation capacity, and vital life support functions (such as global climate regulation) provided by well-functioning ecosystems (Envisioning a Sustainable and Desirable America Network, 2001)." Costanza and Daly (1992) compare renewable NC to machines that are subject to degradation while non-renewable NC is analogous to inventories which can be liquidated.

An ecosystem is defined by the 1992 Convention on Biological Diversity as: "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (Markandya et al., 2002, p.69)." Ecosystem services are in simplistic terms nature's entities and functions which enable existence (Millennium Ecosystem Assessment, 2003). Although ecosystems function as a whole their services can be characterized. The Millennium Ecosystem Assessment (2003) organizes ecosystem services by grouping them into four categories: Provisioning services include the basic necessities we consume and require for our survival and well-being; Regulating services provide us with a habitable environment; Cultural ecosystem services benefit people in a nonmaterial manner; Supporting ecosystem services are necessary for the continuation of the other three types of ecosystem services (see Figure 1).

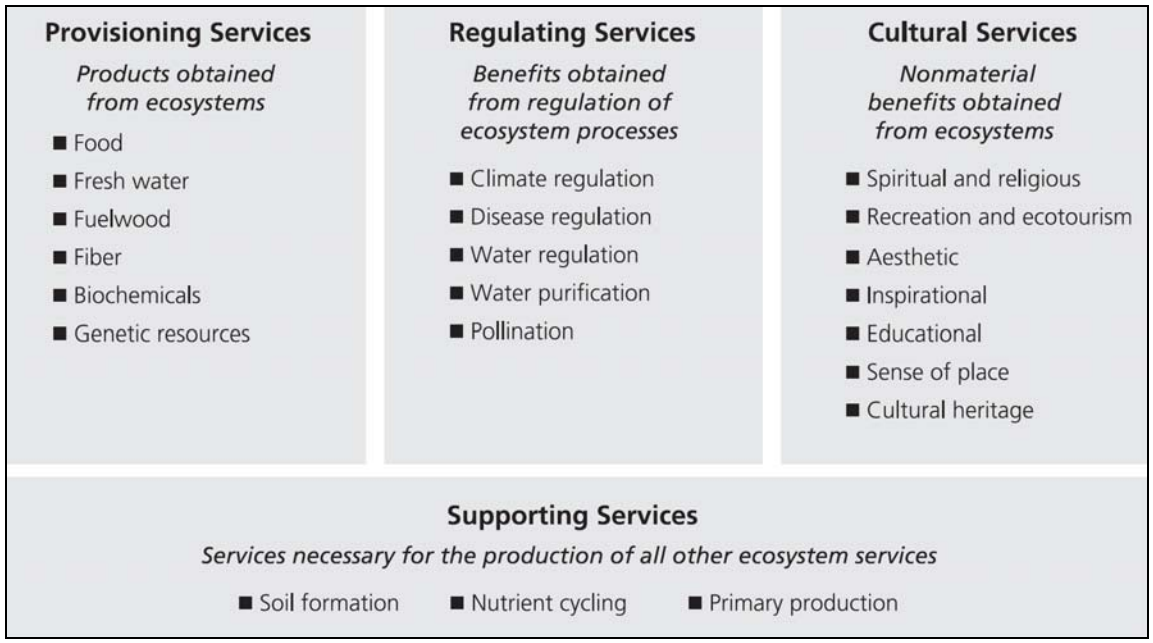


**Figure 1**: Ecosystem services are the benefits people obtain from ecosystems (Millennium Ecosystem Assessment, 2003, p. 57).

Ecosystem services flow from NC. For instance, NC in the form of flowers, pollen and pollinators are required to perform the ecosystem service of pollination (Binning, Cork, Parry, & Shelton, 2001). NC becomes an ecosystem provisional service when it is harvested for a particular use. For example, bee pollen, natural capital when embedded in the natural environment, becomes an ecosystem provisional service when extracted for human consumption. NC must be interconnected, healthy and whole to provide ecosystem services. Its ability to provide services is compromised when degraded,

exploited, disturbed or fragmented and is improved when preserved, enhanced or reconnected. NC is the basis for human capital, social capital and built or manufactured capital.

Drawing from the above information a "Natural Capital Approach" is defined as follows:

> ***A means for identifying and quantifying the natural environment and associated ecosystem services leading to better decision-making for managing, preserving and restoring natural environments.***

Identifying and quantifying NC and its ecosystem services provides additional rationale for effective environmental management. Consequently, an appropriately designed NCA is a bridging concept between effective environmental management and sustainable development (Fenech et al., 2003). Costanza and Daly affirm that "maintaining natural capital stocks is a prudent and achievable policy for insuring sustainable development (Costanza & Daly, 1992, p. 37)."

## 2.3. Conceptual Evaluation

The NCA is compared and contrasted to other environmental planning and management approaches. According to Mitchell (2002), the distinction between environmental planning and management is the following:

> "Environmental planning is the identification of possible future natural environmental end states, and development of courses of action to reach such end states. Environmental Management is the actual decisions and actions concerning policy and practice regarding how resources and the environment are appraised, protected, allocated, developed, used, rehabilitated, remediated and restored, monitored and evaluated (Mitchell, 2002, p. 6)."

Environmental management approaches vary based on a number of factors such as worldviews, capacities and methodologies. For instance, well-being measurement methods, natural capital substitutability, command and control environmental legislation, community focused ecosystems management provide a few examples of approaches that have emerged to complement or shape environmental planning and management.

Environmental Planning and Management Approaches have evolved substantially over the past several decades. The industrial revolution led to a dramatic increase in the conversion of natural raw materials into the production of good, fueling an exponential rise in population and economic growth. The ensuing rapid depletion of natural resources and increase in pollution emissions resulted in considerable public health impacts. The need to regulate and develop standards for pollution emissions to protect the public and the environment became a necessity. A Media-based Approach was adopted to develop pollution emission standards for the air, water and land base of the environment. This Media-based Approach has proved to be insufficient for the protection of natural ecosystems as they continue to erode worldwide (Millennium Ecosystem Assessment, 2005). The Ecosystem Approach is a holistic way of coexisting with the natural environment. It is based on a localized approach to natural resources management perfected by the accumulation of traditional ecological knowledge. The Ecosystem Approach respects the limitations of ecosystems to provide goods and services required for the well-being of all populations that depend on them. The Economic Growth, Media-based and Ecosystem Approaches cover a wide spectrum of environmental planning and management methods. They will be described in general terms and compared and contrasted with the Natural Capital Approach.

### *2.3.1. Economic Growth Approach*

In economic theory, ecosystems are embedded within economic systems (Fenech et al., 2003) and the natural environment is narrowly perceived as a provider of raw materials and a pollution sink. Natural resources are used for the production of goods and services to meet the needs and wants of human populations (Chee, 2004; Fenech et al., 2003). Furthermore, a natural resource can be depleted and eradicated as it is substitutable with another (R. Ayres et al., 1996; Fenech et al., 2003). Human ingenuity is relied upon to maintain or increase the production of goods by improving raw material processing efficiencies and finding replacements (R. Ayres et al., 1996). Chee (2004) summarizes neo-classical economic theory as follows:

- Market essentialism: Markets where exchanges of goods occur are the best institutions for allocating scarce resources.

- Substitution, resource fungibility and technological optimism: Natural resources and processes are substitutable and interchangeable. Human ingenuity will solve natural resources scarcities through substitution.

- Utilitarian, anthropocentric and instrumentalist ethical framework: The natural environment is an instrument for fulfilling human satisfaction where objects are assigned values based on human wants and perceptions.

- Consumer choice theory and the notion of a rational actor: Human behaviour is assumed to be "rational" while operating within a market which can be described as: being self interested and purposeful; expressing preferences based on structured and invariable values which can be measured through the willingness to pay for a good or service; having complete knowledge and understanding about a decision and related possible outcomes; and maximizing utility based on personal constraints and possible states of the world.

Economic growth is believed to improve human well-being via the consumption and accumulation of goods (Vemuri & Costanza, 2006). The Gross Domestic Product (GDP), a measure of financial expenditures for the consumption of goods, has typically been and continues to be used to measure economic growth (R. Ayres et al., 1996; Vemuri & Costanza, 2006). "GDP is the total market value of all final goods and services produced in a country in a given year (Encyclopedia Britannica, 2007)." GDP is calculated by summing the total consumer, investment and government spending, plus the difference in the value of exports and imports. It does not account for the depletion of NC associated with the production and consumption of goods and services (R. Ayres et al., 1996). Nevertheless, it is used to estimate improvements in the quality of life via economic growth over temporal and spatial scales (R. Ayres et al., 1996).

GDP and economic growth is improved by liquidating natural capital (Naidoo, 2004). Consequently, environmental planning and management is centred on optimizing the extraction and transformation of natural resources for the production of goods and services. Furthermore, associated pollution and wastes streams resulting from natural resource extraction and transformation processes are considered externalities (Bartelmus, 2003). Environmental planning and management is geared toward infinitely increasing economic growth even though non-renewable and renewable natural capital rates of replenishment are constrained and seldom understood (R. Ayres et al., 1996; Meadows et al., 1992; Naidoo, 2004).

The Economic Growth Approach to environmental planning and management is a model that is well established and understood. By virtue of generating income via economic growth expenditures can then be made to preserve and restore the natural environment. Economic considerations hold a lot of influence and often supersede other concerns. Therefore, it is important not to disregard the economic imperative for environmental planning and management. It is also important not to position economic considerations as the dominant imperative as this would lead to imbalances in development where social and environmental considerations will suffer. The GDP, an economic growth measure often misused to assess well-being, is flawed as it fails to incorporate NC which the economy depends on for raw materials and other services. This oversight has lead to notable negative impacts on the environment, social and cultural fabrics of many nations and communities. The Economic Growth Approach is not amenable to effective environmental planning and management but cannot be ignored in the development of environmental policies and management strategies. Unabated economic growth will lead to dire repercussions on the social and environmental systems upon which we depend.

### *2.3.2. Media-based Approach*

The Media-based Approach emerged from the need to develop regulation for air, water and land pollution from human activity (Richardson & Wood, 2006). Public environmental regulation can be traced back to sanitation and town planning statutes implemented in the U.K. during the mid-nineteenth century (Richardson & Wood, 2006). A number of countries followed and implemented environmentally related laws. The majority of India's forests were governed by forest management legislation by the early twentieth century (Richardson & Wood, 2006). Environmental law structured around the Media-based Approach became a discipline on its own within the practice of law in the 1960s as scientific understanding on ecological impacts and public awareness on environmental degradation grew (Grumbine, 1994; Richardson & Wood, 2006).

Governments developed and structured environmental laws and policies around a Media-based Approach in order to control and reduce harmful pollution and wastes impacting human health. Agencies, institutions and support structures were established around media-based legislation to support the development of appropriate and well informed regulation. For instance, the Environmental Protection Agency was established in the 1970s in the United States to administer the environmental policy act implemented in 1969 (Richardson & Wood, 2006). "By enacting environmental statutes and establishing specialized administrative agencies with delegated rule-making and enforcement authority, governments created complex, finely detailed regulatory regimes to intervene directly in environmentally harmful social processes (Richardson & Wood, 2006, p. 4)." The development of related environmental planning and management approaches as well as risk management procedures where greatly influenced by media-based environmental legislation (Richardson & Wood, 2006).

The Media-based Approach to formulating environmental regulation, planning and management is well entrenched in international and national environmental governance structures guiding environmental managers toward pollution and environmental impact mitigation (Richardson & Wood, 2006). The Media-based Approach works to protect NC by either implementing reactive and proactive laws for the protection of the environment. Research on pollutant impacts and thresholds led to the development of legislation in the form of emission standards which were often established in reaction to a looming human and environmental health crisis. The loss of NC led to the development of proactive legislation, such as mandatory environmental impact assessments, to protect natural environments from human habitat expansions and encroachments.

Unfortunately, the Media-based Approach has been ineffective and insufficient in regressing environment degradation (D. R. Boyd, 2003; Grumbine, 1994; Richardson & Wood, 2006). Human expansions typically have interconnected impacts across environmental media and do not respect jurisdictional boundaries. "The safety net of U.S. environmental law has been stretched thin as society reaches and exceeds environmental limits through industrial expansion, population growth, and resource consumption (Grumbine, 1994, p. 29)." In addition, environmental threats which are transboundary and global in nature limit the effectiveness of environmental legislation which are usually applied within national boundaries (D. R. Boyd, 2003; Richardson & Wood, 2006).

This environmental planning and management style consists of a sector-based command and control approach through legislation to influence societal behaviour and protect human and environmental health. Environmental regulations and punitive measures are implemented to discourage practices that degrade the environment. The Media-based Approach has failed to curb environmental degradation as environmental regulation is for the most part an "end of pipe" approach. In addition, regulatory systems require a substantive amount of resources for enforcing laws and regulations which can be difficult when there are public funding shortages. It is also limited due to jurisdictional boundaries which are not respected by pollutants and the interconnected nature of environmental degradation which is unrestricted to a particular media. The Media-based Approach must become more proactive in order to protect and enhance NC. An innate sense of responsibility for the protection of the environment can be fostered by promoting a common understanding of the shared benefits that are to be gained from vibrant and healthy natural environments. Strictly encouraging people to adopt behaviours that are conducive for protecting and enhancing the environment has proved to be insufficient.

### *2.3.3. Ecosystem Approach*

The Ecosystem Approach has recently reemerged as a viable Environmental Planning and Management process for a number of reasons (Grumbine, 1994):

- biodiversity continues to degrade as species are going extinct;
- the environment continues to deteriorate;
- theoretical and empirical developments in conservation biology have evolved;
- environmental laws and policies have been insufficient due to population and consumption growth;
- environmental groups challenge resource management policies and practices;
- federal management has often ignored conservation biology concerns and failed to incorporate the public in meaningful decision-making in resource development projects; and
- society is looking to establish and shape a new relationship with nature.

The Ecosystem Approach seeks to understand and manage the biophysical and socio-economic interactions within ecosystems. Grumbine states "Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general good of protecting native ecosystem integrity over the long-term (Grumbine, 1994, p. 31)." Human activities, including economically related activities, are embedded within natural ecosystems (Fenech et al., 2003; Mitchell, 2002). Humans are considered biological entities high up on the food chain that rely on other species to synthesize molecules into food and decompose wastes back into molecules (Fenech et al., 2003). In the Ecosystem Approach the local environment is viewed as a functioning whole where all living and non-living entities are interconnected and in constant interaction.

The Ecosystem Approach stems from the need to understand the environment for survival. People are closely linked to their natural environments and depend on healthy and functioning ecosystems for their livelihood, health and survival (Venema, 2004). Historical and traditional ecological knowledge of the local environment is valued to provide guidance for the management of the natural world. Hunter and gatherer societies have practiced the Ecosystem Approach for centuries. They developed intricate systems of coexistence with fluctuating and healthy ecosystems (Brody, 2001; Venema, 2004). Shifting and settled cultivators sought to manipulate and control natural systems and relied on intact natural ecosystems to a lesser extent for their sustenance (Brody, 2001; Venema, 2004). Industrial cultivation exercise a high level of control over natural ecosystems by using high energy inputs to produce food en masse (Venema, 2004).

According to Dr. David Pitts, Director of Environment Science and Services (Mitchell, 2002), the main elements of the Ecosystem Approach include: "the protection of natural capital, the long-term protection of ecosystems and ecological processes, the maintenance of biological diversity, the sustainable use and harvesting of resources, the recognition and protection of traditional knowledge, customs and practices of indigenous people (Mitchell, 2002, p. 98)." The Convention on Biological Diversity states that the Ecosystem Approach consists of the 12 following guiding principles (Convention on Biological Diversity, 2007):

1. The objectives of management of land, water and living resources are a matter of societal choices.

2. Management should be decentralized to the lowest appropriate level.

3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

4. Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

   a) Reduce those market distortions that adversely affect biological diversity;
   b) Align incentives to promote biodiversity conservation and sustainable use;
   c) Internalize costs and benefits in the given ecosystem to the extent feasible.

5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the Ecosystem Approach.

6. Ecosystem must be managed within the limits of their functioning.

7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

8. Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

9. Management must recognize that change is inevitable.

10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

12. The Ecosystem Approach should involve all relevant sectors of society and scientific disciplines.

The Ecosystem Approach is conceptually holistic and is either comprehensive or integrated in practice. The comprehensive approach aims to understand all the components and relationships of an entire ecosystem in order to manage it effectively which can be very time consuming (Mitchell, 2002). The integrated method is more focused, practical and aims to identify, understand and manage the variables that cause the greatest variations in system behaviour and are amenable to modifications via management interventions (Mitchell, 2002). The NCA is compatible with both Ecosystem Approach implementation methods.

It is best suited for developing environmental planning and management strategies that will be effective and embraced by the communities who will put them into practice. By involving communities in the development and implementation of environmental planning and management strategies, the Ecosystem Approach is well suited for local contexts. It also incorporates local traditional knowledge, which conveys a deep understanding of the local natural environment in a language that can be understood. The Ecosystem Approach does not always translate itself well to higher levels of government. Local realities may be disconnected from national, provincial or municipal goals and objectives. Nevertheless, it provides a solid foundation for developing effective environmental planning and management strategies on which higher levels of government can build coherent and relevant policies for the preservation and enhancement of the environment.

### *2.3.4. Evaluation Synthesis*

The commonalities, differences of the NCA compared to the other environmental management approaches presented above are synthesized. The evaluation is followed by a brief discussion on the compatibility, strengths and weaknesses of the NCA.

The Economic Growth and NCA use similar terms to convey similar concepts. For instance, both approaches use "capital" similarly to express the notion of "a stock yielding a flow (Costanza & Daly, 1992, p. 38)." In the Economic Growth Approach, manufactured and human capital provides the necessary elements to generate additional capital in the form of goods and services. NC will yield additional natural assets over time if the rate of depletion does not surpass the rate of natural replenishment. This commonality is important to highlight as the NCA uses language and concepts compatible with the economic imperative that often dominates personal and political agendas.

The Economic Growth and NC Approaches measure human well-being very differently. The Economic Growth Approach gauges productivity based on human and manufactured capital. Correlating human well-being and economic performance measures based strictly on production and consumption has been widely criticized (Bartelmus, 2003; Costanza & Daly, 1992; Sutton & Costanza, 2002).

> "It is common knowledge that the 'quantitative' measures of economic performance such as the values of production and consumption provide a distorted picture of human wealth and welfare. These measures disregard non-market outputs and amenities, as well as 'external' side effects of economic activity (Bartelmus, 2003, p. 63)."

Many attempts have been made to provide a more accurate measure of human well-being. A few examples include the Human Development Index, the Genuine Progress Indicator, the Index of Sustainable Economic Welfare and the National Wellbeing Index (R. Ayres et al., 1996; Costanza &

Daly, 1992; Daly & Cobb, 1990; Vemuri & Costanza, 2006). The NCA measures and monitors natural ecosystems as they are essential for sustenance and well-being (Millennium Ecosystem Assessment, 2005). Economic growth is concerned with end products for human well-being while the NCA focuses on ensuring that the source of well-being and production is measured and monitored so it can be maintained in perpetuity.

One important distinction between both approaches centres on the substitutability of NC. The Economic Growth Approach assumes that the natural environment is largely substitutable with manufactured capital. Raw materials are exploited without limitation and replaced through human discovery and technological advances to maintain economic growth (Elliot, 2005). The NCA assumes that manufactured and natural capitals are complementary. More manufactured capital requires the consumption of more NC (Elliot, 2005). The NCA provides an accounting basis for ensuring that biophysical limitations are respected. Ayres (2007) acknowledges that many natural raw materials and functions can and are being replaced by advances in human ingenuity and technology but concludes that ecosystem functions essential for survival are likely never to be replaced. He uses the example of nature's ability to reduce atmospheric carbon dioxide concentrations and recombine carbon with other elements, which has evolved over hundreds of millions of years, to further validate his conclusion (R. U. Ayres, 2007). Whether or not natural capital is considered to be substitutable, it is important to remember that all manufactured capital stems from NC (R. U. Ayres, 2007; Costanza & Daly, 1992).

The NC and Approaches are complementary as the NCA provides the necessary knowledge to develop effective regulation for the protection and restoration of NC. The Media-based Approach is comprised of reactive and proactive regulations. It can aim to limit or eliminate pollution emissions or can prevent activities leading to harmful impacts on the environment. Water quality emission standards would constitute reactive environmental regulations while mandatory environmental assessments for development projects would be considered proactive regulation. In general, environmental regulation is geared towards treating the symptoms and not the root causes of environmental degradation (D. R. Boyd, 2003). Boyd states "laws to protect endangered species try to prevent extinction but fail to address the reason why species are at risk in the first place, including excessive harvesting, the introduction of exotic species, and the loss of habitat, all caused by a wide range of human economic activities undertaken to facilitate consumption (D. R. Boyd, 2003, p. 277)." The NCA would aid in addressing the root causes of environmental degradation by providing quantitative and qualitative measures of the natural environment thus enabling the development of proactive environmental legislation.

Media-based environmental legislation has been widely criticized by neo-conservatives who advocate for individual liberty, the superiority of the markets and deregulation. Additionally, critics point out that agencies administering environmental regulation are cumbersome, costly, have limited technical capacity, are unable and reluctant to adapt and are not suited for addressing global environmental problems. "The state is caught between demands to intervene and restrict the mechanism of capitalist accumulation in order to contain its social and environmental impacts and the imperative to allow these mechanisms to operate relatively freely to produce the economic goods, considered necessary to satisfy social welfare (Richardson & Wood, 2006, p. 6)." Media-based "command and control" legislation would be more acceptable if complemented by the NCA as the importance of preserving and restoring NC for human well-being would be accentuated within environmental planning and management strategies.

Pollution has shifted from visible and noticeable point sources to less visible, more dispersed and global in nature. Climate change, ozone depletion and endocrine disruptors are a few examples of the changing face of pollution. "Regulation is changing to address these environmental threats by shifting the focus from local to global, end of pipe to pollution prevention, reliance on scientific expertise,

shift from a zero-sum to win-win approach and a shift in rhetoric from environmental protection to Sustainable Development (Richardson & Wood, 2006, p. 9)." The NCA will provide the information required for the Media-based Approach to evolve and devise environmental regulation that will be more holistic and effective at reducing global environmental threats. "The new environmental problems call for integrated approaches to environmental regulation that seek to prevent environmental damage throughout the entire product life cycle, from initial conception through raw materials extraction and industrial feedstock formulation to ultimate end of life disposal (Richardson & Wood, 2006, p. 10)." Combining NC accounting and media-based environmental legislation will be effective in addressing global environmental threats. Environmental threats must be addressed by changing the way we measure our well-being in order to transform and reduce economic growth and resource consumption patterns. "The core task is to reorient social and economic systems as if the future mattered (Richardson & Wood, 2006, p. 17)."

The Ecosystem Approach as described by the Convention on Biological Diversity consists of comprehensive environmental management principles. The NCA accounts for the natural environment to facilitate the preservation and restoration of NC. The Ecosystem Approach and NCA objectives are similar and complementary. In essence, the NCA can be considered an important element to the effective implementation of the Ecosystem Approach. Recommendations made at the Trondheim Biological Diversity conference for the implementation of an Ecosystem Approach listed below are used to examine the NCA's compatibility with the Ecosystem Approach (Burgiel & Schulman, 1999):

1. Implementation programs should be designed to adjust to the unexpected.

2. Capacity development, monitoring, information and adaptive and participatory management should be accorded high priority.

3. Further knowledge of ecosystem structure, function and process should be generated, and countries should simultaneously implement the Ecosystem Approach.

4. Scientists and local communities should be integrated into decision-making processes.

5. Socio-economic considerations should be linked to ecosystem functions at the management level.

6. Potentially adverse effects of global trade should be monitored and analyzed, and cost-effective mitigation measures should be developed.

7. Ecosystem management should recognize the diversity of social and cultural factors affecting natural resource use.

8. Methodologies to value biodiversity and ecosystem services should be developed.

9. The Ecosystem Approach should be integrated into agriculture, fisheries, forestry and other production systems affecting biodiversity; and possibilities for ecosystem restoration should be further explored, along with cost-effective restoration techniques.

The Ecosystem Approach recommends the adoption of the precautionary principle or risk management approaches when engaging in activities that may have an impact on ecosystems (Burgiel & Schulman, 1999). Additionally, the approach calls for efforts to gain more knowledge on ecosystem functional relationships, response to human impacts and spatial and temporal dynamics. Understanding and measuring ecosystem integrity is one of the primary obstacles to implementing an

Ecosystem Approach and is a fundamental shortfall of most applications of the NCA (Anielski & Wilson, 2006). Nevertheless, accounting NC measurements provide important information for lowering environmental decision-making with ecosystem impact risks.

Equity is of central importance in the adoption of the Ecosystem Approach (Burgiel & Schulman, 1999). Measuring the benefits and services obtained from the natural world is an important requirement for its valuation, removing perverse subsidies and promoting local incentives for adopting sustainable practices thus leading to a more equitable distribution of ecosystem benefits and revenues for their management.

Ecosystem management is best practiced at the lowest appropriate level while balancing local and central management needs (Burgiel & Schulman, 1999). A NC accounting framework could be a supportive structure for decentralized ecosystems management providing a link between local and central levels of environmental management.

A holistic approach is required to manage ecosystems which transcends sectoral divisions at all levels (Burgiel & Schulman, 1999). NC accounting has not typically been practiced in a holistic manner. In order to account components of the natural environment the NCA tends to dissociate and dissect whole functioning natural ecosystems into parts. The development and incorporation of measures to assess the state of NC in a more holistic way remains a challenge. The European Environment Agency has developed land and ecosystem accounts to measure the state of ecosystems and their benefits to socio economic systems.

The Ecosystem Approach calls for adaptive and flexible management methodologies requiring constant feedback through monitoring (Burgiel & Schulman, 1999). NC measurement and monitoring will permit the assessment of its deterioration or improvement required for developing effective adaptive environmental management methods and policies.

The valuation of ecosystem services and biodiversity is fundamental to the application of the Ecosystem Approach. The development of payments for ecosystem services was an explicit recommendation made by the MA (Millennium Ecosystem Assessment, 2005). Although there are no standardized methods, ecosystem services valuation techniques are currently being devised and implemented. By measuring the physical quantities of ecosystem components and their changes over time, the NCA lays the foundation for the valuation of ecosystem services (Anielski & Wilson, 2006, 2007; Costanza et al., 1997; Olewiler, 2004).

Aside from complementarities there are also differences between the Ecosystem Approach and the NCA. The Ecosystem Approach advocates for the management of ecosystems at the lowest appropriate level while the NCA aims to develop a framework that can be suitable for most spatial scales. The Ecosystem Approach emphasizes the need to understand and manage whole systems, their component parts and relationships which in practice can be onerous. The NCA is conducive for the implementation of an integrated Ecosystem Approach which focuses mainly on understanding the components and interactions that have the greatest impacts on the ecosystem behaviour and that can be modified or controlled through management activities.

Overall, the NCA is complementary to the Ecosystem Approach as it facilitates the reconciliation of local spatially based data. The NCA is limited by its typical lack ecosystem integrity measures but methods are being developed and gradually incorporated to assess ecosystem health (Anielski & Wilson, 2006; J.-L. Weber, 2007).

The NCA is compatible will all three environmental planning and management approaches presented above. It is compatible with the Economic Growth Approach as it uses similar language and

concepts from economic principles to relay the importance of preserving and restoring NC. By virtue of speaking the same language, the NCA incorporates the natural environment within the economic dimension of sustainable development. The NCA can be used effectively by the Media-based Approach in order to develop environmental laws and regulation that are proactive as opposed to reactive. For example similar environmental regulations such as mandatory environmental assessments can be developed to protect and enhance NC instead of imposing financial penalties once it is degraded or lost. In essence, the NCA can move environmental legislation from being punitive to incentive-based, as a common understanding of the benefits preserving and enhancing NC grows. The NCA is also compatible with the Ecosystem Approach as it enables communities to translate the importance of protecting and enhancing natural ecosystems in economic terms to higher levels of government. Nevertheless, the NCA does have some drawbacks as it typically fails to include measures of ecosystems integrity. Anielski (2006) recommends the development and incorporation of ecosystem integrity measurements to provide an NC measure that is more comprehensive and true. In addition, the NCA fails to capture the complexities and uncertainties associated with natural ecosystems.

## 2.4. Conceptual Implementation

The implementation of the NCA into economic and environmental systems poses challenges that are briefly explored. Incorporating the NCA within economic systems implies that it must be treated similarly to other types of capital. Incorporating the NCA within environmental management systems is best accomplished by adopting the Ecosystem Approach which is compatible with a plurality of contexts.

### *2.4.1. Economic Systems*

The incorporation of NC within economic systems is difficult unless its value is captured within economic markets. Indeed, a number of resources are traded in markets but a number of NC elements such as ecosystem services are considered a free resource. Typically only the costs incurred for their extraction, conversion and refinement via human and built capital are factored into the value of market traded NC.

Barton (1999) argues that incorporating NC values within a balance sheet would skew a financial report as there are no generated cash flows or potential sale of the public good, its preservation costs are misaligned with its provision and its valuation is highly subjective. Thus, Barton maintains that natural assets must be differentiated from commercial type assets and they should be accounted for separately. He further adds that NC values could be measured in physical opportunity costs of the resource. Foster argues that in order for the natural environments to be considered "capital" they must be associated to a value or cost. "From a Natural Capital perspective, there are no free gifts of nature, but only an endowment of natural capital which like more conventional forms of capital must be conserved and protected from depreciation in order to guarantee long term productivity (Foster, 2003, p. 70)." Consequently, the NCA expands the narrow preoccupation of economics on human production activities to include the effects of those activities on the natural world (Foster, 2003). Conceptually this seems logical but practically the valuation of NC poses a significant challenge. Hence, Barton (1999) maintains that appropriately crafted ecological and social measures are best suited to facilitate the sustainable management of NC. Furthermore, the management of public goods such as NC is best left in the hands of governments. "In the private sector the purpose is financial (profit) and the means are activities. In the public sector, the opposite applies: the purpose is activities and the means are financial (Barton, 1999, p. 227)."

Incorporating NC within economic management systems can be accomplished in a number of ways characterized by the following:

1. All elements of the natural environment are assigned an economic value to influence human behaviour and widen the scope of economics.

2. The management and valuation of NC is carried out by an entity which represents the best interests of the public.

Many variations between the two characterizations above exist. For example, conservation banking in the United States and BioBanking in Australia have been established by governments to promote the "no net loss" of biodiversity (Fox & Nino-Murcia, 2005; United States Department of the Interior, 2003). Regulations to protect biodiversity from development project impacts have created markets where permits are obtained by supporting offset initiatives. Another variation is proposed by Hansell et al. (2003) where an independent entity representing the interests of the environment is appointed by local governments.The representatives are responsible for issuing and distributing development permits in a "pseudo market" governed by local ecosystem regeneration capacities (Hansell et al., 2003). "An ecosystem functions as a market in which essential services are maintained and regulated by mechanisms such as biological competition, predation and symbiosis in what may be an analogue to the invisible hand of Adam Smith (Hansell et al., 2003, p. 204)."

Beyond current market structures where individual preferences are revealed, public valuation techniques are being developed and implemented (Binning et al., 2001; Cork et al., 2001; Wilson & Howarth, 2002). This could potentially lead to the establishment of localized watershed-based policies or markets where public preferences are expressed to measure trade-offs between ecosystem services and development impacts.

Incorporating the NCA within economic systems requires the development of a means to measure and value the benefits that we currently receive freely from nature. More importantly, it requires the realignment of human behaviour and economic activity with the regenerative and waste assimilative capacity of natural ecosystems (D. R. Boyd, 2003; Foster, 2003; Hansell et al., 2003).

### *2.4.2. Environmental Systems*

Incorporating the NCA within environmental systems requires sensitivity to multiple contexts so it can be compatible with a wide range of environmental planning and management approaches. Dissociated and holistic measures of whole ecosystems are required to be useful in developing effective environmental management policies.

An NCA aligned with the Ecosystem Approach principles will incorporate knowledge of ecosystem structures, functions and processes, temporal and spatial dynamics. In addition, as people are part of ecosystems, understanding human perspectives, influences and preferences as well as social processes cannot be ignored (Dale, 2007b; Waltner-Toews & Kay, 2005). Effective ecosystem management will include ecological and human considerations and their interactive processes (Costanza et al., 1998; Straton, 2006; Waltner-Toews & Kay, 2005). Similarly, the NCA must be cognizant of human and natural systems in order to provide measures that are relevant and useful for sustainable development.

The plurality of social and cultural factors implies that the NCA cannot be overly prescriptive as it must be adaptable to local contexts. Sound scientific information and local knowledge is required to harmonize the NCA with a multiplicity of contexts. Waltner-Toews and Kay (2005) characterize this

approach as "integrating ways of knowing with ways of doing" where ways of knowing includes not only knowledge gained from conventional science but also from other epistemological stances.

The NCA dissociates whole ecosystems into elements that can be measured, quantified and valued. This requirement is described by Foster as follows: "There is no capital in the natural world and the very idea of natural capital whatever its measure will reflect human interests (Foster, 2003, p. 71)." The NCA requires some compartmentalization of the natural environment so that it can be measured and valued (Costanza et al., 1998). In this way the NCA incorporates social processes and human preferences towards resource use within environmental planning and management systems leaving natural valuation estimates open for debate (Straton, 2006).

Along with quantifying ecosystem elements, holistic measurements of ecosystems are required. One of the main criticisms of NC accounting is that it falls short of providing a suitable measure of ecosystems integrity (Anielski & Wilson, 2006). Costanza et al. (1998) call for the development of non-linear models that simulate whole ecosystems to evaluate changes. Winkler (2006a; 2006b) attempts to provide a whole systems evaluation approach by developing an interdependent dynamic model encompassing natural, economic and societal features. His model includes value systems, uncertainty and novelty parameters to explore unpredictable and novel change.

The integration of the NCA within environmental management systems consists of ensuring compatibility with multiple environmental planning and management approaches. This can be achieved by aligning the NCA with the general principles of the ecosystems approach. Accurate disaggregated and holistic measurements of the natural environment are required to eliminate practices that negatively impact ecosystems and promote NC enhancement and restoration efforts. "The maintenance of ecological functionality within the context of economic and social wants and needs is essentially the concept of sustainable development (Straton, 2006, p. 409)."

# 3. NATURAL CAPITAL IMPLEMENTATION INITIATIVES

Natural Capital (NC) implementation and research initiatives are instrumental for building knowledge on implementing a Natural Capital Approach (NCA). Selections of these important NC initiatives are presented and analyzed to deduce lessons for the elaboration of a Canadian NCA.

International initiatives in China and Australia are examined at the government, regional and grassroots levels. High level government initiatives describe efforts to establish NC accounting frameworks. Decentralized initiatives provide insights on how NC related initiatives are manifesting themselves on the ground. This typically involves a number of partners working together to implement sustainable development projects.

In Canada, federal, provincial and regional and Non-government Organizations (NGOs) NC implementation initiatives are providing insights for the development of a unified national NCA. Statistics Canada is devising a statistical foundation for the NCA and the National Round Table on the Environment and the Economy has made explicit recommendations for the preservation and restoration of NC. The Province of Alberta is conducting NC valuing studies and the Greater Vancouver Regional District is devising and implementing biodiversity protection plans. The NC studies completed by the Canadian Boreal Initiative and Ducks Unlimited Canada provide valuable methodological information and results that advance the development and adoption of a Canadian NCA.

Natural Capitalism, The Natural Step and Soft Path Designs are innovative approaches for the implementation of the NCA. They are being embraced by the private and public sectors as they are more sustainable and profitable over the long-term compared to traditional business and development models.

## 3.1. International Initiatives

Initiatives adopted by China and Australia are investigated. China is developing a comprehensive green accounting framework to track the deterioration and enhancement of its NC so it can devise effective environmental policies for maintaining a sustainable economy and enhancing the well-being of its people. Australia has adopted the "Sustainable Australia" framework and is tracking its NC through its "Natural Assets" accounting program. The establishment of the Hainan Province in China into an Ecological Province, and the Ecosystem Services Project in the Goulburn Broken Catchment, Australia will be explored to identify lessons learned from these initiatives.

### *3.1.1. China's Green GDP Index*

China has experienced significant economic growth over the last two and half decades. Their real GDP per capita has grown at an average of eight per cent annually since 1978 (Chen, 2005). Along with achieving impressive improvements in economic growth China has managed to better the education and life expectancy of its people (Chen, 2005). Unfortunately, this unprecedented economic growth and improvements in welfare has come with a heavy price. NC losses and pollution impacts were largely neglected in the initial stages of developing the country's economy. Since 1985, China has considerably increased its investments in pollution-abatement techniques and equipment

to impede and reverse the erosion of its NC. Although these expenditures have helped many environmental damages have been difficult to reverse. For instance, deforestation and desertification is causing severe and frequent sand storm events in Northern China (Bi, Feng, Wu, Wang, & Zhu, 2007; Chen, 2005). Furthermore, the Chinese have had to endure increasing levels air pollution particularly in large cities (Kan et al., 2007; Yi, Hao, & Tang, 2007). The government continues to make concerted efforts to protect their NC by having implemented family planning, ameliorated their environmental protection policies and adopted a strategy for sustainable development (Mitchell, 2002).

In addition, China is investing considerable efforts in developing a Green GDP Index which would account for the degradation of their natural environments and adjust their GDP accordingly. Boyd (2007) defines Green GDP as being a single index which aggregates market goods and services and ecological elements to provide a measure of well-being. "Green GDP "trues up" conventional GDP to account for non-marketed ecological contributions to welfare (J. Boyd, 2007, p. 721)." The State Environmental Protection Administration and the National Bureau of Statistics set out to develop an integrated environmental and economic accounting system for tracking NC depletion (land, minerals, forest, water and fishery resources) and environmental degradation costs (environmental pollution and ecological damage). Ideally the Green GDP Index would evaluate over 20 environmental pollution causes and associated costs. Significant efforts remain before China can boast to have formulated and implemented a comprehensive and accurate national Green GDP Index. Nevertheless, the Chinese government is forging ahead and is becoming a research leader in developing a comprehensive and complete environmental and economic accounting framework (Chinese Academy for Environmental Planning, 2006).

The State Environmental Protection Administration and the National Bureau of Statistics jointly published and released the first incarnation of China's Green GDP Index in "China Green National Accounting Study Report 2004" on September 8, 2006. The accounting system was limited to the evaluation of 10 sources of pollution and associated economic losses: "health, agricultural, and materials losses caused by air pollution; health, industrial, and agricultural production losses and water shortage caused by water pollution; and the economic loss caused by the occupation of land for solid waste disposal (Chinese Academy for Environmental Planning, 2006)." It neglected to incorporate NC depletion and ecological damage due to technical and systematic difficulties. The study found that pollution impacts amounted to 511.8 billion Yuan or 3.05 per cent of the national GDP in economic losses. The pollution abatement infrastructure investment and operation costs required for treating pollutant emissions amounted to 1080 billion Yuan or seven per cent of the GDP and 287.4 billion per year or 1.8 per cent of the GDP. Although this first attempt provided an incomplete snapshot of the economic costs associated with environmental degradation it did quantify conservatively the importance of protecting the environment in order to maintain economic growth and well-being of the country.

A Task Force established by the China Council for International Cooperation on Environment and Development investigated economic growth and environmental questions. They produced a report which provided policy recommendations on balancing the economy and the environment. The five main recommendations that came out of the report were (Jiange & Bartelmus, 2006):

1. Increase investments in environmental protection and pollution control.
2. Enhance mechanisms for collecting valid environmental information.
3. Enhance the circular economy toward environmental protection.
4. Improve environmental management systems by clarifying the authority and responsibilities of the various levels of governments.
5. Reform pricing and taxation mechanisms to include full cost pricing for the use of the environment and natural resources.

Recommendation 2 emphasizes the need for establishing first-class measurement and monitoring infrastructures for collecting reliable environmental information. Specifically, the report recommends (Jiange & Bartelmus, 2006):

- improving national environmental pollution monitoring and tracking systems;
- land use and land cover change monitoring and tracking systems;
- enhancing legal enforcement and supervision capacity for environmental protection;
- expanding green GDP accounting pilot projects and introduce material flow accounting nationwide; and
- providing regular environment and resource information to the public.

In addition, the Task Force provided specific direction on the collection of environmental data and improving the Green GDP Index. The report calls for an assessment of the current status of China's environmental information monitoring infrastructure and the data quality assurance systems. Six detailed recommendations to enhance the Green GDP are (Jiange & Bartelmus, 2006):

1. Incorporate additional information for decision and policy-making.
2. Establish a common national integrated environmental-economic accounting framework.
3. Establish close collaborations between statistical services and data users.
4. Gain experience in green accounting via pilot projects at the various levels.
5. Establish partnerships with ongoing green accounting initiatives and projects.
6. Explore data requirements and availability for modelling trends and options.

China's success in meeting their economic growth and environmental sustainability targets will have a significant impact on the world's NC (Cornelius & Story, 2007). It is imperative for China to evolve in an environmentally sustainable fashion to maintain their economy and well-being. The Chinese government has undertaken the vision of establishing a "Harmonious Xiao Kang Society" which requires that "human and economic development does not undermine China's natural resource base and ecosystems without which the sustainability of human well-being itself would deteriorate (Jiange & Bartelmus, 2006)." To fulfill this sustainable vision, China is becoming a world leader in developing tools for preserving and enhancing their NC which they believe will lead them towards a sustainable future.

### *3.1.2. Australia's Environmental Assets Accounting*

Australia's environmental management policies are centred on their "Sustainable Australia" framework. The Australian Bureau of Statistics tracks and reports on a number of its environmental assets and Australia's Department of Environment and Heritage provides periodic reports on the state of the environment. Australia has in place the essential infrastructure and monitoring and reporting mechanisms for implementing an NCA.

The Australian government has embraced an Ecologically Sustainable Development (ESD) vision for their country which they defined as follows: "using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased (Department of the Environment and Water Resources, 1992)." The idea is also conveyed in the primary goal of the ESD which is: "Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (Department of the Environment and Water Resources, 1992)." The

two main features that are at the core of the ESD are described below (Department of the Environment and Water Resources, 1992):

- decisions and actions must be taken in an integrated way and must consider the social and environmental implications for Australia, the international community and the biosphere; and
- decisions and actions must take into account long-term rather than short-term considerations.

In order to manifest this vision the government of Australia devised a number of guiding principles which must be observed and practiced in a holistic manner to realize Australia's Ecologically Sustainable Development vision. (Department of the Environment and Water Resources, 1992):

- decision-making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations;
- where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- The global dimension of environmental impacts of actions and policies should be recognized and considered;
- the need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognized;
- the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognized;
- cost-effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms; and
- decisions and actions should provide for broad community involvement on issues which affect them.

In addition, to embracing sustainability goals and objectives Australia is also developing tools to measure and monitor its success towards realizing the ESD vision.

The Australian Bureau of Statistics (ABS) has been tracking environmental assets since 1993 within their System of National Accounts as part of their commitment under its Agenda 21 resolution (Australian Bureau of Statistics, 2003; Statistics Canada, 2006a). The ABS tracks environmental assets that fit within an asset boundary in their national and sector balance sheets. An environmental asset fits into the asset boundary only if it has an identifiable owner who can benefit economically from the use of the asset. This guideline has limited ABS's environmental assets accounting to land, subsoil assets and native standing timber. Environmental assets such as water and fish do not have specific boundaries and a specific owner who can benefit economically from their use. "Environmental assets such as atmospheric and terrestrial ecosystems are outside the scope of economic assets as they do not have an identifiable owner (Australian Bureau of Statistics, 2003)." In addition, environmental assets that can only be valued with subjective and tenuous valuation techniques are not included in the balance sheet.

Australia's total assets amounted to 3.46 billion AUSD in 2001, from which 33 per cent or 1.16 billion AUSD of the total consisted of environmental assets (Australian Bureau of Statistics, 2003). Land resources, subsoil assets and standing native timber accounted for 84, 15 and one per cent respectively of the total environmental assets value (Australian Bureau of Statistics, 2003). The values added for services provided by the environment are considered implicit in the value of a product which reflects the input of labour, produced and natural capital. No deductions are made for the depletion or degradation of the natural environment which is problematic as this implies that Australia could completely run down its NC without having any impact on their income. In addition,

natural assets do not depreciate like produced capital assets as they are either extracted and used or degraded as a result of economic activity.
The ABS understands the shortfalls of its national environmental assets accounting approach and is making efforts to make it more comprehensive. They have developed satellite environmental accounts to take into consideration energy, greenhouse gas emissions, fish, water and environmental protection expenditures. Methods for incorporating accounting adjustments for environmental degradation, resource depletion and externalities associated with human activity, imperative for linking national accounts and sustainability, are also being developed (Hill, 2004). In addition environmental pressure indicators are being developed which will be linked to environmental threat contributors.

The ABS has decided to exclude NC non-market benefits such as ecosystem services which are considered to be embedded in the value of final products. Although this rationale is not incorrect it is not conducive to the preservation and restoration of NC. Incorporating ecosystem service values within the national balance sheet would provide additional economic rationale for maintaining and restoring healthy and integral ecosystems. This shortfall is currently being addressed by Australian academic research efforts. Cork et al. (2001) state that economic systems that emphasize individual values and preferences over that of communities leads to ecosystem degradation. The Australian environmental assets accounting system is limited to accounting assets attributed to a specific owner. The ecosystem services project, a research initiative spearheaded by CSIRO, is exploring innovative ways to incorporate community values (such as citizen's juries) within economic decision-making.

### *3.1.3. The Ecological Province – Hainan, China*

The province of Hainan in China has a surface area of 34,000 km² and had a population of 7.3 million people in 2000 (Mitchell, 2002). It is an island surrounded by the waters of the South China Sea and the Gulf of Tonkin with unique biophysical features such as mangroves and native forests, biodiversity and fragile ecosystems (see Figure 2) (Li & Lee, 1997; Zhang, Tachibana, & Nagata, 2006). Thirty-seven species of mangroves have been documented in China and thirty five types can be found in the Hainan province (Li & Lee, 1997). Additionally, Hainan's forests have been identified as being in the earlier stages of forest areas (Zhang et al., 2006). Due to its unique and rich natural environments the provincial government of Hainan decided to become the first official "eco-province" of China in 1999. "The goal of the people of Hainan Province is to achieve an ecological province which has a sound tropical island ecosystem, a developed ecological industry and a culture which achieves harmony between nature and humans and a first rate living environment (Mitchell, 2002, p.


**Figure 2:** Map of the Hainan Province (Maps of China, Undated; Wertz, 1998).

54)." This initiative provides the central government of China with a model for establishing a thriving economy in harmony with the preservation of ecosystems.

In order to achieve this vision the provincial government has identified a number of important goals and tasks to be undertaken. A number of laws, regulations and management systems have been adopted to prevent environmental pollution. It is taking advantage of modern developments in science and technology to facilitate sustainable development. In planning, managing and decision-making the government is now weighing economic, social and environmental benefits as well as short and long-term benefits. It is replacing traditional industrialized development which calls for high energy inputs and leads to increased pollution emissions by developing a high performing ecological economy based on social, economic and cultural ventures that are beneficial to the natural environment.

Central to their efforts in becoming an "ecological province" is the development and establishment of ecological values amongst its inhabitants. The central value that is being inculcated can be summarized as follows: "who disrupts the ecological environment damages productive forces, who preserves the ecological environment protects productive forces and who improves the ecological environment develops productive forces (Mitchell, 2002, p. 53)." To instill ecological values in its populace the provincial government is: spreading scientific knowledge about ecological systems, conducting education programs on ecosystems, promoting and encouraging modes of production and consumption that are beneficial to natural ecosystems, enhancing ecological awareness among decision-makers and entrepreneurs. These efforts will facilitate the realization of their provincial ecological vision.

The province is currently striving to develop and implement eco-compensation policies to protect its natural environments and reduce poverty amongst the local indigenous people who actively engage in conservation practices. In addition, it is believed that the eco-compensation schemes will be applicable and transferable to other parts of China. The central Chinese government is amenable to payments for ecosystems (PES) schemes and has already successfully implemented the Sloping Land Conversion Program (a 50 billion Yuan expenditure and 7.2 million ha of cropland enrolled) and the Forest Ecosystem Compensation Fund (a 2 billion Yuan annual expenditure covering 26 million ha of private forest area) (Scherr, Bennett, Loughney, & Canby, 2006). Information gathering on PES pilot studies and policy developments is currently in progress. The Hainan province has partnered with the World Conservation Union (IUCN) in its information gathering efforts (Sayegh, 2006). The insights collected will be compiled at the end of the project in a report entitled "Provisional Administrative Regulation for Ecological Compensation Mechanism in Hainan Province (Sayegh, 2006)."

China has a top-down culture that is contradictory to the ecological approach described in Chapter 2. Public participation is a notion that can often be foreign in China and unlikely to be applied (Wang & Wall, 2007; Xu, 2005). Wang (2007) describes a case where people in Hainan province were forcibly relocated to make way for the development of tourism operations, to explain how top-down planning can be ameliorated to accommodate for the needs of the weak and displaced stakeholders. Nevertheless, the Chinese central government and the Hainan province are making efforts to incorporate stakeholder welfare considerations and public participation in its decision-making, planning and management processes with respect to their development efforts. The Chinese central government is showing signs of supporting local governance for the management of natural resources (Xu, 2005). For example, "the Organic Law of 1998 granted villages the legal right to self-government and gave indigenous communities greater responsibility for land and resource use (Xu et al., 2005)."

In summary, the Hainan province strives to become an "Ecological Province" by instilling in its residents the central value that protecting and enhancing the natural environment is analogous to protecting and enhancing "productive forces." It has also adopted laws, regulations and management systems to protect the environment and adopted balanced planning, management and decision-making that permit them to weigh social, economic and environmental, short term and long term benefits which is conducive to sustainable development. Although China has typically governed in a top-down fashion, the province of Hainan is taking steps to encourage public participation in their development efforts to become a sustainable "Ecological Province" aligning themselves with the principles of the ecosystem approach.

### *3.1.4. Ecosystem Services Project – Goulburn Broken Catchment, Australia*

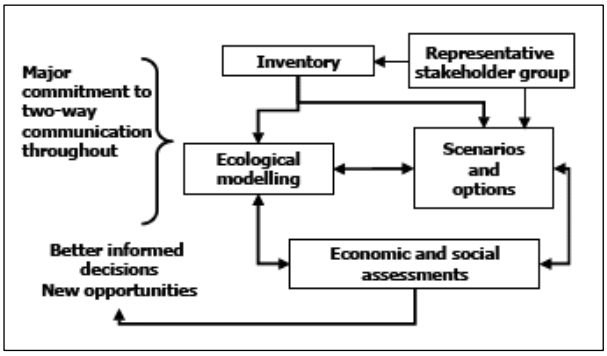


**Figure 3:** Ecosystem Approach Framework for Australia (Cork, Shelton, Binning, & Parry, 2001).

The ecosystem services project, initiated by CSIRO and the Myer Foundation, consists of seven different case study regions covering various parts of Australia. The primary goal of the ecosystem project is to learn how best to provide the right information to policy developers and decision-makers to initiate and introduce land management practices that are more sustainable (Binning et al., 2001). The ecosystem project builds on the ecosystem approach depicted in Figure 4.

The Goulburn Broken Catchment located in Northern Victoria is one of the seven regions being studied. Considered the "food bowl" of Australia it has a land surface of 2.5 million hectares and is home to approximately 200,000 people (Binning et al., 2001). The northern region of the catchment is primarily used for irrigated agriculture, the central dryland is used for grazing and cropping and the southern high country region supports a thriving tourism industry and is valued for its recreational uses. The Goulburn Broken Catchment is experiencing significant economic growth (an expected GDP of $4.37 billion in 2005) (Binning et al., 2001).

The ultimate goal of the Ecosystem Services Project in the Catchment is succinctly described as follows: "The Catchment's economic and social wealth is inextricably woven into the fabric of the region's natural resource base. In order to maintain this base it is essential that natural assets and the ecosystem services that flow from them remain healthy and viable (Binning et al., 2001, p. 2)." A Natural Assets inventory was initiated to explore the interdependencies between the Natural Assets, Ecosystem Services and Goods produced within the catchment. The conceptual framework below shows the dependence of the production of goods on the natural assets within the catchment. The inputs to the production of goods, regeneration of the natural assets and assimilation of wastes are provided by ecosystem services derived from natural assets. For example, flowers, pollen and pollinators (insects, birds, etc…) are natural assets that are integral for the ecosystem service of pollination which could be important for the viable production of certain fruits, vegetables and crops. A reduction in natural assets leads invariably to a deficit in ecosystem services.

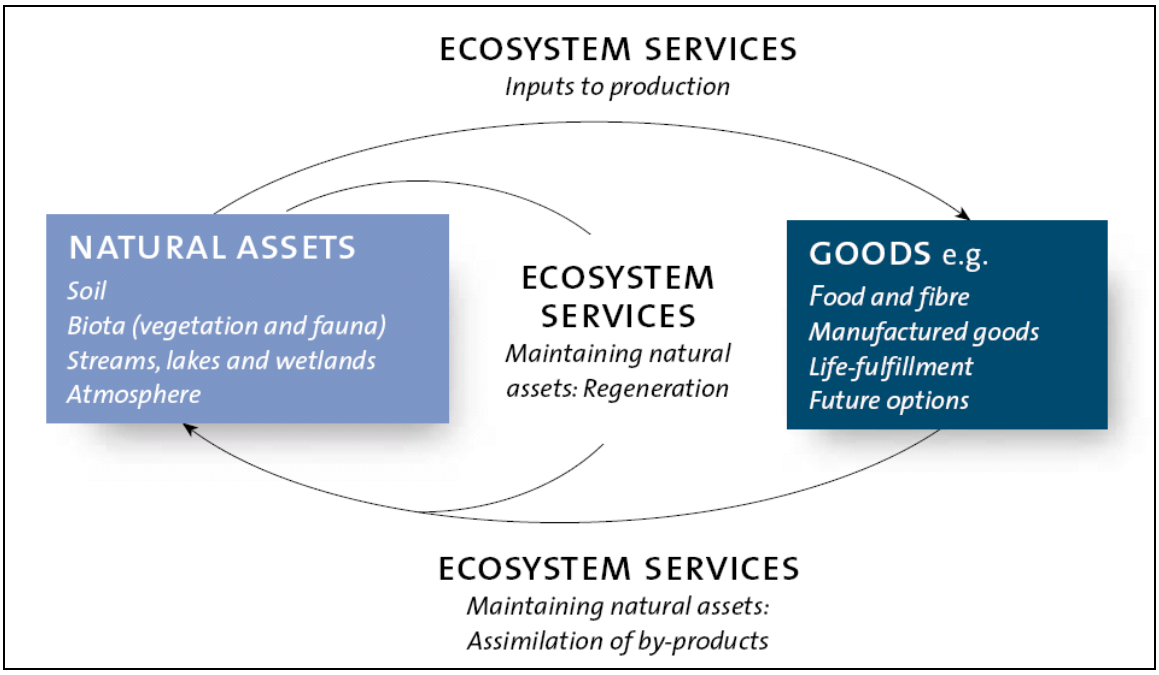


**Figure 4:** Goulburn Broken Catchment Natural Assets conceptual framework (Binning et al., 2001, p. 5).

The inventory begins by identifying the various industries, associated goods derived from them and their respective monetary values. It then goes on to identify and assess the ecosystem services that are important for the production of the goods and the impact of the land-use or industry on the capacity of the natural assets to provide the service. From this inventory, findings are derived and summarized into key issues for policy development considerations.

Each ecosystem service is described in light of its importance to the industry it supports within the catchment. The various threats undermining the viability of natural assets and opportunities and actions that could enhance the provision of the ecosystem service are explored. Suggestions are then provided for ensuring that the ecosystem services provision is maintained by either identifying knowledge gaps or adopting remedial actions.

The strength of the Natural Assets approach is that the ecosystem services focused on are clearly linked and imperative to the livelihoods of the catchment population. Natural Assets can then be managed for the value they provide as opposed to attempting to remediate problems surfacing from inappropriate natural resource management (Binning et al., 2001). The main shortfall is that goods produced within the catchment and their relative importance will change with time. Therefore, centering a natural assets assessment based on the production of particular goods may be difficult and costly if they change frequently.

Recommendations to improve the approach have been devised. A full assessment of the substitutability of the ecosystem services must be integral to the natural assets approach so that best management practices can be determined. For instance, fertilizers and pesticides can replace ecosystem services which will lead to a discussion of the pros and cons of more intensive agricultural systems in the catchment. The importation and exportation of goods into the catchment must be included in the assessment so that their impacts internal and external to the catchment can be considered. The influences of markets and institutions on land-use and production methods require examination to predict with greater accuracy the importance of ecosystem services to future land-uses.

## 3.2. Canadian Research Initiatives

Relevant Canadian ongoing research initiatives provide additional and useful insights for the development of an NCA for Canada. Federal, Provincial and Regional and Non-government Organization implementation initiatives are presented.

Initiatives for adopting the NCA at the federal level have been initiated within various ministries. Statistics Canada was instrumental in promoting the importance of national environmental data collection in the late 1970s. Their work is foundational for implementing an NCA within Canada. The National Round Table on the Environment and the Economy's report on securing NC provided 20 recommendations for the conservation of NC within Canada. These recommendations facilitate the development, implementation and fine tuning of an NCA to operationalize sustainable development.

Initiatives for incorporating NC preservation and enhancement programs are unfolding within provincial and regional levels of government. Alberta Environment in partnership with Environment Canada is working on the valuation of their water resources. The Greater Vancouver Regional District is progressing towards incorporating programs to enhance biodiversity.

NGOs have played a key role in advancing the body of knowledge on Natural Capital. Anielski and Wilson's report for the Canadian Boreal Initiative and Oleweiler's report for Ducks Unlimited and The Nature Conservancy of Canada are seminal Canadian NC research efforts.

### *3.2.1. Statistics Canada*

David Rapport and Anthony Friend (1979) of Statistics Canada expressed the need for collecting environmental information by publishing "Towards a comprehensive framework for environmental statistics: A stress-response approach" in 1979. The document promoted the collection of environmental data in order to (Rapport & Friend, 1979, p. 14):

- "properly assess environmental and economic trade-offs;
- indicate areas in which new or modified environmental legislation is required;
- enable the public to evaluate the "quality" of the environment; and
- preserve and rehabilitate endangered ecosystems."

The ultimate goal was to characterize the relationship between human activities and the transformation of the state of the environment by measuring environmental stressors and consequent environmental, collective and individual responses (Rapport & Friend, 1979). With this document, Statistics Canada laid the groundwork for tracking information on the health of natural environments.

Statistics Canada currently tracks a variety of environmental information under the following categories: Air and Climate, Environmental Protection, Environmental Quality, Natural Resources and Pollution and Waste. Economic and physical data are collected on a wide range of environmentally related information such as expenditures for environmental protection, withdrawal uses of water, forest areas and timber stock values. In addition to publishing data and statistical analyses, Statistics Canada also conducts research and publishes reports on Human Activity and the Environment (HAE) and Linking the Environment and the Economy (EConnections). Research on HAE is published annually and provides Canadians with a statistical depiction of human activity and

its relationship to the natural environment. "HAE reports are organized using the state-pressure-response framework, in which information is classified as measuring the state of the physical environment at a point in time, the pressure placed on the environment by human activities, or the socio-economic response to environmental conditions (Statistics Canada, 2006b, p. 5)." The Econnections program focuses on publishing a number of indicators to track progress on economic development and environmental sustainability. This research aims to develop a strong link between the economy and the environment. Statistics Canada continues to expand their work on measuring and tracking the condition of Canada's natural environments.

Statistics Canada and the OECD have recently released a working paper, for the Economic Commission for Europe Conference of European Statisticians, which outlines general requirements for developing an NC measurement framework by tracking NC stocks, flows and states (Smith & Smith, 2006). NC stocks consist of the natural resources and the land which provide materials and services, for a particular time period. Their measurement is often problematic particularly when they do not have market values. Flow measurements enable the forecasting of how human activities will degrade or enhance NC over time and can be categorized into quantitative and qualitative measurements. Quantitative flow measurements consist of activities which impact the quantity of NC such as the extraction or restoration rates of natural resources. Qualitative measurements consist of activities that degrade or enhance the health of the natural environment such as waste flows, rates of change in land-use and land cover. Environmental investments are also considered flow measurements as they can enhance or degrade NC. Measuring the state of the natural environment consists of qualitatively measuring the outcomes of ecosystem functions. Ecosystems cannot be measured directly but the outcomes of their functions can be measured qualitatively. For example, air quality, water quality, biodiversity and soil fertility are qualitative measures of ecosystem function outcomes. State measurements are important for environmental planning and management. Due to our limited understanding on the complexities of ecosystem functions they require substantial development. The working paper concludes by recommending further research efforts in standardized NC valuation techniques, developing a better understanding of what is meant by substitution with respect to ecosystem services and expanding our body of knowledge on ecosystem functions in order to better define and measure their qualitative outcomes.

The Canadian System of Environmental and Resource Accounts developed by Statistics Canada, starts incorporating the ideas discussed above and is presented in detail in section 4.1.3. The important work being spearheaded by Statistics Canada is integral to the development of the NCA within Canada.

### *3.2.2. National Round Table on the Environment and the Economy*

As part of the National Round Table on the Environment and the Economy's (NRTEE) efforts to improve the quality of economic and environment policy developments, a State of the Debate Report was compiled on "Securing Canada's Natural Capital: A Vision for Nature Conservation in the 21st Century." The report, published in 2003, was produced by the Round Table Conservation of Natural Heritage Task Force composed of 26 representatives from governments, public and private sectors.

The goals of the program and ensuing report were to promote the stewardship of our natural environments among Canadians and to mold and uphold new and current tools to better preserve, maintain and restore the long-term health of ecosystems (National Round Table on the Environment and the Economy, 2003). At the core of the report lies the notion that "natural capital provides the fundamental underpinnings of a healthy society and economy (National Round Table on the Environment and the Economy, 2003, p. 4)." The report proposes a strategic framework for action and 20 recommendations.

The strategic framework for action proposed by the NRTEE consists of around five core elements leading to better conservation practices for the preservation and enhancement of Canada's Natural Capital.

1. Adopt integrated planning on whole landscapes to devise conservation solutions that incorporate social, economic and environmental values. Integrated land-use planning must be adopted in order to make informed decisions on conservation and development requirements.

2. Encourage industry to become better stewards of the natural environment. There are currently little government incentives for industry to preserve or restore natural environments. All levels of government must examine and reshape their policy and legislative structures to promote voluntary stewardship by resource industries.

3. Support and encourage Canadian stewardship of the natural environment by promoting community conservation planning and monitoring. Incentives should be devised by the federal government for private landowners to conserve and encourage stewardship actions.

4. Build a strong and accessible knowledge base for conservation in Canada. Effective conservation planning requires comprehensive conservation information. The development of a coherent and nationally consistent conservation knowledge database should be a priority.

5. Incorporate the value of nature in economic decision-making by valuing NC. Conservation considerations must be appropriately valued to incorporate them in economic decision-making within government. The development and standardization of NC valuation methodologies would greatly facilitate the inclusion of NC values within economic decision-making.

The strategic framework for action is supported by 20 specific recommendations which are grouped into; Conservation planning programs, methods and priorities; Enhancing the NC conservation knowledge base; Development of policies and incentives for conservation stewardship; Investments in NC conservation. The recommendations are presented in detail below.

Conservation planning programs, methods and priorities are provided in the report. The NRTEE recommends the following conservation planning measures:

1. Conservation plans must be devised rapidly for the Mackenzie Valley and the Canadian Boreal Forest.
2. Integrated land-use planning must be adopted by all levels of government so that conservation and industrial development decisions can be weighed evenly in a timely fashion.
3. Federal and provincial governments must complete conservation and land-use plans before issuing licences for major construction or extractive operations such as oil or gas pipeline constructions.
4. Priority sites in fragmented southern landscapes must be conserved by supporting local community planning and monitoring activities.
5. Developing a national sustainable tourism strategy would enhance economic benefits of protected areas for local communities.
6. The network and comprehensive conservation plans of the Marine Protected Areas must be completed by 2003.

Enhancing and expanding Canada's conservation knowledge would greatly assist Canadians in becoming better environmental stewards. Recommendations pertaining to improving Canada's conservation knowledge base are:

1. Establishing a conservation information database consisting of (National Round Table on the Environment and the Economy, 2003, p. xvii):
    - A national electronic biodiversity information network.
    - A standard national classification of both terrestrial and aquatic biological communities.
    - A national land-cover monitoring program.
    - A national gap analysis program.
    - A publicly accessible digital map and database of all conservation areas in Canada.
    - A nationally coordinated community monitoring network to provide for the specific needs of local and regional stakeholders.
2. Developing a suitable system of national accounts, the Canadian Information System for the Environment and a standardized methodology for the valuation of Natural Capital.
3. Developing GIS decision support systems that can be used by communities in social, economic, conservation planning and community development.
4. Establishing the Canadian Biosphere Reserve Secretariat to coordinate the work of reserves and share best practices for regional conservation planning.
5. Supporting traditional land-use studies for Aboriginal communities to enhance the local traditional ecological knowledge base.

The establishment of incentives for the conservation of NC within the public and private sectors by various levels of government will greatly promote the stewardship of the natural environment. Recommendations for providing incentives for environmental stewardship are:

- Enhancing the benefits of conservation for Aboriginal communities.
- Establishing policies and legislative structures that promote voluntary stewardship amongst resources industries.
- Developing and introducing a suite of conservation incentives for private landowners via Environmental Farm Plans or their equivalents.
- Enhancing the Ecogifts Program to encourage private landowners to conserve ecologically sensitive lands.

Investments in NC conservation are primordial. The NRTEE recommends expenditures in a number of ongoing programs and the establishment of the National Conservation Fund to secure NC for future generations. The NRTEE recommended the following expenditures for NC conservation:

- $500 million over five years to implement Canada's Ocean Strategy.
- $50 million over five years to fund the SeaMap program, identify information gaps, collect new information and produce a "State of the Oceans" report to be published every five years.
- Fund over five years the establishment of new parks ($300 million) and the enhancement of the network of wildlife areas and migratory bird sanctuaries ($175 million).
- Establish a National Conservation Fund to encourage provinces, territories and conservation community groups to match federal investments in conservation. The funds would be utilized to support priority conservation activities.

The last recommendation called for the establishment of a Prime Minister's Conservation Council to monitor and report on the government's progress on adopting the recommendations outlined in the report.

At the core of the recommendations, provided by the NRTEE, is the need for expanding and enhancing the NC conservation knowledge base. The development of standardized methods and measurement techniques for monitoring and valuing NC is in its infancy in Canada. Making

Canadians aware of the significant impacts that NC losses will have on well-being will garner more support for NC conservation planning, incentive programs and investments. Expanding, enhancing and disseminating NC conservation knowledge is crucial for the preservation and restoration of NC and the adoption of an NCA. The report concludes by stressing that time is of the essence and that Canadians must act quickly to instil in all its citizens a sense of stewardship for natural environments and that the conservation of NC is crucial to maintain human well-being and a competitive economy

### *3.2.3. Province of Alberta*

Western Canadians recognize the importance of their natural heritage and believe that environmental protection and economic prosperity are complementary (Worbets & Berdahl, 2003). In a recent poll conducted by Ipsos Reid, the state of the environment was the leading concern amongst Albertan residents (Ipsos Reid, 2006). The Canada West Foundation states that there is a need in Western Canada "to recognize and celebrate natural capital; to measure our success in preserving natural capital; to protect and build natural capital; to respect dominant land-uses (such as protecting agricultural and ranching lands); to identify and develop opportunities for sustainable wilderness, heritage and urban tourism, and to create new integrated management systems for land and water resources (Worbets & Berdahl, 2003, p. 1)." The long-term well-being and prosperity of Western Canada depends on its ability to balance economic growth and environmental preservation.

Competing interests for the use and access to Alberta's water resources have encouraged Alberta Environment in partnership with Environment Canada to work on gaining an understanding of the full value of water within the province. This was necessary as the rapid expansion of their population and industries, with special reference to the oil and gas sectors, are increasingly straining the quality and quantity of their surface and ground water. Building on the work completed by Gardner and Pinfold for Environment Canada and Statistics Canada (Gardner Pinfold Consulting Economists Limited, 2000, 2002), the province of Alberta has been progressive in attempting to incorporate NC considerations in their environmental management frameworks. A study has recently been completed by Garnder Pinfold Consulting Economists Limited (2006) that assesses the overall value of water of the South Saskatchewan River Basin (SSRB) to be approximately 1 billion CDN in 2004. This estimate is conservative as minimum values were used and a number of data gaps existed. The research team examined water values by water consumption activities which are summarized in Table 1.

| TABLE 1: South Saskatchewan River Basin Water Values | | | | |
|---|---|---|---|---|
| **Consumption activity** | **Description** | **Water Consumption ($m^3$)** | **Water Values ($million)** | **Valuation Technique** |
| Agricultural Production | Crop production, livestock watering and greenhouse production. | 2.9 billion | 202 | Rent Valuation Techniques (a variation of the cost-savings approach) and Replacement Cost (the installation costs of wells to make up for surface water shortfalls) |
| Domestic Use | Municipal, farm and rural non-farm household water consumption. | 212 million | 460 | Derived Market Demand Curve Approach and Willingness to Pay. |
| Commercial Activities | Businesses and Institutional water consumption. | 77 million | 42 | Derived Market Demand Curve Approach and Willingness to Pay. |
| Industrial Production | Chemical, petroleum refining, pulp and paper and food processing industries. | 344.5 million | 138 | Shadow Price Value |
| Oil and Gas, Mining and Mineral Activities | Oil and Gas Extraction mining and mineral production | 6.3 million | 4.1 | Cost of Water Intake, Treatment and Recirculation. |
| Hydro Power Generation | Flow of water providing hydraulic power to turn turbines | 377.5 billion | 38.4 | Alternative Cost Approach (replacing hydro power with thermal power plants) |
| Thermal Power Generation | Water used for cooling | 113.5 million | 78 | Alternative Cost Approach (replacing coal power with gas power plants) |
| Recreation Activities | Recreational fishing | N/A | 15.4 | Benefit Transfer Approach |
| Passive Uses | Pleasure gained from the existence of a body of water. | N/A | 21.5 | Benefit Transfer Approach |
| Ecosystem Services | Wetland and riparian habitat services | N/A | N/A | Was not estimated but partly captured in recreational and passive uses. |

The results obtained from this water valuation exercise display the economic importance of water for the activities being carried out in the SSRB. Without access to water resources a number of the activities listed above would not be possible or economically feasible. The overall water resource value estimate is conservative as because is irreplaceable for a number of human activities such as drinking, crop growing, and fishing.

This study also highlights the importance and need for gathering accurate NC data. Many data gaps still exist in the valuation of NC, particularly for passive use ecosystem service values. Although Gardner Pinfold Economist Limited (2006) did not include additional ecosystem services, due to a lack of data and a concern for double counting, they acknowledge that estimating additional ecosystem service values would increase the value of water in the SSRB significantly. It is imperative to have in place NC measurement, monitoring, data collection and quality control techniques and infrastructures in order to implement an effective and useful NCA. For example, if the water treatment service value by wetlands and riparian areas was to be estimated it would help build an economic rationale for their protection from development. This argument can be extended to all other forms NC. Environmental planning and management strategies will only be effective if they stem from NC data that is reliable.

### *3.2.4. Greater Vancouver Regional District*

The Greater Vancouver Regional District (GVRD) is currently developing a business case for biodiversity conservation. In doing so, the GVRD is integrating NC within the district's economic analysis for enhancing biodiversity and ecosystems services which will benefit human well-being. Biodiversity is defined as the variety of species and ecosystems on earth and the ecological process of which they are a part of including ecosystem, species and the genetic diversity components (Greater Vancouver Regional District, 2004).

The GVRD's biodiversity includes and is supported by a network of natural areas, urban forests, riparian and foreshore areas, and public and private open spaces.

> "While there are significant green reserves in the region, there is a lack of coordination in land management to conserve biodiversity. Development patterns have resulted in habitat fragmentation, impaired ecological functions, increases in invasive species and species at risk which impact the region's livability and sustainability (Haid, 2006, p. 2)."

For these reasons the Biodiversity Conservation Strategy for the Greater Vancouver Region was developed. The mission of this strategy is "to work collectively to understand, identify and conserve a diversity of natural habitats and life sustaining functions while recognizing the inseparable links between the health of the environment, sustainable communities and quality of life (Greater Vancouver Regional District, 2004)." Partners of this strategy include the Georgia Basin Action Plan, Burrard Inlet Environmental Action Plan, Fraser River Estuary Management Plan, Environment Canada, BC Ministry of Environment, GVRD.

The Biodiversity Conservation Strategy was developed in 4 phases. In Phase I the partnership was formed to share information, identify gaps, and set targets. Phase II was comprised of two parts: 1) Issues Assessments where key roles, issues and priorities were defined. 2) Habitat and Biodiversity Assessments which provides a broad regional assessment based on technical data, studies and mapping. In this step a set of indicator species and habitat requirements were listed in a report used to evaluate biodiversity. A case study was also conducted in the highly urbanized Still Creek watershed to evaluate the status of biodiversity, develop strategies that build on the Still Creek Integrated Stormwater Management Plan and test the applicability of the City Green modelling tool.

In Phase III focus was put on clarifying the mission, goals and priorities that are summarized in three reports investigating issues and strategic directions. A broad regional assessment of biodiversity was conducted and maps were prepared for biodiversity conservation planning. A regional habitat assessment was also conducted along with an interpretation of the mapping assessment. Phase IV aimed to define core habitat areas and corridors, identify actions and promote opportunities for cooperative land management. During this phase a workshop was conducted on December 15, 2004, to obtain input from stakeholders on the preliminary directions for the strategy. This was followed by another workshop on July 13, 2006 where stakeholders helped build the Action Plan.

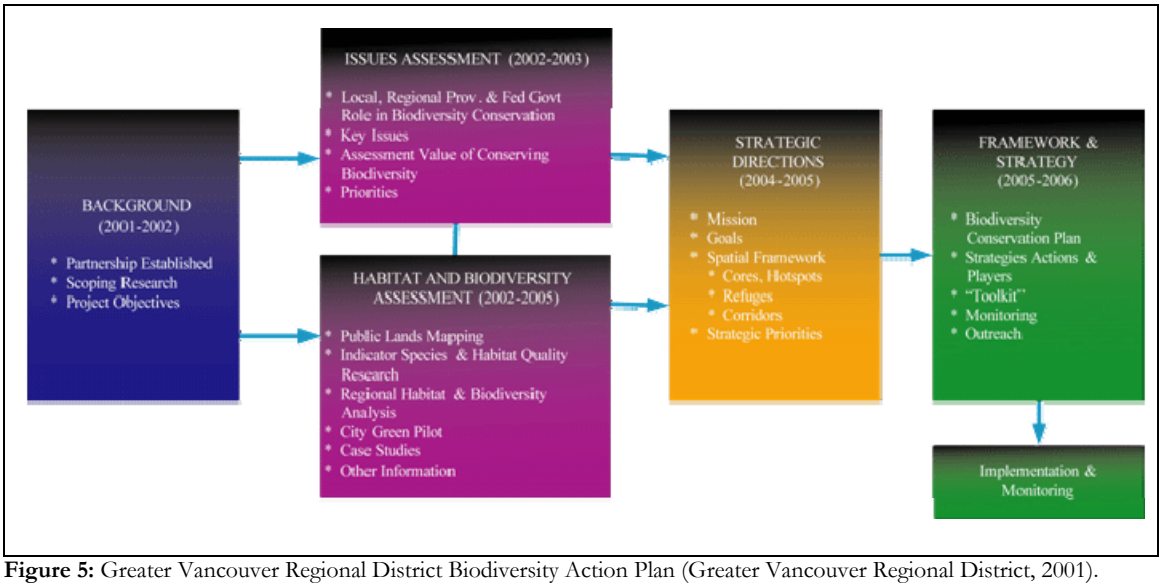


**Figure 5:** Greater Vancouver Regional District Biodiversity Action Plan (Greater Vancouver Regional District, 2001).

A draft Biodiversity Action Plan is now being developed, the key goals of which are to:

- Conserve significant ecosystems and habitats;
- Connect habitat areas into a network;
- Enhance the quality and diversity of existing habitats.
- Understand and share information about the value of biodiversity;
- Collaborate and build partnerships.

Ultimately, this project will develop a strategic framework with information and tools for partners to work together to conserve biodiversity. It will identify and include (Haid, 2006):

1. Areas of regional biodiversity significance
2. Existing and potential regional habitat corridors
3. Areas of regional biodiversity significance within and outside of protected areas and the Green zone
4. Management strategies and tools to (Haid, 2006, p. 3):

    - Conserve priority biodiversity areas inside and outside of the Green Zone.
    - Protect species at risk.
    - Control invasive species
    - Maintain and establish regional ecological corridors.
    - Conserve biodiversity on farmland (i.e. cover cropping, hedgerows, edge management).

- Conserve biodiversity in urban areas and as part of future developments (i.e. native plantings, pesticide reduction, etc.).
- Share and improve regional habitat and biodiversity mapping.
- Monitor biodiversity regionally.
- Communicate the importance of biodiversity in regional sustainability.

By virtue of working towards enhancing its biodiversity GVRD is preserving and restoring its NC which will benefit the local human and wildlife populations.

### *3.2.5. The Canadian Boreal Initiative*

In "Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems," Mark Anielski and Sarah Wilson present the economic value of the many ecological goods and services provided by Canada's boreal region which covers 58.5 per cent of Canada's land mass (Anielski & Wilson, 2006). For this purpose, they developed the Boreal Ecosystem Wealth Accounting System (BEWAS), a tool for measuring and reporting on the physical conditions and the full economic value of the boreal region's natural capital and ecosystem services (see Figure 7). The goal of organizing the broad range of ecological services provided by Canada's boreal region into a BEWAS is to give Canadian decision-makers an NC balance sheet for assessing the sustainability and full economic value of the boreal regions. Most of the ecosystem services identified and measured in the BEWAS go unaccounted for in conventional economic decision-making. This study, however, begins to estimate some of the economic value of the boreal region's ecological services using the BEWAS as an analytic and reporting framework. The results of the preliminary economic valuation estimates are summarized Table 2.

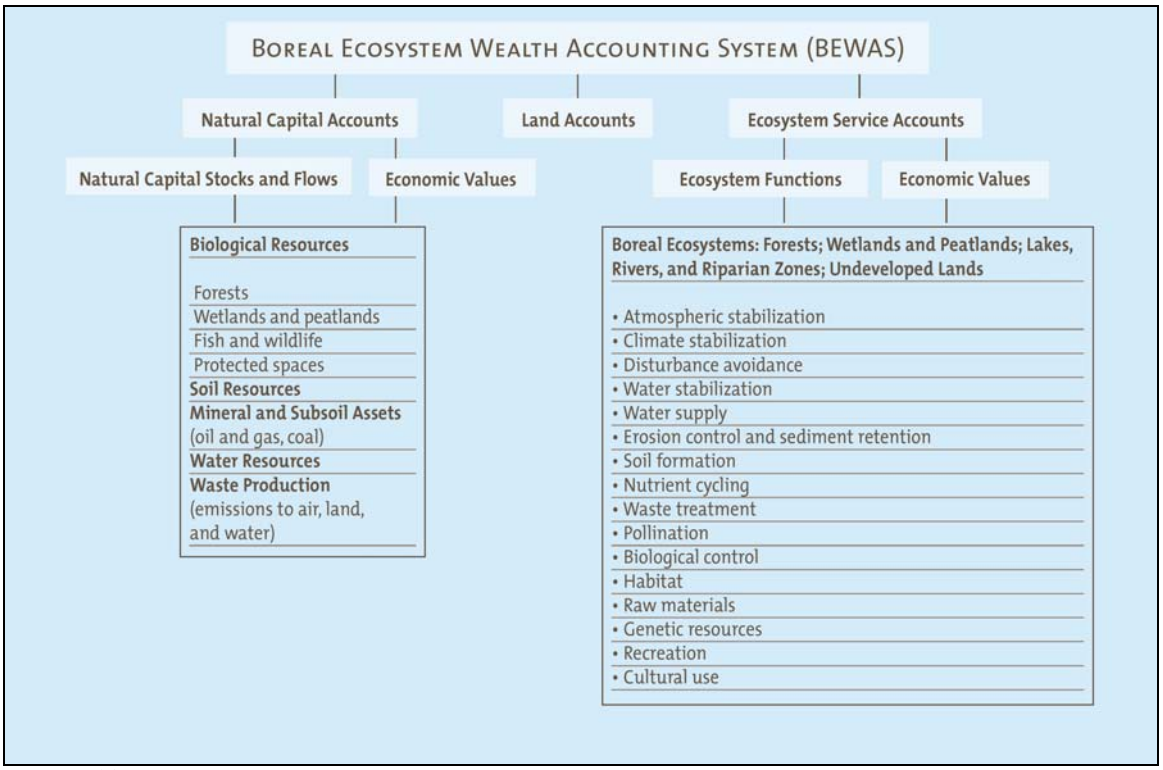


**Figure 6:** The Boreal Ecosystem Wealth Accounting System (Anielski & Wilson, 2006, p. 15).

| **TABLE 2: Summary of Natural Capital Economic Values for Canada's Boreal Region** (Anielski & Wilson, 2006, p. 62) | |
|---|---|
| Boreal Ecosystem Wealth Natural Capital Accounts | Monetary Economic Values (2002$ per annum) |
| Forests | **Market values:**<br>• $14.9 billion in estimated market value of forestry-related GDP in the boreal region (est. 2002)<br>**Costs:**<br>• $150 million in estimated cost of carbon emissions from forest industry activity in the boreal region (deduction against forestry-related GDP)<br>**Non-market values:**<br>• $5.4 billion in value for pest control services by birds<br>• $4.5 billion for nature-related activities<br>• $1.85 billion for annual net carbon sequestration (excludes peatlands)<br>• $575 million in subsistence value for Aboriginal peoples<br>• $79 million in non-timber forest products<br>• $18 million for watershed service (i.e., municipal water use)<br>• $12 million for passive conservation value |
| Wetlands and peatlands | **Non-market values:**<br>• $77.0 billion for flood control and water filtering by peatlands only<br>• $3.4 billion for flood control, water filtering, and biodiversity value by non-peatland wetland<br>• $383 million for estimated annual replacement cost value of peatlands sequestering carbon |
| Minerals and subsoil assets | **Market values:**<br>• $14.5 billion in GDP from mining, and oil and gas industrial activities in the boreal region (est. 2002)<br>**Costs:**<br>• $541 million in federal government expenditures as estimated subsidies to oil and gas sector in the boreal region<br>• $474 million in government expenditures as estimated subsidies to mining sector in the boreal region |
| Water resources | **Market values:**<br>• $19.5 billion in GDP for hydroelectric generation from dams and reservoirs in the Boreal Shield ecozone (est. 2002) |

The market values associated with the use of some of the boreal region's NC resources (e.g. timber, minerals, water) are calculated based on estimates of their contribution to Canada's GDP which are adjusted for some of the negative environmental and societal costs associated with natural resource extraction activities. The estimated net market value of boreal NC extraction in 2002 is estimated at

$37.8 billion. The estimated total non-market value of boreal ecosystem services, which include the economic value of carbon sequestration by forests and peatlands, nature related recreation, water supply and regulation, in 2002 is $93.2 billion. Therefore, the total non-market value of boreal ecosystem services is 2.5 times greater than the net market value of boreal natural capital extraction. This result suggests that the ecological and socio-economic benefits of boreal ecosystem services, in their current state, are significantly greater than the market values derived from current industrial development. The primary shortcoming of the BEWAS estimates for 2002 is the lack of data on both NC and the condition of ecosystems.

Wilson and Anielski continued their work by publishing 'The Real Wealth of the Mackenzie Region' (Anielski & Wilson, 2007). This study is the first attempt at establishing a preliminary account of the spatial distribution of natural resources, land covers and ecozones, and their respective economic, societal and ecological values within a Canadian watershed.

The Mackenzie watershed which includes the Mackenzie River covers 170 million hectares, an area 2.6 times the size of the province of Alberta. The study advances a light emission intensity technique based on satellite imagery to make GDP estimations, assesses NC inventories and adopts ecological valuation methods to help decision-makers balance economic development while sustaining natural environments.

Based on the light emission analysis, the GDP in the Mackenzie watershed was totaled at $41.9 billion while the "Ecosystem Services Product" (ESP) values for various land cover types totaled $448 billion. Unlike the Boreal wealth accounts, this study did not include government subsidies, pollution costs or other externalities measures such as carbon emissions from industrial operations industries. These costs which can be estimated to be roughly 23 per cent of the market GDP, should be deducted as a depreciation cost. The key contributors to the ESP values include climate regulation (carbon storage and annual carbon sequestration services) and water stabilization, regulation and supply.

To account for the impact of oil, gas, forestry and agricultural developments, the authors use satellite imagery to map the extent of linear disturbance associated with these activities and overlaid these on the land cover map to estimate how much of the land cover has been impacted. Figure 7 shows how much area within the watershed has been impacted by linear disturbance and thus may be experiencing potential stresses or losses in ecosystem functions. Since it is difficult to translate the fragmentation and loss of ecological integrity into losses in the value of ecological goods and services, the authors suggest that a range of ecological depreciation costs could be used, from 0 to 100 per cent of potential ESP values depending on the land cover or ecozone type, in relation to the degree of anthropogenic disturbance. The authors emphasize that this is a first step and that further work could be undertaken to assess the

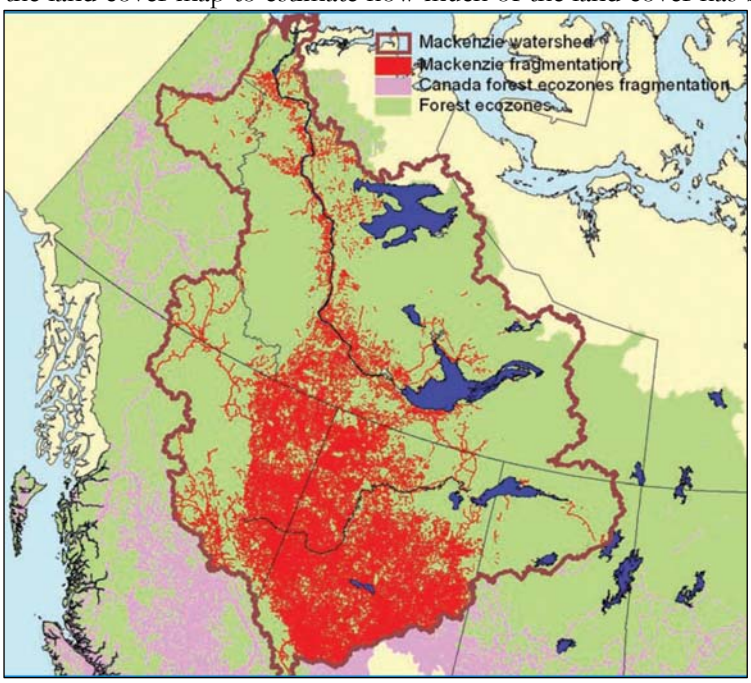


**Figure 7**: Human disturbances in the Mackenzie Valley watershed (Anielski & Wilson, 2007, p. 17).

cumulative ecological impact of industrial development and associated losses in ESP. To highlight the erosion of capacity for ecological service, reference is made to the cumulative impact analysis carried out by biologist Brad Stelfox on the industrial and agricultural development in Alberta. He estimates a loss of 250 million tones of forest biotic carbon representing a $9.6 billion loss based on recent carbon value estimates (Anielski & Wilson, 2007).

In conclusion, the authors have shown that the full wealth of the Mackenzie and Boreal region is significantly discounted when measured only in terms of market value. Since NC accounting and management is in its infancy within Canada, they make the following general recommendations:

1) Comprehensive inventories of NC values are undertaken at national, provincial, territorial and regional scales.
2) Research be undertaken to better understand the relationship between industrial development and NC.
3) Consistent values and methods for NC accounting are adopted on a national basis.
4) Decision-makers move more actively to safeguard areas where NC values can be secured across Canada's boreal region for the benefit of current and future generations.
5) Innovative mechanisms to integrate NC values into market-value economics and sustainable practices must be explored.

### *3.2.6. Ducks Unlimited*

Ducks Unlimited Canada (DUC) has taken a leadership role in shedding light upon the value of Canada's NC by commissioning several researchers to analyze, quantify and qualify existing social, economic and environmental data, with a special emphasis on wetland systems. The position of DUC is that our "Natural Capital is often overlooked in the calculation of Canada's assets, even though the goods and services they produce are vital to the health and survival of our population and economy (Ducks Unlimited Canada, 2006)." Large volumes of financial data have been collected which clearly establish the environmental, social and economic values and interrelationships of Canada's natural heritage, and to demonstrate the importance of including NC in all phases of planning and decision-making. This data supports the following statement made by the Government of Canada in 2005 on Natural Values: "The wealth of a Nation is directly connected to the quantity and quality of its capital. The more capital a country has, the higher its productivity, competitiveness and incomes are likely to be (Ducks Unlimited Canada, 2006)."

DUC's research provides an excellent understanding of the losses incurred, the current risks and the rapid degradation of Canadian NC over the past century. They point out that the number one cause for habitat loss and degradation of NC is human activity. Experience has shown that substitutes for NC can be far more expensive to duplicate and operate than those already existing in nature (Olewiler, 2004). Ultimately, one can never recreate natural systems with the same and level of complexity, harmony and interconnecting webs of relationships that have evolved over millenniums.

Several large scale disasters that significantly impacted Canadian communities are highlighted to show the interrelating costs to society. For example, DUC points to the contamination of drinking water in Walkerton, Ontario and North Battleford, Saskatchewan which had a serious negative impact upon the economy, leading to a health crisis and the loss of human lives. To further strengthen the links between environment, society and the economy DUC directs our attention to the economic costs incurred as a result of these disasters, which is estimated between $64.5 and 155 million (CBC News Online, 2004).

DUC acknowledges that there are vast knowledge gaps in understanding and implementing NC concepts into community and government planning, problem solving and decision-making. Natural systems are highly complex and many of the interrelationships are not fully understood. This is an important consideration, as these knowledge gaps lead to a loss of inclusiveness in the measurement and calculation of natural values for problem solving and decision-making. To address the issue of knowledge gaps, DUC repeatedly stresses the need for governments to provide funding and support for further research. Lastly, NC variables and indicators are vast and subject to frequent and rapid changes over time (Olewiler, 2006). To accommodate continuous change, it is paramount that the indicators be updated and refined with each new evaluation (Olewiler, 2006).

DUC has identified several strategies for successful implementation of an NCA in environmental management. Fundamental to an effective strategy is the concept of using a business model to translate natural values into economic terms for decision-making. Human systems are built upon economic systems which utilize the environment for producing goods and services for human benefit. Therefore, it is only logical to translate natural goods and services into values that can be easily recognized and integrated into our economic system of governance. Translating ecosystems into budgets, will lead to more inclusive representation of data within our current management systems leading to a more integrated and holistic decision-making processes. Factoring the water treatment value of wetlands, which is worth at least $230 million per year in the lower Fraser Valley, into development planning would help provide an economic rationale for protecting and restoring wetlands (Gabor et al., 2004; Olewiler, 2004).

Integrated Watershed Management (IWM) is an example of a methodology where NC plays an important role in the whole systems management of watersheds (Gabor et al., 2004). IWM is all inclusive, involving multiple stakeholders to vision and design the principles, goals and expected outcomes of watershed management and development initiatives. IWM includes the regular project management cycles of evaluation, planning implementation and monitoring of watersheds for environmental management. For example, the use of IWM conducted by New York City led to a decision to protect 80,000 acres of their watershed by disbursing US$1.8 billion to private landowners for protecting and enhancing NC versus spending US$8 billion on a new water treatment plant.

DUC repeatedly stresses the importance of developing effective sector specific policies, legislation, certification and standards to protect ecosystems. Olewiler (2004), recommends that the federal government create a national task force to measure NC to revise traditional economic forecasting and to conserve and restore Canada's NC. Lastly, educational programs need to be funded and implemented at all levels within society to promote the intrinsic value of natural resources, and to remind Canadian citizens that our natural heritage cannot be easily replaced, restored or recreated by humankind with the same levels of integrity, splendor and value.

## 3.3. Innovative Approaches

Environmental planning and management strategies have been devised to promote a way of life that is sustainable. Natural Capitalism, The Natural Step and Soft Paths designs provide innovative approaches for engaging and designing business, technological and social systems to preserve and enhance NC.

### *3.3.1. Natural Capitalism*

The rapid loss of NC on which economic prosperity depends on inspired the conception of Natural Capitalism which recognizes the interdependency between the production and consumption of goods and the availability and supply of NC (Hawken et al., 1999a). Viewed by Hawken, Lovins and Lovins as the next industrial revolution, Natural Capitalism rests on four principles: "increase the productivity of natural resources, shift to biologically inspired production models, move to a solutions-based business model and reinvest in NC (Hawken et al., 1999a, pp. 146-148)."

Radically increasing the productivity of natural resources involves redesigning our production systems to reduce the depletion of natural resources and pollution. Dramatic increases in the productivity of natural resources can be achieved by adopting whole system design approaches and innovative technologies. By taking into consideration all matter and energy involved in a production process holistically one can design systems that are less material and energy intensive. For example, smaller pumps can be used if piping is properly sized and laid out with less bends (Hawken, Lovins, & Lovins, 1999b). The tendency to design systems with smaller pipes in order to save costs up front leads to the requirement for energy intensive pumps to compensate for increases in wall friction. Innovative technologies that are less material and energy intensive lead to dramatic improvements in the productivity of natural resources.

Biomimicry is the redesigning of industrial processes based on biological systems (Hawken et al., 1999a). Designing closed loop systems of production is an example of a biologically inspired production model. An industrial operation is designed in such a way that wastes from one production process become raw materials for another thus mimicking natural environments where nothing is wasted (Hawken et al., 1999b). "Every output of manufacturing should either be composted into natural nutrients and returned to the ecosystem or be remanufactured into new products (Hawken et al., 1999b, p. 153)." The living machine is an example of Biomimicry. By assembling a mini ecosystem in the form of microorganism, algae, fish and aquatic plants, biodegradable waste is broken down and absorbed from water rendering it safe to emit to the natural environment (Todd, Brown, & Wells, 2003).

Replacing a product-based economy into a service-based economy would result in a significant improvement in resource use efficiencies. For instance, instead of selling light bulbs one could provide the service of lighting. The lighting provider has an incentive to provide quality lighting to their customers for the least cost possible by using high efficiency lighting systems (energy efficient fixtures, light bulbs, etc…) (Hawken et al., 1999b). The acquisition of goods will then be replaced by quality services that promote performance and well-being (Hawken et al., 1999a).

Investing in the conservation and enhancement of Natural Capital is primordial for reversing the planetary destruction of natural environments and for maintaining ecosystem services. Aronson et al. (2006) argue that restoring NC leads to an improved economy and quality of life for all. A number of examples exist where investments in NC not only enhances human well-being but can also be economically profitable. For instance, the California Rice Industry Association discovered that flooding 30 per cent of the Sacramento rice fields after the harvest created a seasonal wetland which provided waterfowl habitat, enhanced groundwater recharge and improved the fertility of their soils. "Working with nature is more productive than working against it. Reinvesting in nature allows farmers, fishermen, and forest managers to match or exceed the high yields and profits sustained by traditional input-intensive, chemically driven practices (Hawken et al., 1999b, p. 156)."

### *3.3.2. The Natural Step*

The Natural Step (TNS) is a nonprofit organization founded in 1989 by Karl-Henrik Robert, a Swedish scientist (The Natural Step Canada, Undated). TNS framework was devised in response to the depletion of life sustaining natural environments. A funnel is used to describe this phenomenon. By losing NC we have less room to maneuver and we start moving to the narrowing end of the funnel. By expanding and restoring our natural environments we move to the larger opening of the funnel giving us more room to maneuver to meet our needs. Human society damages nature when the following occurs (The Natural Step, 2000):

1. Concentrations of substances are continuously rising because they are dispersed in nature from the Earth's crust faster than they are returned.
2. Concentrations of substances produced by society are continuously rising because society disperses them faster than they can be broken down and built into new resources by nature.
3. The natural environment is degraded by extracting more than nature can replenish or by other forms of ecosystem manipulation.

TNS framework is based on four system conditions that are derived from the laws of thermodynamics: "all mass and energy in the universe is conserved, energy and matter spreads spontaneously and disperses, material quality is in the concentration and structure of matter, plants create structure and order by using energy from sunlight (The Natural Step Canada, Undated)."

TNS uses a backcasting approach based on four principles to aid in designing approaches for sustainable development (see Figure 8). According to TNS the following conditions must be met in order to have a sustainable society (The Natural Step, 2000):

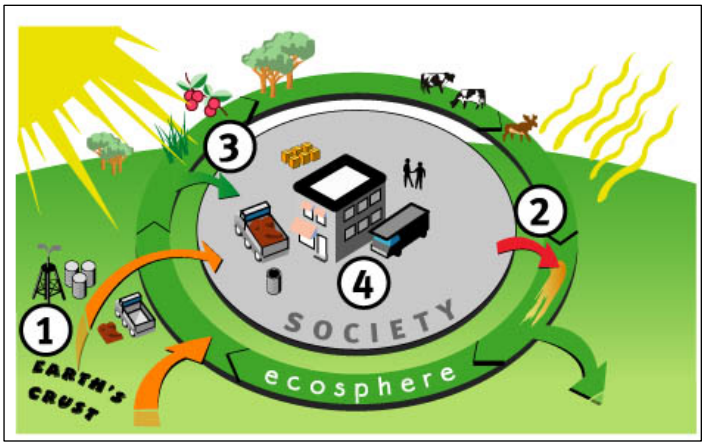


**Figure 8** - The Natural Step backcasting approach (The Natural Step Canada, Undated).

1. "Eliminate our contribution to systematic increases in concentration of substances from the earth's crust.
2. Eliminate our contribution to systematic increases in concentrations of substances produced by society
3. Eliminate our contribution to systematic physical degradation of the natural environment through over-harvesting, introductions and other forms of modification, and
4. Meet human needs in our society and worldwide, over and above

the substitution and dematerialization required in meeting the first three objectives (The Natural Step, 2000)."

Explicitly this means; Lowering the amount of heavy metals, phosphorus, sulfur and carbon that we extract from the Earth's crust and emit to the environment; Eradicating non-biodegradable substances such as chlorofluorocarbons, pesticides, dioxins that we manufacture and emit to the environment; Eliminating human activities that physically degrade the environment such as over harvesting fish, clear cutting forests, building on fertile lands and introducing non-native species; Promoting the equitable treatment of all people by addressing problems such as famine, mental

illness, social stress and access to clean drinking water (The Natural Step, 2000). TNS approach tackles the root causes of environmental issues (The Natural Step, 2000).

### *3.3.3. Soft Path Designs*

Amory Lovins coined the term "soft paths" in 1976 to describe systems of energy provision that are renewable and more efficient rather than centralized and wasteful (Rocky Mountain Institute, 2006). Soft path design is the art of supplying a resource of sufficient quantity and quality to satisfactorily fulfill a need in the most efficient manner. Soft path designs are typically small, distributed sources of supply that directly addresses the end uses and treats wastes on-site while hard path designs are usually large centralized sources of supply that are sized based on forecasted demands and growth with waste sources that are treated offsite at a considerable expense. Soft path designs are now being devised to meet a number of human needs such as drinking water, food and sanitation. The Rocky Mountain Institute advocates for the replacement of resource depleting and polluting hard path designs by soft path designs. "Wherever there is a hard path, there is also a soft one and a host of opportunities to go with it (Rocky Mountain Institute, 2006)."

The soft path approach focuses on "why" we need certain things and then designs a system that will meet the need with the least impact. For instance, the focus is placed on providing calories and protein as opposed to irrigation, sanitation instead of flush toilets and grass species that require no watering instead of lawn watering systems (Rose, 2004). The first step in the soft path design approach consists of meeting a particular need by a means that is less energy and resource intensive. The second step in the soft path design approach consists of changing or modifying a particular need in order for it to be less resource and energy intensive. For example, water can be used more efficiently to support a particular diet and can be reduced even more substantially if the diet is modified. Soft path designs use backcasting techniques to devise feasible paths leading to a preferred and sustainable future. "The goal of soft path analysis is to offer practical policy advice and not merely idealized alternatives (Rose, 2004, p. 4)."

## 3.4. Initiatives Analysis

On the international front efforts at the government level are focused on developing general guidelines and accurate methods for measuring NC in order to develop environmental planning and management systems that are more effective. China's vision for a "Xiao Kang" society and Australia's Ecological Sustainable Development Vision provide a general national direction for protecting and enhancing the country's NC. China's Green GDP Index and Australia's natural asset accounts provide additional information to manage the environment in a sustainable manner. National governments are realizing the importance of maintaining their NC in order to continue to have a thriving economy and maintain their population's well-being. For example, China's extraordinary economic growth and substantial environmental degradation has forced the central government to make efforts to measure and monitor its NC in order to maintain its economy. Similar efforts are being experienced at a more localized scale.

The Hainan Province has declared itself an ecological province and the ecosystem service project headed by CSIRO is researching new methods for valuing ecosystem services in partnership with the community. Central to the vision of the Hainan province is their efforts to instill in all its citizen a sense of connection and stewardship with the natural environment that sustains them. By virtue of focusing on the ecosystem services that enable and facilitate the livelihoods of the citizens of the Goulburn Broken Catchment the ecosystem services project is conveying the importance of

preserving and enhancing the natural assets of the watershed. Along with developing a central vision for sustainable development and methods of measuring and accounting NC at the national level it is of crucial importance to foster values within citizens that will be conducive for promoting the importance of NC. An effective way to achieve this is to demonstrate the importance of ecosystem services in supporting livelihoods. This is being achieved by initiatives implemented by the Hainan Province and The Ecosystem Project in the Goulburn Broken Catchment.

Within Canada many efforts have been initiated at the national, provincial, regional and NGO scales to develop an NCA for the country. Statistics Canada is researching and developing new and effective methods for measuring NC and proposed an NC measurement framework to the OECD based on stocks, flows and states. This method would incorporate a dynamic dimension to the static measurement techniques of NC which is often criticized by ecologists. The NRTEE's 20 recommendations for the protection of Canada's NC call for national efforts to develop information systems such as GIS-based decision support systems and an electronic biodiversity network to aid in environmental planning and management. In addition, the NRTEE recommends the development of incentive programs to encourage landowners to preserve and protect NC on their lands. At the provincial and regional scales the province of Alberta has made considerable efforts to quantify the value of its water resources and the GVRD has recognized the importance of maintaining and enhancing its biodiversity. The Albertan government is developing an NC valuation approach by having valued the water resources of the SSRB. The GVRD has made considerable efforts in order to quantify, measure and gauge the biodiversity within its regional boundary which is leading to concerted efforts to enhance habitats and biodiversity. The NC research conducted by the CBI and the DUC highlight the value of maintaining NC for the economy and the well-being of the Canadian people.

The Canadian case studies stress the urgent development of methodologies for the assessment and valuation of NC. Standardized NC assessment methods that can be used by all levels of government and citizen groups will greatly facilitate NC protection and restoration efforts. An important step in developing these methods is to establish accessible environment planning and management information systems. Incentive programs for landowners will help promote NC protection. The value of NC is best evaluated at the watershed scale as demonstrated by the province of Alberta and the Canadian Boreal Initiative. Protecting biodiversity implies the protection of NC leading to the perpetuation of ecosystem services that will benefit everyone. All these efforts demonstrate the considerable strives being made in all parts of Canada for the preservation and restoration of our natural environments. Developing an overarching system to harness the energies being expended by all entities involved in NC research and implementation initiatives is fundamental to developing and implementing an effective NCA within Canada.

Natural Capitalism, The Natural Step and Soft Path Designs provide conceptual and practical frameworks that are being implemented successfully. Interface Inc. a carpeting company and big advocate of Natural Capitalism now sell their floor covering services as opposed to carpets. This has forced them to rethink their business model so that it can be sustainable over the long term. Whistler is using The Natural Step to develop the town in an environmentally sustainable way for the 2010 Winter Olympics. These innovative models facilitate the elaboration and implementation of an NCA.

# 4. MOVING TOWARDS A UNIFIED PRACTICE

Moving the Natural Capital Approach (NCA) to a unified practice requires sound Natural Capital (NC) assessment methodologies from which to develop a suitable and comprehensive NC informatics architecture. Valuation methodologies are being increasingly utilized to then quantify the benefits provided by natural environments (Smith, 2007). Integrating this information within economic and environmental policy development and decision-making frameworks is imperative to build a rationale for sustaining our natural environments and maintain social and economic well-being.

The UN's System of Environmental and Economic Accounts (SEEA 2003), the World Bank's National Wealth Measurements (NWM) and Statistics Canada's Canadian System for Resource and Environmental Accounts (CSERA) provide a good foundation from which to develop suitable NC assessment methodologies. The European Environment Agency elaborated a spatially based ecosystem accounting framework based from the SEEA 2003 to measure and monitor natural assets and ecosystems. This state of the art ecosystem accounting framework is used to present an NC informatics architecture comprised of NC and ecosystem stocks, flows and state accounts. By virtue of being linked to ecosystem types and economic sectors, these measurements highlight the importance of maintaining healthy ecosystem for human well-being.

Although there are no standardized methods for the valuation of NC and ecosystem services valuation using evolving methods is occurring as estimated values are better than none (Lange, 2007). Valuation methods advocated by the United Nations, the World Bank and Statistics Canada are presented and discussed. Conceptual and practical advances are being made to value environmental benefits.

As governments, communities and NGOs internationally and domestically are increasingly aware of the benefits we receive from natural environments the NCA is becoming a useful tool for integrating economics and ecology for the formulation of sustainable development policy. The integration of the NCA within governance and policy development will lead to more effective decision-making for sustainable development. The assessment, valuation and integration of NC within environmental and economic management systems are presented in this chapter.

## 4.1. Natural Capital Assessment

Natural Capital Assessment approaches developed by the United Nations, the World Bank and Statistics Canada provide a foundation for the development of a comprehensive methodology for measuring NC. These approaches fall short on a number of aspects which are important for the elaboration of a comprehensive NCA. For example, non-market ecosystem service values and ecosystem health measurements are for the most part excluded from the assessment. An overview of these NC assessment methods is presented.

### *4.1.1. System of Environmental and Economic Accounts*

The System of Environmental and Economic Accounts (SEEA) was born out of the development of the System of National Accounts (SNA 1993) which lacked considerations for environmental accounting. The SNA 1993 is constrained when accounting for NC as it is governed by the following tenet:

> "Naturally occurring assets over which ownership rights have been established and are effectively enforced qualify as economic assets and are to be recorded in balance sheets. Such assets do not necessarily have to be owned by individual units, and may be owned collectively by groups of units or by governments on behalf of entire communities. In order to comply with the general definition of an economic asset, natural assets must not only be owned but be capable of bringing economic benefits to their owners, given the technology, scientific knowledge, economic infrastructure, available resources and set of relative prices prevailing on the dates to which the balance sheet relates or expected in the near future (Statistics Canada, 2006a, p. 4)."

To remediate the NC accounting shortfalls of the SNA 1993, the UN Statistics Division published the "Handbook of National Accounting: Integrated Environmental and Economic Accounting" which came to be known as the SEEA 1993. The London Group on Environmental Accounting[1] revised the 1993 edition and published an enhanced version in 2003. Created as a national environmental accounting guide, the SEEA 2003 is well suited for measurement approaches based on the NC concept (Smith, 2007).

The SEEA 2003 describes the interaction between economic activities and the natural environment in physical and monetary terms and adjusts the Net Domestic Product to account for the enhancement or degradation of the natural environment (Statistics Canada, 2006a). It tracks NC stocks used in the economy, material and energy flows, expenditures in environmental protection and management, and the economic impacts of environmental degradation and depletion. SEEA's NC stock measures are comprised of natural resources (mineral and energy resources, soil resources, water resources and biological resources), land and associated surface water and ecosystems.

The SEEA 2003 incorporates a number of quantitative and qualitative NC accounts within the land and ecosystem accounts of the balance sheet. Land and ecosystem accounts are characterized by basic and supplementary accounts. Basic accounts include land covers and uses tracked over time, while supplementary accounts provide measures related to land cover and uses that are qualitative.

> "The development of land and ecosystem accounts that adequately deal with the complexity of land and ecosystems as environmental assets is new and closely linked to the appearance of georeferenced land-use or land-cover data. A general consensus on the need and the basic structure of a comprehensive approach to and ecosystem accounting is emerging within and between many countries. The use of land and ecosystems are often characterised by specific regional or national interests or circumstances. This results in a high heterogeneity of observation methods, reporting formats and data available at these different levels (United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, & World Bank, 2003, p. 373)."

The SEEA 2003 makes a valiant attempt at incorporating ecosystem related considerations in its accounting methodology but fails to include sufficient information on a number of NC, ecosystem services and well-being measures and relationships. The economic ecosystem model shown in Figure 9, points out that there are a number of stocks and flows that are neglected or insufficiently described

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[1] "The London Group is one of a number of similar "city groups" formed by statistical agencies since the late 1980s. Each of these groups treats a particular area of statistics. Although they are independent bodies made up of countries that voluntarily contribute their expertise and finance their own involvement, the city groups report annually on their work programmes to the United Nations Statistical Commission (Smith, 2007, p. 593)."

by the SNA and SEEA 2003. This is partly due to their adherence for providing measurements in monetary terms. The SEEA 2003 does not value natural features that cannot be assessed using standardized valuation techniques. In addition, it does not incorporate system dynamics such as feedbacks, and flow on effects which are important for assessing the states of an interrelated national environmental economic system (Gunderson & Holling, 2002; Walker & Pearson, 2007).

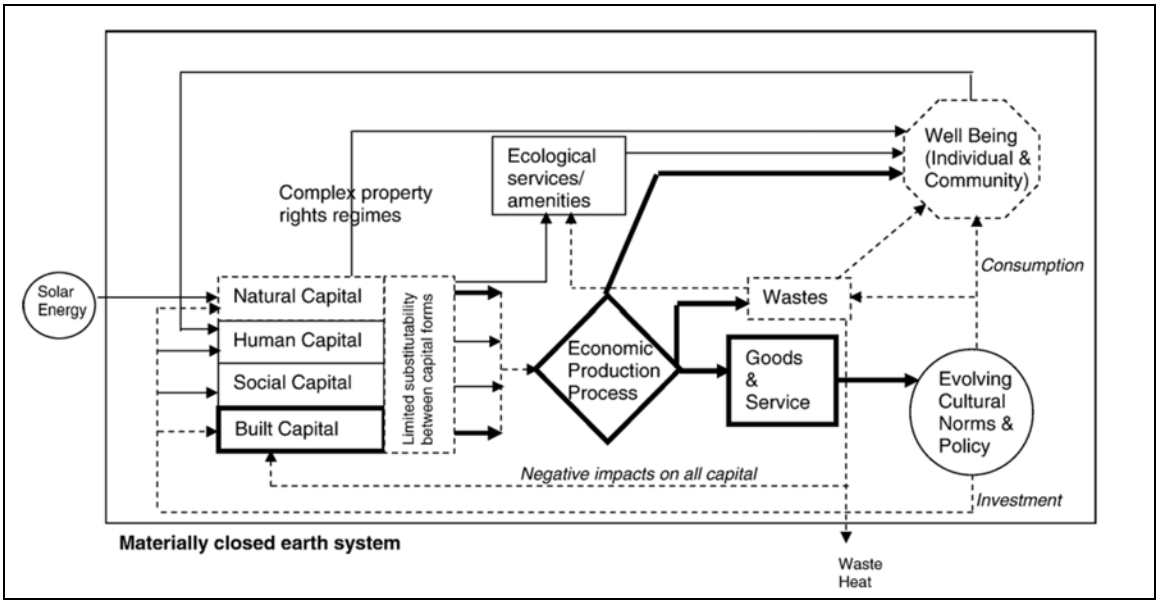


**Figure 10:** The model provides a depiction of the ecological economic system. The thick lines represent the stocks and flows that are included in the SNA and SEEA, the dashed lines are only partially covered and the thin lines are not accounted for (Walker & Pearson, 2007).

The SEEA 2003 recognizes the requirement for additional and integrated input from a number of disciplines and data streams in order to develop land and ecosystem accounts that are more comprehensive and useful. "Co-operation between statisticians, economists, geographers and biologists as well as flexibility in adjusting the accounts to the available data sources and the classifications they use is therefore essential in the implementation of land and ecosystem accounts (United Nations et al., 2003, p. 374)." In addition, the SEEA 2003 attempts to capture quality measures of the natural environment by advocating the combination of accounting and indicator measures of the natural environment. For example, linking surface areas with biodiversity measures would provide a means for evaluating the quality of a particular ecosystem. The SEEA 2003 lays the groundwork for incorporating additional NC considerations within national accounting frameworks.

### *4.1.2. World Bank Wealth Measurement Approach*

In "Where is the Wealth of Nations?" published in 2006 the World Bank assesses the total wealth of countries by measuring their produced, natural and human and institutional capital. The document concludes that NC represents a greater share of wealth (approximately one quarter) than produced capital in most low income countries. This highlights the importance of preserving and enhancing NC as development and growth cannot be sustained if it is strictly based on depleting the environment (The World Bank, 2006).

To measure NC, the World Bank uses market values to derive an NC proxy based on subsoil assets, timber resources, non-timber forest products (NTFPs), cropland, pasture land and protected areas (The World Bank, 2006). "Natural resource stock values are based upon country-level data on

physical stocks and estimates of natural resource rents based on world prices and local costs (The World Bank, 2006, p. XIV)." Subsoil assets are estimated based on resource rents and productivity discounted over time with a conservative reserve to production ratio estimation of 20 years. Timber accessibility (located within 50 km of infrastructure) and the net present value of rents from roundwood production with a four per cent discount rate are used to estimate the value of timber resources. NTFPs consist of small forest-based products, hunting, recreation, watershed protection and option and existence values. NTFP values are calculated by assuming that only 10 per cent of forests are accessible to benefit from them and that they are worth $145 USD per hectare with a net present value calculated over 25 years. Cropland value is estimated by calculating the net present value of resource rent estimations of maize, rice, wheat and proxies for fruits and vegetables, oil and beverages, and roots and pulses, with a four per cent discount rate over 25 years. The value of pasture lands are calculated based on 45 per cent of the output value of beef, lamb, milk and wool at international prices which is then used to calculate a net present value with a four per cent discount rate over 25 years. Protected areas are estimated using a quasi opportunity cost measure based on the lower per hectare returns of pasture lands and cropland

All elements included in the World Bank NC proxy are estimated using market values. As a number of natural assets and ecosystem services do not have market values this NC assessment approach is very limited. "The estimates of natural wealth are limited by data—fish stocks and subsoil water are not measured in the estimates—while the environmental services that underpin human societies and economies are not measured explicitly (The World Bank, 2006, p. XV)." The World Bank falls short of providing sufficient quantitative as well as qualitative NC measures to guide effective environmental planning and management. Nevertheless, the methodology used for estimating NC wealth in "Where is the Wealth of Nations?" rests on well established economic principles and contributes to the development of NC measurement, assessment and valuation methodologies.

### *4.1.3. Canadian System of Environmental and Resource Accounts*

Statistics Canada's Canadian System of Environmental and Resource Accounts (CSERA) is the culmination of conceptual work which began in the early 1980s and formal development initiated in 1992 (Statistics Canada, 2006a). Tailored after the SEEA 2003, the CSERA is very similar with the exception that it does not adjust the Net Domestic Product. As the Canadian equivalent to the SEEA 2003, the CSERA complements the Canadian SNA providing national accounts that are more comprehensive. The CSERA focuses on accounting Natural Resource Stock Accounts, Material and Energy Flows and Expenditures on Environmental Protection.

Natural Resource Stock Accounts are composed of subsoil, land and timber assets. Subsoil assets include crude oil; natural gas and by-products; crude bitumen (or tar sands); lignite, sub-bituminous and bituminous coal; metals (copper, nickel, zinc, lead, gold, silver, molybdenum, iron and uranium); and potash. These are measured in physical and monetary terms on an annual basis. Timber is accounted for in physical and monetary terms based on accessible, productive, non-reserved forestland. The overall landmass is treated differently in the land accounts as it is a fixed stock and does not change over time. It is comprised of five layers of spatial reference data (Statistics Canada, 2006a):

1. The physical foundation which includes boundaries and ecoregions.
2. Land cover which describes the physical nature of the land.
3. Land-use which describes how the land is being utilized for human and non-human activities.
4. Land potential provides biophysical properties such as climate, geology, topography and soil characteristics.
5. Land value estimates by spatial unit.

Accounts for fish and wildlife stocks are currently being developed.

Material and Energy Flow Accounts (MEFA) track material, energy and waste flows between the economy and the environment. The MEFA records the quantities of natural resources harvested and how they are consumed as well as quantities of waste produced, and if they are recycled or discarded (Statistics Canada, 2006a). Due to the data intensiveness of the MEFA results are published four years after the annual data has been collected which is problematic for timely and effective environmental planning and management efforts. Nevertheless, the MEFA are expanding to include more elements and efforts are being made to reduce reporting time lags. To date MEFA have been developed for greenhouse gas, energy, water, pelagic fish, and agricultural products.

The Environmental Protection and Expenditure Accounts (EPEA) provide a measure of the Canadian demand for environmental protection and financial investments that constitute an economic burden (Statistics Canada, 2006a). The EPEA measures capital and operating expenditures on environmental protection by households, governments and businesses. Data collection challenges that existed within the business sector have been addressed by the compilation and implementation of new surveys. Government environmental protection expenditure data has been compiled dating back to the 1970s. Household expenditure accounts have been limited to automobile pollution control devices and solid waste and sewage treatment supplied by the private sector (Statistics Canada, 2006a).

In order for the CSERA to be more comprehensive Statistics Canada is working on a number of fronts to improve and expand the accounts. Physical and monetary measures for land areas that offer environmental services in addition to raw materials are being developed. "The environmental systems that provide these ecosystem services must be seen to represent natural capital in the same way that timber or mineral stocks do (Statistics Canada, 2006a, p. 11)." Accounts are being expanded to include the quality measures of the natural environment. Valuation techniques for non-market goods and services are being researched. The MEFA will include additional natural resources and waste flows such as timber, metallic and non-metallic natural resources and waste flows reported in the National Resource Pollutant Inventory. In addition, the MEFA will include estimations of recycled waste used for production. The aggregation of disparate material flows into a meaningful measure is being explored. Additional household environmental protection expenditures and supply-demand information for environmental protection equipment are being developed.

The CSREA was conceived to facilitate the development of a sustainable economy by providing information so that NC is maintained over the long-term. Specifically, it provides a measure of the rate of consumption of renewable resources and if it is kept within its regenerative capacity, the exploitation rate of subsoil assets and if it is being kept within the discovery rate of new sources, the flows of waste material associated with an economic activity, the amount of waste being recycled, the patterns of land-use and their changes, expenditures for environmental protection. The CSERA provides a vast array of data that is crucial and valuable for developing effective environmental planning and development strategies.

## 4.2. Natural Capital Informatics Architecture

State of the art research and the ecosystems approach suggests that developing environmental planning and management policies must be sensitive to contextual specificities if they are to be effective (Burgiel & Schulman, 1999; Longo & Hodge, 2007). Spatially grounded information obtained from remote sensing technologies provides environmental, economic and social context specific information that is cost effective (C. Weber & Puissant, 2003). For example, Weber and

Puissant (2003) use satellite imagery to study the urbanization of the metropolitan area of Tunis which helps understand the socio-economic processes that have influenced the expansion of this capital city.

An NCA which rests on spatially grounded information will be relevant and useful for the development of effective environmental planning and management policies at various scales. In accentuating the need to measure and monitor natural environments Weber states: "The ultimate ambition of land and ecosystem accounts is to provide information that will support environmental policy integration by clarifying and quantifying trade-offs between environmental priorities, their costs, the benefits they bring to the society and the benefits of environment friendly policies in agriculture, land and urban planning and economic development in general (J.-L. Weber, 2007, p. 706)." The need to integrate information generated from remote sensing technologies, in situ monitoring systems and socio-economic statistics is ever more important as it provides improved methods to gauge ecosystem health and human well-being.

### *4.2.1. General Framework*

An NCA structured on a spatially based informatics architecture comprised of ecological subsystems is envisioned. National NC accounts consisting of ecosystem services and ecological integrity measures to gauge the economic importance and health of ecosystems could complement the System of National Accounts. The general framework provides a step towards developing biophysical and economically grounded standardized methods to assess, prioritize and justify environmental management expenditures.

The informatics architecture can be built on ecological subsystems which can be any spatial scale deemed useful. The watershed is a fitting ecological subsystem on which to base an NC assessment framework as it is the most logical spatial scale for devising environmental planning and management policies (see Figure 10) (Kaufman, 2002). This does not preclude the possibility for using other types of ecological subsystems to frame the ecosystem accounts, such as ecological zones or land covers (see Figures 11 and 12).

NC information can be aggregated at an appropriate spatial scale (municipal, provincial or national) to develop environmental planning or management policies. Data aggregation enables intra and inter-comparisons between various spatial scales to track progress. However, aggregation flexibility implies that NC assessment methods need to have some level of consistency across ecological subsystems (Smith, 2007).

The proposed spatially based NC informatics architecture is designed to assess an area's NC and better align economic development with environmental signals (see Figure 13). Tracking the loss or gain of hectares of wetlands, prairies and forests will provide policy-makers with a rate of deterioration or restoration of natural environments. Context specific measures of ecosystems will assist local communities with maintaining and enhancing ecosystem integrity. Further to natural ecosystem physical assessments estimating their service values in monetary terms will help build an economic rationale for their preservation and restoration.


**Figure 11:** Canada is divided into 23 major river basins (Pearse, Bertrand, & MacLaren, 1985). The basin can be divided into watersheds and sub-watershed which are suitable ecological subsystems to develop effective environmental planning and management policies.


**Figure 12:** Canada's terrestrial ecozones are a reflection of climate and hydrological regimes enabling the evolution of distinct ecosystems. Canada is composed of 15 distinct ecozones (Wiken E.B. et al., 1996).

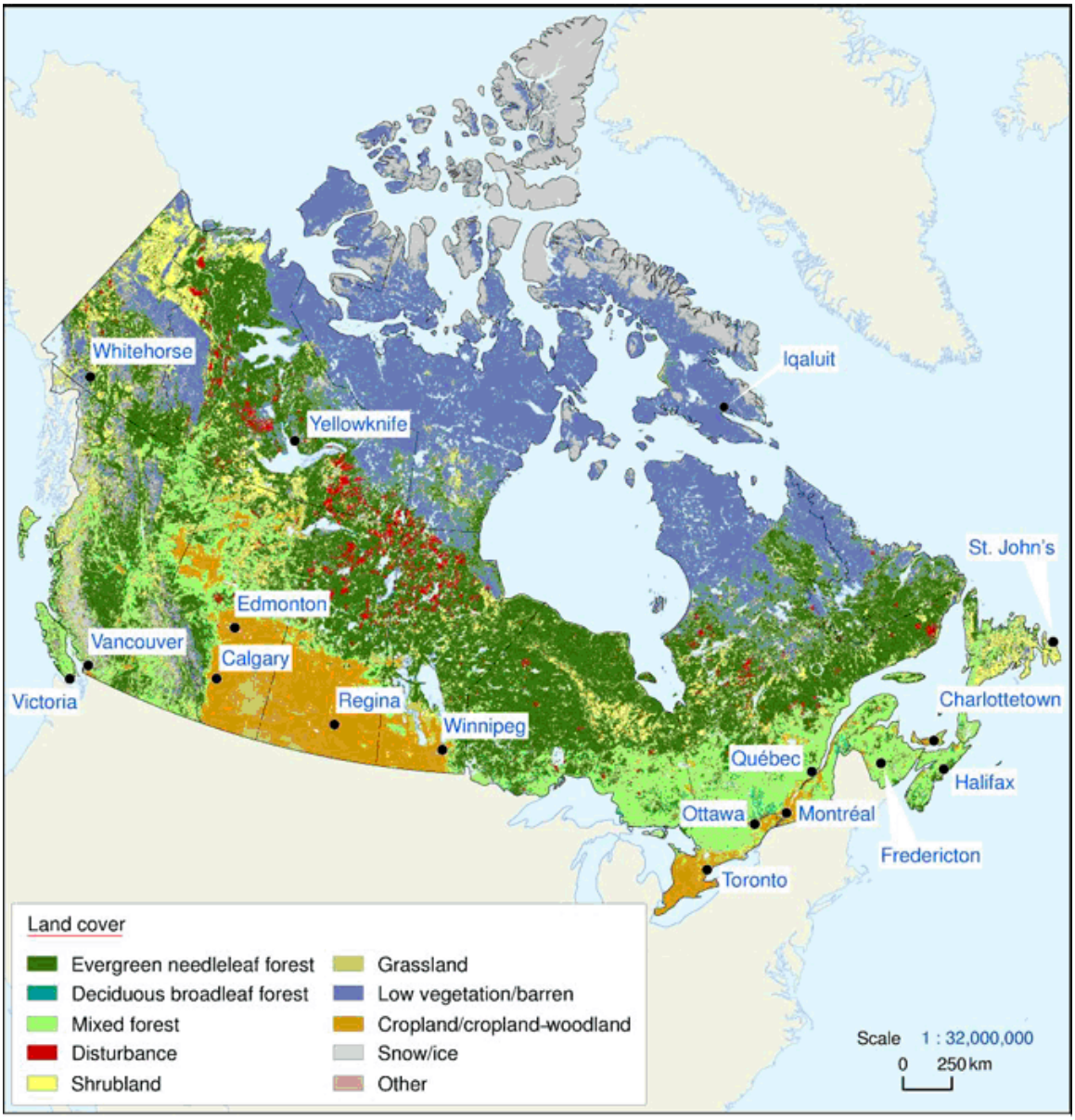


**Figure 13**: Twelve different land cover classes are used to characterize Canada's land covers. (Latilovic, Zhu, Cihlar, Giri, & Olthof, 2004). Information on land-uses and potential ecosystem services can be derived from land cover maps.

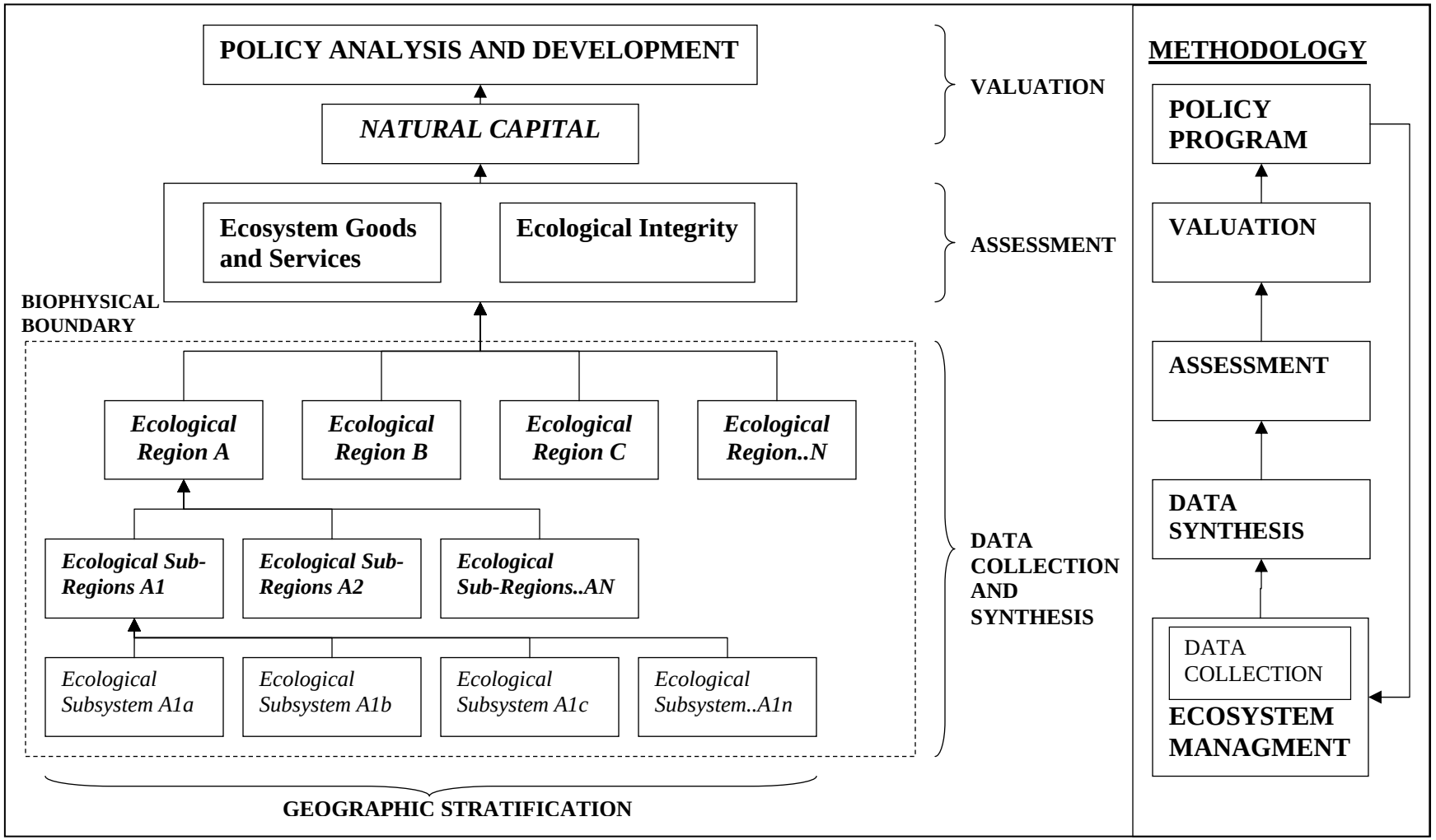


**Figure 14**: **The general framework for the proposed Natural Capital Approach informatics architecture. Biophysical data are collected and synthesized from spatial units that make up a preferred geographical stratification system. The data are then assessed and valued in order to provide Natural Capital information for an environmental policy analysis and development program. The policies then influence ecosystem management on some spatial scale such as a watershed.**

### *4.2.2. Ecosystem Accounting*

The European Environment Agency (EEA) modified the SEEA 2003 and grounded it in spatial information to assess the state of the environment within a number of European countries. The EEA ecosystem accounting framework serves as an NC assessment methodology for the informatics architecture proposed. The Boreal Ecosystem Wealth Accounting System (BEWAS) (Anielski & Wilson, 2006) and the Canadian System of Environmental and Resource Accounts (CSERA) (Statistics Canada, 2006a) are compared with the EEA ecosystem accounting approach.

The ecosystem accounting framework consists of three sets of accounts (see Figure 10). The ecosystem stocks and state accounts provide a measure of the quantity and quality of ecosystems in order to assess their overall condition. They are divided into core stocks and flows and stock diversity/integrity accounts which are used to assess the state of ecosystems. The flows of ecosystem goods and services and the natural assets accounts are closely interlinked and focus on the socio-economic benefits derived from ecosystem functions and services while retaining their geographical dimension. They consist of four distinct accounts: Material and energy flows, Functions and services, Supply use of ecosystems goods and services, Natural assets accounts.

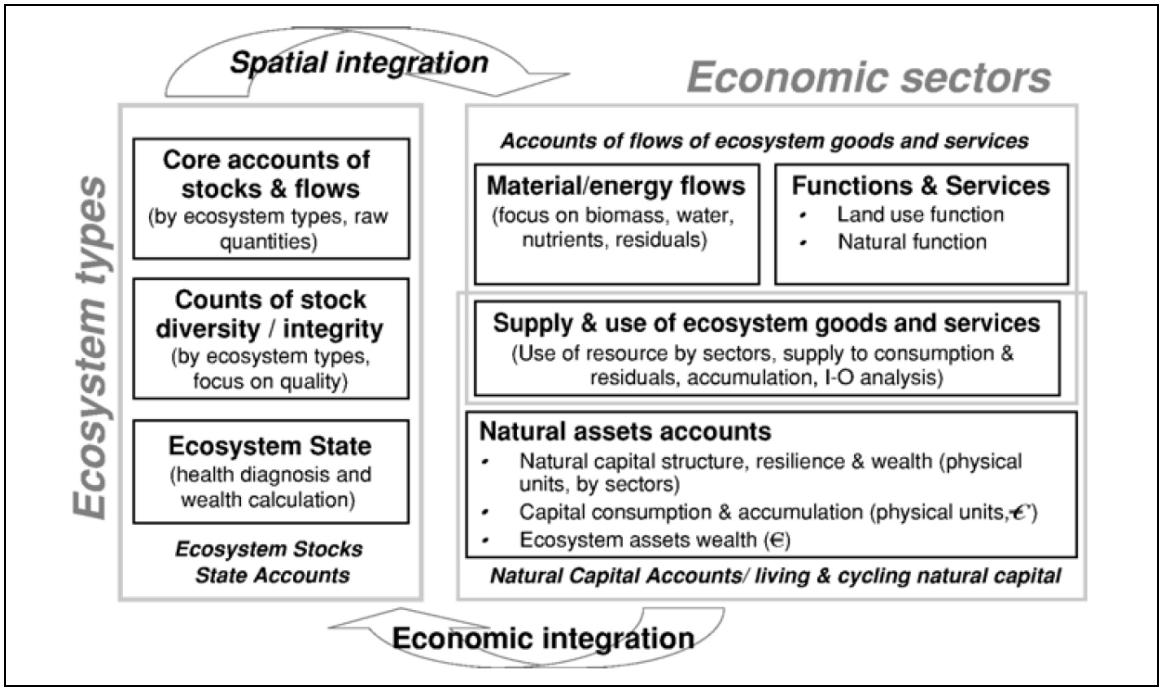


**Figure 15:** The European Environmental Agency ecosystem accounting framework (J.-L. Weber, 2007, p. 701).

***Core Ecosystem Accounts Stocks and Flows:*** They consist of quantitative measures made up terrestrial and marine ecosystems, biomass, water quantity, nitrogen and phosphorus:

1. Terrestrial ecosystems:

    - Land cover: Determined by using geographical data based on the spatial resolution desired. For instance, macro-scale indicators are practical for determining general trends while meso-scale indicators are better understood by local populations thus providing an

opportunity to include their perceptions in the generation of a collective trend (J.-L. Weber, 2007). Surface areas as used to provide a measure for land covers.[2]

- Rivers: Basin maps are used to determine the arborescence of the rivers. This enables the establishment of number of reaches and their classification according to their size and/or position in the network (J.-L. Weber, 2007). Rivers can be measured using Kilometre of Standard River (a 1 km length river with a flow of 1 $m^3/s$) or surface area.
- Small ecosystems: Ascertained using remote sensing or sampling techniques. The existence of small ecosystems is more important than their surface area. Therefore, they are measured in number of units as opposed to surface area.

2. Marine ecosystems: Difficulties in dividing the sea into systems is the main challenge in measuring marine ecosystems. Coastal ecosystems can be mapped by defining a land substrate which are likely to change with the interaction of the sea and streams (J.-L. Weber, 2007). Measuring marine ecosystems will require the development of novel methodologies that can incorporate fluid external and internal relations.

3. Biomass: Measuring biomass enables the monitoring of important ecosystem functions or transformations such as carbon sequestration, biodiversity primary productivity and desertification. Changes in biomass can also be linked to human activities such as forestry or agricultural practices. Biomass flows into and within the economy are captured in the Material Flow Accounts (MFAs). For example, human appropriations of net primary production are typically captured in the MFAs (J.-L. Weber, 2007). It is advantageous to measure biomass stocks at the ecosystem scale as material flows can then be linked to their ecosystem of origin enabling the development of thresholds. The biomass stocks are measured in soil biomass, vegetation and fauna which are typically measured in dry matter, carbon and energy.[3]

4. Water quantity: Comprised of water quantities found in rivers, lakes and soil which are important to gauge water supply and potential for vegetation growth. Water flows are connected to water supply and use accounts detailed by sectors (J.-L. Weber, 2007).

5. Nitrogen: A key component of nutrient cycling, nitrogen is measured strictly as a flow and is reported in tonnes.

6. Phosphorus: A key component of nutrient cycling, phosphorus is measured strictly as a flow and is reported in tonnes.

7. Flora and fauna: Measured in number of units, groups, volumes and tons, flora and fauna are typically measured in a semi-quantitative fashion due to data gaps.

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[2] Land cover accounts have been produced by the European Environment Agency using a scale of 1/100,000 and 44 different land cover classes. The data are comprehensive and comparable among countries and over time. "Land cover accounts describe the stocks and the flows of consumption (of initial land cover) and formation (of new land cover) and are presented according to drivers such as urban development (urban residential sprawl, sprawl of economic activities), agriculture (conversion from forested & natural land to agriculture, agriculture internal conversions, withdrawal of farming with or without forest creation), forestry (forest creation and management), water bodies creation and management and natural and multiple causes (natural rotations, coastal erosion, fires, melting of glaciers) (J.-L. Weber, 2007, p. 698)."

[3] Biomass can be assessed by estimating the total dry matter or energy captured by the natural environment. Standing crop and net primary production are two measures commonly used to provide information on an area's total biomass and growth potential. Standing crop is the total biomass found in a given area for a particular point in time measured in calories or grams (dry organic matter) per square meter. Net primary production provides a rate of biomass production for a given area and period of time usually measured calories or grams (dry organic matter) per square meter per year (University of Michigan, 2005).

***Counts of stock diversity/integrity:*** To develop ecosystem health measures ecosystem integrity, diversity and threshold counts are required in addition to ecosystem stock and flow measurements (J.-L. Weber, 2007). The EEA shaped their ecosystem diversity and integrity measurements by tracking the following symptoms of distress (J.-L. Weber, 2007):

- Horizontal or vertical (between biota and substrates) nutrient cycling pattern disruptions.
- Opportunistic or introduced species adaptation strategies typified by increased reproductive rates, shorter life cycles and smaller growth sizes.
- Destabilisation or loss of habitats, structural complexity or modifications in hydrology patterns.

These symptoms can be assessed using a number of methods. The EEA has selected to focus on the following seven approaches to measure ecosystem diversity and integrity (J.-L. Weber, 2007):

- Nutrient cycling pattern disruptions inferred from the core accounts.
- Structure and morphology of the landscape analyzed using ecosystem natural edges, potential connectivity, texture and diversity.
- Fragmentation of ecosystems and landscapes measured using fragmentation metrics such as edge density, patches density, proximity, contagion, contrast and effective mesh size.
- Water stress based on accounting water stocks, flows and abstractions.
- Water quality of river ecosystems described by its physico-chemical and biological composition, its ability to assimilate waste, energy dimension and overall health.
- Chemical distress monitored using a variety of biomarkers in accordance with ecotoxicology.
- Biodiversity gauged by monitoring species (composition, number of endangered and invasive species) and habitat (refuge and spawning/nursery areas) diversity.

Specified ecosystem resilience[4] to shocks and stress offers another potential measure of ecosystem integrity (Heal, 2007; Walker & Pearson, 2007). For example, a critical threshold is reached when a depth to water table reaches two metres as salt is drawn up by capillary action raising soil salinity. When measuring the stock of top soil, no distinctions are made between soils having a depth to water table of three or 30 metres which is inadequate as the latter is more resilient to water table depth fluctuations. Resilience measurements offer good prospects for assessing ecosystem integrity.

***Ecosystem State:*** Taken together the ecosystem quantitative and qualitative measurements enable the assessment of the ecosystem state. This provides a measure of their overall quantities in physical terms and their health in relative terms. The EEA have developed four classes of ecosystem health (J.-L. Weber, 2007):

- homeostasis state (no alteration);
- resilience state (able to compensate);
- reversible process (degradation); and
- irreversible change (death).

[4] "Resilience is the capacity of an ecosystem to buffer disturbance, measured as the capacity to undergo change while still maintaining the same structure, functions and feedbacks (Walker & Pearson, 2007, p. 3)." Specified ecosystem resilience is the resilience of a particular ecosystem stock or flow to a specified shock.

The ecosystem state is determined based on the methodology used to analyze the symptoms of distress which can vary widely based on the selection of the symptoms considered and their respective weighting.

***Material/Energy Flows:*** They are composed primarily of ecosystem supporting services such as biomass, nutrient and water cycling. Ecosystem supporting service benefits are obtained indirectly through the consumption and extraction of natural resources. The material and flow accounts mirrors some of the information provided in the core ecosystem stock and flow accounts but are organized in economic sectors, goods and services as opposed to ecosystems.

***Functions and Services:*** Land-use and Natural Function accounts assess on a spatial basis the benefits derived from marketed and non-marketed ecosystem services and associated land-use impacts on the land and its ecosystems. Land-use Functions relate to the direct use of land for the production of goods and services as well as social and cultural services. Land-use functions can be numerous. For instance, wetlands provide habitat for waterfowl, prevent floods, retain and assimilate nutrients, sequester carbon and offer fishing and hunting opportunities. Natural functions refers mainly to ecosystem regulating services such as hydrological and climate regulation, soil formation and wildlife habitat (J.-L. Weber, 2007). These accounts enable the evaluation of trade-offs between meeting human needs and preserving ecosystems to benefit from their functions and services.

In addition, the Functions and Services accounts also capture the effects of land-use or anthropogenic stressors on the land and its ecosystems. These are composed of four main types (J.-L. Weber, 2007):

- physical restructuring;
- introduction of exotic or invasive species;
- discharge of toxic substances; and
- over-harvesting.

The land-use impacts reiterate the health diagnosis provided by the ecosystem diversity/integrity and ecosystem state accounts. In addition, they link the identified stressors to the supply and use of ecosystem services by human activities such as agriculture, forestry, transportation and population growth.

***Supply & Use of Ecosystem Services and Services:*** These accounts are comprised of measures used in conventional economic analysis which consist primarily of provisioning ecosystem services such as the resource use of materials.

***Natural Assets Accounts:*** They provide measures of NC structures, resilience and wealth in physical units and by economic sectors. Capital consumption and accumulation of ecosystem assets and wealth are assessed over time.

### *4.2.3. Accounting Framework Comparisons*

Many elements of the EEA ecosystem accounting framework are captured by other environmental accounting systems. This comes as no surprise as a number of environmental accounting systems, including the EEA ecosystem accounting framework, have been developed based on the SEEA 2003. The Boreal Environmental Wealth Accounting System (BEWAS) (Anielski & Wilson, 2006) and the Canadian System for Environmental and Resource Accounts (CSERA) are no exceptions (Statistics

Canada, 2006a). Their similarities with the EEA Ecosystem Accounting framework are summarized in Table 3.

**TABLE 3: Similarities between Environmental Accounting Frameworks:** Comparison between the Ecosystem Framework, the Boreal Environmental Wealth Accounting System (BEWAS) and the Canadian System for Environmental and Resource Accounts (CSERA).

| **Ecosystem Accounting** | **Boreal Environmental Wealth Accounting System** | | | **Canadian System for Environmental and Resource Accounts** | | |
|---|---|---|---|---|---|---|
| | Natural Capital Stocks | Land | Ecosystem Service | Natural Resource Stocks | Material and Energy Flow | Environ-mental Protection Expenditure |
| **Core ecosystem stocks and flows** | | ✓ | ✓ | ✓ | ✓ | |
| **Counts of stock diversity / integrity** | | | | | | |
| **Ecosystem state** | | | | | | |
| **Material / energy flows** | ✓ | | | | ✓ | |
| **Functions and services** | | | ✓ | | | |
| **Supply and use of ecosystem goods and services** | | | ✓ | ✓ | ✓ | |
| **Natural assets accounts** | ✓ | ✓ | | ✓ | | |

The BEWAS consists of Natural Capital Stock, Land and Ecosystem Service accounts. It was developed to provide a more comprehensive estimate of the total wealth of the Canadian Boreal Forest. The Natural Capital Stock accounts captures information provided in the Material Energy Flows and Natural Assets Accounts. For example, the BEWAS calculates the additions and reductions of timber from a given stock over a specified period of time. The Land Accounts provides similar information as the Core Ecosystem Stock and Flow and the Natural Assets accounts. The BEWAS land accounts consist of forests, wetlands and peatlands, water bodies (rivers, stream and lakes) and non-designated land surface areas. The Ecosystem Services accounts captures information provided by the Core Ecosystem Stock and Flow, Functions and Services and Supply and Use of Ecosystem Goods and Services accounts. The BEWAS assesses sixteen ecosystem services based on land cover type.

The CSERA consists of Natural Resource Stocks, Material and Energy Flows and Environmental Protection Expenditures accounts. It was developed to complement the Canadian System of National Accounts by providing additional environmental accounts. The Natural Resource Stock accounts provide similar information to the Core Ecosystem Stock Flow, Supply and Use of

Ecosystem Goods and Services and Natural Assets accounts. The Natural Resource Stock accounts provide surface areas for twelve land cover types. The Material Energy Flow accounts captures information provided by the Core and Material and Energy Flow, Core Ecosystem Stock Flow, Supply and Use of Ecosystem Goods and Services accounts. The Material and Energy Flow accounts track material, energy and water flows between the economy and the environment. The Environmental Expenditure Accounts does not correspond directly with any of the accounts provided in the ecosystem accounting framework as it focuses on tracking expenditures on pollution protection devices.

The BEWAS and the CSERA do not directly measure ecosystem integrity or assess an ecosystem state. The lack of quality measures of Natural Capital is an important shortfall as they are imperative to accurately assess a nation's wealth and its population's well-being.

### *4.2.4. Remote Sensing*

The development of the NCA informatics architecture proposed relies heavily on spatial data gathered using remote sensing technologies. These technologies, comprised primarily of geographical information systems, aerial photography, and satellite imagery, have gained considerable international currency in the past few decades providing invaluable information for developing plans in all sectors of society (Salam, Ross, & Beveridge, 2003; Smil, 2000; United States Geological Survey, 2007; C. Weber & Puissant, 2003). Canadian remote sensing applications being developed by the Canada Centre for Remote Sensing, GeoConnections and the National Land and Water Inventory System provides a foundation on which to develop the informatics architecture proposed.

The Canada Centre for Remote Sensing is responsible for providing remotely sensed data for various applications. It is involved with partners in the development of the Canadian Geospatial Data Infrastructure and a number of Geographic Information System (GIS) applications. Their programs cover a wide range of thematic areas such as supporting the development of strong and safe communities, a clean environment and trade and investment opportunities. For example, their geomatics for the sustainable development of natural resources project consists of developing and communicating the use of basic geospatial information layers for a number of geographical features of interest to facilitate the sustainable development of natural resource.

GeoConnections, a national partnership program, is currently providing expertise and funding to expand and use the Canadian Geospatial Data Infrastructure (CGDI) which supports planning and decision-making in the areas of public health, public safety, aboriginal communities and sustainable development (GeoConnections, 2005). The program is striving to provide Canadians with accessible social, economic and environmental information though the CGDI, an online connective network. For instance, Pollution Probe in partnership with GeoConnections, is developing a spatially based online planning tool based on the CGDI to support the sustainable management of the Ottawa River watershed (GeoConnections, 2006). The "EnviroBrain" will enable planning officials to exchange information and devise strategies to protect the water resource. For instance, "EnviroBrain" may enable the development of compensation schemes for upstream farmers to use less fertilizer which will cut down water treatment needs downstream. GeoConnections is laying the first comprehensive and coordinated national spatial information grid by connecting various sources of geographical data across the country (GeoConnections, 2005). The CGDI will become invaluable for delivering and accessing valuable spatial information for the development of effective sustainable development plans and policies.

The National Land and Water Information Services (NLWIS), led by Agriculture and Agri-Food Canada, consists of the development of an online tool designed to support Canadians in making

land-use decisions. The tool will provide agri-environmental data on land-use, soils, water, climate and biodiversity. It will be built using Geographical Information Systems (GIS) technology following national standards and specifications and federal geomatic policies and practices to ensure its relevance across the country (Agriculture and Agri-Food Canada, 2005). The NLWIS will link a number of agri-environment information sources and efforts to better use natural resources and deliver this information via the internet. GIS mapping technology will support municipalities develop sound agri-environmental plans. "For example, analysis of detailed geospatial information on soil types, ground cover, soil drainage and setback distances from manure storage would encourage responsible environmental choices (Agriculture and Agri-Food Canada, 2005)." The overall goal is to promote responsible land-use decisions that will help balance economic development with environmental sustainability.

## 4.3. Natural Capital Valuation

According to the Millennium Ecosystem Assessment over half of the world's ecosystem services have been degraded and are threatened (Tallis & Kareiva, 2005). To avert the degradation of NC and its associated ecosystem services methodologies for its valuation have expanded rapidly. Although a number of methodologies for valuing ecosystem services exist there is no standard method (Carpenter et al., 2006).

The values of goods and services exchanged on markets reveal an individual's willingness to pay (WTP) for their direct use. Ecosystem services used indirectly by society and have no exchange markets to reveal their values. Perceived economic values of ecosystem services are vastly subjective and context specific. Nevertheless, they provide useful information for economic and environmental decision-making and are getting notable attention from the private and public sectors (Tallis & Kareiva, 2005).

The United Nations' System of Environmental and Economic Accounts (SEEA 2003), the World Bank's National Wealth Measurements (NWM) and Statistics Canada's Canadian System of Environmental and Resource Accounts (CSERA) use different approaches to estimate the values of natural assets, land and ecosystems. These approaches vary widely based on the goals of the accounting system. Significant challenges remain in harmonizing environmental and economic accounts and incorporating additional NC values within the balance sheet.

### *4.3.1. Valuation Approaches*

NC valuation approaches can be organized into revealed and stated preferences methods. Revealed methods use data on actual behaviour and consumption patterns while stated preference methods rely on responses to queries to estimate the WTP for certain goods and services.

The values of NC goods or services traded in existing markets can be determined by their market prices partly driven by supply and demand and production costs. The market price uses standard economic techniques or revealed preferences data to measure economic benefits from marketed goods based on quantities purchased and supplied at various prices (King & Mazzotta, 2000).

The productivity method is used to evaluate the direct impact of environmental quality on the cost of producing a certain good (King & Mazzotta, 2000). For example, the cost required to eliminate agricultural runoff would be compared against the cost of purifying water at a treatment plant (Olewiler, 2004; Postel & Thompson, 2005).

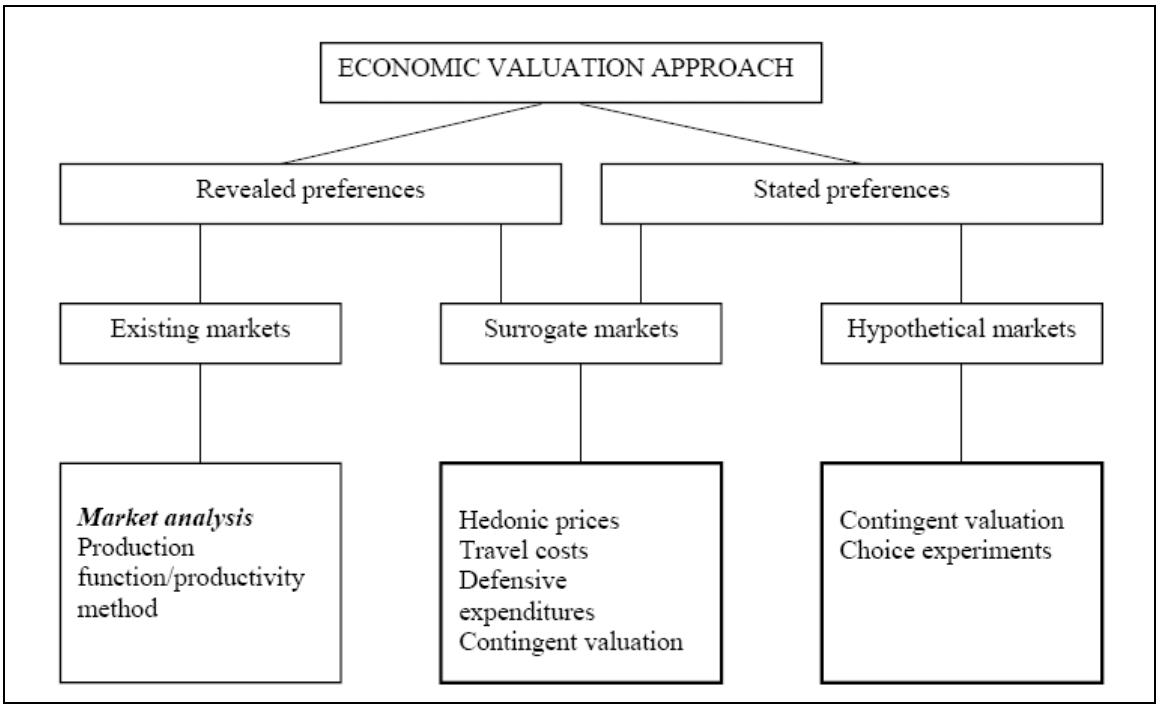


**Figure 16**: Valuation methodologies (Source: United Nations Economic and Social Council, 2006, p. 31)

Revealed and stated preference methods within surrogate and hypothetical markets are used to capture values of ecosystem goods and services that are not incorporated in existing market values. The hedonic price method is used to determine the value of qualitative natural capital characteristics traded via market goods. For instance there is generally a higher demand for houses located in quiet neighbourhoods or in non-polluted environments which increases their value. The travel cost method aims to determine the value of natural capital for recreational purposes. Financial expenditures to travel to certain places are reflections of their recreational value. Defensive expenditures, also known as damage cost avoided, replacement cost and substitute cost, are estimated by evaluating the costs of mitigating or avoiding adverse environmental impacts or externalities such as air pollution or flooding. This method assumes that the cost of avoiding damages or replacing ecosystem services flowing from natural capital, provide a means to estimate their value (King & Mazzotta).

The contingent valuation method uses WTP questions on hypothetical situations to determine the value of NC and ecosystem services. It is the most widely used method for estimating non-use values. For example, people might be asked their WTP for better air quality, biodiversity or aesthetically pleasing landscapes. The information collected using the contingent valuation method can easily be questioned as it consists of stated preferences based on hypothetical situations. Choice experiments involve ranking and scoring selected NC or ecosystem services and their estimated values allowing the analysis of preferred environmental policy options. Comparing and ranking NC restoration programs with different outcomes is an example of a choice experiment.

Conducting site specific natural capital valuation studies using the valuation approaches presented can be time consuming and expensive (McComb, Lantz, Nash, & Rittmaster, 2006). Benefits transfer techniques are methods used to increase the accuracy of transferring natural capital and ecosystem service valuation information from one context to another (Wilson & Hoehn, 2006). As valuation studies have grown over the years benefit transfer techniques have become more accurate for estimating ecosystem services values (Wilson & Hoehn, 2006). Carefully transferring valuation

information offers an economically viable approach to include ecosystem services values in decision-making.

### *4.3.2. Valuation Applications*

The SEEA 2003, the NWM and the CSERA illustrate how NC and ecosystem services valuations are being carried out. These accounting frameworks utilize different valuation approaches based on their goals and objectives. In general, valuation approaches used to estimate natural assets that have market values are well established and are similar amongst the three accounting frameworks. Environmental elements that do not have market values are valued using techniques that are not considered economically rigorous or simply mentioned as a possible future accounting addition which will depend on valuation technique developments.

The SEEA 2003 was devised to provide guidance for the development of a comprehensive environmental and economic accounting system. It does not prescribe one way of developing a system of accounts but presents harmonized approaches, best practices and alternatives with arguments for and against (United Nations et al., 2003). The SEEA 2003 complements the System of National Accounts (SNA) by extending its boundaries to include non-produced environmental assets that do not have market values.

The SEEA 2003 uses market prices, associated market transactions and estimation methods based on economic theory of price and value to generate NC and ecosystem service values. Natural resource values are estimated by calculating the resource rent based on market prices, production costs, expected life lengths and discount rates. Ecosystem assets are recognized in the SEEA 2003 as providing a number of indirect use benefits such as the regulation of geochemical flows and the cleansing air, water and soil. Valuing ecosystem assets is problematic as it is their whole system functions that provide benefits. The SEEA 2003 uses valuation techniques for measuring degradation to estimate the value of ecosystem services. The idea is to attribute a value to the quality of ecosystems via the costs associated with preventing or rectifying the degradation of ecosystem functions. This approach which is typical of project appraisals, enables the evaluation of trade-offs between environmental and non-environmental objectives. The SEEA 2003 acknowledges the importance of monetary estimation for non-market goods and services for aggregation and evaluation of trade-offs with goods and services that have market values.

To calculate NWM, the World Bank assesses produced, natural and human capital stocks which are calculated using market values and local extraction and harvesting costs. The Net Present Value of resource rents is used to calculate the income derived from a country's NC over an assumed lifetime. The valuation of NC is limited to natural resource rent estimations derived from non-renewable resources (oil, natural gas, coal, and mineral resources), cropland, pastureland, forested (timber extraction and non-timber forest products) and protected areas. NTFPs and protected areas are crudely estimated by using proxies derived from the other resources. Specific ecosystem services and benefits are considered free gifts of nature and are neglected in the NC wealth contribution.

The CSERA's Natural Resource Stock Accounts (NRSA) measures the important natural resources stocks in Canada in physical and where possible in monetary terms. The initial development of the NRSA has focused on natural resources stocks that have market values which enabled the calculation of their resource rents using the net present value method. For the most part, the NRSA does not capture natural resources without market values. However, these accounts will be expanded to include natural resources that provide benefits not measured by the economy as valuation methodologies evolve and become standardized. For instance, the land account of the NRSA will include non-market values for forests and parkland and agricultural land once suitable methodologies

are developed (Statistics Canada, 2006a). The CSERA acknowledges the importance of ecosystem functions to our well-being but does not provide explicitly a means for estimating their values.

### *4.3.3. Valuation Challenges*

Physical measures are precursors for the estimation of monetary values. They are limiting as they cannot be aggregated without losing important information for assessing the loss or gain of NC. Monetary values facilitate the aggregation and comparison of physical measures. They also enable the compilation of an overall measure of well-being. However, measuring environmental assets in monetary terms is plagued by conceptual and practical challenges which continue to fuel debates over the legitimacy of valuing natural environments (Smith, 2007). For instance, the substitutability of natural environments and the goods and services they provide is the subject of controversy (Smith, 2007; Spash, 2000). Some argue that substituting NC is not possible as all forms of capital stem from nature. This notion is important to grasp as many ecosystems are non-linear and discontinuous and changes can be irreversible (Farber, Costanza, & Wilson, 2002; Gunderson & Holling, 2002). The lack of standardized methods for estimating environmental asset values and obtaining reliable data is problematic. When a good or service is sold in a market, good information is provided about its price, and therefore an aspect of its value. However, as is usually the case with ecosystem goods and services, there is no market transaction from which to gather information.

Economic value provides only the value of a carefully specified change, with all others held constant. In practical terms, it is deemed more feasible to strive towards quantifying the value of a well defined marginal change (Barg & Swanson, 2004). However, economic values do not include the value of the system as a whole (Pearce, 1993). Whole system valuation is important as human preferences will vary with time and space but the objective qualities required for natural environments to contribute to human well-being remain the same. "The capacity of ecosystems to contribute to value lies within their components, connective structure and the functions they perform, so, the instrumental value goal must refer to the maintenance of the health and quality of these components and connections in a way that maximizes their functionality which in turn will maximize their potential for economic value (Straton, 2006, p. 409)."

Determining which NC components should be valued and at what resolutions is a significant challenge. The SEEA 2003 identifies three main types of ecosystems, terrestrial, aquatic and atmospheric, which all contribute to the following three services: "regulating global material and energy flows, absorbing human wastes and providing environmental amenities (United Nations et al., 2003, p. 257)." Depending on the need and utility, ecosystems and services can be further sub-divided and statistics provided for each one (United Nations et al., 2003). The SEEA 2003 advocates developing an accounting framework that is tailored to be useful for a given context as opposed to striving for the standardization of an accounting method. NC attributes emerge from ecological systems and provide a relevant scale for its measurement and valuation (Straton, 2006). For example, soil properties that contribute to a successful crop emerge as a result of the soil system components. Too fine or too coarse a resolution may be meaningless and useless depending on the information requirements for achieving a particular goal. For example, information on the quality of each soil particle making up a soil system may not be useful for agriculture but could be useful for a forensic investigation.

In order to avoid double counting and provide a clearer direction for valuing ecosystem services, Boyd (2007) argues that ecosystem services are strictly "the end products of nature (p. 719)." For example, the ecosystem services of soil regeneration and fertility, pollination and precipitation are encompassed in crop production. This notion is problematic for the protection of NC as the ecological functions and services that contribute to the attainment of "end products" are not

accounted for. The approach advocated by Boyd is pragmatic and economically sound but may inadvertently lead to a disconnected and narrowed image of ecosystems and their services. To remedy this potential eventuality, the SEEA 2003 purposefully double counts natural elements in their ecosystem and natural resource asset accounts.

> "Forests that are used as a source of timber are classified as natural resource assets. Since these same forests provide other benefits as well (carbon absorption for example), they are also classified as ecosystem assets. This reflects the fact that these forests provide more than one kind of benefit. As natural resources, they provide direct use benefits, while as components of ecosystems they provide indirect use benefits. It is necessary to recognise both roles of forests and other biological resources if a complete picture of the benefits provided to humans by the environment is to be captured in the SEEA (United Nations et al., 2003, p. 257)."

Double counting is introduced to highlight and examine the different kinds of environmental benefits we receive. By stepping beyond the bounds of formal accounting rules the SEEA 2003 provides a more comprehensive account on the state of the economy and the environment.

## 4.4. Natural Capital Integration

The NCA integrates itself into governance and policy development by bridging the gap between the economy and ecology. Measuring and monitoring the effects of human activities on our natural environments will help devise effective sustainable development strategies. "A natural capital model would be a scientifically mandated means of establishing which environmental issues need to be addressed and a means of evaluating how adequately they are addressed (Foster, 2003, p. 72)." The aim of the NCA is to provide the measures and signals needed to align human activity with the physical limitations of the natural environment.

### *4.4.1. Governance*

The resolution at which the NCA is developed and its compatibility with varying scales of governance is an important consideration for its relevance and effectiveness. Statistics New Zealand (2006) calls for the development of an NCA that is transferable and meaningful for various spatial scales, includes cross-boundary movements of NC and NC benefits, is comparable and has universal relevance and does not encroach on confidential information. "The notion of sustainability begins at the small scale and feeds into larger community, city and national outcomes generates the need for this information to be available at different scales (Statistics New Zealand, 2006, p. 5)." Ideally, the NCA would also be comprehensible internationally to facilitate the assessment and monitoring of the world's NC. Clearly, methodologies are required to develop and integrate an NCA that can translate local realities and measures that are transferable to regional, provincial and national levels of governance.

Governance spatial scales or institutional borders have been primarily drawn based on human priorities (Kaufman, 2002). These borders have led to complexities in dealing with environmental issues which do not respect jurisdictional boundaries (D. R. Boyd, 2003; Richardson & Wood, 2006). To address these transboundary environmental problems additional governance structures based on basins and watersheds have been established (Kaufman, 2002). For instance, the Red River Basin Commission, established in 2002, works across the national boundaries of Canada and the United States to develop a shared vision and actions for addressing land and water issues. These watershed

based governance structures have had some successes in developing programs to slow and reverse environmental degradation as the watershed provides the most logical spatial scale on which to base the management of natural environments. "Watersheds form the best hydrological planning units for land, water, and ecosystem management (Kaufman, 2002, p. 57)." Delineating jurisdictions and creating governance structures based on watersheds should be initiated whenever possible (Kaufman, 2002). Aligning the NCA with the emerging trend towards watershed-based Integrated Water Resource Management is an important policy direction.

### *4.4.2. Policy Development*

Policy-makers are faced with the significant challenge of balancing socio-economic activities and sustaining the natural environment. Increasingly, governments are looking at introducing a variety of policy instruments such as environmental taxes and subsidies, incentive programs, permits and licenses, communication and education programs and the establishment of environmental management partnerships as opposed to environmental legislation to restrict or encourage certain behaviours (Statistics Canada, 2006a). Sound information based on environmental statistics and economic models is required to assess the trade-offs and impacts associated with the introduction of policy instruments into the public domain. Communication and education, setting partnerships and including all stakeholders will allow the implementation of effective NC stewardship plans.

There is a need to develop NC incentive programs to offer alternatives environmental regulatory approaches. Wilkie states "natural capital incentives are powerful tools and it is likely that the role of incentives will strengthen as environmental public policy continues to evolve (Wilkie, 2005, p. 1)." These NC incentive programs need to be (Wilkie, 2005):

- complementary to current regulatory frameworks;
- innovative and flexible to stimulate continuous improvement;
- proactive and effective which tends to be least costing;
- measurable and verifiable to ensure that they are being effective;
- participatory to promote cooperation amongst stakeholders; and
- rewarding to encourage continual improvement.

A successful NC incentives-based program would be built on education and outreach, research and analysis of NC incentive frameworks, learning partnerships, small scale pilot projects and measuring and monitoring existing incentive initiatives (Wilkie, 2005). Incentives would compel people to become better stewards of the natural environments (DeFries, Foley, & Asner, 2004).

Payments for Ecosystem Services (PES) are emerging as an effective incentive for NC conservation in many parts of the world. PES schemes consist of paying individuals or communities for the preservation and restoration of NC so that all can benefit from their ecosystem services (Tallis & Kareiva, 2005). Although PES is not a panacea to all Natural Capital woes it can be an effective incentive and point of entry for promoting NC stewardship. "PES is a highly promising conservation approach that can benefit buyers, sellers and improve the resource base, but it is unlikely to completely outstrip other conservation instruments (Wunder, 2005, p. 1)."

The integration of NC within the domain of policy-making is closely linked with developments in environmental accounting. Environmental statistics are often incomplete and missing completely. For example, in Canada there are no national data on the extent and quality of wetlands (Smith, 2007). This is problematic as ecosystems provide essential services such as carbon sequestration and

water supply that have very high values (Anielski & Wilson, 2006; Olewiler, 2004). Accessibility to the data is often difficult and more attention is required for their management and distribution. Environmental data collection methodological changes over time are necessary for improving data quality but can limit the compatibility and comparability of the data. To realize their full impact in the public policy realm environmental statistics "must be made more complete, more readily accessible and more coherent among themselves and with economic and social statistics (Smith, 2007, p. 594)."

Moving the NCA into the mainstream of policy-making is a significant challenge that is dependent on the nature, quantity and quality of the environmental information and statistics that can be accessed. In order to overcome this challenge a clear conceptual framework for data collection that will meet the needs of a wide range of users is required. The conceptual framework provides the rationale for the selection of data collected, their organization and their importance. To ensure that the environmental information is relevant and useful it needs to be comprehensive, consistent and coherent. The data need to be comprehensive so it can be representative of an entire system. For instance, "statistics with a regional dimension must be measured for all regions represented in the system (Smith, 2007, p. 594)." Information that is gathered and measured in a consistent fashion over time will enable the analysis of trends. Internal coherence enables comparability between the statistics within the system and external coherence facilitates comparability and combinability with statistics from other systems.

Integrating NC concepts and information within policy-making is making inroads with the development and adoption of the SEEA 2003 which is well suited for supporting the capital approach to sustainability. The SEEA 2003 is expected to lead to a convergence of international environmental accounting as it will be elevated to an international standard in 2010, it represents a collective effort between a number of nations and international agencies lending itself to a higher degree of acceptance and it incorporates a number of accepted practices (Smith, 2007). More importantly, the SEEA 2003 provides guidance on generating a range of information that is useful for developing environmental policy. Physical accounts and hybrid accounts provide a means for evaluating economic activities in physical terms as well as monetary terms. For example, the SEEA's hybrid accounts link pollution or energy use with particular economic activities.

Although progress is being made, significant challenges remain for integrating NC within policy development structures. For instance, to effectively analyse alternative environmental policies a common metric is required for the examination of costs and benefits. Policy analysis typically relies on economic analysis and modelling which uses monetary measures to asses trade-offs (United Nations et al., 2003). This is problematic as a number of elements within the natural environment do not have market values and are difficult to assess monetarily. NC assessment and valuation methodologies are evolving to address this challenge.

A historical analysis of the loss or gain of NC and the policies that have influenced these changes provides a good platform on which to develop new policies aimed at preserving and restoring natural environments. For example, understanding the policies that have led to the transformation of the landscape in the Canadian prairies and the establishment of a well entrenched agricultural production system is a starting point for analyzing the trade-offs between continued economic activity and impacts to the environment. Ducks Unlimited Canada estimates that "up to 70% of wetlands have been lost in the settled areas of Canada." The drainage of wetlands for agriculture needs to be properly assessed as their ecosystem services have significant environmental and economic value manifested as flood prevention, carbon sequestration and water filtration to name a few. Establishing links between policies and human activities provides a basis for understanding the degradation or loss of NC which is a good starting point for devising effective policies to remedy the situation.

A biophysically and economically grounded standardized methodology for assessing and valuing NC will provide access to the resources required to establish effective environmental management programs. Prioritizing which environment management objectives should be pursued and justifying NC related expenditures to Treasury Boards are key practical applications of NC assessment and valuation. The Community Pastures Program (CPP), championed by the Prairie Farm Rehabilitation Administration (PFRA) and implemented to rehabilitate lands that were lost to desertification provides a good example of the importance assessing and valuing NC. To justify continued public expenditures on the CPP, the PFRA conducted a study which included biophysical and economic information to demonstrate that the benefits (54.9 million) of the program outweighed the costs (21.9 million) (Kulshreshtha & Pearson, 2006). Applying the NCA provides economic rationale for effective environmental management programming and applications.

The development of values centred on the protection and enhancement of NC through education programs and promoting the discovery and dissemination of scientific knowledge will encourage behaviours that are conducive to sustaining natural environments. Natural Capital stewardship plans that recognize and resonate with the heritage and cultural values of the local communities involved are more likely to be successful (Longo & Hodge, 2007). Education and communication campaigns can be effective at shifting attitudes and behaviours (Dale, 2007a). For instance, the anti-smoking campaign has been successful in changing people's attitudes in twenty years (Dale, 2007a). The "Natural Values: Linking the Environment to the Economy" brochures produced by Ducks Unlimited of Canada are great examples of communication efforts for NC preservation. These brochures succinctly communicate the many attributes and benefits of preserving and protecting various types of NC.

The incorporation of local knowledge into the NCA is important as it represents a rich source of contextual information that is usually well understood by local populations. The importance of local knowledge cannot be undermined as it often represents knowledge and wisdom gained through generations of experimentation. For example, the level of sophistication of traditional Balinese irrigation systems, which have been designed over many centuries, are such that civil engineers have not been able to suggest significant improvements (Mitchell, 2002). Additionally, it is easier to communicate concepts and ideas using language and knowledge that resonates with local populations. Incorporating local knowledge in the NCA will ensure that important information and opportunities for effective communication will not be missed.

An NCA that facilitates the development of partnerships and inclusion of all stakeholders will be effective and sustainable (Dale, 2007a). This is necessary as sustainable development issues "are dynamically interconnected and cannot be dealt with in isolation by anyone community alone, as many of them span traditional jurisdictions and local capacity (Dale, 2007b, p. 5)." Partnerships facilitate access to additional resources, information and understanding which are crucial for defining problems effectively, devising alternative solutions and creating a sense of acceptance and responsibility for implementing action plans (Mitchell, 2002). Ideally, a partnership will be entirely collaborative where power, ownership and risk are equally shared (Mitchell, 2002). All stakeholders potentially affected or benefiting from an NC stewardship plan should be included to ensure that all interests are represented. Partnerships and the inclusion of all stakeholders will increase the likelihood for the acceptance, effective development and implementation of an NCA.

# 5. THE ENVIRONMENT CANADA NATURAL CAPITAL FRAMEWORK

Environment Canada's preliminary research on the Natural Capital (NC) concept led to the development of its NC framework in May 2006. The framework is analyzed to highlight its main strengths and weaknesses and suggest possibilities for improvement.

General steps for implementing the framework within the Canadian context and its implications for policy development are explored. The Natural Capital Approach (NCA) represents a bridging concept between socio-economics and the environment and a means for operationalizing sustainable development. Applying the framework through pilot studies provides an opportunity for Environment Canada to build a NC policy architecture.

## 5.1. Reflections on the Framework

The Environment Canada NC framework is the culmination of preliminary NC research on integrating the concept within environmental policy-making (see Figure 16). The articulation of the Vision, Principle Goals and Objectives shapes the orientation of the NCA around maintaining economic competitiveness while preserving and restoring natural environments. This orientation is consistent with the ecological economics literature which promotes sustainable economic development by respecting the provisional and assimilative capacities of the natural environment. It is also consistent with NC international and domestic implementation initiatives explored in Chapter 3, which aspire to enhance human well-being by balancing economic development and environmental preservation and restoration. The framework articulates the NC's interconnected nature, economic importance and physical limitations. It then provides a range of expansive action statements for its preservation and restoration.

Its main strength is its broad formulation which encompasses a wide range of NC related considerations. As a point of entry for incorporating NC concepts within economic and environmental decision-making, planning and management, the framework is well suited for guiding high level programming. It lays out balanced aspirations of economic prosperity and environmental preservation and enhancement. The framework provides a broad conceptual outline for devising a NC informatics architecture, programs and projects to fulfill its vision, principle goals and objectives.

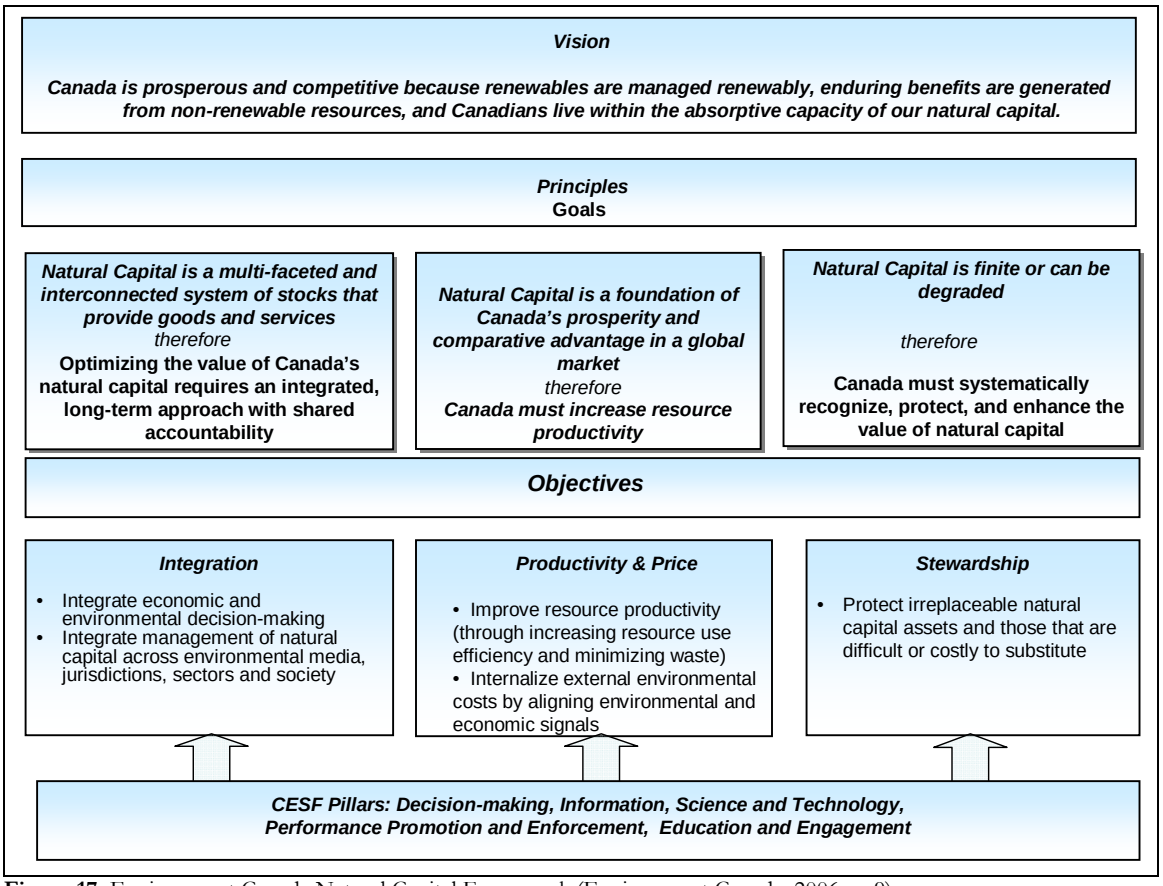


**Figure 17:** Environment Canada Natural Capital Framework (Environment Canada, 2006, p. 9).

The NC framework lacks detail for its implementation which can be drawn from international and domestic developments in environmental accounting. The System of Economic and Environmental Accounts (SEEA 2003) and the Canadian System of Environmental Accounts (CSERA) are comprehensive environmental accounting systems that offer a foundation on which to build an NC informatics architecture. Leveraging Statistics Canada's environmental accounting work for tracking NC will advance Environment Canada's efforts to implement the NCA. Consequently, reference to these guidelines in the framework could provide the detail required to guide NCA implementation efforts.

The language used to describe the vision, principal goals and objectives of the NCA framework is critically analyzed in Table 4 to provide recommendations for its improvement.

| **TABLE 4: Critical Analysis of the Environment Canada NCA Framework** | | |
|---|---|---|
| NCA Framework Element | Articulation | Critical Analysis |
| Vision | Canada is prosperous and competitive because renewables are managed renewably, enduring benefits are generated from non-renewable resources, and Canadians live within the absorptive capacity of our natural capital. | The vision statement is well articulated as it provides considerations for sustaining renewable and non-renewable resources and lowering NC degradation by living within it assimilative capacity. |
| Principle Goals | *Natural Capital is a multi-faceted and interconnected system of stocks that provide goods and services* – Optimizing the value of Canada's natural capital requires an integrated, long-term approach with shared accountability. | The statements "long-term approach" and "shared accountability" are not explicit enough to understand exactly what is being prescribed. A reference to multi-generational equity in the articulation of the principal goal will clarify the statement. |
| | *Natural Capital is a foundation of Canada's prosperity and comparative advantage in a global market* – Canada must increase resource productivity | Increasing resource productivity can be misinterpreted with resource extraction. The term "productivity" could be replaced with the term "sustainability." |
| | *Natural Capital is finite or can be degraded* – Canada must systematically recognize, protect, and enhance the value of natural capital | This principal goal can be misinterpreted so that only the value of NC is recognized, protected and enhanced. Conveying clearly that NC must be recognized, protected and that only its value must be enhanced will facilitate comprehension. |
| Objectives | Integrate economic and environmental decision-making<br><br>Integrate management of natural capital across environmental media, jurisdictions, sectors and society | This statement could be more detailed. It is useful for implementing the NC concept as it promotes its integration within governance and society. |
| | Improve resource productivity (through increasing resource use efficiency and minimizing waste)<br><br>Internalize external environmental costs by aligning environmental and economic signals. | This statement is clear and useful for implementing the NC concept as it provides enough detail on improving resource productivity. |
| | Protect irreplaceable natural capital assets and those that are difficult or costly to substitute. | The statement "irreplaceable NC assets" is unclear. Irreplaceable can mean non-renewable NC or the critical NC required to maintain ecosystem integrity. |

## 5.2. Implementing the Framework

Statistics Canada's CSERA is an accounting framework that was developed with influences from the SEEA 2003. It provides a good foundation on which to build a NC informatics architecture for the implementation of the NCA. One of the primary shortcomings of the CSERA is that it does not account for ecological integrity which is primordial for gauging the provisional and assimilative capacities of ecosystems. In addition, Statistics Canada is working to expand the CSERA to include ecosystem service values. Environment Canada has the opportunity to shape Statistics Canada's CSERA by providing expertise in assessing ecological integrity and ecosystem service value estimates. The Canadian Wildlife Service research on biodiversity and environmental indicators offers in house expertise for devising suitable ecosystem integrity measures to assess the state of the natural environment (Environment Canada, 2005). Ecosystem service value information in the Environment Valuation Reference Inventory administered by Environment Canada can be used to expand the CSERA. By actively participating in further developments of the CSERA, Environment Canada can influence its development to ensure that it will be an effective NC informatics architecture for implementing the NCA.

Environment Canada has an opportunity to become the policy architects of the NCA. In the spirit of adaptive management[5] which professes "learning by doing" pilot studies which test the NC concept could be initiated and led by Environment Canada. The lessons gained from these implementation studies will provide valuable insights for designing policies conducive for NC preservation and restoration. The pilot studies will also expose policies that impede expected beneficial outcomes of the NCA so they can be rectified. In addition, designing the implementation studies using a participatory approach provides an opportunity for establishing community partnerships which can be invaluable in shaping effective ecosystem management policies.

The establishment of ecosystem service values is required to implement the framework and align economic development with environmental signals. The Ecosystem Valuation Reference Inventory (EVRI), the largest valuation study depository in the world, represents Environment Canada's efforts to incorporate ecosystem service values into their decision-making (McComb et al., 2006). Environment Canada supports and administers the EVRI which provides a number of studies and data on ecosystem service values. The CSERA is being expanded to include additional environmental values in its accounting framework. Linking the CSERA with the EVRI could help Statistics Canada and Environment Canada advance the implementation of the NCA. Valuing ecosystem services is primordial to operationalize the NCA and continued efforts to expand the database, to expand environmental accounting frameworks such as the CSERA, will greatly facilitate its implementation.

The NC framework could transcend organizational barriers[6]. Emerging complex problems such as climate change require integrative policy development and solutions. The NCA promotes integrative policy-making as it balances economic and environmental imperatives. This could lead to further policy coherence and consistency horizontally across federal departments and vertically with

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[5] Adaptive management provides a basis for coping with the complexities and uncertainties associated with social and ecological systems by adopting a trial and error model where changes are made in an incremental fashion to continuously learn from them (Dale, 2007a).

[6] Organizational barriers are referred to by Dale as solitudes, stovepipes and silos. "Solitudes refers to deep cleavages based on language, cultural and religious, and other forms of exclusion. Silos refer to divisions between sectors such as research and business, researchers and government policy-makers, and between governments. Stovepipes are separations within an organization or business, for example, between and within government departments and in universities, among disciplines (Dale, 2007a, p. 3)."

provincial and municipal agencies enhancing policy effectiveness. The NCA is an overarching concept under which government efforts to enhance the economy and the environment can coalesce.

By bridging conceptual gaps between the economy and ecology, the NCA can provide an effective medium for building political consensus for NC preservation and enhancement policies.

> "In the political arena there is little agreement about the extent of environmental problems, the ecologically most sound policies for ameliorating environmental degradation, and the most effective and efficient means of implementing these policies. A natural capital model, mandated by both economic science and ecological science, could be a powerful force assisting the creation of political consensus so that corrective policy could be implemented (Foster, 2003, p. 72)."

While the NCA may help build political consensus around NC preservation and enhancement policies it will not resolve the "ought-is" dichotomy between political agendas on how the world ought to be and scientific descriptions of how the world is (Foster, 2003). A well designed NCA will provide politicians and policy-makers with a convincing rationale, based on economic and environmental measures derived from scientific principles, to better align economic activities with ecological realities.

Complexities and uncertainties[7] associated with natural systems provide a considerable challenge to implementing the NCA. To manage the knowledge gaps in our understanding of complex human and natural systems, provisions are required for managing uncertainties and changes that will arise (Gunderson & Holling, 2002). Adaptive management and modelling help address complexities and uncertainties. Adaptive management is well suited to deal with the dynamic nature of ecosystems as it is structurally decentralized, flexible, interactive, collegial, participatory and organic. Models, though imprecise, gives us a language that can represent the complex interactions of environmental, economic and social systems.

In conclusion, the NC framework is a broad and comprehensive outline that lacks an implementation strategy. This void can be filled by Statistics Canada's CSERA which provides a foundation for building a NC informatics architecture. Environment Canada has the expertise to enhance and shape the CSERA by designing ecosystem integrity measures (Canadian Wildlife Service – biodiversity and environmental indicators work) and ecosystem service value estimates (the Ecosystem Valuation Reference Inventory). An NC-based pilot study led by Environment Canada will be invaluable to gain experience applying the CSERA and designing NC preservation and enhancement policies. The NC framework can provide a means to bridge organizational barriers and build political consensus as it aims to balance economic and environmental imperatives. Adaptive management and modelling are tools that can be used to manage complexity and uncertainty which will help implement the NCA.

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[7] Mitchell defines various levels of uncertainty as follows: "Risk: Know the odds; Uncertainty: Know only key variables and their parameters; Ignorance: Do not know the questions that should be posed; Indeterminacy: Understanding not possible due to open causal chains (Mitchell, 2002, p. 16)."

# 6. CONCLUSIONS AND RECOMMENDATION

The Natural Capital Approach (NCA) is a means for identifying and quantifying natural resources and associated ecosystem goods and services that can help integrate ecosystem-oriented management with economic decision-making and development. By integrating economic and environment imperatives, it operationalizes the ecosystem approach and facilitates policy-making for sustainable development. Environment Canada is exploring the concept to develop effective environmental policies.

The Environment Canada NC framework is a broad and comprehensive outline that lacks an implementation strategy. This void can be filled by Statistics Canada's CSERA which provides a foundation for building a NC informatics architecture. Environment Canada has the expertise to enhance and shape the CSERA by designing ecosystem integrity measures (Canadian Wildlife Service – biodiversity and environmental indicators work) and ecosystem service value estimates (the Ecosystem Valuation Reference Inventory). An NC-based pilot study led by Environment Canada will be invaluable to gain experience applying the CSERA and designing NC preservation and enhancement policies. These insights can then be used to enhance the current Environment Canada NC framework.

We recommend an Environment Canada-piloted ecosystem-scale application of ecological goods and services valuation for policy analysis and design. The pilot study will assist in demonstrating:

- the utility of the CSERA for environmental policy analysis and development;
- the policy saliency of an NC and ecosystem services valuation exercise; and
- the relevance of NC and ecosystem services valuation for analyzing and justifying NC stewardship and restoration programming in economic terms to key agencies such as the Treasury Board.

The Red and Assiniboine River system in Southern Manitoba—a sub-basin within the Lake Winnipeg—watershed is a suitable location to carry out an NC-based analysis. The transformation of the landscape in Southern Manitoba is marked by a dramatic loss of prairie, forest and wetland covers that have been converted into croplands. NC losses are partly responsible for the degradation of Lake Winnipeg, which has become the most eutrophic large lake in the world. The preservation and restoration of NC such as wetlands, which provide nutrient mitigation and absorption services, would greatly help improve the Lake's condition. An IISD-Environment Canada joint NC pilot study in the Red-Assiniboine River system will have the synergistic benefits of demonstrating the relevance of the NCA for effective environmental policy-making and NC preservation and restoration for recovering Lake Winnipeg.

The Environment Canada and Statistics Canada NC work would benefit greatly from pilot applications to real-world ecosystem management issues. We regard the Lake Winnipeg Watershed as an excellent candidate for an ecosystem-scale case study to demonstrate the policy utility of ecosystem service valuation and further federal NC research and policy development capacity.

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