DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
UNITED NATIONS

System of Environmental Economic Accounting

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# System of Environmental-Economic Accounting 2012 – Experimental Ecosystem Accounting Revision

## First Global Consultation on:

### Chapter 3: Spatial units for Ecosystem Accounting

### Chapter 4: Accounting for Ecosystem Extent

### Chapter 5: Accounting for Ecosystem Condition

## *Comments Form*

**Deadline for responses: 30 April 2020 – extension granted to 8 May 2020**
**Send responses to: seea@un.org**

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| Name: | This is a collation of comments provided by<br>Becky Schmidt, Richard Mount, Simon Ferrier, Anna Richards and Suzanne Prober<br>*We are a team of CSIRO scientists engaged in environmental-economic accounting. These comments are not the consolidated view of CSIRO as an organisation.* |
| Organization & country: | Commonwealth Scientific and Industrial Research Organisation (CSIRO) Land and Water, Australia |

The comment form has been designed to facilitate the analysis of comments. There are nine guiding questions in the form, please respond to the questions in the indicated boxes below. To submit responses please save this document and send it as an attachment to the following e-mail address: seea@un.org.

All documents can be also found on the SEEA EEA Revision website at: https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision

In case you have any questions or have issues with accessing the documents, please contact us at seea@un.org

**Question 1: Do you have any comments on the definition and description of ecosystem assets and ecosystem accounting areas and the associated measurement boundaries and treatments?**

**Ecosystem assets**

(1) The definitions and descriptions are generally clear and coherent. The acknowledgement that the ecosystem assets simply need to exist (P3.8), rather than having some kind of ownership or management, is an important step and opens up a clear path to accounting for 'intrinsic' values, that is, values based on ecological knowledge and directly relevant to ecosystem existence and functioning, such as for condition accounting.

We **recommend** including an additional higher level, conceptual definition of the *ecosystem asset* that is useful for ecosystem accounting purposes and that builds on and complements the existing overarching definition for an *ecosystem* (P3.7) and also the measurement oriented definition for ecosystem asset as a statistical *spatial unit (EA, P3.5)*. We suggest a definition based on the SNA definition for an economic asset yet still acknowledges that an ecosystem asset only needs to exist and is not dependent on ownership or flows of benefits to human (P3.8). A proposed definition is as follows:

"***An ecosystem asset is a store of value representing a series of benefits and opportunities accruing to all ecosystem participants by maintaining the processes of primary productivity, reproduction, growth (respiration), accumulation, release and evolution (adaptation) over a period of time."***

This definition provides a much richer idea of the ecosystem and a stronger conceptual basis for the ecosystem and the various processes and functions relevant to its existence yet is very consistent with the SNA definition for an economic asset.

**Expand definition of spatial units beyond ecosystem types**

(2) The definition of spatial units is important when accounting for ecosystem types and the proposed structure provides a powerful and useful framework for proceeding. However, we note that some thematic account data, such as some biodiversity variables, may be based on characteristics that do not depend on the ecosystem types. We anticipate that such data could be aggregated directly to some useful accounting construct other than ecosystem types, such as by public/private sector etc. These sort of accounts may or may not be useful for integration with SNA accounts, yet are still useful for many other purposes. This means that, for some forms of ecosystem accounts, while still being spatially based, ecosystem types are not relevant. For example, some types of changes in biodiversity can be reported by administrative areas in tables and maps yet not require ecosystem types to be defined for either data compilation or reporting purposes. We note that this is consistent with our understanding of the approach inferred in the last sentence of P5.7 about treatment of characteristics across many ecosystem types. While it may be possible to assign measurements of this sort of ecosystem characteristics to specific ecosystem types as suggested in P5.43, we suggest it may not always make sense to do so and **request guidance** on an alternative form of presentation. More detail on this in our response to your Q2.

**BSU**

We congratulate the authors for the increased clarity about the spatial concepts and processing required for ecosystem accounting. Separating the definition of the spatial units from the guidance about extent accounting helps this clarity. We have some specific comments:

(1) Given that remote sensing and spatial modelling holds much promise for ecosystem accounting due to their temporal and spatial characteristics, **is it possible** to provide more detailed guidance about the level of accuracy required to meet area frame sampling quality for official statistics and, separately, accounting purposes? At a workshop at the Fenner School, ANU (http://wald.anu.edu.au/eo4eea/) these issues were explored and here is some relevant literature:

- Global Strategy to improve Agricultural and Rural Statistics (GSARS). 2017. *Handbook on Remote Sensing for Agricultural Statistics*. GSARS Handbook: Rome. http://gsars.org/wp-content/uploads/2017/09/GS-REMOTE-SENSING-HANDBOOK-FINAL-04.pdf
- UN, et al. 2017 *Earth Observations for Official Statistics: Satellite Imagery and Geospatial Data Task Team Report*. Authors: Australian Bureau of Statistics, Queensland University of Technology, Queensland Government, CSIRO, National Institute of Statistics and Geography, Mexico. Available from the UN website as a white paper: https://unstats.un.org/bigdata/taskteams/satellite/
- Global Strategy to improve Agricultural and Rural Statistics (GSARS). 2015. *Handbook on Master Sampling Frames for Agricultural Statistics: Frame Development, Sample Design and Estimation*. GSARS Handbook: endorsed by UN Statistical Commission. Rome. http://gsars.org/wp-content/uploads/2016/02/MSF-010216-web.pdf

(2) CSIRO Land and Water is currently conducting research into the use of BSU for ecosystem accounting purposes and has found that organising the data as outlined in chapter 3, while extremely powerful for the compilation of the basic ecosystem accounts, also enables highly flexible and efficient analyses of the data when extending the use of the accounts to answer specific questions. The BSU structure enables the transfer of most of the attributes about ecosystem characteristics, plus all other ancillary/contextual data, into relational databases. This allows very simple, fast spatial processing yet sophisticated and extremely fast querying of the data held in the associated relational databases. This is particularly important given the vast amounts of remote sensing and modelling data relevant to ecosystem accounting. We **strongly endorse** the BSU data structure and anticipate many useful tools will quickly merge to assist their development and implementation soon.

(3) However, in Appendix 3.3, we **take issue** with the statements that infer a reference grid approach requires a loss of information. We think that there is a false assumption presented here that a reference grid needs to simplify the data to a single value per grid for each data layer. However, this is not correct and sub-grid information can be easily retained using a vector reference grid, sometimes referred to as vector tiling. For a square grid, the reference grid is made up of square polygons that exhaustively and exclusively cover the EAA with each grid cell having a unique ID. All data layers can be 'cut up' with the reference grid and the partitioned parts within each grid cell receive the unique ID. This means all original data is retained, including any associated attributes, and so, if necessary, can still be extracted with queries. This approach is documented and implemented in a number of places, for example, by Statistics Norway (Strand and Bloch 2009), The European Environment Agency (Strand et al 2016; see fig below) and Japanese

Statistics Bureau and researchers (Aki-Hiro et al 2017). We **recommend** that this approach is described and strongly recommended in Chapter 3 including in Appendix 3.3.

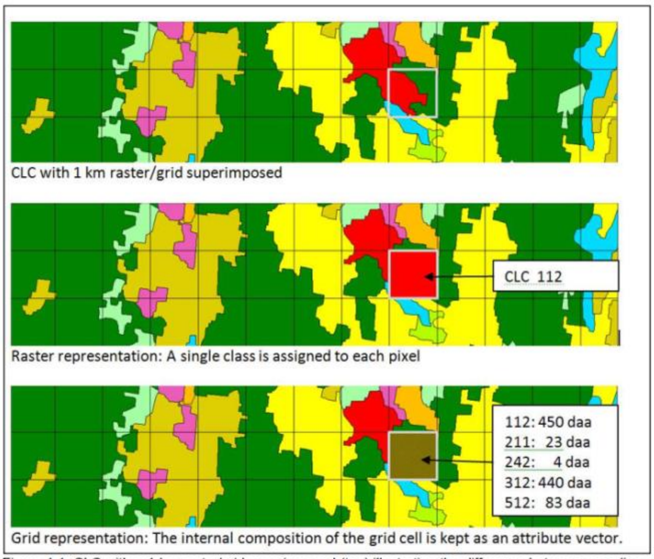


Figure 1.1: CLC with a 1 km raster/grid superimposed (top) illustrating the difference between encoding a particular unit as raster pixel (centre) or a grid cell (bottom). "daa" is a Norwegian unit: 10 daa = 1 hectare.

(3) Minor: typo in 3.62 – change 'build up' to 'built up'.

**Question 2. Do you have any comments on the use of the IUCN Global Ecosystem Typology as the SEEA Ecosystem Type Reference Classification?**

(4) From a biodiversity perspective, the IUCN Global Ecosystem Typology (GET) is **a logical choice**, all things considered, and offers reasonably good potential as a foundation for biodiversity measurement and analysis. However, for this potential to be realised adequately, it is **highly desirable** that accounts based on this typology move beyond simply assessing and reporting changes in the extent and condition of individual ecosystem types (ETs). From the perspective of the CBD's definition of biodiversity – i.e. "the variability among living organisms from all sources … this includes diversity within species, between species, and of ecosystems" – assessing change in the extent and condition of individual ecosystems should not be regarded as an end in itself, but rather as a stepping stone towards assessing change in overall "diversity of ecosystems".

(5) Any given ecosystem classification, including the IUCN GET, attempts to partition a highly complex multidimensional world into a simple set of classes, each of which is as biologically homogeneous, and as ecologically self-contained, as possible. Deciding what classification resolution (number of classes) to employ involves an important trade-off between these two criteria. By splitting broad classes to achieve greater within-class homogeneity – e.g. splitting rainforest into different types of rainforest – the resulting classes become less self-contained (from an ecological-process perspective) and exhibit higher levels of overlap in biological composition (e.g. number of species shared) between classes. This has significant implications for the use of discrete ecosystem classifications in assessing change in the state of ecosystem diversity in accordance with the CBD's biodiversity definition. Regardless of the precise classification employed, any such assessment needs to ideally move beyond treating ecosystem types as internally homogeneous, and mutually exclusive from one another in terms of both biological composition and ecological processes.

**Question 3. Do you have any comments on the recording of changes in ecosystem extent and ecosystem condition, including the recording of ecosystem conversions, as described in chapters 4 and 5?**

(6) We **appreciate** the guidance on the accounting entries ('managed expansion' etc.); however, due to extreme difficulty in distinguishing natural changes vs changes due to mixed natural and human activity, we **recommend** renaming the 'Natural' expansions and regressions to something like 'Unmanaged' expansions and regressions. (P4.13)

(7) We **support** the approach in 4.2.1 where some unmanaged (natural) changes do not change the ecosystem type. We have developed a set of dynamic ecosystem models for Australia that define dynamic reference states in which endogenous disturbances merely result in multiple expressions within the same ecosystem type. Whilst more complex, this approach supports the ability to distinguish between changes within an ecosystem type, and changes to a different ecosystem type.

(8) We **support** the purpose of accounting for ecosystem condition as set out in S5.1.1, clearly focussing condition on the ecological integrity etc. This has added clarity and helps guide the sometimes complex decisions about what exactly are the essential accounting concepts to define and measure for condition accounting.

(9) One issue is that *extent* and *condition* are intertwined (not mutually exclusive) in so far as a reduction in extent is also often a reduction in quality (condition) due to the associated capacity of an ecosystem to continue to function ecologically and, where relevant, supply ecosystem services. Further, while extent is certainly an important characteristic of an ecosystem asset, and it is privileged in the SEEA-EEA because of the emphasis on a spatial approach, it may not always be the best way to track ecosystem condition. We **recommend** further guidance be included that allows for tracking changes in the spatial characteristics to be used as part of measuring condition, such as absolute location, spatial relationships (e.g. fragmentation and connectedness) and spatial extent. For example, the second sentence in P5.2 could read, "Quality is assessed with respect to ecosystem structure, function, ~~and~~ composition and spatial characteristics which, in turn, underpin the ecological integrity of the ecosystem, and support its capacity to supply ecosystem services." P5.14 could be similarly modified. This approach is supported by the Ecosystem Condition Typology (Table 5.1) and in Appendix 5.2. This issue is also explored in P5.78. An either/or approach is currently proposed: either include change in extent (e.g. habitat) or include it in condition. **Would it be possible** to include the extent data in both the extent and condition account where extent is relevant to condition?

(10) P5.8: we are doubtful that "overall measures for ecosystem condition" can be established; rather, it seems much more likely there will be ecological measures of ecosystem condition that are relevant to particular aspects of ecosystems. This is consistent with the ecosystem condition accounts presented to date, which are mostly thematic in character (with the possible exception of J.L. Weber's *ecu*).
We **recommend** that the guidance clearly states that, though the intention is to perceive the condition of an ecosystem, the view provided by any account will always be through the filter of the account purpose (e.g. relevance to management objectives) and limited by available ecosystem knowledge and data.

(11) Ancillary data. We **strongly disagree** that climate data is not changing on a scale that is relevant to management of ecosystems. There is a vast literature on how climate change,

consistent with theoretical knowledge, is measurably changing at a rate relevant to policy decision making. For example, the *anticipated return* from a plantation forest can be modified using current climate data trends (e.g. on a five-yearly basis) and forecast using climate predictions. These calculations can be presented in tonnes of timber in a standard SEEA account format and go to the valuation of the asset. The underlying climate data (e.g. rainfall, temperature, evapotranspiration, aridity, climate wetness etc.) can also be presented as a flow or stock account of a critical ecosystem characteristic with high management salience and credibility and provide important legitimacy to environmental management disclosures. This should be recognised, with the caveat that measures of the underlying ecosystem stock is the preferable measurement if available.

(12) Conversions. We consider the explanation and guidance for recording conversions is **clear and practical**.

(13) P5.86 seems unnecessarily complicated as the condition assessment appears straightforward and will be on the extent of each of the two ecosystem types, first at time one and second on the different extent at time two. As argued previously, if the change in the extent of an ecosystem asset (increase or decrease) can be credibly related to a change in condition, then it could form part of the condition assessment.

(14) **Environmental pressure data**. We endorse the approach to enable reporting of pressure data as it is often exactly these that are available and, further, they are characteristics of the ecosystem of most pertinence for management. Pressure data is particularly useful in interpretation of changes in account data between measurement years (i.e. for 'attribution of change'). We think it is preferable to use stocks as the key variables used to describe assets and calculate their condition, but information on pressures provides an opportunity to attribute the drivers of change. This is also where climate information is be critical (as a driver of change). We would like **further guidance** on attribution of change as it is probably the information most needed by managers and policy makers.

Pressure variables and indicators may be most usefully described, for ecosystem accounting purposes, as inter-ecosystem or intra-ecosystem flows, consistent with the basic SEEA ecosystems conceptual model in fig 2.2 (SEEA-EEA 2012). We have named them as ‘flows to’ or ‘flows within’ the ecosystem and are a form of ecosystem change driver.

(15) Typo? in last sentence of P5.75).

**Question 4. Do you have any comments on the three-stage approach to accounting for ecosystem condition, including the aggregation of condition variables and indicators?**

We think considerable clarity is added by explicitly distinguishing variables, indicators, sub-indexes and indexes, though we have several comments and criticisms as follows

(16) The ecosystem characteristics, variables and indicators selection criteria in table 5.2 are **helpful.**

(17)The emphasis in P5.50 on defining and documenting the variables and metrics is **appreciated** as this is crucial for establishing the credibility of ecosystem accounting.

(18) For table 5.3: We anticipate that we can also record the state of an ecosystem asset in a 'category' or 'class' where we don't have numerical data (i.e. 'level'). For example, an ecosystem asset of a particular type may have a range of 'states' based on scientific knowledge, and, in the absence of numerical data, the characteristic of interest is whether the asset is still in the same state (say, state A) or has changed to a different state (say, state B). We could report the area of the ecosystem type in each of its various states (A vs B vs C etc) and any conversion between ecosystem types as well. At this point the measurements are 'neutral' yet are ecologically significant and relevant to multiple management objectives and, therefore, to interpretation by various stakeholders-managers-owners. Is this interpretation correct? If so, could you **please** add guidance to this effect? Ah, P5.70 noted with reference to classes.

**Dynamic condition measures**

(19) For P5.41 the authors state that "…ecosystem assets (EA) and these are expected to be delineated such that they are reasonably homogeneous in terms of their main characteristics" and hence, the ecosystem variable account includes a single level at each time point for each variable. In P3.7 ecosystems are defined as a 'dynamic complex of plant, animal and micro-organism...". We could see an example where the dynamic nature of ecosystems may be difficult to interpret in terms of a set of single variable measures for the different Ecosystem Condition Typology (ECT) classes.

(20) For example, in fire-disturbed woodlands, species composition and vegetation structural features will change with time since fire. A woodland 5 years post-fire will have very different values for a range of variables in each of the ECT classes e.g. understorey species richness, overstorey canopy cover etc, compared to a woodland 25 years post fire. However, both these examples would be classified within the same ecosystem type and have similar ecosystem integrity even though they are in a different stage of the disturbance-recovery cycle. If these two examples were classed as separate ecosystem assets within an ET, their different measures of various variables within ECT classes would likely result in a different condition score, with the 25 years post-fire woodland given a higher score due to its greater similarity to a reference condition if this is based on a least disturbed definition (see P5.35).

(21) In contrast, in P5.31 the authors suggest using a natural reference condition in which the "structure, composition and processes (including food chains, species populations, nutrient and hydrological cycles) are intact and thus dominated by natural ecological and evolutionary processes, incorporating self-regeneration, and involving dynamic equilibria in response to natural disturbance regimes". If this reference condition is used, then both the 5 y and 25 y post-fire woodland may have the same condition. We think that the definition of reference condition that accounts for the dynamic expression of ecosystems across space and time is more consistent with current ecological theory, but

may be difficult to capture in the current ecosystem condition variable, indicator and index accounts due to the need to have a single measure for each variable. In other words, there is perhaps a disconnect between acknowledgement of dynamic ecosystem behaviour and variability in Chapter 5 and the structure of the account's tables, in which, as far as we are aware, there is no capacity to capture variation in the expression of ecosystem characteristics along gradients of natural disturbance and recovery.

(22) One option is to (1) articulate the challenge in the SEEA document, and (2) allow for inclusion of states and expressions (or key divisions across a gradient) as separate columns in the account tables. This also enables a landscape view regarding the preferred amounts of each expression in the landscape (e.g. % old-growth woodland, % at 0-10 yr since fire). This of course makes the account much more complex but may be useful for some purposes.

**Unfavourable reference condition level**

(23) In section 5.55 variables are transformed based on a reference condition variable and an 'unfavourable' reference level. There is, however, no discussion around the interpretation of the 'unfavourable reference level'. Is this interpreted as the value of ECT class variables when ecosystems meet collapse criteria? It would be helpful to also indicate how the 'unfavourable' reference level is related to an anthropogenic reference condition and how this level is interpreted if an anthropogenic reference is used (e.g. an urban park might be an 'unfavourable' reference level for a forest ecosystem that has been highly fragmented, but this might also be the 'favourable' level if anthropogenic reference conditions are used).

**Question 5. Do you have any comments on the description and application of the concept of reference condition and the use of both natural and anthropogenic reference conditions in accounting for ecosystem condition?**

Comments on reference condition

(24) There are **serious problems** with adopting a singular focus on indicators having a "strong inherent 'normative' interpretation" (table 5.2, P5.23) as the exact same data should be able to be interpreted differently in the light of any interpreter's worldview, knowledge, interests and intentions. Because it is far too complex to take into account all stakeholder's worldviews and, therefore, to identify a 'favourable value', we urge a more 'neutral' approach to scaling the indicators, similar to the approach for variables (P5.52); one where reference levels (P5.25) are based on ecological knowledge and relevant to 'judgement usefulness' for a broad range of account users, rather than 'decision usefulness' for selected account users. This also has implications for P5.28 as it states that threshold levels for significant change in ecosystem functioning should not be used, yet this is precisely how the quality of an ecosystem can be assessed, or the conversion from one ecosystem type to another can be identified. It is also relevant to the reasoning in P5.30 about reference condition. We note the guidance that other types of rescaling functions can be used in P5.56.

(25) We **suggest** that the framing of ecosystem condition indicators should be agnostic to values and the way they may be deployed in decision making, but note that the reference concept applied in ecosystem accounting must place nature (native biodiversity) and its requirements at the heart of the conceptual framing and

terminology. Thus, it might be better to remove emotive language such as ”good”, ”bad”, ”favourable”, ”unfavourable” and instead focus on a scale of ecosystem integrity from the reference (ecosystems that have integrity) to a range in departure from reference conditions (degree of modification) through to a completely modified system that retains no characteristics of the reference (but may still be viewed as favourable by stakeholders with particular worldviews). The use of this language is consistent with the conceptual framing in Annex 5.1.

(26) The description and argument for the use of reference condition is **well-thought through**, while providing flexibility in interpretation, depending on different national circumstances. One additional point on terminology is the focus on ’natural’ versus ’anthropogenic’ (see P5.31-5.36). This language implies that people are separate from ecosystems, and all human-mediated actions result in changes to the reference condition. While human activity has played a substantial role in transforming ecosystem condition across the planet, there are also many human-mediated activities that are critical to the maintenance of ecosystem condition. Many Indigenous and First Nations peoples have a long history of environmental stewardship, and when this stewardship is not maintained or connection to country is broken (e.g. Indigenous-driven fire regimes in northern Australian savannas) then degradation in ecosystem condition can occur. We **suggest a clarification** around the term *natural* in P5.31 so that it doesn’t exclude the possibility that anthropogenic actions that maintain ecosystem integrity might be important, and an acknowledgement that nature is a socio-ecological system and it is not correct to persist with a purely *non-anthropogenic* versus *anthropogenic* dichotomy when comparing *reference* and *departure from reference* . This also opens the door for the ability to expand the ECT classes to include cultural variables that may be important for articulating ecosystem condition under different circumstances.

(27) **Indexes**. the option of a sub-index is important because it allows a breakdown of WHAT is in poor condition in an ecosystem. A single index often unavoidably adds together apples and oranges, necessarily involving a subjective judgement of the relative importance of different elements.

(28) Typos? P5.70: scores are shown to be between 0-100 rather than 0-1.

**Question 6. Do you have any comments on Ecosystem Condition Typology for organising characteristics, data and indicators about ecosystem condition?**

(29) The Ecosystem Condition Typology (Table 5.1) is a **useful** approach and adds clarity.

(30) Using the current approach to summing condition indices to get an overall condition score seems to exclude the use of other ways to determine an overall condition score for an ecosystem asset e.g. via Habitat Condition Assessment System (HCAS, https://research.csiro.au/biodiversity-knowledge/projects/hcas/) or via expert elicitation of a single condition number. Perhaps there could be some **guidance** around this.

**Question 7. Do you have any other comments on Chapter 3?**

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| None |

**Question 8. Do you have any other comments on Chapter 4?**

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| None |

**Question 9. Do you have any other comments on Chapter 5?**

**Biodiversity accounting**

(31) P5.80. We have problems with the last sentence that states "The spatial accounting units should be based on ecosystem types." As previously argued, it would be preferable to not restrict biodiversity accounting to ecosystem types (ET). The broader biodiversity-assessment community has long been thinking about, and developing, approaches and tools to address the challenge of incorporating information on internal variation within ecosystem types, and relationships between types, into the derivation of biodiversity metrics and indicators at the ecosystem level. Closer consideration of this body of work is **strongly recommended** if SEEA-EEA has an interest in promoting development of accounts which truly assess change in ecosystem diversity (*sensu* the CBD's biodiversity definition) – building on, and adding considerable value to, existing ecosystem extent and condition accounts.

(32) In more detail, the fundamental spatial structure adopted for SEEA EEA accounting poses some significant challenges for linking extent and condition accounts meaningfully to the derivation of biodiversity-relevant metrics or indicators. An implicit assumption associated with the definition of ecosystem assets (EAs) as contiguous ecosystem occurrences (effectively patches) nested within ecosystem types (ETs), seems to be that the ecosystem condition account for a given ecosystem accounting area (EAA) can be derived by simply summing or averaging the condition values of all EAs within each ET within that EAA. In other words, ecosystem condition is assumed to scale spatially in a simple additive manner, and therefore the challenge of condition assessment reduces to simply assessing the condition of individual EAs (virtually the sole focus of Chapter 5). This assumption is particularly problematic from a biodiversity perspective, for two important reasons:

a. Persistence of biological entities (e.g. species) contributing to the collective biodiversity of an ET is a function not only of the condition of individual EAs within that ET, but also of spatial relationships and interactions between multiple EAs – e.g. the major effect that varying levels of isolation and/or connectedness of EAs has on population and metapopulation dynamics. This is further complicated by the reality that many species will utilise resources from, or will disperse through, more than one ecosystem type – and therefore the effect of spatial configuration of EAs on biodiversity persistence needs to be considered collectively across, not just within, individual ETs.

b. Many species will also occupy only parts of each of the ETs in which they are known to occur, especially if ETs are defined at a relatively high (general) level of classification. For example, a species might be limited to a particular subset of the environmental and/or geographical space spanned by an ET (depending on the precise niche requirements, and biogeographical limits, of the species concerned). This means that the amount and quality of habitat available for species associated with an ET is not simply a function of total ecosystem extent and condition, but also of how well remaining occurrences (EAs) of this ET span, or 'represent', gradients of environmental and geographical variation within that ecosystem.

(33) The importance of these two phenomena has long been recognised in the biodiversity-assessment literature and they are now being routinely addressed, with increasing levels of rigour, by several biodiversity metrics and indicators applied at landscape, national and global scales. The **key lesson** from this broader body of work is that, if ecosystem condition accounts under SEEA EEA are to make a useful contribution to assessing change in the state of biodiversity across large spatial extents (e.g. for CBD reporting), then we **recommend** Chapter 5's existing focus on theory and methods for assessing ecosystem condition at local scale – i.e. within individual EAs – needs to be augmented by an equally in-depth consideration of ecologically-appropriate methods for scaling up this EA-level assessment to report meaningfully on the changing state of whole ETs at EAA level.

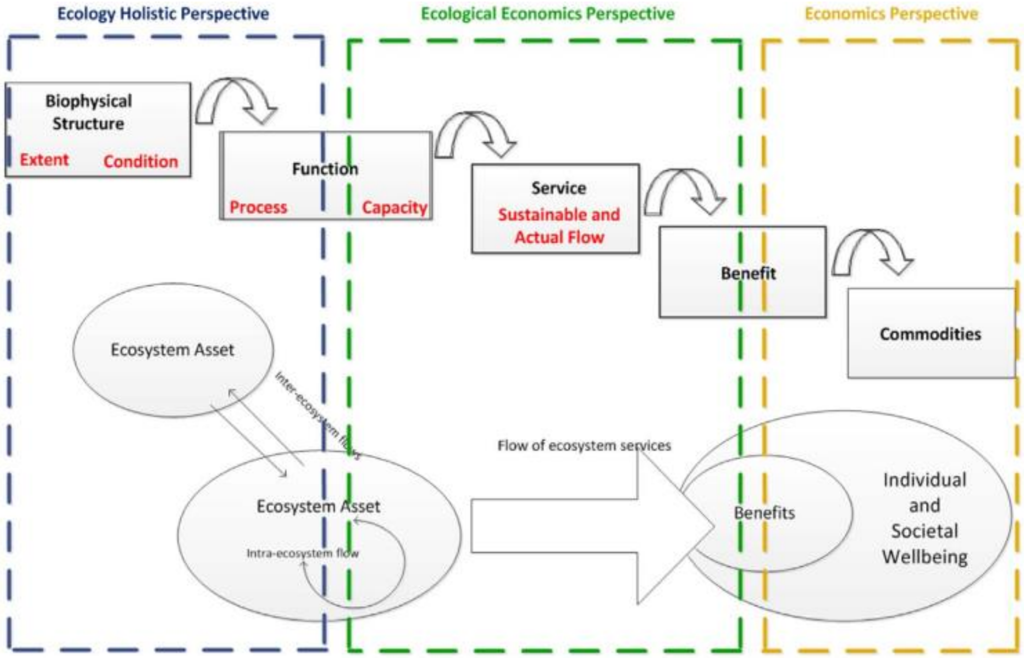
**Capacity accounting**

(34) We look forward to further guidance about capacity accounting as we consider it, or a concept very similar to it, to be a crucial set of accounts, including when accounting for 'intrinsic' values – that is, the capacity concept should *also* work for intrinsic, eco-centric ecosystem condition-related accounting as well as utilitarian ecosystem service oriented accounting. In other words, we argue that the **concept** of *capacity* is usefully applied to inter- and intra-ecosystem flows.

(35) An accounting question might be, "what is the capacity of the ecosystem to continue to (re)produce itself and maintain its own functioning and processes (primary productivity, reproduction, growth (respiration), accumulation, release (decay) and evolution (adaptation)) over a period of time?" Accounting for this would require ecological knowledge (scientific and/or traditional knowledge) about sustainable operating ranges. For example, in simple terms, if credible estimates of changes in the likely persistence of species into the future can be made, then, as that remains stable or goes up or down, so too does the capacity of the ecosystem to maintain itself remains stable or goes up or down. This is consistent with the concepts presented in La Notte et al (2017, 2019). The figure below presents the Ecosystem Service Cascade alongside the SEEA-EEA Conceptual Framework (La Notte et al., 2017a). We note the role of *capacity* as the link between ecosystem *function* and the flow of ecosystem *service*.

(36) We **recommend** that the concept of *capacity* also be applied to inter- and intra-ecosystem flows, intermediate services and the potential supply of ecosystem services, not only to ecosystem services. This would also enable tracking of *degradation* and *enhancement* from an eco-centric perspective; again, an existing accounting concept that could be adapted to an eco-centric perspective with the

added advantage that it is a more direct and complete measure of ecosystem asset degradation that one simply coupled to sustainable flows of particular ecosystem services.




(37) Another aspect of capacity accounting that deserves much more attention is the contribution that biological diversity, at both species and ecosystem levels, is increasingly recognised as making to the capacity of ecosystems to maintain, over the longer term, fundamental processes and functions underpinning ongoing delivery of key ecosystem services, particularly in the face of significant environmental fluctuation and/or directional change (e.g. climate change). Ecosystem and/or species extent and condition accounts can deal effectively with present-day dependence of ecosystem services on gross structural or functional attributes of ecosystems, or on particular service-providing species. But this leaves largely unaddressed the potentially crucial relationship between retention of biodiversity (i.e. biological diversity in the true sense) and long-term maintenance of ecosystem functions and services.

(38) Minor: The references are missing from Chapter 5