ELSEVIER

Journal of Environmental Management 82 (2007) 457–470

Journal of Environmental Management

www.elsevier.com/locate/jenvman

Landscape ecological assessment: A tool for integrating biodiversity issues in strategic environmental assessment and planning

U.M. Mörtberg[a,*], B. Balfors[a], W.C. Knol[b]

[a]*Department of Land and Water Resources Engineering, Royal Institute of Technology, SE-100 44 Stockholm, Sweden*
[b]*Department of Water and the Environment, Alterra Green World Research, P.O. Box 47, 6700 AA Wageningen, The Netherlands*

Received 16 June 2004; received in revised form 9 January 2006; accepted 10 January 2006
Available online 29 March 2006

Abstract

To achieve a sustainable development, impacts on biodiversity of urbanisation, new infrastructure projects and other land use changes must be considered on landscape and regional scales. This requires that important decisions are made after a systematic evaluation of environmental impacts. Landscape ecology can provide a conceptual framework for the assessment of consequences of long-term development processes like urbanisation on biodiversity components, and for evaluating and visualising the impacts of alternative planning scenarios. The aim of this paper was to develop methods for integrating biodiversity issues in planning and strategic environmental assessment in an urbanising environment, on landscape and regional levels.

In order to test developed methods, a case study was conducted in the region of Stockholm, the capital of Sweden, and the study area embraced the city centre, suburbs and peri-urban areas. Focal species were tested as indicators of habitat quality, quantity and connectivity in the landscape. Predictive modelling of habitat distribution in geographic information systems involved the modelling of focal species occurrences based on empirical data, incorporated in a landscape ecological decision support system. When habitat models were retrieved, they were applied on future planning scenarios in order to predict and assess the impacts on focal species. The scenario involving a diffuse exploitation pattern had the greatest negative impacts on the habitat networks of focal species. The scenarios with concentrated exploitation also had negative impacts, although they were possible to mitigate quite easily. The predictions of the impacts on habitats networks of focal species made it possible to quantify, integrate and visualise the effects of urbanisation scenarios on aspects of biodiversity on a landscape level.

Keywords: Urbanisation; (regional) planning; Strategic environmental assessment; Scenarios; Predictions; Habitat networks; Focal species; Biodiversity indicators; GIS

1. Introduction

In the footsteps of the industrialisation, agricultural societies have been transformed into urbanised landscapes. In Sweden, like in many other European countries, the urbanisation process has been going on for a long time and today around 80% of the Swedish population lives in urban areas (Nyström, 1997). In order to meet the demands for new housing areas, additional office facilities and better transportation systems, new areas are required for exploitation. This puts a high pressure on the remaining areas of nature in urban regions.

Unexploited areas in and around cities accommodate a multitude of qualities, both ecological and recreational (Office of Regional Planning and Urban Transportation (ORPUT), 1996, 2001a; Miller and Hobbs, 2002; Ricketts and Imhoff, 2003). The areas of natural and semi-natural vegetation offer living conditions for a variety of species, and are therefore essential for maintaining biodiversity. However, due to the ongoing urbanisation these areas are prone to a continuous fragmentation process and loss of habitat quality. At the political level a number of decisions have been made that emphasise nature conservation and the preservation of green areas. In Sweden, the Governmental environmental objectives require that biodiversity is preserved and dispersal possibilities are safeguarded (Government Bill, 1998). This is also in line with the

*Corresponding author. Tel.: +46 8 790 86 08; fax: +46 8 411 07 75.
E-mail address: mortberg@kth.se (U.M. Mörtberg).

0301-4797/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvman.2006.01.005

Convention on Biodiversity, where an ecosystem approach is adopted and should be applied whenever appropriate (Official Journal of the European Communities (OJEU), 1993). Further, in the sixth EU Environmental Action Programme, biodiversity is one of four priority areas where action is required. An objective and priority area for action on nature and biodiversity is the conservation of species and habitats, with special concern to preventing habitat fragmentation (OJEU, 2002).

In response to the political ambitions, the impacts of new developments in urban areas require careful consideration. Therefore the consequences of urban expansions need to be analysed prior to any decision that provides for the exploitation of green areas. When such a decision concerns a project, for example the construction of a motorway, the legal requirements on environmental impact assessment (EIA) state that the impacts of the project are identified before a decision is made. However, initial decisions on urban expansion and major infrastructure investments are often made at a strategic stage where the long-term development of an urban region is determined. For this type of decisions the EIA regulations can not be applied. Instead a strategic environmental assessment (SEA) can be prepared, which addresses the environmental impacts of a strategic decision (Lee and Walsh, 1992; Thérivel et al., 1992; Partidário, 1996; Glasson et al., 1999; Fischer, 2002; Balfors and Schmidtbauer, 2002).

In Sweden, stricter demands on environmental assessment are raised since the Environmental Code came into force in 1999. In the European context, regulations on environmental impact assessment have been tightened in the amended EU Directive for project EIA from 1997 (OJEU, 1997). The recent enactment of a new EU Directive concerning the assessment of the effects of certain plans and programmes on the environment (OJEU, 2001) strengthens the need for environmental consideration in physical planning. Both directives emphasise the importance of identifying impacts at an early stage of the planning process.

The Directives require a general incorporation of SEA in European planning systems, but still there exists a high degree of uncertainty on how a SEA should be carried out. In for example, Sadler and Verheem (1996) and Verheem and Tonk (2000), a number of methodological and procedural complications related to SEA are identified and discussed. A main issue in this discussion is that each SEA requires an approach that is adapted to the particular qualities of the plan, programme or policy. Hildén et al. (1998) stated that the high level of abstraction of plans, programmes and policies involves a major methodological problem for the prediction of impacts.

The integration of biodiversity issues in the assessment requires prediction tools that employ relevant knowledge on the impact of land use changes on the fauna and flora inhabiting the area. Loss and fragmentation of natural habitats are major causes of decline of biodiversity (Fahrig, 1997), but the magnitude and significance of the impacts on biodiversity are not easy to determine, as this depends on various aspects such as the landscape context of the claimed area, the scope of the proposed development and the vulnerability of a species to external influences. Effects of habitat loss and fragmentation and relations between landscape pattern and ecological processes are studied in landscape ecology, where the landscape level is considered as more inclusive than the ecosystem level, as it is a collection of ecosystems (Forman and Godron, 1986; Farina, 2000; Wiens, 2002). For the protection of biodiversity, considerations are needed at genetic, species and ecosystem scales, and the quality, quantity and connectivity of natural habitats are essential. A site-based conservation approach is not sufficient, but rather a look at persistence requirements of species and communities in the entire landscape. Suitable and accessible habitat can be planned in habitat networks, consisting of core areas sufficient for species' persistence in the landscape, linked together through corridors, which enable dispersal (Opdam et al., 2002). In this way, landscape ecology can provide knowledge and a conceptual framework for the assessment of ecological consequences of long-term development on wildlife potential (Fernandes, 2000; Aspinall and Pearson, 2000; Botequilha Leitão and Ahern, 2002).

Habitat loss and fragmentation are consequences of the urbanisation process, which also causes disturbances on remaining nature areas. Thus, biodiversity is gradually affected, but the level of change is varying in different parts of an urbanising landscape. Consequences of urbanisation like habitat fragmentation and disturbance effects have been explored by for example Bolger et al. (1997), Sauvajot et al. (1998) and Mörtberg (1996, 1998, 2001) and were reviewed in Fernandez-Juricic and Jokimaki (2001). Ecological effects of infrastructure like habitat fragmentation and associated barrier effects on the movements of sensitive species have been studied by for instance Forman (2000), and reviewed in Trocmé et al. (2002). As a result of urbanisation and infrastructure development, apparently small impacts on individual sites can result in considerable cumulative effects on the availability of natural habitat in a region, which calls for a landscape perspective in impact assessment.

Within the research of conservation biology and landscape ecology, simulations and predictions of species' occurrences are growing fields (e.g. Akçakaya and Raphael, 1998; Dettmers and Bart, 1999; Guisan and Zimmermann, 2000; Scott et al., 2002). Such predictions are based on an established relation between the occurrence of a species and environmental variables, describing its suitable habitat. These environmental variables are used to predict potential sites for the species. Predictive habitat models, using GIS, can be applied over large areas and are useful in the conservation and management of ecosystems (Guisan and Zimmermann, 2000; Scott et al., 2002; Geneletti, 2002). In several studies (e.g. Natuhara and Imai, 1999; Watson et al., 2001; Coops and Catling, 2002), predictive models are used to assess the ecological effects of