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Ecological process indicators used for nature protection scenarios in agricultural landscapes of SW Norway

Annette Bär[a,b], Jörg Löffler[a,*]

[a] *University of Bonn, Department of Geography, Germany*
[b] *University of Oldenburg, Institute of Biology and Environmental Sciences, Germany*

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Abstract

Conflicts between changing landscapes and static nature protection concepts were addressed as an example of the agricultural landscape of SW Norway. We aimed to deduce indicators for spatio-temporal landscape changes to draw scenarios for future protection perspectives of a RAMSAR and nature reserve. To estimate the variability of bird diversity, changes in vegetation patterns were analysed to predict bird occurrence. We obtained a differentiated analysis of present landscape dynamics by measuring landscape structure, vegetation, hydrology and nutrient concentration. Multivariate statistics were used to extract the main driving forces for changes in vegetation patterns out of a complex landscape ecological data set. Subsequently, we compared the measured data with those of past landscape stages to determine landscape changes and their mechanisms at different spatio-temporal scales. Ecological process indicators (EPI) were derived, and three different indicator constellations were used for scenario descriptions. These scenarios were chosen as to the current assumptions of typical contrasting nature protection strategies. Concluding, we used EPIs to evaluate nature protection aims and to assess scenarios of changing landscapes. This approach will be transferable to other examples of nature protection conflicts in the agricultural landscape in general.

Keywords: Biodiversity; Landscape dynamics; Landscape management; Landscape metrics; RAMSAR reserve; Sustainable development; Vegetation mapping; Wetland ecosystems

1. Introduction

Cultural landscapes show spatio-temporal changes of landscape structures according to intensive human impact and natural succession (Lundberg, 2000; Waldhardt et al., 2004). Thus, current discussions about changing landscapes and process-oriented protection strategies (Pickett et al., 1992; Lundberg, 1996; Skånes, 1997) have to consider the question of appropriate protection. As an example of the agricultural landscape of SW Norway, we chose a study area at Lake Grudevatn (Jæren). High diversity in plant and bird life led to the designation of the site as

* Corresponding author. Tel.: +49 228 73 7239.
E-mail address: loeffler@giub.uni-bonn.de (J. Löffler).

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nature reserve in 1974 and as a RAMSAR reserve (convention on wetlands signed in Ramsar, Iran 1971) in 1985 (Wetlands International, 2004). High plant and bird diversity as a reason for protection was not further specified in the protection aims, so it remained unclear what kind of species composition was desired: a species composition of traditional agricultural landscapes, in coincident with wetland protection (RAMSAR), a species composition of minimal anthropogenic disturbed areas, or a mosaic of both which favors high total species numbers but of more common species. Consequently, nor monitoring of plant and bird species occurrence neither landscape management measures have been carried out to observe landscape changes or to maintain a desired status of species composition within the protected area. Thus, the landscape character has strongly changed since 1974 caused mainly by shifts in distribution and composition of vegetation units.

Due to the lack of specified protection aims and continuing monitoring data the challenge was to use the approach of ''space-for-time substitution'' (Pickett et al., 1992). This approach should be combined with available external data about past landscape stages in order to determine ongoing and past changes. Our study was framed by a general increasing interest in deducing indicators to monitor environmental change (Tiner, 2004). Our approach was focused on developing ecological indicators that represented different vegetation transforming processes at different spatial scales and time perspectives, hereafter referred to as ecological process indicators (EPI). In detail, these indicators should be extracted by mapping recent vegetation patterns and measuring corresponding hydrological and nutritional conditions. The structural status quo of the landscape should then be compared with past stages of spatial vegetation succession over the past decades. As it is known that bird occurrence, abundance and habitat selection is strongly influenced by vegetation structures (Cody, 1987; Jones, 2001; Tõnu et al., 2005), the information about changes in vegetation patterns should be used to estimate the variability of bird diversity.

Using the derived EPIs to adjust different variable constellations we aimed to suggest scenarios to illustrate landscape changes and possible future developments with respect to their relevance for bird life at Lake Grudevatn. We intended to focus on major principles of medium- and long-term landscape changes; precise predictions of short-term configurations of species and species numbers were not intended. Our sub-goals were:

(a) to test a combination of multi-scale environmental variables and methods, including a short investigation period combined with different historic data sources in order to determine the complex of medium-term and long-term landscape transforming processes,
(b) to use vegetation changes as predictor for bird diversity, and
(c) to derive EPIs for scenarios of landscape development in a RAMSAR and nature reserve by addressing conflicts between changing landscapes and static nature protection concepts.

2. Material and methods

Field work was carried out at Lake Grudevatn, Klepp community (Jæren, SW Norway). The wetland is protected as bird and nature reserve, covering 110 and 47 ha of land, respectively, and is surrounded by intensively used arable land and pasture resulting in considerable nutrient supply caused by drainage ditches (Molværsmyr et al., 1989; Molværsmyr, 1990). The water table shows high oscillations and flooding occurs regularly. During the 20th century substantial anthropogenic changes were caused by drainage measures in order to extend the amount of agricultural land. Water table lowering and an increased nutrient supply caused rapid vegetation succession and accelerated sedimentation at the lake shores (Olafsrud, 1993).

Fig. 1 describes our methodological approach at different spatio-temporal scales. The present status quo of the bird and nature reserve was investigated between May and August 2002. Vegetation was mapped at 115 single square plots ($5 \text{ m} \times 5 \text{ m}$) aggregated to 18 transects along different topographic and moisture gradients around the lake. The distance between the plots was determined for each transect according to the change of plant species compositions. Plant species abundance was recorded using the Domin-scale (Kent and Coker, 1992). On the micro-scale, vegetation types were defined after Fremstad (1997) whose scheme was often used as a national