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Integrating ecosystem services into spatial planning—A spatial decision support tool

Adrienne Grêt-Regamey[a,*], Jürg Altwegg[b], Elina A. Sirén[a], Maarten J. van Strien[a], Bettina Weibel[a]

[a] Planning of Landscape and Urban Systems, Swiss Federal Institute of Technology (ETH), Stefano-Franscini-Platz 5, 8093 Zurich, Switzerland
[b] Office for Spatial Development, Baudirektion Kanton Zürich, Stampfenbachstrasse 12, 8090 Zurich, Switzerland

HIGHLIGHTS

- Ecosystem services were not considered when planning building zones in Switzerland.
- Considering ecosystem services in planning can alter urban development patterns.
- A web-based tool integrating ecosystem services fosters transdisciplinarity.
- Integrating ecosystem services in spatial planning is most effective in urban peripheries for securing fertile soils.

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ABSTRACT

Urbanization is viewed as endangering more critical habitats of global value and is more ubiquitous than any other human activity affecting biodiversity, climate, water and nutrient cycles at multiple scales. Spatial and landscape planning can help create alternative urban patterns protecting ecosystems and thus supporting the provision of needed services they provide. While many approaches exist to make the values of nature explicit, new tools are needed to interpret the vast quantity of information in an integrated assessment to support planning. In this study, we present a new spatial decision support tool PALM ("Potential Allocation of urban development areas for sustainable Land Management") aimed at supporting the allocation of urban development zones. A GIS-based MCDA approach was integrated into a web-based platform that allows distributing a requested amount of urban development areas within a selected perimeter based on ecosystem services and locational factors. The short running time of different user-defined scenarios allows exploring consequences and tradeoffs between decisions in an interactive way, thus making it a useful tool to support discussions in participatory planning processes. The results of the application of PALM in a case study region in Switzerland show that integrating ecosystem services when distributing urban development areas is particularly effective in urban peripheries, where building zones are shifted towards urban centers securing the productive soils located around cities. This shift of building zones from the urban peripheries to the urban centers when considering ecosystem services is less pronounced in rural areas, as they provide fewer ecosystem services. However, the results also show that integrating ecosystem services in spatial planning needs to be embedded in the right policy context: Ecosystem services can only be traded-off for locational factors if the perimeter of the case study ranges across municipalities. Whereas this transparent and flexible platform offers a suitable tool at the beginning of a planning process, we also discuss further development needs.

1. Introduction

Today more people live in urban than in rural areas (United Nations, 2014): in Northern America and Western Europe, early industrialized areas showed an accelerated increase of urbanization in the 19th century (Antrop, 2004), and today about 75% of Europeans live in cities (EEA, 2015, chap. 2). Urban expansion rates

* Corresponding author.
E-mail addresses: gret@ethz.ch (A. Grêt-Regamey), juerg.altwegg@bd.zh.ch (J. Altwegg), esiren@ethz.ch (E.A. Sirén), vanstrien@ethz.ch (M.J. van Strien), bweibel@ethz.ch (B. Weibel).

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exceed population growth rates (Seto, Fragkias, Güneralp, & Reilly, 2011), and under current trends a tripling of the urban area by 2030 is assumed (Seto, Güneralp, & Hutyra, 2012). The impacts of these growing urban areas on the environment are complex and cover both social and ecological aspects at different scales, ranging from changes in social structures to the loss of ecosystem functions and the provision of their services (Grimm et al., 2008). In general, land use is becoming independent from local ecological conditions and increasingly driven by large scale processes, which results in a loss of traditional landscapes (Antrop, 2004). Although land use policies have been used for decades to drive the expansion of settlement areas and transport infrastructure, spatial planning has only recently started focusing on the design of alternative urban patterns that secure the provision of essential ecosystem services (ES; Wissen Hayek, Teich, Klein, & Grêt-Regamey, 2015).

Different patterns of urban expansion can be related to factors such as capital flows, transportation costs or land use policy (Seto et al., 2011). In Switzerland, urbanization is highly decentralized resulting in a network of relatively small cities with strongest population growth in urban peripheries (Schmid, 2014). Due to topography, settlements are mainly located in the lower areas between the Jura Mountains and the Alps (i.e. Swiss Plateau). The population has increased from 4.7 million inhabitants in 1950 to 8 million in 2013, of which 6 million live in urban areas (FSO, 2013). Between 1985 and 2009 urban areas have increased by over 23% mostly at the expense of agricultural land (mainly grassland). The average land consumption in Switzerland is 407 m^2 per person with large differences across the country (FSO, 2015). In line with the global trend of expanding urban areas, the required space for living in Switzerland has increased two and a half times as fast as the population, which is related to a tendency towards smaller households in combination with higher living space requirements per person (FSO, 2015). A variety of new regulations attempts to limit urban sprawl in urban peripheries in Switzerland, such as (1) the revision of the Swiss national spatial planning regulation in 2013, which prescribes the reduction of building zone reserves in the next years, (2) an initiative from 2012 limiting the amount of second homes to 20% per municipality, or (3) initiatives at the cantonal level to protect cultivated land, which were accepted in 2012 in the canton of Zurich and 2014 in the canton of Berne. Furthermore, the Swiss Biodiversity Strategy requires the conservation of biodiversity within urban areas under Target 6, Action III (FOEN, 2012a). Due to a the Swiss direct democratic policy process requiring consensus, the implementation of these new regulations can be challenging, particularly when municipalities are mandated to unzone valuable building land under the revised national spatial planning law. As several authors have shown (e.g. Pacione, 2003; Scholz, 2011), increasing the acceptance of more sustainable and socially acceptable land use change can be supported by inter- and transdisciplinary collaboration processes. However, tools that support such processes and that facilitate balancing ecological considerations and social aspects of urbanization are rare and have not been implemented in practice in Switzerland.

Integrating ES into spatial planning might be a promising approach towards sustainable development because it supports making such services explicit, and thereby fosters the discussions about tradeoffs between ecological and socio-economic aspects when developing new urban areas. Examples of the use of ES for informing real-world decisions can be found in Ruckelshaus, McKenzie, Tallis, Guerry, Daily and Kareiva (2015) who evaluated the successful applications of ES information in ten spatial planning contexts. Other such examples include, for example, Schaefer et al. (2015), who provided examples of incorporating ES in land use planning in the United States, Arkema et al. (2015), who reported on a ground-breaking effort to use ES values and models within a coastal planning process, or Li et al. (2015), who presented the Relocation and Settlement Program of Southern Shaanxi Province – an ecosystem service protection and human development policy. However, as Rosenthal et al. (2014) state in their five enabling factors of decision-making, providing a set of ES maps alone will probably not change the course of action. Pertinent data need to be combined and applied appropriately in an iterative science-policy process, where decisions are repeatedly revisited. Integrating ES into spatial planning calls thus for transdisciplinary tools and approaches that allow integrating the ES information into decision-making processes.

Efforts are made to develop decision support tools integrating ES, for example, under the umbrella of the EU FP7 projects OPERAs (http://www.operas-project.eu/) and OpenNESS (http://www.openness-project.eu/), but the choice of the appropriate tool remains difficult because they differ in their complexity, transferability, time and data requirements. Reviewing seventeen decision support tools, Bagstad et al. (2013) found that the tools vary highly in their applicability to different locations and decision contexts, and many tools were considered to be too cost and time consuming to be widely applicable. These authors identified a large tradeoff between complex, resource intensive tools with high accuracies and simple but more transparent approaches. In general, the availability and accessibility of data were identified as major challenges (Bagstad, Semmens, Waage, & Winthrop, 2013). In order to determine the suitability of land for a certain use, multi-criteria decision analysis (MCDA) approaches have been identified as highly useful, as they allow integrating different aspects of decision-making and preferences while maintaining high transparency (Malczewski, 2006). Although MCDA approaches are potentially time consuming, technically complex and dependent on the willingness of stakeholders to participate, they facilitate structuring the decision process and making tradeoffs explicit (Gamper & Turcanu, 2007). The possibility to integrate stakeholder preferences by individual selections of criteria and weights, facilitates consensus finding, makes planning processes more efficient and the options more realizable, as they are likely to become more widely accepted (Boroushaki & Malczewski, 2010). This promotes stakeholder involvement especially for decisions about the allocation of scarce resources, which bear a high conflict potential due to conflicting interests between involved stakeholders and tradeoffs between economic, ecological and social aspects (Gamper & Turcanu, 2007). Ianni and Geneletti (2010) for example show how participatory workshops and expert panels can help reduce costs of integrating more criteria and better manage bias. ES were, for example, integrated as criteria in MCDA approaches to evaluate renewable energy sites (Grêt-Regamey & Wissen Hayek, 2012) or to study the effects of land use change on ES provision (Fontana et al., 2013). Geneletti (2010) and Geneletti and van Duren (2008) used a set of nature's services to rank landfill sites and to evaluate protected area zoning, respectively. Also for strategic urban planning, ecosystem functions were integrated into a MCDA-based spatial decision support tool (Schetke, Haase, & Kötter, 2012). Focusing on forest management, Uhde et al. (2015) provide a recent review on how ES can be integrated into MCDA methods.

In this article, we present a new spatial decision support tool aimed at supporting the allocation of urban development zones. An MCDA approach was integrated into a web-based platform that allows distributing a requested amount of urban development areas within a selected perimeter. The MCDA integrates both ES and locational factors. Locational factors are assumed to determine suitable locations for buildings and are often used in standard urban economic models to determine land price (e.g. Alonso, 1964). After describing the development of the new tool called PALM ("Potential Allocation of urban development areas for sustainable Land Management"), we present how PALM was tested in an interactive workshop with a regional development planning group in the