POTENTIAL APPLICATIONS OF LANDSCAPE ECOLOGICAL PATCH-GRADIENT MAPS IN NATURE CONSERVATIONAL LANDSCAPE PLANNING

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Abstract

There are rather limited opportunities for using the results of landscape ecology in practical nature conservation. The reasonS for this are – at least partly – the different scales and frames of the two fields. For more effective cooperation there is an opportunity for landscape ecology to determine patch-gradients that are helpful for nature protection in expanding the living space of endangered species via CORINE land use-pattern in mixed use agricultural areas. Such alternative migration tracks become valuable in places, where landscape ecological corridors and stepping stone places are missing. The method applies the gradient concept of landscape structure of McGarigal and Cushman (2005). Determination of patch-gradients can be a good background material for settlement- and infrastructure planning; and for the elaboration of medium- and long term nature protection concepts or for even general landscape protection strategies as well.

Keywords: landscape metrics, land use pattern and patch-mosaics, conservation biology

1. Introduction

Both, ecologic general landscape planning and nature protection planning is **based on the current landscape structure** (Mezősi et al. 1993; Forman, 1995; Marsch, 1997; Ahern, 2005). The structure of the landscape mosaic means the frame what is reshaped in accordance with new demands of the society during the process of landscape planning. Socio-economic and political developments of the last 20 years, along with the joining to the European Union **redefines land use priorities** in Hungary (Csorba and Novák, 2003; Ángyán, 2008).

On one hand, the utilization of traditional landscape potentials decreases gradually. There is no need for agricultural production on less fertile lands, mining industry is not profitable in many places any more, etc. On the other hand, landscapes with favorable bioclimatic endowments − for instance − have become more valuable. It is favorable as well if air, waters and soil have high buffer capacity, the regenerative capacity of the ecologic system of an area is high, or geologic endowments are suitable for waste disposal (Bastian, 1992). However, there are two traditional natural potentials what have remained important still. Despite modern technologies, relief can still hinder building up and construction of traffic lines. Other key potential is the availability of waters: water sources, water retention and water supplies have been becoming even more important in central-East- and South Europe, which face the impacts of Global Warming.

Two new social demands cause serious changes in land use patterns all over the World. Every societies − even in the underdeveloped countries − requires greater and greater areas for **recreation** (Wascher, 2005) if not for its own citizens then for tourists. Fishing villages become popular holiday destinations in the most underdeveloped countries suddenly, and ski courses are being built on former pastures in the most remote and uninhabited mountain regions. Anyway, well-kept, harmonic and aesthetic landscapes have an increasing value in every place of or planet. Maintenance of sights is becoming a highly profitable investment today. It is economic to abandon ugly quarries to hide gas tanks and create attracting settlements in many places of the planet (Wascher and Jongman, 2000).

Areas that can be used for recreation are at least partly suitable for **nature protection purposes**, the other new social demand as well. Naturally, the partner of nature protection is not mass tourism, but ecotourism, photo tourism and soft tourism, which have a dynamically growing importance within the powerful industry of tourism. Nature protection has a serious impact on the way of thinking of the whole human kind. Although, we are far from the level what would be desirable according to committed nature protection activists, but remembering the situation of the nature- and environment protection of the World 30-40 years ago, the development is uncontestable (Kerényi, 2002).

This latter two important social demands have a strong effect on modern landscape planning, this way the trend of landscape planning improves which takes into account the ecologic functioning and structure of landscapes (Csima et al. 2004).

Landscape ecology provides a background for such practical fields; it is a science with strong interdisciplinary and anthropogenic approach. (Mezősi and Rakonczai, 1997, Wu and Hobbs, 2007). One of its source sciences is Geography from where its spatial and landscape approach and anthropogenic impacts are originated (Csorba, 1997a; Kertész, 2003). Its other source is ecology, what has integrated into landscape ecology its systematic approach focused on the interactions between living and non living natural processes, and the functioning of living and non living systems.

Landscape ecology has two main fields of research. First one examines the ecologic **functioning** of landscapes, while the second field is **landscape structure** analyses. (Csorba, 2007). The highly complex system of the connections of landscape forming elements – although not from each aspect – is well represented by the visual appearance of the landscape. From visual structure, the matrix-patch-corridor patterns of landscapes good conclusions can be drawn on the principal functioning of landscapes and less visible internal connections can be revealed (Wiens and Moss, 2005).

A relatively new branch of landscape structure research is **landscape metry**, what deals with the characteristics and changes of the mosaic-like spatial structure of our environment. It has elaborated several tools with growing value for landscape planning during the last 10-15 years.

2. Landscape metric preliminaries and Hungarian results

First Landscape metric examinations have been originated from **quantitative landscape research** in Hungary as well, but the adequate technical background for real landscape metric research was missing till the mid 1990's. Landscape metric research requires large scale satellite images and digital maps along with the high capacity computer hardware and software. Introduction of the CORINE database, and the FRAGSTATS software have been remarkable steps in this field (McGarigal and Marks, 1995; Mari and Mattányi, 2002). It is important to mention the „Quantitative Methods in Landscape Ecology" (Turner and Gardner, 1991) from the literature background. In the second half of the 1990's the works of Farina (1998), Hargis et al. (1998) Klopatek and Gardner (1999) meant significant scientific breakthrough. Works of Pedroli and Jaeger have proved the widening opportunities of use of landscape metric results via landscape aesthetic (Pedroli, 2000) and landscape fragmentation analyses (Jaeger, 2002). Antrop and van Eetvelde (2000) have carried out landscape metric analyses on suburban built-up landscapes; while Blaschke (2000) has taken the first steps towards nature protection use of landscape metric data.

Lóczy (2002), then Kollányi (2006) have reviewed the wide variety of landscape metric indices in Hungary. Research works with the special aim of landscape analyses have been carried out in the Institutions of Geography of the University of Szeged and Debrecen (Mezősi and Fejes, 2004; Csorba et al. 2006; Szabó and Csorba, 2008).

The highly complex field of research of the landscape structure studies involves the following areas of geography and landscape ecology:

- general land use landscape description (Haines-Young, 2005; Csorba, 2007b)
- studies on landscape development and landscape history (Bastian, 2000)
- comprehensive landscape structure similarity analyses (Szabó and Csorba, 2008)

- landscape fragmentation caused by traffic- and settlements networks (Csorba, 2007a).

3. Landscape ecological and landscape planning work

There are remarkable possibilities in the use of landscape metric data in landscape planning also. It is undeniable, however, that some basic requirements of landscape planning is hard to satisfy for landscape ecologists.

Landscape ecologists, naturally, consider **landscapes as entities**, while landscape planners usually deal with individual parts or fragments of the landscapes. Another problem is the **scale**. Landscape ecologists can determine landscape borders with an accuracy of some hundreds of meters and prefer 1:10 000 – 1:25 000 maps to describe the structure and functioning of landscapes. Some hundreds of meters plus or minus mean an unacceptably high level of inaccuracy for landscape planners. Landscape planners use 1:3000 – 1:5000 scale in accordance with the requirements of technical design (Csima and Kincses, 1999).

If landscape ecologists want to achieve results that have real practical value for landscape planners, they should analyze landscape development processes in more detailed landscape structure maps. In a highly mosaic-like cultural-landscape, for instance, examinations have to carry out on plot-level, what is a hard task for landscape ecologists, since there are very few detailed examinations and result at this scale. However, this scale is not entirely unfamiliar in landscape ecology, since the spatial extent of landscape patches, stepping stone ecotopes reach only several hectares many times, and landscape ecological and green corridors are 5-10 meters wide sometimes. Anyhow, landscape ecology has rather little information on landscape functioning at this scale. When there are raising doubts on the function ability of landscape corridors for example, landscape ecologists can refer to rather little measured data (Forman, 1995; Farina, 1998; Ingegnoli, 2002). There are vivid discussions on the landscape ecologic barrier effect of the motorways: to what degree do they alter the species composition of the ecotopes and the vitality of the populations in their neighborhood? There are opinions that these effects are remarkable, while others believe that they are negligible (Forman and Alexander, 1998; Erritzoe et al. 2003; Langgermach et al. 2006).

There are no principal technical obstacles of plot-level examinations of landscape processes. Remote sensing data are within 1 meter resolution, so if landscape ecologists can give useful advice to landscape planners on the base of spatial patterns only, the cooperation can be fruitful. The only thing that should be kept in mind that this type of landscape ecologic evaluation deals mainly with landscape patterns, spatial structures and the structure of the visual sight. There is a relatively strong accordance among the researchers on the question to what degree are reflected the internal networks of connections and delicate functions of landscapes in the before mentioned parameters? In other words: the structure of the landscapes what can be seen, mapped and photographed represents even if not perfectly, but **to a high degree** the real processes and features of the working of the internal landscape structures (Fekete et al. 2000; Wu and Hobbs, 2002; Hof and Flather, 2007).

4. Landscape ecological patch-gradients

Land use forms a strong barrier for the migration of animals and spread of plants in highly mosaic-like Central European cultural landscapes. Different land use forms have different barrier impacts, but it is a general rule that suitability of an ecotope for the animal and plant species of its original ecosystem decreases with the increasing intensity of land use. Weeds, flux species, culture follower species; adjective species on general are exceptions to a certain degree. They can tolerate even some medium intensity land use forms, like plough lands abandoned plantations etc., in fact their most abundant populations have been adapted to such sites (Mihály and Botta-Dukát, 2004).

One of the most significant achievements of recent landscape ecological studies was the verification of the positive impact of **landscape ecological corridors** on the stability of ecosystems. (Forman, 1995; Linehan et al. 1995; Csorba, 1996; Ingegnoli, 2002; Kertész, 2003; Konkolyné Gyuró, 2005; Kerényi, 2007). The degree and general nature of that before mentioned positive effect has not been proved yet, but it is undeniable that the measure of the advantageous effects accedes the disadvantageous impacts on both, global and regional level. When the importance of linear forms connecting ecological patches had been realized; the conservation, reinforcement, compensation and organization into networks at landscape-, regional-, national-, and continental levels of those landscape elements that work as ecological corridors has become the main aim of nature protection. There have already been spectacular results of the program of the International Union for Nature Conservation (IUCN) launched 10 years ago in Europe in this field (Pirnat, 2000; van der Sluis et al. 2004; Tardy and Duhay, 2008).

Although, in addition to their migration function, landscape ecological corridors contribute to the maintenance of the ecologic system with their habitat, material and energy sink functions either, they can not balance fully the barrier effects of cultural landscapes fragmented by settlements, roads, channels and intensive agricultural lands. For this reason, interrupted corridors, and especially, a type of them, **stepping stone ecotopes** have a significant supplementary role for mobile animal (that can fly) and plant species. (Wascher, 2005; Kerényi, 2007). For those living creatures that can not leave the micro environments favorable for them for even a short distance (several ten meters) the gap sections of interrupted corridors mean migration barriers that they can not overcome. For those plants species which spread in the air or via animals such dispersal barriers do not form that strong obstacles, or the degree of the barrier effect depends on the mobility of animals.

The networks of landscape ecological corridors supported by stepping stone ecotope patches can maintain oligo- or mesohemerob level in many cultural landscapes. For less mobile living creatures this supplemented ecological network can not provide enough opportunities to maintain the stability of their populations and the ecosystems. The **only migration alternative** is for them to move from their natural ecotpes (forest bushy-forest or grassy meadow) to other **patches that are slightly different** in ecological endowments only. For example, if there is a grassy-bushy connection between two isolated meadow patches, it can provide a real migration opportunity for their animals and plants. If the grass patch is surrounded by plough lands and plantations and its only connection to the next grass patch is the grassy-bushy patch, that connecting element has a strategic importance there obviously. In Hungarian landscape types elements of the **patch-gradients** are built up from the following land use patches usually;

> forest → bushy-forest → meadow/pasture → fallow → plough lands → wine yards/plantations → built up areas

These categories can easily been determined in satellite images in the usual patch-type categorization system of the CORINE software. Naturally, in most landscapes and landscape fragments there is not presented the full patch spectrum just a pattern that consists of 2-4 patch types:

> forest → bushy-forest → meadow/pasture → fallow
> bushy-forest → meadow/pasture → fallow → plough lands → vineyards
> meadow/pasture → fallow → plough lands → built up areas

Results of a patch-gradient analysis are presented via a hypothetical land use pattern in Fig. 1.

Ecologically committed landscape planning should take into account such landscape pattern situations with a special emphasis. Patch series, where differences between the elements of the series are the smallest, therefore they mean the **weakest barrier** to migration, can easily be established using highly detailed landscape ecological maps.

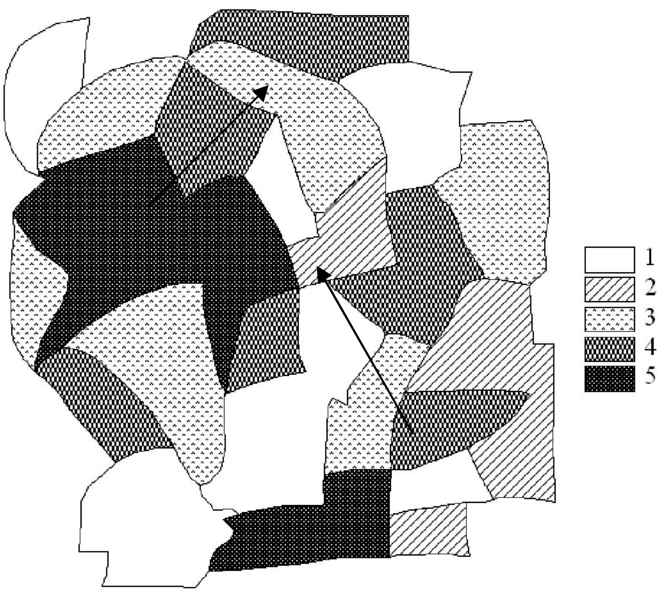

Fig. 1. A hypothetical land use map for patch-gradient analysis (Legend: 1: plough land; 2: vineyard; 3: meadow/pasture; 4: bushy-forest; 5: forest)

With the combination of some landscape metric parameters like patch density, nearest-neighbor index, fractal–dimension index, etc. and the patch type distance described before, very good landscape planning maps can be achieved. This method can be a practical application of the landscape structure gradient conception published by McGarigal and Cushman (2005). Authors of the before cited work claim that instead of rather pullulated and too general landscape metric indexes;

> „*we would better served by quantifying the local landscape pattern across space as it may be experienced by the organisms of interest, given their perceptual abilities.”*(McGarigal and Cushman, 2005)
>
> *„We advocate the expansion of the paradigm to include a gradient-based concept of landscape structure that subsumes the patch-mosaic model as a special case. The gradient approach we advocate allows for a more realistic representation of landscape heterogeneity by not presupposing discrete structures, facilitates multivariate representations of heterogeneity compatible with advanced statistical and modeling techniques used in other disciplines, and provides a flexible framework for accommodating organism-centered analyses.”* (in the same place)

According to the authors the moving-window analysis method of the FRAGSTATS software is suitable for carrying out such analyses.

We believe that the determination of patch-gradient series method presented here is in close connection to the method proposed by the before cited authors and can provide a good background material for practical nature and species protection. Obviously, these patch pattern gradients mean not much help in planning for “generally speaking” all living creatures. However, when the purpose of the research is to find opportunities to widen a shrunken and endangered ecotope of **a well defined species group** or certain **species**, the method is useful indeed. On the other hand, there is an opportunity to use patch-gradient maps in the elaboration of the long term strategic aims of nature protection as well.

5. Conclusions

One of the most challenging tasks of nature protection is to provide migration or “escape” lines for the most endangered species of the Red Book. Such planning tasks usually got more freedom and social support, what makes possible to reach advantageous changes in land use patterns. By determining patch-gradients landscape ecology can give real help to nature protection in the stabilization of the conditions of endangered species, species groups and ecotopes.

Patch-gradient maps can be helpful in forecasting less acute situations and in rolling back disadvantageous tendencies at expected nature protection “hot-spots”. These results can serve well in general nature protection planning, medium and long term settlement development and infrastructure planning. Patch-gradient maps can lead to significant results in basic research on one hand and they are valuable in **nature protection prevention** works as well. Forecasting land use tendencies and determination of critical places makes possible to take steps to prevent major disturbances of the functioning of the natural system. Prevention always means smaller conflicts and material-mental investments than solving acute problems…

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