DE2 (Märkische Schweiz, Germany):
Mapping landscape services, competition and synergies

Objective

The application of spatially explicit methods that incorporate the locations of supply and demand of landscape services represents a key challenge for research, and there is the necessity to develop and test different approaches to quantify and (jointly) map different services across the landscape, highlighting "hotspots" with synergies and conflicts. Therefore the objective of this study is to present a flexible and generally applicable probabilistic approach to landscape scale assessment and mapping of different landscape services. The main goals of this ad-hoc study are: (i) assess and map landscape services using a non-parametric probabilistic approach; (ii) to highlight the spatial structure of each service using semivariogram models; (iii) calculate and map the joint provision of different couples of services using joint probabilities; and iv) to evaluate the difference existing in term of multiple service provision in different sub-landscapes of the CSA. The landscape services subject to this study have been identified and selected by relevance for the region. In January 2013, 13 local stakeholders from administration, regional management, NGOs and agriculture carried out a prioritisation and weighting procedure of landscape services based on inter-linkages with land management on the one side and with the endowment for regional socio-economic welfare and competitiveness on the other.

Methodology

The services considered in this studies are: i) habitat provision (HAB), ii) crop production (PRO), iii) visual appreciation (VIS), iv) water regulation (WAR), and v) water storage (WAS). Within a probabilistic framework, landscape services are considered as the realization of a stochastic process called random function. Their spatial properties can be described and modelled using second order statistics, such as the semivariogram which describes the spatial relationships between data and models the spatial heterogeneity of the different landscape components. For each service, a specific indicator based on the occurrence of specific landscape elements or local soil conditions was chosen. A stratified random sampling design was adopted in order to assess the occurrence of service potential provision within buffers around sampling points, and observations were coded 0 (absence of service provision) or 1 (presence of service provision) in order to calculate the experimental indicator semivariograms. The semivariograms were then modelled in order to produce probability maps of services provision via geostatistical simulations. The maps produced can display the occurrence of single services or that of joint couples of services, allowing the identification of service bundles, highlighting the occurrence of potential synergies and conflicts between services.

Results

Results, displayed in terms of single and joint probability maps, provide new insights about the composition and interrelation of multiple services in a region. It is shown that each landscape service is characterised by a specific spatial pattern, described in terms of heterogeneity and spatial range. Setting a probability threshold of service occurrence > 0.50, 10% of the area under agricultural land uses provides no landscape services, 35% delivers one service while 25% and 19% supply two and three services respectively. The share of agricultural area with a potential joint provision of four services equals 10%, while only 1.4% of the area has a potential to deliver five joint landscape services. Table 1 reports the mean joint probability values and standard deviations (in brackets) for the occurrence of pairs of selected landscape services for the whole case study area under agricultural land uses The highest mean join probability is that observed for the common supply of production and habitat services (30%), highlighting the occurrence of hotspots of services provision with possible conflicts due to the on-going intensification of agricultural management (Fig. 1-4).

Table 1. Mean joint probability values and standard deviations (in brackets) for the occurrence of pairs of selected landscape services for the whole area under agricultural land uses. (N = 26,390). HAB: habitat for species; PRO: agricultural production; VIS: visual appreciation; WAR: water regulation; WAS: water supply.

Landscape services	***HAB***	***PROD***	***VIS***	***WAR***	***WAS***
HAB	-				
PROD	0.279 (0.310)	-			
VIS	0.166	0.228	-		
WAR	0.076 (0.166)	0.111 (0.207)	0.112 (0.187)	-	
WAS	0.076 (0.166)	0.233 (0.266)	0.112 (0.187)	0.055 (0.142)	-

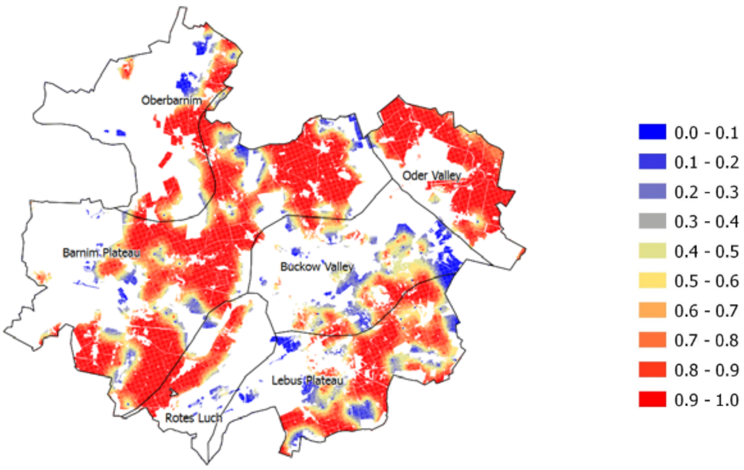

Figure 1. Probability for crop production (PRO).

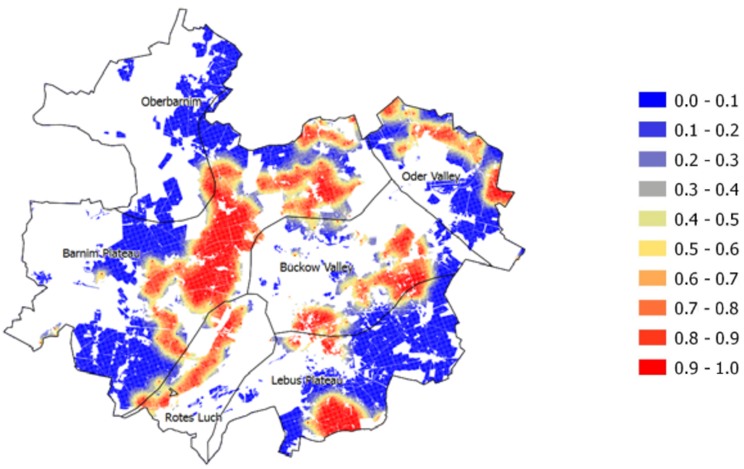

Figure 2. Probability for habitat for species (HAB).

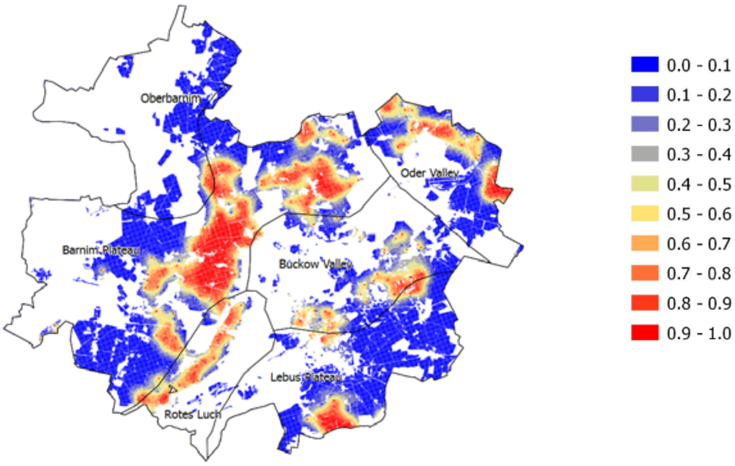

Figure 3. Join probability of HAB-PRO potential supply.

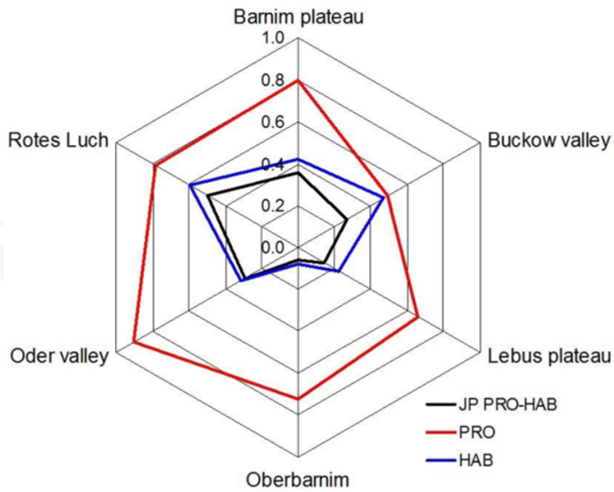

Figure 4. Average single and joint probabilities of PRO and HAB provision in the six landscape units of the CSA.

Results highlighted also that three out of six sub-landscapes (Lebus Plateau and Oberbarnim, and the River Oder Valley) are strongly oriented towards the provision of one single service, i.e. crop provision (PRO), while in the other three landscapes a joint supply of diversified services is observed (Fig. 5). In the sub-landscape of the Barnim Plateau, PRO is still the dominant service, nevertheless substantial supply of VIS, HAB and WAS services is observed. In the case of the glacial valley of Rotes Luch, HAB and WAR supplies are nearly equal to PRO, while in the case of the other glacial valley, i.e. the Buckow Valley, the supply of WAS is more pronounced of PRO, followed by a substantially equivalent provision of VIS and HAB services.

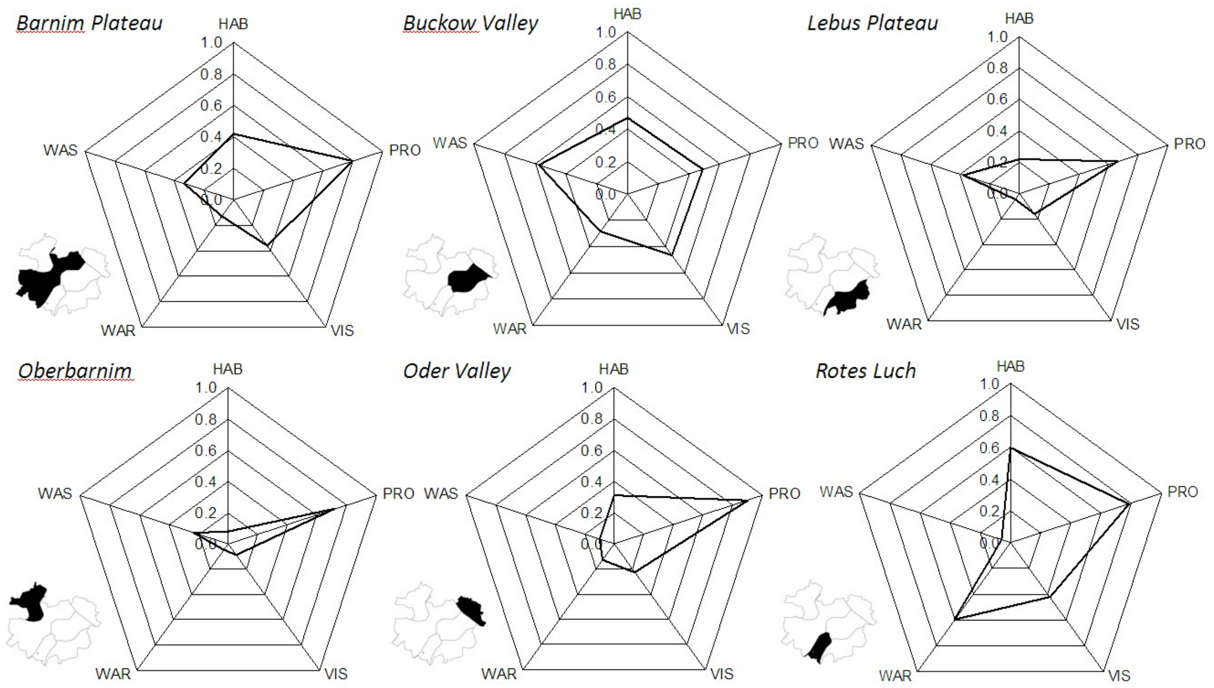

Figure 5. Trade-offs between the five landscape services in the six sub-landscapes of the study area. Habitat for species (HAB); agricultural production (PRO); visual appreciation (VIS); water regulation (WAR); water supply (WAS).

The occurrence of possible services bundles is presented in Table 2, which identifies the areas of joint coupling of services and their ranks under the different thresholds. The stability of the results of the analysis is confirmed by the fact that the ranks are nearly the same under the different thresholds. As multiple service areas decrease with increasing probabilities, the optimal threshold should be selected by decision makers based on their specific targets.

Table 2. Service bundles areas (% of total area) under different probability thresholds. HAB: habitat for species; PRO: agricultural production; VIS: visual appreciation; WAR: water regulation; WAS: water supply.

Joint Services	*p ≥ 0.9*		*p ≥ 0.8*		*p ≥ 0.75*		*p ≥ 0.60*		*p ≥ 0.50*		*p ≥ 0.40*		*p ≥ 0.25*		*Avg.*	*Var.*
	area	rank	area	rank	area	rank	area	rank	area	rank	area	rank	area	rank		
PRO-HAB	5.7%	1	11.8%	1	15.5%	1	26.1%	1	32.4%	1	38.8%	1	47.7%	1	1.0	0.00
PRO-VIS	4.5%	2	8.5%	2	10.5%	2	17.9%	2	23.8%	3	30.8%	2	40.4%	3	2.3	0.24
WAS-PRO	2.8%	4	7.4%	3	9.8%	3	17.8%	3	23.9%	2	30.8%	3	41.7%	2	2.9	0.48
HAB-VIS	3.2%	3	6.5%	4	7.9%	4	14.1%	4	18.7%	4	24.0%	4	31.9%	4	3.9	0.14
WAS-HAB	1.4%	5	3.5%	5	5.0%	5	10.3%	5	14.0%	5	18.0%	5	25.9%	5	5.0	0.00
PRO-WAR	1.0%	6	3.1%	6	4.4%	6	8.0%	6	10.6%	6	13.8%	7	19.7%	7	6.3	0.24
WAS-VIS	0.5%	7	1.7%	8	2.5%	7	6.7%	7	10.0%	7	14.6%	6	23.2%	6	6.9	0.48
VIS-WAR	0.5%	8	1.8%	7	2.4%	8	5.3%	9	7.5%	8	10.7%	8	15.8%	9	8.1	0.48
HAB-WAR	0.2%	10	1.2%	9	2.2%	9	5.3%	8	7.5%	9	10.5%	9	16.0%	8	8.9	0.48
WAS-WAR	0.3%	9	1.0%	10	1.5%	10	3.3%	10	4.8%	10	7.0%	10	11.6%	10	9.9	0.14

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

Managed landscape elements play an important role for the regional competitiveness and quality of life of the local population. Probability maps provide a straightforward visualization tool to explore the impact of one or more landscape element based indicators on the likelihood of single or joint landscape services potential supply. The approach developed in this study allows for a spatially explicit assessment of services co-occurrence at any given location within a given landscape, highlighting the occurrence of hot and cold spots of potential (joint) supply of selected ecosystem services. The assessment of service richness can be made at different aggregation levels (municipality, landscape unit, land cover unit) and under different probability thresholds in order to support different stakeholder in planning and decision making.

Lesson learned & Policy Recommendations

In order to support sustainable land use decision-making, the analysis of spatial heterogeneity and patterns of the diverse functions and services across a given landscape should be able to explore and identify interaction effects and potential spatial synergies, i.e. 'multiple win locations' or multifunctional 'hotspots'. These are linked to the presence of specific and different landscape attributes in agricultural fields which are of pivotal importance for the supply of landscape services. As landscape management measures, designed at different decisional levels and implemented at different spatial scales, have a deep impact on these landscape elements, measures should first of all aim at maintaining a targeted level of multi-functional landscape functions, i.e. supporting a diverse set of ecosystem services. The rural economy and competitiveness can be supported by agricultural and landscape policies (i.e. European Common Agricultural Policy) targeting at maintaining and establishing the considered landscape attributes. Regretfully the ongoing scale enlargement and intensification of agricultural practices is a major threat to landscape structures and elements, affecting their capacity to deliver ecosystem services, with a negative impact on the socio-economic development and competitiveness of the whole area.

References

Ungaro, F., Zasada, I., Piorr, A. (2014). Mapping landscape services, spatial synergies and trade-offs. A case study using variogram models and geostatistical simulations in an agrarian landscape in North-East Germany. *Ecological Indicators* 46, 367-378.

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