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SEEA Experimental Ecosystem Accounts

Accounting for ecosystem capital in physical terms:

(for discussion)

REVISION OF THE SYSTEM OF ENVIRONMENTAL - ECONOMIC ACCOUNTING (SEEA)

SEEA Experimental Ecosystem Accounts

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DRAFT

Chapter 4: Accounting for ecosystem capital in physical terms

The following text has been drafted for discussion among UNCEEA members as part of the process of developing the SEEA Experimental Ecosystem Accounts. The material should not be considered definitive and should not be quoted.

Chapter 4: Accounting for ecosystem capital in physical terms

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Chapter 4: Accounting for ecosystem capital

4.1 Introduction

4.1 One of the important motivations for ecosystem accounting is to assess whether ecosystem capital is declining or, conversely, whether efforts to restore ecosystems to improve their functioning are having a positive effect. While these questions are clear, determining the answers is not straightforward.

4.2 Ecosystem capital can be measured using the related concepts of condition and capacity. While the exact nature of the relationship is generally unknown, the capacity of an ecosystem to deliver ecosystem services can be understood as a function of the condition of an ecosystem and the extent of that ecosystem. Ideally, it would be possible to make direct assessments of both the capacity and condition of ecosystem capital for individual ecosystems at various points in time. Using this information, it would be possible to determine the change in the ecosystem capital such that measures of consumption of ecosystem capital or improvement in ecosystem capital might be compiled. Such direct assessments would ideally reflect a complete understanding of the way in which ecosystems are functioning, including their longer term potential to continue to deliver ecosystem services.

4.3 Unfortunately, while such direct assessments are possible for some of the key components of ecosystems (e.g. land, water, soil, carbon and biodiversity) they may not be representative of the total ecosystem capacity or condition. Additionally, at this time, there is not full scientific understanding of the relationships and processes within an ecosystem that would enable a complete assessment to be made, nor is there a complete understanding of flows and dependencies between ecosystems. [1] From an accounting and measurement perspective, it is also the case that the complexity of ecosystems is not something that can be neatly represented in a single number.

4.4 At the same time, for the purposes of ecosystem accounting it is not necessary to build complete ecological models and measure every possible stock and flow. Rather, what is needed is to identify the most relevant proxies for assessing ecosystem capital from the perspective of providing aggregated information for policy and analytical purposes.

4.5 With this in mind, the approach outlined here involves a decomposition of ecosystems into relevant components or properties, and an assessment of the state of each component or property in the context of the ecosystem as a whole and its ability to continue to contribute to the delivery of ecosystem services. From this set of information, conclusions may be drawn about the overall condition of the ecosystem and its capacity to deliver ecosystem services.

4.6 This approach is somewhat analogous to the way in which assessments are made of a person's health. In that case a doctor will assess the condition and performance of various vital organs and factors such as blood pressure, temperature, etc, and, by considering a range of indicators, the doctor is able to make assessments of overall individual health.

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[1] The emerging development of earth simulation models that integrate landscape scale measurement, remote sensing information, and models of water, carbon and nutrient cycles, may present opportunities for direct assessment but the use of these models for accounting purposes is not discussed here.

4.7 The challenge in applying this approach in an ecosystem context is to identify the appropriate components and characteristics and then to determine the relevant indicators. In particular, it is important not to lose sight of the fact that ecosystems function by all components working together and it is not a simple case of adding together an assessment of each component.

4.8 This chapter outlines a way in which a component based approach to the assessment of ecosystem capital may be carried out within an accounting structure, the relationship of this approach to other aspects of ecosystem accounting, and the current limits of this approach.

4.2 General logic of a component based approach to ecosystem capital assessment

4.9 As presented in Chapter 2, within the ecosystem accounting approach presented in the SEEA Experimental Ecosystem Accounts, assessment of ecosystem capital is considered to have three primary parts. First, there is consideration of the quantity or "extent" of an ecosystem. The extent of an ecosystem relates to the physical space or area covered by an ecosystem. Individual ecosystems are often seen as contiguous areas. Ecosystems can be classified in specific ecosystem types according to a range of classification systems, that have been developed both at the global and at national scales (and sometimes even at sub-national scales). Over time, the area covered by a specific ecosystem type may increase or decrease, for instance as a consequence of land use conversion.

4.10 Commonly, this is reflected in measures of the area of a particular land cover type and thus increases or decreases in the area of a particular type of land cover (and related attributes) may be used to infer increases or decreases in the extent of different types of ecosystems.

4.11 Second, there is consideration of the quality or "condition" of an ecosystem. The measurement of condition is important since it indicates how ecosystems are changing over time and because condition influences the capacity of ecosystems to supply ecosystem services. The condition of the ecosystem is related to the status or integrity of its components and structure, and the functioning of ecological processes within the ecosystem. Ecosystem condition can be captured in specific indicators that reflect the overall status and functioning of the ecosystem, for instance in terms of the presence or abundance of specific species relevant to ecosystem condition. Ecosystem degradation or rehabilitation will generally be reflected in changes in ecosystem condition. Condition can be analysed in terms of changes from one year to the next, or be compared to a reference condition, in case a suitable reference condition is available. Often, a non-disturbed ecosystem is used as reference condition, however in many parts of the world ecosystems have been influenced by human modification for many centuries and a non-disturbed ecosystem condition is difficult to define.

4.12 Third, and most importantly from the perspective of the SEEA, there should be consideration of the "capacity" of an ecosystem to generate ecosystem services. In broad terms, the capacity of an ecosystem to generate services is a function of both the extent and the condition of an ecosystem. In this sense, condition reflects the capacity to supply ecosystem services per spatial unit (e.g. per hectare). Thus, for example, improved condition of an unchanging extent would suggest increased capacity. The focus on capacity is important in an accounting context since it provides a link between the assessment of the state of an ecosystem and the benefits that are obtained from ecosystems. Further, as will be explained, a focus on capacity to generate ecosystem services provides a rationale for the selection of components of an ecosystem that are to be assessed.

4.13 Measures of capacity should be seen as indicating the capacity to supply services at present, as well as indicating the capacity of the ecosystem to sustain the supply of ecosystem services in the future. For instance, the capacity to support timber harvest over time is a function of both standing stock of timber and the regenerative capacity of the associated ecosystem. In this situation, sustaining ecosystem services supply over time depends on a range of factors both internal (e.g. soil fertility) and external to the ecosystem (e.g. climate change). Degradation may be reflected in a reduction in (i) the present capacity to supply services, (ii) the regenerative capacity and future capacity, or (iii) the resilience of the ecosystem (i.e. the capacity of the ecosystem to deal with disturbance, e.g. extreme weather events). Typically, a number of assumptions are required to analyse the capacity of ecosystem to sustain ecosystem services supply in the future, such as no change in management or no change in the expected occurrence (probability) of extreme events (fire, drought, heavy rainfall).

4.14 There are often trade-offs in ecosystem management, in particular with regards to the use of provisioning services. The use of one service (e.g. timber felling), may affect the supply of other services (e.g. recreation or biodiversity conservation). Hence, assessment of the capacity of an ecosystem to supply ecosystem services should usually be based on consideration of a specific expected or likely mix of services as a function of ecosystem management (e.g. rotational felling with reduced recreation opportunities in parcels that were recently felled). As stated above, it may in many cases be convenient to use current ecosystem management as a basis for determining this mix of services. However, care needs to be taken were current management practises lead to ecosystem degradation or rehabilitation (e.g. because felling rates exceed the capacity of the ecosystem to recover from felling) since it cannot be assumed that the current mix of services can be supplied indefinitely.

4.15 Note that the relation between ecosystem condition and capacity to supply ecosystem services is complex. It is important to realise that changes in condition will not affect all ecosystem services generated by a particular ecosystem in the same manner. Moreover, a change in condition may lead to a decrease in the capacity to supply some services, but an increase for other services. Also, it is not necessarily the case that an undisturbed ecosystem condition represents the ecosystem condition generating most or the most valuable benefits. In general, it is the aggregated supply of ecosystem services from a mix of different land uses and ecosystem types that will be best aligned with the demand for ecosystem services from society.

4.16 The *capacity* to generate ecosystem services should not be based on the set of ecosystem services that might be generated if alternative technologies, economic arrangements and social contexts existed or may be developed in the future. Using an accounting framework such scenario building and assessment can be undertaken but it is not strictly accounting as described here in the SEEA.

4.17 Using this three part model of extent, condition and capacity to assess the state of an ecosystem allows the measurement of the consumption of or increase in ecosystem capital. Within this model, consumption of ecosystem capital is measured as the decrease in the capacity of an ecosystem to generate ecosystem services that is due to human activity. Thus it is accepted that there may also be changes in the capacity of an ecosystem between two points in time (i.e. over an accounting period) that arise due to natural causes. For example, the capacity of a forest to deliver provisioning services in the form of timber might be significantly reduced through a forest fire caused by lightning strikes. In practise, it may be difficult to separate human and natural causes, for instance the impacts of fire due to lightning may be exacerbated through human-induced changes in the forest ecosystem (e.g. changes in species composition).

4.18 The recognition that ecosystem capacity may rise or fall due to natural causes or due to human activity is an important aspect of the SEEA. This is so because, conceptually, capital consumption measures (including consumption of ecosystem capital and consumption of fixed capital) are attributed within the accounting framework to a "responsible" economic unit and consequently, these costs may be deducted from the income of these economic units. Consumption of ecosystem capital is therefore not only a part of accounting for ecosystem capital, but also provides a direct link to the activity of economic units and the accounting for income.

4.3 Measuring ecosystem capital

4.19 Measuring ecosystem capital involves recording both the extent and the condition of the ecosystem, jointly they determine the capacity of the ecosystem to supply services. As stated above, the starting point of the measurement is to analyse extent and condition based on present ecosystem use, and considering the present environmental and socio-economic context in which the services are generated. An important caveat therefore is that the capacity to supply ecosystem services may underestimate the potential of the ecosystem to supply services in different conditions, which however falls outside the scope of SEEA.

4.20 <u>Measuring the extent of ecosystems</u>. The 'extent' of an ecosystem relates to the physical space or area covered by an ecosystem. Ecosystems may be distinguished on the basis of being relatively homogeneous in terms of ecological properties such as species composition, vegetation structure, crown cover, soil type, water tables, etc. Ecosystems can be distinguished at different scales, from an individual pond in a forest up to the forest itself. At the highest ecological scale, the world is divided into different biomes. For accounting purposes, every individual ecosystem can be seen as an ecosystem accounting unit (EAU). Different approaches to aggregate information on individual EAUs are possible, for instance aggregation within ecosystem types, or within administrative boundaries.

4.21 Given that ecosystems are spatially defined, as is much of the information relevant to the valuation of ecosystem services, there is a need to identify EAUs on a map. Because land cover is a major aspect of any classification system for ecosystem type, and because detailed land cover maps are available across the globe based on maps and remote sensing imagery, a practical way to identify EAUs is on the basis of land cover. Based on a land cover map, individual EAUs may be identified based on land cover complemented where relevant with other information such as specific ecosystem properties, presence of roads or rivers dissecting ecosystems, etc.

4.22 <u>Measuring the condition of ecosystems</u>. Measuring ecosystem condition is not straightforward, and the need for methodological refinement is not often matched by the availability of sufficient data. Hence, a number of basic entry points can be taken to record ecosystem condition. Assessment methodologies and data needs usually will need to be compared with data availability and the potential to acquire additional data given available time and budget, with consideration of the scientific evidence supporting the interpretation of ecological data in a manner conducive to developing ecosystem accounts.

4.23 A first entry point involves establishing an objective benchmark for measuring ecosystem condition – often referred to as a reference condition. Using a reference condition it is possible to assess the condition of various components of an ecosystem that are selected to give a representative assessment of the condition of the ecosystem. Examples of components include the vegetation, fauna, water, and soils. The mix of components will vary depending on the ecosystem as may the relevant reference condition. One approach to selecting a reference condition is to base it an assessment of the natural or potential condition of an ecosystem in the absence of significant human alteration, i.e. its naturalness. An alternative would be to select a point in time – e.g. 2001 – and compare the condition of the ecosystem relative to the condition in that year.

4.24 Provided that a complete coverage of relevant components can be assessed, this approach will provide at least an assessment of the change in the condition of ecosystem capital. However, it is noted that the connection between condition measures of these types and the flow of ecosystem services is not clear. While in general terms declines in condition are likely to imply declines in capacity, if the reference condition is based on the degree of "naturalness" of an ecosystem there is no specific relationship that can be defined between the condition and the extent to which ecosystem services may be delivered. Thus, this entry point is likely to provide relevant information for specific services, such as biodiversity conservation, or the potential for recreation. Other services, such as air filtration or some provisioning services may or may not be connected to the ecosystem condition measured in this way.

4.25 A second entry point is to identify specific indicators for ecosystem condition on the basis of the ecosystem services supplied. The type of indicators required to reflect the capacity of the ecosystem to supply ecosystem services as a function of ecosystem condition differ strongly for provisioning, regulating and cultural services.

4.26 For provisioning services, indicators need to reflect both the available stock that can be harvested of the service in question, for instance the standing stock of timber in an ecosystem, and the regeneration or growth rate for these stocks (for instance the mean annual increment of timber). In turn, the regeneration or growth rate is dependent on the overall condition of the ecosystem. For instance, forests affected by soil degradation will have a lower regeneration rate. However, establishing the specific link between regeneration and overall ecosystem condition is not straightforward, a range of different variables and complex ecological processes are generally involved. Since these factors differ with ecological and climatic conditions, countries will need to establish the relation between ecosystem condition and capacity to supply ecosystem services for the ecosystems in their countries. Such assessments will normally require the involvement of multidisciplinary expertise, for instance specific knowledge of forestry and forest ecology in the case of determining capacity to supply timber over time.

4.27 Regulating services are related to ecological processes, and there is no harvest or extraction involved. Often, regulating services can be linked to specific ecosystem components or properties, even though the sustained supply of services (as in the case of provisioning services) depends on the functioning of the ecosystem as a whole. For instance, air filtration involves the capture of air pollutants by vegetation, and the capacity of the ecosystem to trap air pollutants is related to its Leaf Area Index, i.e. the total surface area of leaves, expressed in m^2 per hectare. The Leaf Area Index is influenced by degradation or rehabilitation of the ecosystem (e.g. changes in species composition, or in crown cover), but is not necessarily related to the naturalness of the vegetation.

4.28 Typical for regulating services is that the relationship between ecosystem services and benefits often has a spatial aspect. For instance, the ecosystem service air filtration will not lead to a benefit if there are no people living in the area where air quality is improved. Likewise, the service flood protection (e.g. by a coral reef or mangrove forest) will not lead to a benefit if there are no people living nearby, or there is no infrastructure in the zone at risk from flooding. The only exception in this case is carbon sequestration, since the impact of one unit of carbon sequestered on the global climate is the same regardless where the sequestration takes place.

4.29 Regulating services will generally have a high spatial variability. For instance both marine flood risk and the mitigation of flood risk by a protective ecosystem vary as a function of local topography and distance from the sea. The spatial aspect of regulating services means that the generation of regulation services can only be meaningfully analysed in a Geographical Information System (GIS), with the potential exception of carbon sequestration. In a GIS, the processes and/or components of the ecosystem that support the supply of regulating services need to be recorded, as well as the relevant features of the physical or socio-economic environment in which the service is generated. The required resolution depends on the specific ecosystem service and on data availability.

4.30 Changes in the condition of the ecosystem may or may not lead to changes in the capacity to supply regulating services, depending on which specific ecosystem components or processes are affected. For instance, extinction of a rare, endemic species in a forest will affect the biodiversity service and perhaps the recreation service, but, unless this species was important for ecosystem functioning (e.g. a non-substitutable pollinator of specific tree species) it would not affect the air filtration (LAI) or the flood protection service provided. Hence, changes in the capacity to provide regulating services need to be recorded on the basis of specific indicators selected to reflect ecosystem functioning with regards to these services.

4.31 Cultural services are highly varied in terms of the type of benefits supplied and the relation of these benefits with the ecosystem. Recreation and tourism is related to the attractiveness of an area, which is a function of for instance landscape, vegetation, wildlife, visitor facilities, presence of hiking trails, etc. The actual number of people that visit an area is a function of both its attractiveness and the demand for recreation (which in turn is related to for example population density, income levels, and perhaps to the availability of alternative tourism destinations). Degradation of an ecosystem, or investments in rehabilitation of an ecosystem (reforestation, construction of hiking trails, etc.) is reflected in the attractiveness, but not necessarily in the actual service provided (i.e. the actual number of visitors). Note also that recreation and tourism may not be necessarily related to biodiversity or ecological quality, many visitors enjoy scenery or the presence of a beach rather than specific ecological attributes.

4.32 Biodiversity conservation is a service which is relevant across scales, from local to global (although not necessarily appreciated in a similar fashion at the local versus the national or global level, e.g. think of protected elephant populations causing local damages). For reasons explained in Chapter 2 and 3, biodiversity can be seen as both an indicator of ecosystem functioning and as a service in itself. In the case of biodiversity, it is complex to distinguish the ‘capacity to conserve biodiversity’ from the actual ‘conservation of biodiversity’. In principle, the conservation of biodiversity can be related to the current presence of biodiversity, expressed for instance as the number of species (in specific classes). The capacity to conserve biodiversity can be related to the long-term conservation of these species (or other aspects of biodiversity), which is dependent on the presence of long-term viable populations (as a function of for example size of the habitat, or genetic diversity of the population).

4.33 Overall, this second point of entry that takes into account a large range of different aspects of an ecosystem through the window of ecosystem services leads to the identification of a wide range of indicators of ecosystem change that are specific to the services being supplied by a given ecosystem.

4.34 A more generic approach, but one still based on the perspective of ecosystem services is to consider indicators of ecosystem change that underpin a number of ecosystem services at the same time. Thus, focus is placed on accounting for changes from the perspective of core ecosystem processes such as the carbon cycle, the water cycle and the nutrient cycle that underpin provisioning services and some regulating services. In addition, indicators of changes in landscape and biodiversity may be included to represent the capacity to generate a range of cultural and other regulating services. This type of approach can be more standardised across multiple ecosystem but consequently the link between capacity and change in condition will not be as tight for any individual ecosystem.

4.4 Compiling ecosystem capital accounts

Note by the SEEA Editor: It is intended that this section give an overview of the methods available for compiling ecosystem capital accounts building on the principles outlined in Sections 4.2 and 4.3. This section will also provide more detail on the integration of ecosystem condition and ecosystem capacity indicators, and on possible approaches to measuring overall ecosystem capacity and condition using composite indicators and common measurement units. Only a very limited amount of text has been drafted on these topics at this stage.

4.35 Ecosystem capital accounts are intended to organise non-monetary information regarding the extent, condition and capacity of ecosystems to generate ecosystem services at present and in the future. The overall assessment of an ecosystem is a challenging exercise requiring an understanding of the relative importance of individual components. Examples of ecosystem capital accounts for some of the common types of land cover and landscape units are described in Section 4.5 (to be developed). These examples show that while the structures may vary, the underlying principle of organising data on the extent, condition and capacity of ecosystems is valid .

4.36 When applying the approach at a macro level, i.e. across ecosystem types, it is likely to be most useful to develop a common set of data and indicators for particular ecosystem components in different ecosystem types. Further, it is likely to become apparent that there are some components of ecosystems, notably soil, biomass and water, that are common and essential components of all ecosystems. Nonetheless, the ability to apply a consistent underlying accounting logic is central to the ability to frame the discussion around ecosystem capacity.

4.37 The ecosystem capital account will need to be developed in a GIS, given the spatial diversity and heterogeneity of ecosystem services. The GIS will contain the relevant datasets required to analyse ecosystem capital. Although the specific datasets will need to be determined on a country basis, there are a number of basic resource accounts that are fundamental to ecosystem accounting and will typically need to be developed in each country. These include: (i) land accounts; (ii) biomass & carbon accounts; (iii) water accounts; (iv) soil accounts; and (v) biodiversity accounts. A number of these accounts are described in the SEEA Central Framework.

Compilation of land accounts

4.38 To provide an overall context for ecosystem capacity accounts and important initial step is the compilation of land accounts. These accounts – described in SEEA Central Framework Section 5.6 – establish a basic set of information about changes in the extent of different land covers which are likely to approximate ecosystem types. At the same time, it is important to take into account the structures emerging from the development of ecosystem accounting units (as presented in Chapter 2). Of particular relevance in a SEEA context is that land accounts have a scope that extends to a national level thus providing the required scope for ecosystem accounts.

4.39 Many countries have a variety of land cover and related statistics and this information set is becoming more developed as remote sensing technology is increasingly applied in these contexts. It is recognised that ongoing international collaboration on the development of land accounts for the purposes of ecosystem accounting will be an important part of the implementation of SEEA more generally.

Note by the SEEA editor: Text will be drafted to describe basic resource accounts as listed above and explain the links within ecosystem capital accounts.

4.5 Examples of ecosystem capital accounts for selected ecosystem types

Text to be drafted.

4.6 Accounting for carbon

4.7 Accounting for biodiversity

See paper “Accounting for carbon and biodiversity” which provides preliminary draft text for Sections 4.6 and 4.7.