System of Environmental Economic Accounting

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Background paper

Session 3c: Ecosystem services

Ecosystem services cross-cutting issues

Summary Paper

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ECOSYSTEM SERVICES CROSS-CUTTING ISSUES – SUMMARY PAPER

This summary note sets out some of the main points arising from a set of nine cross-cutting issue working papers drafted by a range of authors. The papers are all attached, as annexes.

The papers arose out of the discussions on individual services which are summarised in a separate paper. They should be regarded as working documents. The aim is get clarity on the issues raised, the areas where widespread agreement is likely to be possible, and those areas which require further consideration and/or testing.

The papers are taken in the following order:

1. Cultivated and non-cultivated biomass services (#9)
2. Treatment of the use of space (#4)
3. Connections between services (#1)
4. Reducing/preventing externalities (#5)
5. Mediated/unmediated flows (#2)
6. Outputs/outcomes/benefits (#8)
7. Counterfactuals (#7)
8. Abiotic components of ecosystems (#3)
9. Spatial allocation of services (#6)

1 CULTIVATED AND UNCULTIVATED BIOMASS (#9)

This paper presents two options for the recording of biomass provisioning. The first option is to make no distinction between cultivated and uncultivated sources of biomass, recognising that the distinctions are not always clear or deployed in the economic accounts and, from an ecosystems point of view, the desirability of consistent treatment of the ecosystem asset in terms of removals of essentially the same materials from the same ecosystem type within the same account.

The second option is to maintain consistency with the SNA and SEEA CF, and separately record annual accumulation of biomass drawn from cultivated sources and actual extraction from uncultivated sources. This might imply use of different unit prices as the nature of the service provided is different.

The paper outlines some of the pros and cons and offers a number of criteria that could be used to inform the choice.

Questions for discussion: Are these the two main options? What are the key criteria needed for making the decision?

2 USE OF SPACE (#4)

This paper suggests that the ecosystem has to have an active role in the provision of services. The implication is that use of space for building should not be regarded as an ecosystem service. However, there are other uses made of natural capital which do not give such clear cut delineations: examples given are sink functions (passive storage of waste materials); use of space for transportation; and use of space for recreation. The paper concludes that navigation (carrier services) and space for recreation should be included as services, but that passive storage of waste and land based transportation should not be viewed as ecosystem services. The paper does not draw any conclusion about air transportation services.

Questions for discussion: Are these the right conclusions? Are there other 'hard cases' that need to be considered? How should use of space for air transportation be treated?

3 CONNECTIONS BETWEEN SERVICES (#1)

This paper distinguishes a number of different service flows, some of which support the final production of an ecosystem service, others which are used directly in final economic production or final household consumption. Some of these flows are symbiotic and others have a negative effect on other current or future ecosystem services. There are also flows of residuals which have an impact on ecosystem condition and flows of other services.

Adding to the complexity of this picture, the flows may be within the same ecosystem, between ecosystems of the same type, or between ecosystem types. The distinction between these three will depend to some extent upon how ecosystem types are defined. Conceptually, however, it is possible to set out an input-output framework which would support the understanding of the last two categories, in both physical and potentially monetary terms. The latter will be necessary in order to avoid double-counting.

In order to implement such an input-output analysis, it will be essential to have a clear understanding of the environment - economy boundary. Accounting for water flows in particular raises a number of challenges, which will require separate examination.

The paper concludes that more work is needed to understand how bundles of ecosystem services interact (discussed further under Paper #6 below), how to account for the negative impacts of the different flows and their impact on capacity, and how to delineate clearly between supporting, intermediate and final services.

Questions for discussion: Given some of the complexities of the different flows, to what extent can we expect to get clarity within the revised SEEA-EEA on how best to

record them within an input-output framework? Are we able to delineate these flows meaningfully within the accounting framework?

4 REDUCING/PREVENTING EXTERNALITIES (#5)

This paper sets out four options for recording the contribution of ecosystems in reducing or preventing externalities such as fire or CO_2 emissions from degraded peatlands.

Option 1 is simply to exclude them from the SEEA EEA altogether. It is not clear if this implies that such flows should nevertheless be described within the SEEA-EEA framework as an extension to the SEEA-EEA (as is done in some Corporate Natural Capital Accounts and also with restoration costs).

Option 2 is to include them as an ecosystem service: this could be challenging as it would either involve defining a reference point from which to assess the positive contribution of the ecosystem, or recording the flows as disservices and hence the positive contribution as the reduction in disservices.

Option 3 is to include disservices within the condition account, as an indicator of pressure on ecosystem condition.

Option 4 is to record carbon flows in the carbon account. However, this would not enable other externalities to be accounted for in a satisfactory way.

The paper concludes that further discussion is needed on the options.

Questions for discussion: Are there any front runners amongst these four options? Are there other options that need to be considered?

5 MEDIATED AND UNMEDIATED FLOWS (#2)

This paper discusses a variety of ways in which ecosystems deal with flows of pollutants or residuals. Some flows are actively mediated, others are absorbed (e.g. into sediment) or passed on to other ecosystems, and some flows remain in the ecosystem in an unmediated form, causing either degradation to the ecosystem or potential damage to other forms of life (including humans). The range of pollutants involved and the interactions between pollutants or between pollutants and the ecosystem, means that it will be particularly challenging to record all these flows within the accounting framework.

The paper acknowledges the need to do further work, starting with a few key pollutants, and comes to the following tentative conclusions:

- The passive co-location of pollutants (e.g. on bare rock surfaces) is not a service, but absorption of pollutants into sediment (e.g. carbon which is then stored in marine sediment) should be included as a service

- Active mediation of pollutants, including the transformation of one pollutant into a less toxic form, should be considered an ecosystem service

- In some circumstances the transportation of pollutants to other media might also be considered an ecosystem service

Questions for discussion: Are these distinction conceptually appropriate? Are there other ways in which the ecosystem interacts with "residuals" from the economy pollution which need to be accounted for?

6 DISTINGUISHING OUTPUTS, OUTCOMES AND BENEFITS (#8)

This paper focuses on the terminology used to describe different flows, with particular reference to the recording of health benefits within the accounting framework. The paper concludes that it would be appropriate to allow the term 'benefits' to encompass both outputs and outcomes. This would allow the definition of beneficiaries to include not just users of the output but also those whose outcomes are affected from the use of the services, recognising that beneficiary identification, especially as far as health benefits are concerned, may be necessary in order to identify transaction prices.

Question for discussion: Do we agree with the proposal for the term benefits to encompass both outputs and outcomes?

7 DEFINING THE COUNTERFACTUAL (#7)

This paper discusses two options for measuring the flows of regulating services. For this group of services, the level of the service is largely determined by the need for it (the 'demand'). If there is no risk of flooding, or if there are no pollutants to be mediated, then there is no service. It follows that one option for quantifying the level of service is to compare two empirical states: one where the demand exists and is being met, and one where the demand is not being met. If other factors are identical or properly controlled for, the difference should indicate something about the level of the service actually being generated by the ecosystem. This approach has not been widely tested in an accounting context and would seem to require detailed information about the factors which determine the difference between the two states. It does however have the merit of being based upon real conditions.

The other option is to assume an appropriate counterfactual, generally taking the form of an absence of the ecosystem (e.g. no biomass or soil carbon accumulation for carbon sequestration). In the past, assumptions about the nature of the counterfactual have not always been consistent between different services; and the requirement to assume a hypothetical state might be seen as a disadvantage.

Questions for discussion: Is a 'risk' or 'likelihood' based approach viable as a means of determining the volume and value of <u>all</u> regulating services for a national level account? If not, does it make sense to mix and match for different services/ circumstances? What are the advantages and disadvantages compared with the classical counterfactual approach?

8 ABIOTIC COMPONENTS OF ECOSYSTEMS (#3)

This paper discusses whether services which are provided largely by abiotic components of ecosystems, such as dilution of pollutants by water, or coastal protection by unvegetated banks of shingle, should be viewed as ecosystem services. The conclusion reached is that they should, as they are provided essentially by the ecosystem functioning as a whole. However, there are some issues yet to be resolved e.g. those relating to the treatment of sea cliffs providing coastal protection. In this case it may not make sense to assume a complete absence of the cliff as the counterfactual, and it may be that a realistic risk-based scenario comparison would be a more appropriate approach to adopt.

Questions for discussion: This issue is closely linked with the issue of the counterfactual. Are there alternative criteria which would provide more a standardised determination of when a particular ecosystem asset is providing a service?

9 SPATIAL ALLOCATION OF SERVICES (#6)

This paper discusses both the challenges of allocating services to ecosystem assets and also the advantages and disadvantages of 'bundling together' multiple ecosystem services. Ecosystem service delivery is often dependent upon a combination of ecosystem assets (e.g. fish rely on different habitats during their life cycle) and services either need to be apportioned across a landscape or assigned to the location of realised demand or supply, in order to avoid double-counting. A 'value-added' approach may offer a potential solution to allocating value to different assets. Alternatively the service may either be allocated to the areas of the beneficiaries, providing relevant information is available, or to the more general 'supplying area'. There are some second-best approaches available but these will need to be tested further.

As far as bundling is concerned, the paper concludes that 'vertical stacking' of different ecosystem services is more likely to meet accounting needs where interest in the volumes of particular services are likely of interest to end users.

Questions for discussion: Are these the main options for allocating services to multiple areas? Do we agree with the pros and cons? Do we agree with the preference for 'vertical stacking' of different ecosystem services?

ANNEXES

CONTENTS

Connections between ecosystem services and implications for accounting

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1. Introduction

Ecosystem services flow from ecosystem assets and generate benefits in their intersection with humans. Since multiple ecosystem services often flow from the same spatial asset, the services are often naturally interconnected in synergistic/non-synergistic ways. Several of such interconnections have been highlighted in prior working group discussion papers. For example, Burkhard et al. (WG #3 paper) suggest that soil retention serves as a base for healthy soil (e.g. by adding organic matters), thus affecting production of food and raw materials. In addition, soil retention services also affect climate, water quality and flood regulation. Similarly, Harris et al. (WG #4 paper) suggest that the air filtration service has close links with outdoor recreation, noise abatement and local climate regulation. Our discussion paper elaborates on those interconnections (between different ecosystem services and their associated benefits) with particular focus on water-related ecosystem services and makes observations on how to treat them in ecosystem accounting. The issue of bundling of services from a single ecosystem asset is mentioned briefly, but will be developed more extensively in a separate discussion paper (#6). The paper concludes with recommendations on areas for further research.

2. Interaction between multiple ecosystem services in accounting context

Multiple studies have evaluated the interactions between ecosystem services, with some focusing on indirect interactions and others focusing on direct interactions. Indirect interactions may be viewed as those situations where conversion of one ecosystem service into a received benefit affects another ecosystem service by modulating the conditions of the ecosystem asset or directly affecting ecosystem services associated with the indirectly impacted ecosystem service. Direct interactions are those where the realization of one ecosystem service benefit affects the realization of another ecosystem service benefit without any intermediary effect on another ecosystem asset or ecosystem service. For example, provision of shellfish (with their filtration capabilities) for consumption may impact the water quality in an area, thereby indirectly altering the potential provisioning of recreational ecosystem service benefits (e.g., swimming and boating). In this case, while there is an indirect interaction of the use of shellfish as a food source with the provision of recreational ecosystem service benefits, there is a direct interaction of the extraction of the shellfish from the environment with the intermediate ecosystem service of nutrient removal, which then links to a range of final ecosystem services and their associated benefits (such as clean water for recreation). Incidental interactions are also possible, whereby different ecosystem services are provided by the same ecosystem asset but are otherwise unrelated with each other apart from their generation in the same spatial location. For example; a forest may provide carbon sequestration as well as amenity services but, apart from the two services being reliant on the same asset, the delivery of one does not affect provision by the other.

Trade-off (i.e., loss of one ecosystem service with gain in another) and synergy (i.e., gains in both ecosystem services) analysis are frequently the lens through which the literature has evaluated interactions between ecosystem services. Bennett et al. (2009) show a number of examples when two services share a common driver and one or both impact the other. Synergies in flood control and water quality (Zedler 2003), trade-offs in carbon sequestration and water quantity (Engel et al. 2005), synergies in regulation of algae growth and tourism (Hughes et al. 2005), and synergies in moisture retention and carbon sequestration (de Val et al. 2006) have also been documented. Raudsepp-Hearne (2010) conducted a spatial analysis of ecosystem service proxies in Quebec and evaluated 66 pairwise correlations between a range of ecosystem services (e.g., crop production, deer hunting, carbon sequestration). 34 of 66 were found to be significantly correlated, with synergies among regulating services (e.g., carbon sequestration, soil phosphorous retention, soil organic matter and negative correlations between crop production (a provisioning service) and all regulating services). Spatial evaluation of synergies and trade-offs in the European Union (Maes 2012) and in the Midwest United States (Qui 2013) also found trade-offs between crop production and regulating services; Qui (2013) did however indicate potential of both water quality and crop production to be high. These findings generally correspond to a broader review of the literature that found a high likelihood of trade-offs versus synergies where provisioning services are involved (Howe 2014). While there are potential interactions across a broad range of ecosystem service categories, we have decided to focus on the case of water-related ecosystem services.

Another important way to explore interactions between ecosystem services, particularly in an accounting context, is by distinguishing between final vs. intermediate benefits. In an extensive literature review to explore the definition and uses of the terms, Karl and Sudherland (2018) described final ecosystem services as benefits that can be accounted for in biophysical or monetary terms (e.g., fisheries output). Intermediate services, in turn, are defined as those associated primarily with the biophysical structures and processes that maintain ecosystems, with little or no direct benefits to people, but ultimately allowing conditions needed for the provision of final benefits. These would include what has commonly been described regulating and supporting services (e.g., water purification (intermediate service) for the water supply for household consumption (final ecosystem service)). Their findings suggest that intermediate ecosystem services have been more commonly defined by their exclusion from the final ecosystem services categories (ibid). In the section below, we will explore these concepts in the context of accounting for water-related services.

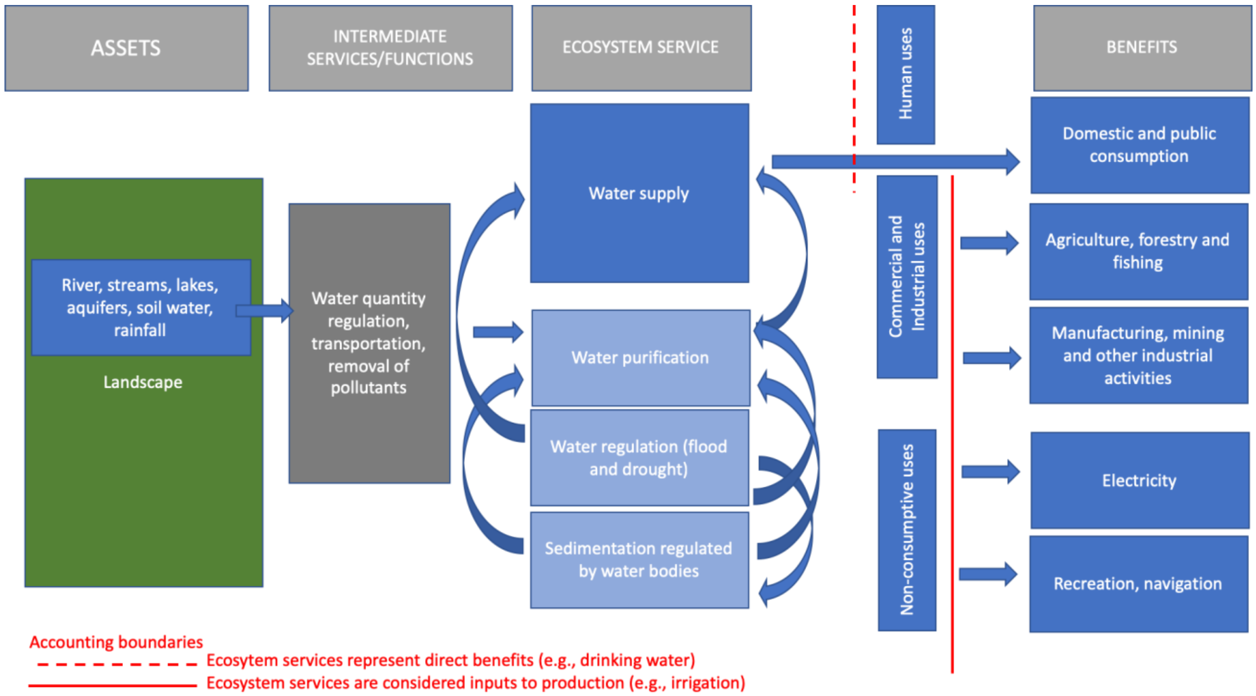

Figure 1: Illustrative diagram exploring ecosystem services connections with a focus on water-related services. Note: Concepts are provided in a simplistic way and several complexities and confounding factors are not included.

3. The nature of the issue from the water-related services perspective

Water-related services (and/or water-mediated services), including water supply and water purification and erosion control, are controlled by the hydrological connectivity of the biophysical system. For example, the role of headwater streams (1st to 3rd order) and their interactions with the landscape as they move from upland to lowland areas needs to be considered when evaluating the range of services provided. Since nutrient processing in streams is mediated by hydrologic interactions with biotic (e.g., species, vegetation) and abiotic (soil) elements of a spatial area, the water purification service that emerges from those interactions is intrinsically linked with the water supply service. Both services may be intermediate and required, for example, in the final service of clean water for drinking; on the other hand, water supply may be sufficient (without consideration of purification) for non-consumptive benefits associated with water such as navigation or in cases where the water supply is not contaminated at the headwater origin and does not encounter contamination in its trajectory.

The water supply service also interacts with other ecosystem services and their associated benefits. Changes in water quality from excess inputs of nutrient and sediments into streams from croplands (Allan 2004), for example, might result in reductions in the amount of water available for use due to increases in the cost of drinking-water treatment (e.g., Ernst et al. 2004, Singh and Mishra 2014), assuming absence of other water sources or more cost-effective technologies to treat water (see Figure 2). Several researchers have explored the connections between distinct, yet interrelated, water-mediated ecosystem services. Soil erosion control, for example, is strongly linked to flood regulation as increased sediment deposition from excess soil erosion raises river beds, flood risks increase (Yin et al. 2014; Roebeling et al. 2013). Erosion control is also connected to water supply for other benefits such as hydroelectricity, irrigation, biodiversity, nutrient retention, and fisheries (Chapman et al 2014; De Baets et al. 2011; Valiela et al. 2013; also see Alam 2018 for a methodological discussion on economic valuation).

The challenge from an accounting perspective is to determine how to clearly delineate between intermediate and final ecosystem services and to develop strategies for accounting for these services over time. This is important not just from a physical accounting perspective (i.e., what indicators of quantity are tracked and where are they tracked on the landscape and what other connected indicators should also be tracked), but also from a monetary accounting perspective (i.e., how is the value for the final service related to the values of intermediate services). As noted above, spatial allocation of bundled interacting service is also intrinsically tied into this question, but will be the topic of a separate discussion paper.

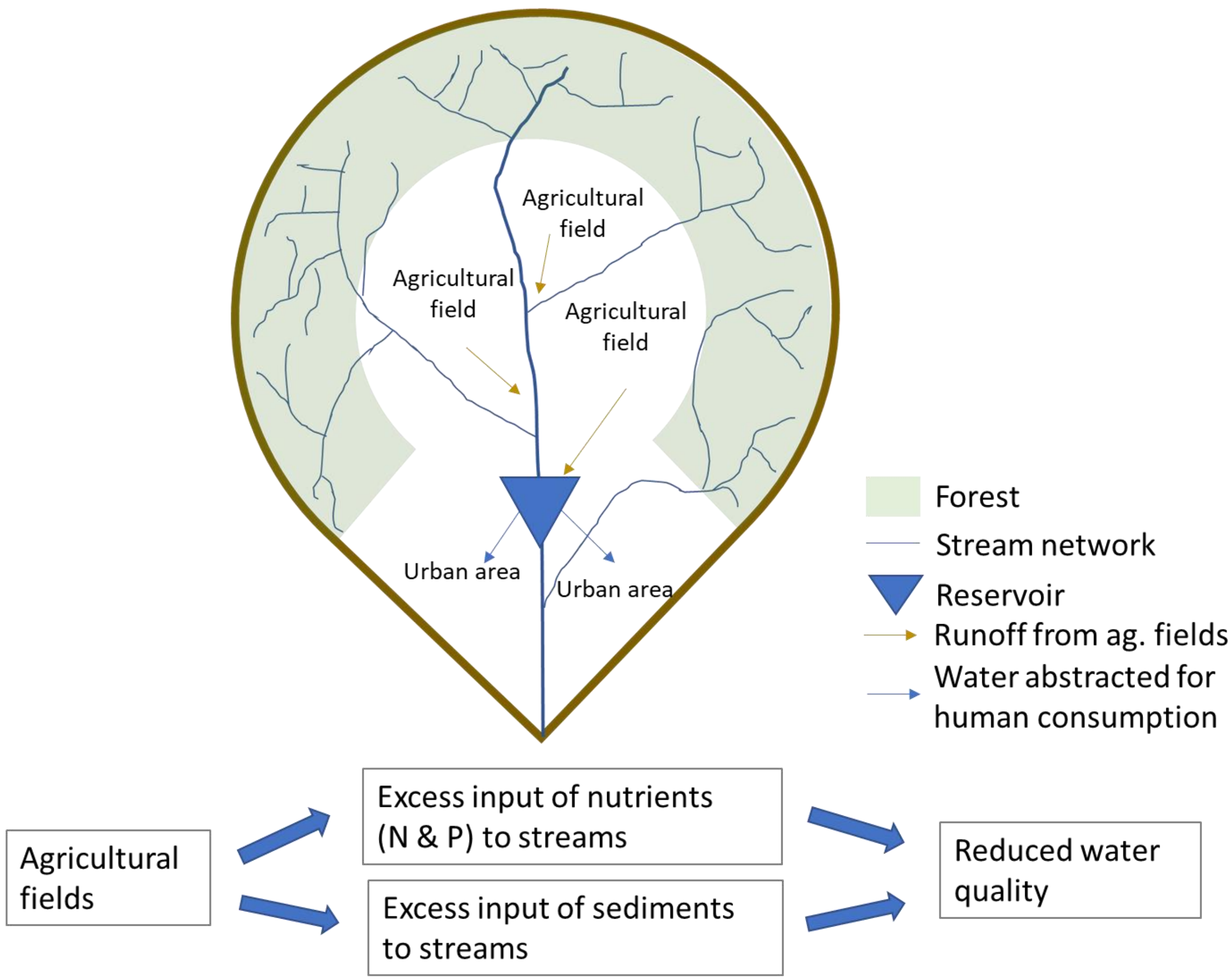

Figure 2: Influence of food provisioning service on water supply via decreased water quality

4. Potential accounting treatments

While the ecosystem accounting system should not be expected to answer all inquiries related to the data collected (e.g., how does a change in water quality relate to a change in fish biomass over time?), it should provide a consistent approach to evaluating ecosystem service use and supply over time so that end users may investigate potential interactions. So long as the competing and synergistic services are adequately disaggregated into intermediate or final services and evaluated independently, this should not pose other than a logistical challenge for the accounting exercise (i.e., how to represent it in supply and use tables). Assessment of whether interacting uses of ecosystem services are synergistic or trade-offs should also be feasible so long as the same services are tracked consistently over time in the accounting system. Gains for one service should be matched by losses in the other services. It should be noted that these gains and losses may have different units (e.g., loss of drinking water (m3) versus gains of wheat (bushels) as they are associated with different ecosystem service benefits.

Challenges arise, however, (1) if the same benefit is measured multiple times and then added (i.e. double counted) – such as water purification measured as an independent service in a geography where final ecosystem services of clean water for drinking and provisioning of non-contaminated species are also quantified; and, related to this, (2) if sufficient distinction is not made between what is intermediate and what is a final service vis-à-vis the expected beneficiaries. Double-counting may arise in physical terms when the same "water" is providing various services (consumptive vs non-consumptive uses) and in monetary terms if adding value of final product with value of intermediate services that contribute to product. Being aware of this potential may be sufficient to avoid double counting. The need to consider beneficiaries in determining if a service is intermediate or final must also be considered so that interrelated services are appropriately tracked in a supply and use table. In this way services may be inputs to other services (similar, perhaps, to intermediate consumption). The (highly simplified) table below provide a simple example of how this might be done within an Ecosystem Accounting Unit (EAU) that could be further evaluated.

	Generation of ecosystem service				**Use of ecosystem service**			
	Lakes	Streams	Ocean	Wetland	Households	Agriculture	Water for industrial uses	Water for non-contact recreation
Water supply	400	200	0	50		500	100	40
Water purification				10				
Water safe for drinking					10			

Table 1. Illustrative example of addressing the EAU provision vs. use of ecosystem services as a means to distinguish between intermediate and final services in the context of SUT context.

As in the table above, certain accounting rules may need to be developed that will likely be country/region/municipality specific. Water safe for drinking in this case, for example, can only come from the portion (10) of the total water supply (50) that has been purified by the wetland. There also would need to be a rule so that individuals did not sum the "wetland" generation category and assume 60 units, rather than 50 are available from the wetland. Whether or not the tables balance will depend on whether or not the set of supplies and uses of ecosystem services has been comprehensively documented. The water purification service may also have to be divided between households and the recreational ecosystem service benefit if it involves contact recreation

5. Areas for further investigation

Several issues are arising for further investigation. There have been a fair bit of scientific studies on how bundles of ecosystem services spatially interact. However those studies naturally do not go further into describing what that interaction means in terms of contribution to the economy via final benefits. This seems to be an open area for accounting community to focus on.

Research into the issue of ecosystem degradation and its capacity is still in its infancy (but see Schröter et al 2014). How capacity determines provision of multiple services in bundles at the optimum level (e.g. maintaining biodiversity while generating revenue from timber concessions) needs to be further studied. Similarly important is studying degradation of assets and determination of available services in different time horizons.
Other areas for further investigation include:

- When does interconnected ecosystem services provide synergies/positive correlation and how to disentangle them in physical measurements?
- What services reinforce the provision of others (such as from water regulation to water quantity + water quality).
- When does this regulation is manifested in negative correlation (such as from water regulation to water supply vs flood control)?

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The treatment of mediated and unmediated flows

Lead author: Rocky Harris 12 April 2019

There are a few ecosystem services which may be regarded as sink services, in the sense that the ecosystem acts as a sink or receiver of residuals from economic activity. The flows of residuals may take the form of solid waste, effluent or air emissions, and may be received by any type of ecosystem.

These flows will be recorded as flows of residuals within the Central Framework accounts between the economy and the environment and may not necessarily equate to ecosystem service flows. Specifically there are a number of distinctions that need to be made when linking the flows of residuals to the flow of services.

Storage of waste residuals

First, we need to take a view on whether the residuals are simply stored unchanged on the surface of the land or water or whether they are mediated or absorbed in some way. A clear example of the first might be the storage of inert material such as mining waste on land, which would fall under the category of the use of the ecosystem as providing a space for economic activities (in this case 'waste disposal'). This issue is considered further under Cross-cutting Issue #4.

Passing the problem on

A second category of flows relates to the situation where the ecosystem acts as a conduit for the storage of the residuals in another ecosystem. Examples of this would include the flow of contaminants from effluent into the freshwater environment, which are then either deposited within the sediment or passed on to the marine environment. Ultimately these may be stored (safely or not so safely) in the sediment or the water column but in this case the ecosystem has played an active role in removing and to some extent storing the pollutants.

This role would appear to constitute an ecosystem service in its own right although its monetary value may depend upon the view taken of the benefit derived from the relocation of the pollutants.

Mediated flows

The third category of flows relates to the service provided by the ecosystem in mediating or 'processing' pollutants. This service is widely recognised – examples include air filtration, water purification, sewage sludge absorption, carbon sequestration – but the term 'mediation' is not always interpreted in the same way. Most of the focus (e.g. CICES) has been on the biochemical transformation of wastes by living processes such as micro-organisms, algae, plants and animals, which would ignore the service provided by abiotic components of ecosystems in breaking the pollutants down or diluting or dispersing them. The role of abiotic components of ecosystems is considered further in Cross-cutting Issue #3. For the purposes of this note the key point is that the flows are mediated in some way by the forces of nature, which can therefore be seen as providing a service.

Unmediated flows

The fourth category of flows relates to those pollutants which are not mediated, or are insufficiently mediated, and therefore 'remain a problem'. These flows will include flows which are 'passed on' to other ecosystems (Category 2 above). They may also include flows of pollutants which have been transformed by chemical reactions subsequent to the emission but are still not fully mediated by natural forces. Examples of this include chemical reactions of nitrogen dioxides with other pollutants [Citation from Air filtration paper required].

Over time concentrations of these pollutants may build up and affect the quality of the ecosystem and/or the capacity to deliver ecosystem services. It follows that measures of the concentrations of some pollutants may be key measures of the condition of ecosystem services. Examples include eutrophication levels, air quality and soil quality indicators [Citation from WG2 documents required].

Demand for services

The foregoing discussion does not make any real distinction between the provision of a waste disposal service and the provision of a waste mediation service: where the waste stream has entered the environment but the pollution is not effectively 'dealt with', the service cannot seen as being provided (it could be likened to the bin men collecting the rubbish, taking it round the back and dumping it in your back garden). Hence emissions of pollutants might be seen as representing a demand for services (and an important measure of the pressure on ecosystems) but cannot necessarily be seen as being equal to the service. In practice, however, the key measure of the demand for the service will be represented by pollution concentrations: there may be time lapses and spatial distance between the date and point of the emissions and the date and location at which the service is provided.

Defining and recording the service

From an ecosystem accounting perspective, the amount of the service provided can be represented by the quantity of pollutants which have been 'dealt with' by the ecosystem. This includes not just active biochemical processing by living organisms, but a range of other processes including the passive storage of pollutants which have been relocated from the original point of release to the environment. As with other services, the value and importance of these physical flows will vary and aggregating the flows in terms of physical volume will not provide a reliable indication of the nature of the service. In practice the accounts will need to record detail about the specific types of pollutants mediated by different ecosystems.

The accounts also ideally need to record (or at least take into account) the specific way in which ecosystems mediate the flows, as the chemical processes involved may generate other pollutants which will need to be accounted for in some way. Some processes will also be less effective than others in dealing with the pollution. As discussed above, the relationship between the initial flow of residuals from the economy and the delivery of a mediation/storage service is a complex one, which will vary by time and place as well as from pollutant to pollutant.

Although not critical to the process of recoding the service within the ecosystem accounts, it may be helpful to separate out the waste mediation service by reference to the media into which the pollutants were first released.

Air. All ecosystems are affected by air-borne pollutants to some extent. The Research Papers demonstrated that vegetated ecosystems located near to urban areas were most important in dealing with these pollutants and hence providing an air filtration service. However, the role of marine areas in dealing with air-borne pollution has not yet been fully explored within an ecosystem accounting framework: whilst it is clear that marine ecosystems are being affected by pollutants, it is not yet clear how much of this is due to air-borne pollution and how much of the air-borne pollution is effectively mediated by the marine environment.

Land. The extent to which ecosystems deal with waste disposal on land is also relatively unexplored. A typical example might be processing of farm waste and sewage sludge by agricultural ecosystems, but there are many other flows (such as clean up services provided by animals in urban areas) which have yet to be thought through from an accounting perspective. We also need to recognise that there are interactions between different ecosystems, especially as far as the impact of agricultural run-off on freshwater and marine ecosystems is concerned.

Water. The range of pollutants and the different processes involved means that this is a particularly challenging service to record within the ecosystem accounts. As with air filtration, it will be important to focus initially on a few key pollutants and a limited range of processes.

Conclusions

- Best to focus initially on a few key pollutants and a limited range of processes

- Passive storage of pollutants (e.g. on bare rock surfaces) is not a service, but absorption of pollutants into sediment (e.g. carbon stored in marine sediment) should be included as a service

- Areas for further discussion include the treatment of the transportation of pollutants to other media and the transformation of one pollutants into less toxic forms

The role of abiotic components of the ecosystem

Lead author: Rocky Harris 12 April 2019

While it is accepted that ecosystems are a combination of biotic and abiotic components, often the focus in the definition of ecosystem services is on the functioning of the biotic components. If these components are not actively involved in the production of the service, then it might be argued that it is not the ecosystem itself which is making the difference and providing the benefit. The following examples come to mind.

Mediation of air pollutants by abiotic components

This example refers to air pollutants landing on water or bare earth, which are absorbed, diluted, diffused or transported in some way but not actively mediated by biotic components. CICES for example restricts the provision of waste mediation services to those provided by living processes e.g. bio-remediation by micro-organisms, algae, plants and animals. The relevant research paper concluded that mediation by abiotic components was a relevant service but that its omission was not in general likely to be significant. This service is discussed in more detail in Cross-cutting Issue paper #2, which concludes that since the abiotic elements of the ecosystem are active in mediating the flows, it is providing a relevant service. This should not be taken to imply that the 'storage' of pollutants on the surface of bare rock should be included as a relevant service: the pollutants have to be absorbed in some way.

Coastal protection services provided by unvegetated shingle or sand dunes

This example relates to Cross-cutting Issue paper #7 concerning the counterfactual assumed in measuring the volume of ecosystem services. A common assumption is 'no vegetation', however it is generally accepted that coastal protection services are provided by sand dunes and shingle barriers, whether vegetated or not (for example, CICES refers to water flow regulation without any reference to just biotic components).

The issue here may not be whether some unvegetated ecosystems provide a relevant service, but whether it makes sense to include all possible ecosystems within scope - for example whether sea cliffs also provide a coastal protection service. A possible solution may be only to include those ecosystems where it is possible to conceive of losing the service if the ecosystem were depleted or degraded in some way as a result of anthropogenic activities.

Sandy beaches contributing to recreation services

This example focuses on the nature of the ecosystem which is providing the service, rather than the functioning of particular biotic components. Again, it seems to be generally accepted that, if recreation services are relevant services as far as ecosystem accounts are concerned, then it does not make any sense to limit the service only to those ecosystems where biotic components are making an identifiable contribution. Note that the provision of space for economic activities is discussed in more detail in Cross-cutting Issue paper #4.

Water filtration and water regulation services provided by bare but unsealed soil

In this case water permeating through the upper (largely inanimate) soil levels may benefit from water purification services and may also provide a more continuous supply of water to groundwater sources.

Conclusion

These four examples can be taken as reasonably representative of the principle that ecosystem services are relevant to ecosystem accounts when they are provided by the ecosystem as a whole, notwithstanding that some services may be provided solely by the existence of abiotic components. An additional principle (see also the conclusions of Cross-cutting Issue #4) is that as far as waste mediation is concerned, the ecosystem needs to be active in some way: pollutants deposited on bare rock which are not absorbed would not be included in scope.

In practice other lines may need to be drawn (e.g. the provision of coastal protection by sea cliffs).

A note on biotic and abiotic flows (reference Issue #10)

A related but separate concern is the distinction between abiotic flows and biotic flows. This distinction is particularly clear in the recent version of CICES where, for example, water supply is considered an abiotic service. The SEEA EEA makes a similar distinction:

"Ecosystem services do not represent the complete set of flows from the environment. Important examples of other environmental flows include the extraction of mineral and energy resources, energy from the sun for the growing of crops and as a renewable source of energy, and the movement of wind and tides, which can be captured to provide sources of energy. More broadly, the environment provides the space in which economic and other human activity takes place, and the provision of space may be conceptualised as an environmental flow. Collectively, these other environmental flows are referred to as *abiotic services*." (para 2.28)

Para 3.20 goes further to make an exception as far as water supply is concerned:

“The boundary between ecosystem services and abiotic services is defined by the scope of the processes that are relevant in their generation. It is considered that ecosystem services are generated as a result of bio-physical, physio-chemical, and other physical processes and interactions within and between ecosystems – i.e. through ecosystem processes. Abiotic services are not generated as a result of ecosystem processes, although there may be particularly close relationships between abiotic resources and ecosystem processes. It is noted that while water is an abiotic resource, its provision from the environment is considered to be generated through ecosystem processes and hence the provision of water is considered an ecosystem service.”

In practice these distinctions are not particularly important. As para 3.21 makes clear, there may be trade-offs between biotic and abiotic flows, and it will be important for the SEEA framework to account for both in a consistent manner. For example, wave power and tidal power are also abiotic flows but may be seen as ecosystem services in the sense that they are derived from the intrinsic nature of the marine environment and the way in which it functions. As with water provisioning, such flows may be recorded in both Central Framework and SEEA EEA accounts.

ANNEX D PAPER #4

The treatment of the use of space

Lead author: Rocky Harris 12 April 2019

This issue arises in several contexts. Examples of uses on which decisions will be needed as to whether they represent services within the scope of ecosystem accounting include:

- Sink functions: use of space for storage of waste from economic activities. In Cross-cutting Issue papers #2 and #3 we make a distinction between active mediation/storage of pollutants (whether by biotic or abiotic components of the ecosystem) and the passive use of space in which the nature of the ecosystem does nothing to contribute towards the provision of the service (e.g. air pollutants landing on bare rock). Hence the use of the atmosphere for storage of carbon is not treated as an ecosystem service. Nor would the use of space on land to store waste in (managed or unmanaged) waste disposal sites be included.

- Use of space for building. The SEEA EEA (para 2.28) refers to the environment as providing the space in which economic and other human activity takes place, with the provision of space conceptualised as an environmental flow. But elsewhere [ref. needed] we take the view that “there is little merit in regarding the provision of space for economic activities as a service provided by natural capital, since the nature of the space is a given and cannot readily be altered”. Whilst different land cover types will be more or less suitable for construction of buildings, in general it would not seem appropriate to view any of the value of the land under the building as being attributable to the ecosystem.

- Use of space for transportation. An exception might be made in the case of open water and marine habitats which might be viewed as providing carrier services. Unlike land-based activities, freshwater and potentially marine navigation is dependent upon ecosystems functioning well and can therefore arguably be included within the list of key services provided by those ecosystems. The Technical Recommendations (para 9.97) also make reference to the possibility of treating the atmosphere as an ecosystem asset which provides space for air transport.

- Use of space for recreation. This issue is discussed in detail in Research paper #9/10. Along with other cultural services, there is no physical ecosystem process occurring within the environment or extractive use of the ecosystem, however the view taken is that the ecosystem nevertheless provides a service because of the nature of the ecosystem itself, as it provides a physical space and landscape features which people enjoy, view, or undertake activities in (hiking, cycling) (SEEA EEA Table 3.4).

These examples suggest that we need to make clear distinctions between uses which benefit from the ongoing and intrinsic qualities of the ecosystem, and uses which are largely or entirely neutral as far as the type or nature of ecosystem is concerned. This suggests that navigation should be included as a service (notwithstanding any difficulties in measuring or valuing the service). In contrast, passive storage of waste should not be viewed as an ecosystem service.

Services that prevent/reduce externalities such as fire or CO_2 emissions from drained, degraded peatlands.

Author: Lars Hein

Draft, 9 May 2019

CONTENTS

1. INTRODUCTION

In the definition of ecosystem services for SEEA EEA there are a number of cross-cutting issues that are the topic of a specific discussion note. This paper addresses the conceptual challenge to deal with services that relate to the prevention of negative externalities. The challenge is that negative (or positive) externalities are not measured in the SNA or the SEEA EEA. At the same time, there are ecosystems for which these externalities are a major concern for ecosystem management. Compiling accounts while ignoring these externalities leads to incomplete information for ecosystem management, in these systems, and will reduce the interest of policy makers and users in the accounts. The discussions on if and how to include externalities in SEEA EEA are only just beginning, and this note can only present a few first, tentative thoughts. Specifically, the note presents a few options for including in the SEEA EEA framework two effects: CO_2 emissions from drained peatlands and smog leading to health effects from drained peatlands. These are selected because the author of this paper is familiar with these two externalities in a range of contexts, because they are of major interest in managing peatland ecosystems, and because the issues faced with including or excluding these externalities are likely to be comparable to those facing including (or not) other externalities.

Other externalities from ecosystems relate to, for instance, crop damages or even injuries from wildlife in nearby settled areas (which is often related to increasing pressure on habitats for wildlife), pest and diseases originating in natural ecosystems (note there is also a pest and disease control service provided by some ecosystems), forest fires originating in nature reserves and subsequently threatening and in some cases destroying people's houses. Where appropriate and feasible, a link the representativeness for other externalities is discussed. I discuss in each subsequent chapter the advantages and disadvantages of an option, starting with the option of disregarding externalities.

Note that this note is only mean to serve as input in the discussions in the workshop in New York (Glen Cove) in June 2019, all ideas and suggestions raised are tentative only.

2. OPTION 1. NOT INCLUDING EXTERNALITIES

Advantage. This is the simplest option from an institutional perspective, since no modifications of the SEEA EEA framework are required, and since it is consistent with the SNA to not include externalities in the accounts.

Disadvantage. An information set that is in some cases of overriding importance for ecosystem service is disregarded, which – in some cases – much reduces the relevance of the accounts to support ecosystem management. For instance, peatlands cover several percent of the globe's surface, and are responsible for between 5 to 10% of the global CO_2 emissions (the range is so wide since there are important variations between years, and because there are high uncertainties on emissions levels in particular in boreal ecosystems). Fire form peatlands is a major health concern in SE Asia, and is one of the main reasons for the Government of Indonesia's interest in better peat management.

3. OPTION 2. INCLUDING REDUCED EXTERNALITIES IN THE ECOSYSTEM SERVICES SUPPLY AND USE ACCOUNTS

Advantage. This option allows expressing the service in both physical and monetary terms, and makes the effect clearly visible in the accounts since it places the service on par with the supply of other services.
Disadvantage. A main disadvantage is that either: (i) a baseline / counterfactual needs to be defined; or (ii) the service needs to be expressed as a disservice in the case of a negative externality. This is shown in the table below.

Service	Baseline / counterfactual	Service	Issues
Reduced CO_2 emissions in health peatlands compared to drained peatlands	Drained peatlands - defined on the basis of the *average* drainage level of peatlands in a country), say this is 50 cm.	In undrained peatlands a total of say 50 ton CO_2/ha/year is avoided (compared to 50 cm drainage)	In many peatlands the drainage level will be more than 50 cm – in which case the choice is between 1. recording no service being supplied (meaning there is a discrepancy between service supply and emissions, and meaning that increasing drainage levels from 50 to 150 cm (or reducing them at levels below 50 cm) does not show up in the accounts, at least not in the services account); or 2. accept negative service supply in areas drained more than 50 cm.
	Drained peatlands - defined on the basis of the *deepest* drainage level of peatlands in a country), say this is 150 cm.	In undrained peatlands a total of say 150 ton CO_2/ha/year is avoided (compared to the maximum of 150 cm drainage found in a country)	Less conceptual issues compared to the previous option, but the choice of the counterfactual seems a bit arbitrary. There may well be only very few sites with such deep drainage.
	A potentially credible baseline is developed *for each individual area/site*		An issue in this case is that protected peatlands would not supply a service (since they are not allowed to be converted or drained), but unprotected peatlands that may be drained would provide the service. This seems counterintuitive. It would also be a lot of work, and perhaps involve arbitrary choices, to establish a baseline per site/area/province.
Disservice			
Emissions lead to a negative service (in drained peatlands)	No need to establish a counterfactual		The disservice would be expressed in costs not benefits, presenting a considerable difference with the SNA.

4. OPTION 3. INCLUDING DISSERVICES IN THE CONDITION ACCOUNT

Advantage. An advantage of placing disservices in the condition account is that the account is more flexible compared to the ecosystem services supply and use account. The condition account allows including indicators related to pressure as well as state of ecosystems. There is also the possibility to refer condition vis-a-vis a baseline condition. This would align well with the intention of indicating the externalities form degraded ecosystems. In principle, it could be examined if, following the DPSIR framework (drivers, pressures, state, impact, responses), the condition account could be expanded somewhat compared to current interpretations in the SEEA EEA framework, in order to also include pressure indicators. This would potentially look as indicated in the table below. The information in the table can include different types of externalities (e.g. health effects are a second order impact, derived from the emission of smog from peat fires). The externalities described in the table can be aggregated in different ways. A major advantage compared to the previous option is that there is no need to define a baseline/counterfactual.

Ecosystem: peat			
Pressure indicators	State indicators	Impact indicators - physical	Impact indicators – monetary
Ha of peat converted to other uses (e.g. grassland, plantation)	Ha of drained peat, in different classes		
	0-5 cm drainage: .. ha	CO_2 emitted: ton CO_2/year	.. US$/year
		Smog emitted: ton PM2.5/year	.. US$/year of which:
		Health impacts caused: .. premature mortality cases /year	.. US$/year
		Health impacts caused: .. lung cancer cases /year	.. US$/year
		Health impacts caused: .. cardiovascular cases /year	.. US$/year
	5-30 cm drainage: .. ha	CO_2 emitted: ton CO_2/year	.. US$/year
		Smog emitted: ton PM2.5/year	.. US$/year of which:
		Health impacts caused: .. premature mortality cases /year	.. US$/year
		Health impacts caused: .. lung cancer cases /year	.. US$/year
		Health impacts caused: .. cardiovascular cases /year	.. US$/year
	30-60 cm drainage: .. ha	As above	
	60-100 cm drainage: ..ha	As above	
	100-150 cm drainage: .. ha	As above	

Disadvantage. To date, it has been postulated that the condition account comprises only physical indicators. If externalities are to be captured also in monetary indicators (which seems preferable to allow their consideration in ecosystem management) and if externalities are brought into the condition account then it may need to be accepted that the condition account can include also monetary indicators as in the table above.

5. OPTION 4. INCLUDING CO_2 EMISSIONS IN THE CARBON ACCOUNT

Advantage: this option would require the least modifications of the SEEA framework, indeed CO_2 emissions from peat have been included in the Netherlands SEEA EEA accounts only in the carbon account. There are no fires in peatlands in the Netherlands, to date.
Disadvantage. An obvious disadvantage is that other externalities, not related to CO_2 (or CH_4) emissions cannot be included in the Carbon account.

6. CONCLUSIONS

All options have advantages and disadvantages. Further discussion is needed to select the most promising option(s) for further testing. A consideration is that also for some regulating ecosystem services a counterfactual is needed, as in the case of erosion control or air filtration. In both cases there seems to be an emerging consensus that the counterfactual could be bare land. I.e. erosion control of an ecosystem is the amount of avoided erosion compared to a counterfactual of bare land. A question is if there are parallels with the avoidance of externalities (for instance, erosion could be seen in part as a negative externality of certain land use). The issue is that this counterfactual does not translate well to some other externalities, as demonstrated by the case of peatlands. Here, the externality does not result from the absence of vegetation but in part from active human intervention in the ecosystem, i.e. through drainage, and in part from (semi-)natural processes such as fire (of which the risk is exacerbated by drainage). Hence, there is not always an easy way to design the counterfactual for dealing with externalities. As explained in the Introduction paragraph, it is too early to draw firm conclusions on if and how to include externalities in SEEA EEA. This note provides a preliminary sketch of some of the options that are potentially feasible, in most cases requiring a modification of the SEEA EEA as currently designed. The general trade-off seems to be that the largest modifications lead to the most comprehensive options to include externalities (i.e. options 2 and 3 above).

Spatial allocation of services to ecosystem assets and the bundling of services

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The nature of the problem(s)

The SEEA Experimental Ecosystem Accounting (EEA) differs from more traditional accounting approaches in its spatial focus on both supply and use of ecosystem services. Given this focus, decisions need to be made related to the association of ecosystem services (and their credit or debit) with specific spatially defined units on the landscape. Since ecosystem services are, by their nature, generated by the interaction of multiple spatial assets and the realization of the benefit may be distant from the source spatial area, complications arise in determining how (or if) to allocate the physical and monetary flows. Associated with this is the fact that a single spatial area may generate multiple ecosystem services that may interact with each other in various ways.

The objective of this paper is to provide an evaluation of how to allocate ecosystem services to spatial assets and how to address the bundling of services from a landscape, using examples of what has been considered and developed in ecosystem service crediting and payment approaches. This paper will not focus as significantly on the interacting nature of ecosystem services, since that is the focus of a separate paper.

Allocation of services to ecosystem assets

A key element of allocating ecosystem services to ecosystem assets is the development of models that are capable of tracing the supply and demand intersections with the ecosystem asset and the eventually delivered ecosystem services. Some models will be useful for tracing the supply-related elements of production associated with an ecosystem service, while other models will be needed to trace demand-side effects. For example, a SWAT model may generate how much erosion can be avoided or sediment retained by a particular ecosystem asset, but it cannot be immediately known who/how many users will use this particular supply of water and what level of water quality they require for that use. Alternatively, or in addition, we can measure how much water is being used, say, in hydro-energy production, based on hydro power plant's information such as reservoir capacity, sedimentation rate etc. (but more difficult to partition the relative contributions of particular assets to the regulation of that water quality). A combination of both of these analyses are necessary to determine how to allocate supply and use to spatial landscape areas (Arias et al. 2011, Schmitt et al. 2018).

The SWAT model's production of an estimate of sediment retention within the watershed also highlights the scale-related challenge of allocating ecosystem services to assets. While it may be readily possible to allocate hydrologic services from the watershed as a whole, it becomes more difficult to evaluate the relative contributions of the various ecosystem types (for example, by vegetation type) without running scenarios with and without such habitat or deriving the value of individual pixels based on their locations (Ricketts and Lonsdorf 2013, Kennedy et al 2016, Polasky et al. 2011). Spatially-explicit models like InVEST and ARIES make such mapping easier than with a lumped model like SWAT that combines all land uses occurring in similar soil and slope classes into a single hydrologic response unit, though SWAT typically is more accurate (Bagstad et al. 2013) From an accounting perspective, however it may not be necessary to determine the relative impacts of changes across different ecosystem assets in different locations, and such detailed questions may be better left for researchers/end users/policy makers informing and making decisions about how to best manage a given watershed.

Additional complexities arise from the fact that multiple, spatially distinct ecosystem assets often jointly contribute to the production of an eventual ecosystem service. Fish as a provisioning service are a good example of this since fish rely on different habitats and spatial areas for different segments of their life cycle and are often extracted in an area distinct from these locations. A mangrove may provide an important nursery ground and spawning ground, while various open water areas and benthic habitat may provide feeding areas. The question then becomes how to allocate the "production" of the fish generated by the various areas. Such an allocation would require an understanding of the life history of the fish as well as some weighting for the relative contribution to biomass of each of the spatially delineated areas (if biomass extracted were the metric for the ecosystem service generated).

The various ecosystem assets may also not both be direct contributors to the final service (biomass, in the fish example above), but instead their contribution may be in regulating the conditions (e.g., filtering contaminants from entering the water) that ensure that the service is provided in a given condition (e.g., biomass that is safe to eat). It is worth revisiting how to attribute "final" ecosystem services to both the site of their point of entry into the economic system (e.g., the point of extraction for fish) as well as to intermediate ecosystems (perhaps by giving different appropriate weights based on input-output relationships). Double counting should not be an issue if some fraction of a service is apportioned across a landscape; however, if services are not apportioned, care should be taken so that a service is assigned either to the location of realized demand or the location of supply, but not both.

Transboundary questions raise an important need for coordination across national jurisdictions in a global accounting system. Examples of transboundary issues may include: climate regulation, water supply by transboundary basins (e.g. Mekong delta), offshore fisheries etc. There will need to be coordination across statistical and environmental agencies to ensure that similar approaches are used for spatially allocating ecosystem services to ecosystem assets to avoid double counting on a global level. For example, assuming generation of the service and delivery occur across national borders, if one country assigns the ecosystem service flow to the point of extraction (final delivery point) and another assigns it to the point of supply/generation, summation across both will result in a double counting of the service. Apportioning the service across assets should be less prone to such double counting, so long as the "rest of world" apportionment were consistent across the ledgers of the two countries (and, of course, apportionment weights were agreed and consistent).

Bundling of multiple services

"Bundling" generally refers to the delivery (either past, current, or potential) of multiple ecosystem services from a given spatial area on the landscape (Qui and Turner 2013, Renard et al 2015). These services may interact with each other in their delivery in synergistic or non-synergistic (tradeoff) ways (Bennett et al. 2009). As mentioned in the introduction, these interactions are the focus of a separate paper. Here we focus on bundling (and alternative constructs for consideration of ecosystem services from a defined spatial area) in the context of credit/trading/payment for ecosystem services (PES) systems.

Since crediting and PES systems need to determine their strategy for providing credit or paying for the delivery of an ecosystem service, much work on the question of "bundling" versus "stacking" has occurred within these contexts. Bundling refers to the combination of the multiple services occurring on a given unit of land into a single credit or single payment (e.g., you are paid for restoring a wetland and the bundle of services associated with a wetland is included within that payment). Stacking, more specifically—vertical stacking, quantifies the various services provided by a single ecosystem area and then pays separately for each of the services that are generated on that one area that is affected by a given action (e.g., conservation, restoration). Using the previous example of restoration of a wetland, the responsible party would be paid for carbon sequestration credits generated as well as for biodiversity maintained or generated at the site.

The use of either bundling or stacking in crediting and PES schemes may be driven by practical considerations. Bundling, for example, avoids the need to fully quantify all of the ecosystem services associated with a given spatial area as only one credit type is provided; of course, the "value" of the credit needs to incorporate some sense of the range and quantity of services provided, though not necessarily with the same level of detail as required in a stacking approach. A stacking approach also requires that credit or PES "markets" are developed for each of the services generated (e.g., carbon sequestration vs biodiversity provisioning), which would likely result in higher transaction costs for the administering authority. Stacking may also run the risk of double counting (if the payment level for a carbon credit is based on the potential social cost of impacts on species biodiversity, then payment of a separate biodiversity credit would result in an overpayment to the supplier). Accounting systems and credit/PES systems have different objectives and end goals, so what works well in one context may not be appropriate in the other.

Potential accounting treatments

From an ecosystem accounting perspective, the greater the ability to delineate the various and multiple contributions of single and non-overlapping spatial areas to delivery of ecosystem services, the better. Value-added approaches used in national accounting/analysis of supply chains and trade flows may provide some parallels in this regard. While the final number used by decision makers may be a "scaled up" indicator of the ecosystem service for the locality/region/nation as a whole, the ability to disaggregate that number will likely be critical for determining potential policy actions. In this vein, apportioning of the service across spatial ecosystem areas of contribution seems reasonable as an accounting approach, and is a fundamental conceptual framework in the ecosystem services community. The way ecosystem service scientists differentiate between a potential service and a realized service is to delineate the area providing benefit to a specific beneficiary, often called a "serviceshed" (Tallis et al. 2015, Mandle et al. 2015, Ma et al. 2019). The concept is not difficult to apply, but the spatial data to locate beneficiaries or their access or use points are often missing. Where are people accessing their water from? What are property values in a flood plain? How far do people travel to recreate?

In the absence of an ability to apportion based on existing scientific and expert judgment, clear rules on whether the service should be associated with the spatial area of "generation" (the potential service) versus the spatial area of intersection with the economy/receipt by beneficiaries (the serviceshed, delineating the realized service) may be a "second best" solution. It should be noted, however, that for many/most services there may not be a straightforward location to flag as its single "supplying area," which may lead to a default to rely on using the spatial area where the ecosystem service reaches its "final" transfer to the economic production system.

Taking a vertical stacking approach rather than bundling likewise seems the most optimal approach for addressing the issue of multiple ecosystem services generated by the same spatial asset. Bundling may work in crediting and PES systems, but seems less useful in an accounting approach where metrics for the various specific ecosystem services are likely of interest to end users. However, this will require careful development of models that disaggregate the metrics for each of the services that may be associated with a given habitat type. Perhaps this highlights the benefit of prioritizing a set of ecosystem services and metrics for initial piloting of the ecosystem accounts rather than attempting to track all ecosystem services provided by a spatial area.

Concluding remarks

The issue of allocation of ecosystem services to spatial assets will require more on-the-ground pilot testing to determine the recommended approaches from an accounting perspective. As those implementing accounts attempt to allocate the ecosystem services across spatial areas, the limitations and potential of existing data sources to implement this allocation/attribution will become better understood. This will allow for an understanding of preferred versus second-best approaches for dealing with the spatial allocation question. As accounts are implemented and tested and shared with end users, there will also be a better understanding of the scale of analysis needed by those users, which may lessen the spatial attribution challenges.

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Defining the counterfactual for quantification of ecosystem services flows in the context of ecosystem accounting

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Background

The flows of several ecosystem services, especially regulating services, are typically hard to measure and to quantify. Quantification issues arise because a) many ES are co-produced by natural and anthropogenic factors, which hardly can be separated from each other, and b) there are often no reference situations in the real world, where the flow of the targeted ecosystem services is not present at all. To address both cases, the counterfactual concept can be applied in ecosystem accounting.

Definition and purpose of counterfactual

- Commonly used in economic and policy analysis.
- Defined as the prediction of what would have happened in the absence of an intervention or, in ecological contexts, when certain ecosystem structures/elements and related processes and functions are absent.
- Estimating the counterfactual is needed for robust causal analysis (Varian 2016), that is, to test the effect of an intervention (e.g. policy change, land use change) on something (e.g. ecosystems and people).
- Analysis that includes the counterfactual can be used to compare two states of the world: the world in which the intervention occurred and the world in which it did not – the latter is the counterfactual.

Applications to ecosystem service assessments – testing a proposed environmental policy intervention

- Extending the economics definition of counterfactual to ecosystem services would require comparison of two states:
    1. The flow of ecosystem services under current management (e.g. land use) regimes (the counterfactual).
    2. The flow of ecosystem services under a proposed intervention or alternative ecosystem management regime.

- Counterfactual assessment is critical in testing the efficacy of environmental policy (Ferraro 2009) and management measures.

<u>Applications to ecosystem service assessments – simulating a world without natural ecosystem processes</u>

- The counterfactual can also be used to describe an ecosystem absent of current ecosystem structures or elements, functional species and resulting ecological processes and functions.
- This ecosystem could be a simulated and often hypothetical world, where all biodiversity and/or habitats are removed.
- This approach could be used to measure the specific contribution of certain habitats, biodiversity and/or ecological processes to an ecosystem service outcome such as soil retention.
- In the case of soil retention, two states would be measured:
    1. The flow of soil retention ecosystem services under current land cover (vegetation) and land management (e.g. agriculture) regimes.
    2. The (reduced/lacking) flow of soil retention ecosystem services, where all forests and other vegetation cover are removed leaving just bare soil – the counterfactual.
- In the case of water flow regulation, the two states would be:
    1. The flow of water flow regulating ecosystem services under current land cover and management, including water retention basins, wetlands, vegetation (relevant for evapotranspiration), coastal protection elements, etc.
    2. The (reduced/lacking) flow of soil water regulating ecosystem services, where all flood-regulating elements and natural vegetation are removed – the counterfactual

Counterfactuals can be relevant also for assessment and accounting of other regulating ecosystem services, such as nutrient regulation, pest and disease control, pollination or natural hazard regulation in general.
It could be tested whether counterfactuals can be used for the other categories of ES (provisioning and cultural ES).

<u>Examples of counterfactual analysis in ecosystem services</u>

- Ferraro *et al.* (2015) estimated supply of ecosystem services (carbon sequestration) in tropical forests (in Brazil, Costa Rica, Indonesia and Thailand) with increased level of protection versus the supply of services without the increased protection (the counterfactual).

- Jones and Lewis (2015) estimate the effects of PES program on land cover change and use a counterfactual to assess land cover change in the absence of the PES program.

Relevance to Ecosystem Accounting

- Counterfactual analysis is used to identify the marginal change in ecosystem service flow with and without some human intervention or ecosystem structure/elements.
- The marginal change can go into ecosystem accounting tables.
- Can be used therefore to quantify, over a time period, the impact of a policy intervention, measured in an ecosystem accounting framework – can then link to SNA to assess impacts on GDP (for example) from an environmental policy intervention.

Alternative approach: combined risk (ecosystem service demand) and ecosystem flow analysis

Conceptual background:

- Many regulating ecosystem services refer to *avoided events*, such as regulation of floods, erosions, storms, fires, pests, diseases or 'natural hazards" in general.
- Thus, the conceptual idea behind the accounting of such ecosystem services is that if certain events *do not* take place or take place in a reduced number or intensity, the flow of the related ecosystem service would be high.
- This, however, only makes sense in areas and times where there is a *risk* for the respective event/hazard to happen. In ecosystem services supply-demand contexts, such a risk would denote the *demand* for the respective regulating service.
- Consequently, without a risk for the event to happen, the related regulating ecosystem service would not be demanded and, in the end, no ecosystem service flow would be realised.

Example soil retention regulating ecosystem services:

- A flow of this ES is only needed in areas with a risk for soil erosion (soil erosion as the event/hazard closely related to soil retention).
- There is for instance no/very low risk for soil erosion in areas with dense vegetation cover, no slope, hardly-erodible soil types/texture and non-intensive rain events.
- Risks for soil erosion can be calculated for instance based on USLE (Universal Soil Loss Equation, calculating potential soil erosion).
- Comparing areas with significant risks for soil erosion with areas where soil erosion is actually taking place reveals areas where the flow of soil retention ecosystem services was not sufficiently to meet the demand for it. Areas of high risk and no soil erosion events denote areas of sufficient soil retention ES flow (supply meets the demand).

Such an approach, combining risks with events that are actually taking place in order to calculate ecosystem services flows, can be applied for all regulating ecosystem services with flows that are based on avoided events or the reduction of certain conditions, such as flood regulation, water/air purification (where pollutants would denote the risk), storm/fire protection, (excess) nutrient regulation, pest/disease control and natural hazard regulation in general. It should be tested in the context of SEEA EEA / NCA whether such an approach is more applicable and more close to real conditions than counterfactuals, that are assuming the (often strongly hypothetical) non-presence of interventions or relevant ecosystem elements.

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Distinguishing outputs, outcomes and benefits

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Ecosystem services cross-cutting issues

Distinguishing outputs, outcomes and benefits

Background

This note discusses one of the cross-cutting issues that is being considered as part of the SEEA EEA revision WG#3 discussion paper on the treatment of ecosystem services. This cross-cutting issue on distinguishing outputs, outcomes and benefits is a particular concern in terms of ensuring coherent descriptions of ecosystem services but also in aligning treatments with the discussion of similar issues in the national accounts. Of particular interest here is the discussion of ecosystem services and benefits related to health.

The framework for connecting ecosystem services, benefits and outputs

The SEEA EEA framework has a specific context for ecosystem services defining them as ***contributions of ecosystems to benefits used in economic and other human activity*** (SEEA EEA 2.23). This note starts from this framing and seeks to provide some clarity on the meaning of the word benefits within this definition and related concepts of outputs and outcomes which emerge regularly in the discussion. Ultimately, the connections between ecosystems, ecosystem services, benefits, outputs and outcomes will be reflected for different ecosystem services in logic chains which can serve as the basis for creating a common approach to measurement and discussion.

The choice of the word "benefits" in the SEEA EEA was not optimal. The intention, with a national accounting perspective in mind, is to refer to a concept that is equivalent to the concept of products or outputs within the System of National Accounts (SNA). In this context, benefits encompass those goods and services that are transacted between economic units (covering businesses, households and governments).

With this in mind, the SEEA EEA identified two types of benefits: ***SNA benefits*** which are those products (outputs) that are already recorded within the production boundary of the SNA, or put simply the products that are within scope of the measurement of gross domestic product (GDP). This will include all products that are considered the final consumption of households as well as all products that are inputs to the production of other goods and services (e.g. inputs of fuel and fertilizer in agricultural production).

The other benefits are ***non-SNA benefits*** which reflect products not in scope of the SNA production boundary. These are still conceptually goods and services in the sense that they are consumed and used, they are just not in the SNA.

It should be clear that other terms might have been used to refer to the same concept. For example, in the UK NEA the term "goods" was applied, perhaps in the sense of public goods. The challenge is that the variety of circumstances to be encompassed limits the potential to find a single word.

The importance of distinguishing the concept of benefits in the ecosystem accounting framework is that it is necessary to identify the different steps in the extended production chain as comprehensively as possible in order to describe consistent treatments across different ecosystem services and with different users. To support this proposition, consider the following examples

- Ecosystem service of pollination as an input in the production of apples by a farmer, in which case, the apples are an SNA benefit.
- Ecosystem service of water purification as an input in the production of water supply services by a water supply company, in which case the water supply services are an SNA benefit.
- Ecosystem service of air filtration as an input in the generation of cleaner air, in which case the cleaner air is a non-SNA benefit that is consumed or experienced by people.

In all cases, the benefits are the results of processes that result in products or outputs that are consumed, used or experienced. It is fundamental to recognize that the term benefit (both SNA and non-SNA) in the SEEA EEA is used to refer to some production that is exchanged between two economic units; and to which ecosystem services contribute. Conceptually then, benefits are a synonym for outputs in an SNA context.

> Note #1: The terminology used here to describe specific ecosystem services and benefits is currently the subject of discussion – the choices here should be seen as indicative only.
>
> Note #2: More discussion is needed to clarify the precise nature of the transactions and associated units/entities that should be recorded in the case of ecosystem services and non-SNA benefits. (This discussion does not influence the discussion here)

Linking benefits and outputs to outcomes

An important feature in the concept of benefits as just described is that there is no judgement as to whether the benefit/output has final consequences that are good or bad.

To consider this further, a companion example to the pollination of apples could be the pollination of tobacco plants. In the ecosystem accounting framing the tobacco plants/leaves will be treated as a benefit to the tobacco farmer (i.e. sales of outputs) notwithstanding the general acceptance that the final consumption of tobacco in cigarettes will have negative health consequences for the consumer (and likely others). Further, the accounting reality of "bad benefits" would seem to laymen an explanation for why restoration costs in response to natural resource damages increase GDP growth.

In this context, the concept of an outcome is proposed here to refer to the health consequences of the final consumption or use of an output. The potential mix of good and bad outcomes can be very broad ranging and may lead through many layers or steps. For example, the consumption of apples may lead to positive outcomes with respect to nutrition, health and well-being or, likely far more rarely, someone might choke while eating an apple and suffer badly. Other outcomes might concern standards of living, quality of life, social cohesion, justice, peace, etc. While all of these outcomes are observable and will commonly vary from person to person and from context to context, they are different in character to the underlying output/benefit since they cannot be exchanged or transacted between two economic units.

In national accounting, the distinction between outputs and outcomes has been most actively considered in the context of health services. The interest in this area developed through the 1990s as countries increasingly developed their methods for measuring the volume of GDP. A key point was the release in 2005 in the UK of the Atkinson Review into the measurement of government output which place front and centre the problems of using input based approaches to measurement of government services in volume terms. The discussion in this area culminated in the 2008 OECD handbook on measuring the volume of health and education services (OECD Handbook).

The distinction between output and outcome emerges in the OECD Handbook in the context of assessing quality changes that take place over time which in turn means that it cannot be assumed that the quantities consumed have a neutral relationship to overall utility. To explain further consider the following extract from the OECD Handbook

> "Consumers attach utility to a good or to a service because it affects outcome, i.e., a particular state that they value and which can be measured. One could also say that outcome is an intermediate step between consumption and utility and this is indeed the way it has been treated in the literature. For example, Berndt et al. (1998) distinguish between medical care ('output' in our terminology), the state of health ('outcome' in our terminology) and utility. They envisage a relationship whereby utility depends, among other variables, on the state of health and where the state of health is itself dependent on health care services, on the environment, lifestyle etc.)." (OECD Handbook, para 1.21)

Further, the OECD Handbook provides the following discussion of the use of the term outcome

> **Box 2. The meanings of 'outcome'**
>
> Outcome has been used in different ways in the relevant literature on health services. Two usages are common:
>
> In the health care literature, 'outcome' is typically defined as the resulting change in health status that is directly attributable to the health care received. Triplett (2001) indicates this usage in the cost-effectiveness literature and quotes Gold et al. (1996) who define a health outcome as the end result of a medical intervention, or the change in health status associated with the intervention over some evaluation period or over the patient's lifetime. Employed in this sense, some authors suggest that the 'output' of the health care industry be measured by 'outcome'.
>
> Among national accountants, 'outcome' is typically used to describe a state that consumers value, for example the health status without necessarily relating the change in this state to the medical intervention. For example, Eurostat (2001) gives as examples of "outcome indicators" the level of education of the population, life expectancy, or the level of crime. Atkinson (2005) has the same usage of the word. Understood in this sense, outcome in itself cannot be a useful way to measure output or the effectiveness of the health or education system. In terms of national accounts semantics, the 'marginal contribution of the health care industry to outcome' is the equivalent to the notion of 'outcome' as used in the health care literature.
>
> As long as a particular definition is used consistently, the substance of the argument is of course unaffected and the only question is the usefulness of definition or the other. As the present handbook follows in the line of Eurostat (2001) and the Atkinson Review (2005), it also employs the term 'outcome' in the sense of the national accounts literature.

For ecosystem accounting, it is proposed to retain this distinction between output/benefit and outcome.

Implications for the recording of health outcomes in ecosystem accounting

There is little doubt that in the literature on the measurement and valuation of ecosystem services there is significant focus on the consequences for human health. Most provisioning services, many regulating services and most cultural services can be linked reasonably directly to people's physical and mental health. The key from accounting perspective is to ensure a focus on contributions in which case building clear logic chains is fundamental.

The basic logic is therefore to build from ecosystem services and consider their contribution to outputs/benefits and in turn their contribution to outcomes (of which health status will be a key focus). The importance of focusing on contributions is to ensure that the relative importance of different steps in the logic chain is well understood. This is particularly important the further along the chain one proceeds since the number of contributing factors will increase.

For example, the value of increasing health status (say measured using quality adjusted life years) may be able to be measured but of particular interest is understanding the sources, enabling factors and pathways of health improvement. It may well be the case that ecosystem services are an important source, but there will be other enabling factors and hence the value of increases in health status (reflecting an outcome) will not be equal to the contribution, and hence value, of ecosystem services.

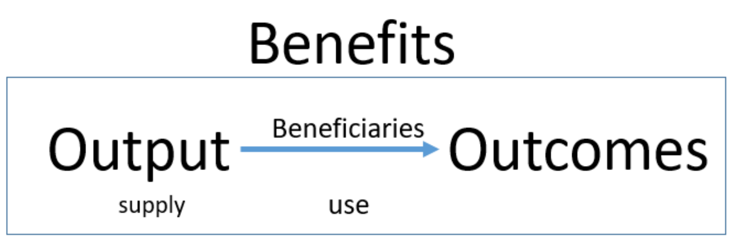
In terms of valuation it is relevant to recognize that where there is a chain involving ecosystem services – benefits/outputs – outcomes, it will be equally appropriate to value ecosystem services either as contributions to outputs or as contributions to outcomes – the key is to focus on the contribution rather than the outputs or outcomes.

Proposal concerning the use of the word benefits

The discussion in this note stick strict to the application of the word "benefits" as intended in the SEEA EEA, explaining that there is an alignment between the use of the word benefits and outputs. However, there may be strong reason to suggest that this use of the term benefits is not sufficiently consistent with general use of the term, especially given that many are not familiar with the accounting concepts surrounding outputs being items that are transacted.

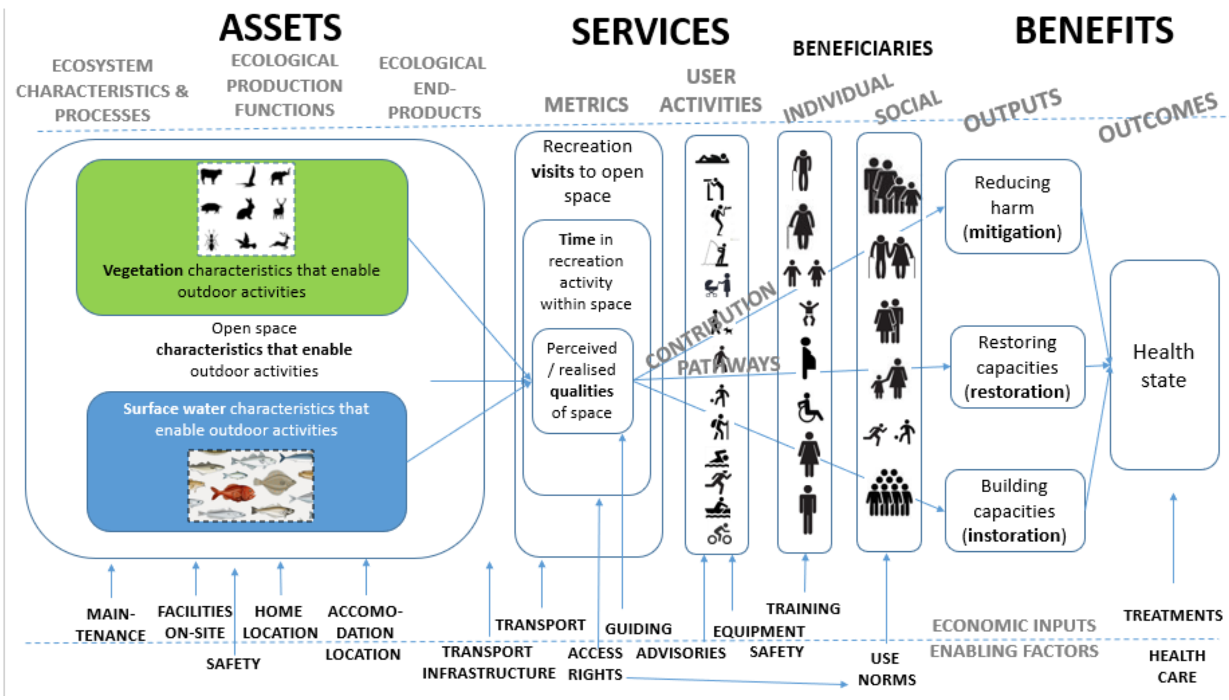
A suggested alternative that supports communication of the key concepts within ecosystem accounting is to allow the term benefits to encompass two concepts – outputs and outcomes. While the primary difference between outputs and outcomes in an accounting sense is that outputs can be transacted, or put differently, outputs can be supplied and used while outcomes are, in effect, achieved. Common use of the term benefits reasonably encompasses both depending on the context. The figure below summarises the proposal.

Figure: Proposal for "benefits" encompasses both outputs and outcomes.



An advantage of this proposal is that the associated term beneficiaries can be considered to apply not only to users of outputs but also to encompass those people (population groups) whose outcomes are affected from the use of ecosystem services and outputs. Indeed, "benefits" serves to identify the use of outputs by particular beneficiaries – subjects who consume, use, and experience the ecosystem service. Without beneficiary identification subjective value is not identified and further, beneficiary identification is necessary to identify transaction prices. In particular, beneficiary identification is necessary to identify health outcomes, because the characteristics of use and of the beneficiaries combine to modulate the pathways to health. The figure below gives an example of the types of pathways that might be considered.

Figure: Linking assets, services and benefits to health outcomes



In measurement and accounting terms it should be clear that both outputs and outcomes may be the focus of measurement. However, as for the national accounts, the limit of the ecosystem accounts is the measurement and valuation of outputs, recognizing that in many contexts the measurement and valuation of outcomes will be of policy and analytical interest.

Treatment of the SNA distinction between cultivated and natural production processes

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CONTENTS

1. INTRODUCTION

The cross-cutting issue of distinguishing between natural versus man-made ecosystems has been treated in the positioning paper on defining ecosystem services, which was also prepared in support of the June 2019 meeting in New York. This cross-cutting paper presents a brief synthesis of the proposals made in this paper, and it subsequently reflects upon how the theme is relevant for other provisioning (and other) services. Annex A presents a brief technical background.

2. SYNTHESIS OF PROPOSALS MADE IN THE POSITION PAPER

The SNA makes a fundamental distinction between cultivated and natural ecosystems, as elaborated in Annex A. However, critical to the depiction of the logic chain for many provisioning services is that the ecosystem asset generating the ecosystem services exists on a continuum of naturalness (from largely natural to fully modified by people). A key question then is whether the degree of naturalness of the ecosystem asset affects the description of the ecosystem service itself, rather than only the quantification of the flow. Related to this is the question what this means for defining the service. In accounting efforts to date, as well as in the global ecosystem services assessment (TEEB, MA, IPBES) two options have been followed: (i) defining the service sensu strictu as the ecological contribution of ecosystems to crop production (reflecting e.g. earth worm activity, nutrient storage and release in soils, and a great deal of other processes); or (ii) defining the service as the output itself, while recognising that this is the result of both the ecosystem and the way it is managed (by the farmer). A parallel here is that in many cases if not all the output of the system is a function of both the natural processes occurring in the ecosystem and the way the ecosystem is managed. However, in the case of some farming systems (as in intensive aquaculture systems) the importance of managed processes compared to natural processes is relatively large.

Defining crop and timber provisioning services. In order to quantify the service in case an approach is used based on assessing the ecological contributions to crop provisioning, often an approach is considered based on soil quality. There are several dozens of ecological processes that influence the suitability of land for crop production, which in turn depends upon climate, land preparation carried out by the farmer (e.g. levelling of undulating terrain, etc.), and ultimately crop production also depends upon how well the farmer is using these resources. Of these processes, soil is clearly linked to the ecological properties of the ecosystem. An example of a comprehensive effort to assess the suitability of land is the qualitative German soil Muelcher index. However, it needs to be noted that these processes will vary considerably between different agro-ecological zones, and that hence if this approach is followed also countries with few data on agricultural soils would need to develop such indicators and monitoring systems. Also, not in all agro ecological zones soil is the strongest predictor for the ecosystem's potential to support farming, in dry areas this may be water availability. In all cases, defining an aggregated indicator properly reflecting agricultural potential is not straightforward, and quite different approaches need to followed for individual countries and often also within countries.

The alternative (option 2) is to define this service in physical terms as the amount of products resulting from agricultural land. A key issue is that this reflects the benefits rather than the service. Clearly, crops are produced with ecological capital as one of the inputs in addition to labour, intermediate inputs and machinery. It is relevant to consider the consistency between defining different types of provisioning services and not only consider crop provisioning. In this context, the ecosystem service 'provisioning of timber' (i.e. the amount of standing timber that is harvested, quantified in terms of volume and quality just prior to the actual harvest) also takes the physical output as the indicator for the service, rather than the various processes that lead to crop production, at least in natural forests. However a distinction may be made between natural and man-managed ecosystems. In this case the SNA specifies that the accumulation of biomass in plantations is the benefit. It may be possible to, for this benefit, define the service as the ecological processes contributing to the service. In natural systems, the output is seen as the benefit in the SNA, and in this case the ecological processes contributing to this benefit may be very hard to quantify, given that not all ecological processes result in a benefit (e.g. many of the trees in a natural forest may not be harvested).

Defining fish provisioning services. Fisheries biomass forms the base for a range of potential ecosystem service flows and benefits, ranging across provisioning services (food for consumption), cultural services (fish catch for recreational enjoyment), and regulating services (influencing the biomass of other fish populations). Each of these service flows and benefits impacts different end users and therefore rely on different methods for their measurement and valuation. As with the use of terrestrial biomass a challenge lies in bringing in specificity to the definition of the service. One option is to define the service in terms of fish available for harvest, and a second option is to quantify the service based on actual fish harvested. The position paper on fisheries did not discuss in detail potential different approaches for defining the services in natural (e.g. the ocean) and man-made (e.g. an aquaculture pond) ecosystems – but there is a clear parallel with defining crop provisioning services. A related question is how to define the benefit versus defining the service. A possibility here is to use the fish brought on board as the service, the fish landed on-shore as the benefit. In practice, however, these may often be the same, or it may be time consuming and data intensive to differentiate between the two. Related to this is the question what to do with by-catch and discarded catch, would they be excluded or included from the physical volume of the ES? These issues are not yet resolved and will be further discussed in the June 2019 meeting. In general, it seems as if it may be preferred to have consistency between the definition of fish as a provisioning service and crops and timber as provisioning services.

3. IMPLICATIONS FOR DIFFERENTIATING BETWEEN MAN-MADE VERSUS NATURAL ECOSYSTEMS

As described in the position paper on defining ecosystem services, the choice of making a distinction between man-made and natural ecosystems is linked to the way provisioning ecosystem services are defined. In particular, if it is chosen to not distinguish between natural and man-made lands, this seems not well aligned with recording provisioning services in terms of an increase in biomass, since this latter option is only relevant for managed ecosystems (e.g. plantation forests rather than natural forests). For further detail, the reader is referred to this position paper.

As input into the discussion on distinguishing between man-made (or cultivated) and natural ecosystems, some key advantages and disadvantages of both options are presented below. Clearly, an advantage of one option may imply a similar disadvantage of the other option, but these double counts are not included in the table below.

Option	Advantages	Disadvantages
No distinction between natural and man-made (or cultivated) ecosystems	May simplify the recording of ecosystem services in the SEEA EEA, since there would not be a difference in recording between provisioning services supplied in man-made and natural ecosystems.	An accommodation needs to be found on how to connect outputs from ecosystems as measured in SEEA EEA to the SNA. A point for further consideration is that the SEEA EEA records services and the SNA benefits, although it seems unlikely to be helpful to not record differences in provisioning services between natural and man-made ecosystems in SEEA EEA and to impute this difference when recording benefits in the SNA.
Distinction made between these two types of ecosystems	Aligned with SNA and SEEA CF, hence facilitates integration	Difficult to separate the two type of ecosystems, in reality there is a continuum. The SNA specifies how to make the distinction but the issue is more prominent for SEEA EEA (since this focusses on ecosystems) – and maintaining this distinction would likely be a main point of discussion when ecologists and statisticians work together to compile

		ecosystem accounts (since a large number of ecologists may find such a distinction artificial and unhelpful). This distinction is also not proposed in the Millennium Ecosystem Assessment, the TEEB or in IPBES.

In general, it is recommended to combine the discussion on distinguishing between man-made and natural ecosystems with the discussion on how to define provisioning services (based on inputs form ecosystems such as water, nutrients – or based on outputs such as crops). It is also recommended to look for consistency in defining the different types of provisioning services (in particular but not limited to crops, timber and fish provisioning). General criteria that could potentially be considered in deciding if a distinction between man-made and natural ecosystems is maintained in the SEEA EEA include:

- Consistency with existing statistical standards in particular the SNA and SEEA CF. How can consistency with SEEA CF and the SNA be ensured?
- Measurability: can the distinction be made in practice? How much time and effort will it cost countries?
- Policy relevance: is it policy relevant to distinguish between the two types of ecosystems?
- Policy implications: Will differentiating between natural and man-made ecosystems, AND recording services in a different way in the two types of ecosystems, lead to a bias in the valuation of ecosystem services supplied by both systems? (e.g. in case biomass accumulation in plantations is valued then the value may be higher than realised in practice, specifically in case there are losses due to fire, storms, etc., before actual harvest takes place. This may lead to an unfair bias in favour of cultivated ecosystems in the measurement of ecosystem service or asset value).
- Acceptability: will differentiating between the two systems be acceptable, from a conceptual perspective, to the people compiling and using the SEEA EEA accounts?
- Alignment with current practices in statistical offices: to what degree do NSOs currently differentiate between man-made and natural ecosystems?

There may be additional relevant criteria, which could be discussed in the June 2019 meeting in Glen Cove.

APPENDIX A. DIFFERENCES IN RECORDING SERVICES AND BENEFITS IN NATURAL AND CULTIVATED ECOSYSTEMS IN THE SNA AND SEEA CF

(based on the SEEA CF, the SEEA EEA framework, and the SEEA EEA TR)

An ecosystem service is defined as the ecosystem's contribution to the benefit. For example, in the case of timber, the ecosystem service pertains to the contribution made by the ecosystem to harvested timber, i.e. the service is the accumulation of woody biomass in the ecosystem that is subsequently harvested. Accumulation of other biomass (e.g. in branches, below ground biomass, or in species that are not harvested) is not relevant for this service. In order to maintain that the physical output from the ecosystem equals the physical input in the economy (in the ecosystem services supply and use accounts), it is necessary that volume of wood/timber recorded is the same in the supply and in the use account. A related question is what to do with felling residues, they could potentially be included in the service and returned to the ecosystem (so not included in the benefit), or the service could be measured net of felling residues (in which case there is a discrepancy between the amount of timber extracted from the ecosystem and the actual service). In the SEEA CF, these flows are termed natural resource residuals.

For timber harvesting, in the SNA and the SEEA CF, there is a difference in the time of recording of the ecosystem services depending on whether the growth of the tree is considered cultivated or natural. Cultivated biological resources are, for example, from plantations and natural resources are for example timber stands in natural forests. In reality, there is a grey line between the two, there are many ecosystems where management levels are intermediate (e.g. consider the well-known case of jungle rubber forests, where enrichment planting increases the density of rubber trees). This distinction is based on, among others, ownership and degree of control of the owner on the ecological processes (i.e. planting of seedlings, pruning, fertilizing, etc.). The SEEA CF presents guidance on how to distinguish between these two levels of management for national accounting purposes.

In the case of both cultivated and natural resources, the ecosystem service is defined as the accumulation of woody biomass used for timber harvesting. However, in the case of cultivated resources, the accumulation is recorded progressively on an annual basis, based on the expectation that the total accumulated biomass will be harvested (unless there are natural disasters such as fire, which can be recorded as 'other changes in volume' in timber stock). In the case of natural biological resources, the accumulation is recorded in total at the time of actual harvest of timber in the forest.

The reason for this difference in recording is that in the case of cultivated resources it is expected that all accumulated biomass is harvested at the end of the growing cycle. In the case of natural forest resources, only species of commercial interest are harvested (determined by timber species, age and quality of the individual trees, etc.). Hence it cannot be assessed a priori which parts of the annual accumulation of biomass is harvested in the case of natural resources. In the case of services from ecosystems that are to a high degree natural, the ecosystem's contribution is facilitating growth of the species that is harvested, be it a wild strawberry, medicinal bark, or a fish in the ocean. The distinction between cultivated and natural biological resources in SEEA EEA would facilitate integration with the SNA where the same distinction in the time of recording is made.

For annual crops, the distinction between cultivated and natural biological resources effectively disappears. The large majority of crops are grown as cultivated resources, and since they are harvested on an annual basis, the annual accumulation of crop biomass equals the annual harvest, except in case of natural disasters.