Expert Meeting on Ecosystem Accounts
Melbourne, Australia
16-18 May 2012
http://unstats.un.org/unsd/envaccounting/seeaLES/egm2/lod.htm

Defining accounting structures for ecosystems and ecosystem services
Discussion Paper

By: *Carl Obst*

Defining accounting structures for ecosystems and ecosystem services

Discussion paper for 1st Editorial Board meeting on SEEA Experimental Ecosystem Accounts

21-23 March, 2012

Carl Obst, SEEA Editor.

1. Introduction

1. This paper outlines the issues associated with defining an accounting structure for ecosystem accounts and proposes underlying models on which relevant structures might be based.
2. The paper does not encompass discussion of a range of related conceptual issues such as issues concerning statistical units, methods of valuation or classification of ecosystem services. These matters are covered in other discussion papers. Also the paper does not discuss the significant practical measurement challenges that are the reality in accounting for ecosystems.
3. There are a number of objectives in defining an accounting structure. These include
    - Developing a common set of base concepts and related terminology to aid discussion of the variety of measurement issues.
    - Organising information on ecosystems in a coherent manner and identifying information gaps.
    - Allowing connections to be drawn to environmental/economic information compiled following the SEEA Central Framework
    - Permitting integration with the standard national accounts (as described in the System of National Accounts (SNA)) in the areas of wealth accounting, the recording of the production and consumption of ecosystem services, the attribution of degradation of ecosystems to economic units, and the recording of expenditure by economic units for the maintenance and restoration of ecosystems.
4. The paper proceeds in the following way. First, it provides a conceptualisation of ecosystems in the context of defined spatial areas and economic and social assets. Second, it proposes an approach to defining ecosystem services in the context of other flows usually discussed with regard to ecosystems (e.g. functions, processes, benefits). Third, the paper proposes accounting structures for the organisation of information on ecosystems and ecosystem services.

5. Fourth, ways in which measures of ecosystems and ecosystems might be integrated with the accounting structure of the SNA are discussed. Here choices can be made between different analogies for describing ecosystems, each leading to different accounting structures. It is noted that the integration with the SNA only relates to measures in monetary terms and the choice of accounting structure for integration does not affect the accounting structures chosen for ecosystems and ecosystem services which can be used to organise information measured in either physical or monetary terms.
6. Following each section relevant questions are included for discussion at the meeting.

Question 1.1: Several objectives of developing an accounting structure are noted above – are these appropriate, are there other objectives?

2. Conceptualising ecosystems

7. An important initial consideration in accounting for ecosystems is whether the object of measurement is a defined, contiguous, spatial area. For the purpose of developing a model of ecosystems it is not important how large or small this area might be or how varied and complex. A model for accounting purposes must be able to encompass all different types of spatial areas. Using a starting point of spatial areas differs from economic accounting in that while economic units may be attributed to certain countries or locations there is no restriction on one enterprise being located in numerous places or many businesses using the same space.
8. The remainder of this paper assumes that a defined spatial area is the starting point and refers to this defined spatial area as an ecosystem. It is accepted that a further conversation is required on how a spatial area should be defined and the terminology that should be used to refer to different types and aggregations of spatial units in ecosystem accounting.
9. It is also noted that this accounting perspective differs from the logic underpinning accounting for individual environmental assets as defined in the SEEA Central Framework (Volume 1). In Volume 1 the focus is on distinct types of natural features such as mineral resources, timber, fish, water and soil. The same accounting logic as explained there can be extended to develop accounting for individual species (eg elephants, or whales) or any other individual component of the environment.
10. Further, the accounting logic of Volume 1 can be extended to consider changes in the condition or health of individual components. Thus for example, the overall health of the population of blue whales might be considered within an accounting framework. This aspect of accounting is not developed in Volume 1 and may be picked up in Volume 2, but it must be considered as distinct from considering the accounting for a distinct spatial area.

11. It may be that, in accounting for a spatial area, it is necessary to develop metrics for the individual components of particular significance but as implied, the accounting for individual components does not present any particular challenges for accounting even if the practical measurement challenges may be daunting.

12. Thus, the particular challenge in accounting for ecosystems is to consider, within a given spatial area, (i) the stocks and flows that represent the interactions between the various individual components; and (ii) the relationship between those stocks and flows and human activity.

13. For accounting purposes it seems reasonable to assume that an ecosystem can be assessed at particular points in time. Variously these may be considered assessments of an ecosystem's structure, condition, health, state, composition, or characteristics.

14. Generally, assessments at different points in time will reveal changes in the structure, condition, etc., of the ecosystem. These changes will be driven by two primary causes – natural processes and human induced changes. Natural processes are many and varied including soil formation, nutrient regulation, photosynthesis, water supply, biological control, reproduction and growth, waste treatment, carbon sequestration, etc.

15. These assessments of stocks and flows (i.e. changes in) of ecosystems can be brought together in the form of asset accounts. A proposed structure for asset accounts is presented in Section 4.

16. The common conceptualisation of ecosystems is a relatively un-built up (often described as natural) area of land. However, the logic of the underlying accounting model should not be dependent on the degree of naturalness or extent of human influence over the landscape. Indeed, there remain few areas of the world untouched by humans. Thus, the accounting model should work equally well for pristine forests and large cities. The measurement scope may be subsequently set to exclude certain areas but that is a separate implementation/compilation decision.

17. The implications of this conclusion are important. Since a majority of spatial areas will include people and/or physical structures built by people (including roads for example) some further clarifications are required as to the precise focus of ecosystem accounting within a given spatial area.

18. To make these clarifications it is necessary to consider the concepts of ecosystem functions or processes. These are the natural interactions and changes that take place between and within the individual components of an ecosystem. These process and functions are reflected in things such as the hydrological cycle, the carbon cycle, and various biochemical processes such as photosynthesis. It is the stocks and flows of the individual components that are involved in these processes and that together constitute an ecosystem that is the focus of ecosystem accounting.

19. From this point, assessing the stocks and flows related to physical structures built by people are out of scope. Even though their existence may affect the way in which ecosystem functions and processes take place, accounting for these structures is not within the scope of ecosystem asset accounts, since these structures are not active participants in the various ecosystem functions and processes.

20. In addition, by convention, people themselves (and related concepts of human and social capital) are excluded from ecosystem asset accounts since it is the impact of humans on ecosystems that is the primary accounting objective.

Question 2.1: Is the assumed starting point of a defined spatial area the correct one for ecosystem accounting?

Question 2.2: Should SEEA Experimental Ecosystem Accounts discuss the accounting for the condition of individual components in addition to the condition of ecosystems?

Question 2.3: Is a rationale needed to limit the scope of ecosystem asset accounting within defined spatial areas and, if so, are the proposals and logic presented above appropriate?

3. Ecosystem services

21. A focus on accounting for ecosystems is most generally motivated by a desire to understand the benefits that the economy, and society more generally, receives from the environment. Clear examples of these benefits include the benefits from the extraction of oil, from the felling of timber and the catching of fish. Further reflection on the benefits reveals an incredibly broad range of contributions from the environment including water bodies acting as a sink for pollution, the carbon sequestration in forests and soil, the provision of places for recreation, among many others benefits.

22. There are three ways in which the benefits may be obtained

    (i) the benefits reflect outcomes from natural processes where obtaining the benefits necessarily requires physical removal of material from the ecosystem (e.g. wood from trees, berries from forests).

    (ii) the benefits reflect outcomes from natural processes but there is no physical removal of materials (e.g. benefits from carbon sequestration, absorption of wastes, pollination of orchards by bees, and the benefits from clean air). Although there may be no physical removal there may be important negative changes in ecosystem condition as a result of obtaining these benefits. At the same time, generation of the benefits may be supported by human activity (e.g. through reforestation).

    (iii) the benefits are not the outcome of natural processes per se and reflect the use and appreciation of the natural environment

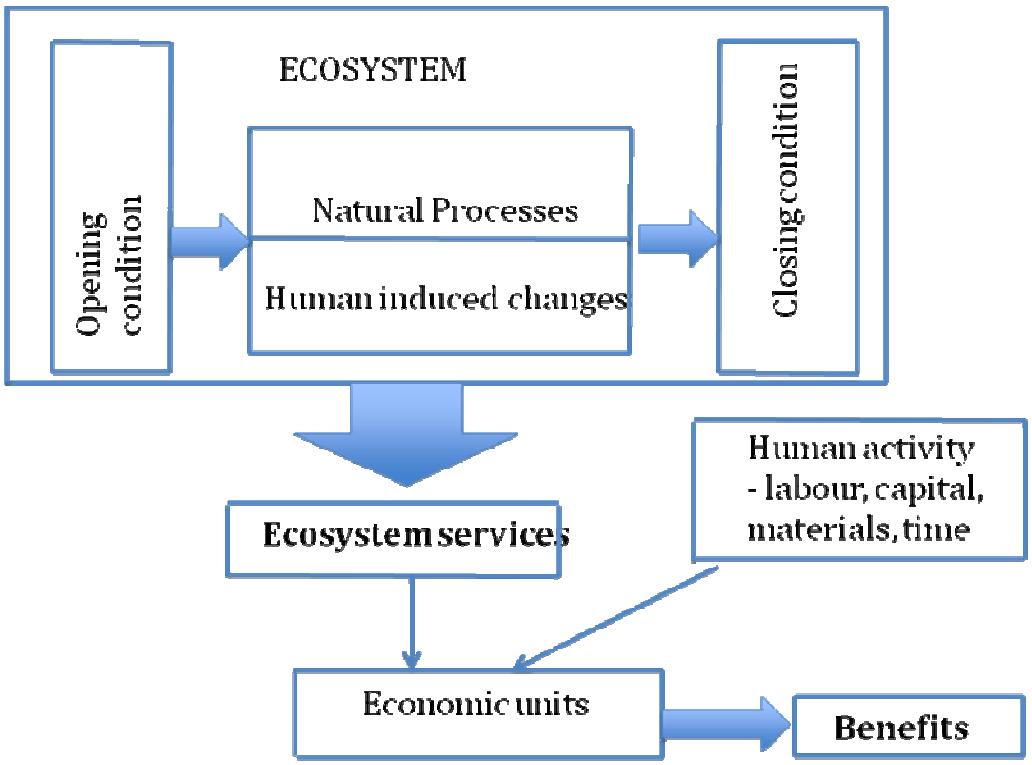
(e.g. the enjoyment of scenery on a drive to the mountains, skiing, watching nature documentaries).

23. In all cases the benefits involve an interaction (tangible or intangible) between humans and the ecosystem. In many cases this interaction is explicit and is evidenced by the investment of people in harvesting tools and associated labour and time. In these cases the generation of the benefits thus involves both inputs from the environment and inputs from humans. In economic accounting terms the combination of inputs to create benefits is considered a production function. Generally, this is conceived as labour, inputs of capital (usually only produced assets), and intermediate inputs (outputs from other enterprises e.g. materials, services, fuels, etc). In other cases, the benefits arise without substantial action.

24. Traditional economic accounting does not incorporate the inputs from the environment as part of the process of producing these benefits and indeed, in many situations the benefits themselves are not incorporated. Thus, beyond measuring stocks and changes in ecosystems in asset accounts, a key objective of ecosystem accounting is to bring together information on the benefits from ecosystems to the economy and society.

25. The basic model proposed in this paper is shown in Figure 1.

Figure 1: Ecosystems, ecosystem services and benefits



26. Of particular significance is the distinction made between the benefits and the ecosystem services. This distinction is needed to recognise that, to varying degrees, the benefits require both an input from the ecosystem and other inputs (nature documentaries would have little cultural appeal without cameras, televisions and presenters).

27. The second key distinction is between ecosystem services and ecosystem processes and functions. While there are strong links between these two flows, ecosystem services only arise when they are inputs to the generation of benefits to humans. Thus, for example, the growth of trees in a forest (an ecosystem process) may or may not be linked to a flow of ecosystem services in the form of timber resources depending on whether the forest is protected from logging activity.

28. This second distinction also raises the matter that flows of ecosystem services are not equivalent to changes in ecosystem condition. While in some cases, a flow of ecosystem services necessarily involves a change in ecosystem condition (e.g. the felling of trees in a forest), in other cases ecosystem condition may not be greatly affected (e.g. the benefits of carbon sequestration from protected forests). More starkly, increases (decreases) in flows of ecosystem services do not always imply decreases (increase) in ecosystem condition. Overall, since a defined relationship between flows of ecosystem services and changes in ecosystem condition cannot be assumed, the accounting model must be sufficient flexible to deal with all potentialities.

29. In the discussion of ecosystem services reference is often made to them being either market or non-market services. References to market ecosystem services generally occur when there is physical removal of things such as timber and fish that are then sold on markets but may also occur in cases of the production of recreational services. References to non-market ecosystem services arise for the range of other ecosystem services where there is no physical removal for subsequent sale or the benefits are cultural.

30. However, the distinction between market and non-market ecosystem services is not appropriate within the model presented in Figure 1. Rather, all ecosystem services are non-market and it is the benefits that may be obtained either through sale on markets or whose value needs to be imputed using non-market valuation approaches.

31. It is true that some ecosystem services are inputs into the production of products which are sold on markets (e.g. sales of fish, timber). But, there is generally no market for the fish in the ocean before they are caught – i.e. there is no transaction with the ecosystem itself. Increasingly markets are being created around ecosystem services but this is not the general case. Thus, irrespective of how clearly or neatly ecosystem services fit into a production function they remain non-marketed inputs.

32. A more useful distinction within this general area is to recognise individual and collective ecosystem services. Collective and individual

services are flows conceptualised in the System of National Accounts by distinguishing those services provided by government that may be consumed only by individuals (e.g. health services, education services) and those services that are provided on behalf of all members of a society (e.g. defence, legal system, etc).

33. Accounting for collective services is undertaken by assuming that the government provides and consumes the services on behalf of the society as a whole. For individual services is it possible to account for them as being provided by government and consumed by households. The same approach could also be applied in accounting for ecosystem services.

34. Another distinction that is commonly made in the discussion of ecosystem services is between intermediate and final ecosystem services. Under this distinction there are some flows that lead to benefits in which case the flows are considered final ecosystem services and there are some flows which are essentially internal to the operation of the ecosystem and hence may be considered as intermediate flows in the sense that they are needed to ensure the delivery of the final services. In a number of cases intermediate ecosystem services and referred to as supporting services.

35. The model presented in Figure 1 does not make a distinction between intermediate and final ecosystem services and, in fact the scope of ecosystem services in Figure 1 is limited to those flows considered to be final services. There are a number of reasons for this approach.

36. First, ecosystem services arise only when there is interaction with and benefits to humans and hence depending on the ecosystem the same flow may or may not be an ecosystem service. For example, the growth of trees will represent an ecosystem service in the provision of timber if the trees are logged. If there is no logging the trees will still grow but there is no ecosystem services in terms of provision of timber. Rather, one might imagine that the growth of trees is useful for the delivery of carbon sequestration services, for example. While it would be possible to conceive that the growth of trees might be final in one case and intermediate in the other this overlooks the fact that in being "intermediate" there is no interaction with humans and hence the flow does not satisfy the underlying definition of an ecosystem service.

37. Second, it will be the case that some ecosystem services (defined following Figure 1) lead to benefits that are used in the final consumption of households and government and some are used in the intermediate consumption of enterprises. Here the terms final and intermediate have well-established uses within traditional national accounts that should be retained. Thus, it is proposed that ecosystem services be considered as inputs to the production of final and intermediate consumption rather than being considered intermediate or final in and of themselves.

38. It is important to note that removing references to intermediate or supporting ecosystem services is not aimed at excluding the measurement of these flows. Rather, for the purposes of accounting

structure it is a matter of placing the measurement of these flows in the right context. In fact these flows should be recorded as part of considering the changing condition of ecosystems – in effect these flows are part of ecosystem processes.

39. Finally, the model in Figure 1 does not make a distinction between ecosystem goods and services which has been suggested in various papers. In some papers the distinction is made between the physical removal of material from the ecosystem (e.g. timber, fish) which are referred to as ecosystem goods and other flows such as carbon sequestration which are referred to as ecosystem services. This distinction is reasonably analogous to the distinction made in national accounts and economic statistics between goods and services. While possible there seems little analytical advantage in making this distinction.
40. In other papers the notion of goods is related to the notion of benefits developed in Figure 1. While this terminology is possible it seems problematic in two ways. First, there is a large potential for confusion with the interpretation of ecosystem goods as being materials removed from the environment. Second, the benefits discussed in Figure 1 may be embodied in a range of products both goods and services. Thus using the word "goods" as a substitute for "benefits" may be interpreted as narrowing the scope of benefits. It is recommended that the term "goods" not be applied in the description of the ecosystem services flows.

Question 3.1: Are the distinctions made between benefits, ecosystem services, and ecosystem processes correct and appropriate? Are the terms chosen agreed?

Question 3.2 Should references to market and non-market ecosystem services be excluded from SEEA?

Question 3.3 Should references to individual and collective ecosystem services be developed in SEEA?

Question 3.4 Should references to final and intermediate ecosystem services be excluded from SEEA?

4. Structures to account for ecosystem condition and ecosystem services

Accounting for ecosystem condition: Asset accounts

41. In terms of the actual ecosystem accounting structure, first, there must be an asset account showing opening and closing condition by type of ecosystem – see Table 1. The asset account can in principle encompass recording on many components and characteristics of an ecosystem and it may be that composite and indicator/proxy based approaches are relevant.

42. A basic descriptive starting point for the analysis of ecosystems may be the recording of land cover accounts encompassing entries for the stock of land cover and changes in the stock (see SEEA Part 1, Section 5.6 for an example of such a form of an asset account). In theory, an asset account might be structured for an individual spatial area of interest (or selections of spatial areas) given the conceptual starting point for the accounting for ecosystems.

Table 1. Basic structure of an asset account for ecosystems

	Type of ecosystem (e.g. land cover type, specific spatial area)				
Opening condition (beginning of period)					
Human induced changes of which: Degradation Restoration					
Changes due to natural processes					
Closing condition (end of period)					

43. In practice, it is broadly accepted that measuring an ecosystem as a whole is a conceptual and measurement challenge. Hence, a measurement approach that focuses on a selected number of specific components/ characteristics within an ecosystem might be appropriate. The EEA for example, has proposed assessing ecosystems in terms of carbon/biomass, water, green infrastructure and biodiversity. Recording the stocks and flows of each of these components for each type of ecosystem would represent a set of asset accounts. The EEA then weights these components together to form an indicator of total ecological potential which is in effect an indicator of the condition of an ecosystem at any given point in time. This type of measurement approach can still be accommodated within a broad concept of an asset account – it is a question of measurement approach rather than accounting structure.
44. An asset account should also show relevant changes in the condition of ecosystems with a particular interest in whether the changes are natural processes or due to human activity. EEA proposes a related type of recording based on stress factors.
45. An asset account must also consider the recording of the degradation of ecosystems and improvements in ecosystems (e.g. through restoration programs or natural growth). It is noted at this point that improvements in ecosystems – for whatever reason – do not constitute flows of ecosystem services. Rather, improvements represent increases in the capacity to produce ecosystem services in the future.
46. A critical measurement issue for asset accounts is the definition and classification of ecosystems. Often this may be defined on the basis of land

cover type (e.g. forests, mangroves, etc). Fundamentally, ecosystems must be defined in reference to a particular spatial area although it may not be the case that a particular spatial delineation is appropriate for the analysis of all types of ecosystem services. This complex measurement issue is discussed separately.

47. A common source of confusion for those not familiar with economic accounting structures is the potential for related entries to be recorded multiple times within a single accounting structure. This is sometimes considered a "double count" but this is not the case. It is quite appropriate to record changes in assets and flows of production in both production accounts and asset accounts. For example, the production of machinery and the investment in machinery relate to the same physical item but are recorded in different places in the accounting structure. This does not constitute a double count. The same is true for ecosystem services and changes in ecosystems. Indeed, the apparent desire to record all relevant flows within a single account has generated much confused application of accounting structures and principles in ecosystem accounting to date.

Ecosystem services accounts

48. The second type of account in the accounting structure is an ecosystem services account showing flows of different types of ecosystem services by type ecosystem. If presented immediately following an asset account using the same classification of spatial areas, it would be clear as to how changes in the condition of an ecosystem were related to flows of ecosystem services. In some cases the flow of ecosystem services might be directly related to a change in the ecosystem condition (e.g. logging of forests) but in other cases ecosystem services may be provided without any change in ecosystem condition.

49. Of particular analytical usefulness in the context of the SEEA, the ecosystem services account should also be compiled by type of economic unit. Thus the total supply of each ecosystem service from ecosystems should be recorded as being used / consumed by economic units such as enterprises, households and government. A distinction might be made between individual and collective ecosystem services at this point as well as entries reflecting whether the benefits arising from the ecosystem services are incorporated in the current SNA production boundary.

Table 2. Possible structure for ecosystem services accounts

		Type of ecosystem (e.g. land cover type, specific spatial area)				
Type of ecosystem service (by CICES theme/class)	**Type of using economic unit**					
Provisioning	Enterprises					
	Households					
	Government					
	Total					
Regulating and maintenance	Enterprises					
	Households					
	Government					
	Total					
Cultural	Enterprises					
	Households					
	Government					
	Total					

50. A difficult issue that must be confronted in supporting analysis of the link between ecosystems and economic activity is the extent to which meaningful connections can be made between the activities of economic units and defined spatial areas. The assumption underpinning the structure of Table 2 is that for a given spatial area it is possible to not only measure the flows of ecosystem services but also to determine the using economic unit. For many provisioning and some cultural services this link may be reasonably obvious (e.g. wood from forests is used by forestry enterprises). However, for many regulating services drawing this link may be difficult. It is likely that assumptions will need to be made about use at the level of individual ecosystem services.

Indicators and analytical measures

51. Based on information in the asset account and ecosystem services account it is possible to develop a range of indicators, aggregates and other analytical measures that may be of interest. Indeed, various entries to these account may be based on separately developed indicators which are considered the best measures of the particular concepts being targeted – e.g. ecosystem condition.

52. For example, the simplified ecosystem capital accounts developed by the EEA contain a suite of different indicators and aggregates that may be compiled within the basic framework outlined here.

53. The various stocks and flows in these accounts may also be valued in monetary terms. The significant measurement issues in undertaking this step are discussed in separate papers.

Question 4.1 Noting that issues of classification remain to be resolved, is the basic structure of the asset account for ecosystem condition appropriate?

Question 4.2 Are the proposed structures of accounts for ecosystem services appropriate?

5. Integration of ecosystem stock and flow accounts with SNA accounts

54. The accounting structures of asset accounts and ecosystem services accounts provide a framework for organising information about ecosystems and contain useful information on the links between ecosystems and economic activity. All of these accounts should be compiled, to the extent that information can be gathered, in physical terms.

55. In theory these accounts can also be compiled in monetary terms. Once valuation in monetary terms has been undertaken, it is logical to consider accounting structures that allow an integration of the information on ecosystems within the established accounting structures of the SNA. This section outlines how such an integration may proceed.

56. It is recalled that the key objectives in undertaking such an integration are the development of wealth accounting, recording the production and consumption of ecosystem services, the attribution of degradation of ecosystems to economic units, and the recording of expenditure by economic units for the maintenance and restoration of ecosystems.

57. The valuation of ecosystems and ecosystem services is very complex philosophically, conceptually and practically. However, these complex issues are not discussed here – it is simply assumed that valuation is possible. Put differently, the choice of accounting structure is not dependent on the choice of approach to valuation.

Extension of the production boundary

58. Within the SNA one of the most important measurement boundaries is the production boundary. It defines the scope of goods and services that are "produced" by an economy. In effect it defines the scope of GDP and other key measures of economic activity. While a large proportion of the goods and services (collectively referred to as "products") within the

production boundary are considered market products, many products are non-market – for example the education and health services provided by governments. Many market and non-market products use ecosystem services as inputs following the model discussed in Section 3.

59. The first accounting question that arises in relation to integrating ecosystems with the SNA is whether the production boundary should be extended to incorporate a more complete range of benefits that arise from the use of ecosystem services as inputs. Thus, while the production of timber and fish using ecosystem services as inputs is within the SNA production boundary, it is possible to extend the production boundary to recognise benefits that arise from, for example, carbon sequestration, and the amenity of natural landscapes. On the whole, these extensions to the production boundary relate to collective benefits to society at large rather than benefits able to be captured by individuals.

60. Extending the production boundary is not particularly difficult provided a clear set of additional products can be defined. As a point of reference, the production boundary of the SNA has a general conceptual basis but in fact represents a series of choices about what should or should not be included based on an assessment of measurability, interpretation and past practice.

61. While possible, the definition of a broader production boundary has significant accounting ramifications. These issues are discussed in this section.

Producers of ecosystem services

62. The immediate questions that arise in an extension of the production boundary are (i) who should be considered the producer of the new products (i.e. the benefits that are not currently included in the SNA production boundary), and (ii) how should the ecosystem services that give rise to the benefits be recorded as inputs. Broadly, there are two approaches that can be taken to answering these questions. Often the description of these approaches is confused and the language used inconsistent with the underlying SNA with which these flows are to be integrated.

63. In descriptive terms both approaches are plausible and may resonate clearly as analogies for integrating ecosystem and economic accounting. However, each approach has quite different implications for the accounting structure and hence careful description of the approaches is needed to ensure a clear consistency with traditional accounting concepts and structures. The approaches are described here as Model A and Model B.

Model A

64. Model A builds directly on the treatment of ecosystems themselves as being natural capital and by applying the logic of recent developments in

accounting for produced assets in the standard economic accounts. Model A considers the producer of the new products to be one of the current set of economic units (enterprises, households or government) depending on who is using the ecosystem in a defined spatial area.

65. The production function by which the benefits are produced has outputs of the new benefits and inputs of labour, produced assets, other products (intermediate inputs) and ecosystem services. The ecosystem services themselves are flows of capital services from the ecosystem. These flows are analogous to flows of capital services from produced assets which are considered the inputs from assets in standard growth accounting productivity analysis.

66. Capital services represent the contribution that an asset makes over its lifetime which is distinct in concept from the changes in the value of the asset (i.e. the asset's depreciation). Depending on the asset, the flow of capital services may be relatively constant over the life of the asset or may fall steadily. Capital services are combined with labour and other inputs in the production of goods and services.

67. Applying this logic to ecosystems suggests that ecosystem services represent the flow of capital services from natural capital that are then combined with capital services from produced assets and with labour and other inputs to produce benefits. These "natural capital services" are not produced themselves but instead are internal to the overall production of benefits by economic units (including government on behalf of society).

68. From the perspective of the current producers, Model A extends the portfolio of assets used by an economic unit and extends the set of outputs produced.

Model B

69. Under Model B the benefits are still produced by economic units but the ecosystem services are produced by ecosystems. That is, ecosystems become a new type of producing unit (in addition to enterprises, households and government).

70. The underlying production function is such that the individual components within ecosystems (i.e. the plants, soil , water, animals, etc) are treated as assets used by the ecosystem to produce outputs of ecosystem services. These outputs are then sold to other units as intermediate inputs in the production of benefits. In this model the natural capital becomes the individual components within the ecosystem rather than the ecosystem itself.

Comparison between Model A and Model B

Wealth accounting

71. For wealth accounting Model A is simpler to implement in terms of accounting structure. In essence, the ecosystems are shown as part of an

extended balance sheet of relevant economic units. Consequently, meeting the objective of wealth accounting to compare the relative contributions of different assets is straightforward at either an economic unit or total economy level.

72. Model B on the other hand has a more complex interpretation. In order to complete the balance sheet for the new ecosystem unit it is necessary to transfer the current individual components that are on the balance sheets of economic units (e.g. timber resources, land & soil) to the new ecosystem balance sheet. This new balance sheet may then be compared to values of other assets (produced assets for example) held by economic units. However, it is not possible to undertake such a comparison for a single type of economic unit.

73. In addition, under Model B the value of the individual components on the balance sheet of the ecosystems cannot be assumed to be equal to the value of the ecosystem itself. The analogy here is that the value of an enterprise is not equal to the sum of all individual assets that it owns. It would be possible to compare the value of ecosystem producing units to that of other producing units except that the balance sheets of the other producing units exclude the individual components that have been attributed to ecosystem units.

74. Overall, Model A would seem to hold clear advantages in simplicity for the purposes of wealth accounting.

Recording ecosystem services flows

75. For the purposes of recording the flows of ecosystem services within a general accounting structure Model B has advantages. Under Model B there are additional outputs to be recorded following usual recording principles. These outputs are matched by flows of intermediate consumption of the ecosystem services by economic units who then use the inputs to produce the benefits/products. In essence there is an externalisation of these flows by creating another producing unit. This accounting is not dissimilar to the approach to the recording of ancillary activity in the SNA.

76. For Model A, because the ecosystem capital services are not an explicit flow between producing units but are regarded as flows internal to a producing unit (as are all capital services from produced assets), there is no explicit recording of ecosystem service flows within the accounting structure.

77. What is recorded equally in both models are flows of benefits (as outputs and either intermediate or final consumption) between economic units.

Recording degradation by economic units

78. While the supply and use of ecosystem services can be more easily viewed through Model B, this model does not directly account for the

degradation of ecosystems by economic units. Rather, since the assets underpinning the ecosystem (the individual components) are on the balance sheet of the ecosystem the degradation is attributed, in the first instance, to the ecosystem producing unit.

79. A further complication of Model B is that the total degradation attributable to the ecosystem should reflect the sum of the degradation of the individual components, which may or may not reflect the degradation of the ecosystem as a whole.

80. Under Model A, since the ecosystem as an asset is part of the balance sheet of the relevant economic unit, the degradation of the ecosystem is accounted for directly as a cost against the income of those economic units in a manner analogous to the deduction of consumption of fixed capital (depreciation).

81. It is important to recognise that the flow of ecosystem services need bear no close connection to any ecosystem degradation. Thus, it may be quite misleading to conclude under Model B that the use of ecosystem services by economic units (reflected as intermediate consumption of ecosystem services) is an alternative measure of degradation. Put differently, although both intermediate consumption and degradation are deductions from output they are not analogous flows. Further, while it would be possible to allocate the degradation initially allocated to ecosystem producing units to other units (for example, through a series of degradation related transfers), it is unclear what meaning might be placed on an aggregate that involved the deduction of both the intermediate consumption of ecosystem services and the degradation of ecosystems. (In economic accounting terms this would be analogous to deducting both the cost of hiring a machine and the depreciation of that machine.)

Recording investment in ecosystems

82. A related accounting issue is recording investment in the environment for the purposes of maintaining and restoring ecosystems. Following standard economic accounting these investments would be recorded as expenditure by the relevant economic units. Under Model A, since the ecosystem is recorded as part of their overall portfolio there can be a direct connection between any relevant expenditure and improvements in the value of ecosystems on the balance sheet. In effect, the recording is analogous to the treatment of capital formation on produced assets.

83. Under Model B, it would be necessary to consider how to reflect the expenditure to maintain and restore ecosystems by economic units as changing an asset that is on the balance sheet of the ecosystem producing unit. This may be done using a series of capital transfers.

Spatial links between ecosystems and economic units

84. While the accounting structure of Model A is relatively straightforward, a difficulty does arise under in that it is necessary to attribute ownership of the ecosystem (i.e. to the specific spatial area) to one or more economic units. Put differently, the natural capital must form part of the balance sheet of an economic unit. In some cases, for example, soil owned and used by a farmer, this attribution is quite obvious.

85. However, even within a single ecosystem owned by a single unit (e.g. a farm) there may be ecosystem services produced that are inputs to the production of broader collective benefits (e.g. the collective benefits of carbon sequestration). There are two main choices by which this situation can be taken into account. First, each ecosystem can be deemed to be owned by only one economic unit (for many areas the default may be government ownership on behalf of society) and then ecosystem services from a given area may be transferred to other units – effectively hiring out the ecosystem to another unit. Second, the ecosystem may be partitioned such that certain types of ecosystem services flow to certain units. For example, soil services flow to the farmer and carbon sequestration services flow to the government (who consumes them on behalf of society). The ecosystem is then partitioned to reflect the appropriate share of natural capital that is used by each unit in the generation of the specific ecosystem services.

86. Under the first approach all degradation would be allocated to the single owning unit which may be appropriate from the perspective of ensuring that degradation is attributed to the manager of the area. Under the second approach degradation would be partitioned between economic units.

87. Under Model B the need to allocate economic units to spatial areas does not arise since all of the use of ecosystems is separated out into a new producing unit. Flows from this new unit to existing economic units can be recorded without needing to consider how the ecosystem itself is attributed on a balance sheet.

Summary

88. On balance, particularly for the purposes of wealth accounting and accounting for degradation, it is recommended that the accounting structure implied by Model A be adopted in the SEEA. Despite the need to consider carefully the spatial linkages to economic units, it presents as a simpler extension of the widely mentioned natural capital approach and can be formulated as a logical extension of the accounting for environmental assets in SEEA Volume 1.

Question 5.1 Is it agreed that an extension to the production boundary of the SNA should be incorporated in the SEEA?

Question 5.2 Do models A and B reflect the main choices for accounting structure or are other models relevant?

Question 5.3 Is there agreement with the conclusion of the paper to adopt Model A in the discussion of this issue in the SEEA.