P30.03

Modelling changes in ecosystem service supply based on vegetation projections

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In this paper we introduce a simple framework for estimating ecosystem integrity and ecosystem service (ES) supply based on the concept of natural capital index (NCI). NCI builds upon a simple and straightforward conceptual model (ten Brink, 2000):

$$NCI = ecosystem\ quantity \times ecosystem\ quality$$

where both quality and quantity are expressed relative to an "optimal" or "intact" baseline. The concept is based on the assumption that biodiversity loss can be modelled as a process driven by two main components: habitat loss due to conversion of natural areas into agricultural fields or urban area, and the degradation of the remaining habitat patches, caused by overexploitation, pollution, fragmentation, invasive species, etc. Thus, NCI summarizes the extent to which a landscape has preserved its original (baseline) natural capital (Figure 1). Combining habitat quality and quantity into one indicator, NCI relies on a hypothetical equivalence between smaller intact, and larger, but degraded patches in terms of ecological value.

NCI can be observed as a framework for constructing ecological state indicators with existing implementations for large scale species abundance data (abundance-based NCI) and global change driver data (pressure-based NCI). This latter has been used several times in earth system modelling studies, since with the help of global pressure scenarios as proxies for future ecosystem state, projections on the state biodiversity can be made. However the relationship between anthropogenic pressure and ecosystem state is not always straightforward. On the other hand, even though relying on more direct indicators, abundance-based NCI is not applicable in predictive assessments, since abundance data are available only in retrospect.

In this paper we propose a very simple framework based on the concept of NCI, which can be used to evaluate future availability of ESs based on vegetation cover projections (Figure 2). Such projections can be produced either by earth system models, dynamic global vegetation models (DGVM) or regional vegetation models. To provide realistic projections (beyond evaluating *potential* vegetation and *potential* supply of ES in a climate-equilibrium situation) vegetation classes should allow for semi natural and degraded habitats as well as main land-use categories. If the primary output of models is potential vegetation, the outputs can be refined by means of land use modelling or land use scenarios.

In order to translate projected vegetation cover into indicators for future ES availability / stability, a simple parameterization scheme is proposed using estimated "relative supply scores" assigned to each vegetation class for each modelled ES separately.

As an illustration of the whole process we present here a similar analysis for actual (2003-2005) vegetation cover data for Hungary. The primary data source to assess ES supply indicators was the MÉTA database: a spatially explicit field-based national habitat database for Hungary (Molnár et al., 2007), comprising over 300 vegetation classes (the valid combinations of 86 habitat types and 5 degradation categories). We estimated indicators for the availability of two general ESs: "Biodiversity sustenance" and "Ecological stability", however the inclusion of more specific services is also possible. The usage of spatially detailed actual data makes it conceptually possible to design a test study on the applicability of the proposed framework, which we consider our next task.

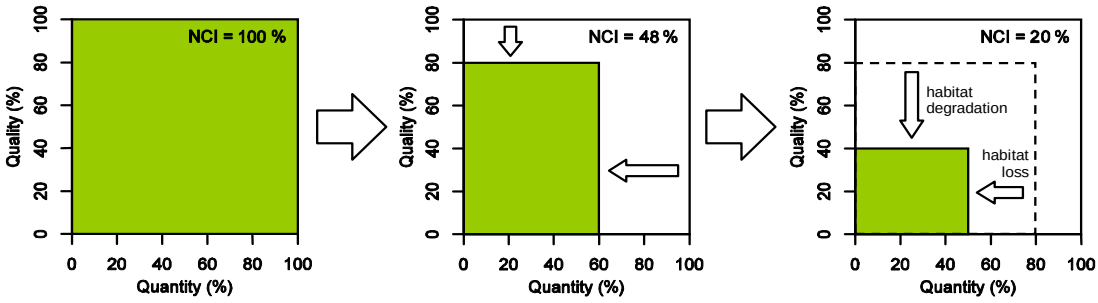

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Figure 1: The original natural capital index (NCI) concept, defined as the product of remaining ecosystem size (quantity) and its quality (ten Brink, 2000)

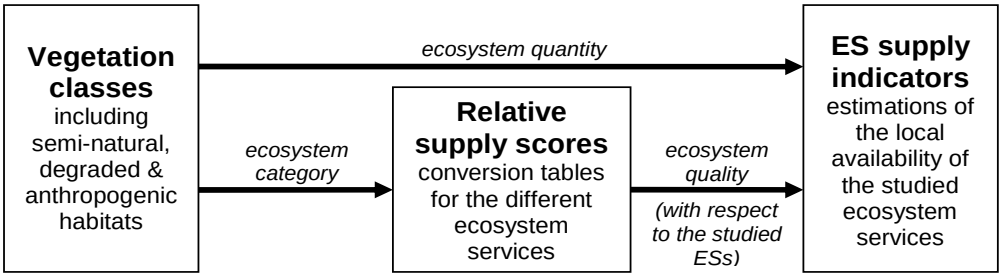

Figure 2: The framework for calculating local ecosystem service (ES) supply indicators based on projected vegetation distribution

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