

Landscape ecology for SEA: lessons learned

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Strategic environmental assessment (SEA) calls for analysis of processes and patterns at landscape scale, which gives the opportunity to include ecosystem services in decision-making. In order to understand how planning decisions affect ecosystem services such as biodiversity, it is necessary to analyse ecological processes on landscape and regional scales. Landscape ecology provides methods and tools for addressing effects on landscape scale, such as effects of habitat loss and fragmentation, which are caused by a wide array of human-induced changes and pose critical threats to biodiversity and other ecosystem services. Thus, in order to be able to assess impacts on biodiversity, spatial methods and tools based on landscape ecological principles need to be developed. This paper addresses the use of spatial methods and tools, scale problems, visualization and communication for incorporating landscape ecological methods in SEA. The study is based on lessons learned from experiences in Sweden and Italy that refer to SEA for different levels of planning, from local to regional. This will lead to increased understanding and a discussion on key issues on how planning processes can be improved through the use of effective tools for analyzing landscape and its ecosystem services.

Introduction

Urbanisation entails challenges for urban planning as to support the development of cities and built-up areas that provide a good and healthy living environment. Due to the ongoing urban development, the environment in urban areas is affected as result of new land use claims on existing green areas and additional emissions of noise, air and water pollutants which have an impact on an already strained living environment. In order to counteract a further degradation of the urban environment, the role of disciplinary expertise regarding, for example, the impact of human activities on ecological processes has to be strengthened in planning and decision making.

In many European cities, urbanisation has resulted in geographically wide-spread cities or city networks, which leaves space with green areas between the built-up areas. The green areas accommodate a variety of qualities, both ecological and recreational (Miller and Hobbs, 2002), which offer opportunities for leisure activities close to urban settlements and provide a basis for biodiversity and other ecosystem services. To sustain or develop biodiversity in an urbanised region, a number of interrelated ecological conditions have to be fulfilled. One aspect is the existence of core areas where the ecological processes are intact which provides habitat for various species. Other preconditions are connectivity to

facilitate the exchange between core areas, and time continuity regarding natural habitats. Also ecotones are important for the long-term preservation of biodiversity in a regional perspective. This involves that qualities or areas that play a role in an ecosystem context have to be protected in order to maintain biodiversity.

In recent debates the compact city has been put forward as a central design principle for sustainable urban development. As a result of the proposed policy remaining green areas close to the city will be developed for housing or other urban land use. In a regional perspective, ongoing urbanisation will also lay claims in peri-urban areas for housing, infrastructure or other developments (Balfors et al. 2005). Hence, existing ecological networks will be affected due to habitat loss and fragmentation. Therefore planning should have access to knowledge on ecosystem dynamics on a landscape level, in order to preserve nature and biodiversity values, or at least mitigate the impacts of ongoing developments on these values, which in the long term would contribute to sustainable urban development.

Landscape ecological expertise in a planning context

In accordance with national and international policy objectives, biodiversity should be maintained for future generations and therefore species' habitats and ecosystems and their functions and processes must be safeguarded (Official Journal of European Communities, 1993). This involves that landscape, biodiversity and other ecosystems services should be considered as integrated urban functions that need to co-exist in urbanised regions. However, since ecological processes like species persistence and dispersal often work on large scales, a site-based approach will not be sufficient for the consideration of biodiversity. Instead, it will be necessary to consider the quality, quantity and spatial cohesion of natural habitats and persistence requirements of species and communities in the entire landscape.

To achieve an adequate integration of biodiversity aspects in planning, landscape ecological expertise is required to provide relevant knowledge on patterns and dynamics of ecosystems and their vulnerability for interventions and change. In landscape ecology, the relation between landscape patterns and ecosystem processes is studied (Forman & Godron, 1986; Wu 2008), and since effects of habitat loss and fragmentation on biodiversity are addressed, methods are widely applicable in impact assessment of landscape level changes (e.g. Opdam & Wiens, 2002). Such expertise is important to analyse how ecosystem services can be optimised in urbanised regions and how resilient social-ecological systems can be designed to deal with disturbances while retaining their essential functions. This involves that urban development is adjusted to the ecosystems' limitations of adaptation.

To incorporate landscape ecological expertise in urban planning, tools and models are required, which add time scales and spatial dimensions to knowledge on ecological processes. The outputs of these tools will support the search for design alternatives that take into account biodiversity and other ecosystem services. In addition, the results of the modelling activities have to be related to the realities of governance and planning. While the outcome of the planning tools are primarily two-dimensional, planning practice takes place in a multi-scalar context which implies that the proposed development only can be accomplished through directed actions on different levels of governance. In this process SEA could play a role as an interface between landscape ecological expertise on one hand and urban planning and governance on the other.

Landscape ecological approach in SEA

Tools

Urban and urbanizing areas can be seen as complex social-ecological systems where the interactions between humans and urban green areas are intricate and occur on different scales. For impact prediction in the complex urban systems, the task would be to represent both biodiversity, human demands of a livable landscape and their interactions, in relation to impacts of urbanization. For this task, landscape ecology provides suitable methods and tools that have the potential to analyse and predict probable changes. In particular, methods based on geographical information systems (GIS) can be used for this type of analysis, including land change models, predicting urban development, vegetation growth and other land cover and land use changes. Such models are based on spatial information of vegetation types and land cover, for habitat suitability and landscape connectivity. These can be related to habitat models for prioritized biodiversity components (e.g. Gontier et al. 2006, 2010, Hepinstall et al. 2008) and to human neighborhood/loci models, accounting for recreation and other local resource use.



Figure 1. Example of the outcome of a GIS-based landscape ecological model: a visualization of suitable and available habitat for dispersal-limited species tied to coniferous forest. On top the base line situation, and below the situation after in-fill development in a suburban area of Stockholm, Sweden (Mörtberg et al. 2010).

An example of the application of a GIS-based landscape ecological assessment tool in an urban planning context is shown in figure 1. On the map suitable and available habitat for prioritised biodiversity components are outlined before and after planned development in the City of Stockholm (Mörtberg et al. 2010). The developed tool is used as decision support in EIA and could be used in SEA for analyzing alternative development scenarios in the municipal comprehensive plan.

GIS-based impact prediction tools allow not only the integration of scientific knowledge in the planning process, but facilitate also the priority setting of planners and stakeholders. For this purpose, a suitable tool is represented by spatial multi-criteria evaluation (SMCE), which includes a family of techniques to identify and compare solutions to a spatial problem, based on the combination of multiple factors that can be, at least partially, represented by maps (Malczewski, 1999). This approach takes advantage of both the capability of GIS to manage and process spatial information, and the flexibility of MCE to combine factual information (e.g. fragmentation indicators) with value-based information (e.g., expert's opinion, quality standards, participatory surveys). Taking into account both factual elements and people's values and perceptions is essential to identify options to build consensus around a decision, to reduce conflicts, and consequently to pave the way to successful land-use planning. In order to enhance the participation process, the tools employed in landscape analysis should give emphasis to visualization and on interaction possibilities.

Application in SEA

In GIS-based landscape ecological analysis, spatial indicators are computed and combined to express ecosystem characteristics, such as shape, isolation, heterogeneity. These indicators are particularly helpful when suitable ecological data are not available or not obtainable because of budget or time constraints. However, one limitation to the practical use of the findings of these studies is that they focus on the identification and computation of indicators, rather than on their interpretation and assessment of the results. In other words, indicators are described, discussed and measured, but rarely linked to a "value judgment" that can be directly employed by planners to guide their decision-making process. This is mainly due to the fact that scientific knowledge and experimental tests are hardly robust enough to infer uncertainty-free interpretations and assessments. A frequent consequence of this limitation is that ecological studies are set aside during land-use planning and land allocation procedures, because they do not come to clearly understandable conclusions and suggestions. In order to avoid this, we should ensure the best knowledge available about a phenomenon to be conveyed to decision-makers. In many cases, this "best knowledge" is represented by expert opinion, which needs to be collected, formalised and linked to the output of the spatial analyses (Geneletti, 2005).

In different research projects, methods and tools have been developed for integrating biodiversity issues in planning and SEA in urbanising environments. In order to offer a more proactive planning approach, the concept landscape ecological assessment (LEA) was developed (Mörtberg et al., 2007). This concept provides a structured process for the assessment of biodiversity impacts of alternative development scenarios and relates it to specified biodiversity targets. LEA is primarily based on landscape ecological knowledge, which also defines the scale of the assessments. A basic assumption in LEA is that biodiversity on a landscape scale can be maintained through the preservation of habitat networks, sufficient for the persistence of assemblages of native species. This assumption is endorsed by landscape ecological research (e.g. Opdam & Wiens, 2002) as mentioned earlier, but challenged under the conditions of climate change which will add a factor of uncertainty. Even so, the experiences from the application of tools and methods that have been

developed open up for a wider use in EIA and SEA for the assessment of biodiversity issues in planning. This will help to shift focus from areas that are included in nature protection schemes to ecosystem networks which also involves areas without specific conservation status.

Finally, in order to be useful in SEA, landscape ecological analysis must deal with the uncertain nature of planning: spatial plans are characterized by a great degree of generality and uncertainty that makes the prediction of their effects more difficult. The methods and techniques employed in SEA must be able to inform decision-making in conditions of uncertainty and vague information. For this reason, scenario analysis is commonly listed among the elements of the 'SEA toolbox'. Scenarios can be defined as descriptions of a range of possible futures based on a series of 'if-then' propositions. In order to effectively support plan makers, landscape ecological analysis in SEA should include methods to compare the effects on biodiversity of alternative plan policies, under different scenario conditions.

Conclusion

The application of landscape ecological expertise in SEA and planning for analysing ecological processes and landscape patterns is crucial for maintaining ecosystem services in urbanised regions. Experiences from research on landscape ecological analysis show that GIS prediction tools can be applied to add a spatial and temporal component to the analysis and to visualise and communicate biodiversity impacts. Furthermore, these tools can help to highlight uncertainty aspects of the analyses, which enhance the transparency of planning and decision making. In order to facilitate the integration of these tools in SEA, indicators and scientific knowledge should be intelligible to strengthen the role of landscape ecological assessments in planning and decision making.

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