VEGETATION-BASED NATURAL CAPITAL INDEX: AN EASY TO UNDERSTAND, POLICY RELEVANT ECOSYSTEM STATE INDICATOR

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1. Introduction

Most human activities have a determinative influence on natural ecosystems. Even the minor routine decisions of individuals may impact the state of surrounding landscape, not to mention the decisions of local and regional spatial planning and environmental policies. In these cases, circumspect evaluation of possible alternatives is needed in order to determine how to use natural environment most effectively and have the least harmful effect.

In the last decades, much effort has been devoted to develop metrics, which can easily be understood by anyone, to provide a clear and scientifically sound evaluation about the state of ecosystems. Several, aggregated biodiversity indicators were developed for following up large-scale changes in the biosphere of our planet *(e.g. EEA 2007).* However, indicators related to land use changes are still lacking behind. Because most land-use decisions are made at the local or regional levels, instruments supporting decisions are also most needed at these levels. Local and regional policy-related questions (like environmental impact assessments or strategic environmental assessments, both built into law and order of Hungary and the EU) require different kind of indicators, which can provide high spatial and thematic resolution. Due to the lack of appropriate databases (fine resolution ecological data with a broad spatial coverage), such indicators are remarkably lacking worldwide.

In this paper we describe a new low-level policy-relevant ecosystem state indicator, the vegetation-based natural capital index of Hungary. That indicator was designed for the MÉTA database, the national vegetation database of Hungary *(Molnár et al. 2007)*, which is detailed enough for local and regional applications. However, the same concept can possibly be used for any database with similar habitat-categories and naturalness scores worldwide.

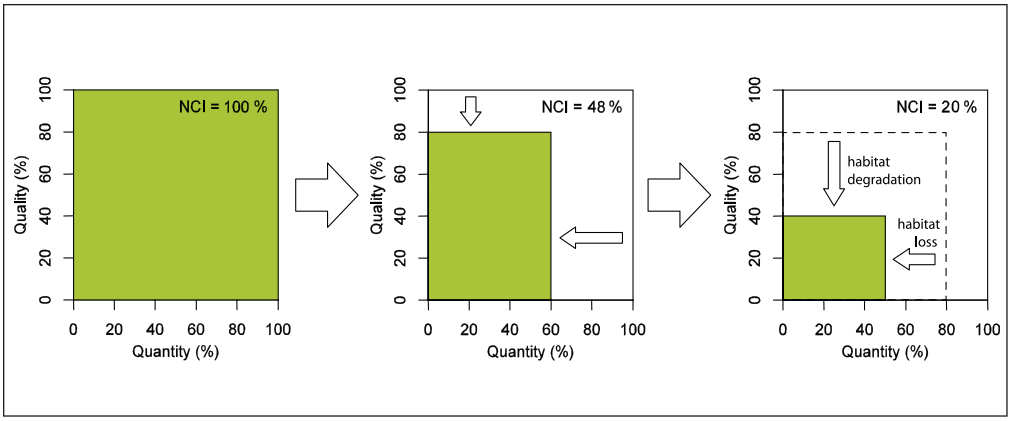

Figure1: Demonstrating the calculation of NCI: the NCI value of an area equals the product of the quality and quantity of the remaining natural and semi-natural areas, which falls into the interval [0,1]. For example, if the half of the habitats is destroyed in an area and the naturalness of the remaining ones is reduced to 40%, that means only the 20% of the original natural capital remains in the area.

2. The formulation of the indicator

The concept of the Hungarian vegetation-based natural capital index is based on an indicator of similar name (Natural Capital Index, NCI) developed in the Netherlands at the end of the 1990s *(ten Brink 2000)*. The original formula expresses the differences between former and actual natural conditions of a complex landscape using numerical data. The vegetation-based natural capital index we use is simply an adapted version of this original concept to the MÉTA database *(Czúcz et al. 2008; Czúcz et al. in press, Figure 1):*

$$NCI = \text{ecosystem quality} \times \text{ecosystem quantity}$$

If the landscape is composed of several patches of different size, ecosystem type and ecological quality, then the NCI value for the entire landscape is interpreted as the sum of the products of individual subunits, where size is interpreted as a proportion of the entire landscape, and quality is interpreted with respect to an intact baseline. In this way, the indicator estimates the proportion of the original ecosystems that have persisted in a particular region of interest. For this, the relative presence of ecosystem is characterized with the quantity and quality (naturalness) of the vegetation-cover. Defining relative naturalness of habitats can be carried out in several ways, among which two main NCI calculations were determined and built into MÉTA database, considering the contribution of vegetation to ecosystem services *(Czúcz et al. 2008).* Consequently, the greater the area and naturalness of semi-natural vegetation in a landscape, the higher the value of the natural capital index is.

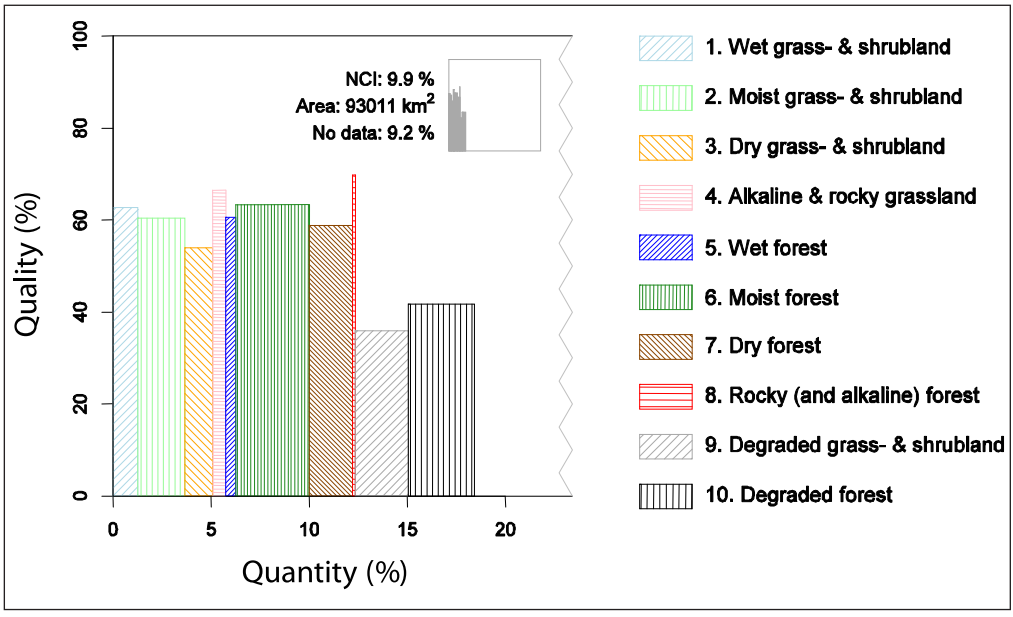

Figure 2: Natural capital of Hungary according to ecosystem types in a profile diagram. To enhance tractability and to reduce the blank space, the X axis does not reach 100%. The small diagram in the top right corner serves as an illustration how the diagram would look like if both axes filled their entire (0-100%) domain.

3. Utilization and interpretation

It is apparent from the definition and the methods of calculations that NCI is flexible enough to give evaluations of landscapes at various scales. An important and advantageous property of this metric is that it can be used for quick and superficial comparisons, as well as extensive and detailed evaluations. NCI values for larger areas can namely be disaggregated in various ways into the sum of different components:

Thematic disaggregation: the contribution of specific ecosystem types to the overall NCI value of a larger region can be easily estimated in a straightforward way. Thematic disaggregation produces a kind of habitat-profile, characteristic to the vegetation-heritage of an area (Figure 2-3).
Spatial disaggregation: the NCI value of a larger region corresponds to the area-weighted average of NCI values of its sub-regions, no matter how the sub-regions are delineated. This rule can help to identify the specific contributions of any area of interest to the NCI of the larger region (Figure 3).

The evaluation of the contributions of different subregions and ecosystem-types can bring new perspectives for policy applications. Flexible disaggregation makes it possible in a decision-making process to survey not only the factual quantitative values, but also the underlying causes and patterns. Consequently, this standardized metric can be used successfully in local and regional policy-relevant decision-making to handle practical questions or in planning and authorization tasks, as well as in environmental communication.

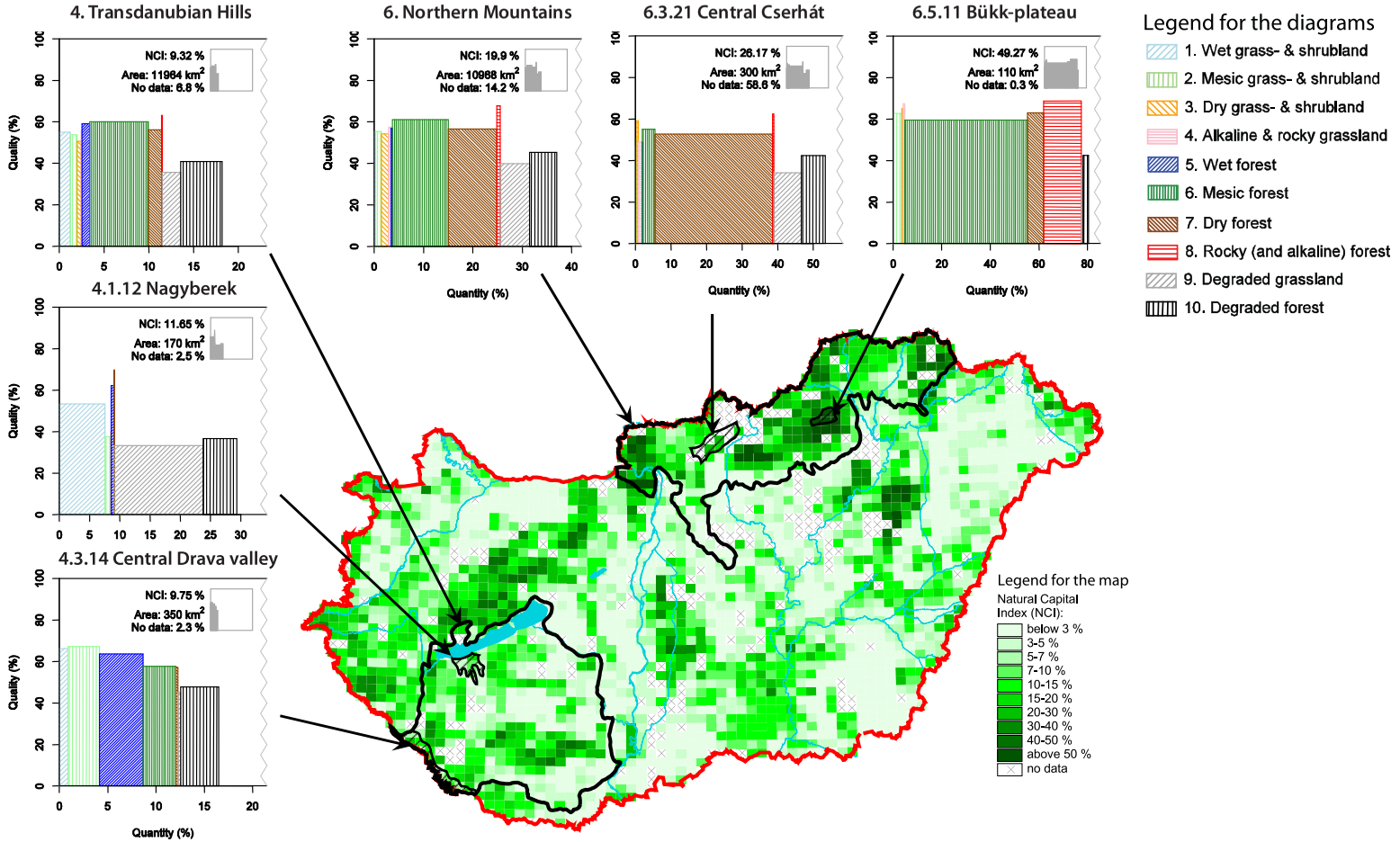

Figure 3: A NCI map of Hungary showing the NCI values of each MÉTA quadrat (~5×5 km), with profile diagrams for a series of nested geographic macro- and micro-regions.

4. Limitations and research needs

As every indicator, also the Hungarian vegetation-based natural capital index has several important limitations, which have to be taken carefully into account to avoid misleading interpretations. These limitations follow directly from the characteristics of the underlying datasets and the methods of calculation:

- The MÉTA database is the result of a single non-repeated survey *(Molnár et al. 2007).* Consequently the NCI values calculated from the MÉTA database all represent ecosystem state at the time of the survey. Updates (new surveys) for smaller areas are simple, but for larger areas a complete survey may be infeasible. The site network of the Hungarian National Biodiversity Monitoring Network (NBMR), which covers 3% of the country and gets resurveyed every 8 years with a fundamentally similar methodology, can also add some temporal perspective *(Takács and Molnár 2009)*. The use of these new maps and older, reconstructed habitat-maps offer the possibility of monitoring NCI changes *(e.g. Biró et al. 2006).*
- According to the characteristics of the MÉTA database, vegetation-based NCI primarily focuses on natural and semi-natural habitats, whereas anthropogenic habitats are hardly represented in the currently used version of this aggregate metric database. Nevertheless, agricultural and urban sites can harbour significant biodiversity if managed properly, and provide relevant ecosystem services to the society.
- Being an essentially linear, additive metric method, NCI cannot capture outstanding natural values. Unique values and other important nonlinear characteristics (like presence of specific and rare species, historical or landscape values, regeneration potential, etc.) need to be taken into account separately.
- NCI does not consider the spatial pattern of the individual patches (landscape ecological characteristics of the studied region). As an indicator of dynamic processes, landscape structure can be an important component of ecosystem integrity, for which MÉTA database offers additional metrics.

If these limitations are carefully observed and respected, the overinterpretation of the NCI values can be avoided. Vegetation-based NCI, as a standardised indicator, describes the ecological state of larger areas from just one perspective (even if it is perhaps the most general and meaningful from all the possible perspectives). In order to get a more complete analysis, NCI alone is not enough, and many other aspects and characteristics of local ecosystems should also be considered.

To improve the reliability of vegetation-based NCI, agricultural and urban areas should be more realistically represented in the underlying data sets. As there are detailed data sources for agriculture and land use, such improvements could even be incorporated retrospectively.

One further important task is to perform case studies, which estimate the connection between NCI and other relevant ecological and environmental indicators. Such studies could provide an important justification, and delineate a scope of practical utility for the use of this relatively simple indicator.

NCI is a useful tool in a broad range of local and regional policy contexts, as well as environmental communication. For critical decisions, decision-makers have to be familiar with all important aspects of the situation, and thus a limited selection of NCI values alone may not constitute an appropriate basis for the decision. As it is true in general, no single metric can replace professional competence and detailed local knowledge.

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