Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 161 (2016) 2297 – 2303

Procedia Engineering

www.elsevier.com/locate/procedia

World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium 2016, WMCAUS 2016

Managing Multiple Ecosystem Services for Landscape Conservation: A Green Infrastructure in Lombardy Region

Andrea Arcidiacono[a], Silvia Ronchi[a,*], Stefano Salata[b]

a Politecnico di Milano, Department of Architecture and Urban Studies, via Bonardi 3, 20133, Milano (MI), Italy
b Politecnico di Torino, Interuniversity Department of Regional and Urban Studies and Planning, viale Mattioli 39, 10125 Torino, Italy

Abstract

The spatial assessment of Ecosystem' Services could inform and support planning process to achieve sustainability as a major challenge for local community. Among others, the definition and implementation of Green Infrastructure based on the delivery of multiple ES is a key element of environmental planning aimed to maintain and restore the natural capital considering the interrelations between social and ecological aspects. The paper proposes a methodology for the spatial identification of the Regional Green Infrastructures in Lombardy Region (north-west of Italy) as a structural layer of landscape planning. Regional Green Infrastructures is designed to incorporate the multifunctional use of natural capital, especially its naturalistic, recreational and landscape vocation. The biophysical models of Habitat Quality were used as a proxy of natural values, the community maps of Recreation Potential with the Heritage properties was used as a proxy of recreation values, and finally a kernel density of positive visual elements has been used as a proxy of landscape values. The outputs were elaborated mainly using InVEST 3.2.0 software, integrated with a weighted overlay analysis tool of ArcGIS 10.3 version. Results were used to frame a preliminary base of landscape values for RGI, and are presented as a possible methodology to define a prescriptive layer of the new Regional Landscape Plan.

Peer-review under responsibility of the organizing committee of WMCAUS 2016

Keywords: ecosystem service; landscape; spatial planning; green infrastructures; multifunctionality;

1. Introduction

One of the major benefit of Ecosystem Services (ES) analysis and mapping is the possibility to integrate landscape

* Corresponding author: Tel.: +39 0223995448
E-mail address: silvia.ronchi@polimi.it

Peer-review under responsibility of the organizing committee of WMCAUS 2016
doi:10.1016/j.proeng.2016.08.831

planning with additional values that directly contributes to human well-being. Particularly, the uses of new approaches and methodologies aimed to integrate traditional analysis of landscape values with ES modelling increases the possibility to better define sustainable environmental policy [1,2,3,4]. The state of ES depends on the interaction between the natural environment and human pressure and the landscape is the framework in which this interaction occurs [2]. Recently, the concept of ES raised attention because increased its relation with planning disciplines [5, 6, 7, 9]: when ES are embedded into planning procedures, the land use regulation is largely oriented to efficiency [10,11,12]. Thus using trade-off among different ES as a proxy for land use sustainability [9] it is possible to define well-being as the final goal for local communities, considering people health as the major target of environmental quality [14,17]. The multifunctional characterization of Green Infrastructure (GI) emerges from interactions between different types of ES, such as habitat quality, recreational quality, visual and aesthetical quality founded upon the network of natural and semi-natural areas, features and green spaces in rural and urban, terrestrial, freshwater, coastal and marine areas [14]. The purpose of research is to introduce a methodological procedure to define and spatially design a Regional Green Infrastructure (RGI) in Lombardy Region (north-west of Italy) as one of the main prescriptive layer of the new Regional Landscape Plan. The cartographic and normative definition of the RGI is functional to identify strategies for urban and landscape restoration at local scale according to the landscape value of environment, to the characteristics of places, to the pedestrian connectivity and the aesthetical valorisation of open fields also in urban environment, considering cultural values as fundamental elements for planning discipline [15].

2. Green infrastructures and Ecosystem services for Planning

The European Commission launched a Green Infrastructure Strategy promoting GI as “a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ES and protect biodiversity in both rural and urban settings” [16]. More specifically, the planned European Strategy aim to support Target 2 of the EU biodiversity strategy to 2020 [17] which establish that “By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems”. The target achievement requires an integration of GI into multileveled policies and, widely, in the decision making process. Despite the recent cultural advancement in recognizing the value of natural elements and the economic, social and environmental benefits of GI, there is still a widespread lack of awareness on their importance [3,4], also demonstrated by the frequent failure to manage them appropriately [18]. As suggested by European Commission, GI are a territorial tool for natural regeneration, for re-establish a specific ES and for landscape conservation. Nonetheless, GI can promote the multiple delivery of ES, improving the general ecosystem functioning. Therefore, mapping ES for GI is essential for planning purposes, especially ones focused on environmental and landscape protection, but the spatial definition of GI is dependent on the assessment of state and trends of ecosystems and their services. The process is dependent on data availability and the possibility to manage spatially explicit information of natural resources distribution for ES [19] also considering the most appropriate scale. The GI definition is mainly dependent on two factors: the multi-scale levels and the multi-functional perspective [7]. The multi-scale level is required when ecological and landscape issues are solved using planning disciplines which is referred to administrative level. But the dimension, geometries and shapes of natural and landscape processes are not fitting with administrative boundaries; this imply that the government of such issues require a multi-scale integrated approach moving through a macro scale, including ES function provided at right level, to micro scale, accounting also the site specific ES functions. The multi-scale approach requires also a variable legislative framework for planning instruments: for example, the promotion of GI framework at regional scale should demand operational actions to local level. On the other hand, the multi-functional perspective is about the inclusion of ecological, recreational, cultural, aesthetic functions in the GI structures; conceived as the ability of areas to fulfil more than one function simultaneously, such as the provision for healthy recreation whilst performing natural services. Such approach requires both technical advancement in planning analysis and management to optimise these functions.

3. The Landscape Plan of Lombardy region: a multifunctional approach for mapping GI

In Italy, Landscape planning is disciplined at regional level by law according with national reference guidelines framework. In Lombardy Region the article 19 of the Planning Law n. 12 of 2005 introduces the Regional Territorial Plan (PTR - Piano Territoriale Regionale) with the aim to provide a regulative framework on different State-Region competences, according with the national legislation on landscape and environment (Code of cultural heritage and

landscape - Legislative decree 42/2004). The Regional Territorial Plan is composed by a specific side, which is dedicated to landscape prescriptions. Such part is called "Regional Landscape Plan" (PPR – Piano Paesaggistico Regionale) in force from 2001. The first release of PTR was in 2010, after four years was decided to draw up a new version according to legislative updates and, therefore, also for PPR was submitted to revise the plan renewing its contents, especially the prescriptive part for landscape regulation. A research group of the Department of Architecture and Urban Studies (DAStU) - Politecnico di Milano (Research group: Gabriele Pasqui, Andrea Arcidiacono, Alberta Cazzani, Stefano Coloru, Paolo Dilda, Marika Fior, Federico Ghirardelli, Daniela Giannoccaro, Giulio Giordano, Silvia Ronchi, Stefano Salata) was commissioned in the early 2014 by the Regional Unit on "Environment, energy and sustainable development" of Lombardy Region to establish a technical partnership supporting the new Landscape Plan. Among Plan's target there was the design of the RGI, which is promoted only as a guideline in the legal framework of the Plan (art. 24, normative framework) without prescriptive implications and, as consequence, without a spatial definition that could be shared and included at lower administrative levels (provincial or municipal). PTR defines the RGI and the Regional Ecological Infrastructure (REI) as priority infrastructures for Lombardy Region. Even if the components of the REI and RGI are mostly in common, the aim of the two regional infrastructures are different: the first one is dedicated to the maintenance of biodiversity and ecological connections, the second one includes such aspect of biodiversity preservation but with additional considerations on landscape valorisation and recreation. By a legal point of view, the different is substantial: the REI is spatially recognized with a normative framework (defined by Regional Committee Resolution n°10962/2009), while RGI is only mentioned as some guideline principles without spatial definition. The methodological framework defines RGI adopting a multidisciplinary approach considering three fundamental ES as proxies of natural quality, in terms of biodiversity integrity, cultural and recreation potential, and landscape value considering the characters of the anthropic landscape. The overlaid value of the three functions gives a preliminary structure to RGI recognizing its multifunctionality.

4. Mapping multifunctional ES

As introduced, mapping ES for GI is essential for environmental and landscape planning that includes sustainability in the decision making process. ES assessment for planning at different scales can directly contribute to enforce a "holistic approach" on territorial government [16,23]. For ES mapping was selected the software InVEST-Integrated Valuation of Ecosystem Services and Tradeoffs that may be useful for informing resource management strategies and quantitative ranking of scenarios supporting decision making to evaluate possible trade-off between alternative territorial development policies. The software generates maps and values aimed to steer decision making by individuals, corporations, and governments at local [21], regional [22] or global [23] scale. The RGI definition has been conducted selecting 2 of the 17 models provided by InVEST: Habitat Quality and Recreation and tourism. In addition to these layers, an intersection of values has been launched with the constitutive elements of anthropic landscape derived by the Code of cultural heritage and landscape (Legislative decree 42/2004).

4.1 Mapping the overall ecological quality using the Habitat Quality model

The Habitat Quality (HQ) model is a proxy of the general ecological value of the territory because it estimates the extent of habitat and vegetation types across a landscape and express the ability of the ecosystem to provide appropriate conditions for species persistence. The indicator reflect both the proximity of Habitat to anthropic land uses and the intensity of disturb caused by such areas [24]. HQ has been considered a synthetic indicator of the ecological state of the Region. The construction of the dataset input directly affect the model's output. Once each input is prepared, the model run applying a "per pixel" equation, which generates a relative value of the habitat ranging from 0 to 1.
Specifically, the inputs are:

- The current Land Use/Land Cover (LULC). In the case of Lombardy region, the selected LULC was "DUSAF – Destinazione d'Uso dei Suoli Agricoli e Forestali" made by ERSAF in 2012 and based on Corine Land Cover classification system. The raster resolution was 30*30 meters using the third level of legend.
- Threats assigning the maximum distance over which each threat affects Habitats, expressed in kilometres; a weighted impact of each threat on Habitats, expressed with 1 at the highest to 0 at the lowest; and, finally, the decay of threat;

Table 1. Threats used as input for HQ InVEST model.

Threat	Max_dist	Weight	Decay
Infrastructure (highways, roads, railways)	1	0.65	Linear
Anthropised areas (Urbanized areas, productive areas, dumps, construction sites, urban green areas)	0.4	0.8	Linear

- Accessibility of habitat to threats composed by values that ranges from 0 to 1. When values are 1 the site is fully accessible without any restrictions to the threats while 0 correspond to the territory less likely to be access by threats.

Table 2. Accessibility to sources of degradation used as input for HQ InVEST model.

ID	Access
Natura 2000 network (Site of Community Importance and Special Protection Areas)	0.00
National and Regional parks / Secondary element of the Regional Ecological Network / Priority area for biodiversity conservation*	0.20
Local parks	0.80
Primary element of the Regional Ecological Network	0.10
remaining territory	1

* The methodology used was inspired by the approach of eco-regional conservation [25]

- Habitat type and sensitivity of each habitat type to threats using a Habitat score from 0 to 1. The input file is a table with the individual value assignments. The Habitat value of each single land use class was based on the Biological Territorial Capacity index that is a synthetic function based on (1) the concept of resistance stability; (2) the principal types of ecosystems of the ecosphere; (3) their metabolic data (biomass, gross primary production, respiration, R/PG, R/B) [26].

The output map (figure 1) shows the distribution of HQ values per cell. Such clustered output showed clearly the part of the regional territory which provides environmental quality and support habitats and biodiversity. This preliminary result is important because it is crucial to construct and enforce the local framework of green areas capable to maintain the continuity of the entire ecological system, and the exchange of flows and materials between primary elements (high quality habitat) and secondary elements (medium quality habitat), within the less relevant green areas among the settlement system.

4.2 The Recreation and tourism model

Cultural ES are defined as “non-material benefits that people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience” [27]. This benefits ranges from opportunities for tourism and recreational activities, appreciation of natural scenery, sense of place and belonging, education and science, to inspiration for culture, art and design. Most of the recreation services are “nature-based”, meaning that these services are generated by interactions or appreciation of the natural environment. The InVEST recreation model uses information on visitation rates and traveller origins worldwide provided by Flickr online social media [28]. The model extracts the georeferenced photos uploaded into the Flickr website and finally it estimates the average annual photo-user-days (PUD) as a proxy for visitation rate. The tool performs a linear regression, relating the arrangement of predictor variables in each cell to user-days across all cells. The data required are the Area of Interest (AOI), which is the geographic shape of the study area (Lombardy Region) and the cell size resolution cell and additional global datasets as source of better data when these are not available at local scale: Population from Ridge National Laboratory LandScan (2010), Open Street Map (2012) features, Protected Areas from UNEP-WCMC World Data Base on Protected Areas (2012), LULC form ESA GlobCover (2008). The output maps show patterns of recreational use in Lombardy region (see Fig. 1. right).

4.3 The Anthropic heritage

The above-mentioned models were integrated with the constitutive elements of anthropic landscape composed by the catalogue of the Code of cultural heritage and landscape (Legislative decree 42/2004). Each elements of anthropic

landscape were evaluated with a score that ranges from 0 to 1 using the degree of constraint (reported in Table 3) and subsequently a pattern of "density" of such prescription was outlined using the Kernel density function of ArcGIS 10.3.

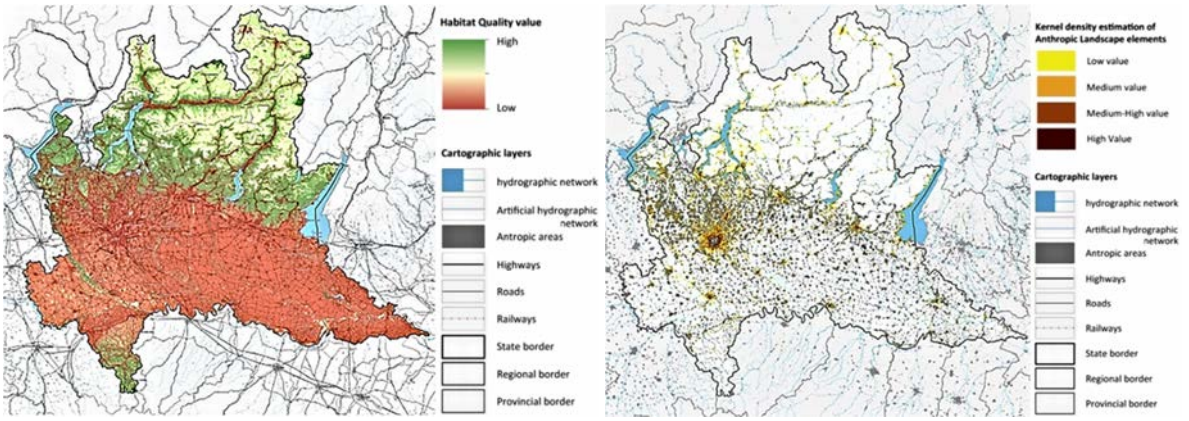

Fig. 1. Lombardy region: (left) the Habitat Quality output developed with InVEST software; (right) the Recreation scenario output developed with InVEST software.

The output show where the concentration of anthropic landscape's elements is higher considering the value assigned. The higher value is distributed in the primary hills close to the lake and in the Apennines region characterized by vineyard and particular geomorphological condition, and finally in the valley floor of Sondrio province where the river Adda, the regional parks and the historical and architectural elements structure the entire area (see Fig. 2 left).

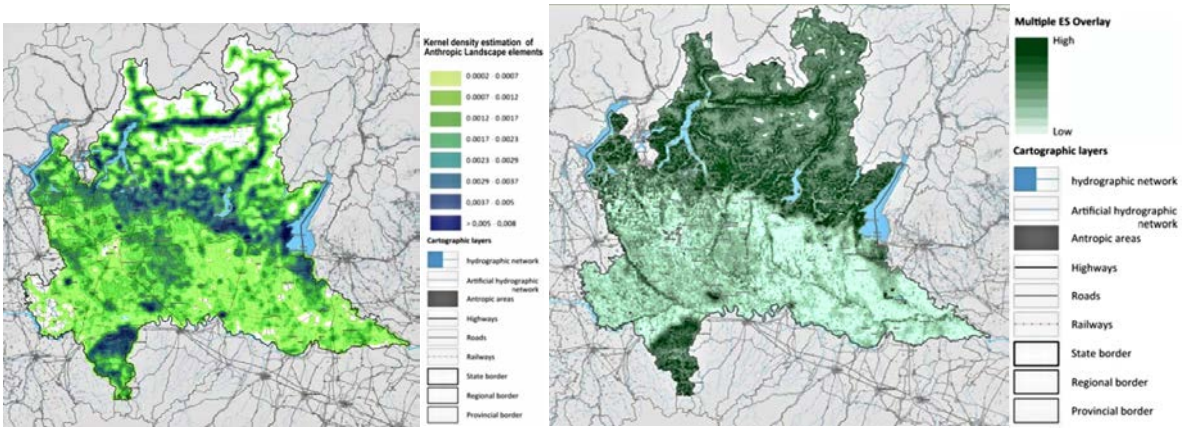

Fig. 2. Lombardy region: (left) Kernel density estimation of Anthropic Landscape elements; (right) Multiple ES Overlay.

5. Results and Discussions

5.1 A multiple overlapping analysis for the definition of the Regional Green Infrastructure

Once the models where prepared it was used a multiple overlapping analysis between them. The layers were homogenised transforming the raster file in vector file, and the results were finally combined. The operation for a spatial pattern of ES was made using ArcGIS 10.3 intersect tool and after the sum of each single value was normalized to outline an equal distribution from 0 to 1. The total values are classified in 10 rates using the Jenks algorithm and

distributed in cartography (see Fig. 2 right). The results show a spatial distribution of a first possible selection of values for a RGI framework in Lombardy region. The definition of the RGI is useful to frame prescriptive rules for a Landscape regeneration and environmental improvements. The network design of RGI assure that the interventions are defined in an overall framework assuming a strategical approach that guarantee the preservation of high landscape values.

Table 3. Elements of anthropic landscape and related value assigned considering the degree of constraint.

Elements of anthropic landscape	Value
Real estate elements with historical and architectural value	1
National Park	0.8
Regional park and reserves	0.7
Natural monuments	0.5
UNESCO sites / Natura 2000 network	0.6
River and buffer zone of 150 meters / Lake and buffer zone of 300 meters / Alpes and Apennines region	0.3
Zone C of the National Plan on Hydrogeological risk (PAI) / GEOsites (Area with high geological value)	0.2
Woods and Forests / Wetland / Area with high archaeological value / Glacier	0.1

Moreover, each single landscape regeneration project is coordinated by a common policy that can cumulatively increase the human benefits. As previously explained, the RGI shares some of the contents and the shape with the REI, recognizing its natural value but adding other area with higher cultural or landscape vocation.
The combination of the two regional infrastructures could reinforce both: when ecological characterization of places is recognized and defended as well as its landscape value, then an integrated system of protection should guarantee the maintenance of the original character of the territory. The integration between instruments is also a result of a different vocation of the two infrastructures: if the REI is mainly designated to preserve the biophysical values of natural areas, and its legislative framework defines a system of protection and defence of its areas; the vocation of RGI is much more dedicated to steer local project of landscape valorisation, also with the selection of masterplan transformations aimed to re-define relations among settlements, open fields, natural values and the rural characters of the territory. It is recognized that even if such areas are perfectly conserved from the biodiversity point of view, land-use changes in the surrounding areas might compromise their conservation efficacy [29], as habitat quality and ecological functioning of protected areas may be heavily affected by surrounding resources and dynamics [30]. The definition of RGI, in addition to the REI, could avoid the effect isolation of such natural protected area preserving them from Human-induced alteration, especially land use changes, and degradation of habitats [31].

6. Conclusions

The paper presented a way to integrate tools for matching ecological functions and landscape values using the case of study of Regional Landscape Plan. Direct effect on human well-being can be assessed and monitored and thus also social health and quality of life improves with a better management of landscape natural resources. The spatial distribution of RGI gives the possibility to integrate landscaping values as an additional tool of PPR which guarantee the recognition of multiple ES value. By the way the paper try to overcome the main limitations of some experiences that includes ES mapping in planning processes but only as a description without prescriptive framework for land use planning. Therefore, there is an urgent need to raise awareness on ES among decision-makers and stakeholders but also building citizens' awareness for environmental conservation and for enhance human well-being. Even if the promotion at regional level of ES does not guarantee consciousness-raising, it could be considered a first important step to systematic ES assessment for planning. In this framework, the identification of RGI with ES approach in a regional plan implies that all the local administrations had to recount to this instrument when defining its local plan. In a downscaling perspective, the RGI is theorized with a spatial mapping at regional level and after included and considered at lower level defining project actions for landscape regeneration that could increase the provision of ES. The operability of such approach require coordination and cooperation across political and administrative levels. It must be managed on scales ranging from the regional to the local guaranteeing, in this way, that interventions and/or investments for specific regeneration actions are aligned and coordinated in a general strategy.

References

[1] T.P. Karjalainen, M. Marttunen, S. Sarkki, A.-M. Rytkönen, Integrating ecosystem services into environmental impact assessment: An analytic–deliberative approach, Environ. Impact Assess. Rev. 40 (2013) 54–64. doi:10.1016/j.eiar.2012.12.001.

[2] M. Potschin, R. Haines-Young, Landscapes, sustainability and the place-based analysis of ecosystem services, Landsc. Ecol. 28 (2013) 1053–1065. doi:10.1007/s10980-012-9756-x.
[3] J. Ahern, S. Cilliers, J. Niemelä, The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation, Landsc. Urban Plan. 125 (2014) 254–259. doi:10.1016/j.landurbplan.2014.01.020.
[4] N. Kabisch, Ecosystem service implementation and governance challenges in urban green space planning—The case of Berlin, Germany, Land Use Policy. 42 (2015) 557–567. doi:10.1016/j.landusepol.2014.09.005.
[5] E. Primmer, E. Furman, Operationalising ecosystem service approaches for governance: Do measuring, mapping and valuing integrate sector-specific knowledge systems?, Ecosyst. Serv. 1 (2012) 85–92. doi:10.1016/j.ecoser.2012.07.008.
[6] M. Artmann, Institutional efficiency of urban soil sealing management – From raising awareness to better implementation of sustainable development in Germany, Landsc. Urban Plan. 131 (2014) 83–95. doi:10.1016/j.landurbplan.2014.07.015.
[7] R. Hansen, N. Frantzeskaki, T. McPhearson, E. Rall, N. Kabisch, A. Kaczorowska, et al., The uptake of the ecosystem services concept in planning discourses of European and American cities, Ecosyst. Serv. 12 (2015) 228–246. doi:10.1016/j.ecoser.2014.11.013.
[8] J. Langemeyer, E. Gómez-Baggethun, D. Haase, S. Scheuer, T. Elmqvist, Bridging the gap between ecosystem service assessments and land-use planning through Multi-Criteria Decision Analysis (MCDA), Environ. Sci. Policy. (2016). doi:10.1016/j.envsci.2016.02.013.
[9] N. Dendoncker, H. Keune, S. Jacobs, E. Gómez-Baggethun, Ecosystem Services, Elsevier, 2013. doi:10.1016/B978-0-12-419964-4.00001-9.
[10] B. Ostro, L. Chestnut, Assessing the health benefits of reducing particulate matter air pollution in the United States., Environ. Res. 76 (1998) 94–106. doi:10.1006/enrs.1997.3799.
[11] E. Gómez-Baggethun, D.N. Barton, Classifying and valuing ecosystem services for urban planning, Ecol. Econ. 86 (2012) 235–245. doi:10.1016/j.ecolecon.2012.08.019.
[12] A. McBratney, D.J. Field, A. Koch, The dimensions of soil security, Geoderma. 213 (2014) 203–213. doi:10.1016/j.geoderma.2013.08.013.
[13] N.D. Crossman, B.A. Bryan, D. King, Integration of landscape-scale and site-scale metrics for prioritising investments in natural capital, in: 18th World IMACS Congr. MODSIM09 Int. Congr. Model. Simul. Interfacing Model. Simul. with Math. Comput. Sci. Proc., 2009: pp. 2363–2369.
[14] S. Naumann, M. Rayment, P. Nolan, T.M. Forest, S. Gill, G. Infrastructure, et al., Design, implementation and cost elements of Green Infrastructure projects. Final Report, (2011).
[15] J. Martinez-Alier, G. Munda, J. O'Neill, Weak comparability of values as a foundation for ecological economics, Ecol. Econ. 26 (1998) 277–286. doi:10.1016/S0921-8009(97)00120-1.
[16] European Comission, Building a Green Infrastructure for Europe, (2013) 24. doi:10.2779/54125.
[17] European Commission, Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions, (2011) 17.
[18] E. Commission, The Multifunctionality of Green Infrastructure, Sci. Environ. Policy. (2012) 1–36.
[19] J. Maes, B. Egoh, L. Willemen, C. Liquete, P. Vihervaara, J.P. Schägner, et al., Mapping ecosystem services for policy support and decision making in the European Union, Ecosyst. Serv. 1 (2012) 31–39. doi:10.1016/j.ecoser.2012.06.004.
[20] A.A. Batabyal, J.R. Kahn, R. V O'Neill, On the scarcity value of ecosystem services, J. Environ. Econ. Manage. 46 (2003) 334–352. doi:10.1016/S0095-0696(02)00040-2.
[21] N.M. Nelson, a Wright, R.G. Lowry, N. Mutrie, Where is the Theoretical Basis for Understanding and Measuring the Environment for Physical Activity?, Environ. Health Insights. 2 (2008) 111–116.
[22] K.M.A. Chan, M.R. Shaw, D.R. Cameron, E.C. Underwood, G.C. Daily, Conservation planning for ecosystem services, PLoS Biol. 4 (2006) 2138–2152. doi:10.1371/journal.pbio.0040379.
[23] R. Naidoo, a Balmford, R. Costanza, B. Fisher, R.E. Green, B. Lehner, et al., Global mapping of ecosystem services and conservation priorities., Proc. Natl. Acad. Sci. U. S. A. 105 (2008) 9495–9500. doi:10.1073/pnas.0707823105.
[24] E. Nelson, D. Ennaanay, S. Wolny, N. Olwero, D. Pennington, G. Mendoza, et al., InVEST 2 . 0 Beta User ' s Guide : Integrated Valuation of Ecosystem Services and Tradeoffs, 2011.
[25] E. Dinerstein, G. Powell, D. Olson, E. Wikramanayake, R. Abell, E. Underwood, et al., A workbook for conducting biological assessments and developing biodiversity visions for ecoregion-based conservation Part I : terrestrial ecoregions, Program. (2000) 250.
[26] V. Ingegnoli, E. Giglio, Landscape biodiversity changes in forest vegetation and the case study of the Lavaz{é} Pass (Trentino, Italy), Annu. Di Bot. 8 (2008) 21–29.
[27] Millennium Ecosystem Assessment, Ecosystems and human well-being, 2005. doi:10.1196/annals.1439.003.
[28] S. a Wood, A.D. Guerry, J.M. Silver, M. Lacayo, Using social media to quantify nature-based tourism and recreation., Sci. Rep. 3 (2013) 2976. doi:10.1038/srep02976.
[29] R. Defries, A. Hansen, B.L. Turner, R. Reid, J. Liu, R. Defries, et al., Land Use Change Around Protected Areas : Management To Balance Human Needs and Ecological Function, 17 (2015) 1031–1038.
[30] D. a. Jones, A.J. Hansen, K. Bly, K. Doherty, J.P. Verschuyl, J.I. Paugh, et al., Monitoring land use and cover around parks: A conceptual approach, Remote Sens. Environ. 113 (2009) 1346–1356. doi:10.1016/j.rse.2008.08.018.
[31] I. Palomo, B. Martín-López, P. Zorrilla-Miras, D. García Del Amo, C. Montes, Deliberative mapping of ecosystem services within and around Doñana National Park (SW Spain) in relation to land use change, Reg. Environ. Chang. 14 (2013) 237–251. doi:10.1007/s10113-013-0488-5.