PROPOSAL METHOD OF LANDSCAPE TYPOLOGY IN THE CZECH REPUBLIC

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Abstract
The paper introduces a new methodological system of a complex landscape typology. In comparison with the former typologies the basic difference is that the presented typology is based on exact, easily quantified data covering both natural and cultural landscape conditions, which can be classified in GIS. By combining chosen thematic layers a new unique raster dataset was created where each pixel has a specific combination of selected characteristics. All pixels of the same summary characteristics represent a particular landscape type. The unique landscape types were generalized and combined with similar ones in polygons defined by eCognition segmentation process. The output of the used methodology is a map representing preliminary landscape types of the contemporary Czech landscape that will be the subject of further modifications and interpretations.

Key words: landscape typology – cultural landscape – eCognition – GIS

Introduction

Landscape classification, regionalization and typology represent one the most important subjects of study for landscape sciences, which could yield significant results in landscape conservation and planning as well. Although different landscape typologies were developed in the Czech Republic in the past (e.g. DEMEK ET AL., 1977; ATLAS ŽIVOTNÍHO PROSTŘEDÍ A ZDRAVÍ OBYVATEL ČSFR, 1992; KOLEJKA, LIPSKÝ, 1999), none of them is widely used and applicable in recent situation. Latest landscape typology developed by research group of LÖW ET AL. was not published completely yet, therefore could not be reviewed critically. Whereas unified complex landscape typologies exist commonly abroad (e.g. ATLAS KRAJINY SR, 2002), there is number of different landscape classifications based on subjective expert approaches in the Czech Republic.

This situation is caused by the fact, that landscape as a complex spatial and changeable system represent study subject for wide spectrum of different disciplines as geoecology, human environmentalism or landscape design and architecture. Therefore the individual approaches to landscape typology and its conclusions vary diametrically according to specialization and erudition of its authors.

The paper introduces a new method of complex objective typology for the contemporary Czech landscape. The basic difference is that presented typology is based on exact, easily quantified data covering both natural and cultural landscape conditions, which could be classified in GIS. Prepared maps will be published in new Atlas of Landscape of the Czech Republic.

Methods

I. The choice of controlling and landscape-character representatively expressing components

The usage of exact quantifiable datasets is the main difference to other approaches to landscape classification in the Czech Republic. The incorporation of all environmental and socioeconomic variables that determine the landscape character would be difficult due to different weight of each variable and due to different time and spatial scale. Therefore the first most important step was to determine components, from the hierarchical system below (Fig.1), that representatively express the landscape character. The selection had to reflect the importance of each component in delimitation of landscape types, however the data quality and accessibility was a constraint. In the Czech Republic climate, relief and geological substrate were selected as the main components describing the natural environment (primary landscape structure) and land use with landscape heterogeneity were selected as the best available components describing the secondary landscape structure.

The input data were as follows:

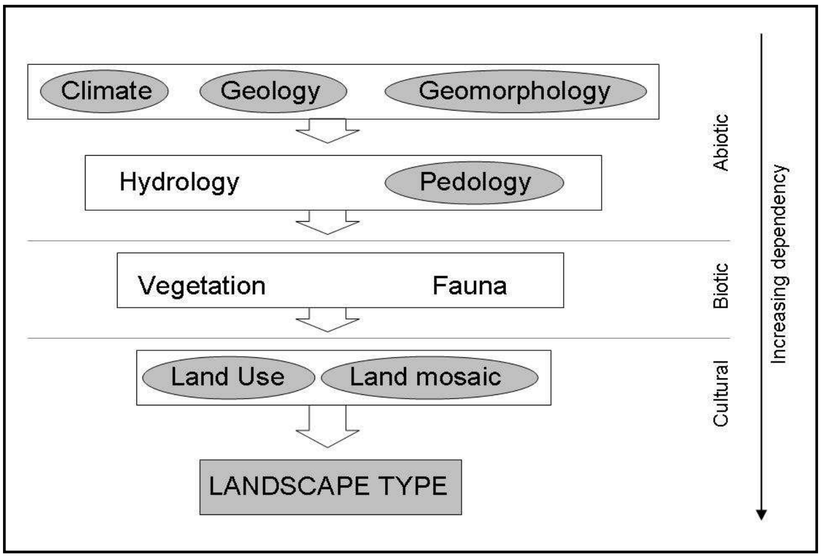
Environmental data

- climate (derived from climatic regionalization according to Quitt, 1971)
- parent geological substrate (derived from geological database GEO CR 500 and Soil map of the ČR)
- relief expressed by altitude and vertical heterogeneity (derived from elevation grid DEM ArcCR 500)

Secondary landscape structure

- land use (derived from CORINE Land Cover 2000 database)
- landscape secondary structure heterogeneity (derived from CORINE Land Cover 2000 database)

Fig.1: Selection of representative natural and cultural components for typology (After Mücher et al. 2003, modified)



II. Datasets pre – processing: generalization and reclassification

Firstly all datasets were generalized according to their thematic content important from classification point of view. In case of **climate** there were left all original 13 classes (T2 - CH7) of mezzo - climatic regionalization after Quitt (1971) as it shown in Table 1.

Table 1: Categories of climatic regionalization (after Quitt, 1971)

Code	**Type**	**Category of CLIM**
1	T4	Warm climatic region type 4
2	T2	Warm climatic region type 2
3	MT11	Moderate climatic region type 11
4	MT10	Moderate climatic region type 10
5	MT9	Moderate climatic region type 9
6	MT7	Moderate climatic region type 7
7	MT5	Moderate climatic region type 5
8	MT4	Moderate climatic region type 4
9	MT3	Moderate climatic region type 3
10	MT2	Moderate climatic region type 2
11	CH7	Cold climatic region type 7
12	CH6	Cold climatic region type 6
12	CH4	Cold climatic region type 4

Next thematic layer **– parent geological substrate** - was created by synthesis of geological (*GEO ČR 500, 1:500 000, Czech geological survey*) and pedogeographical datasets (*Map of Soil Types of the Czech Republic, 1:200 000, Němeček et al*.). Original 19 classes of geological dataset were merged into 6 categories; consecutively 3 classes covering specific sediment substrates were generated from Soil map of CR. Resultant thematic layer represents generalized but accurate dataset of 9 basic types of parent material (Tab.2).

Table 2: Categories of parent geological substrate (derived from GEO ČR 500; Soil Map, Němeček et al.)

Code	**Type**	**Category of SUB**
1	v	Vulcanites
2	p	Plutonites
3	m	Metamorphites
4	s	Sediments of covered formation
5	b	Specific sediments of Barrandien
6	k	Karsts sediments
7	c	Mesozoic sediments
8	q	Quaternary sediments
9	a	Alluvial sediments

Other information layers important for typology of natural landscape were derived from digital elevation model (*DEM*) with pixel size 200x200m, that is part of *Topographical database ArcČR 500*. Simple categorization of landscape into 6 **altitude levels** covering landforms from lowlands to mountains is one of the basic inputs.

Table 3: Categories of altitude levels (derived from DEM, ArcČR 500)

Code	Type	Category of DEM	Altitude levels
1	L	Lowlands	0 - 250
2	D	Downs	250 – 500
3	H	Highlands	500 - 750
4	U	Uplands	750 - 1000
5	M	Mountains	1000 - 1250
6	A	Alpine mountains	1250 - 1600

Vertical heterogeneity was derived from the same database by geostatistical function standard deviation, which describes dataset variety – altitudes in the net of $1km^2$ square size. This output was compared to traditional vertical heterogeneity evaluation. Final results of database computation were reclassified into 4 categories representing basic types of landscape surface according to vertical heterogeneity from flat to undulating.

Table 4: Categories of vertical heterogeneity (derived from DEM, ArcČR 500)

Code	Type	Category of VAR	Interval of standard deviation of altitude per $1km^2$
1	f	Flat	0 – 10
2	u	Undulate	10 - 25
3	h	Hilly	25 - 50
4	m	Mountainous	50 - 150

Additional typological process was managed by using land use / **land cover** information derived from database CORINE Land Cover 2000. Original 28 categories of CORINE's nomenclature, mapped in the Czech Republic, were generalized to 10 classes significant for classification of landscape types as it is shown in Tab. 5.

Table 5: Categories of land cover (derived from CORINE Land Cover 2000)

Code	Type	Category of LC
1	x	Anthropogenic areas
2	a	Arable land
3	k	Permanent cultures
4	s	Pastures
5	h	Heterogeneous agriculture areas
6	c	Coniferous forests
7	d	Deciduous forests
8	o	Open bare spaces
9	t	Wetlands
10	w	Waters

Moreover the same dataset was used for deriving **land cover heterogeneity** information by applying geostatistical function "Variety" – which evaluates number of different land cover categories in given space – here square of $1km^2$ net again. According to the results 4 types of landscape heterogeneity from completely homogeneous (1 - 2 classes per $1km^2$) up to intensely heterogeneous (7 – 8 classes) were generated.

Table 5: Categories of land cover heterogeneity (derived from CORINE Land Cover 2000)

Code	Type	Category of HET	Number of classes
1	c	Completely homogeneous	1 - 2
2	m	Homogeneous	3 - 5
3	t	Heterogeneous	5 - 6
4	h	Completely heterogeneous	7 - 8

Dataset created this way were transformed to raster type layers with identical pixel size 200x200m. All classes of each thematic layer hold unique code number, therefore a complex of unified and comparable datasets was developed and processed by methods of raster algebra in GIS environment. Unique code of each pixel is built by following computation:

TYPE_N = CLIM + SUB + DEM + VAR + LC + HET
e.g. TYPE_N = T2.q.L.f.a.c
TYPE_N = 2.8.1.1.2.1

III. RGB synthesis of selected datasets

One of the keynote steps in proposal typology is RGB synthesis representing original way of combination of selected input layers in ArcGIS environment. For this purpose primary – not derived – layers were used: climate, parent geological material, altitude levels and land use. Three of these layers carry color channel information, the fourth one is without any information. Spectral characteristic of synthesized scene is changeable according to input layers integration (for example: RED channel – climate, GREEN – parent material, BLUE – altitude, NO CHANNEL – land use). Use of four channels representing particular layers is important for parallel typological processing of both natural and cultural environment.

Firstly cultural information is reduced due to delineation types of natural landscapes, further the weight of natural factors is set low and existing scene is segmented just according to land cover information. Similarly as it shown above in the method of raster calculation each pixel is characterized by unique code – bands combination. For example pixel with RGB values 933 is part of highland area in moderate climatic region type 3 with metamorphites as parent material. The information about land cover could be gained by shifting channels. The final result is an ERDAS Imagine file, visually similar to satellite scenes, which could be classified by remote sensing methods.

IV. Delineation of landscape types polygons by segmentation of RGB scene

Second keynote step of typology process is use of controlled segmentation of RGB scene. It's allowed in the environment of software eCognition, which is unique object oriented software, where image classification is based on attributes of image object rather than on attributes of individual pixels (Mücher et al. 2003).

RGB composite image could be changed by linking different bands to different input levels, therefore multiple segmentation on various hierarchical levels is possible. The basic principle of this process is merging of related pixels of similar spectral characteristics. Groups of these related pixels represent specific landscape types, whose delineation is done by process of multiresolution segmentation. Weight of each input layer could be set differently and so influence of particular natural or cultural factors could be reduced or accentuated. This method solves the most problematic step in typological process – definition of landscape types – in an objective and independent way. eCognition software also allows export of created polygons into GIS environment.

In case of landscape typology of the Czech Republic firstly segmentation based on natural data (CLIM, SUB and DEM) was done, in order to delineate types of natural landscape. As the second step - next segmentation process on lower hierarchical level based on land cover data was performed in resulting natural units.

Conclusion - characterization and interpretation of delimited landscape types

The delimited polygons were imported to the ArcGIS 9.1 software. A unique code was assigned to each polygon and the zonal statistics was carried out within each polygon using Spatial Analyst for ArcGIS. The statistics considered above mentioned input raster datasets that enabled us to characterize each polygon from the viewpoint of climate, relief and geological substrate. When characterizing the geological substrate and climate the algorithm "majority" was chosen reflecting the prevailing kind of substrate or climatic region within each polygon. When characterizing the relief mean altitude was calculated. The obtained characteristics were cartographically expressed.

There were 45 unique natural landscape units delimited within the Czech Republic in the highest scale level, however the exact number of delimited landscape units was not the main aim. The main target, of the applied approach to landscape typology, was to suggest and test a widely applicable method (choice of datasets, preprocessing of datasets) of landscape typology. The next and the most important step is further testing, considering spatial scale, before the final list of landscape types of the Czech Republic is published.

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