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Ecosystem Accounting – Policy Applications

Draft

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1 Issue

There is a growing consensus that ecosystems around the world are deteriorating. This understanding, along with the increasing demand for information on environmental sustainability as demonstrated through reports such as the Millennium Ecosystem Assessment[1], The Economics of Ecosystems and Biodiversity[2] (TEEB), the Stiglitz-Sen-Fitoussi Report[3], the World Bank WAVES[4] project and the Strategic plan for Biodiversity 2011-2020,[5] have furthered demand for ecosystem accounts.

In 1992 at the Rio Earth Summit environmental accounts were proposed as a way of integrating the environment in decision-making (United Nations 1993). As a result, a handbook for integrated environmental and economic accounting was published. Updated in 2003, it forms the basis of the international System of Integrated Environmental and Economic Accounts (SEEA) and employs accounting concepts and structures compatible with the System of National Accounts. It enables stocks and flows of environmental assets (natural resources, land and ecosystems) to be represented in physical as well as financial measures.

The SEEA is currently undergoing revision. Volume 1 contains the Central Framework and Volume 2 will contain a framework for experimental ecosystem accounts, which will help provide a better understanding of the market and non-market goods and services provided by ecosystems.[6]

Discussions are ongoing through the UN Committee of Experts on Environmental and Economic Accounting (UNCEEA) on the development of standards and classifications for experimental ecosystem accounts led by the United Nations Statistics Division (UNSD), the European Environment Agency (EEA) and the World Bank. These discussions are informed by work going on around the world, including at the EEA with the development of Simplified Ecosystem Capital Accounts, at Statistics Canada with its

[1] Millennium Ecosystem Assessment, 2003, *A framework for assessment*, http://www.maweb.org/en/Framework.aspx.
[2] TEEB (The Economics of Ecosystems and Biodiversity, 2010, Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB, http://www.teebweb.org/Portals/25/TEEB%20Synthesis/TEEB_SynthReport_09_2010_online.pdf.
[3] Stiglitz, J. E., A. Sen, and J-P Fitoussi, 2009, Report by the Commission on the Measurement of Economic Performance and Social Progress, http://www.stiglitz-sen-fitoussi.fr/.
[4] World Bank, n.d., Wealth Accounting and Valuation of Ecosystem Services, www.worldbank.org/programs/waves.
[5] See http://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf (accessed Feb. 10, 2012).
[6] United Nations Statistics Division, 2012, Land and Ecosystems Accounts, http://unstats.un.org/unsd/envaccounting/les.asp (accessed February 22, 2012).

project on Measuring Ecosystem Goods and Services (MEGS), and at the Australian Bureau of Statistics with its Pilot Land Accounts for the Great Barrier Reef.

This document considers current and potential applications of ecosystem accounting and some of the key conceptual, structural, methodological issues that influence its relevance and usefulness for various policy needs. It is intended as an input for the Integrated System of Environmental and Economic Accounts (SEEA) Vol. II and will support understanding of the policy context surrounding ecosystem accounts.

The main focus in Canada will be to provide time series information at a national scale. However, it is also important to consider how the accounts can and should be used at sub-national scales since these potential uses may entail specific requirements as to the design, construction and methods used.

Since the final structure of the accounts has not been determined under SEEA and countries have been encouraged to move forward with experimental accounts, a number of policy applications may be considered. Ecosystem accounting is a general-purpose approach that could have applications in many domains. However, given the structure and methodologies chosen in a particular country or sub-national territory, not all policy applications will be as feasible or appropriate as others. Appendix 1 provides an overview of the different perspectives being brought together in this multi-disciplinary activity of ecosystem accounting.

This document considers the general purpose and potential users of ecosystem accounts and provides a typology, as well as Canadian and international examples, of current and potential uses. It then considers some of the main dimensions that will constrain or facilitate the use of ecosystem accounts.

2 Background

2.1 Ecosystems, ecosystem goods and services and ecosystem accounts

Ecosystems are natural systems of biotic and abiotic elements functioning as a unit. They produce goods and services (EGS) that contribute to human well-being.

Classification of ecosystem services was originally intended to highlight renewable natural capital (such as plants and animals), as opposed to non-renewable capital such as subsoil assets (such as fossil fuels, metals and minerals). A Common International Standard for Ecosystem Services (CICES) is currently being developed as part of the revision of the SEEA. This classification still considers some non-renewable resources but does exclude sub-soil assets. As per the CICES, ecosystem services can be categorized according to three themes: Provisioning, Regulating and Maintenance, and Cultural.[7,8]

Although standards for the structure of ecosystem accounts have not yet been finalized, they are generally agreed to include the following general elements:

- Stocks in physical units and changes in stocks; the quantity and quality of the ecosystems and changes within a given period

[7] European Environment Agency, 2011, Common International Classification of Ecosystem Services (CICES): 2011 Update. Prepared for UNSD Expert Meeting on Ecosystem Accounts, 5-7 December 2011, London.

[8] Provisioning services included in the CICES can be considered final outputs, in that they are directly consumed or used by people.

- Stocks in monetary units; this could refer to either comprehensive values[9] or maintenance costs to measure the cost of ecosystem maintenance or degradation ("ecological debt")
- Flows to and from the economy in physical units; measures of final ecosystem goods and services in physical units represent flows from the ecosystems to the economy
- Flows in monetary terms; this would include monetary values of ecosystem goods and services.

2.2 Ecosystem accounts: general purpose

Statistics Canada has emphasized that the first step in the development of an environmental framework is the identification of the high-level policy objective it will inform. It identifies the objective of maintaining environmental quality for the purpose of maintaining human well-being."[10]

Ecosystem accounts within this framework are being designed to provide comprehensive and structured data to policy makers and the public that will allow for the exploration of questions relating to the impacts of economic growth on ecosystems and the implications for sustainability. Information provided would also allow for decision-making regarding the most effective use of ecosystems in support of human well-being, such as finding optimal development pathways that take into account economic, environmental and social objectives. TEEB's recommendation to upgrade the system of national accounts to include the value of changes in natural capital stocks and ecosystem services would support better management of natural assets.[11] For example, data recorded in ecosystem accounts might be used to facilitate performance reporting, environmental assessment and trade-off decisions in land use planning. Eventually this information might support macroeconomic aggregates, comparable to GDP to inform economic policy.

One benefit of ecosystem accounts is that they are based on coherent classifications, standards and concepts and are designed to complement environmental and economic accounts that are consistent with the System of National Accounts framework. One objective of this linkage is to develop "green accounting" indicators that will allow for economic analysis that explicitly accounts for ecosystem values.

The more rigorous methodologies that underpin an accounting approach will improve the coherence of existing environmental statistics, which may use differing methodologies, frameworks and standards and are frequently not comparable across jurisdictions.

2.3 Potential users

Potential users of ecosystem accounts at the federal government level include departments of environment, natural resources, fisheries and oceans, agriculture, public safety, health, transport, as well as industry and finance. Other potential users include provincial, regional and local government decision-makers. In Canada, the provinces have jurisdiction over natural resources and land management.

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[9] Such as the net present value of the expected future flow of services as used in the valuation of natural resource stocks.
[10] Statistics Canada, A Framework for Developing Environmental Statistics, 27 October, 2009, p. 12.
[11] Sukhdev, P. et al., 2010, The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the approach conclusions and recommendations of TEEB, p.26.

The accounts would support information needs and research agendas of academics, non-governmental organizations, and businesses by providing a coherent framework for research and reporting. They and could also help support greater knowledge and understanding of natural capital among the general public by providing consistent concepts and statistics.

3 Policy applications of environmental accounts

To date the emphasis in SEEA has been on measuring the economic impact of natural resource depletion. Revealing the prices associated with stocks and flows of physical assets is an important step towards more efficient use of natural resources; it can tell us how efficiently natural resources are being used to support our economy and how economic activity impacts on the stocks of those physical assets.[12]

The management of our environment is not just about the rate or economic efficiency of resource depletion. We must also manage the **condition** of the environment. If environmental accounting is to contribute to the sustainable management of the world's natural environment, it must be able to measure the impact of economic activity on the conditions of ecosystems and the biodiversity that comprise them.[13]

Ecosystem accounts will provide the opportunity not only to analyze the economic impact of environmental degradation, but also the environmental impact of economic activity.[14]

Lange's[15] review of policy application of environmental accounts provides insight on how natural resource asset (including ecosystems), pollutant and material flow and environmental protection accounts and environment-adjusted macroeconomic aggregates support decision-making. She provides the following typology for policy applications of environmental accounts:

1. Stock accounts:
    a. monitor total wealth and changes in natural capital
    b. provide information to assess whether resource management is achieving goals of economic efficiency, sustainability and equity
2. Physical and monetary flow accounts:
    a. provide information to assess pressure on the environment and evaluate alternative options for reducing pressure
    b. undertake environmental-economic modeling in support of policy analysis and strategic planning
3. Accounts for SNA adjustment

This typology is useful to classify national-level applications; a broader classification will be required to include local applications and those in areas related to environment and natural resources but not usually considered in the same domain such as health and security.

[12] Personal Communication, Jane McDonald, Wentworth Group, February 21, 2012.
[13] Personal Communication, Jane McDonald, Wentworth Group, February 21, 2012.
[14] Personal Communication, Jane McDonald, Wentworth Group, February 21, 2012.
[15] Lange, G.M, 2003, Policy Applications of Environmental Accounting, Environmental Economics Series, No. 88, The World Bank.

3.1 Policy applications of ecosystem accounts

In the context of degrading ecosystems, the motivation for implementing ecosystem accounts stems from the need to provide better information to support decision-making. The key question that ecosystem accounting must answer is: how do we grow the economy while ensuring that the capacity of ecosystems to renew themselves and to provide goods and services is maintained?

Information provided through ecosystem accounts could potentially inform a broad spectrum of policies at different scales and could help monitor consequences of decisions and actions taken. We focus here on examples of how newly-developed ecosystem accounts might support operational activities and analyses at resource and environment departments, (e.g., biophysical and valuation data would support policy development, reporting and regulatory activities) and how they might support mainstream decision-making for sustainable development.

Possible applications and uses of ecosystem accounts in sustainable development, natural resources, land use and environmental policy can be grouped according to the following general categories:

- Information supports monitoring (e.g. of resource quantity or quality over time, sustainable development reporting.)
- Information supports specific policy or process need (e.g. cost benefit analysis, modeling, renewable and non-renewable resource management, land use planning)
- Information supports education and awareness purposes (e.g. to inform conservation decisions and investments in environmental protection)[16]

The above categories can also be further refined to assess distributional effects against target policy groups (e.g. gender, age, culture).[17] Ecosystem accounts can be seen as a macro-level tool, but they can also be applied at regional and local spatial scales.

Below, we include examples, at various jurisdictional levels, of policy objectives and programs for which coherent information on the state and change in the state of ecosystems as well as on ecosystem services has been or may be useful. These examples shed light on potential users and types of policy applications we might see for data from the ecosystem accounts.

3.1.1 Information supports monitoring

Ecosystem accounts would be a useful accountability tool to set and track progress in meeting policy targets. They also provide a means of assessing whether environmental expenditures result in improved environmental outcomes, as measured by the change in the condition of ecosystem assets.[18]

[16] Personal Communication, Jack Ruitenbeek, H.J. Ruitenbeek Resource Consulting, January 24, 2012.
[17] Ibid.
[18] Personal Communication, Jane McDonald, Wentworth Group, February 21, 2012.

Accounts could support reporting demands by providing supplementary information for the Canadian Environmental Sustainability Indicators (CESI), supporting reporting under Canada's Federal Sustainable Development Strategy (FSDS). The FSDS is a government-wide approach to achieving environmental sustainability across federal departments by integrating economic, social and environmental considerations in decision-making. It requires effective measurement, monitoring and reporting in order to track and report on progress towards environmental sustainability and progress in addressing national priorities of climate change and air quality, maintaining water quality and availability, protecting nature.

Ecosystem accounts would support demands for measures of ecosystem quality and biophysical data to monitor and report on environmental conditions that would be linked to economic activity. By providing information that is coherent and comparable at regional and local scale data, they would help monitor the threats to ecosystems as well as the causes of those threats and their costs to society.

Ecosystem accounts could enhance the relevance, reliability and comparability of statistics underlying sustainable development indicators of natural capital. The Québec government uses the capital-based approach, a conceptual framework for measuring sustainable development based on total national wealth, including financial, produced, natural, human and social capital. As part of this work, it has established a list of sustainable development indicators for "measuring the overall progress of Québec society toward sustainable development."[19] Québec's sustainable development indicators for natural capital are the area of land in protected areas, the area of land zoned for agricultural use, the state of forest ecosystems, the water quality at the mouth of the main southern watersheds, the annual percentage of days without smog, the annual air quality index, and trends in mean annual temperature.[20]

The accounts would also support other environmental reporting initiatives. Data from the accounts could be included or could supplement existing environmental indicators and reports. British Columbia Ministry of Environment, like environment ministries in other provinces, produces regular state of the environment reports and updates environmental indicators to monitor changes in environmental condition and support informed decision-making.[21]

3.1.2 Information supports specific policy or process need

Ecosystem accounts data could be used in development and land use decisions, regulatory analysis, modeling and other policy analyses.

Ecosystem accounts would support informed decision-making pertaining to land use and development, for example through identification of high quality areas. A comprehensive

[19] Ministère du Développement durable, de l'Environnement et des Parcs, Québec, 2002, *Sustainable Development Indicators*, http://www.mddep.gouv.qc.ca/developpement/indicateurs/index-en.htm (accessed November18, 2011).
[20] Institut de la statistique du Québec, 2012, *Sustainable Development Indicators (The Capital Approach)*, http://www.stat.gouv.qc.ca/donstat/dev_durable/indicateur1_an.htm (accessed November 18, 2011).
[21] BC Ministry of Environment, n.d., State of Environment Reporting: Environmental Indicators, http://www.env.gov.bc.ca/soe/indicators/ (accessed January 10, 2012).

source of biophysical and valuation data could be particularly helpful given that resources are often not available to conduct new site-specific studies.[22]

The Alberta Ministry of Environment and Water has conducted an assessment of ecosystem goods and services in southern Alberta to support identification of priority ecosystem goods and services and help inform land use under Alberta's Land Use Framework.[23] The province's Land Stewardship Act provides the means for government to identify its economic, environmental and social objectives and coordinate decisions surrounding land, species, human settlements, natural resources and the environment, including accounting for and addressing cumulative effects. Regional land use plans are required.

Regional and municipal governments have significant jurisdiction over land use in Canadian cities, developing regional growth strategies and land use plans. If accounts are presented at a local scale, regional governments could use biophysical and valuation data to support identification of sensitive ecosystems and help provide rationales to protect natural areas. For example, Metro Vancouver is developing a Green Infrastructure Network, based on an inventory of Sensitive Ecosystems that will "identify and map at-risk, fragile and ecologically important ecosystems throughout the region."[24]

The ecosystem approach "is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way."[25] The understanding of ecosystems and their interrelations with the economy is central to this approach. It takes an integrated view of environmental problems whose scope is increasingly multi-sectoral (e.g. climate change and loss of biological diversity). Hence, this approach requires the development of environmental statistics using a comprehensive and coherent framework based on the concept of ecosystems and linked to socioeconomics data.

In Québec, the ecosystem approach is being applied in forest and water management. The *Sustainable Forest Development Act* establishes progressive implementation of ecosystem management, the objective of which is "to adhere to a set of values and meet human needs by using ecosystem processes and functions and by maintaining the ecosystem's integrity."[26] Québec's National Water Policy uses integrated water management at the watershed level, which is based on an ecosystem approach.[27]

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[22] Personal Communication, Michele Macintyre, Unit Head, Environmental Economics, Science Policy and Economics Section, Environmental Sustainability and Strategic Policy, BC Ministry of Environment, January 6, 2012.

[23] O2 Planning and Design Inc., 2009, Ecosystem Goods and Services in Southern Alberta: A Framework for Assessing Natural Asset Condition, Prepared for Alberta Ministry of Environment.

[24] Metro Vancouver, 2011, Metro Vancouver's Ecological Health Action Plan, http://www.metrovancouver.org/planning/development/ecologicalhealth/EcologicalHealthDocs/ECOHealthActionPlan_Nov2011.pdf (accessed January 10, 2011).

[25] *Ecosystem Approach*, http://www.cbd.int/ecosystem/ (accessed November 18, 2011).

[26] Ministère du Développement durable, de l'Environnement et des Parcs, Québec, 2002, Mise en œuvre des recommandations de la Commission d'étude sur la gestion de la forêt publique québécoise (*in French only*). http://www.mrnf.gouv.qc.ca/forets/evolution/evolution-oeuvre.jsp (accessed November 18, 2011); Commission d'étude sur la gestion de la forêt publique québecoise, 2004, *Rapport*, p. 47 (*in French only*). http://www.mrnf.gouv.qc.ca/publications/forets/consultation/rapport-coulombe.pdf (accessed November 18 2011). Free translation.

[27] Ministère du Développement durable, de l'Environnement et des Parcs, Québec, 2002, La gestion intégrée de l'eau par bassin versant (*in French only*). http://www.mddep.gouv.qc.ca/eau/bassinversant/index.htm (accessed November 18, 2011).

Ecosystem accounts would support regulatory analysis, including providing information for development of compensation mechanisms and environmental assessment. Ecosystem accounts would make it possible to evaluate the efficiency of compensation mechanisms with regard to the conservation of ecosystems and to the preservation of ecosystem services at national and regional levels. Ecosystem accounts could also support operationalization of compensation mechanisms at local levels. They could be used to model the impacts of development projects on ecosystems (e.g. reduction in size, losses of ecosystem services) and to compare different compensation scenarios.

With regard to the valuation required for compensation, one of two types of value would be adequate depending on whether the ecosystem loss is compensated by a replacement ecosystem or by financial means. Monetary valuation based on restoration costs gives a value that represents the cost of creating a replacement ecosystem. Where it is not feasible to replace the ecosystem, monetary valuation based on ecosystem services would in theory yield an adequate value for financial compensation since it measures the value of lost ecosystem service flows. This is an example of weak sustainability since one type of capital (ecosystem) is being substituted by another (financial).

In partnership with Environment Canada, Ducks Unlimited and other groups, the Alberta Ministry of Environment and Water has been involved in developing a Wetlands Assessment Pilot Project under its new Wetlands Policy.[28] They consider avoidance or mitigation as preferred options, with compensation as an alternative. Better valuation of ecosystem goods and services would help improve efforts to avoid or mitigate loss or degradation of wetlands, by identifying high function and high value areas, and help make the economic argument for avoidance and mitigation.

Interest is growing in the development of habitat banking systems, schemes that create credits for purchase by industry and developers to compensate for activities that negatively impact habitat.[29] For example, hydro-electric producers or metal mining operations may be interested in participating in habitat banking to compensate for damage to fish habitat. Accounts information could support assessment of certified habitat banking credits and compensation requirements, supporting creation of a market for this type of compensation program. However, it has been recognized that "a viable market of biodiversity credits will only be created by regulation that defines equivalence between those debits and credits, and enforces compensation obligations."[30]

At least two compensation mechanisms are being developed in Québec including programs for wildlife habitat and wetland management as described below:

- According to the operational guidelines for the conservation of wildlife habitats protected under the *Act respecting the conservation and development of wildlife*[31],

[28] Personal Communication, Gillian Kerr, Ecosystem Goods and Services Policy Advisor, Socio-Economics and Governance Section, Alberta Ministry of Environment and Water, January 20, 2012.
[29] British Ecological Society, 2009, Growing Interest in Habitat Banking, http://britishecologicalsociety.org/blog/blog/2010/03/09/growing-interest-in-habitat-banking/ (accessed February 14, 2012).
[30] Dickie, I. & Tucker, G., 2010, The Use of Market-Based Instruments for Biodiversity Protection – The Case of Habitat Banking: Summary Report, Prepared for European Commission DG Environment, http://ec.europa.eu/environment/enveco/index.htm (accessed January 10, 2012).
[31] http://www.mrnf.gouv.qc.ca/publications/faune/lignes-directrices-habitats.pdf and http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/C_61_1/C61_1_A.htm (accessed March 1, 2012).

the Ministère des Ressources naturelles et de la Faune du Québec (MRNF, Québec Ministry of Natural Resources and Wildlife) must preserve the wildlife habitat stock with regard to both area and quality. When a wildlife habitat loss is considered unavoidable, the preferred approach is to provide a replacement habitat, while financial compensation is the least-preferred option. Financial compensation necessitates, among other things, that the value of the loss be determined. However, the evaluation currently being conducted is not based on harmonized methods that can withstand criticism. Faune Québec would like to introduce a wildlife habitat loss evaluation framework that would provide reliable and objective values to support negotiations with promoters and ensure the comparability of evaluations between regions for more predictability, equality and credibility[32].

- The Ministère du Développement durable, de l'Environnement et des Parcs du Québec (MDDEP, Québec Ministry of Sustainable Development, Environment and Parks) is undertaking a strategic evaluation for the preservation of wetland biodiversity, including ecosystem services. It would like to establish guidelines for clear, equitable and transparent management of the development project authorization regime. Sustainable wetland management guidelines will need to include compensation mechanisms for wetland losses that are acceptable to promoters as well as a means of evaluating the efficiency and economic impact of compensation with regard to the preservation of ecosystem services[33].

Similarly, Fisheries and Oceans Canada (DFO) could use ecosystem accounts data as part of its analysis of habitat compensation requirements under its policy of no net loss of fish habitat. The B.C. Ministry of Environment is developing a voluntary environmental mitigation policy to avoid, minimize or offset environmental damage.[34]

Accounts data would also support the analysis of potential environmental effects from development, e.g. providing information for project environmental assessment at the Canadian Environmental Assessment Agency and provincial environmental assessment programs.

Accounts information would provide information for modeling and other policy-relevant analyses. Accounts data could be used by Agriculture and Agri-food Canada for the development of market-based incentive programs for farmers. For example, the Alberta carbon offset system, established in 2007, includes several agricultural projects.[35] Manitoba has piloted an Alternative Land Use Services project that provides payments to farmers to maintain and enhance wetlands, riparian areas, ecologically sensitive lands and natural areas.[36] The prices generated through such programs might also feed back into ecosystem accounts.

The accounts could also provide data to support modeling for disaster mitigation and risk assessment. For example, Natural Resources Canada (NRCan) and Defence R&D Canada (DRDC)–Centre for Security Sciences are jointly involved in development of a

[32] Personal Communication, Stéphane Martinez, Service de la mise en valeur de la ressource et des territoires fauniques, Direction du développement socio-économique, des partenariats et de l'éducation, Ministère des Ressources naturelles et de la Faune, March 1, 2012.
[33] Personal Communication, Benoît Limoges, formally at the Direction du patrimoine écologique et des parcs, Ministère du Développement durable, de l'Environnement et des Parcs, November 23, 2011.
[34] Personal Communication, Jennifer Maxwell, Manager, Science Policy and Economics Section, Environmental Sustainability and Strategic Policy, BC Ministry of Environment, December 30, 2011.
[35] Agriculture and Agri-Food Canada AESB Policy Research Division & Federal-Provincial Ecological Goods and Services Working Group, 2011, Ecological Goods and Services.
[36] Ibid.

natural hazards damage prediction tool based on the US Federal Emergency Management Agency – Hazards US (FEMA HAZUS) model. DRDC is also involved in assessment of vulnerabilities and consequences from a risk assessment perspective, including geo-specific risk dashboards and maps.

Ecosystem accounts could provide the basis for measuring the environmental liability related to ecosystem losses or degradation. Research to integrate governmental environmental liabilities into the calculation of the government debt in the historic revision of the Canadian System of National Accounts is ongoing.

An environmental liability representing the costs incurred in remediating contaminated sites for which the Québec government is responsible has been entered in Québec's public accounts since 2006-2007. At the beginning of 2011-2012, the environmental liability entered in the public accounts amounted to $3,169 million dollars for 2,401 sites on record.[37]

Ecosystem accounting with spatially explicit information would inform investment and prioritization decisions. Information from the accounts could be used in cost-benefit and multi-criteria analyses and could evaluate the cost-effectiveness of environmental expenditures and investments.[38] Accounts information could be used to analyze how to improve or maintain ecosystems at the least cost to the economy.[39]

3.1.3 Information supports education and awareness purposes

Ecosystem accounts, including measures of ecosystem quality, could contribute substantially to education and awareness. Ecosystems are rarely viewed as producers of goods and services that are essential to human well-being.

Many organizations in government and the private sector require ecosystem information to support environmental and triple-bottom line reporting. For example, BC Hydro reports on environmental performance indicators to assess the environmental impact of operational activities. As part of their strategies for the 2010/11-2012/13 Service Plan, they indicate they will better "understand the ecosystem services that support our business, such as the natural cycles in climate and water."[40]

Metro Vancouver, a regional district in British Columbia, has indicated ecosystem accounts data could support reporting to policy makers and the public through the Metro Vancouver Sustainability Report and help build public support for environmental protection, for example providing the rationale for upgrades to the wastewater treatment plants at Iona Island and Lions Gate, conservation of wetlands such as Burns Bog, and conservation of the forested watersheds that protect drinking water quality.[41]

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[37] Finances Québec (2011), Public Accounts Consolidated financial statements of the Gouvernement du Québec. Fiscal year ended March 31, 2011. Volume 1, pages 114, 160. http://www.finances.gouv.qc.ca/documents/Comptespublics/en/CPTEN_vol1-2010-2011.pdf (accessed November 25, 2011).

[38] Cosier, P. 2011, Accounting for the Condition of Environment Assets, Prepared for the Expert meeting on Ecosystem Accounts, 5-7, December 2011.

[39] Personal Communication, Jane McDonald, Wentworth Group, February 21, 2012.

[40] BC Hydro, 2011, BC Hydro Annual Report 2011, http://www.bchydro.com/etc/medialib/internet/documents/annual_report/2011_BCH_AnnualReport.Par.0001.File.2011-BCH-Annual-Report.pdf (accessed January 10, 2012).

[41] Personal Communication, Ann Rowan, Division Manager, Sustainability Policy and Research, Policy Planning Department Metro Vancouver, January 6, 2012.

3.2 Mainstreaming use of ecosystem accounts information

While the biophysical data and economic valuations to be provided through ecosystem accounts most directly inform questions surrounding land use and production of natural products such as agricultural and forestry products, the potential application of ecosystem accounts is much more wide-ranging. Ideally, the accounts will support integration and use of ecosystem information across various economic sectors (agriculture, forestry, etc.) and domains of society (health, security, etc.). For example, data on ecosystem goods and services could contribute to policy issues surrounding well-being including health, income, security, cultural amenities, infrastructure, heritage, and others. Analysis of policies in these domains often includes modeling and scenario development, which could be enhanced by including links to how ecosystem services affect the policy target or are affected by it. For example, Bordt and Smith[42] discuss the measurement challenges in tracking the health and security impacts of climate change. Coherent ecosystem accounts would address many of these measurement challenges.

Hamilton and Lutz, in their 1996 examination of the policy uses of resource and environmental accounts, highlighted the need for integration of economic, natural resource and environmental policies and indicated that "monetized and physical environment accounts can support policy models that depict the broad environmental consequences of different economic strategies as well as the economic consequences of resource and environmental policies."[43] However, promoting the use of ecosystem accounts in economic and social policy remains a key challenge.

Three main issues hinder our ability to gain control of environmental change: a lack of systematic understanding of the condition of our environmental assets and how they are changing over time, ad hoc consideration of the environment in our decision making processes and inefficient resource allocation to environmental problems.[44]

Despite growing awareness of the importance of more holistic approaches and consideration of cumulative effects in development planning, incorporation of ecosystem measures in applied contexts is a work in progress. TEEB found that although the MA "helped foster use of the concept of ecosystem services…progress in its practical application in land use planning and decision making has been slow."[45]

Possible impediments include a lack of accessible and comprehensive data, lack of awareness or knowledge of how to apply this information, and separation across departmental mandates and responsibilities, among others. While ecosystem accounts will address issues of data availability and coherence, they would be best applied in a holistic approach to decision-making.

At a provincial level, Québec is moving forward in applying the ecosystem approach in specific applications such as forestry and water policy. The B.C. Ministry of Environment

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[42] Bordt, M., and R. Smith. 2008. "Measuring the Impacts of Climate Change: Are Central Statistical Offices Prepared to Track the Impacts of Climate Change?" Paper presented at the Conference on Climate Change and Official Statistics, Oslo, Norway, 14-16 April 2008

[43] Hamilton, K. & E. Lutz, 1996, Green National Accounts: Policy Uses and Empirical Experience. World Bank, Environmental Economics Series, Paper No. 039.

[44] Personal Communication, Jane McDonald, Wentworth Group, February 21, 2012.

[45] De Groot, R., et al., 2010, "Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation," *The Economics of Ecosystems and Biodiversity: The Ecological and Economic Foundations,* (DO, Chapter 1)*,* p. 4.

is working on a cumulative effects/integrated decision making framework, which seeks to provide objective information on environmental, social and economic values for decision making.[46]

Use of strategic environmental assessments (SEA) can help ensure environmental considerations "contribute to the development of policies, plans and programs on an equal basis with economic and social analysis."[47] In Canada, these assessments, which focus at a general or conceptual level, are conducted on all proposals submitted to federal ministers or Cabinet for approval where implementation may result in important environmental effects.[48] Analysis of environmental effects should consider potential environmental outcomes, the scope and nature of environmental effects, mitigation and enhancement opportunities and residual effects. Ecosystem accounts could enhance this analysis by providing a coherent core of data.

Another way to engage non-traditional users of ecosystem information, is to clearly define the issue, for example, by making it clear how development goals are underpinned by ecosystem services or how wetlands' ability to clean contaminants can be tied to health impacts.[49]

3.3 Other international examples of development of ecosystem accounts and potential policy applications

In July 2011, the European Union enacted Regulation No. 691/2011 on European environmental economic accounts, which establishes a common framework for environmental economic accounts including modules on air emissions, environmental taxes and material flows.[50] The regulation includes provision for pilot studies "to test the feasibility of introducing new environmental economic account modules"[51] such as Environmental Protection Accounts, Environmental Goods and Services Sector, Energy Accounts, Water Accounts, Waste Accounts, Forest Accounts and Ecosystem Services Accounts among others.[52]

The EEA has begun to examine the feasibility of developing ecosystem capital accounts, to begin to account for natural resources that are not seen as economic assets by the market.[53] The UNSD, European Environment Agency (EEA) and World Bank indicate that international initiatives such as the MA, TEEB, WAVES and others are driving the

[46] Personal Communication, Jennifer Maxwell, Manager, Science Policy and Economics Section, Environmental Sustainability and Strategic Policy, BC Ministry of Environment, December 30, 2011.
[47] Government of Canada, 2010, Strategic Environmental Assessment: The Cabinet Directive on the Environmental Assessment of Policy, Plans and Program Proposals, Catalogue no. EN 106-95/2010E.
[48] Government of Canada, 2010, Strategic Environmental Assessment: The Cabinet Directive on the Environmental Assessment of Policy, Plans and Program Proposals, Catalogue no. EN 106-95/2010E.
[49] Personal Communication, Gillian Kerr, Ecosystem Goods and Services Policy Advisor, Socio-Economics and Governance Section, Alberta Ministry of Environment and Water, January 20, 2012.
[50] Official Journal of the European Union, 2011, Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts.
[51] Official Journal of the European Union, 2011, Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts, p. 4.
[52] Official Journal of the European Union, 2011, Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts, p. 5.
[53] European Environment Agency, 2011, An Experimental Framework for Ecosystem Capital Accounting in Europe, EEA Technical Report No. 13/2011.

demand for ecosystem accounting.[54] They identify "the assessment of the impact of economic activities on the health (or state, capacity, functioning) of ecosystems" as "primary purpose" of ecosystem accounts.[55]

The UK National Ecosystem Assessment (UK NEA) evaluated the UK natural environment in terms of the benefits it provides to society and the nation's continuing prosperity.[56] It found that 30% of the services provided by the natural environment were in decline.[57] As a result, the government has developed a white paper laying out actions to mainstream the value of nature across society. As part of efforts to "grow a green economy" the report indicates that natural capital will be fully included in the UK Environmental Accounts.[58] It indicates that the value of natural capital needs to be taken into account as part of economic planning, by comparing the costs and benefits of different actions, and prioritizing natural capital investment based on those that will provide the best returns. It also indicates that environmental taxes and other market-based instruments might be used to deliver better environmental and economic outcomes.[59]

The Swiss Federal Office for the Environment (FOEN) has identified a list of physical indicators that represent ecosystem goods and services providing benefits for health and well-being, security, natural diversity and production factors and[60] FOEN indicates that the inventory should be used for general communication purposes about the contribution of nature to welfare.

Australia is developing trial Regional Environmental Accounts for 10 of its 56 regions using the Wentworth Group's *Accounting for Nature* model.[61] This method is based on development of a common unit of measure for environmental asset condition that compares current environmental conditions to reference condition benchmarks. Goals of this work are to help inform public policy decisions, measure whether environmental investments are helping to maintain natural capital and inform development of SEEA Volume II.[62]

4 Factors affecting use of ecosystem accounts

As a first step in determining how ecosystem accounts can support policy needs, consideration should be given to the main audience for whom this data will be useful. The needs of local government leaders in approving land-use planning decisions will be different from those using accounts data to facilitate national performance reporting.

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[54] Department of Economic and Social Affairs, Statistics Division, United Nations, SEEA Experimental Ecosystem Accounts: A Proposed Outline, Road Map and List of Issues. Prepared for the 17th Meeting of the London Group on Environmental Accounting, 12-15 September, 2011, Stockholm, Sweden.
[55] Ibid.
[56] UK NEA, 2011, The UK National Ecosystem Assessment: Synthesis of Key Findings, p. 15.
[57] UK DEFRA, 2011, The Natural Choice: securing the value of nature, p. 3.
[58] UK DEFRA, 2011, The Natural Choice: securing the value of nature, p. 36.
[59] UK DEFRA, 2011, The Natural Choice: securing the value of nature, p. 37.
[60] Staub, C., W. Ott, F. Heusi, G. Klingler, a. Jenny, M. Häcki, A. Hauser. 2011. Indicators for Ecosystem Goods and Services: Framework, methodology and recommendations for a welfare-related environmental reporting. Federal Office for the Environment FOEN. Bern. Environmental studies no. 1102:17 S.
[61] Cosier, P. 2011, Accounting for the Condition of Environment Assets, Prepared for the Expert meeting on Ecosystem Accounts, 5-7, December 2011.
[62] Cosier, P. 2011, Accounting for the Condition of Environment Assets, Prepared for the Expert meeting on Ecosystem Accounts, 5-7, December 2011, p. 11-12.

Developing ecosystem accounts as part of existing environmental accounts linked to the System of National Economic Accounts helps present this information to an important user base of researchers in government, academia, and non-governmental organizations. As well, international comparisons and analyses by organizations such as the UN, OECD, Eurostat and World Bank are generally done using statistics produced from the national accounts.

While the concepts behind ecosystem services and their valuation have become better understood by environmental science and policy professionals over the past decade, these concepts are still relatively new for the general public. As reported in the UK National Ecosystem Assessment, "*ecosystem services* is not a meaningful framework of interpretation of human-environment relations for the vast majority of people."[63] Additional effort may be needed to help publicize and develop widespread understanding of ecosystem accounts to encourage use by different stakeholders including the media.

Ecosystem accounts using sound methodologies, while ensuring that end-products are presented in a clear and accessible way will enhance their utility for a broad range of stakeholders.

4.1 Scale

The geographic scale of data available will influence its usefulness for various programs and projects.

While dissemination of ecosystem accounts in Canada will respect existing ecological classification boundaries (ecozone, ecoregion, ecodistrict, drainage areas etc.), it must be recognized that jurisdictional boundaries are more frequently used for decision-making. To maximize usefulness, accounts should allow users to aggregate or view data according to provincial and territorial boundaries and, where possible, lower levels of geography such as administrative regions and municipalities.

Data aggregated at a high-level of geography are likely of greater use for regular reporting through national indicators. However, the reliability of estimates at higher levels of geography is generally lower and the process of creating those estimates requires assumptions (e.g., about the similarity of one forest area to another) that may result in estimates that are not appropriate for certain types of decisions. Valuation studies can be very case-specific, affecting the validity of transferring values from one area to another or scaling up to larger geographical settings.

Data aggregated at a high-level of geography will likely be of limited use for land use planning and site-specific analysis and decision-making, which require local data. In some cases, local governments may find it sufficient to downsample values published at a higher level of geography to local situations for illustrative purposes; however, this may not always be the case. Local policy makers and the general public are most influenced by data that reflects and is directly applicable to local features and landmarks. Uptake and use of this data beyond use by science professionals and environmental economists may require local, fine-scale indicators.

In the longer-term, it would be beneficial to be able to disseminate ecosystem data through a web portal/mapping tool that would allow users to drill-down to the geographic level of their choice.

[63] UK NEA, 2011, The UK National Ecosystem Assessment: Synthesis of Key Findings, p. 40.

4.2 Quality assessment, physical measures and monetary values

Ecosystem accounts are generally considered to include information on quantity (extent), quality and value of ecosystem stocks, as well as information on flows of ecosystem goods and services measured in physical and monetary terms.

Various quality measures have been proposed by different groups working on the development of ecosystem accounts. For example, the Australian Wentworth group has proposed use of reference condition benchmarks, with values between 0 and 100 to reflect the quality of an environmental asset or indicator.[64] Benefits of such an approach include the ability to measure changes in condition over time and the ability to compare the relative quality of different ecosystem indicators with reference to their benchmark condition.

Another type of comparison could be made between the quality of a given ecosystem in reference to a similar pristine ecosystem for the same time period. Although this method does not provide time series information, it does allow for comparison between different ecosystems, allowing for identification of possible problem areas.

Other proposals have suggested the use of net carbon balance or a biodiversity index as indicators of ecosystem quality or composite ecosystem condition indicators, as part of larger frameworks for assessing ecosystem health. While topic-based quality indicators inform users about specific issues, they may do so to the exclusion of other concerns. For example, if the only issue being tracked is GHG emissions, one may overlook biodiversity losses or the negative human health impacts of ecosystem degradation. Ecosystem accounts would support the development of a range of conceptually and empirically related quality indicators to allow a more comprehensive view. Adoption of specific indicators as quality measures for the accounts requires a clear understanding of their intended purpose and end-user information requirements.

Physical measures or proxy physical measures, such as hectares of wetlands, tonnes of timber, or number of park visitors, can be used to measure both stock and flows. Physical flow measures are generally well understood; however, they might be less useful for certain types of analysis given that they sometimes cannot be aggregated into a single measure, which limits comparability and overall quantification of different goods and service flows.

Some controversy exists about the usefulness of providing monetary estimates of the total value of ecosystem assets. One report criticizes valuation studies that determine the total economic stock of natural capital, indicating their goal is often "to generate 'big numbers' so that EGS can claim a prominent seat at the 'public policy table.'"[65] However, such measures can inform many policy needs[66] and draw attention to the value of services provided by the environment from an education and awareness perspective. A

[64] Cosier, P. & J. MacDonald (Wentworth Group), 2010, A common currency for building environmental (ecosystem) accounts, Prepared for the London Group on Environmental Accounting, 25-28 October 2010, Santiago, Chile.
[65] DSS Management Consultants Inc., 2010, Technical Report: Valuation of Ecological Goods and Services in Canada's Natural Resource Sectors, Prepared for Environment Canada.
[66] Thompson, Ian D. et al., 2011, Forest biodiversity and the delivery of ecosystem goods and services: Translating science into policy, Bioscience, 61(12), pp. 972-981.

key issue is fitness for use, which relates to the level of precision needed for specific applications.[67]

Prices are widely understood by the general public and policy makers. Consequently, there is a demand to provide monetary valuations of ecosystem goods and services despite a lack of information.[68] Improving the reliability of information on the monetary value of ecosystem goods and services will support use in analysis and reporting for a broad range of users.

Determining monetary values of ecosystem goods or services is a complex undertaking and, given current methods and data, may not be possible in some cases. While it may be relatively easy to measure the value of a product such as timber, it is less meaningful to measure monetary values for critical flows for which no substitute exists since monetary values become infinite under conditions of scarcity.[69] For such critical stocks and flows, physical measures of extent and quality are called for.

4.3 Structure and methods—linking to policy applications

International discussions on the structure of ecosystem accounts are ongoing and a clear consensus has not yet emerged on the final design or methodology (see Appendix 1). Individual methods that have been proposed may not support all potential uses. Table 1 below provides a structure to consider potential benefits of the different accounting approaches and valuation methods.

Initial plans for Statistics Canada's MEGS project identified use of a table identifying ecosystems, their respective areas and quality measures (stocks) and monetary values of ecosystem goods and services per hectare (flows), grouped according to CICES classifications (Appendix 2). A benefit of this approach is that it provides a clear and easily-understood structure that can be used to communicate the values and benefits of specific ecosystem types. The accounts would be spatially nested, allowing presentation of data at different ecosystem classification levels.

Accounts structured this way would provide estimates of the monetary value of ecosystem goods and services in Canada, i.e. the total value of goods and services provided by Canada's stock of natural assets including ecosystems, where such values can be estimated. Accounts structured in this way do not explicitly represent the values of alternative values of ecosystem goods and services under different conditions (known as marginal values). Analysis would show how the extent, quality and value have changed in the past, but assumptions outside of the accounts would be required to develop scenarios of what may happen in the future.

Other approaches proposed for ecosystem accounts include the EEA's Simplified Ecosystem Capital Accounts, which are to include physical accounts of stocks and flows, with valuation of changes in stocks based on real expenditures or costs of restoration programs[70] as well as valuation of selected ecosystem services, without attempting to aggregate the service values into an estimate of the stock's total economic value at a

[67] Patrick ten Brink, Institute for European Environmental Policy, Presentation on The economics of Ecosystems and Biodiversity (TEEB) – Policy applications of ecosystem accounts. 5-7 December, 2011, London.
[68] Ibid.
[69] DSS Management Consultants Inc., 2010, Technical Report: Valuation of Ecological Goods and Services in Canada's Natural Resource Sectors, Prepared for Environment Canada.
[70] EEA (2011)

given time. Valuation would not be applied to all ecosystem stocks, but rather to changes in stocks, thus allowing for a representation of an ecological debt and for adjustments of macroeconomic aggregates.

Valuation methods have been identified that are appropriate for different ecosystem services and analytical requirements. Methods that incorporate production function methods have been applied to nature-related economic products (apples, timber and fish). Such approaches could be used to measure the embedded natural subsidy value of products and the impact on economic output of any change in ecosystem services supplied using input-output tables.[71] Although further work is needed to develop these methods, would potentially allow policy analysts to understand the link between a specific action, its impact on ecosystem goods and services, and the resulting change in economic output. One benefit of the production function approach is that it links to products included in the System of National Accounts and could be used in General Equilibrium Modelling (GEM) currently used in many government financial planning activities.

Table 1. Linking approaches and valuation methods to policy applications

Accounting Approach	Application	Positive/Negatives of approach	Example of user
Structured national environmental accounts including comprehensive valuation of ecosystem services	Reporting: Provides a broader perspective on national wealth. Supports indicators to monitor and report on change in ecosystem services to compare to in economic indicators. Supports assessment of sustainability of resource use. Policy: Could inform national priority setting and scenario building.	+ Coherent with System of National Accounts - Feasibility still under study - Difficult to obtain consensus on methods - Lack of data requires estimation	SEEA, UK NEI (to some extent), MEGS
Structured national environmental accounts focusing on estimation of costs of ecosystem restoration (Analogous to consumption of fixed capital)	Policy: Measurement of the ecological debt and adjustment of Net Domestic Product, National Income and Final Consumption	+ Entirely compatible with SNA concepts - Less amenable to local applications	EEA[72]
Green accounting (in principle includes structured national environmental accounts above)	Currently applied largely to local problem solving using various methodologies.	+ Encourages awareness of value of ecosystem services - No specific methodology or structured account	Pavan Sukhdev (personal communication), TEEB
Total Economic Value (TEV)	Largely for awareness purposes. Used to characterize the contribution that EGS make to society's general well-being.	+ Provides a broad scope of all values - May encourage double-counting if added without elimination of overlaps	TEEB
Pseudo-markets	Reverse auction where landowners offer to maintain a specified level of ecosystem services. This establishes a demand curve.	+ Works for local areas to allocate conservation funds - no supply curve since supply is limited to funds available '- Difficult to scale to national level	Victoria, Australia [1], Manitoba, Canada [2]

[71] Ibid.

[72] "Paying for ecosystem capital depreciation is […] an idea at work in several areas": "The target of 'maximum temperature increase of 2 degrees' refers to degradation of the atmosphere. The cost of keeping below this target is 'ecosystem capital consumption'"; REDD+; in the European Environmental Liability Directive of 2004, "the remediation costs of [ecosystem] impacts are ecosystem capital consumption"; and so on (EEA, 2011, p. 22).

Nature index, common currency, ecosystem health	Biophysical indicators to monitor changes in ecosystem quality or health. Can be used in conjunction with economic indicators to assess sustainability of economic activities.	+ Does not require monetary valuation of ecosystem services '- Subjective weighting of underlying indicators to create one aggregate	Norway [3], Australia [4], Rapport [5]
UK NEA (uses various methods)	Assess scenarios; impact on EGS values of different development paths	+ Adjusts EGS values to net out the contribution of human inputs to final goods and services	UK NEA
Valuation Method	**Application**	**Positive/Negatives of approach**	**Example of user**
Primary studies (using many methods but applied at local scale)	Biophysical measures and local estimation of values good for local decision making.	+ Best approach for local area - Difficult to scale up to regional or national level - often focused on one local issue rather than establishing comprehensive account	EVRI (Environmental Valuation Research Inventory) [6]
Site-specific benefits transfer	Attributing values to a "policy site" based on values determined in the past for a "study site". This can augment or substitute for a primary study. As with primary studies can inform local decision making about alternative land uses.	+ Can provide reasonable estimates if demand function is properly estimated - study areas need to have similar biophysical characteristics	Various practitioners: Ruitenbeek [7] Wilson and Hoehn (2006) [8]
Meta-analysis and benefits transfer to develop comprehensive valuation.	Global, national, regional awareness building, communications and priority setting.	+ Relatively simple methodology. - Criticism of large-scale benefits transfer without accounting for socio-economic context. - Underlying studies generally not sufficiently documented	Costanza (1997) [9], Ontario (2010) [10]
Production function (PF)	Assess ecosystem services as "natural subsidy" to economic production. Best for integrating with existing production (agriculture, forestry, fisheries) policy modeling.	+ Compatible with financial General Equilibrium Modeling. - Only addresses inputs to economic production.	DSS (2010) [11], Ian Bateman [12]
Willingness to pay, willingness to accept, choice modeling surveys	Used for establishing a pseudo price for ecosystem services when markets don't exist. Appropriate for prioritization between different development alternatives.	+ Well-established methodology - Often requires comparison or aggregation of market with non-market (consumer surplus) prices	Adamowicz [13], EVRI, Ducks Unlimited [14], RIASs

Note: The listing of approaches is freeform for the current draft. Certain approaches are included within others or overlap with others. They are named as commonly discussed. It would be beneficial to develop this into a more rigorous taxonomy.

Additional references: [1] http://www.dse.vic.gov.au/conservation-and-environment/biodiversity/rural-landscapes/bushtender; [2] http://www.iisd.org/wic/research/ecosystem/ecotender.asp; [3] http://english.dirnat.no/content/500042128/The-Norwegian-Nature-Index; [4] http://unstats.un.org/unsd/envaccounting/londongroup/meeting16/LG16_22a.pdf; [5] David J. Rapport, Bill L. Lasley, Dennis E. Rolston, N. Ole Nielsen, Calvin O. Qualset, Ardeshir B. Damania. 2003. *Managing for Healthy Ecosystems*. CRC Press, Boca Raton, Florida; [6] www.evri.ca; [7] Ruitenbeek HJ (1999) *Blue pricing of undersea treasures needs and opportunities for environmental economics research on coral reef management in South East Asia*. Paper presented to the 12th Biannual Workshop of the Environmental Economics Program for South East Asia, Singapore, 11-14 May. IDRC, Singapore. [8] Wilson, M.A., and J. Hoehn. 2006. Environmental Benefits Transfer: Methods, Applications and New Directions - Benefits Transfer. Ecological economics. Volume 60, Issue 2, Pages 335-482 (1 December 2006); [9] Costanza, R. et al. 1997. *The value of the world's ecosystem services and natural capital*. Nature vol 387 (May 1997); [10] http://www.mnr.gov.on.ca/en/Business/LUEPS/2ColumnSubPage/279467.html; [11] http://biodivcanada.ca/54B96EDA-BA11-422A-9EBB-985ADE9E0861/valuation_e.pdf; [12] Bateman, I.J. & Jones, A.P. (2003) *Contrasting conventional with multi-level modelling approaches to metaanalysis: An illustration using UK woodland recreation values.* Land Economics, 79(2), 235–258; [13] Bennett, J. and W. Adamowicz. 2001. *Some Fundamentals of Environmental Choice Modelling*. In: J. Bennett and R. Blamey (eds). The Choice Modelling Approach to Environmental Valuation. Edward Elgar. Northampton. p. 37-69; [14] http://www.ducks.ca/conserve/wetland_values/pdf/natcap-strategy-2en.pdf.

5 Conclusions and recommendations

International efforts to produce ecosystem accounts are currently at the research and experimental stage, so it is difficult to anticipate how the accounts will eventually be

structured. However as developers continue to work and refine methodologies and develop the framework for publishing these statistics, the question of who is the primary audience for information from the accounts should be kept at the forefront.

The UNSD, EEA and World Bank have indicated that "statistics from the accounts will inform formulation and impact assessments for land and ecosystem management, regulatory and fiscal policies…particularly at the national and international levels."[73] There is also a significant demand for such information at sub-national levels, and at local and regional scales, however, ecosystem accounts will not address all policy needs relating to environmental statistics.

Although it will not be possible to provide information to satisfy all the detailed information requirements of local users, eventual dissemination plans should consider methods that will allow for presentation of biophysical and other data at low-level geographies and scales where this is possible. Future use of a web-mapping or other online tool would allow users to identify ecosystem values and quality measures for specific geographical areas and aggregate or dissect the areas for their purposes.

While recognizing the challenges in assigning monetary values to ecosystem services, there is a policy demand for these types of measures. Engaging users from mainstream economic, health and other policy departments will require additional effort to define and identify the issue of concern, as well as a focus on practical applications of the data. Identifying champions who understand the possibilities of this information may be required to promote the use of this information in these areas.

Alternative indicators of ecosystem quality under consideration provide different perspectives (e.g. change in degradation over time versus difference in degradation compared with a pristine location) or provide information regarding a particular aspect of quality (e.g. biodiversity index, net carbon balance or composite indicators of ecosystem health). There are positives and negatives for each approach; therefore it will be important to consider the expected use of this information before selecting a single approach or measure.

The UNSD/EEA/WB expert group is currently debating the structure and methodologies to be used in SEEA Volume II, bringing together expert perspectives from around the world to develop ecosystem accounts (Appendix 1). It may be of benefit to further validate the usefulness of planned structures and tables, presenting early mock-ups to a wide network of potential data users for comment. Initial pilot data could focus on key areas or hot spots in order to best demonstrate potential uses and generate interest in the accounts.

[73] Department of Economic and Social Affairs, Statistics Division, United Nations, SEEA Experimental Ecosystem Accounts: A Proposed Outline, Road Map and List of Issues. Prepared for the 17th Meeting of the London Group on Environmental Accounting, 12-15 September, 2011, Stockholm, Sweden.

Appendix 1 - Contexts for ecosystem accounting

Note: This section was written by Michael Bordt. It is intended to serve as a background to ecosystem accounting in general.

1 Background

Although the main topic of this paper is the policy application of ecosystem accounts, such a paper requires a description of these accounts. Since the structure, concepts and methods of ecosystem accounting are still under development, the paper assumes a generic, broad definition that may not coincide with all the contributors' perspectives on their nature and purpose.

This appendix suggests a framework for the diverse paradigms that will need to meld further to make progress towards a more rigorous consensus on the details of ecosystem accounting.

Discussions of the UNSD/EEA/World Bank in London[74] focused on ten issues with the intended result being to achieve consensus on all ten. Convergence on all ten issues is important if SEEA Volume 2 on Experimental Ecosystem Accounts is to focus on the "how" of ecosystem accounting as well as the "why" and the "what".

The ten issues and main questions were:

- Issue 1 – Policy applications of ecosystem accounts: The main discussion was on fitness for use of information derived from ecosystem accounts.
- Issue 2 – Structure of accounts: Two models were proposed: Model A being economy-centric and Model B being ecosystem-centric.
- Issue 3 – Land cover mapping, land cover classifications, and accounting units: Several approaches were discussed but the core question was "What is the statistical unit?" that is, the basic unit for which information is provided.
- Issue 4 – Net ecosystem carbon accounts: While a comprehensive carbon account is important, the purpose for discussing this here was to investigate the suitability of Net Carbon Balance as an indicator of ecosystem quality that would serve to assess physical stocks.
- Issue 5 – Landscape accounts and landscape ecological potential: These were also proposed as high-level indicators of ecosystem quality.
- Issue 6 – Biodiversity accounts and indexes: These were also proposed as high-level indicators of ecosystem quality.
- Issue 7 – Ecosystem Health/Total ecological potential: These were also proposed as high-level indicators of ecosystem quality.
- Issue 8 – Classification of ecosystem services: This was to assess CICES as an adequate framework for classifying the important ecosystem services.
- Issue 9 – Prioritization of ecosystem services: This raised the question as to how to prioritize ecosystem services in terms of which to address and "get right" initially.
- Issue 10 – Principles of monetary valuation: This discussed the difficulties in attributing market prices to many ecosystem services. It suggested some alternatives to "willingness to pay" approaches such as developing pseudo-markets.

[74] UNSD/EEA/WB Expert meeting on Ecosystem Accounts. London, UK. Dec. 5-7, 2012. See http://unstats.un.org/unsd/envaccounting/seeaLES/egm/lod.htm for background papers and presentations.

While certain areas of consensus were achieved, there was some divergence on the overall terminology, definitions, concepts or methodology of ecosystem accounting. The meeting adjourned with the conclusion that SEEA Volume 2 would focus on establishing a common terminology, definitions and classification and would set a scope within which participants could conduct "experiments" over the ensuing years. That is, Volume 2 would focus on the "why" and the "what".

1.1 The perspectives

The following statements are often taken as absolutes in discussions about ecosystem accounting but putting them into context will help show why few of them actually are absolutes in either ethical or scientific terms. Following are some perspectives that suggest ***limiting the scope or approaches*** used in ecosystem accounts:

- You can't value natural assets in monetary terms. They are too important so instead measure only the degradation cost as an indication of natural debt.
- Market-based prices are most reliable and prices based on consumer surplus are to be avoided.
- We don't know enough about ecosystem functions to put a value on most of the services they provide.
- Ecosystem responses are non-linear and non-linearity cannot be treated in an accounting framework.
- Valuing ecosystems just puts a "For Sale" sign on them.
- The information we have is not good enough to make decisions.
- You can't scale up local information to the regional or national level.

Following are some perspectives that imply ***enabling the development*** of flexible ecosystem accounts:

- Any price on ecosystem services is better than no price.
- It is important to conduct local studies to find optimal environmental-economic solutions.
- Classifications can be developed that incorporate new knowledge and data as the accounts are developed.
- Ecosystem accounts should represent a simplification of ecosystem function as we understand it today, not necessarily all we know about ecosystems.
- Ecosystem accounts should provide the basis for analytical uses but not necessarily incorporate all the data and assumptions required to conduct that analysis.
- Ecosystem accounts should allow aggregates (indicators) that can be used for communications and general priority-setting.

2 The contexts

We define here a set of contexts, which can be seen as a group of related paradigms. For example, the context "Field of Study" groups together the paradigms largely related with the academic background or the nature of work of the expert. Ecosystem accounts are being discussed by experts of various backgrounds (biologists, ecologists, environmental economists, economists, policy analysts etc.) and each brings to the discussion their unique perspective.

The contexts to be discussed are:

- **Field of study (discipline):** Science (ecology, biology, physics, chemistry, geography, engineering, geomatics), economics (environmental, welfare, micro, macro, national accounting), policy analysis and application. Each discipline is important, but to establish ecosystem accounts, there need to be some core principles that all agree to. Pavan Sukhdev[75] suggests that the only commonality among the 550 participants in the TEEB process was that they believed it was important to understand the economics of ecosystems and biodiversity. Developing structured ecosystem accounts will require further convergence on other principles mentioned here.
- **Timeframe:** What we *can* do now versus what we *should be trying* to do in the foreseeable future. Ecosystem accounting will require both a firm grounding in current knowledge, data availability and policy applications as well as a vision of what knowledge, data and applications could and should be developed to maximize the utility of the accounts in the future.
- **Spatial scale:** Local versus regional, national, global thinking. Ecosystem accounting will require the ability to select a scale appropriate for the application. Some issues are very local (e.g., how much to pay a farmer to reduce downstream pollution so that water purification costs are reduced), while others are global (e.g., atmospheric GHG concentrations). Ecosystem accounts are sometimes considered parallels to national accounts leading to national estimates of natural wealth and security of provisioning services. Similar principles could be applied at a local level but with more detailed and precise data.
- **Fitness for use:** Varying levels of decisions require varying levels of precision[76]. Many analysts are reluctant to produce the "big number", that is, a national or global estimate of the value of ecosystem services. Most will agree that to produce such a number would require many assumptions and estimations and would therefore be at risk of being in error. However, if the main purpose of such a number is to raise awareness or to understand the relative importance of ecosystems, then the ecosystem account should support its calculation. A very important point is that the assumptions need to be clearly stated and understood by the user.

  Applications, such as priority setting, may require fewer assumptions and estimations thereby resulting in more accurate and defensible results.

  Uses that involve financial transactions, such as payment for damages, would require the most defensible estimates since results could be challenged in court.

- **Narrative:** Garnåsjordet[77] suggests four main narratives (points of view): harvesting of resources, ecosystem functioning, cultural values, conservation values. This context links together some of the issues around who is developing the ecosystem accounts and for which purpose are they envisioned. Some other contexts are related (e.g., scientific, field of study) but some new ones are suggested:

    - **Ethical:** Ecosystems have a right to exist without being valued; ecosystems exist to provide sustainable services to humans; ecosystems exist to feed

[75] Sukhdev, Pavan, 2012, The Economics of Ecosystems and Biodiversity (TEEB) – Reflections and Next Steps, Presentation at Environment Canada, Gatineau, Quebec. February 7, 2012.
[76] Ten Brink, Patrick, 2011, The Economics of Ecosystems and Biodiversity (TEEB) - Policy applications of ecosystem accounts, Presentation at UNSD/EEA/WB Expert meeting on Ecosystem Accounts, London, UK. Dec. 5-7, 2012.
[77] Garnåsjordet, Per Arild, 2011, Comments on: Accounting for the condition of environmental assets. Presentation at UNSD/EEA/WB Expert meeting on Ecosystem Accounts, London, UK. Dec. 5-7, 2012.

short-term profits. A common paradigm is that ecosystems are a source of services based on natural capital that should be exploited in a manner that maintains their capacity to provide those services. Conservationists may believe that ecosystems should not be valued since this encourages exploitation. Some businesses and governments may give environmental concerns a lower priority while confronting immediate financial concerns.

- **Cultural:** Ecosystems contribute more to human well-being than the market resources we can harvest from them (religious, cultural, existence...); cultural benefits are secondary to more direct contributions to well-being. Certain cultural icons (such as the Grand Canyon or the Ganges River) are an essential part of a culture's identity. They are considered difficult or impossible to value in monetary terms, which leaves them out of economic analyses.

Each narrative implies an emphasis on different indicators. All of the implied indicators could be derived from a single ecosystem account. However, certain indicators would be selected or given higher priority depending on the perspective being illustrated.

- **Application:** The perspectives indicate varying opinions about what ecosystem accounts are to be used for. These include: understanding ecosystem function; building a flexible accounting system; analytical uses of data from ecosystem function or accounts; decision making; solving a local resource allocation problem. This context is related to the perspective/narrative context in that it captures the paradigms of those collaborating to construct ecosystem accounts. The discussion is often enriched by a focus on ecosystem function, analytical applications or specific local issues. More focused discussions would be cognizant of the fact that a flexible accounting structure needs to capture some of the principles of ecosystem function but not all the knowledge surrounding it. It needs to be supportive of a range of analytical applications but it doesn't need to incorporate all foreseen analytical methods and classifications. Similarly, an account could provide background information and a structure for specific decisions without necessarily incorporating all the data required to conduct the analysis.
- **Method:** Some of the perspectives assume that data will be derived from a single methodological approach such as: production function; willingness to pay surveys; Total Economic Value; meta-analysis of existing primary studies; benefit-cost analysis. This overlaps somewhat with the Field of Study and Application contexts. Dependence on one method may limit the scope of the underlying accounts. It is important to distinguish between methods used to populate the accounts and analytical methods used to apply the accounts. A flexible national-level account would not be limited to incorporating data from a single approach. In fact, being able to compare results from different approaches improves the robustness of the accounts.

All of these taken together provide a multi-dimensional space into which the perspectives can be placed. Some perspectives noted in the first section may cross one or more of the paradigms within a context. For example, environmental economists should be cognizant of both the science and economics perspectives.

3 An initial analysis

This section presents an initial analysis of putting each of the perspectives into one or more contexts.

Table 1. Perspectives in context

	Context						
Limiting perspective	**Field of study**	**Time frame**	**Spatial scale**	**Fitness for use**	**Pers-pective**	**Applic-ation**	**Method**
You can't value natural assets in monetary terms. They are too important so instead measure only the degradation cost as an indication of natural debt.	Any	Now	Any	High Quality	Conser-vation values	Decision making	Any
Market-based prices are most reliable and prices based on consumer surplus are to be avoided.	National Accountin g	Now	National	High Quality	Any	Flexible accounts	Benefit-cost
We don't know enough about ecosystem functions to put a value on most of the services they provide.	Ecology	Now	Any	High Quality	Ecological function	Under-standing ecosyste m	Any
Ecosystem responses are non-linear and non-linearity cannot be treated in an accounting framework.	Ecology	Now	Any	Any	Ecological function	Analysis	Benefit-cost
Valuing ecosystems just puts a "For Sale" sign on them.	Any	Now	Any	Any	Conser-vation values	Any	Any
The information we have is not good enough to make decisions.	Any	Now	Any	High Quality	Any	Decision making	Any
You can't scale up local information to the regional or national level.	Ecology	Now	Local	High Quality	Ecological function	Under-standing ecosyste m	Meta-analysis
Enabling perspective							
Any price on ecosystem services is better than no price.	Economic s	Medium -term	Any	Medium	Any	Decision making	Any
It is important to conduct local studies to find optimal environmental-economic solutions.	Economic s	Medium -term	Local	Medium	Any	Solving local problems	Any
Classifications can be developed that incorporate new knowledge and data as the accounts are developed.	Any	Future	Any	Any	Any	Flexible accounts	Any
Ecosystem accounts should represent a simplification of ecosystem function as we understand it today, not necessarily all we know about ecosystems.	National accountin g	Any	National	High quality	Any	Flexible accounts	Any
Ecosystem accounts should provide the basis for analytical uses but not necessarily incorporate all the data and assumptions required to conduct that analysis.	National accountin g	Any	National	High quality	Any	Flexible accounts	Any
Ecosystem accounts should allow aggregates (indicators) that can be used for communications and general priority-setting.	Any	Now	Any	Medium	Any	Flexible accounts	Any

All of the limiting perspectives above presume current knowledge and data availability. Many also presume that for the given application, high quality data are necessary.

The enabling perspectives tend to reflect some dominance of economics and national accounting thinking. Three of the perspectives are based on the assumption that even medium-quality data are sufficient for communications or general decision making purposes. Most are directed towards supporting the creation of a flexible set of ecosystem accounts.

3.1 The path forward

It would be important for practitioners to situate themselves within the multi-dimensional space described above. A short questionnaire could be developed that reveals their underlying paradigms.

Multi-disciplinary initiatives require cross-disciplinary thinking. The initial challenge is to create a common understanding of the principles and goals of the initiative. The second is to provide learning opportunities so that limiting perspectives can be replaced by enabling ones. Joint problem-solving and priority-setting are useful activities to develop an appreciation for cross-disciplinarity.

Project goals can be formulated that take into account the multiple contexts and position the project within the multi-dimensional space. This could take into account a change in context over the duration of the project. For example, we are “here” now, we would like to be “there” in 3 years and “over there” in 10 years.

4 Appendix 2 - MEGS Project

Measuring Ecosystem Goods and Services (MEGS) is a Canadian interdepartmental project to develop statistical infrastructure to support the valuation of ecosystem goods and services and create pilot ecosystem accounts.

Through the MEGS project, Statistics Canada and partner organizations: Environment Canada, Agriculture and Agri-Food Canada, Fisheries and Oceans Canada, Natural Resources Canada, Parks Canada and Policy Horizons are building the statistical infrastructure for a System of Ecological Accounts, including developing spatial infrastructure, integrating biophysical data and developing a consistent approach to valuation.

As part of the overarching vision, project goals include providing high quality data to policy makers and the public that allow for the exploration of questions relating to the impacts of growth on the natural capital base and implications for sustainability, as well as the most effective use of natural capital in support of human well-being.

Demand for this project included the 2010 recommendation by the Deputy Ministers' policy committee on Climate Change, Energy and Environment to adapt Statistics Canada's environment and resource accounts by incorporating data on biodiversity and ecosystem goods and services.[78] Further consideration has since been given to the priorities of partner organizations, for example legislated reporting requirements through the Federal Sustainable Development Strategy.

Other departments including Industry Canada, Finance Canada and Human Resources and Skills Development Canada were involved in the initial project design and are considered potential users. Other potential data users include provincial, regional and local decision-makers. For example, valuation data might be used to facilitate performance reporting, environmental assessment and trade-off decisions in land use planning.

The MEGS vision of ecosystem accounts includes data on the stock of ecosystems and flows of ecosystem goods and services, using physical, monetary and qualitative measures, classified by standard ecosystems groupings (e.g. wetlands, lakes/rivers, forests, rangeland etc.) For example, physical stock information would include information on the extent or size of ecosystems, but also requires consideration of qualitative dimensions, while physical and monetary flows measure the quantity and value of ecosystem goods and services provided by the ecosystem.

Project plans have identified possible creation of a grid structure modified from Costanza et al.'s table estimating the average global value of annual ecosystem services.[79] The identified table components include ecosystems and their respective areas, quality measures and values of ecosystem goods and service/hectare according to CICES classifications.

[78] Reference to GCPEDIA, http://www.gcpedia.gc.ca/wiki/GCPEDIA:FAQ_index

[79] Costanza, R. et al., 1997, "The value of the world's ecosystem services and natural capita," *Nature,* vol. 387, 15 May 1997.