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Biodiversity and National Accounting

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Abstract

Biodiversity, a property of natural areas, provides a range of benefits to the economy including bioprospecting rents, knowledge and insurance, ecotourism fees, and ecosystem services. Many of these values can be broken out in the System of National Accounts, leading to better estimates of the economic losses when natural areas are degraded or destroyed. Developing countries harbor the great majority of biodiversity, and this diversity provides benefits, including knowledge and carbon sequestration, to the whole world. However, protecting biodiversity is particularly costly for developing countries: the opportunity cost of foregoing development of natural areas exceeds 1 percent of gross domestic product in 58 developing countries, versus only four OECD countries. The Global Environment Facility can offset these costs through grant finance, but annual Global Environment Facility finance and co-finance averages only 8 percent of the opportunity costs faced by low-income countries.

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Biodiversity and National Accounting

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Introduction

The absence of any valuation of the depletion and degradation of natural resources and the natural environment in the System of National Accounts (SNA) leads at best to policy complacency and at worst to policy mistakes. As *The Changing Wealth of Nations* (World Bank 2011) documents, the effect of this absence is likely to be felt most keenly in developing countries, where natural resources and the natural environment constitute 21%-35% of total wealth.

Ignoring the consumption of all forms of capital flatters the growth rates of gross domestic product (GDP) in all countries, which can be a powerful source of complacency. In poor countries that are highly dependent on exhaustible natural resources, the combination of fiscal policies and resource sector policies can result in gross wealth creation that is positive and growing, while the net change in produced plus natural wealth, unmeasured in the SNA, is negative – this is a policy mistake of the first order.

As a large literature attests, and as will be reviewed below, biodiversity is a source of economic benefits. Most of these benefits are currently measured in the SNA. The problem, and a key source of policy errors, is that there is no *explicit* measure of these benefits. As a result, development decisions guided by the traditional indicators of the SNA, such as GDP growth, can harm natural areas and the biodiversity which they harbor, leading to unforeseen losses of wellbeing. Policy surprises abound.

For commercial natural resources, the adoption of the System of Environmental-Economic Accounting (SEEA) as a United Nations statistical standard (United Nations 2012) is a major step forward in defining the contribution of natural resources to national income, including the effects of depleting these resources. From a biodiversity perspective this work is still incomplete, however, because work on accounting for ecosystem services, in particular, is ongoing.

This paper explores the extent to which biodiversity and changes in biodiversity could be measured within the existing structure of the SNA, as well as assessing how the SNA could be extended to include a broader portion of the value of biodiversity. We begin by summarizing the treatment of natural resources in the national balance sheet account, and review key portions of

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[1] Kirk Hamilton is Lead Economist, Development Research Group, The World Bank. The comments of Dieter Helm, Colin Mayer, Ed Barbier, Giles Atkinson and Mike Toman are acknowledged with thanks. The research and conclusions presented are solely the author's and should not be attributed to the World Bank, its Executive Directors, or governments of World Bank member countries.

the literature addressing the economic value of biodiversity. We then turn to a discussion of the accounting issues and potential ways forward in accounting for biodiversity in the SNA.

A significant proportion of the world's biodiversity resides in protected areas. We conclude with an empirical analysis of the value of protected areas as published in *The Changing Wealth of Nations*. A key insight is that there is an opportunity cost that countries face in establishing protected areas. The striking empirical finding is that the annual opportunity cost of maintaining protected areas is a much higher share of GDP in many developing countries than in OECD countries – the opportunity cost exceeds 1% of GDP in 58 developing countries vs. only 4 OECD countries. And flows of concessional finance to offset this cost, via the Global Environment Facility and its co-finance, average only 8% of the annual opportunity cost in low income countries.

Balance sheets and biodiversity

Although it is not generally emphasized when graduate students in economics are taught about national accounting, the national balance sheet is arguably the root construct of the whole SNA. The balance sheet defines the system boundary for the SNA and one of the principal aggregates defined in the SNA, gross national income (GNI), represents the gross return on the assets measured in the balance sheet. In exploring the current and potential treatment of biodiversity in national accounting, therefore, the balance sheet is the appropriate place to start.

Natural resources appear in national balance sheet accounts as a category of non-produced assets. By defining biodiversity to be a property of a natural system, we can begin to understand its role in the SNA. Specifically, SNA 2008 (the latest standard for national accounting, published in United Nations 2009) characterizes natural assets in the following manner:

- "Only those naturally occurring resources over which ownership rights have been established and are effectively enforced can […] qualify as economic assets and be recorded in balance sheets. They do not necessarily have to be owned by individual units, and may be owned collectively by groups of units or by governments on behalf of entire communities. (Para 10.167)

- …In order to comply with the general definition of an economic asset, natural assets must not only be owned but must also be capable of bringing economic benefits to their owners, given the technology, scientific knowledge, economic infrastructure, available resources and set of relative prices prevailing on the dates to which the balance sheet relates. (Para 10.168)

- …When […] forests or the animals, birds, fish, etc. [living in the wild] are actually owned by institutional units and are a source of benefit to their owners, they constitute economic assets." (Para 10.169)

This characterization leans heavily toward commercial natural resources – but, since governments are typically the owners of undeveloped land including protected areas, the door is at least partially open to the inclusion of biodiverse natural areas as economic assets in the balance sheet, to the extent that they yield economic benefits to governments.[2] The obvious next question, of course, is to understand how biodiversity can yield economic benefits, the subject of the next section.

Biodiversity as a source of value

Polasky *et al.* (2005) provide a reasonably comprehensive assessment of the economics of biodiversity, and they derive a useful classification of the sources of value derived from biodiversity. First, individual species may have *use* and *existence values*.[3] Examples of the former include hunting, fishing, wildlife photography and nature tourism.. 'Using' species generally entails associated commercial activities which are measured in the SNA, while existence values are not (nor indeed are option values for preserving species). Use values also generate fee income for governments in the form of admission fees to natural areas and licenses for the use of particular species.

Biodiversity may also be a source of *bioprospecting* revenues and is an integral part of the *production of ecosystem services* in natural areas.[4] Bioprospecting involves the search for commercially valuable products from natural species, and their discovery yields both commercial activities and a potential stream of rents to the owners of the species in question. Ecosystem services are broad, covering the categories of supporting, provisioning, regulating and cultural services as defined in the Millennium Ecosystem Assessment (2005) – provisioning services overlap substantially with the use values just defined.

Heal (2000) identifies two additional sources of value from biodiversity: *knowledge* and *insurance.* Studying species which make up biodiverse communities may yield knowledge of value in the production of pharmaceuticals and the products of biotechnology – this is obviously closely linked to bioprospecting. And the genetic makeup of related species (e.g. wild variants of

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[2] However, it is important to note that the treatment to date in balance sheet accounts has been to value public lands, and their associated biodiversity, at zero.

[3] In this paper we focus on existence or bequest values linked to biodiversity, but of course these make up part of the broader class of non-use values in the usual Total Economic Value hierarchy.

[4] In fact Polasky *et al.* conclude that there is considerable evidence that higher biodiversity is linked to higher productivity of natural areas.

commercial crops) may provide insurance in the form of new genetic material which can help commercial species such as food crops adapt to pathogens.[5]

Mace *et al.* (2012) argue that biodiversity can be an important regulator of ecosystem processes, a final ecosystem service, and a good in and of itself. This conception of biodiversity can be mapped to the values outlined above: the regulation of ecosystem processes contributes to the production of ecosystem services; biodiversity as an ecosystem service overlaps with bioprospecting and knowledge values; and biodiversity as a good (charismatic species, for example) is directly linked to use values.

There is a parallel between the insurance values provided by biodiversity and the ecological concept of resilience. Walker *et al.* (2010) argue that ecosystem resilience is itself an asset that should be valued in any inclusive measure of total wealth. An alternative way to express the argument is to say that the expected value of wealth is positively related to the level of resilience of the ecosystem. To the extent that biodiversity contributes to ecosystem resilience, it can serve as a type of insurance on existing asset values.

It is important to note that at least two of these sources of value for biodiversity may constitute global public goods – some ecosystem services may provide global benefits, by sequestering carbon for example, while knowledge has inherent global public good characteristics (at least in the absence of patents). This is an important consideration since much of the world's biodiversity resides in developing countries.

Potential treatments of biodiversity in the national balance sheet

While biodiversity has tended to be measured in terms of relative species abundance or joint dissimilarity of species (Polasky *et al.* 2005), from the perspective of the national balance sheet it is perhaps simplest to conceive of it as a property of a natural area – one property among many, including soil, hydrology, geology, topography, climate, and location. In what follows we concentrate on valuing natural areas conceived as land[6] possessing a bundle of properties, including biodiversity.

Based on the preceding assessment of biodiversity as a source of value, several potential treatments of biodiversity in the balance sheet accounts suggest themselves. The most direct link concerns use values, where fees paid for the use of nature represent economic benefits accruing

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[5] These various types of value for biodiversity are interrelated. The decision to conserve a natural area creates an option value - bioprospecting is one approach to seeking this value and knowledge is one realization of this value. Conservation of natural areas has an opportunity cost, but it may also have a benefit in terms of insurance - incurring the opportunity cost may increase expected utility in the face of climate and natural disaster risks

[6] Marine protected areas lying within a country's exclusive economic zone can have similar values to those we describe, but there may be issues concerning fugitive species passing into and out of national waters.

to the owners of natural areas and their associated biodiversity. Taking present values of these fees would give a value for natural assets which could fit consistently within the SNA balance sheet account. However, this would not necessarily be a good measure of the economic value of the natural asset because park fees and other usage fees are generally not tapping the full willingness to pay of the people visiting and using the natural area. Additionally, it is important to note that the total willingness to pay to use the natural area is linked to the bundle of properties possessed by the area, including its biodiversity.

In countries where surveys of users have measured the willingness to pay (per person per day)[7] for the enjoyment of the natural area, it may be possible to reflect this in the balance sheet. While the SNA measures only the value of actual transactions, with few imputations, bringing values of natural areas into the balance sheet based on stated willingness to pay could be done if (i) due care is taken in the survey design, and (ii) there is evidence that willingness to pay actually varies as the properties of the natural area, including biodiversity, change. If implemented in national accounts, the result would be an imputed value of national wealth and an associated measure of national income which includes the imputed consumption of benefits over and above the actual user fee paid.

Ecotourism is another example of use value which provides economic benefits to natural tourism operators as well as park entry fees to government. If the natural areas visited by the ecotourists are privately owned then the capitalized rents generated by ecotourism already form part of the national balance sheet – although the land may retain its 'natural' characteristics, it is effectively a commercial natural resource. If the ecotourist visits a lodge in a national park, then the rents paid by the lodge owner to the government contribute to government income and therefore to the asset value of the national park.

Bioprospecting rents are also economic benefits accruing to the owner of a natural area, but Polasky *et al.* (2005) note that the expected values of bioprospecting rents are low, generally less than the financial costs of the conservation of natural areas. The value of the knowledge which can be gained from diverse species can in principle be measured and ascribed to the natural areas which are the source of the species.

As highlighted above, biodiversity is an integral part of the production of ecosystem services, and there is evidence that increasing biodiversity increases the productivity of natural areas. This

[7] The stipulation that the surveys measure willingness to pay to use the natural area per person per day is important, since this is in effect a price, and the relevant quantity is the number of person-days demanded. Imputing the additional consumption of benefits from the natural area is therefore consistent with national accounting conventions which stipulate that final expenditure is the summing up of 'p times q' values, excluding consumer surplus. This suggests, however, that the survey should attempt to measure the demand curve for person-days of use of the natural area.

suggests that natural areas, including protected areas, can also be valued on the basis of the ecosystem services they provide.

The key point to recognize when valuing ecosystem services is that the great majority of these services are provided to the rest of the economy as externalities[8] – think of pollinators inhabiting a natural area which provide pollination services to surrounding farms. This has two consequences. First, the values of ecosystem services will already be capitalized in other asset values, such as farmland. Second, accounting for ecosystem service values violates the SNA convention that natural resources have value to the extent that they yield economic benefits to their owners – in this case the beneficiaries are third parties, such as owners of farmland who benefit from the external supply of (costless) environmental services.

Adding up the values of the ecosystem services provided by a natural area and capitalizing these values separately in the national balance sheet would therefore typically be double-counting. To the extent that the value of natural areas is expressed through externalities, the role of accounting for ecosystem services is to disaggregate the existing asset values in the national balance sheet into their different sources of value, including sources from the ecosystem services generated by natural areas – total national wealth will not increase.

If we assume that the different use values, bioprospecting / knowledge values and ecosystem service values of biodiverse areas are *in principle* measured in the national balance sheet, an interesting question is whether there are other sources of value from biodiversity which would not already be measured in the values of existing assets. Two possibilities suggest themselves: insurance values and existence values.

Insurance values linked to the biodiversity harbored in natural areas are expected values, based on the probability of a catastrophic risk to a commercial crop (for example), the probability that the natural area contains species which can yield genetic information of use in adapting the commercial crop to withstand the risk, and the value of the potential catastrophe. Assuming the necessary data can be found, measuring the insurance value of biodiversity would in fact increase the estimated total wealth of the economy. Note, however, that this would not increase measured GNI in the national accounts, although it could be argued that it increases the expected value of GNI in the face of some known probability of a catastrophe of a given size.

Placing existence (or bequest) values on the biodiversity assets of a country would immediately take you outside the SNA boundary.[9] From an accounting perspective this would increase

[8] Perrings (2012) also makes this point, although he focuses on transboundary externalities. Payments for environmental service (PES) schemes effectively internalize the externality, however, with the payment forming part of GNI. Pagiola (2008) provides an example for Costa Rica.
[9] Since stated preference methods are the tools required to establish existence values, measuring the total existence value of the suite of biodiversity possessed by a country would also be subject to well-known difficulties, including

measured consumption to include the dollar value of the flow of benefits tied to the existence of species, while the balance sheet would expand to include the capitalized value of this flow. As long as what is measured is 'pure' existence value (i.e. completely excluding any of the other values just discussed), there would be no double-counting in the accounts. Existence values are obviously another form of externality, since the households benefiting from the existence of the biodiversity are not paying a user fee to the owner of the asset.

As this discussion makes clear, biodiverse natural areas provide multiple flows of benefits. The capitalized values of these benefits can in principle be added up without double-counting in the balance sheet.

This discussion has concentrated on the diverse values of natural areas that could be valued in the balance sheet, focusing on those values that are linked to biodiversity. It has not talked specifically about the value of biodiversity in the balance sheet, and this is because of the difficulty in decomposing the value of natural areas into their different sources of value. While bioprospecting and knowledge values may be specific to the quantity and character of biodiversity, this is less obviously true for natural areas as a source of user fees, ecotourism rents and ecosystem services – what is being valued is a composite good made up of diverse components including soil, hydrology, geology, topography, climate, location, and biodiversity, as noted above.

It may be possible, however, to derive many of the *marginal* values of the specific properties of a natural area. This is discussed in the next section.

Measuring net income and net saving

The link between the wealth inherent in natural areas and GNI is a natural starting point for thinking about biodiversity, net income and net saving. A key point is that many of the economic benefits derived from biodiverse natural areas are already captured in GNI – user fees, ecotourism expenditures, bioprospecting rents, the economic value of knowledge derived from biodiversity, and the external benefits provided by ecosystem services are all included in GNI. As just noted, the insurance services provided by biodiversity are probably not reflected in GNI, nor are the flows of existence values since they lie outside the SNA boundary.

From an analytical perspective, one of the principal reasons for building the national balance sheet account is to shed light on the sustainability of development. Pearce and Atkinson (1993) were the first to present empirical estimates of net national saving adjusted for resource depletion and damage to the environment. They interpret the adjusted saving measure as an indicator of

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the evidence that survey respondents have difficulty putting rational values on individual species vs. collections of species.

sustainable development, and subsequent growth-theoretic papers by Hamilton and Clemens (1999), Dasgupta and Mäler (2000) and Asheim and Weitzman (2001) provided the theoretical underpinning – net (or 'genuine') saving, calculated as the net change in real wealth, is a dollar-valued measure of the change in social welfare. Negative genuine saving indicates that the country is on an unsustainable path.

An overarching issue in measuring genuine saving is the need to measure the change in *real* asset values, measured as a fixed price times the quantity which is added to or subtracted from the underlying stock. The relevant price is the shadow price of a unit of the asset, or the change in social welfare associated with a marginal change in the quantity of the asset.

Barbier (2012) provides a useful overview of how production function techniques can be used to measure marginal values of ecosystem services, and we generalize this to the case of biodiversity in Annex I. The basic idea is that we can conceive the flow of benefits provided by a natural area as the result of a 'natural production function,' where the inputs to production are the different properties of the natural area, including biodiversity as measured (for example) by relative species abundance. Changes in the flow of benefits as well as the associated changes in the properties of the ecosystem can be used to model the production function econometrically, and the coefficients on the inputs to the production function represent the marginal values of the different ecosystem properties.

While it is simple to write out the math for this technique, as shown in Annex I, Barbier (2007) enumerates the complexities involved. In particular, this assumes the availability of data on changes in the economic benefits derived from a natural area as well as the associated changes in the components and properties of the natural area, including, in this case, the quantity of biodiversity. A quantitative understanding of the structure and function of the ecosystem is required. Market imperfections have to be taken into account, as well as stock effects when changes in ecosystem services are sufficiently large. For insurance services provided by biodiversity, the production function approach requires the estimation of the damages to human wellbeing avoided by having biodiverse natural areas.

If the SNA boundary were extended and existence values were brought into the national balance sheet, many of the difficulties in measuring existence value using stated preference methods would come to the fore. And it is unclear whether the total existence value would fall if a single species became (locally) extinct – for example, people might value the existence of other species more as a result of the extinction. Existence values may simply not lend themselves to marginal valuation.

Conversely, if values of the benefits from the use of natural areas, based on surveys of willingness to pay, were brought into imputed measures of total wealth and national income, it would be possible to value changes in natural areas (including biodiversity) as long as a key proviso noted in the previous section applies – it must be the case that stated willingness to pay varies systematically with changes in the properties of the natural area. If this were the case, then in principle the relevant portion of the utility function for the users of natural areas could be estimated, yielding marginal values of the different properties of the natural area.

While we concluded the previous section by noting the likely difficulties in arriving at any additive decomposition of the values of natural areas into their component properties, including biodiversity, production function techniques offer a way to measure marginal changes in the flow of benefits from natural areas associated with marginal changes in the properties of the natural area. In principle this opens the door to adjusting the measure of genuine saving to reflect losses of biodiversity, but the practical difficulties should not be underestimated. These difficulties in measuring genuine saving spill over to measuring net income, which is defined as the sum of consumption and net (genuine) saving.

We now turn to an analysis of the World Bank's estimates of the value of protected areas.

Valuing conservation in national accounts: Empirical estimates

As the foregoing has emphasized, biodiversity can provide a range of functions of value to human wellbeing. In theory and in practice this contribution to wellbeing can be valued, but what are lacking are comprehensive estimates of these values both within and across countries – the literature on valuing biodiversity is generally concerned with specific ecosystems in specific countries.

As a proxy for biodiversity values, we analyze the values of terrestrial protected areas across countries, exploiting figures published in *The Changing Wealth of Nations* (World Bank 2011). This is clearly not the same as valuing biodiversity, but there is at least a link: protected areas harbor much, but certainly not all, of the world's biodiversity. However, just as there are no comprehensive measures of biodiversity values across countries, there is a similar lack of cross-country estimates of the value of natural areas based upon the value of the environmental services provided by these areas. The World Bank therefore falls back upon quasi-opportunity costs as the basis of valuation.

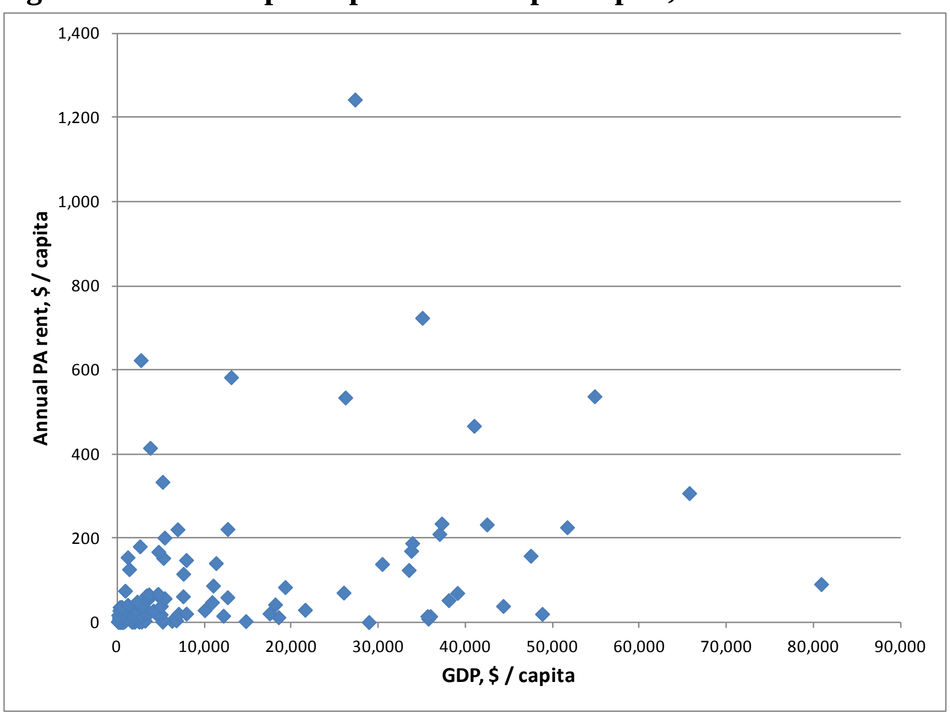
Starting from estimates of the extent of terrestrial protected areas from the World Conservation Monitoring Centre (as published in the *World Development Indicators*), World Bank (2011) assumes that the best alternative use for protected land is in agriculture. It further assumes that areas subject to protection are not the most productive agricultural lands – first, because most such conversions to agriculture would already have occurred over the course of history, and second, because it is unlikely that a government would choose to declare prime agricultural land as a protected reserve. World Bank (2011) therefore values protected areas at the same per-hectare value as what is, on average, the least productive agricultural land in a given country – hence the notion of a 'quasi-opportunity cost.'[10] The assumption is that the government establishing a protected area values the newly protected land at least as much as if it were in its alternative agriculture use. As such, the quasi-opportunity cost is therefore a lower bound on the value of protected areas.

What we analyze in the following subsections is therefore easily a third-best measure of the value of biodiversity in national balance sheets. But the analysis is not without interest, and it leads to some tentative policy conclusions.

Protected area rents in relation to GDP

While World Bank (2011) publishes the asset value of protected areas – it forms part of the aggregate value of natural capital and, more broadly, comprehensive wealth – here we focus on the annual land rent from protected areas ('PA rents') per capita.[11] The natural question to ask is how this is related to GDP per capita across countries, and Figure 1 provides the answer.

Figure 1. PA rents per capita vs. GDP per capita, 2005



Source: Derived from data published in World Bank (2011)

[10] In practice, World Bank (2011) uses the lower of cropland and pastureland average per-hectare values in each country. For simplicity we refer to 'opportunity costs' in lieu of 'quasi-opportunity costs' in what follows.
[11] World Bank (2011) attempts to value the wealth available to the current generation, and therefore calculates land asset values as the present value of land rents over a 25 year horizon.

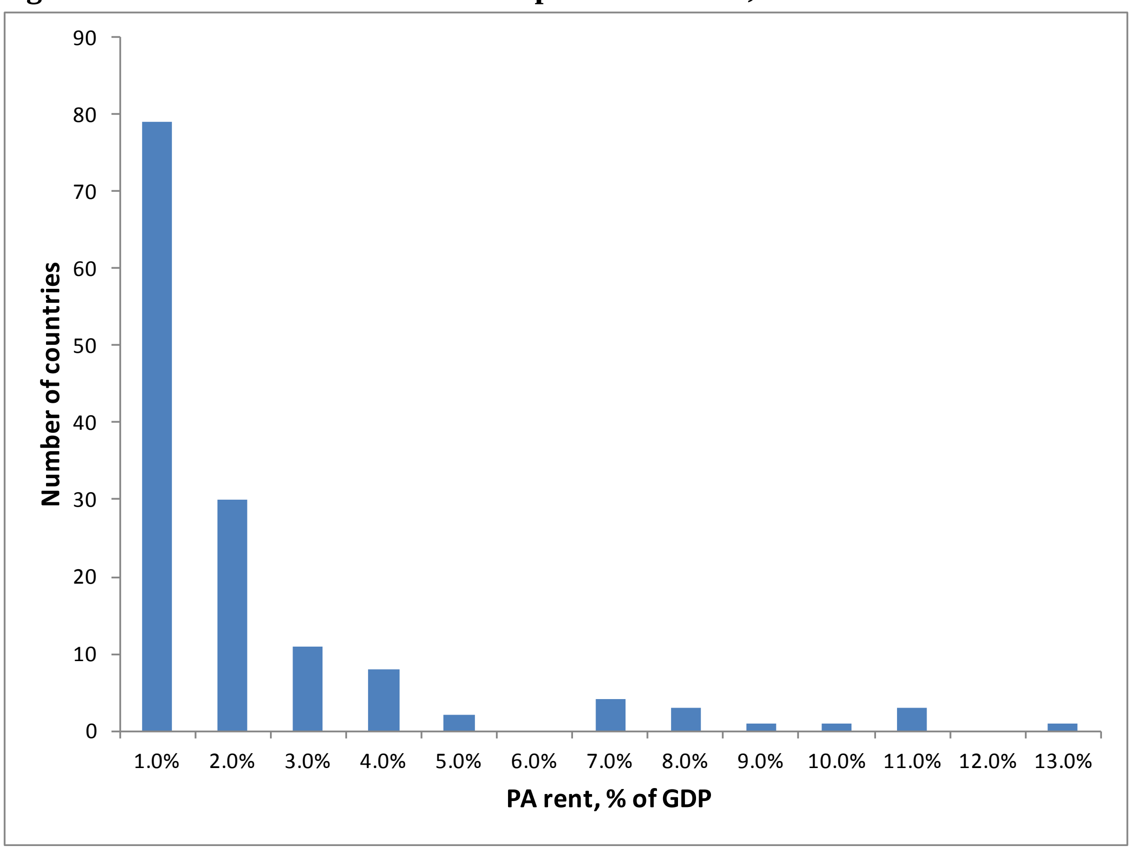
The next obvious question to examine is the variation in PA rents as a percent of GDP across countries.

The scatter in Figure 1 shows no discernible trend or pattern, and this is not entirely surprising. While land rents per hectare will tend to rise with GDP per capita, owing to better technology, there is no obvious reason why the underlying endowment (land suited to be protected areas) should vary with income. There is conceivably a greater willingness of high income countries to establish protected areas than in developing countries, but we show below that this is not borne out by the data.

PA rents as a percent of GDP

Figure 2 shows the distribution of the PA rent percentage across the 146 developed and developing countries in the sample from World Bank (2011).

Figure 2. Distribution of PA rents as a percent of GDP, 2005



Source: Derived from World Bank (2011). Note that Ecuador (22.6%) is not shown.

The distribution is highly skewed, with PA rents comprising 1% or less of GDP in 55% of the countries in the sample, and 2% or less of GDP in 76% of the countries in the sample. With some exceptions, therefore, PA rents tend to be a small share of GDP. This leads to the next analytical question: How do these shares of GDP vary across income classes of countries?[12]

PA rents as a share of GDP across income classes

Annex II Tables A1 – A3 present the detailed figures on GDP per capita, PA asset values per capita and PA rents as a share of GDP for each of the countries in the sample, classified by income category. Using 1% and 5% of GDP as thresholds, Table 1 summarizes the findings.

The striking result in Table 1 is the high proportion of developing countries where PA rents exceed 1% of GDP, often by a large amount. Only four OECD countries – Sweden (1.1%), Slovak Republic (1.2%), Canada (2.1%), and New Zealand (4.5%) – had shares of GDP above 1%.

Table 1. Countries with PA rents > 1% of GDP, by income class, 2005

	Low income	Middle income	OECD
# of countries in class	41	65	29
# of countries in class with PA rents > 1% of GDP	24	34	4
% of countries in class with PA rents > 1% of GDP	59%	52%	14%
Which countries had PA rents > 5% of GDP?	Benin (6%) Kenya (7%) Lao PDR (7%) Tajikistan (8%) Nepal (9%) Ethiopia (10%) Uganda (11%)	Dominica (6%) Thailand (7%) Cameroon (8%) Honduras (9%) Belize (11%) Bhutan (12%) Ecuador (23%)	

Source: Author's calculations based on World Bank (2011)

Explaining the high PA rents as a share of GDP in developing countries

Table 2 lays out three potentially relevant indicators to explain this high share of PA rents in the GDP of developing countries. The first two are physical measures – hectares of protected area per capita and protected area as a percent of total land area. The third is a measure derived from

[12] We use the standard income classes of the World Bank, low and middle income, as well as OECD countries.

the comprehensive wealth accounts published in World Bank (2011) – land values as a share of total wealth.

The physical indicators are clearly not the explanatory variables we are seeking – protected area per capita in developing countries is about 2/3 of the value in OECD countries, while there is little variation in the protected area share of total land area across the different income classes. The third indicator tells the story. Land values (excluding urban land) make up only 1.4% of the total wealth of OECD countries, while it is 10 to 20 times higher as a proportion of wealth in middle and low income countries. Since the opportunity cost of creating a protected area is based on the rents from agricultural land, this will necessarily be a much larger share of GDP in developing countries compared with OECD countries.

Table 2. Protected area extent and land values by income class, 2005

	Low income	Middle income	OECD
Protected area per capita, ha.	0.22	0.21	0.34
Protected area as a percent of total land area	10.8%	10.6%	11.8%
Land value (cropland, pastureland, forested land, protected areas) as a percent of total wealth	29.5%	12.8%	1.4%

Source: derived from World Bank (2011) and *World Development Indicators*

Policy implications, and some caveats

Protected areas and the biodiversity they harbor provide both local and global benefits. The institution that finances environmental global public goods is the Global Environment Facility (GEF), and it is worth assessing the level of finance that it disburses for biodiversity protection.

According to the GEF's *Annual Report 2010*, the total finance it provided for biodiversity conservation from 1991 to 2010 amounted to $3.1 bn, while this amount leveraged a further $8.4 bn in co-finance from development partners. In total, therefore, GEF finance and co-finance averaged $575 mn per year for biodiversity conservation over these two decades. This finance is provided to both low and middle income countries, but the bulk of it is allocated to the mega-diverse middle income giants: Brazil, China and Indonesia.

We can put this figure in context by measuring the PA rents for *low income* countries as a whole in 2005 – this is the total annual opportunity cost of conservation in these countries. This amounts to $7.6 bn. The average annual GEF finance plus co-finance to both *low and middle income* countries is therefore only 8% of this figure.

Before we jump to the conclusion that biodiversity conservation in low income countries is woefully under-financed, some caveats are in order. First, the GEF role is to finance global environmental public goods, not the local benefits that countries derive from their conservation efforts. So the GEF financing figure *should* be lower than the local opportunity cost of conservation.

Second, World Bank (2011) bases all of its valuation of natural resources on the basis of world prices, as a way to level the playing field when country comparisons are being made. Of course, this is also the appropriate shadow price to use when deriving the value of natural assets. However protected areas, by their very nature, tend to be far from markets and infrastructure in developing countries. As a result, the opportunity costs of conservation derived in World Bank (2011) probably exceed the opportunity cost of conservation at local prices in these countries.

Third, the assumption that protected areas are only as productive as the least valuable category of agricultural land in a given country (the quasi-opportunity cost) may be too strong. If the fact that a given natural area has not been developed for agriculture to date reflects revealed preference – local people know that its agricultural productivity would be very low – then the opportunity costs used in World Bank (2011) would be correspondingly too high.

Granting these caveats, the 8% ratio of GEF biodiversity finance plus co-finance to the World Bank's estimate of low income country opportunity costs for conservation is extremely low, particularly since the bulk of this finance is going to middle income countries.

Conclusions on Biodiversity and National Accounting

Early in this paper we quoted the SNA definitions pertaining to the value of natural resources in the balance sheet account for a country. The basic idea is that the natural resource must produce an economic benefit to its owner in order to be considered an asset. While natural (undeveloped) areas are generally owned by governments, countries building balance sheet accounts have tended to exclude the value of government land in the balance sheet accounts. We present examples of how biodiverse natural areas can provide economic benefits to governments, and therefore could be valued in the balance sheet account.

The literature on the economics of biodiversity points to a range of sources of economic value linked to some quantitative measure of biodiversity. Some of these values, particularly bioprospecting and knowledge values, may be directly linked to specific 'biodiversity assets,' and so could be measured directly in the national balance sheet. For natural areas as a source of user fees, ecotourism rents and ecosystem services, it is much less obvious that the natural area as a composite good lends itself to a decomposition of its total value into specific values associated with the different properties of the natural area, including biodiversity. A specific 'value of biodiversity' in the national balance sheet may therefore be an elusive goal, but an aggregate value of natural areas may be feasible.

On the other hand, given sufficient knowledge of natural systems and sufficient variation in the data on the inputs and outputs of natural systems, it may be possible to derive production functions for the different categories of value provided by natural areas. This in turn could lead to values of the marginal benefits associated with changes in the quantity of biodiversity, and therefore to adjusted measures of net income and net (genuine) saving in an extended national accounting system.[13]

A number of complicating factors arise when it comes to including the value of natural areas in national balance sheet accounts. One important issue is that many user fees are not capturing the full willingness to pay of the user of the natural area. Under fairly stringent conditions – construction of a demand curve for person-days of use of the natural area, where the price is sensitive to any changes in the properties of the natural area – it would be possible to impute augmented values of national wealth and national income based on willingness to pay to use natural areas.

The other big issue is that many natural areas provide benefits as externalities to the wider economy. The consequence of these externalities for wealth measurement is that the inclusion of many ecosystem services in the balance sheet would lead to double-counting. The role of valuing ecosystem services in national accounting is therefore typically to decompose the sources of value underpinning those assets (such as farmland) which benefit from external environmental services.

This external nature of many ecosystem services has policy consequences. The natural areas which are sources of ecosystem services will generally be at risk, since the owner of the natural area (a government or a private actor) may not be aware of, or may not care about, its value to other actors when development decisions are being made. Payments for environmental service schemes (PES) are a policy response which internalizes the externality.

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[13] This ability to measure the marginal values of properties such as biodiversity suggests that constant returns to scale in the production function could lead to an additive decomposition of all the sources of value which could be broken out in the balance sheet account. However, constant returns to scale seems unlikely given the highly non-linear character of many natural systems. This non-linearity also implies that the estimated marginal values of different properties of a natural system are purely local.

On quantification, the analysis of the (quasi-)opportunity costs of conserving natural areas based on wealth accounting data in *The Changing Wealth of Nations* (World Bank 2011) sheds light on the disproportionate burden of conservation costs as a share of GDP being borne in developing countries in comparison with OECD countries. The reason for this is the much larger share of total wealth (and therefore national income) that is derived from land in developing countries compared with OECD countries.

To put these values of protected areas in context, the annual GEF finance and co-finance for biodiversity conservation in all developing countries was, based on a 20 year average, only 8% of the opportunity cost of conservation in low income countries in 2005. This indicates that the opportunity cost of conservation borne by low income countries is not being substantially offset by international flows of concessional finance.

On balance, there is considerable scope to include the use values of natural areas in national accounts. This is so because there are flows of user fees and rents associated with the use of natural areas. As a property of natural areas, biodiversity can be implicitly or explicitly valued in the balance sheet accounts, depending on the nature of the benefits it provides (e.g. use values for nature tourists vs. bioprospecting fees), while marginal changes in biodiversity may be valued depending upon the availability of sufficient data to estimate the associated changes in the production of benefits which people value. Non-use values appear to be much less amenable to valuation in the national accounts, owing to measurement issues and the inherently non-marginal nature of some of these values.

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Annex I – Deriving marginal values of biodiversity using production function techniques

Suppose that a given natural area generates a total annual flow of dollar-valued benefits W, and that this flow is an increasing function of a set of properties of the natural area, N_i, and biodiversity B measured, for example, as relative species abundance. $W(N_i, B)$ can then be conceived as a production function for the value of the natural area. If there is a decrease in the quantity of biodiversity ΔB, the change in the real value of the natural area is given by,

$$-\frac{\partial W}{\partial B} \cdot \Delta B \qquad (1)$$

The partial derivative, which can in principle be estimated econometrically, represents the marginal value of a unit of biodiversity. As a marginal value, this can be used in national accounting, in particular in an adjusted measure of net saving in the economy.

If the natural area is providing a flow of benefits as an externality to another productive activity, such as water regulation services to farmland for example, then the appropriate model is a nested production function. Assume the value of crop production from farmland is given by $F(N_i, W)$, where now the N_i are both the properties of the farmland as well as inputs of capital, labor and intermediate goods such as fertilizer. $W = W\left(N_j, B\right)$ is the production function for water regulation services, which depend on the properties of the ecosystem N_j and its biodiversity B. If there is a decline in the biodiversity of the natural area ΔB, the change in the value of farm production associated with this decline is therefore,

$$-\frac{\partial F}{\partial W} \cdot \frac{\partial W}{\partial B} \cdot \Delta B \qquad (2)$$

Annex II – Data on protected area asset values per capita and land rents

Table A1. Selected low income countries, $ 2005

	GDP/cap	PA asset value / cap	PA rent % GDP
Bangladesh	429	16	0.24%
Benin	562	562	6.40%
Burkina Faso	385	211	3.51%
Burundi	154	13	0.53%
Chad	542	140	1.66%
Comoros	602	330	3.51%
Congo, Dem. Rep.	125	19	0.96%
Ethiopia	165	261	10.13%
Gambia, The	415	10	0.16%
Ghana	496	18	0.23%
Guinea	325	27	0.53%
Guinea-Bissau	419	85	1.29%
Haiti	444	4	0.05%
India	732	145	1.27%
Kenya	526	557	6.78%
Kyrgyz Republic	476	96	1.28%
Lao PDR	475	554	7.47%
Lesotho	662	1	0.01%
Liberia	170	16	0.60%
Madagascar	282	41	0.94%
Malawi	215	60	1.78%
Mali	403	64	1.02%
Mauritania	717	89	0.80%
Moldova	831	56	0.43%
Mozambique	317	12	0.25%
Nepal	298	433	9.30%
Niger	262	160	3.91%
Nigeria	803	17	0.13%
Pakistan	691	286	2.65%
Papua New Guinea	804	319	2.54%
Rwanda	281	114	2.59%
Senegal	800	102	0.82%
Sierra Leone	240	8	0.20%
Sudan	691	295	2.73%
Tajikistan	358	434	7.75%
Togo	391	39	0.64%

	GDP/cap	PA asset value / cap	PA rent % GDP
Uganda	325	558	10.98%
Uzbekistan	547	101	1.18%
Vietnam	642	152	1.52%
Zambia	626	100	1.02%
Zimbabwe	458	79	1.10%

Source: derived from World Bank (2011)

Table A2. Selected middle income countries, $ 2005

	GDP/cap	PA asset value / cap	PA rent % GDP
Albania	2,666	574	1.38%
Algeria	3,112	384	0.79%
Angola	1,857	80	0.27%
Argentina	4,736	320	0.43%
Armenia	1,598	373	1.49%
Azerbaijan	1,578	212	0.86%
Belarus	3,090	560	1.16%
Belize	3,821	6,468	10.84%
Bhutan	1,242	2,407	12.40%
Bolivia	1,044	443	2.72%
Botswana	5,468	888	1.04%
Brazil	4,743	1,042	1.41%
Bulgaria	3,733	938	1.61%
Cameroon	945	1,165	7.89%
Cape Verde	2,055	17	0.05%
Chile	7,631	1,793	1.50%
China	1,731	107	0.40%
Colombia	3,404	993	1.87%
Congo, Rep.	1,723	10	0.04%
Costa Rica	4,633	1,026	1.42%
Côte d'Ivoire	908	39	0.28%
Croatia	10,090	445	0.28%
Dominica	5,247	5,206	6.35%
Dominican Republic	3,670	1,028	1.79%
Ecuador	2,751	9,723	22.62%
El Salvador	2,825	18	0.04%
Fiji	3,655	333	0.58%
Gabon	6,322	49	0.05%
Georgia	1,470	242	1.06%

	GDP/cap	PA asset value / cap	PA rent % GDP
Grenada	6,818	66	0.06%
Guatemala	2,140	463	1.38%
Guyana	1,105	160	0.93%
Honduras	1,412	1,965	8.91%
Indonesia	1,258	411	2.09%
Iran, Islamic Rep.	2,754	267	0.62%
Jamaica	4,179	426	0.65%
Jordan	2,326	759	2.09%
Latvia	6,973	3,444	3.16%
Lithuania	7,604	958	0.81%
Macedonia, FYR	2,937	235	0.51%
Malaysia	5,499	879	1.02%
Mauritius	5,054	288	0.36%
Mexico	7,973	316	0.25%
Mongolia	991	443	2.86%
Morocco	1,931	18	0.06%
Namibia	3,491	826	1.52%
Nicaragua	1,166	549	3.01%
Panama	4,776	2,611	3.50%
Peru	2,881	603	1.34%
Philippines	1,205	302	1.60%
Poland	7,963	2,306	1.85%
Romania	4,572	297	0.42%
Russian Federation	5,337	2,380	2.85%
South Africa	5,234	93	0.11%
Sri Lanka	1,242	640	3.30%
St. Vincent and the Grenadines	5,070	599	0.76%
Swaziland	2,540	17	0.04%
Syrian Arab Republic	1,561	63	0.26%
Thailand	2,644	2,813	6.81%
Tunisia	3,219	51	0.10%
Turkey	7,088	310	0.28%
Ukraine	1,829	266	0.93%
Uruguay	5,252	19	0.02%
Vanuatu	1,862	251	0.86%
Venezuela, RB	5,475	3,136	3.67%

Source: derived from World Bank (2011)

Table A3. Selected OECD countries, $ 2005

	GDP/cap	PA asset value / cap	PA rent % GDP
Australia	33,945	2,932	0.55%
Austria	37,067	3,272	0.57%
Belgium	36,011	222	0.04%
Canada	35,088	11,293	2.06%
Czech Republic	12,706	924	0.47%
Denmark	47,547	2,463	0.33%
Finland	37,319	3,659	0.63%
France	33,819	2,646	0.50%
Germany	33,543	1,935	0.37%
Greece	21,621	458	0.14%
Hungary	10,937	740	0.43%
Iceland	54,885	8,382	0.98%
Ireland	48,866	304	0.04%
Israel	19,330	1,300	0.43%
Italy	30,479	2,158	0.45%
Japan	35,781	128	0.02%
Korea, Rep.	17,551	322	0.12%
Luxembourg	80,925	1,413	0.11%
Mexico	7,973	316	0.25%
Netherlands	39,122	1,082	0.18%
New Zealand	27,354	19,395	4.54%
Norway	65,767	4,788	0.47%
Portugal	18,186	655	0.23%
Slovak Republic	11,385	2,190	1.23%
Spain	26,056	1,095	0.27%
Sweden	41,041	7,284	1.14%
Switzerland	51,734	3,521	0.44%
United Kingdom	38,122	815	0.14%
United States	42,516	3,625	0.55%

Source: derived from World Bank (2011)