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Scale issues in the assessment of ecological impacts using a GIS-based habitat model — A case study for the Stockholm region

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Abstract

Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) provide two interlinked platforms for the assessment of impacts on biodiversity caused by human developments. Although it might be too early to draw conclusions on the efficiency of SEA to assess such impacts, a number of persistent problems have been identified in the case of EIA. Some of these shortcomings concern the lack of proper prediction and impact quantification, and the inadequate/insufficient assessment of cumulative effects. A number of problems are related to the scale(s) at which the assessment is performed. SEA may provide a more adequate framework than EIA to discuss scale-related issues (i.e. cumulative impacts) but it also requires the use of adapted tools. This paper presents a case study where a GIS-based habitat model for the lesser spotted woodpecker is tested, validated and applied to a planning scenario in the Stockholm region in Sweden. The results show that the method adopted offers great prospects to contribute to a better assessment of biodiversity-related impacts. Even though some limitations remain in the form of data requirement and interpretation of the results, the model produced continuous, quantified predictions over the study area and provided a relevant basis for the assessment of cumulative effects. Furthermore, this paper discusses potential conflicts between different scales involved in the assessment — related to administrative boundaries, ecological processes, data availability, the method adopted to perform the assessment and temporal aspects.

Keywords: SEA; EIA; Scale; Data; Biodiversity; Lesser spotted woodpecker; Maxent model; Physical planning; Cumulative impacts

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1. Introduction

Habitat loss and fragmentation caused by human activities are major threats to biodiversity (Saunders et al., 1991; Fahrig, 1997). Changes in land use related to urban, industrial and infrastructure developments are major causes of habitat loss and fragmentation. These changes occur at different scales in space and time. Some major tools to assess the consequences of land use changes related to urbanization and infrastructure developments are environmental assessments in the form of Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). EIA operates at the project level while SEA is applied on policies, plans and programmes. In the European Community, the legislations on both EIA, in the form of the directive on the assessment of the effects of certain public and private projects on the environment (Official Journal of the European Communities, OJ, 1985) and SEA, in the form of the directive on the assessment of the effects of certain plans and programmes on the environment (OJ, 2001) integrate biodiversity-related impacts.

However, quality reviews of Environmental Impact Statements (EISs) for projects in Europe and in the USA pointed out some major failures in the assessment of ecological or biodiversity-related impacts (Treweek et al., 1993; Thompson et al., 1997; Byron et al., 2000; Atkinson et al., 2000; Gontier et al., 2006). Some of the main issues identified were the lack of well-defined, adequate methods, the poor predictive and quantitative nature of the assessments, and difficulties to address cumulative effects in the assessment of impacts on biodiversity. Moreover, another review pointed out that information on the spatial scale used in the assessment was seldom presented explicitly (João, 2002).

Scale-related issues are not specific to ecological assessment within EIA and SEA. Scale is a central issue in ecology (Wiens, 2002) and plays an important role for species diversity distribution (Willis and Whittaker, 2002). In particular the field of landscape ecology has been exploring and studying the role of the spatial dimension in ecology (Botequihla and Ahern, 2002). While in cartography scale refers to the ratio of the distance between two points on a map to the distance between those same points in the real world (e.g. 1:10 000), landscape ecology and other disciplines define the term scale to integrate both grain (cf. resolution) and extent (total size of an area) (Turner et al., 1989; Houston, 2002). These concepts of extent and grain are essential within ecology in general (Jenerette and Wu, 2000) and spatial ecology in particular (Wiens, 2002). As a consequence the expression 'large scale' is often used in ecology when a large area is covered (Noon and Dale, 2002) as opposed to the common meaning in geography and cartography (Houston, 2002) where 'large scale' means more detailed maps covering a smaller area. Patterns of species diversity are strongly related to scales with different variables acting at different spatial scales (Willis and Whittaker, 2002). Many ecological components and factors such as habitat, animal density, patch geometry or resources availability vary and act differently with scale (Morrison and Hall, 2002). Different scales govern different ecological processes and the impact of fragmentation on biodiversity may as well vary depending on the scale that is considered (Olff and Ritchie, 2002). Finally, the scale of observation, influences the patterns described or predicted (Levin, 1992).

Another aspect of scale concerns time. The temporal scale is one main component, along with spatial and organizational scales, of ecological systems variability (Levin, 1992). The dynamic of ecological systems underlines the importance of the temporal scale. Moreover, the dynamic in the urbanization process is also strengthening the importance to consider the temporal scale when studying ecological impacts caused by human activities. The same concepts of grain and extent can be applied to the temporal scale with the grain being the smallest unit of time relevant for a study and the extent being the total duration of time under consideration for a study (Turner et al., 1989).