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Do landscape structural patterns reflect Ecosystem Service provision? – A comparison between protected and unprotected areas throughout the Neusiedler See region

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Abstract

Nowadays, anthropogenic fragmentation is known as a major reason for the worldwide loss of biodiversity. Though nature conservation areas, such as Austria´s National Parks are in situ serving as retreat habitats for a broad range of biota, they are embedded in a complex of landscapes where diverse conflicts of interests like tourism, agriculture and nature conservation coincide. As a first step to enhance the connectivity of landscapes across the borders of protected zones, the status quo and trends of ecologically valuable landscapes have to be evaluated. The main aim of this study was to assess the additional benefit in the provision of important ecosystem services and structure based functional state thatprotected areas are sharing compared to unprotected sites, conducted within an Austrian-Hungarian transnational study region around the Neusiedler See. Therefore, we developed a methodological framework for assessing and mapping ecosystem services based on expert knowledge, spatial information and field data. Further, the crucial relationships between structural patterns and corresponding functional indicators were investigated by the comprehensive use of landscape metrics. Additionally, to get an overview upon landscape connectivity and quality of ecological networks within the region, a series of spatial analysis have been performed. The outcomes of this study provides local stakeholders with valuable information on the service provision capacity and functional statein and outside protected sites andadditionally illustrating hot and cold spots of network patterns.

Keywords

Ecosystem Services, Landscape Functionality, Landscape metrics, Biodiversity, Green Infrastructures

Introduction

During the last few decades, the demand for natural resources has grown considerably due to exponential economic growth, resulting in an enormous pressure on Earth´s ecosystems. As a consequence, our society is faced with various negative effects on the environment, such as habitat loss, fragmentation and degradation, climate change, biological invasions, overexploitation and pollution at global, national and regional level. Especially European cultural landscapes are characterised by a high level of anthropogenic fragmentation and habitat loss which are known as major reasons for the decline of biodiversity in industrialised countries. Countering this development requires an evaluation of the status quo and trends of ecologically valuable landscapes. Two promising possibilities to provide the knowledge basis in meeting the needs of a sustainable development and conservation management inside and outside protected areas are introduced and compared within this study. First, the concept of ecosystem functions, goods and services (MEA 2005) has gained increasing attention in the last years as it highlights the importance and benefits of ecosystems for human welfare. Several authors have dealt with function- and service evaluations (e.g. Costanza et al. 1997; Daily et al. 2000; de Groot et al. 2002, 2006) and the implementation via stakeholders (Hein et al. 2006). Innovative conservation assessment and planning may profit from this approach because it allows for an integrative evaluation of conservation areas and their contribution to human well-being (Chan et al. 2006; Egoh et al. 2008).

The second approach targets on geometrical aspects of the landscape as the crucial relationship between structural patterns and functional indicators in landscapes has continually been stressed (Turner et al. 2001; Moser et al., 2002; Forman 1995; amongst others). It comprises a combined assessment of structural-based landscape functionality (Kuttner et al. in press) which had been developed to provide a comprehensive overview upon landscape connectivity and to evaluate the location and quality of ecologically valuable landscape elements and networks. In this regard, a functioning corridor network that provides dispersal and migration possibilities for a broad range of organismal groups is crucially contributing to the ecological viability and hence functionality of a landscape. Summarised under the term “Green infrastructure” (Benedict & McMahon 2002), the composition and configuration of suitable habitats and corridors for a virtual species group was also investigated within the target region.Another objective of this study is to implement and to compare both concepts of quantifying ecosystem services and landscape structural functionalityby placing a special focus on the comparison between protected and unprotected areas in the Neusiedler See / FertöHanság region. We are aiming to identify hot and cold spots of ecologically relevantecosystem services and ecological networks and to particularly test strength and quality of coherence between the aforementioned assessments.

Study region and methods

Study region

The investigation area is located on both sides of the border between Hungary and Austria. Altogether an area of 2,015 km² is covered (1,120.8 km² located in Austria and 894.2 km² in Hungary, respectively) (see Figure 1).

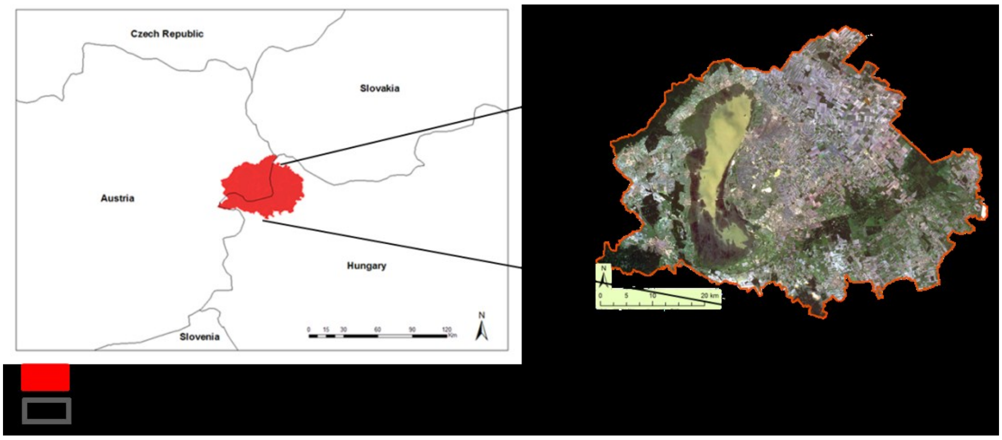

Figure 1: Location of the investigation area withinthe cross boarderregionAustria and Hungary

The predominant climate is Pannonian with annual precipitation rates around 600-800 mm and annual mean temperature of >9°C (ZAMG 2002). The continental lake basin between the Alps and the Carpathians is a north-western overhang of the Small Pannonian Plain at the foothills of the Leitha Mountains and the Rust Hills. The low-lying area encircled by hills and terraces of the immense gravel bed of the Danube was once interconnected with the former Hanság marshland. Today, artificial channels intermingle with the reclaimed lowland, stabilising the water level of the lake and the ground water.

The Neusiedler See and a series of small satellite lakes on the eastern part at 'Seewinkel' constitute the westernmost alkali lakes in Europe and the semi-natural zone around them still forms Europe's second largest reed wetland vegetation which is one of the most important bird refuges in Central Europe, both for breeding and migratory birds. Beyond the wetlands the area consists of extremely rich habitats, presenting a transition zone between the mountain ridges and the lowland of the Pannonian basin. From the unique dry alkaline steppe up to the closed deciduous forests a series of different vegetation types result in high biodiversity. Due to the bio-cultural richness of this landscape, nationally and internationally protected areasincluding National parks in Austria and Hungary, Ramsar sites, Biosphere reserves and Nature 2000 sites are predominant here, crowned by the cross-border cultural landscape being classified by UNESCO on its World Heritage List.

Today two main economic sectors are prevalent in the region: on the one hand intensive agriculture, particularly crop-growing, wine growing and greenhouse-vegetable gardening and on the other hand, tourism, especially around the Neusiedler See. Nowadays the main problem is the growing conflict between these two utilisation claims caused by increasingly land consumption for their uses and additionally interfering with nature conservation related issues.

Methods

In order to reach statistically neat results that could either be scaled up and compared, a common spatial reference system has been developed, including a nested sampling design for the selection of test siteswhich followed several stratifications and exclusion criteria. As a prerequisite, the region has been subdivided into seven single Landform types (LFT; KONKOLY-GYURÓ et al. 2010). These LFTs are expressed by geomorphological peculiarities that are forming the major characteristic shapes of the target region, also resulting in greatly varying land use strategies: "Lake Basin", "Marshlands", "River Floodplains", "Low lying terrace", "Elevated terrace", "Hilly area and hill range", "Low and middle range mountains". Within each LFT, six 2x2 km sample sites were randomly selected by applying a predefined set of exclusion criteria, thereof half of the sites are either located in protected or in unprotected areas (see also Figure 2).

Assessment of Structural Landscape Functionality

Single landscape elements were delineated within each of the 2x2 km sample plots by using object-based image analysis of latest orthophoto imagery and manually corrected afterwards by on-screen digitizing. Then, a key for visual land cover interpretation was applied, where the CORINE land cover interpretation system served as thematic basis to identify 65 different land cover classes. The resulting land cover maps were used for landscape structure analysis, where 46 landscape metrics on class level were calculated using *Fragstats 3.3* (MCGARIGAL et al. 2002). The resulting indices were computationally reduced to 13 in order to gain a core set of most meaningful metrics for the quantification of landscape functionality. As a precondition for proper assessing landscape functionality, the different land cover classes were sectioned into six functionality groups (*Connecting Corridors*, *Dissecting Corridors*, *Valuable Matrix*, *Disturbed Matrix*, *Artificial Matrix* and *Stepping Stones*) and metric outcomes were either positively or negatively related to each of the groups, followed by an aggregation process to reach one final value of landscape functionality. Further, to detect most valuable green infrastructure (GI) elements and network structures, a morphological spatial pattern analysis plus additional cost distance mapping were applied for a predefined virtual species group called "Specialists" which would require less or non-disturbed parts of the landscape as their living space. For further information on the technical part of this study please see also KUTTNER et al., in press.

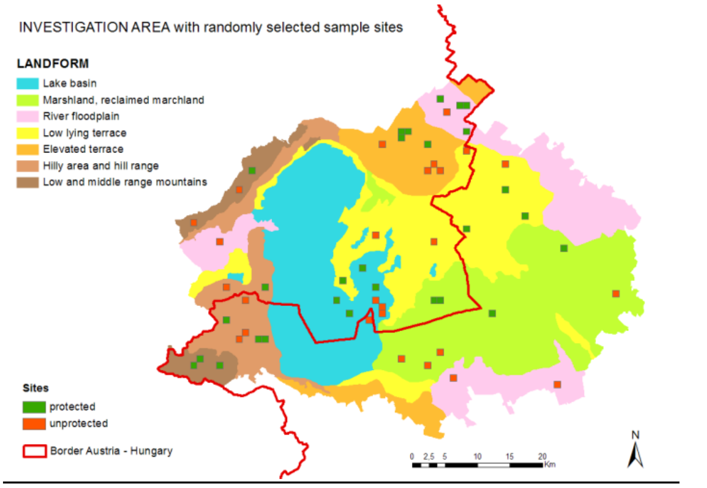

Figure 2: Overview of the entire study region, including the division into LFTs and location of local sample sites

Evaluation of Ecosystem Services
Embedded in the spatial reference framework, we assessed and mapped 14 ecosystem services grouped into three main service categories: *regulation* (local climate regulation, disturbance prevention, water regulation, water supply, soil retention, soil formation, nutrient regulation, pollination, *habitat (*refugium, nursery*)* and *provision (*food, raw materials, genetic resources, medicinal resources)(mainly adapted from DE GROOT 2006).Individual services were analysed at the landscape element scale within the 41 landscape sample sites throughout the 7 LFTs. For the distinction of different service providing units we used the broader habitat type (BHT) classification system (BUNCE et al. 2008, 2011). BHTs were linked to their capacities for providing various ecosystem servicesby an expert based classification system, ranging from "0"to "5". The higher one value turned out, the higher the general relationship between the BHT and its related service. This so called Broader Habitat Approach (HERMANN et al. 2013, in press) is based on a capacity matrix, with values being revised by semi-quantitative data gained from field work. In further steps, service data were aggregated to the main service categories and extrapolated to the LFTs.

Results

Results of the Structural Functionality assessment

The main outcomes of the structural functionality assessment are outlined in Figure 3, exemplarily including GI maps for each LFT. Ecologically most valuable GI-elements and corresponding functionality rating are marked, serving as potential habitats and migration routes for the virtual Specialist species group. In the background, outcomes of the cost surface modelling approach are outlined, ranging from areas that are easy to cross up to barriers within the landscape for the target species group.

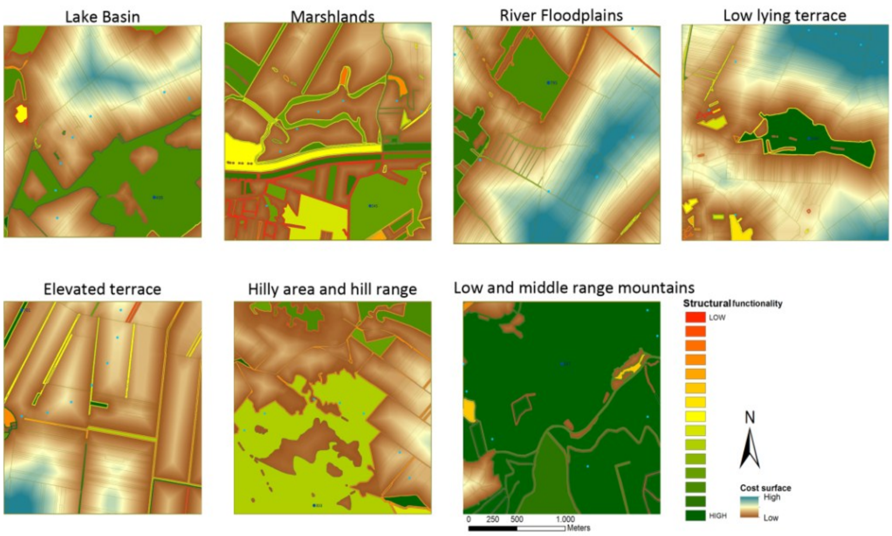

Figure 3: Representative Landscape Functionality maps for each LFT

According distribution of GI-elements, which have previously been classified into 4 subsections of core areas and linear elements, overall number of core areas decreased from 515 (> 0.1 ha) to 229 (> 1 ha) and 70 (> 10 ha). Additionally, 748 linear elements have been mapped, together resulting in a total area captured by GI-elements of approx. 5,800 ha which is about 35 % of the entire investigation area (16,400 ha). Thereof, the majority (56%) is located in the forest dominated LFTs "Hilly area and hill range" and "Low and middle range mountains"while only a minor part (15 %) appears in LFTs "River Floodplains", "Low lying terrace" and "Elevated terrace" where the agricultural sector plays a predominant role.

Between protected and unprotected areas significant variations with regard to structural functionality were also visible. In this context, 838 GI elements were found in protected areas sharing a mean functionality value of 59.95, while in unprotected sites only 723 with mean functionality value of 52.84 were mapped. Subsequent ANOVA testing outlined a significant variance ($p < 0{,}01^{***}$) between these two groups.

Testing interdependencies between single variable outcomes on plot level by the use of unviariate regression techniques revealed a rather strong dependency of mean overall structural functionality (corr. $r^2=0.872$) and mean travelling costs (corr. $r^2=0.729$) per sample plot fromthe areal share of GI-elements located within each plot.

Results of the ESS-provision

The resulting ESS values ranging from "0" to "5" are representingLFT-based mean service values for the main categories *regulation, habitat and provision* (Fig.4).

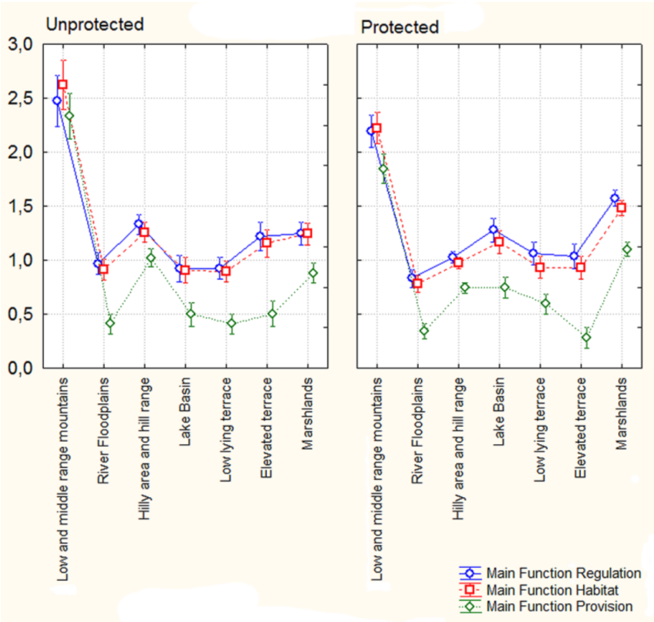

Figure 4: Two Boxplots of ANOVAs targeting main service distribution among the single LFTs in protected and unprotected areas

The course of the lines is quite similar, reflecting that there are no trade-offs between the different service categories. Whereas the *regulation* and *habitat* service values were close to each other, the *provision* services resulted in clearly lower values. Considering the different LFTs, outcomes showed the high diversity within the investigation area ranging from natural and semi-natural areas such as the shallow lake and its reed beds, the remaining marshland and flood plains to the extensively used hilly area and the intensive agricultural regions in the low lying and elevated terraces. Particularly noteworthy were the high values in LFT 'Low and middle range mountains', which were mainly based on the almost homogeneous oak-hornbeam forest and small grassland patches on the hillsides of the deep valleys in the Leithagebirge.

Comparing the main service values *regulation, habitat and provision* between protected and unprotected sites, almost all the LFTs differed significantly except from 'Low and middle range mountain' and 'Low lying terraces' (Fig. 4). However, among the protected sites only 'Marshlands' and 'Lake basin' showed significantly higher values ($F=6{,}7902$; $p \leq 0{,}001$) compared to the unprotected sites. All the other LFTs were characterised by lower values in comparison with the unprotected ones.

Comparison between Ecosystem services and Landscape Structural Functionality

As both assessments were following different theoretical concepts to quantify landscape sustainability with respect towards society on the one side and wildlife on the other, a series of unvariate linear regression analysis revealed coherences between the two approaches.

Scatterplots shown in Figure 5 are visualizing the outcomes of three different regression analyses targeting on the dependency of the Ecosystem main services from the outcomes of the survey on structural functionality. Relationships between the single variables proofed to be significant ($p=0.000$) in all of the cases and the strength of the statistical models turned out to be rather high, ranging from corr. $r^2=0.691$ for the habitat main service to corr. $r^2=0.737$ in case of the regulation main service and corr. $r^2=0.802$ for the provision main service, respectively.

The performance of a stepwise multivariate regression analysis conducted using all main service outcomes at once revealed that all service variables turned out significantly and were integrated in the final regression model, resulting in a corr. r^2=0,819.

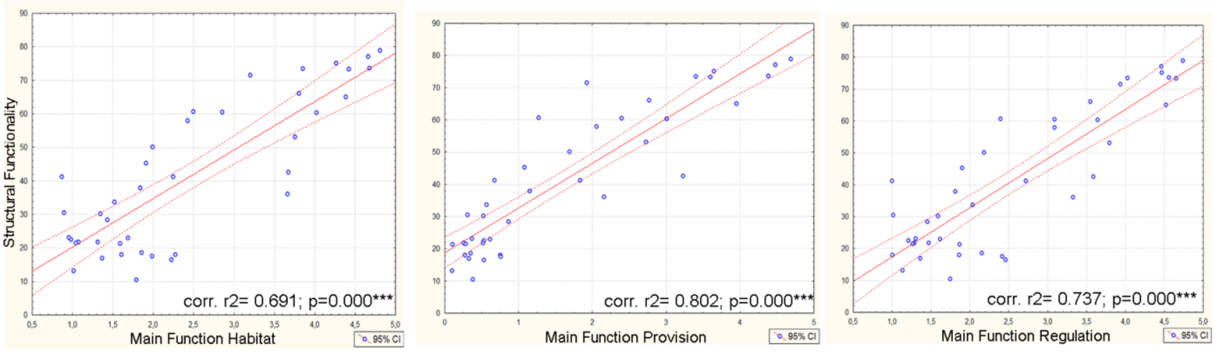

Figure 5: Three scatterplots visualizing outcomes of linear regression analyses between structural functionality and ecosystem main services

Discussion and Conclusions

The remarkable higher service values within the protected sites of the LFTs 'Marshlands' and 'Lake basin' (Fig. 6) might be due to the fact that most of these sites are covered by the national parks 'Neusiedler See-Seewinkel' / 'Fertó-Hansàg' and thus following a broader conservation concept, including core areas and buffer zones. Within the LFT 'Low and middle range mountains' that is characterised by huge forest habitats, the protection status might not be a determining factor regarding ecological quality and ecosystem service provision. As some of the sample sites within the LFT ' Elevated terraces' were also covered by large forested areas under private property, the lower values within the protected sites are thus comprehensible.

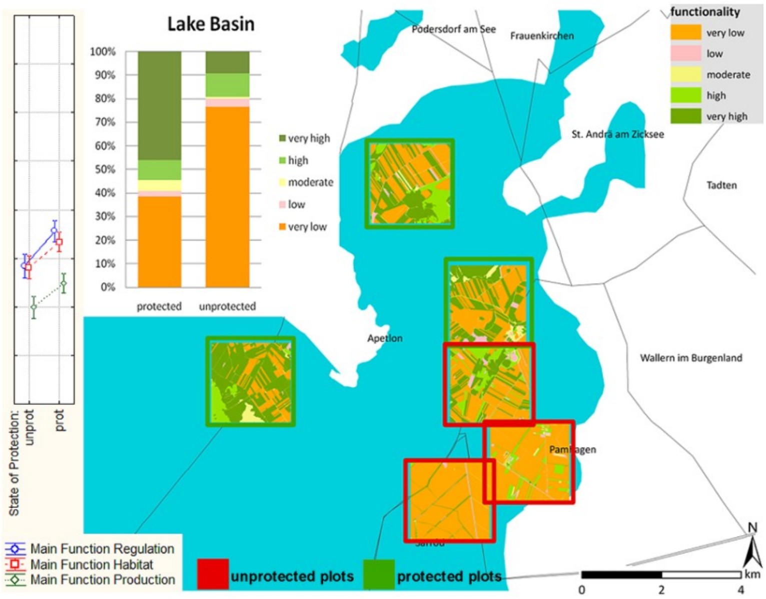

Figure 6: Overview on the sample plots selected in LFT "Lake Basin" and corresponding structural functionality and main ecosystem service charts distinguishing between protected and unprotected sites

Though, Ecosystem Service Provision did not turn out to be significantly higher in some of the protected areas within the single LFTs, distribution of GI-elements and structural functionality values consistently showed higher outcomes. Hence, we assume that the ability of Ecosystem Resilience, which has not been directly investigated in the frame of this study yet, is enhanced in those parts (Fischer et al. 2006). Both assessments are strongly tied together as most ecologically valuable elements are sharing a rather high potential in the provision of pre-selected ecosystem services which have been quantified in the frame of this study. But vice versa, as abiotic functions such as climate-, nutrient regulation or soil formation were in focus, also non-protected but still sustainably managed areas shared a high potential in service provision. As our results confirm, land management seems not to be generally overexploited in the region, especially in non-favourable sites (e.g. forest dominated slopes and rather wet or dry areas that haven´t been reclaimed /drained). On the other hand, areas that have been intensively used for centuries such as LFTs "low and elevated terrace"preformed worst in ecosystem provision and structural functionality.

Our results are congruent with the outcomes of a global study carried out by Naidoo et al. (2006). They explored thatregions selected to maximize biodiversity provide no more ecosystem services than regions chosen randomly.

However, it strongly depends on the target of the respective conservation area. Despite the lack of general concordance, "win–win" areas— regions important for both ecosystem services and biodiversity could also be identified, especially at smaller scales. However, the results are mostly biased by the methods chosen to assess ecosystem services. Levels of congruence between biodiversity and services are poorly understood, and the little quantitative evidence available to date has led to mixed conclusions (CHAN et al. 2006; METZGER et al. 2006). As some services such as pollination are locally explicit and other services, such as climate regulation are occurring at regional scale (HERMANN et al. 2011) it is difficult to assess a wide range of services within a specific service providing unit, e.g. a conservation area. However, despite these challenges we have to face, comparisons between biodiversity related and ecosystem service assessments have the potential to viably support decision-making processes. More research on the quantification and mapping of ecosystem services would improve our understanding on synergies and trade-offs between services and biodiversity. Sustainable development should involve managing for both, in order to enhance human welfare that is linked in diverse ways to biodiversity, conservation and ecosystem services (NAIDOO et al. 2006).

References

BENEDICT, M.A. & E.T. MCMAHON 2002. Green infrastructure: smart conservation for the 21st century. Renew. Res. J. 20, 12–17.

BUNCE, R.G.H., BOGERS, M.M.B., ROCHE, P., WALCZAK, M., GEIJZENDORFFER, I.R., JONGMAN, R.H.G. 2011. Manual for Habitat and Vegetation Surveillance and Monitoring: Temperate, Mediterranean and Desert Biomes. First edition.Wageningen, Alterra report 2154.Accessed December 17, 2011.[online] URL: http://www.ebone.wur.nl/NR/rdonlyres/DADAAB1E-F07C-4AA3-8621-20548A9B7DE6/135332/report2154.pdf.

BUNCE, R.G.H., METZGER, M.J., JONGMAN, R.H.G., BRANDT, J., DE BLUST, G., ELENA-ROSSELLO, R., GROOM, G.B., HALADA, L., HOFER, G., HOWARD, D.C., KOVAR, P., MUCHER, C.A., PADOA- SCHIOPPA, E., PAELINX, D., PALO, A., PEREZ-SOBA, M., RAMOS, I., ROCHE, P., SKANES, H., WRBKA, T. 2008. A standardized procedure for surveillance and monitoring European habitats and provision of spatial data. Landscape Ecol. 23, 11–25.

CHAN, K.M.A., SHAW, M.R., CAMERON, D.R., UNDERWOOD, E.C. & DAILY, G.C. 2006. Conservation planning for ecosystem services.PLoS Biology, 4(11): 2138–2152.

COSTANZA, R. & C. FOLKE 1997. Valuing Ecosystem Services with Efficiency, Fairness, and Sustainability as Goals, in Daily, G.C., ed., Nature's Services: Societal Dependence on Natural Ecosystems, pp. 49–70, Washington DC (Island Press).

DE GROOT, R.S., WILSON, M.A., BOUMANS, R.M.J. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services.Ecol Econ, 41 (3): 393–408.

DE GROOT, R.S. 2006. Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. Land UrbPlann, 75(3-4): 175–186.

EGOH, B., REYERS, B., ROUGET, M., RICHARDSON, D.M., LE MAITRE, D.C. & A.S. VAN JAARSVELD 2008. "Mapping ecosystem services for planning and management", Agriculture, Ecosystems & Environment, 127(1-2): 135–140.

FISCHER, J., LINDENMAYER, D.B., MANNING, A.D. 2006. Biodiversity, ecosystem function, and resilience: ten guiding principles for commodity production landscapes. Front. Ecol. Environm. 4(2), 80-86.

FORMAN, R.T.T. 1995. Land Mosaics – The Ecology of Landscapes and Regions. Cambridge University Press.

HEIN, L., VAN KOPPEN, K., DE GROOT, R.S., VAN IERLAND, E.C. 2006. "Spatial scales, stakeholders and the valuation of ecosystem services", Ecological Economics, 57(2): 209–228.

HERMANN, A., KUTTNER, M., HAINZ-RENETZEDER, C., KONKOLY-GYURÓ, E., TIRÁSZI, A., BRANDENBURG, C., ALLEX, B., ZIENER, K., WRBKA, T. 2013. Assessment framework for landscape services in European cultural landscapes – an Austrian Hungarian case study. Ecol. Ind., in press.

HERMANN, A., SCHLEIFER, S., WRBKA, T. 2011.The concept of ecosystem services regarding landscape research: a review. Living Rev 764 Landsc Res., 5, 1.

KONKOLY-GYURÓ, E., TIRÁSZI, A., WRBKA, T., PRINZ, M., RENETZEDER, C. 2010. Der Charakter grenzüberschreitender Landschaften (Határonátívelotájakkaraktere). University of Western Hungary, Sopron.

KUTTNER, M., HAINZ-RENETZEDER, C., HERMANN, A., WRBKA, T. in press. Borders without barriers – Structural functionality and green infrastructure in the Austrian–Hungarian transboundary region of Lake Neusiedl. Ecol. Ind., in press.

MCGARIGAL, K., CUSHMAN, S.A., NEEL, M.C., ENE, E. 2002. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer Software Program Produced by the Authors at the University of Massachusetts, Amherst.

MEA 2005. Ecosystems and Human Well-being: Multiscale Assessment, Millennium Ecosystem Assessment Series, 4, Washington, DC (Island Press)

METZGER, M.J., ROUNSEVELL, M.D.A., ACOSTA-MICHLIK, L.,LEEMANS, R. & D. SCHROTERE 2006.The vulnerability of ecosystem services to land use change. Agr.Ecos.Env., 114(1): 69–85.

MOSER, D., ZECHMEISTER, H.G., PLUTZAR, C., SAUBERER, N., WRBKA, T., GRABHERR, G. 2002. Landscape shape complexity as an effective measure for plant species richness in rural landscapes. Landscape Ecol. 17, 657–669.

NAIDOO, R. & T.H. RICKETTS 2006.Mapping the economic costs and benefits of conservation.PLoS Biology, 4(11): 2153–2164.

TURNER, M.G., GARDNER, R.H., O'NEILL, R.V. 2001. Landscape Ecology in Theory and Practice, Pattern and Process.Springer, New York.

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