Evaluating the development of the landscape horizontal structure in 2nd half of 20th century – case studies from Northwestern Bohemia

Introduction and objectives

The dissertation thesis can be ranked among landscape ecological studies concentrating on evaluating the development of the horizontal structure of the landscape in specific study areas.

Basic dissertation aim is to evaluate the development of landscape horizontal structure consisting of the landscape pattern diagnosis through the land use development analysis and monitoring the development of the environmental stressors influences (in comparison with calculating the ecological stability index) and through the quantification of landscape components distribution (arrangement) into the landscape horizontal structure via the FRAGSTATS software product. The assessment of the landscape composition and arrangement development by complementary methods, which have their roots both in the European and the North American landscape ecology school, enables to record both aspects of the landscape horizontal structure. Gradual achieving of the following partial objectives in the application part of the work will enable to reach the above mentioned basic aim:

1. to analyse changes in the land use, it means in the composition of the landscape mosaics "building stones", by using historical aerial photographs, ortophotographs, the databasis of the ČÚZK and the LPIS databasis,
2. to apply the method to measure the arrangement, size and shape features of the landscape components (by the FRAGSTATS, Patch Analyst) by using aerial photographs and ortophotographs and to compare recognized trends in the landscape metrics development with the results of applying the same tool at a higher spatial level and for the whole Czech republic, only in the 1990-2000 horizon, with the utilization of CORINE 90 and 2000 data,
3. to evaluate the development of the landscape components quality with the help of monitoring the environmental stressors impacts and to compare the results with the frequently used method of the ecological stability index or anthrophic impact,
4. to interpret the results from applying the stated methods evaluating the landscape horizontal structure, to point at positive and negative aspects in the landscape structure development (in the composition, configuration and quality of land mosaic components),
5. to assess the use of the aforesaid methods and databases, their mutual complementarity, positives and negatives of their application and on the basis of achieved results to propose possible devices and recommendations for landscape management and landscape planning.

Case study and methods

Three study areas chosen with the purpose of evaluating the landscape horizontal structure development in the 2nd half of the 20th century belong to eight areas studied within two research projects (founded by MPSV ČR and GA ČR). The areas were selected mainly with the respect to their individual geographical location and the overall character of geographical conditions, which to some degree predestinates their socioeconomic usage. Three study areas (fig. 1) represent: 1) the dynamically developing border region with an exposed location, situated on the international transportation axis (Prague – Berlin), Petrovicko, 2) the stagnating peripheral locality of Verneřicko and 3) the stably used agricultural landscape of Třebenicko. The study areas are a part of northwest Bohemia, a prominently exposed region in the face of the environmental stressors influences. The purpose for limiting the period under consideration was the effort to record a well marked post-war landscape development (the 2nd half of the 20th century) which in its intensity, scale and type of changes, which occured in the landscape during several decades, is defining in many ways for the present landscape character as well.

Both for monitoring the land use changes and for landscape strucuture quantification by using the FRAGSTATS software, vectorised and interpreted aerial photographs and ortophotographs have been used among others. The land use/land cover analyses can be understood as evaluating the landscape horizontal structure composition, the components of which are seen as individual land use or land cover areas (e.g. Bičík, 1991, Lipský (1993, 1994, 1999, 2002). Besides aerial photographs and ortophotographs it is possible, approximately in the last five years, to compare the databasis of ČÚZK concerning the land use data and the CORINE databasis (1990, 2000) with a source known so far only a little and even less employed by geographers, the LPIS databasis (Land Parcel Identification System). Since 2004 LPIS brings annually detailed information about individual agricultural land use categories, their area and location, and thus throws a totally new light upon previously published analyses of land use (fig. 2).

The evaluation of the land use development was the condition for calculating the ecological stability index (KES). Also the statistical ranking of four at the first glance different kinds of ecological stability coefficients has brought an interesting statement (Lipský, 1998, Löw, Míchal, 2003, Miklós, 1986, Research Institute for Construction and Architecture) with the help of Pearson correlation index. The calculation was carried out on 250 cadastre units of the Ústecký region using the data about land use in 2003 from the cadastral datasets. The result was a strong correlation between all coefficients. Because of this reason it was not necessary to speculate too long which of these varieties to employ for comparison with the rating of environmental stressors influences. In the work the comparison of the monitoring the environmental stressors performance with the simplest ecological stability coefficient (a stable land use area to labile areas) was executed.

For finding the development of quantitative features of landscape components and examining their configuration the landscape metrics calculation by using the Patch Analyst has been used from a set of Anglo-American quantitative tools (EK, 2000, McGarigal, Marks, 1994, O'Neill et al., 1988, Gergel, Turner, 2003). The software product Patch Analyst 3.0 represents a modified version of FRAGSTATS and enables to interconnect with a currently used geographic information software ArcView 9.1 (McGarigal, Marks, 1994). In our case vector data enter into the process of pattern quantification, namely vectorised ortophotomaps and vectorised historical aerial photographs. Acquired vector data CORINE 90 and CORINE 2000 will enable to employ Patch Analyst application also for the whole area of the Czech republic in the classification system (land cover) CORINE, thus offering comparison of trends (because of different spatial scale in viewing not in absolute values, but only trends) in landscape metrics "behaviour", during the 1990-2000 period with trends in model areas. The following landscape metrics have been calculated: "Class area", CA, "Number of patches", NumP, "Patch density", PD, "Mean patch size", MPS, "Total edge", TE, "Edge density", ED, "Mean shape index", MSI, "Area-weighted mean shape index", AWMSI, "Mean patch fractal dimension", MPFD, "Area-weighted mean patch fractal dimension", "Shannon's diversity index", SHDI, "Shannon's evenness index", SHEI.

The evaluation of the anthropogenic stressors impact on individual landscape components together with the quantitative analysis of the stress in the landscape enables to characterize qualitative aspect of the landscape horizontal structure and compare the results with the often used ecological stability coefficient or its analogies. The theory of landscape ecological stressors was developed in Slovakia (e.g. coll of authors, 2002, Šúriová, Izakovičová, 1995, Izakovičová, Miklós, Drdoš, 1997, Ružičková, Kalivodová, Hrnčiarová, 1998, Izakovičová, 2007). Of course even Ingegnoli (2002), Lipský (1998), Antrop (2000b) or Erickson (1999) also use the terms of environmental stressor, anthropopressure or load (stress) of the landscape in connection with the degradation of natural landscape ecological conditions, in connection with the landscape pathology, with anthropogenic disturbances. The advantages of introducing the terms stress and stressor lie in the identification of the causes and the consequences, meaning the driving force and its effect, the result of the influence. The main monitored variables (fig. 3) have been chosen for appropriation of the negative anthropogenic influences on landscape components, their level mirrors the impact of anthropogenic stressors. Taking into account that the specific indicators do not have the same stating ability, identical activity, some of them feature even multifunctional effects, different

weights were assigned to them. The process of stress calculation itself was carried out on the basis of point rating. The maximum range of a chosen indicator for a monitored area was divided into quartiles. Numeric values were assigned as follows: in the range of low (quartiles $Q_1 = 0$), below the average ($Q_2 = 1$), above-average ($Q_3 = 2$) and high ($Q_4 = 3$). These are multiplied by corresponding weights (1 or 2).

Results

Although the method of evaluating the land use development is a frequented research topic in the Czech geography and it brings for sure a useful information about the composition of landscape horizontal structure, its methodological credibility rising from the validity of entry data is being discussed constantly. Fig. 2 brings the comparison of data from LPIS databasis and from dataset of ČÚZK. The results differenciate more and more towards smaller spatial units. A hypothesis has been cofirmed, for spatial scale of regions and districts, that the prevailing arable land in a spatial unit decides also about a high correspondence between the two databases in this category. An extremely high rate of correspondence was achieved in intensively agriculturally exploited districts of Litoměřice and Louny (correspondence of 100% and 94%, the rate of correspondence in agricultural land reaches the rates of 92% and 88% respectively). An opposite extreme rises in a hilly area with large urban agglomerations, in the Děčín (45%) and Ústí nad Labem districts (the rate of correspondence is merely 28%), where the distribution of arable land is only minimal. There is no reason, therefore, why not to pronounce a hypothesis that the conclusions for smaller areas would be similar only with a greater amplitude of results. It shows itself, accordingly, that the validity of the ČÚZK data is very problematic in some areas. On the basis of this comparison it is possible to draw a conclusion that the most optimal source of data for land use evaluating method (though a far more expensive and toilsome source) are aerial photographs, ortophotographs or remote sensing photos, whose evaluation validity depends only on the accuracy of our processing.

The results of the Patch Analyst application for calculating landscape metrics with the use of CORINE data indicate the spatial macroheterogenity features and with the use of aerial photographs spatial microheterogenity parameters. In the landscape microstructure gradually higher representation is gained by forest biocorridors, small groups of trees, solitary trees, shrubs and bushes lining paved and unpaved paths or roads, vegetation bound to the banks of small or big streams and constituting a specific alluvial ecosystems, expanding forest source patches, abandoned areas of meadows found in different stages of the succession process. The higher weight of influence on landscape metrics is therefore gained by natural conditions as the topography, the altutide or the water supply. It shows that from the point of view of natural conditions in the less variable landscape, suitable for an intensive plant production, far less intensive changes occur than in the areas less suitable for an intensive agricultural activity. The results of applying Patch Analyst on CORINE data indicate an increasing rate of polarization between agriculturally intensively exploited areas with the domination of arable land on one side and marginal, abandoned, unexploited, gradually overgrowing areas on the other side. This shows a trend of spatial "macrohomogenization" of the landscape structure in the Czechia. The shapes of areas are simplified and grow in the way as it is usually cited (e.g. Krönert, Steinhardt, Volk, 2001, EK, 2000). Naturally there are differences, too. For example the areas of the Bohemian Central Mountains shows the increase of both the numbers and the density of areas and the decrease of the mean patch areas.

Employing the method of monitoring the impact of anthropogenic stressors and ecological stress quantification enabled to compare the results with the often used KES index (fig. 5). This comparison leads to the statement that neither KES nor KAO (not even any other similarly based index) can reflect landscape components quality as it cannot predicate about specific conditions of particular time periods set by the type and intensity of environmental stressors influences. KES can thus only reveal a certain potential quality value in the case it is accompanied by detailed qualitative information about landscape components (e.g. via an environmental stressors analysis and the presence of stress in the landscape). The results of monitoring the stressors can be likewise as with Slovak landscape ecologists (eds., 2002) presented by means of the territorial system of stressors map (fig. 6).

I see the further stage of the scientific work in finishing the tasks set within two research projects that consist, in compliance with the Slovak LANDEP methodology and topics related to it, in defining environmental land use limits, in identifying reserves and conflicts in the landscape and in the finalization of the works to state optimal trajectories of sustainable land uses. Further, I intend to identify the landscape horizontal structure features by using of Patch Analyst and remote sensing photos as a different data source. Their availability since 1972 and the selective minimal mapping unit will enable to compare the results of calculating landscape metrics for the same areas or totally different ones, perhaps even a markedly larger area. It will enable also to examine mutual correlations of individual landscape metrics with natural preconditions (e.g. the altitude, the steepness, the soil value). I suppose also to continue with a more intensive work with the LPIS databasis, and that, if possible, in spatial format as well, and its correlation with other information sources about the land use.

At the present time I am working thanks to the purchase of 3D Nature sotware and the databasis of 3D objects on the development of the digital landscape modelling, 3D landscape geovisualization, the reconstruction of historical landscapes or simulating landscape scenarios. Thus produced "artificial landscapes" enable e.g. affected groups of inhabitants to decide better and consider which of the landscapes they "like" most. Consequential surveys with local inhabitants can have an undispensable importance for the next theme of landscape esthetics, the landscape character or the visual quality of the landscape. "Virtual landscapes" more and more often enter landscape ecological monographies (Green et al., 2006, Palang, Fry, 2003). The validity of virtual models and 3D landscape visualizations, the validity of evaluating landscape scenery, if you like the level of realism in landscapes simulated by a computer, a so called "LOD problem" – level of detail – engage a line of landscape ecologists (Williams et al., 2007, Appleton, Lovett, 2003, Rohrmann, Bishop, 2002, Ervin, 2001, Orland et al., 2001, Mulhar, 2001, Schmid, 2001, Danahy, 2001, Bishop et al., 2001, Hehl-Lange, 2001).