DE3 (Märkische Schweiz, Germany):
Assessing the effect of scale enlargement on the provision of landscape services

Objective

This object of this study is to present and test a methodology to model and analyse the effect of trees removal on the landscape structure and related ecosystem services. To this aim we used a spatially explicit and generally applicable probabilistic approach to assess and map landscape elements, assuming a stepwise removal following gradual field enlargement. Landscape elements and services are considered as the realization of a stochastic process called random function, and within this probabilistic framework their spatial properties can be described and modelled using second order statistics, such as the variogram. At each removal step we then describe the spatial relationships between elements and model the spatial heterogeneity of the remaining landscape elements. Goal of this work is to analyse and model the changes in the spatial architecture of the landscape under a scenario of increasing removal of tree elements following field enlargement and to assess how these changes in turn affect the supply of habitat services across the landscape with specific reference to a threatened target bird species. The study aims also to elucidate the relationship between the presence of specific landscape elements and the potential supply of a specific habitat service.

Methodology

To assess potential changes in landscape characters and services, we simulate the increasing removal of landscape elements such as single trees, tree groups and lines, hedgerows, alleys and windbreaks following field enlargements. In doing so we made the following assumptions: (i) Only those tree elements within or bordering agricultural fields are considered removable, while trees along primary, secondary, and tertiary roads, and those within settlement areas are assumed to be not removable, as they are not subject to agricultural management; (ii) Tree removal occurs stepwise and is simulated assuming that smaller fields are merged to larger fields and that the tree elements within or bordering them are therefore likely to be eliminated first; (iii) Fields are classified into ten size classes and at each step 50% of the elements within a given field size class are randomly selected and removed until all removable elements within all classes are removed (step 20). The share of removed elements at each step is not equal but constantly decreasing as it is related to the number of field plots within every size class. At step 20, total length of tree-related landscape elements is reduced by nearly 75% (from 504 to 125 km), and, considering all tree elements (i.e. removable and not removable), average density drops from 1,912 (step 0) to 476 m km-2 (step 20). In order to explore the effect of tree removal on landscape services, the case of habitat provision for one bird species, namely the red-backed shrike (*Lanius collurio*), was investigated assessing the changes in tree density at six removal steps (namely at steps 0, 3, 7, 11, 16, and 20), assuming an optimal element density of 40 m ha^{-1} and an activity range of 250 m. The red-backed shrike, listed in the European bird conservation guideline, has high conservation priority in Germany, closely depends on farmland habitats, and is of particular regional importance. The effects of tree elements removal on landscape structure are assessed at each step via observations of landscape elements at random points within a regular reference grid, followed by indicator coding, variogram analysis and kriging of single indicators via sequential indicator simulations. The approach allows the quantification of spatial heterogeneity and modelling of changes in the whole landscape architecture associated with the different rates of landscape elements removal.

Results

The changes in landscape structure were analysed in terms of elements connectivity and spatial heterogeneity. Results showed a turning point in correspondence of a 21% reduction in heterogeneity and a 20% reduction in elements connectivity, resulting from the removal of nearly 50% of the tree elements. In terms of habitat provision, the relative reduction of connectivity at the turning point, is equal to 50% of that at step 0, corresponding to 75% reduction in spatial variability. These figures suggest a faster rate of change in the indicator of optimal element density with respect to the simple elements occurrence indicator. At the turning points the agricultural landscape would reach the limits of its resilience in term of functions and services associated to the removed elements. We suggest that the turning point can be used for benchmarking the maximum extent of endowment for the specific service associated to the occurrence of tree elements in the agricultural fields.

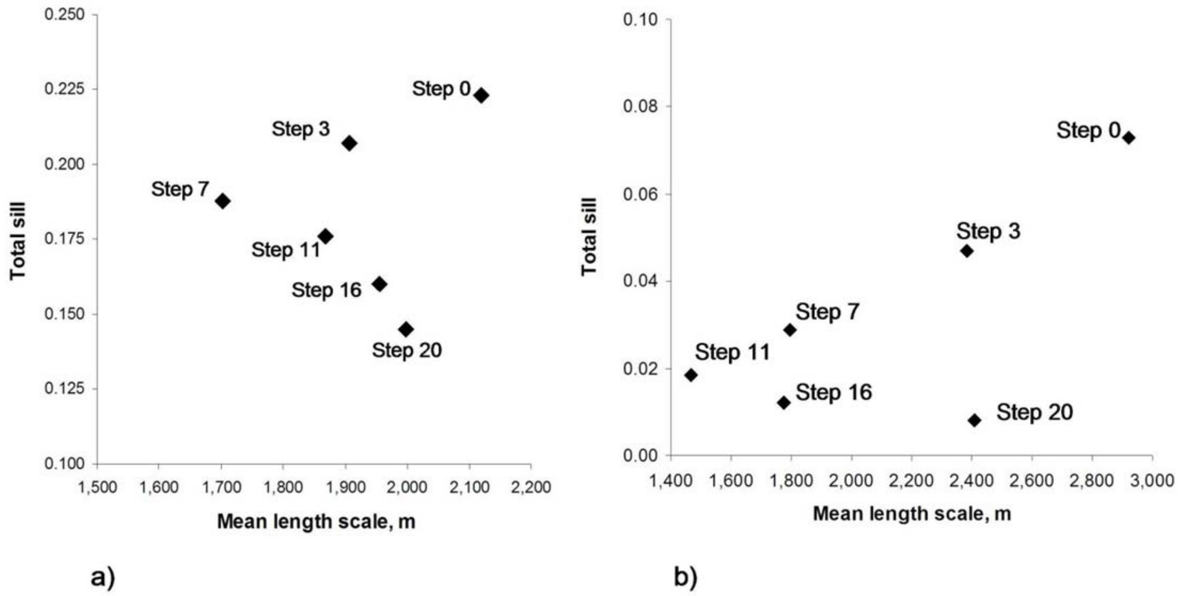

Figure 1. Total sill (spatial heterogeneity) versus mean length scale (spatial connectivity) at six selected removal steps: a) occurrence of tree elements; b) optimal habitat density for red-backed shrike (Lanius collurio).

Results, displayed in terms of probability maps of service provision (Fig. 2), are analysed for the different landscape units of the area, highlighting that a high probability of tree elements occurrence is not always coupled with a probability of habitat provision. The maps depicted in Fig. 1 show clearly how the spatial patterns of the two indicators are affected by the stepwise removal of elements. At step 0, areas with high probability of occurrence of tree elements are mainly clustered continuously around the core of the case study area represented by the nature park. But despite smaller in size and les continuous, spots of frequent occurrence of elements are observed also in the north-east and in the south-east corners of the area. In terms of habitat provision, three relevant clusters are observed in the central-western part of the area and only isolated smaller hot spots are observed in the north- and in the south-eastern parts of the area. The differences in the spatial distribution of the landscape elements and associated habitat provision service can eventually be summarised and visualised at each step and for each of the six distinct sub-landscapes encompassing the study area, highlighting the differences in allocations of the selected service indicators as depending upon landscape structure and composition. The web charts in Figs. 3a and b depict well the difference in provisioning the target habitat supporting service as related to elements occurrence in the sub-landscapes. It is relevant to note that at sub-landscapes level, the high probability of occurrence of tree element is not always coupled with a high probability of habitat provision.

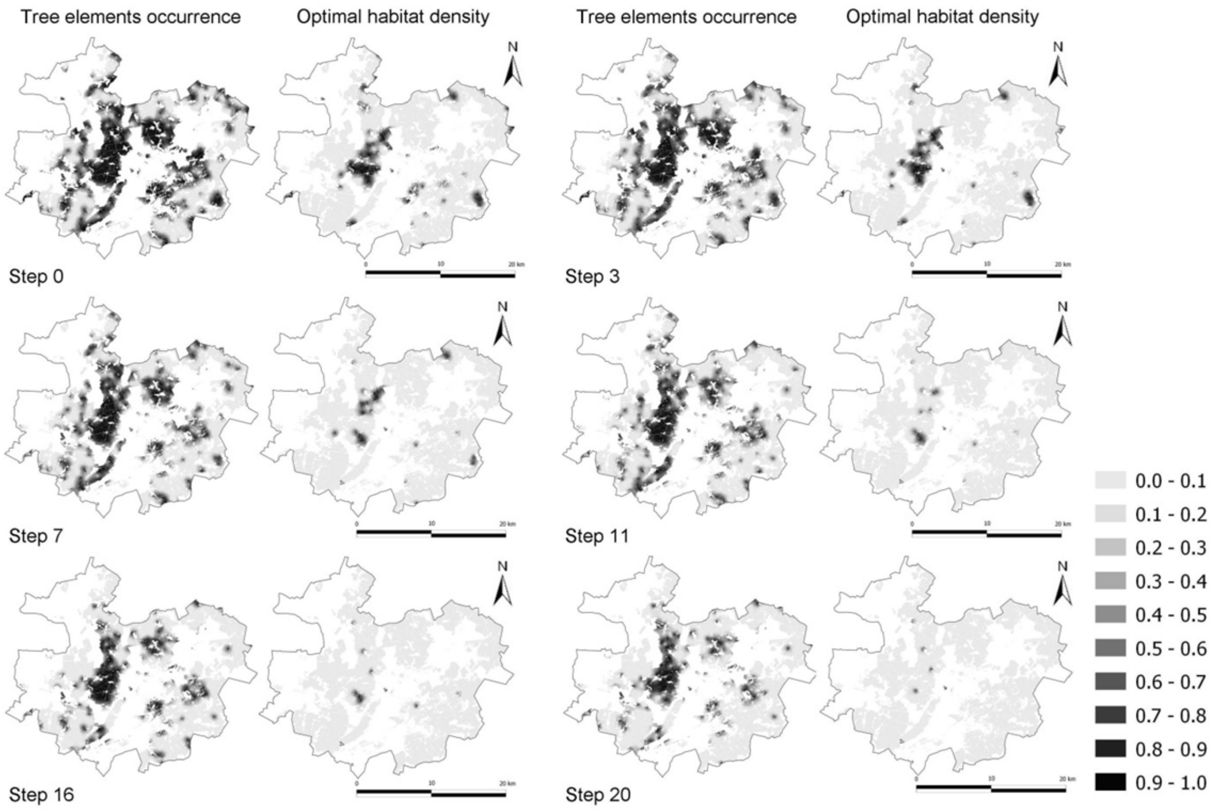

Figure 2. Landscape services probability maps at six selected steps of elements removal: E-type estimates (N = 1,000); left: average probability of occurrence of tree elements; right: average probability of occurrence of optimal habitat density for the red-backed shrike (Lanius collurio).

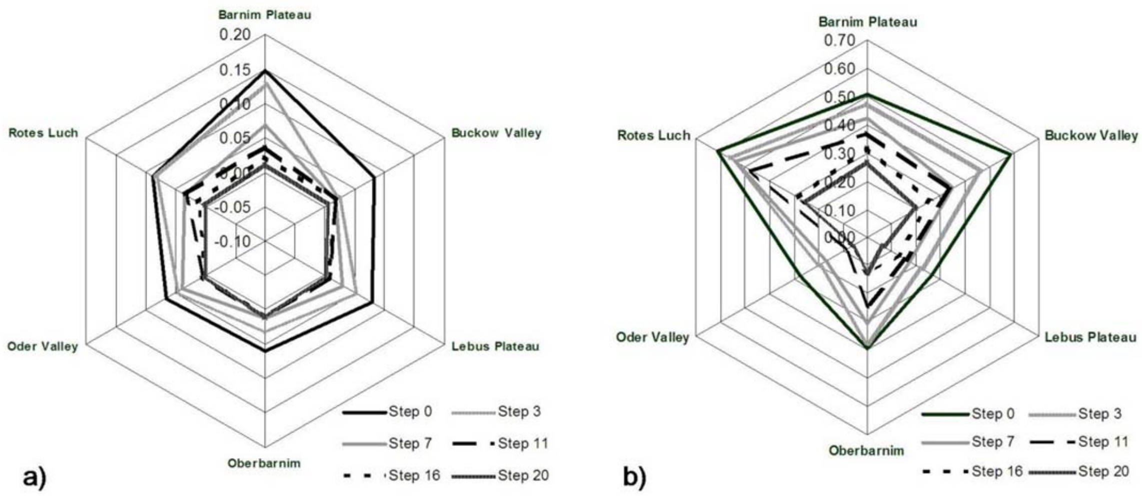

Figure 3. Mean probabilities of provision of the habitat supporting service (a) as related to probabilities of tree elements occurrence (b) in the six sub-landscapes at the selected removal steps.

Given the current landscape structure and spatial characteristics of landscape elements, it has been observed that the rate of habitat provision decrease with the removal of tree elements differs in the landscape sub-units as a response to specific local settings in terms of spatial variability and element connectivity.

Links connecting agents and causal connections through which landscape can potentially affect rural economies and societies

Scale enlargement and intensification of agricultural management is an issue of growing landscape ecological concern in European agriculture in general and in post-socialist countries of Middle and Eastern Europe in particular, where due to a high land market pressure, local cooperatives and individual farmers fail to compete with investment companies active in land grabbing. These changes in land ownership are currently affecting the spatial structure and composition of the rural landscapes being often associated with the removal of landscape elements following the changes in field sizes. At local scale it is highly relevant to assess to which extent these actual and potential changes in landscape structure affect the potential supply of landscape services and whether conflicts between multiple services provision are to be expected. Such knowledge is essential for local governance, given a set of specific driver in order to guide expert or stakeholder assessment based approaches and decision making.

Lesson learned & Policy Recommendations

This study assesses the effect of removal of specific landscape elements within the framework of a 'what if' scenario setting which could support decision makers in the process of policy development and implementation at local and regional scale. In the case at hand, the question whether or at which point of development policy or local governance intervention could be required in order to steer the intensification of land management if resulting in conflicts among provisioning and other ecosystem services. Although the scenarios' settings project observed spatial dynamics to a rather extreme extent, there are useful to assess and quantify landscape responses to management options at a scale which is often ignored when modelling coarser land-cover class changes at regional or global scale. Our findings highlight the potential changes in landscape architecture following field enlargement and tree elements removal and present a quantitative assessment of the decrease in habitat service supply for a target bird species of local and regional relevance. Furthermore they offer the possibility to identify structural and functional resilience thresholds for the management of multifunctional agricultural landscapes with potential for decision support in steering (agricultural policy, landscape planning) ecosystem services.

Reference

Ungaro, F., Zasada, I., Piorr, A. (in review). Assessing and mapping the effect of agricultural field enlargement on landscape elements and on the provision of habitat services. *Landscape Ecology.*

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