The Economics of Ecosystem Services and Biodiversity in Ontario (TEEBO)

Assessing the Knowledge and Gaps

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For the Ontario Ministry of Natural Resources

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Executive Summary

This report assesses the knowledge and gaps on the economics of ecosystem services and biodiversity, as it relates to: 1) the economic valuation of nature's benefits that are mostly unpriced; 2) the accounting of these values so they can be measured and managed along with traditional economic information; 3) the conservation of these values using innovative approaches known as economic instruments.

Ecosystem services are the benefits to humans from nature, including the provision of food, the regulation of air and water quality, the moderation of stormwater, and recreational and spiritual opportunities. Biodiversity is the variety and abundance of life on planet earth. Ecosystem services and biodiversity are economically valuable because they provide scarce benefits to humans. These benefits have become scarcer, which challenges the long-term wellbeing of humans and their economies. Only some of these benefits have a price, such as the products that are bought and sold in the marketplace. Most of these benefits are unpriced – even though they are economically valuable. These unpriced benefits need to be protected because unregulated competitive markets will tend to use them up, which will negatively impact economic productivity and human wellbeing.

The valuation of ecosystem services and biodiversity reveals information about its economic importance. This information can help to consider nature on a more level playing field with commerce, in circumstances where their trade-offs can be considered without undermining sustainability. This information can help to inform if and how development could be made sustainable. It can also help to support ecosystem rehabilitation, as well as the expansion and defence of protected areas.

A growing supply of valuation information in Ontario has tended to focus on the more heavily settled landscapes, mostly in the south, and less so on landscapes to the north and the Great Lakes. The explicit consideration of this information is not mandated by current policy, but there is documented evidence of it being used to communicate the benefits of protection and to help assess the hidden costs of the loss of ecosystem services and biodiversity.

Canada has economic accounts which help to characterize the Ontario economy, based on internationally recognized economic accounting concepts. Currently, only the priced benefits from ecosystem services and biodiversity are included in the economic accounts. As the economic value of unpriced benefits are better understood and measured, their integration into the economic accounts becomes possible. Several approaches are being explored in advanced economies and in Canada, including the design of specific ecosystem accounts. These accounts face many of the same theoretical and practical challenges of economic accounting, plus additional challenges particular to the characteristics of ecosystem services and biodiversity. Innovative national solutions are being explored by the World Bank, the European Union, and Statistics Canada; regional solutions are being explored in Australia and closer to home in Quebec by a working group that aims to develop a provincial system.

Ecosystem services and biodiversity can be protected and enhanced by a combination of regulatory tools that compel actions or outcomes, information programs that raise awareness, and incentives that reward or discourage voluntary actions or outcomes. Economic instruments are incentives and flexible regulatory approaches that can align the economic interests of people and organizations with the environmental interests of ecosystem services and biodiversity. Policymakers can choose from a variety of price-based, quantity-based, liability-based, and information-based economic instruments. The choice of a particular instrument will depend upon several factors, including its purpose, administrative demands, and the availability of information about unpriced values of ecosystem services and biodiversity. One particularly promising approach for biodiversity in Ontario is to create markets for offsets.

1. Introduction

Biodiversity is the variety and abundance of life on planet earth. This is measured by the state of ecosystems, the species that live within them, and their genetic information – all of which have declined in recent history. This decline challenges the long-term wellbeing of humans and their economies. As economies evolve in the 21st century, biodiversity is increasingly important because it is increasingly scarce. Unlike most economic benefits, the benefits from ecosystem services and biodiversity are mostly without a price. Consequently their value is missing from most of the economic measures today.

This omission was not as important earlier in history, when the economy was smaller alongside ecosystems and species that were more abundant and diverse. But today, this omission has important ecological impacts and economic implications. This is motivating many economists and ecologists to work together to better understand the economics of ecosystems and biodiversity.

Ontario's biodiversity is the portfolio of at least 30,000 species and their genetic information (Ontario Ministry of Natural Resources, 2012). This exists within many ecosystems that cover the province, including forests, prairies, grasslands, lakes, streams, wetlands, and tundra. These ecosystems provide many benefits to humans, which are commonly called "ecosystem services." These services include the provisioning of food, fuel, and building materials. These services also include the purification of air and water, the protection of landscapes from stormwater damages, and inspirational benefits.

Like most economically advanced jurisdictions, Ontario is increasingly mindful about the virtues of ecosystem services and biodiversity – and the growing human pressures upon them, from within the province and from abroad. The economic relevance of this information, and information gaps, are increasingly apparent. An outstanding challenge for Ontario is the appraisal of this information and its *integration* into *economic* measures and analysis. This report responds to this challenge.

This report identifies common questions about the economics of ecosystem services and biodiversity. Answers to these questions draw upon the latest insights and initiatives that are relevant to Ontario and the Ontario Biodiversity Strategy, 2011.[1] The result is a report that addresses: 1) the economic valuation of nature's benefits that are mostly unpriced; 2) the accounting of these values so they can be measured and managed along with traditional economic information; 3) the conservation of these values using innovative approaches known as economic instruments.

The content of this report should be understandable to non-economists, with insights that should be agreeable to economists. This report considers ecosystem services and biodiversity together, because they are complements to one another. This is a best practice that was used in the UN-backed assessment of TEEB, The Economics of Ecosystems and Biodiversity (2011).[2] This report focusses on the economics of beneficial biodiversity as distinct from exotic invasive biodiversity, whose economic damages have been documented elsewhere (e.g. Marbek, 2010a, 2010b).

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[1] Among many objectives, the Ontario Biodiversity Strategy, 2011, seeks to "integrate the economic value of biodiversity and ecosystem services into decision making" and "investigate economic tools that encourage biodiversity conservation" (OBC, 2011). See http://www.ontariobiodiversitycouncil.ca

[2] Biodiversity is not a service of ecosystems, nor are ecosystems the service of biodiversity. Generally, biodiversity is used to describe the landscapes that provide ecosystem services; the diversity of landscapes can be measured by the ecosystems that they support, their species, and their genetic information. Landscapes rich in biodiversity are believed to be better able to sustain ecosystem services over time (e.g. Parker & Cranford, 2010). Landscapes rich in ecosystem services tend to have high biodiversity (e.g. Hooper et al., 2005; Flombaum and Sala, 2008).

2. Economic benefits from ecosystem services and biodiversity

What are they, and why are they valuable?

Ecosystem services and biodiversity are economically valuable because they provide scarce benefits to humans. Although there is some debate over the best way to classify ecosystem services, there are generally four categories of services: i) *provisioning services* that provide products such as food, water and raw materials; ii) *regulating services* of air purification, waste treatment, and the moderation of damages from storm-water; iii) *supporting services* such as nutrient cycling and soil formation; and iv) *social/cultural services* that provide aesthetic information and recreation and tourism (OBC, 2011).[3]

The concept of ecosystem services and their economic value is anthropocentric. Economic value is a portion of a much larger and broader overall value of nature, which can only be imagined by multiple disciplinary perspectives, and never ruled by just one. This report's focus on economic value is intended to complement these other forms of value.

Why are many benefits without a price?

For a benefit to have a market price, it must be relatively easy to exclude people from freely enjoying it. This condition works for the benefits of food, fibre, and other products: these can be bought and sold in markets, and therefore have a market price. Almost all of the other services from ecosystems and biodiversity provide benefits that naturally flow across space to benefit many people; their benefits are usually unpriced because it is not easy to exclude people from enjoying them. Examples of unpriced benefits include nature's purification of air and water, the protection of landscapes from storm-water damages, and the inspirational benefits from nature.

Studies from Ontario and around the world routinely find that the unpriced benefits from ecosystems and biodiversity are more valuable to economies than the priced benefits (e.g. see Balmford et al., 2002). However, the unpriced benefits are more likely to be missing from most economic analysis and measures used today. This gap motivates an enhanced appreciation and consideration of the economics of ecosystem services and biodiversity.

How are ecosystem goods and services different, or are they?

Market-priced products from nature, such as food, fuel, and physical materials, can be called *ecosystem goods*. All other benefits to humans from nature are *ecosystem services*, which are rarely exchanged in markets so they are usually without a price. Assessments of ecosystem services commonly categorize nature's ability to provide products as a "provisioning service." This can confuse people who miss the distinction between products and the process of provisioning them, leading them to erroneously wonder if goods are themselves a service (they are not). This confusion is often amplified in Canada with a tendency to lump them together as *Ecosystem Goods and Services* (EG&S) as if the economic and policy issues of goods and services are the same, when they are not (Miller, 2011).

This report counts priced products as ecosystem goods and the process of provisioning them as a service of ecosystems. The suite of "benefits from ecosystems" therefore includes (market-priced) goods and

[3] There is a growing focus in the literature on the distinction between the ecosystem service itself, and the benefits accruing to humans. See Bateman et al. (2010).

services (which may or may not have a price). For clarity, this report always distinguishes between priced and unpriced benefits when this distinction is relevant, as it usually is for valuation and accounting.

Why do ecosystem services and biodiversity need protection?

The unpriced benefits from ecosystem services and biodiversity need some form of deliberate protection[4] because unregulated competitive markets will both overexploit, and undersupply, these services. This happens for the same reason that the benefits are naturally unpriced: it is difficult to earn a private reward for conserving them, when they will freely flow across the landscape to people who do not need to pay for them. Because people can freely enjoy unpriced benefits, it is difficult for private entrepreneurs to profit from selling their benefits, or from finding ways to protect or enhance them.

Few people will voluntarily pay someone to get something that they can already enjoy "for free." This also means that the services could be destroyed or damaged "for free" because those who lose their benefits are not entitled to compensation. This combination of overuse and under-provision challenges the sustenance of ecosystem services and biodiversity. In the language of economics, ecosystem services suffer from "market failure" because their benefits are non-excludable and the consequences of their degradation will be externalized under current institutional arrangements. This is no different in Ontario than it is in comparable jurisdictions.

What happens if they are not protected?

Without protection, most of the benefits from ecosystem services and biodiversity will remain unpriced until they are fully used up. Their increased economic scarcity will fail to be reflected by an increase in a market price. This is troubling because conventional economic thought and policy assumes market prices provide adequate indicators of the relative worth of goods and services.

If the benefits of ecosystem services and biodiversity were fully priced, then several changes might be expected to happen as they become increasingly scarce: entrepreneurs could be rewarded for finding more supply, consumers would be rewarded for conserving and (or) finding substitutes, and policy-makers would be inclined to review policies that affect supply and use. Instead, policy-makers, entrepreneurs, and consumers can be misled into thinking that there is no growing scarcity of ecosystem services and biodiversity, when in fact recent assessments have shown that there is a growing scarcity (Taylor et al., 2012). In the language of economics, this is often called "the new scarcity" problem in contrast to the "old scarcity" problem of a decline in the quality and quantity of ecosystem goods like timber and minerals (e.g. Simpson et al., 2005; Barbier, 2011).

How is the economy impacted by a decline in their unpriced benefits?

A growing scarcity of unpriced ecosystem services will impact upon an economy's *productivity*. Productivity is currently measured by comparing the value of economic production to the cost of inputs needed for that production. The benefits from ecosystem services and biodiversity are not directly

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[4] Deliberate protection of ecosystem services and biodiversity involves sanctioning people who overuse them. About a dozen principles are necessary for the successful governance of unpriced benefits from nature; for more information, see Ostrom (2008). Success usually involves many overlapping spatial scales of governance; efforts to merge them usually result in less successful management. Because the spatial "benefits-shed" of ecosystem services does not usually coincide with political boundaries, some have proposed additional "ecosystem services districts "to support their governance (e.g. Goldman et al., 2007).

measured as an input. However, a growing scarcity of ecosystem services and biodiversity could increase the (priced) costs of production. Producers might have to reconfigure their supply chains to use more inputs from places in the world that have a comparatively greater abundance of ecosystem services, for example water that is cleaner or cooler. Or producers might have to engineer a costly solution that mimics some benefit from nature, such as water purification.

Improved measures of productivity are needed that count nature's unpriced inputs, and the impacts of unpriced outputs like pollution. So far in Canada, this has only been assessed on an experimental basis by Statistics Canada (e.g. Harchaoui et al., 2002; Harchaoui and Lasserre, 2002; Dachraoui and Harchaoui, 2004). A study by Hanna et al. (2010) forecasts the impact of a change in a few unpriced ecosystem services on the (priced) outputs of fruit, harvested wood, and some marine fish harvests in Canada. A 50% reduction in wild pollination of fruit in Canada would result in the loss of $53M of production in a $250M industry; this would increase the price of apples from $365 / tonne to $491 / tonne. The study describes ecosystem services as a "natural subsidy" of economic products.

3. Economic valuation of ecosystem services and biodiversity

What is economic valuation?

Economic valuation is the attempt to estimate the economic value of things. Economic value is a measure of the importance of something to people.[5] Economic value will vary from person to person, and among societies, based upon their income and preferences, which reflects their knowledge, tastes, and customs. Constraints of time, money, and natural resources mean that people (and communities) make trade-offs in order to enjoy the economic value of something.

Market prices do not measure economic value, even though many people assume they do. Market prices express *only a minimum* of economic value that satisfied buyers and sellers, based on the preferences and constraints that each faced. The total economic value of the transaction would have included the value to the buyer and seller beyond the transaction price, which economists call the consumer and producer surplus, respectively. To understand the full economic value of market-priced goods and services, it would be necessary to estimate the value that was enjoyed by consumers and producers beyond its transaction price. Generally the benefit of gathering this extra information is less than the costs to figure it out. For this reason, market prices are usually relied upon to express information about *some of* the economic value that is realised in the marketplace.

It takes effort to estimate the economic value of unpriced things, like most of the benefits from ecosystem services and biodiversity. This effort is necessary because there is no other existing information (like market prices) that could be used as a proxy for some of its economic value. As explained later in this report, the valuation of ecosystem services and biodiversity attempts to estimate their full economic value. Sometimes only a portion of this economic value is estimated, equivalent to a hypothetical price that would have satisfied a market transaction. This underestimate of economic value is still better information for economic decision-making than no estimate at all.[6]

When should valuation be considered?

The consideration of economic value implies a trade-off. For ecosystem services and biodiversity, this means that their economic value should be considered for every trade-off *that is worth considering*. This is an important concept. There is no point considering economic value for a trade-off that is impossible or improbable or objectionable, such as the presence or absence of planet Earth.

Every statement of the economic value of an unpriced benefit from nature will involve or imply a relative comparison. It will be *in relation to* either its current (baseline) scarcity, or some alternative that would imply a higher or lower scarcity. It will reflect the relation between human demand (preferences that reflect needs and/or wants) and the available supply, at a given location at a given moment in time. The phrase "economic benefits *from* a change in ecosystem services and biodiversity…" is more appropriate than "economic benefits *of* biodiversity…" because their value cannot ever be considered in relation to their total absence. Without biodiversity there would be no life and thus no economy; thus there is no

[5] This is just one way of defining and measuring value to humans, and many humans believe that the economic value of ecosystem services is just one form of values that exist.

[6] This report uses the term "economic value" to characterize what economists might usually call "non-market value." This is done because the former term is more intuitive to non-economists than the latter.

point trying to assess the total value of ecosystem services and biodiversity. In the language of economics, this concept is reflected in the theory and practice of "marginal" valuation.

What techniques can be used to value unpriced benefits?

Various approaches are used to express the economic value of unpriced benefits from ecosystem services and biodiversity. The choice of a particular technique, its assumptions and methodology, and the correct interpretation of results have been heavily appraised elsewhere; a good general reference dealing with biodiversity is OECD (2002).[7] When communicating the concept of valuation, it is helpful to say "express the value of…" rather than "putting a price on…" because the latter infers an intention to sell or commodify the benefit, which is not the point.

One set of techniques that economists call *revealed preferences* will infer the value of an unpriced benefit based upon the actual spending on related goods or services in the market. These market-priced goods or services might include the premium paid to live near greenspace or the costs of travelling to experience rare nature. The prices of these market-priced goods or services reflect the level and distribution of economic affluence and the choices available within the marketplace. Specific techniques include the *travel cost method*, *hedonic pricing*, *market price approaches*, or a *productivity approach*.

A *replacement cost* technique involves the pricing of an unpriced benefit as the minimum cost of replacing it with a priced substitute. For example, this could include the costs of replacing biological pest control with chemical substitutes. This technique is useful when there is a human-created substitute that provides an equivalent quantity and quality of the service at the least cost, and would actually be used. This technique will never imply that ecosystem services and biodiversity can be fully replaced with human-created substitutes, nor will it imply that there will always be an obvious replacement. Similar techniques to replacement costs include the techniques of *avoided damage costs* and *substitute costs*.

Another set of techniques that economists call *stated preferences* are used when there is no actual spending on related market-priced goods or services, nor do substitutes exist. Instead, a sample of people is surveyed to rate, rank, or price things that are unpriced in comparison to money (in the case of *contingent valuation*) or something else of value to them (in the case of *contingent choice*). This sample of people can be treated as consumers by asking for their individual and independent answers, or the sample of people can be treated as citizens by allowing them to discuss and debate their individual or collective decision. The sample's response might reflect a Willingness-To-Pay to gain an unpriced benefit, or a Willingness-To-Accept compensation for losing an unpriced benefit. Responses will naturally reflect the level and distribution of economic affluence of the sample of people. Care is taken to be sure that people are not overstating the amount that they would actually be willing to pay or accept.

Since actual spending does not measure full economic value, revealed preference and replacement cost techniques will tend to understate the full economic value of ecosystem services and biodiversity. However these techniques generally require less effort that stated preference techniques that are better able to express full economic value.

All techniques reflect a level of human understanding about the value of benefits from ecosystem services and biodiversity, whether that understanding is within the sample of people who are surveyed, or the

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[7] Another useful reference for non-economists is an introductory guide to valuing ecosystem services produced by the UK's Department for Environment, Food and Rural Affairs (Defra, 2007). A more rigorous treatment to environmental valuation is provided by Freeman (2003).

experts who made an association between people's marketplace behaviour and its relationship to nature's benefits, or whether a natural benefit can be replaced with a human-created substitute. Therefore, economic valuation depends on knowledge about nature. As humanity becomes more informed about the natural science of biodiversity, so too will its valuation of ecosystem services.

When can valuation results be transferred?

Each additional trade-off should be valued anew, when and where it is considered, to the extent that it would involve a change in the baseline economic scarcity of ecosystem services and biodiversity. Conducting a primary valuation exercise requires significant effort, beyond the time and finances available for many decisions. In the absence of primary valuation estimates, decisions may still be reasonably informed by *transferring* the results from one valuation exercise to another one. This approach is often referred to as value transfer.

This transfer can occur through time and (or) space; e.g. results from 2010 updated to 2012 and (or) from region X to region Y. Results can be transferred as point estimates or as mathematical functions, which relate point estimates to key factors such as the number of people affected by the benefit, its quality, and its relative scarcity. For example, Richardson and Loomis devised a single equation that can estimate the economic value of protecting threatened, endangered, and rare species in the USA (Richardson and Loomis, 2009). This equation was derived from 31 studies that produced 67 valuation estimates, generating a transfer error of 34-45%.[8]

If people are generally informed about the economic benefits of natural areas and their relative abundance or rarity, then the monetary valuation of gains or losses will reflect their economic scarcity, which will reflect the perceived importance of the trade-off in relation to the baseline. For this reason, care must be taken when transferring values from one trade-off-scenario to another, to be sure that both scenarios involve gains or losses from a similar baseline.[9] One must also ensure that the people in both scenarios have a similar level and distribution of economic affluence, since a willingness to pay is a function of ability to pay (as is a willingness to accept payment). When transferring estimates across currencies, it is more appropriate to use "corrected" exchange rates, such as "Purchasing Power Parity (PPP)" rather than the actual market exchange rates because PPP rates better reflect the underlying willingness-to-pay and willingness-to-accept of individuals (Ready et al., 2004).

While transferring valuation results provides a relatively quick and inexpensive method for valuing ecosystem services, the results of a transfer exercise should be treated with additional caution. While all environmental valuation estimates are inherently uncertain, value transfer results in an additional layer of uncertainty. In addition, while per-hectare transfers of ecosystem service values are common in many ecosystem service valuation studies in Ontario and around the world, it is important to remember that the values accrue to people, not necessarily the hectare generating the values. Failure to adjust value estimates for population characteristics such as density and income or land characteristics such as availability of substitutes and ecosystem quality may reduce the accuracy of the transfer exercise. In sum, the value transfer method can be useful in providing rough estimates of the value of nature and in identifying situations that require additional primary valuation.

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[8] Transfer error is the accuracy of predicting the original value estimate using the transfer equation. A transfer error of 34-45% implies that the predicted estimates were within 34-45% of the value of the original estimate.

[9] Eftec (2009) provide a useful set of guidelines for the use of value transfer in policy and project appraisal.

Should ecosystem services be valued as a bundle or as components?

One ecosystem will typically provide several ecosystem services. The value of these services can be estimated as the value of the entire bundle. Or the value of the entire bundle can be estimated as the sum of each service – but only those whose value is not already counted or assumed by the value of another. This avoids the potential error of double-counting some services. This approach will be called a "sum-of-the-non-double-counted services" approach, as compared to the first "service-of-the-bundle" approach to valuation.

Whether one approach is better will depend upon the trade-offs being compared. If a meadow is being compared to its replacement with a parking lot, then it makes more sense to value the bundle as a unit because the choice is between its presence and absence. If a meadow is being compared to its replacement with pasture lands, or an afforested area, or a manicured park, then the trade-off is between the composition of this bundle, not its presence or absence. If a parking lot was an additional option, then only a sum-of-the-non-double-counted-services approach would work to evaluate the trade-offs among all the options.

In theory one would hope that both approaches yield the same result for the value of the entire bundle. In practice, the value of the whole is often less than the sum of its component parts when both are compared. People often perceive a greater value to protecting individual species within a landscape, than the entire landscape (e.g. Nunes and van den Bergh, 2001).

How should valuation deal with space?

Ecosystem services and biodiversity provide economic benefits over time and space. Many ecosystem goods can be stockpiled, and transported, such as minerals and fuel. But the benefits from ecosystem services cannot be stockpiled; the air purification benefits of a landscape cannot be conserved for one year to be used twice as much the following year, nor can these benefits be moved around. Consequently the units of their valuation are usually expressed as an amount per unit of time, and over an area of space.

The space is determined by the geography of the trade-off being considered. If the value is described over a landscape that could be host to a number of smaller-scale trade-offs, then the value should be expressed per unit of area. For this reason, spatial value transfer is often used when creating ecosystem accounts. This involves the conversion of a spatially-implied value to a spatially-explicit value; e.g. the original estimate of the value of X provided by the shoreline of Y is divided by the area of shoreline Y so that the value of X is now per unit of area. In theory, some parts of the shoreline would be more or less valuable than the average, but in the absence of more specific information from the original estimate, an average may be a reasonable approximation.

How should valuation deal with time?

In economics, one or many years of flow can be "capitalized" into a time-less stock of money that is equivalent in value from a "present value" perspective. This is typically done by discounting future values according to a mathematical formula that was developed for private financial analysis, where the time-value of money depends upon prevailing rates of return on private investments. Mathematically the same approach can be applied to environmental values, where a flow over time is capitalized to a time-less stock value. Many Ontario studies have applied this technique of discounting to one year's value of ecosystem services; e.g. Wilson (2008a), Kennedy and Wilson (2009).

It is preferable to keep ecosystem service benefits as a flow (e.g., $ per hectare per year), rather than converting them into a hypothetically equivalent stock. Above all, it is best to avoid converting one year's flow to a time-less stock; to do so would assume that its scarcity will not change over time. This is an unrealistic assumption given recent trends of increased scarcity in ecosystem services, e.g. the global Millennium Ecosystem Assessment (MEA, 2003) and the Mixedwood Plains Ecozone Ecosystem Status and Trends Report (Taylor et al., 2012). Even if the future scarcity of ecosystem services could be projected, there are additional challenges particular to discounting, such as the functional form of the discount rate, the appropriate rate itself, and additional assumptions about equity (e.g. see Padilla, 2002). If the values of ecosystem services and biodiversity are being compared to other capitalized values, such as the value of built capital, then it is preferable to convert the capitalized value to a flow, rather than converting the value of ecosystem services to equivalent stock.

4. How valuation can be used to support sustainability

What is sustainability?

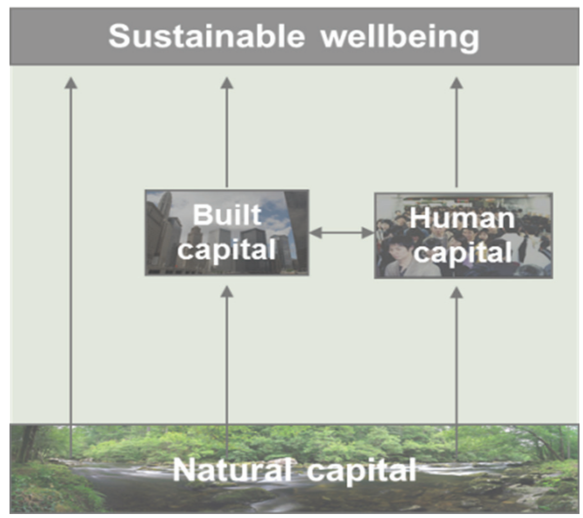
Sustainability involves the integrated management of various types of capital for the purpose of continual wellbeing.

Natural capital provides the priced and unpriced benefits from ecosystem services. Biodiversity describes the quality of natural capital in terms of its variety and abundance of ecosystems, species, and genetic information.

Built capital is sometimes called manufactured or man-made capital; it is the supply of buildings, infrastructure, and machines that provide the benefits of shelter, the outputs from machines, the movement of people and materials and wastes.

In this report, *human capital* is inclusive of social capital and financial capital; it is the asset of people, both individually and in their community context, including their knowledge, their networks, their agreements and contracts, and their capabilities that provide the service of paid and unpaid labour, problem-solving abilities, and so on.

Figure 1: The relationships between three types of capital necessary to sustain wellbeing. The boxes in the figure represent the asset they describe; the arrows represent the flow of benefits. Some benefits from natural capital are directly used to sustain wellbeing; some are transformed into built or human capital. In the language of economics, the flow of benefits can be called income.



Many methods and metrics have been developed to assess sustainability (for a recent survey see Singh et al., 2012). Various theories relate these metrics of sustainability to a jurisdiction's capital endowments (as inputs) and wellbeing (as the intended outcome). These relationships are relevant for the economics of ecosystem services and biodiversity because they inform the measurement of natural capital, the valuation of its benefits, and the tracking of its values and quantities in a jurisdiction's economic accounts.

How does natural capital relate to sustainability?

Natural capital, built capital, and human capital are necessary for wellbeing in Ontario, because they provide necessary services. Natural capital plays a fundamental role of being the source of materials and energy that are transformed into built and human capital – which supports economic wellbeing. *Critical natural capital* is the minimum portion of natural capital that must be protected to sustain wellbeing (Ekins et al., 2003). It is effectively a *safe minimum standard*. It is the portion of natural capital that cannot be sustainably traded-off for more built or human capital (Victor et al., 1995). This is determined by insights from the natural sciences, taking into account resilience, thresholds of irreversible change, and uncertainties in knowledge.

The Ecological Footprint is particularly useful for assessing the sustainability of an economy with regards to its use of natural capital.[10] The Ecological Footprint compares an economy's use of ecosystem services with their available supply, from the natural capital within a jurisdiction, adjusted for its trade balance. A jurisdiction's use (demand) is calculated as the quantity of biologically productive and mutually-exclusive land and water needed to continuously provide (supply) food and materials, and assimilating its wastes, given current technologies. This calculation reflects the specific productivity of land in that jurisdiction, since not all areas offer the same productivity. The calculation reveals the extent to which a jurisdiction's trade with the rest of the world effectively exports or imports biological capacity. In some footprint assessments, 12% of the supply of biological capacity is set aside as a refuge for biodiversity, unavailable for human use.

How should valuation inform sustainability?

To assess the present and future sustainability of a jurisdiction, one must understand the quantities of ecosystem services that are needed (demanded) by an economy. These services are provided (supplied) by the natural capital within a jurisdiction, plus the natural capital within other jurisdictions that provide its imports. The services needed to support a jurisdiction's exports come from its domestic supply plus imports.

Jurisdictions should conserve their critical natural capital in order for all jurisdictions to enjoy a somewhat sustainable provision of ecosystem services and biodiversity. There should be little relevance to valuing the loss of unpriced benefits from critical natural capital, because these benefits should not be considered for a trade-off. Valuation of critical natural capital should only be expected to play a role in communicating the case for protection, as described later in this section of the report.

Services that are provided by non-critical natural capital can be considered for a trade-off without undermining sustainability. In this context, pricing their unpriced benefits will help to inform whether this trade-off is economic or not. A trade-off would be economic if the overall gains appear to be more valuable than the losses.

The concept of "conservation needs" can help to relate valuation to sustainability. The conservation needs of a jurisdiction can be estimated as the supply of critical natural capital that must be protected in order to sustain ecosystem services and biodiversity. The conservation needs of a jurisdiction should be estimated in order to inform sustainable land-use planning. This planning would identify where trade-offs could, and could not, be considered in the context of sustainability. This informs the appropriate and effective use for valuation. In the language of economics, conservation needs should be price-determining, not price-determined (Farley, 2008).

How can valuation inform development decisions?

Development is any transformation of the landscape, which can include its transformation into pasture, a playground, residences, commercial areas, etc. For development to be sustainable, it should not deplete the critical natural capital of a jurisdiction. As described earlier, a jurisdiction's conservation needs

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[10] For a description of how the Ecological Footprint can help account for the sustainability of a jurisdiction, see Wackernagel et al. (1999). In 2002, the Biodiversity Indicators Partnership selected the Ecological Footprint as one of its measures to support the Convention on Biological Diversity. See http://www.twentyten.net

should be assessed first in order to inform if, how, and where development could or should not exist; where development could exist, valuation will help to inform whether it is economic or not.

Valuation can reveal the hidden economic costs of development in terms of the quantities and values of ecosystem services and impacts upon biodiversity. For example, a recent assessment of two development scenarios in the Rouge River watershed compared the impacts of development on ecosystem service values. The cost-benefit analysis estimated that a more sustainable development scenario would result in a net gain of $687 million when compared to a traditional full build-out development scenario (Marbek, 2010c).

The quantification of ecosystem services and biodiversity can help to inform the evaluation of "offsets" that aim to lessen the net impacts of development. For example, the baseline stormwater-buffering capacity of a particular greenfield could be quantified in units of litres of water. The impact upon this capacity of a commercial development could be calculated, based on its proposed design. Design innovations could be assessed in terms of their impact on this capacity; for example the use of green-roofs, permeable pavement, and other off-site solutions like the rehabilitation of degraded wetlands to increase their water-holding capacity. If there were a "no net loss" of ecosystem services and biodiversity, then the development would be permitted as long as it shows how it will minimize the loss of this service (and others). Approaches like this employ macro-control with micro-flexibility, which is a principle of cost-effective environmental policy.

Ontario and other comparable jurisdictions are increasingly employing concepts like "no net loss" or "overall benefit" to minimize the loss of ecosystem services and biodiversity. The European Union has a target of "no net loss of biodiversity and ecosystem services" by 2020 (European Commission, 2011); the Alberta Land-use Framework proposes land conservation offsets to "address biodiversity or natural value loss" (Government of Alberta, 2008); the Endangered Species Act, 2007 in Ontario uses "overall benefit" as a criteria to permit development in regulated habitat; the Toronto and Region Conservation Authority is developing a "protocol for determining compensation for ecosystem services" as a way of "achieving the regional [natural heritage] target" (TRCA, 2009).

How can valuation support ecosystem rehabilitation?

Valuation can help to price the unpriced economic benefits of rehabilitating degraded landscapes.[11] Rehabilitation costs money, so it can be helpful to describe its benefits in monetary terms as well. Presumably the case for ecosystem rehabilitation would be mostly ecological, if not the requirement of a legal settlement; rarely would rehabilitation be judged solely upon its economic merits. For this reason, valuation can *support* rehabilitation but should not *rule* other information about its overall merits.

Valuation could inform the details of rehabilitation, such as making the area accessible to people for recreational purposes, or using bioremediation techniques over more traditional mechanical or chemical ones. To the extent that pricing the unpriced benefits of enhanced ecosystem services and biodiversity will reveal that rehabilitation is not an entire economic sacrifice, then this could be helpful to support action. To the extent that it would reveal economic gains that exceed losses, then this should complement the ecological case.

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[11] See Marbek (2010d) for an Ontario-specific example of a cost-benefit analysis of habitat protection and restoration.

In the USA, economic Cost-Benefit Analysis is mandated for many projects, regardless of their environmental or social merits. Theoretically this analysis should discriminate against projects whose costs exceed benefits. In practice, large-sum environmental projects are still advanced on environmental and social grounds even if their economic costs are estimated to exceed the sum of their priced and unpriced benefits (Goodstein, 2005). In Ontario, Cost-Effectiveness- or Multi-Criteria-Analysis is more likely to be used to assess the impacts of rehabilitation. In all types of economic analysis, unpriced impacts could be valued to see if and how their significance would impact upon the merits of the project.

How can valuation support additional protected areas?

Valuation can help to prioritize the protection of landscapes that are vulnerable to development. Landscapes in Ontario can be newly protected by a variety of means, including restrictive covenants on their title and (or) the transfer of ownership to a conservation-oriented organization. To be effective, valuation should reveal the incremental gains from protection *beyond the baseline probability of loss or impairment* of ecosystem services and biodiversity. This baseline probability of loss is very important; a low probability of loss means the value of its protection is much smaller in comparison to a higher probability of loss. If a development application is being considered, then its probability of loss or impairment is known. If development is not being considered, then the probability of development should be forecast to best inform the prioritization of its protection.[12]

Organizations with an interest in protecting natural areas might find it useful to undertake a Cost-Benefit-Loss Analysis to help prioritize securement. This would integrate the costs of securement with considerations about the value of ecosystem services and biodiversity, multiplied by their baseline probability of loss (e.g. Newburn et al., 2005). Since the market value of land will naturally reflect any economic premium of its location, lands with the highest probability of loss tend to be the most expensive to secure. But this type of land might also provide a high economic value of ecosystem services and biodiversity given its proximity to the built and social capital that would benefit from its services. Integrating these considerations will improve effectiveness.

How can valuation support existing protected areas?

When protected areas are genuinely protected from development trade-offs, the economic valuation of benefits is less relevant. Valuation might still be helpful to communicate the benefits of protected areas, and the relevance of monitoring and assessment programs, although narratives about the benefits might be more useful than monetary values themselves. In many cases, protected areas are only partially protected from development trade-offs, so economic valuation can be very relevant and important.

Protected areas often need to be defended against those who view them as a last-resort source of exploitable natural resources or as a strategically important and inexpensive corridor for energy and transportation infrastructure. If the economic merits of such scenarios are to be entertained, then the decision should be informed about the value of the unpriced benefits of ecosystem services and biodiversity that would be lost.

Because protected areas tend to include very rare if not unique natural features, their economic value should be assessed first-hand rather than relying upon value transfer. Also the valuation methodology

[12] Probabilities might be assessed on the basis of land-use plans, which might include zoning. If there are too many uncertainties, probabilities cannot be determined; scenarios would need to be used to reveal future possibilities.

should reveal people's Willingness-To-Accept (WTA) compensation rather than Willingness-to-Pay (WTP) for protection, since the scenario is one of a loss, not a gain. People tend to be more loss-averse than they are averse to gains, usually by a margin of at least 2:1 (Horowitz and McConnell, 2002).

How can studies be appraised?

Based on the insights from this section of the report, several "best practices" can be used to appraise the contributions of specific studies about the economic value of ecosystem services and biodiversity.

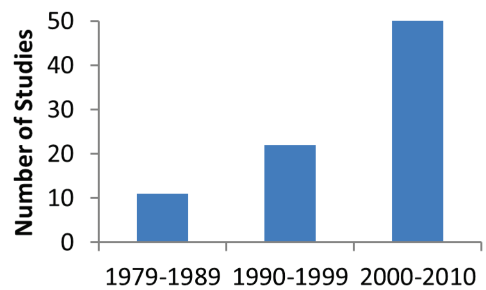
- A study should be clear about whether its valuation of ecosystem services and biodiversity captures their full economic value, or their hypothetical price if traded in the marketplace.
- A study should be clear about how it defines goods as distinct from services – and thus distinguishing the value of priced and unpriced benefits.
- All studies should communicate the appropriate use of the information they contain, or reference a document that provides guidance with respect to the use of the information.
- If the value of services is totalled, the total should not include double-counted benefits.
- A study espousing sustainability should not value the depletion of critical natural capital, or fail to warn users about the dangers of doing this.
- Trade-offs should relate to the spatial resolution of the study.
- A study that uses contingent valuation should present willingness-to-pay estimates for gains and willingness-to-accept for losses.
- If a study uses value transfer:
    - The original sources should be clearly referenced;
    - The original values should embed a similar scarcity of nature;
    - The original values should embed similar socio-economic circumstances;
    - Value estimate ranges should be preserved as ranges, not presented as a point estimate;
    - Corrected exchange rates should be used to convert values between currencies.
- Services should be presented as temporal flows, rather than being converted to a time-less capitalized stock.
- The spatial flow of benefits should be characterized, if not detailed in a Geographic Information System.

5. Economic valuation in Ontario

How much Ontario-specific valuation information exists?

The most comprehensive inventory of Ontario-specific information about the economic benefits from ecosystem services and biodiversity exists in the Environmental Valuation Reference Inventory (EVRI). [13] EVRI is maintained by Environment Canada and is consistently recognized as *the* database of studies on environmental valuation. From a total of over 3,000 studies in EVRI from around the world, 84 of these took place in Ontario.[14] Assessing these Ontario studies reveal that their information is relatively recent, they focus on the services of recreation and the regulation of air and water quality, and they apply more to the southern and settled areas of the province.

Figure 2: Number of Ontario-specific valuation studies retrieved from EVRI database.



Over half of the Ontario studies (50 studies) were published between 2000 and 2010 (see Figure 2). Roughly two-thirds of the studies used primary valuation (54 studies) and one-third used the value transfer approach (30 studies). There has been an increasing trend towards more comprehensive assessments that include multiple ecosystem services; over three-quarters of these assessments have been conducted in the last 4 years.[15]

What about the Far North?

Ontario's far north is believed to provide significant ecosystem services because of its vast area. The local economic value of the services is likely to be low because there are few people in total to accept the benefits, and there is likely a low local scarcity of the services. There may be more non-resident beneficiaries, but they will likely have little awareness and experience of the services. Who has rights to the benefits from the landscape will affect the choice of measures of pay-versus-accept compensation. There exist spatial inventories of the northern landscape, but its resolution is lower than southern land inventories and in the Area of the Undertaking.

In 2008, the International Institute for Sustainable Development assessed the ecosystem services provided by the Pimachiowin Aki World Heritage Project Area, about 40,000 Km^2 straddling the Ontario and Manitoba border. A comparative advantage of this study is that it clearly distinguished the geography of its benefit flows, whereas most other Ontario studies do not. About 25% of the annual economic benefits from ecosystem services flow exclusively to residents of the area (Voora and Barg, 2008). This study used a spatial value transfer approach, and the authors were appropriately cautious when transferring results from other research. The study identified other "potential" services that are appropriate to the

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[13] The Environmental Reference Inventory EVRI can be accessed at www.evri.ca

[14] We also included studies that are in the process of being captured into the EVRI database, but not yet available to the public. These studies should be available by June 2012.

[15] Assessments of multiple ecosystem services across Ontario landscapes include: Olewiler (2004), Canadian Urban Institute (2006), Krantzberg (2006), Wilson (2008a), Wilson (2008b), Voora and Barg (2008), Anielski and Wilson (2009), Troy and Bagstad (2009), Kennedy and Wilson (2009), Marbek (2010b), Marbek (2010c), Marbek (2010d).

landscape (such as carbon storage, water filtration), but whose values could not be applied to the area's smaller non-urban population. The study aimed to "initiate discussion" to support the area's designation for protection; it is not clear how the value of the ecosystem services would be different if the area was designated as a biosphere reserve versus if it was not.

What about the settled areas on the Shield?

Surprisingly little information is available for the southern areas of the Canadian Shield in Ontario. This area has settled landscapes, but a geography that is characterized by a different Provincial landcover inventory than south of the shield. The "non-timber" benefits from forested areas are better understood and valued (e.g. see Sarker and McKenney, 1992) than other land-cover types like alvars. The landscape's conservation needs are locally understood by biosphere reserves, watershed councils, and geographic-based networks like The Land Between. There is a high level of interest in ecosystem services, and many of these organizations are interested in assessing the value of ecosystem services on the landscape and in understanding how this value is affected by trade-offs.

What about the southern settled areas?

Across Southern Ontario, key ecosystem services have been described in relation to the landscape, and some coarse-level data exist as a starting point for project-specific considerations. At this time the most significant original published sources of information (data and/or accounting) are from Sverrisson (2009), Marbek (2010a, 2010b, 2010c), Wilson (2008a, 2008b), Wilson and Kennedy (2009), Troy and Bagstad (2009), and Lantz et al. (2010). Some of them provide overlapping or cross-referenced information, but none of them employ the same accounting system so their estimated values cannot be compared across their overlapping geographies. The 2008 Wilson studies are framed as characterizing a landscape as a whole, while the other studies are framed as characterizing elements of a landscape. The Sverrisson (2009) and the Lantz et al. (2010) wetland study provide original valuation estimates, the other studies transfer existing valuation estimates using original accounting systems.

The most comprehensive single source of southern Ontario information is from Troy and Bagstad (2009). This study presents the most comprehensive synthesis of existing and relevant data in an accounting system that relates these data to the southern landscape. The study does well to follow the common practices of ecosystem service valuation: it focusses on the unpriced benefits rather than summing them with market values of ecosystem goods, and it avoids capitalizing the flows into a stock value. The service of "habitat refugium" is provided as a proxy for biodiversity; the report's discussion notes that biodiversity is an ecological indicator which, like many others, is not yet explicitly related to the levels of provision of ecosystem processes and their corresponding services. The report makes it easy for users to reference the originating studies that provide each point estimate of a service-from-landscape estimate, and to assess the richness or coarseness of data that characterizes the average of this estimate. The report has a very limited discussion about the appropriate use of the information, supplemented with an executive summary written by MNR that provides more than just a summary with additional context and notes of caution about the use and interpretation of the information. It would be valuable to make this data publicly available in a geo-referenced database.

What about the Great Lakes?

A wide array of benefits provided by the Great Lakes ecosystem have been quantified and priced. To date, the focus of Great Lakes valuation literature has been on the benefits of cleaning up polluted sites and the benefits of recreational activities such as swimming, boating and fishing. The most comprehensive compilation and assessment of this information is found in the report "Assessing the Economic Value of Protecting the Great Lakes Ecosystem" which served as a literature review for three related economic analyses (Marbek 2010a, 2010b, 2010c, 2010d). This literature review assessed over 100 studies that collectively contribute to a better understanding of the economic benefits from the Great Lakes. The report also provides an overview of the main findings, gaps and implications for using this information (Marbek 2010a). The three applied economic analyses focused on sustainable watershed development (Marbek 2010c), wetland and stream system protection and restoration (Marbek 2010d), and aquatic invasive species prevention and control (Marbek 2010b).

More broadly, there are several easily digestible documents that assess the state of knowledge of the economic value of water resources in Canada (Renzetti et al., 2011). A document produced for the Canadian Council of Ministers of the Environment provides guidance on the use of water valuation in decision-making in Canada (CCME, 2010).

The economic valuation of large aquatic ecosystems such as the Great Lakes requires careful consideration. Several unique challenges are posed by issues of scale and fluidity of the resource, as well as its bi-national status and international significance as a waterbody. In discussing the different economic values associated with water, it is important to note that because water provides a multitude of ecosystem goods and services. People value the attributes and services they receive from water, not necessarily the water itself.

How is valuation considered in Ontario public policy?

Documented considerations of the economic value of ecosystem services and biodiversity are relatively rare. The examples reveal leadership rather than established practice in the development and operationalization of public policy. This is no different for Ontario than for other comparable jurisdictions, where mainstreaming its use is the current frontier. The development of accounting systems and the support of valuation exercises would expect to lag the more general use of the concept. Where is there documented consideration of the concept and relevant data for Ontario?

Searching Ontario's current consolidated law for the term "biodiversity" or "biological diversity" reveal relatively few instances; it exists only in The Crown Forest Sustainability Act (1994), The Provincial Parks and Conservation Reserves Act (2006), the Endangered Species Act (2007), the Far North Act (2010), and in Regulation 282/98 updated in 2004 under the Assessment Act insofar as it clarifies "conservation land." In these instances, biodiversity is not characterized in economic terms. The term "ecosystem services" is not found in any Act or Regulation. The term "ecosystem" is found in about a dozen acts and regulations in an environmental context not an economic context. The term "sustainability" is found in 40 different acts and regulations, about half of which would be classified as economic policy (e.g. the Regulatory Modernization Act) as distinct from environmental policy (e.g. the Aggregate Resources Act). Similar patterns hold for a search of Federal Acts and Regulations. References to biodiversity and sustainability tend to exist in more recent policy. The debates within the Parliament of Canada and Queen's Park reveal few references to the concept of an economic value of ecosystem services and biodiversity; committee hearings reveal a few references from expert testimony.

Public policy is much broader than what is written in acts and regulations. At the present time there is no consolidated and searchable inventory of the strategic, program, and operational or administrative policy that is additional to the acts and regulations of the crown. To the extent that these forms of policy are more adaptive, then we might expect there to be more use of the terms or concepts of ecosystem services and biodiversity. Indeed there are many documented examples of its insightful use by the Ministry of

Natural Resources, including the Natural Heritage Reference Manual (OMNR, 2010), MNR's Climate Change strategy, and its updated Strategic Directions.

Equally important to this vaster universe of policy documents is the even vaster scope and quality of analysis provided to decision-makers at the stage of policy formation and its application. Evidence provided to Cabinet is confidential so it cannot be assessed; one can only infer that it is more likely to be presented to Cabinet to the extent that it is understood by analysts and advisors in the public service. Many Federal, Provincial, and Municipal policy analysts and advisors have been present at conferences and workshops that present and discuss the economics of ecosystem services and biodiversity (e.g. Latornell 2010, 2011, the Ontario Network on Ecosystem Services forum in 2011). Many have organized their own forums, including the office of the Environmental Commissioner of Ontario in 2010.[16]

How is valuation considered outside of the Ontario government?

Wilson's (2008a) publication of data about the ecosystem services (and its agricultural goods) from the Greenbelt has supported its consideration in communications and in some cases decision-making. This data was used to support the 2009 "Biodiversity Initiative" by Hydro One, the largest electricity transmission and distribution company in Ontario.[17] This aimed to offset the impacts of its Bruce to Milton Transmission Reinforcement Project upon ecosystem services and biodiversity. The offset metric involves the use of data from Wilson's publication, along with other data that quantify the characteristics of off-site offsets in comparison with on-site impacts.

MNR's publication of data and guidance on ecosystem services relevant to southern landscapes (Troy and Bagstad, 2009) appears to have inspired its use and consideration by others outside of government. It was used in an assessment of ecosystem service values that could be impacted by a highway corridor through Flamborough and Burlington (Wilson et al., 2011). This information was also used by the Toronto and Region Conservation Authority in its 2011 Living City Scorecard (TRCA, 2011) and recent 2011 work on an "ecosystem valuation and compensation protocol" that is to be developed to inform policy on of development review dealing with "compensation for ecosystem services" (TRCA, 2009). The value estimates in Troy and Bagstad were used to support a business case for wetland conservation in the Black River subwatershed (Pattison et al., 2011) and is used in communications by various organizations, including the Ontario Forest Association, the Green Infrastructure Coalition, and Alternative Land Use Services (ALUS).

In 2011, the Ontario Biodiversity Strategy was renewed with a much greater emphasis upon ecosystem services and their economic valuation. The strategy sees the valuation of ecosystem services as a means of supporting its conservation of ecosystem services and biodiversity. Specifically the strategy proposes that all sectors act to "integrate the economic value of biodiversity and ecosystem services into decision making" (OBS, 2011). This strategy was developed by the Ontario Biodiversity Council which is made up of members from various sectors and interests in Ontario.

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[16] The Environmental Commissioner of Ontario hosted a Roundtable on Ontario's Ecological Footprint, which featured discussions about the economic value of ecosystem services and biodiversity. See http://www.eco.on.ca/blog/2010/12/21/roundtable-on-ontarios-ecological-footprint/

[17] For more information, see http://www.hydroone.com/Projects/BrucetoMilton/Biodiversity/Pages/Default.aspx

How is valuation being interpreted in Canadian law?

Another way to assess the use of valuation information is by reviewing disputes in the application and interpretation of the laws that exist. The USA provides significantly more examples than in Ontario, but the legal contexts vary so the transfer of knowledge is limited. Presently there are no Ontario tribunal cases that reveal if and how the concept of an *economic* value of ecosystem services and biodiversity play out, perhaps not surprisingly because their consideration is not explicitly mandated by most policy.

The economic value of ecosystem services has been considered by the Supreme Court of Canada. In the 2004 case British Columbia v. Canadian Forest Products Ltd, the Supreme Court noted "the question of compensation for environmental damage is of great importance" and for this reason, "a claim for environmental loss, as in the case of any loss, must be put forward based on a coherent theory of damages, a methodology suitable for their assessment, and supporting evidence."[18] The court reviewed some of the theory and methods of expressing the economic value of unpriced benefits, as presented by the government of British Columbia. The court was not convinced that the government had evidence to suggest it had accounted for the benefits, but rather assumed a somewhat arbitrary premium. Legal commentators suggest that the ruling has nevertheless "laid the blueprint" for future claims of damages against the unpriced economic benefits from nature in this "novel area of environmental litigation" (Davis & Company, 2004).

What challenges the broader use of valuation in decision-making?

One explanation is that this concept and the available data are relatively recent. New concepts and measurements take a while to be codified into public policy. Evidence presented as an answer to the last question supports this. In the meantime, valuation should not have to be mandated in policy for it to be a useful way of integrating environmental considerations into economic analysis. Challenging this would be gaps in the awareness and knowledge about how to use ecosystem service valuation.

Integrative concepts challenge traditional silos of expertise and domains of consideration. Conservation agencies and departments often lack the capacity and interest in economic analysis, so it will be harder for them to integrate economic considerations and advocate that others do the same. Credit Valley Conservation Authority has shown leadership in this area by employing an economist serving as an "Ecological Goods and Services Project Coordinator." Not surprisingly, this organization has been prolific in Ontario with advancing the research and consideration of valuation.[19]

Economics agencies and departments often lack capacity and interest in "the environment." A traditional education in economics will rarely involve any environmental considerations. Such considerations are rarely important in a professional sense. Conventional economic analysis routinely ignores the unpriced benefits of ecosystem services and biodiversity. It also tends to underplay the significance of the priced benefits of ecosystem goods. Food, fuel, and building materials are provided by the economic sectors of agriculture, mining, forestry and fisheries. The value of the total economic contributions of these sectors is often downplayed, as commentators marvel at the economy's evolution "away from natural resources." In fact the output of these sectors is economically important to every jurisdiction because they are *necessary inputs* to every other economic sector, be it e-commerce, financial services, etc. The

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[18] The full text of this judgement can be found at http://scc.lexum.org/en/2004/2004scc38/2004scc38.pdf

[19] A sample of their published work includes Hanna et al. (2008), Hotte et al. (2009), Kennedy and Wilson (2009), Lantz et al. (2010), Green Metrics (2012).

productivity of the sectors that transform ecosystem goods will determine how many other sectors can be supported by their outputs, either at home, or abroad through its exports. This productivity will be affected by the value of ecosystem services and biodiversity, since these are a necessary input to the production of ecosystem goods, which are a necessary input to other sectors.

What are Ontario's valuation needs from a sustainability perspective?

Following the previous section of this report, the sustainability of Ontario would ideally be assessed to inform the appropriate and effective use for valuation, as it relates to development, rehabilitation, the expansion of protected areas and their defence. The present section appraises many assessments of ecosystem services in Ontario, and their valuation, and finds that they were generally not undertaken within an explicit framework of sustainability, such as the identification of the conservation needs of critical natural capital. Fortunately there exists Ontario-specific research that can be used to inform valuation within such a framework, as presented below.

An ecological footprint and biocapacity analysis was undertaken for Ontario in 2010 (Stechbart and Wilson, 2010). This type of analysis was described earlier in the report as a way of assessing a jurisdiction's demand for the benefits from natural capital, in comparison with its available supply. Using 2005 data, the Ontario assessment estimates that the ecological footprint is just below its biocapacity. Almost all of the land mass of the entire province is needed to provide Ontario's economy with provisioning and waste-assimilation services without overshooting the limits of its natural capital base.

From this perspective, future growth in Ontario's economy must become footprint-neutral if it is to be sustained. A requirement for "no net loss" of ecosystem services and biodiversity would help, and would follow examples profiled earlier in this report, including that of the European Commission (2011). Such a requirement would benefit from information about the baseline quantities of ecosystem services and biodiversity that exist. It would also benefit from predictive tools to anticipate the impacts from development, and any offsetting projects, and methods and metrics of making the comparisons and accounting for risks and uncertainties. Such tools and information, and the economic valuation of the quantities, could inform development decisions (as described earlier in this report).

In 2005, a "conservation blueprint" exercise was undertaken within the Great Lakes basin, which covers much of Ontario (Nature Conservancy of Canada and Ministry of Natural Resources, 2005). The baseline aquatic and terrestrial biodiversity was assessed on an eco-region basis over the Canadian portion of the Great Lakes basin. A suite of sustainability-oriented targets was assessed, and used to estimate the conservation needs that would close the gap between targets and the baseline. The exercise did not examine, or suggest, the economic valuation and accounting of ecosystem services and biodiversity. But studies like this ought to inform valuation, insofar as it suggests a conservation baseline and the needs of greater protection in many of the "top-scoring ecological systems" it reveals. This would inform the appropriate use of valuation in the context of rehabilitation, the expansion of protected areas, and their defense (as described earlier). This research was the basis for a cost-benefit analysis of habitat protection and restoration that was undertaken to inform the Ontario government about a Great Lakes strategy, although it employed value-transfer from studies that did not consider this baseline (Marbek, 2010d).

What could help Ontario to understand its conservation needs?

Ideally there would be some sort of a spatially-explicit indicator of vulnerability of either each "pixel" of natural capital, or even specific elements of ecosystem services and biodiversity. Metrics of this sort are being developed in some jurisdictions to support conservation planning. Unfortunately there is presently no information that reveals the likelihood of the loss or impairment of the province's natural capital in the future, although there is research that suggests negative trends for the southern ecozone in Ontario (Taylor et al., 2012). Intuition suggests that natural capital in the heavily settled areas of the south is the most likely to be at risk of being transformed in a way that will lessen its ability to provide valuable ecosystem services.

In Ontario's south, conservation needs have been articulated through the Greenbelt, the Niagara Escarpment, the Oak Ridges Moraine, and many other land-use strategies – including identification of Provincially Significant Wetlands and other natural features. These needs have not been articulated in the language of "critical natural capital" but our assessment is that these land-use strategies imply its concept. These land-use strategies also convey a sense of vulnerability of losing this natural capital in the absence of conservation. In our assessment, this is implied by the use of "Natural Heritage Systems" that identify the spatial configuration of natural systems within an area that is needed to support sustainability. Such systems reveal the critical natural capital that is necessary to support local wellbeing. If the entire heavily settled landscape of Ontario's South would be envisioned as *A System of* Natural Heritage Systems then one could have a more complete picture of the conservation needs for Ontario.

6. Economic accounting of ecosystem services and biodiversity

Why are ecosystem services and biodiversity missing from accounting?

Similar to unpaid work done at home and other non-market activities, most of the economic benefits from ecosystem services and biodiversity are missing from economic accounting because they are unpriced.[20] Only the priced benefits such as timber from ecosystems and biodiversity are counted.

Each jurisdiction has "economic accounts" which track the production and exchange of goods and services in the marketplace. Ontario's economic accounts are based on an international framework called the System of National Accounts (SNA). This system provides a logical and coherent framework for understanding our complex economic system using objective, timely, scientific, and aggregated indicators. The most frequently cited indicator, Gross Domestic Product (GDP), is calculated from the SNA. GDP measures economic activity, or the production and consumption of goods and services in the market. The flow of goods and services in the economy is quantified and then aggregated using their market prices as weights.

The economic accounts are used to report and analyse the relationships between various sectors in the market economy, and to report on changes in a jurisdiction's amount of economic activity. Accounts can be queried by geography but in Canada are typically reported nationally and provincially. Although the accounts are detailed, the detail can be summed to provide important snap shots of the current state of the economy.

The economic accounts command the attention of many decision makers because they provide "executive summaries of complex realities" (Jesinghaus, 1999). Ecosystem services and biodiversity are complex; their indicators can generally be characterized as inaccessible, relying upon sparse data, and not linked to economic measures. Consequently, there is a gap between the needs of policymakers and the current set of biodiversity measurements.[21]

Why should ecosystem services and biodiversity be integrated into accounts?

The impacts of economic activity upon ecosystem services and biodiversity are more significant than ever before. These environmental impacts have economic costs that are often not observed or reflected in the economy over the short term. The case is increasingly being made that impacts of economic activity on environmental systems are putting future economic growth and development at risk (OECD and IEA, 2011). Consequently, the perceived trade-off between economic growth and environmental protection is increasingly being called into question.

Ecologically, it is important to know the state of the environment to highlight conditions, monitor trends, and assess impacts. As reviewed earlier in this report, the economic benefits from unpriced ecosystem services are often more important than their priced goods, and should be managed and accounted for accordingly.

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[20] However, it should be noted that some imputed values are included in the System of National Accounts (SNA) such as the value of housing services.

[21] A recent report produced by the federal, provincial, and territorial governments on the status of biodiversity in Canada identifies many of the key problems and inadequacies associated with biodiversity data (Federal, Provincial and Territorial Governments of Canada, 2010).

Society pays attention to what is measured and also how it is measured. Integrating information about ecosystem services and biodiversity into the economic accounts could support broader and more robust measures of wellbeing. This could provide a more accurate representation of the interdependence of economic and natural systems. Policy makers would no longer be able to view the economy and the natural world as two independent systems.

How can it be integrated into economic accounting?

There are several proposed strategies for integrating natural capital into economic accounts (Boyd, 2012). Four broad approaches are reviewed below. These strategies are best viewed as complementary, not substitutes. They are listed chronologically in the order they were developed.

An integration strategy: Add what's missing

This strategy creates accounts that measure the quantity and value of the benefits of natural capital that are market or 'near market' commodities. Using market, or 'near market', prices, the quantities can be priced.[22]

Statistics Canada's Canadian System of Environmental and Resource Accounts (CSERA) are satellite accounts developed to measure and track the state of Canada's natural capital and environmental assets in both physical and monetary units. These accounts are consistent with the 2003 version of the SEEA. The accounts provide information about natural resource stocks, including land, timber, and subsoil assets, such as minerals, oil and gas, and coal. They also provide information about material and energy flows, which include consumption of materials and energy. The accounts also provide information about expenses on environmental protection by governments, businesses, and households.

In recent years, the World Bank has calculated a sustainability indicator of *adjusted net savings*, which aims to assess the total economic value of a country's capital stock and takes into account the depletion of natural resources, amongst other factors.[23] Because of its reliance on market prices, these accounts work well for environmental goods bought and sold in the market, such as timber, water, oil and minerals. This approach faces limitations for incorporating biodiversity and more intangible ecosystem services that are not exchanged in markets nor routinely valued.

An integration strategy: Subtract what's bad

This strategy adjusts the traditional economic accounts by subtracting the remediation costs, pollution protection expenditures, and health impacts of current economic activity. For example, if pollution causes $10 billion in health impacts each year, this amount is subtracted from the estimate of GDP. The Genuine Progress Indicator (GPI) is a good example of this approach and it includes the negative human impacts on the environment as part of its more comprehensive set of indicators.[24]

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[22] This strategy is largely based on existing work on integrating environmental and economic accounting such as Volume 1 of System of Environmental-Economic Accounting (SEEA) which was substantially revised in 2003 and ongoing revisions (United Nations et al., 2003).

[23] For more information please consult the World Bank's website: http://web.worldbank.org

[24] The GPI is also an example of adding what's missing because it incorporates natural capital. For more information, please consult the GPIAtlantic website: http://www.gpiatlantic.org.

Environmental liabilities are currently accounted in the public accounts of the Federal Government. They represent the estimated costs of remediating contaminated sites for which the government is responsible as well as future costs related to asset restoration (i.e. decommissioning a nuclear plant). The liability is the present value of sum of these costs. The costs are estimated using the best available information and are adjusted each year for changes in estimated and actual costs, new obligations, and the presence of time. These costs are entered into the government's public accounts as a liability. Currently, 2200 contaminated sites and 42 future asset restoration sites present $7.7B in liabilities, plus the cost of another 14,800 contaminated sites where the environmental liability still needs to be determined (Government of Canada, 2011).

An advantage of this strategy is that it is relatively easy to implement and eliminates some of the more egregious examples of 'brown' GDP such as oil spills increasing GDP. On the other hand, some elements of this approach such as health impact valuation are not grounded in SEEA accounting principles. In addition, the narrow scope of ecological assets avoids comprehensive accounting for ecosystems and biodiversity.

An integration strategy: Measure outcomes that matter

This ambitious and diverse set of strategies aims to connect the economic accounts directly with measures of wellbeing. Examples include Bhutan's Gross National Happiness, the Genuine Progress Indicator, and parts of the recent report by the Stiglitz-Sen-Fitoussi Commission (Stiglitz et al., 2010). A Canadian example is the ongoing project on creating an index of wellbeing of Canadians by the Canadian Index of Wellbeing Network.[25] Currently, ecosystem services and biodiversity are implicitly included in these measures to the extent that they affect human wellbeing. In the future, measures might be able to include more explicit linkages, building upon research that has estimated empirical links between wellbeing and ecosystem services. For example, Green Metrics (2011) assessed the importance of ecosystem services to self-reported wellbeing of sampled residents in the Credit Valley.

An integration strategy: Measure inputs that matter

This strategy aims to integrate the ecosystem approach into the economic accounting framework. In a sense, this strategy is similar to the first integration strategy (to add what's missing), but is more comprehensive and explicitly focuses on ecosystems and ecosystem services. There are essentially three components of ecosystem accounts (EEA, 2011a):

1) Basic accounts use land and water cover data to describe the quantity of the different ecosystems and the biomass or carbon stored with them. This first component uses the natural capital concepts of stock and flow.

2) A second set of accounts use indicators to assess ecosystem quality and health and describe the condition of the ecosystem capital base. These indicators do not use prices.

3) A third set of accounts measure the output of ecosystem services (in quantities), their uses, and their values (measured using prices).

Ecosystem accounts reflect many roles ecosystems play in providing benefits to humans. These accounts are designed to evaluate the sustainability of economy-ecosystem interactions from a natural standpoint:

[25] The Canadian Index of Wellbeing is available at http://www.ciw.ca

to measure the state of the ecosystems in terms of quality and quantity, and to estimate the economic value of avoiding ecosystem degradation and damage and the benefits of restoration (EEA, 2010).

Ecosystem accounts are gaining traction in the environmental accounting community for several reasons. They potentially include all types of ecosystems, including the sea, atmosphere, and land (urban, agriculture, forest, soil, and other natural). They provide a systematic and coherent framework for spatial and biophysical data. They are consistent with recent work in ecosystem services valuation. They explicitly incorporate measures of biodiversity.

Is economic accounting only for governments to do?

The underlying concepts, principles, and metrics of ecosystem accounting can be applied in a business setting. One new tool for assessing the impacts of businesses on biodiversity is the Normative Biodiversity Metric (NBM), developed by Econometrica (Econometrica, 2011). NBM assesses impacts using metrics of the degree of 'pristineness' of the land, and accounts for the presence of endangered mammals. These quality metrics are multiplied by the quantity of affected land to derive an overall impact on biodiversity - an NBM score. While an admittedly crude assessment, this tool shows the potential for constructing a biodiversity balance sheet for businesses and other organizations that can be integrated in financial statements or annual reports. Future updates to the tool are planned to capture a more comprehensive indicator of biodiversity impacts.

Non-governmental conservation-oriented organizations can develop ecosystem accounts to help broaden the scope of values considered in planning and economic development. In 2008, the Canadian Boreal Initiative sponsored a pioneering assessment by Anielski and Wilson (2009) of the physical condition and value of natural capital in Canada's Boreal ecosystem. The Boreal Ecosystem Wealth Accounting System (BEWAS) framework made a useful distinction between the market value of natural capital, based upon its timber and oil assets, and the non-market value of natural capital based upon its ecosystem services. The accounting framework revealed that the total annual economic value of unpriced benefits from the boreal ecosystem ($703 billion) significantly outweighed the net value of the priced benefits ($50.9 billion) in the year 2002.

What are some challenges in building ecosystem accounts?

Ecosystems and biodiversity pose many challenges to the construction of a robust and useful set of accounts. Some of these challenges are not unique to ecosystem accounting.[26] Part of the difficulty in formulating new ecosystem accounts is the disagreement about whether these should be simply extensions of the SNA or whether they should be much broader. If ecosystem accounting is only related to extending the SNA, then compliance with the formal accounting practices and conventions in the SNA is necessary. However, if ecosystem accounts are intended to be not just part of the SNA, a more flexible approach to accounting could be used.

The building blocks of the economic accounts are quantities (Q) and prices (P). In the case of GDP, the market defines the quantities (litres of milk, number of computers, etc.) and provides useful weights via market prices. Moreover, accountants of the market economy can make use of market artifacts such as units sold and prices paid to accurately, and relatively quickly, construct the national economic accounts.

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[26] For a further discussion of some of accounting issues that affect the measure of GDP, please see Stiglitz et al. (2010).

This is done by multiplying each Q by its respective P.[27] For ecosystem accounts, there is both a lack of well-defined Qs and Ps. In terms of Q, there is a need for a clear definition of the goods and services to be counted both in terms of quantity and quality. In terms of P, weights are needed to ensure the differences in the value of goods and services are reflected in the index. Clearly, the value of different ecosystem goods and services will largely depend on how they are defined, which underscores the importance of developing standard and robust quantified measures of ecosystem services.

Accounting issues with quantities (Q)

As noted earlier in the report, most ecosystem services are not traded in markets. Quantities are therefore not apparent because there are no inventory data, sales receipts and other common pieces of information economists use to construct the current economic accounts. Progress is being made towards a standard land cover and ecosystem classification, as well as standard ecosystem service taxonomy. There is an ongoing effort to define appropriate indicators of quantities and qualities of ecosystem goods and services (TEEB, 2011; EEA, 2011b).

There is a need to account for the fact that ecosystems are often bundled in terms of providing multiple goods and services. Additionally, ecosystem goods and services are both directly consumed by society and act as inputs into other ecological processes. In the language of economics, ecosystem services and biodiversity provide both intermediate and final benefits. These two factors have important implications for aggregating ecosystem goods and services in terms of dealing with double counting.

One strategy for dealing with the issue of double counting in ecosystem accounting is to focus on final benefits that are “directly consumed, used or enjoyed” (Boyd, 2012). This approach is analogous to GDP which does not include intermediate goods. A second strategy is to recognize, and explicitly state, the dual role of nature. This approach, adopted by the SEEA 2003, may step beyond the bounds of formal accounting rules (Voora and Venema, 2008). For example, forests are classified as natural resource assets as a source of timber and are classified as ecosystem assets as a source of many other ecosystem services such as carbon absorption.

Another related challenge for Q is aggregation. This presents two challenges. The first challenge is how can we aggregate a plethora of biophysical indicators and measures into simpler ecosystem accounting metrics, yet still keep the important information embodied in the various indicators. For example, water quality indices provide a useful single metric that weighs different pollutant indicators and other measures of water quality. The second challenge relates to spatial scales: how similar ecosystem goods and services should be aggregated across different locations such as watersheds and jurisdiction boundaries.

Accounting issues with prices (P)

There is a need to reflect differences in the value of benefits that are included in the accounts. It is important to note that value need not represent economic value and ecological weights could be used. In fact, many common indicators of ecosystem quality such as water quality measures use a single index that weights the effects of different pollutants and nutrients from an ecological perspective. To the extent that

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[27] The distinction and independence between quantity and price is not always clear cut in the traditional economic accounts. For example, the calculation of the aggregate quantity of built capital may rely on present value calculations of net profits which employ an interest rate, which is a price (Victor, 1991).

we want to assess trade-offs between ecosystem services and market goods and services, appraising ecosystem services in terms of economic value can provide useful information for decision making.

Many of the challenges for using economic values as weight are the same challenges for the valuation of the benefits, as discussed earlier. However, one new challenge arises for ensuring economic values are consistent with the present economic accounting framework. Ecosystem service valuation is rooted in welfare economics and individual preferences. These value estimates represent the willingness of society to pay for the gains (or to accept payment for the losses) of benefits. However, as noted earlier, traditional economic accounts use market prices to estimate economic value. Directly comparing WTP and WTA estimates and market price estimates can be problematic because, as noted earlier, market prices do not capture the full economic value of goods and services.[28] Consequently, valuation techniques based on the cost to restore or remediate the damage have been proposed as appropriate methods because they are based on market prices.

The table below further outlines a few of the main advantages and disadvantages of these two valuation techniques in terms of integrating values into the economic accounting framework. Neither valuation technique is clearly more appropriate for ecosystem accounting. However, initial ecosystem accounting initiatives have suggested using restoration costs in the interim as estimations of the costs of ecosystem depreciation (EEA, 2011a). This approach is relatively easier to calculate, and it is compatible with the SNA, which relies on empirical statistics rather than measures of wellbeing.

Table 1: Comparison of different approaches for pricing benefits, based upon Uhde (2011).

	Approach to accounting for the unpriced benefits from ecosystems and biodiversity	
	Estimate economic value	**Estimate restoration costs**
Advantages	Better representation of the value of the benefits to society	Compatible with the SNA because based on market prices Closely connected to underlying ecosystem quantities Can easily aggregate marginal prices at different spatial and temporal scales
Disadvantages	Would not be consistent with the SNA, which uses market prices Aggregating individual preferences at different spatial scales creates issues Collecting and updating data takes a lot of time and effort	Assumes restoration costs equals the value of ecosystem Issues of irreversibility (e.g. species extinction)

Other accounting issues

Biodiversity poses some unique challenges for accounting frameworks. Biodiversity is a multifaceted and elusive concept to define in terms of the building blocks of traditional accounts (the Qs and Ps). Our lack

[28] Specifically, WTP and WTA estimates usually include consumer surplus, while market prices do not.

of understanding of many of biodiversity's key roles in ecosystem services makes it difficult to determine appropriate quantity and quality metrics (Qs), as well as applicable biophysical or economic weights (Ps).

Biodiversity relates to the economic accounts in a multitude of ways: it is an environmental asset, it is an input into economic production, it is an input into the ecosystems (which generate ecosystem goods and services), and it is an indicator of ecosystem condition (McDonald, 2011).

Recognizing this diversity is important for developing ecosystem accounts. Biodiversity can be measured in terms of prices (such as value estimates derived from using nonmarket valuation techniques), quantities (such as tonnes or cubic metres), and qualities (such as indices of its condition, from 0-100) (McDonald, 2011). All three of these metrics provide important, and complementary, information for decision making.

Which accounting initiatives look promising?

Ecosystem accounting is at an experimental stage.[29] Ecosystem accounting purposes, principles, and structure are currently being debated, discussed and developed at international meetings of researchers, academics, and government officials. This accounting community recognizes that ecosystem accounting requires a long-term commitment. However, there is also an appreciation of the need to quickly develop interim accounts, even with the current state of knowledge and data limitations. These initial ecosystem accounts can be revised over time as our experience, knowledge, and data increase. Subsequently, current ecosystem accounts should be regarded as an open and evolving concept.

Many different governments and international organizations are spearheading initiatives to support the development of these ecosystem accounts, within the scope of the general international meetings. Some recent initiatives that are relevant for Ontario are described below.

World Bank's WAVES Partnership

At the international level, the World Bank launched the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Partnership in October 2010.The WAVES Partnership is a five year research initiative that includes representatives from developed and developing nations, experts on accounting at the United Nations and other international organizations, participants from NGOs, and academics. In June 2012, an international program of action on ecosystem accounting will be proposed at the "Ri0+20" Earth Summit. By the end of 2012, the objective is to develop SEEA Volume 2 which will outline an international standardized methodology for valuing ecosystem services.

European Union's Experimental Ecosystem Capital Accounting Framework

In the spirit of quickly mainstreaming ecosystem accounting, the European Environmental Agency (EEA) released an experimental ecosystem capital accounting framework (EEA, 2011a). This simplified ecosystem accounting framework is an initial output from the process to develop more comprehensive accounts. The framework has been applied in a case study of coastal Mediterranean wetlands. As an initial first step, three groups of ecosystem services have been considered: accessible biomass/carbon, accessible water, and accessible regulatory and cultural services.

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[29] In June 2011, the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA) decided to devote volume 2 of the new SEEA to ecosystem accounts.

The framework proposes an "ecosystem capital and biodiversity" account that includes variables that measure biodiversity at the landscape and species/biotopes levels (EEA, 2011a). This appears to be one of the more comprehensive frameworks proposed to date. It aims to capture the demand for, and supply of, what it calls an "ecosystem surplus" that can be used to support human wellbeing without jeopardising the ecosystem sustainability. It would measure the amount of "ecosystem capital" that is degraded, the value of this degradation, and the amount that is embedded in trade. It would use an index of "ecosystem potential unit equivalent" to complement metrics of price and quantity.

Statistics Canada's Measuring Ecosystems Goods and Services (MEGS) initiative

Last year, Statistics Canada secured funding to develop a prototype ecosystem account system in close collaboration with various natural resource departments including Environment Canada, Agriculture and Agrifood Canada, Fisheries and Oceans Canada, Natural Resources Canada (Bordt, 2011; Bordt 2012). This requires developing standard land cover, ecosystem, and ecosystem service classifications, collecting key biophysical data, creating indicators of ecosystem quality and researching appropriate valuation methodologies. Results will be applied to wetlands as a demonstration of its broader potential.

Australia's regional environmental accounts trials

Although most accounting initiatives are scoped at the national and international level, there are also regional and provincial initiatives. In Australia, regional environmental accounts are being developed for 12 of the 56 natural resource management regions (Cosier and McDonald, 2010). These trial accounts will use reference conditions as a benchmark and develop ecosystem health indicators. Ecosystem health indicators are quantified metrics of ecosystem characteristics that can detect change and provide a simple measure for complex systems. These indicators will form the foundation for building the Regional Environmental Accounts. These sets of initiatives are relevant to Ontario because they show that subnational ecosystem accounts are currently being constructed in other jurisdictions.

Québec's working group on ecosystem accounting

In Québec, a new working group has formed titled "Comptes d'écosystèmes pour le Québec: mesure de la biodiversité et des services écologiques" (translated as "Ecosystem accounting for Québec: measure of biodiversity and ecosystem services"). The group aims to develop a network of researchers and students to determine the practicality of ecosystem accounting in Quebec. The working group plans to review the existing literature of ecosystem accounting and apply the methods in a Québec case study. Members include university professors, government officials, and representatives from international organizations such as the Secretariat of the Convention on Biological Diversity. This initiative is relevant to Ontario because of the similar geography the two provinces share.

7. Economic instruments for ecosystem services and biodiversity

What are economic instruments and who do they target?

Ecosystem services and biodiversity can be protected and enhanced by a combination of regulatory tools that compel actions or outcomes, information programs that raise awareness, and incentives that reward or discourage voluntary actions or outcomes.[30] *Economic instruments* categorize incentives that reward best practices beyond regulatory requirements, and regulatory approaches that combine macro-control with micro-flexibility. This type of regulatory approach can result in more cost-effective outcomes than traditional regulatory approaches that uniformly command and control micro behaviour.

Economic instruments aim to align economic self-interest with the interests of ecosystem services and biodiversity. When successful, these instruments correct the market failure outlined in the introduction. These instruments embody the *polluter pays principle* which says that actors[31] causing damage should remedy damages by providing compensation. These instruments also embody the *beneficiary pays principle* which says that actors gaining benefits should pay for them somewhat in proportion to their share of the benefits.

Generally, economic instruments generally target three different groups: *beneficiaries*, *damagers*, and *enhancers* whose actions can improve ecosystem services and biodiversity (Blom et al., 2008). Beneficiaries gain value from biodiversity, so they suffer losses caused by damagers, and gain value from the outcomes of enhancers. Enhancers are motivated to improve ecosystem services and biodiversity by incentives that ought to be provided by beneficiaries (to yield an overall gain) and by damagers (to remedy loss). Enhancers are sometimes called providers, which can confuse people who believe that nature is itself the sole provider of ecosystem services and biodiversity. This belief sees humans managing nature's ability to provide, and transforming and transporting its provisions to market, but nature is the ultimate provider of ecosystem goods and services.

What economic instruments are currently being used in Ontario?

A number of these economic instruments are found in Ontario. Some instruments target the beneficiaries of biodiversity (e.g. fishing licenses, provincial park fees, and water charges). Some instruments target damagers (e.g. water quality trading in the South Nation Conservation Authority watershed). Some instruments target enhancers of biodiversity (e.g. Conservation Land Tax Incentive Program, Managed Forest Tax Incentive Program).

Historically, Canada has lagged behind the world in the use of economic instruments as policy options (OECD, 2004). Governments in Canada, including Ontario, have traditionally relied on subsidies, tax credits and regulations that uniformly command and control the behaviour of specific actors. An assessment by Kenny et al. (2011) for Sustainable Prosperity revealed a growing interest, and documented use, of economic instruments for biodiversity conservation and protection in Canada. The report identifies 40 instruments in use in Canada. It is apparent that economic instruments could be more widely used in Ontario and Canada, to improve either the cost-effectiveness of current environmental objectives, or to enhance environmental objectives without additional overall costs.

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[30] Note that we are not examining economic instruments that remove disincentives (harmful subsidies) to biodiversity conservation in this report. Please see Kenney et al. (2011) for additional information on this topic.

[31] The term "actors" is used to include individuals, businesses, governments and other organizations involved.

What are price-based economic instruments?

Price-based instruments affect the costs or benefits of some behaviour, for the purpose of affecting the quantity of benefits from ecosystem services and biodiversity. Positive incentives (e.g. tax credits, payments, and subsidies) motivate providers and negative incentives (e.g. taxes, charges, and user fees) punish damagers. Success of these instruments relies upon the policymaker being able to set the appropriate price that will motivate actors to voluntarily subscribe (for incentives) or comply (for regulations). Success also requires being able to correctly anticipate how the change in behaviour will affect the quantity of benefits.

Positive price-based instruments set a price at the minimum it takes to get an enhancer to generate the intended outcome. This minimum is known by enhancers, but not known by those setting the price. The payors have to anticipate the amount that it will take to get the provider to generate the outcome. This minimum is the enhancer's net cost of making the change, which economists will say is the direct costs plus the enhancer's "opportunity cost" such as the foregone commercial benefits from using land for agricultural production rather than for serving as a wildlife sanctuary. This minimum can be estimated from the market prices and production costs of certain activities, however there are many unknowns that make this estimation challenging. It can also be estimated by using "reverse auctions" (see next section).

Negative price-based instruments set the price of a tax or fee at least equal to the estimated value of the damage. This relates to valuation and accounting, covered earlier in this report. Environmental taxes may be applied to damagers of ecosystem services and biodiversity to discourage specific pollutants or activities. For example, water charges can be applied to industrial water use to ensure the business is recognizing the value of water in its production decisions. For beneficiaries, a user fee or charge might be used for certain activities that are not damaging, but related; for example, visiting protected areas.

How can reverse auctions support price-based instruments?

Reverse auctions are one way of revealing the minimum price needed for a positive price-based instrument. In this type of an auction, potential enhancers compete for an incentive by under-bidding each other. The winning minimum bid will reveal the cheapest price that is needed to motivate at least one unit of an intended outcome. Economists support reverse auctions because they are very cost-effective. For the same reason of cost-effectiveness, enhancers generally dislike reverse auctions; they would prefer a higher price so they could earn more from doing the same thing.

Around the world, reverse auctions have been used for wetlands (Wetlands Reserve Program (WRP) in the United States, BushTender in Australia) for water (e.g. EcoTender in Australia), for forests (e.g. Tasmania Forest Conservation Fund in Australia) and general agricultural land (e.g. Conservation Reserve Program in United States).

In 2009, a reverse auction for wetlands restoration was conducted in the Assiniboine River watershed in Saskatchewan (Hill et al., 2011). An environmental benefit index was used to rank the final bid price per acre based on the predicted incremental increase in hatched waterfowl nests. A total of 30 bids for 12-year term agreements were successful to restore 211 wetlands covering 211 acres at an overall price of \$182,000. The average annual cost per acre was \$119 with a range of \$21 to \$391. The large cost variability highlights the potential cost savings of using reverse auctions compared to uniform payments. The International Institute for Sustainable Development and Manitoba's Interdepartmental Ecological

Goods and Services Working Group is currently researching using a reverse auction system for nutrient management based on the EcoTender project in Australia.[32]

How can payments for ecosystem services serve as a price-based instrument?

Payments for Ecosystem Services (PES) are a positive price-based incentive. To be successful, these programs must be able to successfully target potential enhancers, and be able to measure their ability to enhance a well-defined benefit, and make the payment conditional upon their success (Wunder, 2005). Ideally, payments should be conditional upon the successful enhancement of specific ecosystem services or biodiversity. In practice, efforts to economise on the administrative demands means that payments are often tied to a parcel of land or certain land use patterns, on the assumption that this relates to an enhancement of biodiversity or ecosystem services. The payment itself can be administered in a variety of ways such as a tax credit, an annual payment, or a one-time payment. Tax credits often prove to be more effective for motivating change than an equivalent value provided by another means. However tax policy is not usually set by ministries or agencies that are accountable to ecosystem services and biodiversity, so tax-based payments are rarely used despite eagerness from natural resource managers.

Between 2007 and 2009, Agriculture and Agri-Food Canada piloted 8 PES projects across the country (Campbell, 2010). Results were used to inform the department, and the country, about various aspects related to the design, effectiveness, and efficiency of PES systems. Of note, tradable permits (a quantity-based economic instrument) tended to be twice as cost-effective as auctions (a way of informing price-based instruments) which were about twice as cost-effective as fixed annual payments (Agriculture and Agri-Food Canada, 2009). Today, a province-wide ALUS program exists in PEI.[33]

In Ontario, two PES pilot projects are underway in Norfolk and Huron County. The Norfolk ALUS pilot project[34] was launched in 2007 and the Huron County Payments for Environmental Goods and Services (PEGS)[35] pilot project was initiated in 2008. Both projects provide an annual incentive payment to participating farmers based on the average land rental rates. Presumably participating farmers will use their most marginal agricultural lands, which likely have market rental rates below the average.

What are quantity-based instruments?

Quantity-based instruments directly affect the quantity of benefits that are used, enhanced or damaged. This quantity of benefits can include specific ecosystem services, or other metrics that relate to them such as the number of hectares of wetlands in a watershed that are newly protected, the quantity of phosphorous entering lake from controlled sources, etc. The quantity of benefits is affected by requirements (for regulations) or voluntary motivations (for incentives) to enhance them (by enhancers) or to pay for their use (by beneficiaries) or to pay for their damage (by damagers). The price of quantity-based instruments is not set, but instead reflects the cost of the affected quantity of benefits.

An accounting system can track who has done what to affect the quantity of benefits. Usually there are permits or some other form of title that keeps track of who has done what to affect the quantity of

[32] http://www.iisd.org/wic/research/ecosystem/ecotender.asp

[33] http://www.gov.pe.ca/growingforward/ALUS

[34] For additional information on Norfolk's ALUS program, please consult the website http://www.norfolkalus.com

[35] A good description and evaluation of Huron's PEGS program is provided by Knight (2010).

benefits. Claims must be excludable, meaning that several actors cannot use the same claim. If this fails, then the quantity of benefits will not be successfully affected, and the instrument will not achieve its objective. A monitoring and auditing system helps the accounting system to contain true information.

Quantity-based instruments can be used in various ways, depending upon the conservation objective of setting up a system. Some quantity-based instruments are allowed to be traded – thereby changing who has the right to claims a quantity of benefits. Some quantity-based systems may allow actors to increase the quantity of benefits, often in the form of credits granted for the creation of biodiversity or ecosystem service offsets, which can sometimes be "banked." Offsets may or may not be allowed to be traded.

How can trading systems support quantity-based instruments?

If there are many enhancers and damagers and beneficiaries involved, then markets can be created to allow the claims to be traded. As long as there are enough actors in the market, trading systems are cost effective because each actor will choose the cheaper alternative: either enhance the quantity of benefits, or buy a claim from someone else that did this. The market price of traded claims will reflect the marginal cost of conservation, which is expected to reflect the marginal cost of a unit of quantity.

The cost-effectiveness of trading systems can be challenged by high transaction and administrative costs depending upon various factors including the costs of accounting, monitoring, and auditing trades. These challenges partly explain the slow uptake of these trading systems in Canada and worldwide. Careful design is required to reduce some of these costs and simplify the trading system.

Water quality trading is a common example of a trading system used in Canada (Voora et al., 2009) and around the world (Flombaum and Sala, 2009). Various watersheds in Ontario are proposing to implement water quality trading systems, including Lake Simcoe (XCG Consultants Ltd et al., 2010).

The South Nation Conservation Authority in Eastern Ontario has created a water quality trading system for phosphorous that covers both point and non-point sources. Landowners get credits for implementing best management practices on their land that reduce phosphorous leaching in the watersheds. Point source polluters can purchase these credits to offset their own phosphorous emissions to their targets. It has been estimated that technological control options would cost 10 times more than the trading system price of $390 to achieve the same reduction in phosphorous (Knight, 2010). This cost-effectiveness on the part of the payors has not lessened its appeal to payees, as 85% of landowners would recommend that other watersheds undertake a similar program (O'Grady, 2011).

How can offsets and banks support quantity-based instruments?

While human developments can often avoid and mitigate environmental impacts such as habitat loss and pollution, there will inevitably be some residual negative impact on ecosystem services and biodiversity. While not always used concurrently, offsets and biodiversity banks can counteract these impacts. Depending upon the rules, offsets might be used to fully offset losses, to succeed with a "no net loss" requirement for development (as discussed earlier in the section on valuation). Offsets can also be used to generate an overall net gain of biodiversity (as suggested later in this section with a hypothetical example called SARBEX). If a gain is created but not yet used to offset a loss, then it is said to be banked.

There are a few Ontario examples of tradable quantity-based instruments aimed at increasing the supply of offsets, such as the Ontario Ecological Credit proposed by the farmer-based Norfolk ALUS Project[36] and the Muskoka EnviroCredits.[37] In both cases, they are voluntary markets with few payors, in spite of interest by people to be paid to enhance ecosystem services and biodiversity.

Biodiversity offsets are created from actions that provide measurable biodiversity benefits such as protecting existing habitat at risk or restoring degraded habitat.[38] Markets for biodiversity offsets are increasing in prevalence and size throughout the world. The 2011 State of Biodiversity Markets identified 45 active programs and a further 27 programs in development (Madsen et al., 2011). A lower bound estimate of the size of the global annual market is $2.4 to $4.0 billion. Australia has been on the forefront of biodiversity banking, although the actions have been carried out at the state level.[39] There are no markets for biodiversity offsets in Ontario. A Business and Biodiversity Offset Programme (BBOP) has been created through international collaboration to support the development of biodiversity offsets that achieve cost-effective and equitable conservation outcomes (BBOP, 2008).

How do equivalence metrics support biodiversity offsets?

Equivalence metrics are used to define and evaluate the benefits of offsets and the impacts of damages that the offset seeks to lessen. This helps to operationalize the concept of no net loss, or an overall net benefit, by comparing gains against losses using a standardized measure. To be effective, metrics should enable decision-makers to compare changes over time, to ensure that offsets are not only somewhat equivalent to losses, but that they are also gains above the baseline state of biodiversity. Ideally, a metric would measure the impact of conservation actions on the likelihood (negative in the case of debits and positive in the case of credits) of the particular species surviving. In practice, surrogate measures are often used such as acreage of habitat or habitat quality. The ecological effectiveness of wetland and conservation banking is heavily dependent upon the equivalence metric; critiques of wetland banking are usually critiques specifically about the equivalence metric, rather than the concept of offsets and banking.

The United States has well-developed programs of wetland-mitigation banking, and conservation banking. In 2010, the estimated payments totalled $1.5 to $2.4 billion which represents over 80% of the global market. To date, around 283,000 hectares (700,000 acres) have been conserved through US programs (Madsen et al., 2010). Federal regulations require metrics that assess equivalence in terms of wetland acreage and function. However, the difficulty in assessing the functional values of wetlands has meant that, in practice, acreage alone serves as the most commonly used metric. For conservation banking, federal guidelines are flexible in determining the metric used to determine credits and debits because conservation banks include both species and habitat credits. Here again, habitat acreage is a more commonly used metric.

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[36] See http://www.norfolkalus.com/index.php?option=com_content&view=article&id=100&Itemid=32

[37] Muskoka Envirocredits is described at http://www.muskokaheritage.org/me/index.htm

[38] Please see Eftec and IEEP (2010) for a more extensive discussion of the habitat banking concepts, legal framework, key design features, and an extensive review of case studies.

[39] Additional information can be found in the Eftec and IEEP (2010) report, Madsen et al. (2011), and a case study on BioBanking is presented in Rodricks (2010).

What could an Ontario market for biodiversity offsets look like?

The proliferation of offset markets around the world begs the question of whether and how one might work within Ontario's present biodiversity policy context. The Endangered Species Act (2007) mandates the protection of endangered and threatened species and their habitat, on a species-specific basis. The Ontario Ministry of Natural Resources may permit actions that affect species and their habitat such as scientific study or actions that are necessary to protect human health and safety. Significant projects that provide provincial-level social or economic benefits can be permitted by Cabinet as long as they do not jeopardize survival and recovery species. All other types of projects could only be permitted by MNR if they would result in "an overall benefit" to the species. The Act does not detail the metrics to be used to calculate overall benefit, but beneficial actions are suggested by species-specific recovery plans. The Ministry finances some beneficial actions, but they are not related to permits and not credited as offsets.

Hypothetically, a Species-At-Risk Benefits Exchange (SARBEX) could be envisioned as a market that would unite offset-seekers with offset-providers. Offset-seekers are typically land developers who have no idea how to provide benefits to species, other than a willingness to pay others to do this. Offset-providers are typically rural landowners and conservation organizations that have the capability to do good things for species, but need funding to make it happen. Currently there is no easy way for these two groups to meet. An online registry could be created to allow offset-seekers and offset-providers to find their match – inspired by the way that online dating works to unite single people, and the way that online classifieds or auctions allow buyers and sellers to agree upon a price. However, the administrative burden of a SARBEX market is relatively high and the careful design of the system would take time.

Hypothetically, MNR could serve as the "market-maker" by creating the registry, establishing its rules, and listing the outcomes that are in demand for particular species, based on the Government Response Statements to recovery plans. It could suggest or establish metrics for those species and circumstances where they can be generalized, and address if and how multi-species benefits could be achieved by single ecosystem-based enhancements. MNR could encourage potential offset-providers to post proposals, and encourage permit-seekers to consult the registry. If successful, this exchange would result in a growing supply of overall benefits financed by private-sector funding, lessening the need and expectation for government funding. Current government funding could be re-directed through this exchange, to initialize it with offset-providers posting their project ideas for the government and everyone else to consider. In the future, such a registry could be broadened to ecosystem service offsets if a "no net loss" threshold is mandated by municipal or provincial planning, as will occur in Europe by 2020.

What are liability-based instruments?

Liability-based instruments create a legal obligation for the cost of damage (including prevention and remediation) for those who cause that damage. This signals individuals and businesses to incorporate the risks and values of environmental damage into their decision-making process. These instruments are based on the polluter pay principle identified and rely upon the ability to price the damages and degradation of ecosystem services and biodiversity. With these damages priced, individuals who are liable will necessarily value the damage, or the risk of damage, and adjust their behaviours accordingly.

While most of the early liability rules focused on air pollution, oil spills, and nuclear risks, more recent liability rules incorporate broader environmental concerns. In Canada, the Environmental Damages Fund collects funds from fines, court orders, and voluntary payments and supports projects that restore the natural environment and conserve wildlife. Priority is given to projects that operate in the same geographic region where the environmental damage occurred. An example is an environmental damage assessment conducted by Environment Canada for a fish kill event on Prince Edward Island. Economists quantified and valuing the damage caused to the local recreational fishery in terms of the lost ecosystem service flow and expenditure. Compensation for the environmental damage resulted was used to finance fish restoration projects in the area (MacDonald et al., 2002).

What are information-based instruments?

Information-based instruments reveal information about the environmental performance of specific products, or processes, or producers. This helps to increase the efficiency of existing private markets by informing consumers and/or investors and/or producers and/or regulators. Businesses with superior performance can be rewarded as compared to businesses with inferior performance. For example, fisheries and the forest industry may have reduced direct impacts on biodiversity (as a result of more efficient or low-impact production processing methods) and biodegradable detergent may have reduced indirect impacts (due to a decreased pollution load). Similarly, ecotourism is a service based on sustainable use of ecosystem services and biodiversity (TEEB, 2011). Tools for quantifying and valuing the environmental impacts of businesses are being developed. The UK-based firm TruCost has developed a process to include the unpriced damages of production, along the supply chain, of specific consumer products. This can inform consumers and allows companies to inform investors with "environmental profit and loss" statements.[40]

Information about biodiversity impacts is captured by some eco-labelling and certification programs for fisheries and forests. The Marine Stewardship Council (MSC) is the world's largest and most recognized sustainable fishing scheme to provide eco-labelling and independently verified certification. MSC-labelled fish products must have been fished in ways that minimize environmental impacts from stocks that are sustainably-managed. In 2009, 2,300 MSC-labelled products were available with a retail value of roughly US$1.4 billion (TEEB, 2011). In the forest industry, there are many certification standards and registration systems. All certification programs used in Canada require some level of conservation of biological diversity and maintenance of wildlife habitat and species diversity. The Ministry of Natural Resources provides advice to forest companies that want to certify their forest lands.[41]

What affects the success of economic instruments?

A general lesson from the economic instrument literature is the importance of anticipating interactions and compatibility. Instruments, funding, and policies controlled by one government department or one level of government will almost always have implications for existing policies enacted by another government department or level of government that target the same actor. The actor might also be influenced by instruments, funding, and policies of non-governmental bodies, such as industry associations. Implications can be effective when instruments complement one another, or they may be ineffective when they contradict. Therefore it is important to identify potential policy interactions in advance of considering economic instruments for the protection and conservation of ecosystem services and biodiversity.

Economic instruments are just one set of tools available to policy makers. There are three other sets of relevant policy instruments such as regulations and standards, public provision, and voluntary

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[40] To learn more about TruCost see http://www.trucost.com/environmental-impact-valuation

[41] http://www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/STEL02_167417.html

programs.[42] Policy instruments need not necessarily be viewed as substitutes and are often complementary to each other. For example, price-based instruments can be effectively used with strict regulations ensuring biodiversity or ecosystem services do not fall below a certain level.

What influences the choice of a specific instrument?

Several criteria can influence the choice of an instrument. These include conservation effectiveness, economic efficiency, equity (including distributional effects), the impacts upon innovation, administrative feasibility, flexibility, the complementarity with other instruments and existing policy frameworks, and the impacts upon stakeholders and their support and participation in its selection and design.[43]

Research about the choice of instruments has revealed several general themes. First, no single instrument is superior along all of the criteria identified above. Table 2 below identifies three different purposes for economic instruments: raising funds, informing markets, and recovering damage costs (Sawyer et al., 2005). In general, the reliance upon the valuation of unpriced benefits and administrative demands increase as the purpose of economic instruments moves from simply raising funds to recovering damage costs. Second, a tailor-made approach is ideal. The choice, design and complexity of the instrument should reflect local conditions. Third, trade-offs exist between the criteria (e.g. economic efficiency and administrative feasibility, efficiency and equity). Fourth, economic instrument design is a dynamic process and may require shifting from one type of instrument to another as ecological and economic conditions change. Fifth, scalability of policies is increasingly important as the use of economic instruments becomes more widespread.

Table 2: Different purposes of economic instruments

	Primary Purpose of an Economic Instrument		
	Raising funds	**Informing markets**	**Recovering damage costs**
Reliance upon the valuation of unpriced benefits	Little	Moderate	High
Administrative Demands	Little	Moderate	High
Examples	Hunting licenses	Permits, payments, bonds	Damage assessments
	→ → Increasing Ecological Effectiveness and Administrative Demands → →		

One specific instrument is not likely to achieve all biodiversity protection and conservation goals. It is more useful to policy to explore portfolios of instruments, as a sort of tool kit. The diversity of activities, sources, and sectors affecting biodiversity requires the implementation of a combination of policy tools. An insightful analogy is to think about economic policy. Economic policy can never be simplified to one policy instrument. Rather, its success relies upon a mixture of policy tools. The same holds true for biodiversity protection and conservation.

[42] Please see Treasury Board of Canada Secretariat (2007) for an outline of a decision-making framework for assessing, selecting and implementing policy instruments.

[43] These criteria are used in regulatory assessments; for more details, see Department of Finance Canada (2005).

8. Conclusions

The economics of ecosystem services and biodiversity is mostly about the economics of value that is neither reflected in markets, nor in the economic accounts that inform jurisdictions about their economy, nor in the self-interested economic motivations of people and organizations.

These gaps threaten the diversity and abundance of life on the planet. These gaps allow the consumption of natural capital to continue unaccounted for, and mask the contributions that ecosystem services and biodiversity make to economic wellbeing. This in turn contributes to the decline of the diversity and abundance of life on the planet. Furthermore, these gaps challenge the productivity and sustainability of economies, and challenge the cost-effective achievement of wellbeing.

All these gaps can be lessened by the quantification and economic valuation of ecosystem services and the benefits from biodiversity. In turn, this information can be integrated into the economic accounts of jurisdictions to better inform economic measures, strategies, and policy – including the use of economic instruments to better align the motivations of people and organizations with goals of biodiversity conservation.

This report is intended to serve as an overview and reference paper on the economics of ecosystem services and biodiversity in Ontario. It profiles and appraises existing work and initiatives in Ontario, and work that is relevant to Ontario from other jurisdictions, in language that should be understandable to a broad audience. Gaps abound, as do opportunities to fill these gaps. Filling these gaps requires networks and collaborations across sectors and domains of knowledge and practice, in Ontario and linked to counterparts around the world.

Prior to World War II, economic accounts did not exist. If people wanted to understand the state of the economy, very crude measures of economic activity were used, such as counting unemployed people on the street, and counting the number of boxcars moving between rail yards (Boyd, 2012). Imagine managing the economy in the absence of this information – without knowing the unemployment rate, without knowing whether the Gross Domestic Product was trending upwards or down, and without knowing the relevance of different sectors in the economy and their relationships to each other. Economic management was difficult. This motivated new measurements and policy approaches, leading to the pragmatic development of present-day economic accounts and approaches to the management of the economy.

Today's generations are alive at the time of a new frontier: integrating economic and environmental considerations for the sake of sustaining economic wellbeing. Management of this integration is difficult if not impossible in the absence of information about the unpriced benefits from nature. Management is also challenged without having economic accounts that relate market transactions, and wealth, to the ecosystems that provide their necessary ingredient of natural capital. These challenges are motivating innovations and collaborations that will hopefully rival the success and speed of the innovations several generations ago.

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