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Using the Ecopath approach for environmental impact assessment—A case study analysis

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ABSTRACT

If a proposed project or plan is likely to negatively impact a Natura 2000 site, it must undergo an environmental impact assessment. Article 6.3 of the Habitats Directive (92/43/EEC) clearly specifies the assessment procedure.

This case study presents the assessment of three different projects that might negatively affect a Natura 2000 site in Germany. The impacts of an industrial area, construction of a road and a wind power generator were investigated using the Ecospace habitat capacity model. The short and long-term effects of these projects were analyzed, considering cumulative effects of habitat loss, noise and light pollution on the environment. By applying Ecospace two alternatives were explored for each proposed project, thereby identifying the strategy with least impact and also determining the environmental damage and how it can be compensated.

This study demonstrates that the Ecopath approach is the number one tool for environmental management in the European Union, as it can deliver the results that are needed to meet all legal requirements and it is also able to solve 'on-going' problems, for example assessment of cumulative and in-combination effects, identification of effective mitigation measures and providing clear, objective conclusions

1. Introduction

The Habitats Directive (92/43/EEC) and Birds Directive (2009/147/EC) shall protect species and habitats in the European Union. Nature Conservation is leaning on two measures, namely the Natura 2000 network of protected habitats and specific species protection that covers over a 1000 animal and plant species, which are listed in the Directives.

In Germany, a total of 4606 Natura 2000 areas had been established until 2014, covering an area of 5.4 million hectares (BfN, 2014). However, today only 28% of protected habitats and 25% of listed species are in a good condition (Dröschmeister et al., 2014). The major threats to biodiversity are known, like agriculture and habitat loss (Dröschmeister et al., 2014). To ensure that project or plans that cause habitat loss do not negatively affect a Natura 2000 site, they must undergo an environmental impact assessment. Article 6.3 of the Habitats Directive (92/43/EEC) clearly specifies the assessment procedure. First, a project is screened and if it can be concluded that there are no negative impacts, authorization may be granted. If negative effects cannot be ruled out, the project has to undergo an appropriate assessment. Here, all cumulative and in-combination effects with other projects have to be assessed and effective mitigation measures might be identified. Only if all negative effects can be ruled out or removed, the authorization may be granted. Apparently the majority (61%) of projects in Germany has been screened out, as "they posed no problem" and in Baden-Württemberg even 90% of projects were not relevant to Natura 2000 areas (Sundseth and Roth, 2013). The Minister of Environment stated in 2007 that "to date the nature conservation Directives have not been prevented any single significant economic development in Germany" (Sundseth and Roth, 2013). Obviously there is a conflict, as nature is mostly in a bad condition, but projects are said to pose no problem in Germany. It is unclear, why the impacts of many projects do not need to be assessed, but there is also a problem with the projects that do undergo an impact assessment. There are "on-going" problems with the environmental impact assessment procedure that might explain the bad environmental condition in Germany (Sundseth and Roth, 2013). Major problems were: poor quality of impact assessments, clear conclusions were missing, assessment of cumulative effects and in-combination effects was needed, mitigation measures were not identified properly, lack of skills or knowledge, lack of understanding key terms, lack of sufficient ecological data and the assessment of significance of impacts was too subjective (Sundseth and Roth, 2013). In Germany, the Federal Agency for Nature Conservation recommends the application of case conventions, which are spatial benchmarks, to assess the

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significance of impacts (Lambrecht and Trautner, 2007; Lambrecht et al., 2004). However, there is reasonable doubt that these spatial benchmarks are able to assess significant impacts (Fretzer and Möckel, 2015). Thus, they do not fulfil the requirements of the European Court of Justice (Fretzer and Möckel, 2015). The Court required certainty that a Natura 2000 site is not negatively affected, if authorization of a project is granted.

Habitat loss is a major threat to biodiversity in Germany and the German government is willing to reduce habitat loss (Dröschmeister et al., 2014), but more projects are planned that might cause further degradation of protected species and habitats.

According to the Federal Ministry of Transport, Germany has one of the densest road networks in Europe, covering 12,917 km of autobahn plus 39,400 km of state roads. Germany will further invest approximately 47 billion Euros in road construction projects over the next years (BMVI, 2010). More roads are being built and planned, as traffic is expected to further increase in the next decade (BMVI, 2010). The ecological effects of roads cause substantial damage to wildlife (Forman and Alexander, 1998; Spellerberg, 1998) and also affect endangered species, such as the red kite (*Milvus milvus*) (Mammen et al., 2014).

Renewable energy projects, such as wind farms, also threaten biodiversity by negatively affecting bats and birds, for example the red kite (*M. milvus*) (Mammen et al., 2014). In 2014 over 24,000 wind energy plants had been raised in Germany and the importance of energy from wind power is expected to increase by 143% in 2030 (BMWI, 2014).

If there is overwhelming public interest, all these projects may be realized even if there are negative effects on Natura 2000 sites (Article 6.4, Habitats Directive). The environment in Germany is not in a good condition (Dröschmeister et al., 2014) and further biodiversity loss will affect the next generations (Essl et al., 2015), so we have to find a way to plan and build these projects without causing environmental damage. These projects need to be assessed properly and if negative effects occur, they have to be effectively compensated on site.

There is “still a real need to set up a more systematic consistent framework” for impact assessment in Europe (Sundseth and Roth, 2013) and other promoted frameworks haven’t been able to fill this gap (Fretzer and Möckel, 2015; Masden et al., 2010; Villarroya and Puig, 2010).

This approach presents Ecospace and its habitat capacity feature as a feasible framework for impact assessment. By using a simple, theoretical model that presents one protected habitat type, such as the woodrush beech forest (listed habitat type No. 9110) and two protected species, such as the stag beetle (*Lucanus cervus*) and the red kite (*M. milvus*), three different types of projects are investigated here: a planned industrial area, construction of a road and a wind turbine generator. By applying Ecospace, two alternatives were explored for each proposed project, thereby identifying the strategy with least impact and also determining the environmental damage and how it can be compensated. This study will demonstrate that the Ecopath approach, in particular, the Ecospace/habitat capacity feature, is able to solve common on-going problems with the environmental impact assessment procedure and hence, improve the implementation of both Directives.

2. Material and method

2.1. Ecopath, Ecosim and Ecospace

Ecopath is a quantitative modelling technique that describes the biomass flows between functional groups (Christensen et al., 2005). A functional group can consist of a single species or a population, a taxonomic family or several taxa, for example, both single species (e.g. red kite, *M. milvus*) and broad taxonomic groupings (e.g. gastropods) form functional groups. Through Ecosim, dynamical simulations of the mass-balanced Ecopath model over a defined time period can be run to investigate alternative management policies, for example hunting or fishing policies (Christensen et al., 2005). The consumption rates in Ecosim, Q_{ij}, are based on the ‘foraging arena’ concept, which states that not all individuals are equally vulnerable to predation. The biomass (B_i) is divided into a vulnerable and an invulnerable component (Christensen et al., 2005). These vulnerabilities are assigned to each predator–prey relationship during the process of model calibration. The set of differential equations is solved in Ecosim using an Adams–Bashford integration routine (Christensen et al., 2005). Ecospace represents biomass dynamics over two-dimensional space and time (Walters et al., 1999). The user can develop a two-dimensional map by defining rectangular grids of cells. Each cell is assigned to a different habitat type and within each cell, the biomass densities are treated as homogenous for trophic interactions, fishing or hunting and movement calculations (Walters et al., 1999). Emigration flows occur from the four surrounding cells that border the cell. Emigration rates to the “outside world” (i.e. to the space outside the boundaries of the grid) are assumed to be compensated by immigration rates from that outside world (Walters et al., 1999).

Based on the spatial-temporal model of Ecospace, the habitat capacity approach drives the foraging capacity of functional groups from the cumulative impacts of multiple environmental factors, for example temperature, noise and light pollution (Christensen et al., 2014). For each environmental factor, an environmental preference function is defined and for each grid cell, a specific habitat capacity value is defined as the product of the environmental preference values. Thus, the biomass distribution for the functional group is derived as a function of the environmental preference functions combined with food web interactions and anthropogenic effects, like hunting or fishing.

2.2. Model development

The Ecospace scenarios performed in this study are based on a published basic Ecopath model that describes a terrestrial ecosystem before the construction of a planned industrial area (Fretzer and Möckel, 2015). This theoretical Ecopath model consists of 31 functional groups and includes a protected species, the stag beetle (*Lucanus cervus*) and a listed habitat type (a woodrush beech forest, habitat type no. 9110) that are both protected by the Habitats Directive and a species protected by the Birds Directive (red kite, *M. milvus*) and agricultural areas, cultivating grass. 11% of the modelled area is covered by woodrush beech forest, 42% is covered by grassland and the remaining 47% of the area are covered by forest, which also includes the stag beetle habitats (Fig. 1). All functional groups in the forest habitat also appear in the stag beetle habitat. The functional groups of the woodrush beech forest habitat are labelled with its habitat number, such as 9110 (Table 1).

The agricultural area is depending on several factors like the application of fertilizer, pesticides, herbicides, irrigation and number of harvests (Benton et al., 2002) and therefore, the agricultural functional groups were highly simplified, only representing a harvest and faunal group for each crop (Fretzer and Möckel, 2015). However, for an appropriate impact assessment the agricultural food web and its impacts on site should be part of the model.

2.3. Data input

The development of the input parameters for the different functional groups will not be repeated here, but all details were already published (Fretzer and Möckel, 2015). The Ecospace analysis is