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NATURAL VEGETATION BASED LANDSCAPE INDICATORS FOR HUNGARY I.: CRITICAL REVIEW AND THE BASIC 'MÉTA' INDICATORS

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Abstract: In the present article we give a critical review about those biodiversity indicators that are in connection with the landscape and the vegetation. Besides, we describe the indicators deriving from the only GIS database, which contains ecologically relevant data for the whole territory of Hungary. Quantity (area), pattern, quality and combined indicators are used globally and at the scale of Europe. Most of these are ecologically irrelevant, principally due to the lack of relevant data. Few indicators are actually employed, but developments are still in progress. On the grounds of the MÉTA database (Landscape Ecological Vegetation Database for Hungary), constructed between 2002 and 2008, we propose the use of the following landscape and vegetation indicators for Hungary: habitat area, habitat texture of the landscape, area of old-fields, regional coverage of invasive species, habitat diversity, Natural Capital Index, area of high value natural areas, proportion of naturalness classes, structural habitat connectivity. Some of these indicators would also be applicable in the Hungarian Biodiversity Monitoring System. In the future, there will be serious need for the elaboration and testing of further indicators, as well as for their detailed definition and their introduction in practice.

Indicators for measuring and communicating status of biodiversity

The main purpose of the elaboration of biodiversity indicators is to enable the measurement of the changes in the surrounding environment, the sustainability of the ecological processes, and subsequently to endow the communication of the information to the society. Another goal is to support the political and economical decision making so that to turn human activities toward a more sustainable world (see, for example, the approach to the CBD objectives of 2010, UNEP 1992, EEA 2007). Therefore, the indicators are primarily not the tools of scientific research, but a kind of service provided by the science for different social strata, on account of the processes of sustainable development, almost everywhere on the face of Earth. So the development of indicators intended to provide special scientific support for the related fields of policy during planning and monitoring. Meanwhile, general indicators, like the GDP in economy (BULLA and GUZLI 2006), are also required. We denominate all the indicators that are related to the state of the living environment – more or less imprecisely – 'biodiversity indicators'. Indicators are generally sorted into a DPSIR (Driving force, Pressure, State, Impact, Response) system, where biodiversity indicators mostly belong to the group of state indicators. In the present article we review the vegetation-based landscape ecological state indicators, then we summarize the basic landscape state indicators that are originated from the MÉTA database (Landscape Ecological Vegetation Database for Hungary).

Biodiversity indicators have been under development since the early 1990's (UNEP 1997, 1999, 2001, OECD 2001, EEA 2000, 2001a, b, c, 2002, EUROSTAT 2001, EEA 2007). Each developmental work uses slightly different terminology and their emphases also differ. Moreover, dissimilar methodology and differing basic datasets of each country led to heterogeneity regarding their indicators. Though we admit that these differences should be harmonized in the long run, now and in the close future, it is more important to begin the measurements, the evaluation of the processes and the communication of the results to the society, than the total harmonization and standardization.

Need for and limitations of quantification and simplification

To enable the characterization of the natural states or to measure their changes, we should quantify them. The world surrounding us is far too complex, so we simplify this complexity and summarize it in the values of indicators. There are many criteria used to select useable indicators, but we have to emphasize that there is no such biodiversity indicator that fills all the requirements. A list of these criteria – based mainly on EEA (most important ones in italics) – are as follows: be policy relevant; provide factual, quantitative information; be responsive to change; be useable (suitable) for scenarios for future projections; monitor progress toward the quantified targets (or thresholds) (means ecologically relevant); be founded on readily available and routinely collected data*;* be consistent in spatial coverage; be sufficient time coverage; be at least national in scale if possible; be understandable (easily comprehensible) and simple; be conceptually and methodologically well founded and representative; be timely.

In practice, the purpose is to use as few indicators as possible, and to apply them in the most efficient manner. In case of landscapes, actual landscape knowledge and relevant landscape models would aid to select a minimum indicator set. Only if we understand the basic functioning of the landscapes, we can select the most relevant indicators.

Selection and calculation of indicators necessarily mean information loss. If we combine datasets we should face with the problem of weighing, and the so important spatial heterogeneities would also be weakened or even eliminated during the calculation. Though, landscape ecological indices simplify the real world very efficiently, they often loss their ecological relevance, in the same time. When evaluating vast areas (countries or continents), another problem is that we have insufficient data on the landscape, vegetation and the fauna, thus we have to use CORINE Land Cover data (BÜTTNER et al. 2002), instead, that are often ecologically irrelevant (in details, see bellow). Although several ecological indicators have been elaborated, only few proved to be suitable and was applied in practise (see below), since relevant ecological features are difficult to quantify. As a result of the methodological difficulties and the insufficient available data, the elaboration and development of indicators is a long-term process, being presently in progress.

What kind of landscape and habitat characteristics should we measure? For instance, the functional quality of the landscape and the habitats, landscape health, the naturalness of the landscape, its regeneration ability, stability, carrying capacity, beauty etc., because the more area is covered by natural habitats in a landscape, and the more close to natural the state of these habitats is, the better the condition of the whole landscape is considered to be, if no direct or indirect human disturbances (e.g. invasive species) endanger the natural processes.

In the present article we review the state indicators ignoring the pressure and response indicators. To the latter category belong, for example: the extension of the protected areas, the money spent on nature conservation, while to the former one: the amount of the different polluting substances, the type of land-use and the change in land-use. The only exception, discussed in this publication, is the indicator 'invasive species', being both state and pressure indicator, at the same time.

Review of landscape and vegetation related indicators (global, European, Hungarian)

In order to fulfill the above mentioned requirements, for the elaboration of the up-to-now developed indicators primarily either the available datasets or those being elaborated in the near future were taken for basis. This should have been done, since we do not have the appropriate methodology for quantifying some of the above characteristics, and further basic research is needed for the development of the proper techniques (e.g. in the case of some ecosystem functions and ecosystem services). So, when defining the indicators the availability of data, the possibility of quantification and the ecological relevance were balanced, generally, at the cost of the latter principle.

Furthermore, most of the indicators, discussed below, are only proposals, and have never been used in practice (at most in pilot projects or only in certain countries). Thus, indicator systems actually in use (or those that will be used in the near future) are also introduced in details after the general overview.

Quantity indicators

Most indicators measure the current extension or the change in the area covered by natural or semi-natural vegetation. Generally, they treat vegetation types in a few, joint or in some major habitat categories (woodland, grassland, wetland). Finer resolution cannot be achieved with these indicators, because the evaluation of broader areas is based on land cover data. These indicators ignore the condition of the habitats (e.g. all the European natural and degraded forests are joined in a single category), the landscape structure, the regeneration potential and the stability of the remnant vegetation. Actually, quantity indicators can be regarded as first rough estimators; however, their great advantage is that they are quite simple ones that can be obtained via standardized calculations. (For instance, Area and state of indigenous vegetation (e.g. total, woodlands, riverine forest) (UNEP 2001); Area of high nature value (EUROPEAN COMMISSION 2001); Change in area and use of grasslands (EEA 2000, 2002); Area of „natural" forest converted to agricultural use (OECD 2001); Availability of wildlife habitat on farmland (NEAVE et al. 2000); Change in the area of natural and ancient semi-natural forest types (MCPFE 2001); Changes in area of heathland, fallowland and hedgerows (BOSCH and SÖDERBÄCK 1997); Changes in the area of natural and ancient semi-natural forest types (BOSCH and SÖDERBÄCK 1997); Current area of the major land ecosystems/habitats (percentage unconverted to cultivation/infrastructure) (PRESCOTT-ALLEN et al. 2000); Difference in total area of a particular habitat type (UNEP 2001); Ecosystem area (WCMC 1996); Ecosystem quantity: self-regenerating habitat (opposed to man-made) (UNEP 1999); Ecosystem quality: wetland drainage and filling (UNEP 1999); Extent of natural habitats as part of agricultural land (WASCHER, 2000); Extent of semi-natural ecosystems, Extent of habitats listed under the Habitats Directive (DUMORTIER et al. 2006), Habitat loss through habitat fragmentation (UNEP 2001); Net area of aquatic ecosystems converted to agricultural use (OECD 2001); Percentage (extent) of area dominated structurally by non-domesticated species (REID et al. 1993, UNEP 2001) (or rate of change) (classified as woodland, wetland, grassland etc.); Percentage special habitat remaining (UNEP 1999); Percentage wet forest land; Percentage area of biotopes important for biodiversity of total area; Percentage wetland area to total area (BOSCH and SÖDERBÄCK 1997); Preservation of high nature and culture value landscapes (EUROPEAN COMMISSION 2000); Preservation of semi-natural habitats (EUROPEAN COMMISSION 2000); Rate of destruction of water habitats per annum (UNEP 2001); Share of agricultural area covered by semi-natural agricultural habitats (OECD 2001); Total area and changes in the area of forests and OWL which is undisturbed by man, natural or ancient semi-natural managed forest and OWL (MCPFE 2001); Total area of wetlands (BOSCH and SÖDERBÄCK 1997); Wetland loss (EUROSTAT 2001); Trends in extent of selected biomes, ecosystems and habitats (EEA 2002, 2007)).

Pattern indicators

Landscape pattern indicators take the spatial pattern of the remnant vegetation also into consideration (see in detail: Barczi, this volume). Actually, these indicators are very simple landscape structure indices, which are estimated on the grounds of land cover – or more rarely habitat – maps. A general problem of these indicators is that they characterize merely the structural pattern of the landscape, and even this with a rather coarse habitat and spatial resolution, instead of the functional characteristics of the landscape (e.g. the possibility of the species to survive or disperse within their metapopulation). Consequently, the ecological relevance of these indicators is usually quite low. (Nevertheless, they are appropriate tools for the documentation of the exploitation of the native landscapes – for example in the boreal climatic zone or in the tropics.) Additionally, they alter the public attitude very effectively, since they turn the attention of politics from the mere extension data onto the importance of the landscape structure. In the future, these indicators may be improved by the application of new data sources (e.g. more detailed habitat maps) or expedient model-based analyses (see the English example below). (Some examples: Changes in average size of a particular habitat type (UNEP 2001); Changes in largest block of a particular habitat type (UNEP 2001); Changes in mean nearest distance between blocks of a particular habitat type (UNEP 2001); Degree of fragmentation of the unconverted portion of each land ecosystem (PRESCOTT-ALLEN et al. 2000); Density of linear elements and diversity of land cover at the level of the holding (European Commission 2001); Ecosystem quality: native vegetation fragmentation (UNEP 1999); Forest physical fragmentation (BOSCH and SÖDERBÄCK 1997); Structural indicators related to forest connectivity, forest fragmentation, forest isolation, edge/interior forest (ESTREGUIL et al 2004); Lenght of linear landscape features in the habitat; Linkages between valuable natural/semi-natural habitat types (WASCHER 2000); Size of selected (threathened) ecosystem (BOSCH and SÖDERBÄCK 1997), Fragmentation of natural and semi-natural areas (EEA 2007)).

Quality indicators

Measuring the condition of the habitats is much more difficult than their quantitative analysis, since it requires more field data (the interpretation of satellite images is insufficient for this purpose). Most often textural quality indicators are applied, such as species lists and abundance data of the species (with the application of phytosociological or floral data). If these indicators rest on large, representative data collected in time series, they measure efficiently the changes in species richness, homogenization of the vegetation and the invasion of weeds. However, they are sometimes used for the rough evaluation of extensive areas, when their relevance decreases. (Such indicators are for example: Change in the number and percentage of threatened species in relation to the total number of forest species (MCPFE 2001); Ecosystem quality: percentage of total species threatened (UNEP 1999); Ecosystem quality: species richness (UNEP 1999); Living Planet Index (UNEP-WWF 2004); Presence and abundance of species with different conservation values and life strategies (SIMON 1988, BORHIDI 1995, KOVÁCS-LÁNG et al. 2000); Presence and abundance of threatened and specialized species (FAMMLER et al. 1998); Species in dry grasslands (EEA 2000); Species richness (number of species per unit area or habitat type) (REID et al. 1993, UNEP 2001)).

For woodlands, further quality indicators have been developed. These estimate the state of naturalness and functionality of the forests on the grounds of the stand structure, age distribution and the dead wood density. (For instance, Complexity and heterogeneity of forest structure (African Timber Organization), Total volume and changes in volume of deadwood by forest type and decomposition stage, (MCPFE 2001, HAHN and CHRISTENSEN 2004), Forest: deadwood (EEA 2007)). We have find no similar indicators elaborated for the grasslands.)

There are indicators, which quantify the spread of invasive species. Since data deriving from fine-scale surveys are lacking, these indicators mainly measure the cumulative change in the number of the invasive species observed in the landscape (or else the money spent on their eradication). Less often they measure the area covered by the invasive species or the extension of the (semi-)natural vegetation degraded as a result of the invasion. Thus, they are relevant only on the national (or on coarser) scale, and their quantification is quite poor. (They are e.g. change in presence, location, area, numbers of invasive plant or animal species (UNEP 2001), Number and costs of invasive species (EEA 2002); Percentage habitat colonized by invasive species (UNEP 1999), Percentage of habitat colonized by invasive species (UNEP 2001), Invasive alien species in Europe (EEA 2007)).

Further general, but improperly defined quality indicators also exist. (E.g. Ecosystem quality (WCMC 1996), Landscape heterogeneity, Habitat diversity (WASCHER 2000)).

Combined indicators

We discuss the Natural Capacity Index (NCI, TEN BRINK 2000) separately, since this index aims to characterize both the qualitative and quantitative changes of the habitats. Quantity is measured as the percentage area of the habitat to the whole region, while quality is represented by the percentage change in the abundance of the characteristic species of the habitat to an imaginary pre-industrial baseline. Finally, the multiplication of this two percentage values gives the NCI value. This index is very suitable for spatial comparisons (see below), but it is difficult to construct time series of it, since this calculation requires pre-industrial population data or other habitat quality data. Additionally, it ignores also the landscape structure.

International initiatives on indicators, indicators in practice

Since Hungarian landscape/vegetation indicators should be at least partially consistent with those of other European countries and of the EU, we review them in more details in this separate section. Experiences on the development of global indicators cannot be used for the elaboration of our national indicators, because their resolution is not as fine as it is required on the level of a country, due to the nature of data available on the global scale.

Convention on Biodiversity (UNEP 1992) played an important role in the development of the indicators. Presently, the following landscape/vegetation CBD indicators are known (UNEP 2005): (1) Trends in extent of selected biomes, ecosystems, and habitats (forests and forest types, peatlands, (natural) grasslands, inland wetlands etc.); (2) Connectivity/fragmentation of ecosystems (potential measures: patch size distribution of terrestrial habitats – forests and possibly other habitat types; fragmentation of river systems). The aim of these indicators is to evaluate the process of approaching the goals of 2010.

EU Indicators (EEA 2004a, b, 2006, 2007) are to be consistent with the CBD indicators. EU has several different landscape/vegetation indicators. (1) The value of the indicator named ‘Trends in extent and composition of selected ecosystems in Europe: Ecosystem coverage’ is calculated on the grounds of CORINE Land Cover data collected in 1990 and 2000. Thus, it uses rather broad habitat categories (EUNIS First level: grassland, woodland and forest, mire, bog and fen, etc.) (EEA, however, regards this an appropriate resolution). (2) ‘Trends in extent and composition of selected ecosystems in Europe: Habitats of European interest’ will be calculated based on report on the Habitats Directive, so habitat resolution will be much higher. (3) The indicator called ‘Connectivity/Fragmentation of ecosystems: Fragmentation of natural and semi-natural areas’ is calculated on the grounds of CORINE Land Cover data collected in 1990 and 2000. (4) The indicator ‘Invasive alien species in Europe’ measures the cummulative species number of invasive species per country or Europe. (5) For forests the ‘Deadwood’ quantity is measured. In 2002, some further indicators were recommended for EU Headline indicators, but most of these were rejected because of the insufficient data and/or the lack of reliable methodology. Some of the omitted ones are the Natural Capital Index (NCI, TEN BRINK, 2000), Habitat Index (undisturbed area + 0.25 (partially disturbed area)/total area * 100 (HANNAH et al. 1994), Biological Quality Index, Relative Wilderness Index. Some further indicators are under development, but also the objectivity of the two mentioned ones could be improved.

Only a few country reports have been published with the application of biodiversity indicators, and one of the most accurate is the English one (DEFRA 2007). This report deals with many indicators that are based on representative datasets, though, concerning several of them, only the process of the development is discussed. (1) Status of UK

Biodiversity Action Plan Priority habitats (key indicator): qualitative assessment (repeated on a five yearly cycle) of whether a habitat is showing evidence of recovery, of remaining stable or of deteriorating. 45 habitats were monitored. Data are not suitable for quantitative evaluation. (2) Plant diversity (based on the phytosociological data of the Countryside Survey, with major habitat categories), (3) Invasive species: this indicator will summarize the abundance of non-native species and quantifies their impact on biodiversity. The indicator is under development. (4) Habitat connectivity: This indicator is also under development, and will measure functional connectivity using modelling to map the habitat network for certain hypothetical species that represent the requirements of a range of actual species. The evaluation of the landscape/vegetation biodiversity indicators of Flanders (Belgium) (DUMORTIER et al. 2006) reveals the actual state, and it does not include time series about the extension of the habitats and the connectivity. For most habitats, principally the Natura 2000 base data are given.

Hungarian experiences on biodiversity indicators

There is no generally accepted biodiversity indicator set for Hungary. However, several surveys have been conducted on environmental condition, with the application of indicators. Among these, the last two ones, independent from each other, will be discussed here. The State of Hungary's environment, published in 2005 (RAKICS 2005), is astonishingly poor concerning landscape ecology and the habitats. The sole indicator, which is in connection with them, is the health condition of the woodlands, but it handles all the deciduous forests in a single category, i.e. it joins beech and oak forests with black locust and poplar plantations. Noteworthy is the fact that referring to vegetation/landscape this evaluative work does not talk about the 'environmental state' but 'landscape and nature conservation', so it uses only response indicators. The Ministry of Environment and Water planned an demanding survey on the environmental condition of Hungary for 2006, but it is not yet published.

In the same time, Hungarian Central Statistical Office and VÁTI published a more detailed, exhaustive report with more and relevant maps (Environmental statistics atlas of Hungary, RAUSZ 2005), yet this work also uses only three landscape/vegetation state indicators: (1) change in the extension of woodlands (unfortunately, it consolidates (semi)natural woodlands and plantations in a common category, though this database would be suitable for the evaluation of the distribution of each tree species, which would reveal both the absolute and the proportional decrease of the area covered by native forests), (2) the health condition of the forests (also combining the categories of (semi-)natural and characterless stands, though woodlands with great and without any natural value could be discussed separately also in this case, and even further approaches would be reflected). (3) The fire hazard category of the regions and the area of forests burnt between 2002 and 2003. Consequently, all these indicators (being based on the data of the State Forest Service) are related to woodlands, and no biodiversity indicator can be found among them. Data on the ecological state and biodiversity of grasslands and wetlands are completely lacking. It is important to indicate that this need could be supplied already in the close future with the application of data obtained from the Hungarian Biodiversity Monitoring System (NBmR, e.g. KOVÁCS-LÁNG and TÖRÖK

1997, TÖRÖK and FODOR 2007) the MÉTA, the Flora mapping (KIRÁLY 2003), the TERMERD (BARTHA et al. 2003) etc. Surprisingly, data on the extension of protected areas cannot be found in the chapter on social response, but in the one dealing with nature conservation (sic!), moreover, the chapter titled 'landscape protection' (sic!) discusses destructions of the landscape caused by mining. As far as we know, the atlas is going to be re-published, when the mentioned gaps could be mostly filled by the inclusion of new data resources.

When preparing the above mentioned works, the authors might have taken the National Base Indicator System (NAIR) into consideration, the development of which, however, ceased – possibly due to the disincentive of the politics. The 1st and 2nd National Development Plans also demand the use of indicators, but e.g. the realisation of the environmental indicators was not consistent, and only country level, very general monitoring is planned (based only on the Habitats Directive report).

Although certain actions were taken to collect some ecologically more relevant data for the national forestry register, but the work has not been accomplished, yet. The naturalness condition of the Hungarian forests was expediently measured in a study by Hungarian botanists and foresters (BARTHA et al. 2003). Based on a representative dataset compiled in the detailed survey of 3000 different forest districts, TERMERD Program has calculated 11 different indices really relevant in the sense of forest ecology (composition and structure of the tree, shrub and grass layer and also of seedlings, dead wood characteristics, the effect of the game and site conditions), all of which is weighed index. As a consolidation of these indices a general principal index was calculated for the whole country. With proper repetition, the methodology and indices of TERMERD are appropriate national indicators.

The habitat mapping program of the NBmR (KOVÁCS-LÁNG and TÖRÖK 1997, KUN and MOLNÁR 1999, TÖRÖK and FODOR 2007), including the vegetation mapping of 125 5×5 km study sites at a scale of 1:25 000 (together with the documentation of the Á-NÉR categories and the estimation of their naturalness), would be a proper basis for the elaboration of several ecologically relevant indicators that represent appropriately our country as a whole. The recommended and tested indicators are: the percentage area of the habitats, the spatial distribution of the Á-NÉR categories, Á-NÉR diversity weighed by naturalness, the distribution of (semi)natural and degraded areas, change in the state of naturalness, change in landscape fragmentation (proportion of edges), the history of the habitat patches, change in the area of invasive species (HORVÁTH 2006, BIRÓ et al. 2006). The phytosociological monitoring program of the NBmR appropriately monitors the changes of species composition, though only in the case of some certain, distinguished Hungarian plant communities. We will be able to obtain regional indicators also from the records and monitoring reports of the Natura 2000 habitats. The monitoring program connected to the Habitats Directive is under development in Hungary. It will also certainly produce some biodiversity indicators.

We can consider the indices, calculated from the results of the program 'Monitoring of Our Common Birds' (MMM) (SZÉP and NAGY 2006) organized by the Monitoring Centre of MME-Birdlife Hungary, as indirect habitat indicators. EU Farmland birds indicator, being the only biodiversity indicator among the twelve items of the EU Structural and Sustainable Development Indicators set, derives from the Pan-European Common Bird Monitoring (PECBM). Nevertheless, MMM avowedly monitors only the state of the common landscapes (and the index concerns only the agrarian landscape), and thus it only indirectly measures the change in the condition of certain habitats. On the same time, this one is the best biodiversity indicator that reflects the general landscape quality of Hungary.

Landscape ecologists from earth sciences have also developed landscape indicators. CSORBA (2005), and BARCZI (this volume) suggested the following indicators of ecologically relevant landscape pattern and landscape functionality. (1) Pattern: measured by perimeter/area ration, patch shape, patch density, patch size distribution and boundary length based on CLC; (2) Landscape diversity: Shannon diveristy of CLC, or MÉTA classes or the categories of the National Ecological Network; (3) Land-cover stability: based on the analysis of historical map series (the geocoded version of several historical military map of the country is already available, but landscape pattern has not been digitalized yet, so this indicator cannot be calculated presently); (4) Landscape coherence: landscape fragmentation and isolation measured by connectance index and patch cohesion index; (5) Landscape health: based on hemeroby and landscape fragmentation (the method for its quantification has not been elaborated, yet). The purpose of these developments is to carry out landscape ecological analyses on geographic bases, although, they declaredly do not aim to prove the ecological relevance.

A new, ecologically relevant, GIS database for Hungary

Up to now, no such ecologically relevant, detailed database was available in Hungary that covers the whole country and which would serve as a ground for the development of different indicators proper for the characterization of all the Hungarian habitats (Á-NÉR) and landscapes. In 2002, we had the possibility to begin the elaboration of such a database. Below, we discuss briefly the most important features of the MÉTA (for details see MOLNÁR 2003, BÖLÖNI et al. 2003, MOLNÁR et al. 2007), then we review the indicators we have developed and the ones being currently under development.

MÉTA program undertook the mapping of the natural vegetation heritage of Hungary (2002–2008). Since we were to use the MÉTA dataset for different scientific, practical and educational purposes, the mapping aimed at the simultaneous documentation of the vegetation and the features of landscape. In order to characterize the landscape as precisely as possible, we documented altogether 17 different features, which reflect the condition of the landscape and the vegetation, as well as the threatening factors. Most of the characteristics cannot be estimated from remotely sensed material, and only an expert can document them during field work, with thorough knowledge on the landscape and the vegetation. The relevant scale of many attributes is some hundred metres, so the mapping process itself had to be spatially detailed.

The mapping was conducted in a hexagonal grid, each hexagon with an extension of 35 ha; mappers spent cca. 7000 days with the field-work. Data are stored in a SQL database, where currently about 94% of the data is compiled.

The most important attribute is the list of the vegetation types of the landscape in case of each hexagon. The system of vegetation types used for the mapping is not as detailed as the traditional phytosociological classification system, but more delicate than that of the land cover mapping. We documented the extension of the vegetation types within the hexagons and their naturalness, we estimated their regeneration potential, the potential vegetation, the neighbourhood of vegetation patches (whether it is sustaining or destructive), their isolation, the characteristic land-use of the grasslands (grazing or mowing), the extension of old-fields and threats endangering the survival of the vegetation (22 different threats were examined), with special emphasis on invasive species (MOLNÁR et al. 2007).

Vegetation-based landscape ecological indicators originating from the MÉTA database

Each indicator is introduced according to the following features: name and definition, what is the reason for its usage, the methodology of its measurement and/or estimation, its consistency with the international indicators, how can be time series constructed for it. Some of the indicators are currently under development, what is also indicated in description.

1. Habitat area: the total area of a certain habitat (e.g. Á-NÉR, Natura 2000) or a group of habitats (e.g. woodland types, zonal habitats, wetlands) or the proportion of its area to the total extension of the region or the whole country. Being a quite general indicator it is consistent with several CBD and EU habitat indicators. However, when applied for Hungary, it is worth using a much finer classification of the habitats, what is also possible on the grounds of the MÉTA and the NBmR. Time series can be constructed from the NBmR and Natura 2000 monitoring or by repeating the MÉTA mapping in about each 10 years.
2. Area of old-fields: actually, a sub-type of the 1st indicator (for old-field can also be regarded as a habitat type), yet no such international indicator exists. It is a rather precise indicator for measuring the land-use intensity and the extension of the areas with good chance to regenerate, as well as for the prediction of the potential spread of invasive species. Time series can be derived in the future from the data of NBmR and MÉTA.
3. Regional coverage of invasive species/Natural area affected by invasive species: the extension of the area covered by invasive species and/or the (semi-)natural vegetation infected by them. Similar international indicators are currently under development. Time series can be derived in the future from the data of NBmR and MÉTA.
4. Habitat diversity: the number and/or the diversity of habitats in a certain region. It is legitimate only in relation to a baseline. Similar international indicators are currently under development. Time series can be derived in the future from the data of NBmR and MÉTA. Possibly, for the evaluation of the landscape, it would be more important to estimate how many habitats are missing from the habitat list of a certain landscape. (For this purpose, suitable local references are required.)
5. Natural Capital Index: the multiplication of the percentage area of (semi-) natural vegetation and the actual quality of the patches. The latter multiplier is given as a percentage proportion to the natural or the "best" condition of the habitat or sometimes to a baseline. In Hungary, the use of the Németh-Seregélyes naturalness classification system is more expedient for the estimation of habitat quality, than the change in population size of certain species. This enabled us to define a baseline

(namely the best possible ('ideal') natural condition of the habitats); what is not always possible if we use data on the abundance of the species (TEN BRINK 2000). Further advantage of the method is its applicability to man-made, semi-natural habitats: the baseline in this case is not the best 'ideal' natural state, but e.g. the state of the hay meadow having covered the area prior to the establishment of the intensive agriculture. This indicator is very suitable for predictive modelling. Though the author (TEN BRINK 2000) recommends the replacement of indicators on natural condition with pressure indicators, we reject this, even in the short run. In our opinion, this indicator has bright prospects, because it is simple, relatively easy to standardize, measure and to communicate to the society. For Hungary, time series can be constructed on the basis of the data of NBmR and MÉTA.

6. Area of high value natural areas: a sub-type of the previous indicator, when we give only the percentage area of habitats with naturalness over a determined value (e.g. 'the bests' i.e. vegetation patches with the naturalness value '5'). Similar international indicators exist. Time series can be derived in the future from the data of NBmR and MÉTA.
7. Proportion of naturalness classes: the distribution of the naturalness values of the habitats in the landscape. No similar international indicator exists. Time series can be derived in the future from the data of NBmR and MÉTA.
8. Structural habitat connectivity/fragmentation: gives the spatial fragmentation and structural connectivity of the habitats and the habitat groups. It can be calculated for example with the application of the proximity index of landscape ecology (GUSTAFSON and PARKER 1992), but other international calculation method might also be acceptable. Expedient modelling could be accomplished with the use of hypothetical species. Time series can be derived in the future from the data of NBmR and MÉTA.

Future prospects

The MÉTA database offers a series of further relevant potential indicators. Some of them are as follows. 'Difference of potential and actual vegetation', that shows how far the actual vegetation of the landscape (the list and pattern of its vegetation types, its extension and natural condition) differs from the natural vegetation. 'Regeneration potential of habitats' demonstrates the regeneration possibilities afforded by the actual condition of habitats and by the surrounding landscape. Though this is an ecological function of great importance, its quantification is rather difficult, so the elaboration of this indicator requires further basic research. 'Ecosystem stability' is another essential component of ecosystem functions and services. The development of this indicator also needs further basic research. 'Pressures to natural habitats' is a pressure indicator that consolidates the different threatening factors endangering the natural habitats (a certain kind of hemeroby value). It is important to note, that this indicator have to aggregate not the potential but the realized effects! 'Areal proportion of protected natural habitat' is also a response indicator that shows the proportion of the actually protected area to the total extension of the (semi-)natural habitats that should be protected. It is more precise than the 'protected area' indicator, because it does not calculate with the total extension but with the area of the (semi-)natural habitats. (Actually, the difference between the values of the protected and non-protected areas can be calculated in the case of all the above-mentioned indicators.)

In the future, the improvement of the MÉTA database and the accomplishment of its possible analyses will give us the opportunity to test and evaluate the applicability and reliability of the indicators. Subsequently, we can start their use in the qualification of environmental conditions, as well as their introduction to the society.

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TERMÉSZETES NÖVÉNYZETRE ALAPULÓ TÁJI MUTATÓSZÁMOK I.: ÁTTEKINTÉS A HASZNÁLT MUTATÓSZÁMOKRÓL ÉS A MÉTA ALAP-MUTATÓSZÁMAI

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Kulcsszavak: tájökológia, biodiverzitás mutatószám, élőhelykiterjedés és -minőség, özönfajok, tájmintázat, Magyarország Élőhelyeinek Térképi Adatbázisa (MÉTA), térinformatika, természeti tőke értéke

Összefoglalás: A cikkben a biodiverzitás mutatószámok közül a tájjal, növényzettel kapcsolatos mutatószámokról készítettünk kritikai áttekintést, valamint megadtuk a hazánk egyetlen, ökológiai szempontból kellően releváns, teljes országot fedő GIS adatbázisából származtatható mutatószámokat. A globális és európai léptékekben használt mutatószámok mennyiségi (területi), mintázati, minőségi és összetett mutatószámok. Ezek jelentős része ökológiailag nem kellően releváns, aminek a fő oka a megfelelő adatforrások és monitorozó programok hiánya. A mutatószámok egy része már használatban van, de a fejlesztések tovább folynak. A 2002 és 2008 között készített, Magyarországi Élőhelyek Térképi Adatbázisa (MÉTA) alapján Magyarországon a következő táji, vegetációs mutatószámok használatát javasoljuk: élőhelyek kiterjedése, parlagok kiterjedése, özönfajok kiterjedése, élőhely-diverzitás, természeti tőke értéke, magas természeti értékű területek kiterjedése, természetességi osztályok aránya, élőhelyek strukturális összekötöttsége. A mutatószámok egy része a Nemzeti Biodiverzitás-monitorozó Rendszer keretében is jól alkalmazható. Az elkövetkezőkben további mutatószámok fejlesztésére, tesztelésére, értelmezésére és használatuk bevezetésére van szükség.