System of Environmental Economic Accounting

2019 Forum of Experts in SEEA Experimental Ecosystem Accounting, 26-27 June 2019, Glen Cove, NY

Background paper

Session 3b: Ecosystem condition

Issues note on reference levels and reference condition

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Version: 20 June 2019

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Issues Note for discussion at the SEEA EEA Technical Working Group - June 2019

Working Group 2: Ecosystem condition

Topic: Reference levels and reference condition

1. Current status

Ecosystem condition accounts are specified for different purposes, that is, intrinsic or instrumental. The purpose is usually achieved in terms of comparison of indicators against reference levels or a reference condition. Setting reference levels is necessary to assess ecosystem degradation, and to perform thematic aggregation (across indicators).

Definitions in Discussion Paper 2.1:

Reference level is a value against which it is meaningful to compare the current value of a variable in order to derive an indicator. A reference level applies to an individual indicator and is likely to differ for different ecosystem types. For example, the reference level for a biomass indicator such as normalized difference vegetation index (NDVI) can be different for a forest, savannah and grassland. Reference levels can be used in the normalization process necessary to generate aggregated indices of condition. Reference levels can also provide context for monitoring change in variables over time, and comparisons over space (across regions).

Reference condition is a consistent set of reference levels across several ecosystem types, which is applied to aggregate indices of condition. In the case of natural ecosystems, the set of reference levels correspond to the natural state for each ecosystem type, for example forest, savannah, grassland, wetland and river. In the case of artificial ecosystem types, the set of reference levels would need to be selected to represent an existing state.

An aggregate sub-index is derived from a combination of indicators that describe a single 'class' of characteristics of the ecosystem type. Combinations of indicators are usually those that show change in ecosystem condition in the same direction. Component indicators (sub-indicators) are assessed in terms of a common standard, weighted appropriately and combined to form a composite.

An aggregate index condenses all characteristics into a single indicator for an ecosystem type, or one characteristic across ecosystem types, where the individual indicators/sub-indices are compared to a consistent set of reference levels (a reference condition). A typology for indicators and an aggregation scheme are used to help aggregate different indicators or sub-indices.

Definitions in SEEA EEA and Technical Recommendations:

SEEA EEA 4.20: The SEEA EEA does not use target conditions currently as a form of a reference condition. A reference condition provides only a comparison point or baseline to which current indicators can be scientifically compared over time.

Tech Rec 4.53: A clear distinction should be made between reference and target conditions. A reference condition should be used solely as a means of estimating relative condition and comparing across ecosystem characteristics and ecosystem types. Target conditions, on the other hand, should be developed through participatory processes, taking into account economic, social and environmental considerations.

Tech Rec 4.71: For some regions in some countries, using natural ecosystems as the reference condition may be appropriate. However, more generally it will be necessary to establish non-natural reference conditions perhaps based on a historical baseline or a condition prescribed in policies (e.g. on water quality), and also taking into account links to the supply of ecosystem services.

2. What are the issues?

1) What are the benefits of using a natural state as a reference condition?
   Using the natural state as the reference condition allows recognition, and therefore the benefit, of the natural state to be incorporated into ecosystem accounts, even if the natural state is not related to supply of ecosystem services. This recognition is important for assessing conservation values.
   Does a natural state mean an ecosystem with no people?

2) Should reference levels and reference conditions be able to use target, desired or optimal states?
   Opinions include:
   (i) Reference levels should be objective (e.g. scientifically based) and ecosystem condition accounts developed by national statistical offices should be devoid of value judgements. Hence, desired normative thresholds or target levels are not appropriate for accounting. Use of target levels would not allow comparison across regions / countries when references are based on different value systems, and are subject to influence by policies and human interpretation. However, this option may also imply that variables where there is no scientific consensus on a meaningful reference level (e.g. a universally optimal level or an unambiguous threshold value) should not be used as condition indicators.
   (ii) Comparison of ecosystem condition indicators against values set in policy targets is necessary to make the information policy relevant.
   (iii) Can the type of reference be separated into reference levels that are objective and target levels that are subjective? If so, how can reference levels and reference conditions be applied in an objective manner? This refers to the selection of reference levels and the extent over which they are applied across indicators and ecosystem types. Secondary or supplementary analyses can then be performed that rely on selection of target levels that may be more subjective.
   Does the use of both condition variables (without reference levels) and condition indicators (with reference levels) allow for both these options?

3) What guidance can be provided about appropriate reference levels?

(i) In regions that have experienced change due to humans for a very long time, a comparison with a natural state can be difficult or even arbitrary.
(ii) A reference condition should take account of the current use of the ecosystem, and this may mean that a natural state is not appropriate.
(iii) Reference levels can be set at upper and lower levels of the range of a condition variable. For example, the upper level may refer to a natural state and the lower level may refer to a degraded state where ecosystem processes are below a threshold for maintaining function.

4) When does a change in ecosystem condition result in a change in extent of an ecosystem type?
For example, change due to land use conversion? How this change in condition is defined will often depend on the reference condition that is applied. If a transition in ecosystem type occurs, how is this recorded in the accounting tables for condition and extent?

5) How to perform the aggregation?
Can reference levels set with different options for the value, or threshold, be aggregated into a single reference condition? How are reference levels managed in developing a hierarchy for aggregation that is scalable, either spatially or temporally? This hierarchy of aggregation involves the indicators and their associated reference levels and methods for weighting.
Should all indicators be normalized/standardized to a common scale (e.g. between 0 and 1, with 1 being the 'good' state)? Or should the indicators already be standardized by default? How should this be done in a 'consistent' way, that keeps comparability between regions and time periods? Do we also need 'lower' reference values (defining a 'bad' state) or is a single ('good'?) reference value always sufficient? What kind of mathematical properties of the indicator should the standardization preserve?

Selection of methods for reference levels and weighting will involve some degree of subjectivity. Equal weighting assumes commensurability and this is not necessarily true across indicators, reference levels or ecosystem types. Non-equal weighting may be appropriate if the different characteristics, measured by their respective indicators, play relatively different roles from an ecological perspective or in their potential supply of ecosystem services. Relationships between characteristics may be non-linear and different thresholds may apply.

6) Testing of the operationalisation of reference levels and reference condition is needed to demonstrate ecosystem condition accounts, together with evaluation of methods used to reference existing condition indicators and aggregate indices, for example, Ecological Integrity Index by CONABIO; Human Footprint, Human Development Index, Norwegian Nature Index; and spatially-defined indicators such as naturalness, stability, self-organisation, intactness.

7) Can reference levels be set for the state of ecosystems within the Anthropocene? How does a changing climate affect the setting of reference levels?

How should setting reference levels take account of global change, including the climate, such that the reference is achievable? Whether or not the reference should be achievable may depend on the purpose of the ecosystem condition account being intrinsic or instrumental.

3. What are the options?

1) Types of reference levels

Reference levels can be baselines, standards, thresholds, limits or benchmarks, and may refer to either or both an upper or lower level of the range of a condition variable.

- Physical or mathematical range limits of the indicator (e.g. NDVI has an inherent 'natural' maximum value of 1 which cannot be exceeded). This option is only available for a limited number of indicators.
- Indicator values corresponding to the natural state of the ecosystem type undisturbed by human activity. (This option may not be meaningful for heavily modified or anthropogenic ecosystem types, like urban or agricultural.)
- Indicator values corresponding to a stable state (e.g. in a sustainable (socio-)ecological equilibrium) where the ecosystem is not undergoing degradation in terms of their ecosystem characteristics or supply of ecosystem services. This option may be more ambiguous to define, but is more suitable for human-modified ecosystem types, e.g. agricultural systems.
- Threshold values (an indicator value above or below which there is evidence that ecosystem condition is sub-optimal, e.g. there is a regime shift).
- Temporal baselines, including
    - the distant historical past (e.g. pre-industrial),
    - an arbitrary point in time (e.g. 2000),
    - the beginning of each accounting period.

  Temporal baselines may differ from region to region (and from accounting period to accounting period), which may hamper spatial/temporal comparisons and the interpretation of aggregated values.

2) Types of target levels

- Desired value (the indicator value that a policy aims to achieve)
- Prescribed value (such as a legislated quality measure)

Targets are mandated by policy, so they change from country to country. They do not exist for all ecosystem types and for all characteristics / indicators - they are more typical for some ecosystem types (e.g. freshwater, marine) and for some indicator classes (e.g. physical and chemical state).

3) Options for thematic aggregation

The aim of aggregation can be to generate a headline index for a specific ecosystem asset.

Issues to be considered when aggregation is planned:

- The type of aggregating function (central tendency):
    - Arithmetic mean (a generally used and easily understood central tendency with many advantageous mathematical properties),

    - Geometric or harmonic mean
    - Median, quantiles, minimum, maximum value (can provide a robust alternative to the arithmetic mean, the “one out all out” option is a special case of using the ‘minimum’ function as the central tendency).
- Weighting:
    - Equal weighting of all indicators,
    - Preferential weighting (e.g. based on expert judgement about relative importance of the indicators / indicator classes), should be well-justified and coordinated to ensure comparability,
    - One out all out approach (the condition index is based on the lowest value indicator).
- Flat or hierarchical approach:
    - A hierarchical approach reflects the structure of an hierarchical indicator classification (e.g. the ECI classes (and subclasses) discussed in DP 2.3) from the bottom to the top (e.g. first aggregate sub-indices from the indicators, and then an index from the sub-indices). Hierarchical aggregation schemes should also contain instructions on how missing indicators / sub-indices should be handled.
    - A flat approach does not consider the hierarchical structure (e.g. a flat arithmetic mean with equal weighting would take the mean of all indicators at once). This approach is biased towards indicator classes with more indicators.

The considerations listed above are only valid for thematic aggregations over various indicators and indicator classes in a single ecosystem asset / ecosystem type. Aggregations involving multiple ecosystem assets (e.g. spatial aggregations of a single indicator, or aggregating cross-cutting indicators across different ecosystem types) might involve other considerations (e.g. weighting by the spatial area).

4. Recommendations

1) The concept of reference levels (defined indicator by indicator) is more general than the concept of reference conditions (defined for all indicators together), so any guidance from SEEA EEA should be formulated in terms of reference levels instead of reference conditions (as much as possible). Any instructions that can be expressed in terms of reference conditions can also be expressed in terms of reference levels.

2) Methods for selection of reference levels (and conditions) should be standardized (as much as possible), transparent and assumptions stated.

3) Ecosystem condition should be assessed against reference levels that are objective (e.g. scientifically based), and does not necessarily relate to an evaluation of good or bad, or the use of the ecosystem.

4) A subsequent assessment can be made against a target condition where the purpose and assumptions are clearly stated. It is recognised that target conditions reflect a preference for a particular use of the ecosystem. They can be policy relevant but also

subject to political bias, and hence may not be appropriate for use by national statistical agencies or for comparison between regions/countries.

5) Change assessed from the beginning of an accounting period should not be recommended because individual years are too subject to variability and inconsistency between indicators or regions of accounting.

6) Reference levels should be used consistently spatially within the accounting area, and temporally.

7) Measures of ecosystem condition may allow for consideration of the resilience of ecosystems and the relationships and dependencies between ecosystem assets, for example, the impact of thresholds for ecosystem characteristics.