Analysis of spatial dependences of ecotons in the basin of Trkmanka river

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Abstract

The transformation of the landscape structure continuously proceeded during the past centuries. The landscape has changed slowly and continuously from the natural landscape, determined only by the physico-geographical conditions of the territory, to the agricultural landscape.

However, faster and more significant landscape changes happened in the 20th century. These changes has led to a remarkable simplification of the landscape structure as a result of compounding and reallotment of land, destroying of balks, field paths and holding covers.

The ecotons have a spatial character, therefore, they appear to be suitable for the research of their usage in geoinformation technologies. Geographical information system (GIS) is a complex information system enabling control, analysis and visualization of spatial data.

Keywords: ***ecoton, landscape structure, Trkmanka***

Introduction

During the last centuries, the changes of the landscape were very intensive. The landscape has changed continuously from the natural landscape, determined only by the physico-geographical conditions of the territory, to the agricultural landscape. This process happened in almost the whole area of our republic with exception of the elevated locations and those territories where climatic, terrain and soil conditions do not allow greater expansion of agricultural production. Nowadays, the authentic structure of the landscape is evident only in the territories with less favorable physico-geographical conditions for the expansion of agriculture.

The transformation of the landscape structure continuously proceeded during the past centuries. However, faster and more significant landscape changes happened in the 20th century. These changes has led to a remarkable simplification of the landscape structure as a result of compounding and reallotment of land, destroying of balks, field paths and land covers. During the fifties of the last century, blocks of arable land were established, whose sizes increased several times during the further development of the socialistic´s agriculture. This happened with increasing concentration of agricultural large-scale production in the seventies of the last century. The formation of larger blocks of arable land totally destroyed the native landscape structure as the landscape was fanatically adapted for only one purpose – agricultural large-scale production supported by heavy mechanization.

The increase of the areas of landscape components resulted in a decrement of the mosaic of the landscape and its generic diversity. This has also affected the ecotons and transition zones between the two different gilds which have decreased together with the simplification of the landscape structure.

The landscape structure, its components and their developments are possible to monitor from several, mutually complementary aspects: arrangement of gradients (abiotic and biotic) across the territory without significant and sharp boundaries; arrangement of areas in the mosaic of the landscape; network of areas and corridors; system of boundaries and rims in the landscape mosaic (Forman, Gordon, 1993).

Area of interest

Analysis of spatial dependences of ecotons was carried out in a scope of cabinet research in a map scale of 1:25 000 in a model area of interested territory of basin of Trkmanka river within the project of GA ČR 205/07/0821 called “Analysis and modeling of dynamics of spatial bonds of ecotons by GIS”.

The area of the basin of Trkmanka river, restricted by the boundary of the drainage basin, is situated in the Southern Moravia, easterly of Brno. Trkmanka river springs in Ždánický les Mts., which is located northwest from Ždanice town, in an altitude of 300 m above the sea level. The river then flows to the south and after 42.5 km of its flow, it pours itself into Dyje river from the left in a place, northeast from Lednice town, with an altitude of 158 m above the sea level.
The interested territory has elongated shape. In the north, the territory comprises of a system of hills called Ždanické vrchy with the highest point called U Slepice (437 m above the sea level), in the south, the territory reaches to the floodplain of the Dyje river. The north part of the area is forested, the middle part of the interested territory represents a typical agricultural landscape with a small portion of woods and the south part of the territory is intensively agriculturally exploited.
The basin of Trkmanka river belongs to the territories with a long history of the settlement and to the regions with a landscape highly influenced by humans. Suitable conditions of this landscape favor highly developed agricultural production that is concentrated mainly on a growing of the grapevine, which represents long-time tradition in this territory.

Ecotons

The boundaries between natural landscape components most frequently exhibit a character of transition zones or zones, they are very rarely sharp or lined. Sharp lines can be found at terrain edges, beside rivers and reservoirs or at anthropogenic objects; they are formed as a result of differential effective usage of the landscape. An ecoton is generally defined as a boundary or transition zone, or edge gild between two or more ecosystems. As a consequence of a crossover, the ecoton often has higher biodiversity and more favorable conditions for organisms than every boundary biocoenosis, thus exhibiting a greater variety of plant and animal species present within it (Hansen et al., 1988; Jeník, 1995 etc.). In other words, the ecoton is an element of the spatial structure of the landscape component (i.e. ecosystem), which represents a differently wide transition zone or line of interface between neighboring landscape components (i.e. ecosystems), which is characterized by a higher diversity of organisms and density of population in comparison with those in both neighboring biocoenosis (the so-called edge-effect) (Odum, 1971; Luczaj, 1994). In the ecoton, one can thus find both species from the neighboring biocoenesis and specific species, typical for this transition zone. However, Hansen and Di Castri (1992) also consider sharp boundaries (i.e. narrow transition zones) to be the ecoton. In today's cultural landscape, the ecotons are the places of the contact of a natural territory with a territory influenced or controlled by humans (i.e. agroecosystems).

From the spatial point of view, the ecotons are characterized by a space and time which reflect the forces of interactions among boundary units (i.e. ecosystems). Hansen and Di Castri (1992) have reported that changes of the space-time structure or functions taking place in the ecoton are faster than changes in the landscape as a whole. The ecotons, as a spatial units, have different internal structure and construction, spatial attributes and other properties, conditioned abiotically and biotically (i.e. contrast, internal product differentiation, width, shape). Simultaneously, they exhibit properties determined by time, development and function – transmittance, stability, elasticity. From the spatial point of view, they can be characterized by following typical properties (Hansen, Di Castri, 1992; Kovář, 1994; Míchal, 1994):

- Plasticity of transition. The transition zone can have different appearance, from gradual to sharp and discontinuous gradients. Sometimes, the ecotons can display the appearance of wedged ledges or tongues, salient from neighboring gilds.
- Time stability. Their existence and/or persistence are determined by the mechanism or factor of their formation. It is affected by a variant degree of dependence on external or internal natural processes and their manifestations. Human activities can also have the influence (planted hedgerows vs. non-grubbing forest belt).
- Ledges from landscape structure. They occur in a different degree of the contrast with each other and neighboring surface objects (in geology, geomorphology – rock and terrain shifts, in succession age of neighboring vegetation, in salinity in aquatic environment – for example at the entry of the river to the sea).
- Biological and spatial stability. The stabilization functions in the landscape result from their graded ability to react on a disturbance in terms of both resistance and/or resilience of the system and in dependence on a degree or intensity of the action of the respective factor.
- Source, support (standby) function. The ecotons influence neighboring, especially adjoining ecosystems, they act as a source of germs or nutrients, they pollute or entrap (dust, pollen, seed, etc.) or "eject" predators or pests to the surrounding.
- Increased density of biomass. The edge-effect represents a tendency of gilds for densification and diversification of the biota in the transition zone. There exist either species from both

neighboring formations or specific species, absent in neighboring territories.

In the landscape, the ecotons thus create a network which presents a stabilization and source element of the landscape and landscape components. The above mentioned properties of the ecotons are influenced by physico-geographical and socioeconomic conditions of the territory.

Methods and procedure of solution

The ecotons have a spatial character, therefore, they appear to be suitable for the research of their usage in geoinformation technologies. Geographical information system (GIS) is a complex information system enabling control, analysis and visualization of spatial data. The system is capable of registering a large amount of data about the object itself, its properties and its position, it allows effective working with this information. In GIS environment, the individual components of the real world, which are thematically divided, can be saved in separate digital spatial layers. These layers can be arbitrarily piled up and from them, one can derive new information. In addition, these layers and their combinations can be subjected to spatial analyses that provide further valuable spatial information which is unreachable from other methods.

The material for the research of the ecoton properties of the basin of Trkmanka river originated from a transfer of the spatial phenomena of the real landscape to the digital vector thematic layers. We have analyzed digital layers of the usage of the landscape of the study area from the years 1877, 1953 and 1995 at the map scale of 1:25 000. The maps of the 3rd Military Survey from the years 1876 – 1878 were the basic source for the oldest digital layer, the sheets of the State Map at the map scale of 1:5 000, derived from the years 1952 – 1953, were used for the digital layer from the fifties and the sheets of the Basic Map at the map scale of 1:10 000, supplemented by the terrain research in 1995, were utilized for the digital layer of 1995.

The layers of the usage of the landscape were modified with respect to the aim and purpose of the study. Therefore, any administrative and possessive features within one facet have not been considered with the aim of construction of the model corresponding to the real landscape as much as possible. The model area represents a terrain of rectangular shape with a surface area of 4442 ha in the middle part of the interested territory.

Vector layers of the land usage have been used as a competent theme, whose categories have been treated as landscape components. Every facet (i.e. polygon) represents a space of the landscape component.

Spatial dependencies

Edges or lines between each facet are considered as ecotons. The net of polygons could be named as the net of ecotons in the real landscape. The development of the identified landscape elements in the watched time horizons is shown in the Table 1.

***Table 1**. Development of landscape secondary structure*

Category	Area (v ha)	Number of facets	Area (v ha)	Number of facets	Area (v ha)	Number of facets
Year	1877		1995		1953	
Woods	316,2	47	443,66	39	572,56	169
Arable land	3361	381	3343,15	326	2630,29	71
Grass fields	56,75	37	143,18	28	21,66	11
Winery	80,2	4	241,3	28	154,39	24
Gardens	524,71	18	89,13	21	276,72	52
Built up area	101,87	9	179,73	12	783,9	57
Water area	1,5	2	2,33	3	2,63	3
Total	4442,23	498	4442,48	457	4442,15	387

Each ecoton is the element of the net, whose qualitative and quantitative properties are influenced by the type of the landscape. The spatial character of the ecotons could be considered as the quantitative indicator. This work is based on the study of these indicators.

Ecoton is the bounding surface between two different landscape elements. Presently there are only a few ecotons in the landscape, which are situated between ecosystems which has never been influenced by the human activity. The influence caused by the human race is one of the most important factors, which could possibly change the spatial properties of the ecotons, especially the width. The width of the ecoton has the affect to the ecological value of the ecoton. Wide ecotons are

mostly situated in the area without any sign of the human activities. On the other side, narrow ecotons are mostly situated in the landscape affected by the above mentioned activities. The width of the ecoton depends on the types of the adjoining landscape elements. In the case of the wide ecotons we could assume, that the ecoton is also the part of both adjoining landscape elements without any sign of the border. On the other side, we can find also very clean bordered ecotons, but these are mostly more narrow.

The length of the ecoton is the attribute, which is composed of two different characteristics. The first one is the absolute length of the ecoton – the length of the centre line in the landscape segment. The analysis of these characteristics in three different time horizons is shown in the Table 2. The second one is the relative length of the ecoton. This is the name, designed by Sklenička (1998). It shows the length of the active border of the ecoton. The proportion of the above mentioned characteristics influences the area of the ecoton.

Table 2: *The analysis of the lengths*

Analysis of the edges	1877	1953	1995
Density of the edges (in m/ha)	147,7	140,8	128,6
Length of the edges (in km)	656,2	625,46	571,7
Average length of the edge of the facet (in m)	1242,8	1368,6	1511,9

It is evident, from the above given values, that the size of the the landscape facets is increasing and the length and the density of the edges is decreasing in the watched time horizons. The density of the ecotons influences the spatial dependency between the rapidity and the direction of the spread. We can also observe the coherence with the fragmentation of the landscape. The number of the landscape elements and the length of the ecotons are direct proportional. The bigger is the length of the ecoton, the bigger is the influence of the ecoton to the inner environment. It causes the decreasing of the diversification, because the bigger parts of the landscape elements are less influenced by their borders and the area is becoming more stable.

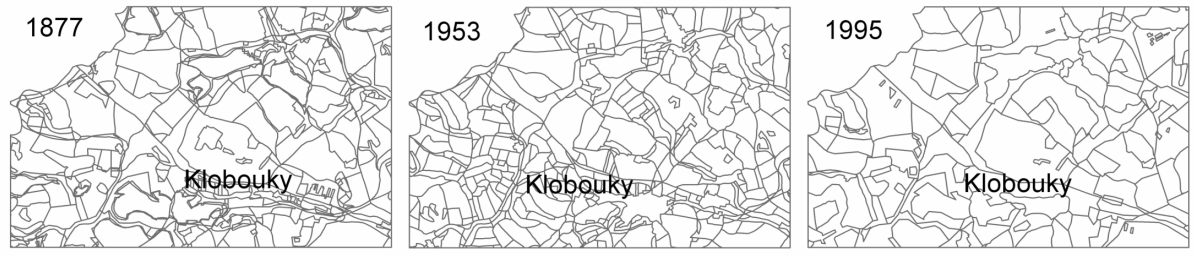

Fig. 1: *Landscape structure in the study area*

Conclusion

According to other authors is goes the development of the landscape with the relation to the ecotons on a wrong tack. We have observed strong changes of the landscape structure in the time horizon 1877 – 1955 in the given area of the Trkmanka river. The area of each facet has grown. The length of the borders has increased. The proportion of each landscape elements has changed also.

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