Using of geographical information systems (GIS) in the ecosystems assessment on the landscape level: Case study from the Czech Republic

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Abstract: Remote sensing and GIS (geographical information systems) are very important methods for assessment of changes and development of ecosystems in the landscape level. This article deals with applying of remote sensing and GIS methods to assessment of ecosystems in agricultural landscape in the Horňácko region, extending to the White Carpathians Mountains Protected Landscape Area (Czech Republic). The aim of this work was to identify and evaluate the state and development of the permanent grass herbages in the Horňácko region (Czech Republic) on the basis of historical and present geodata, aerial and satellite images and other available materials. With the help of the landscape-ecological indices, we are able to describe the state and structure of the permanent grass of geoinformation technologies, especially by employing the GIS and remote sensing. The values of the ecological indices were obtained by application of GIS tools like the Patch Analyst extension, Vector-based Landscape Analysis Tools extension and Image/Spatial Analyst.

Key-Words: GIS methods, land use, ecosystem, landscape indicators, remote sensing.

1 Introduction

Landscape is a complicated dynamic spatial unit influenced by the many factors. It requires constant attention and care for the sustainable conservation of their values which allow existence of human society. The definitions of landscape are a large amount. For this contribution seems to be the best follows: Landscape is a set of specific biotic services, geobiocoenoses, hydrobiocoenoses and techno-anthropoceonoses. Techno-anthropocenoses are understood as systems made up of the community of people and the synantropical cultivated plants, animals, all the technical, cultural and social facilities which community use, and environment which the community interacts, eventually The earth's crust with relief, air, water, soil, biota, and human with his creations interact themselves and come together in the landscape. Scenery is also a mosaic of diverse ecosystems. Human society uses different types of the landscapes differently. The degree of recovery of the landscape consists in the physical or biological terms, which different types of landscapes provide [1]. At the same time, the degree of recovery consists in the ability of regeneration of the landscape. The landscape potential (finding out the possibilities of landscape without any loose, harm or run out) can be determined based on the typology of the landscapes [2]. The impact on the surrounding landscapes should be minimal and also sustainable during the time period.

Geoinformation technologies are specific information technologies used for processing of geodata and geoinformation. A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared. GIS technology can be integrated into any enterprise information system framework.

At present, they become very important tools in geoanalysis and are integral parts of all scientific disciplines that work with spatial data. The fundamental geoinformation technologies include geographical information systems (GIS), remote exploration of the Earth, digital relief models, positional and navigational systems, computer cartography, digital photogrammetry and spatial modeling.

This article deals with applying of remote sensing and GIS methods to assessment of ecosystems in agricultural landscape in the Horňácko region, extending to the White Carpathians Mountains Protected Landscape Area (Czech Republic). The structure of ecosystems and their land cover have dramatically changed since the last hundred years due to the political and economic changes in the central Europe (changes in the ownership and the transfer of the small-scale production to the mass production). The aim of this article is to identify and evaluate these changes of ecosystems in the landscape level.

1.1 GIS in spatial assessment

Implementation of GIS into local government is based on joint government, combined information, integrated and seamless services, web accessibility, efficiency savings and other factors. Rapid advances in GIS technology in the recent years have greatly expanded the utility of GIS and the scope of the application of these spatial data management tools. The elegance of modern GIS tools is their ability to instantly relate varied information types and sources to concrete, real-world circumstances in combination with powerful tools for analyzing and visualizing the feasibility of what can be imagined. However, many current GIS applications do not exploit the full ability of GIS techniques to facilitate the information needs of top-level management. Future GIS is likely to develop additional capabilities in this direction which would build on the large volume of operational spatial data found in many large organizations and governments.

In many foreign countries (USA, Germany, Canada), where GIS implementation has an older history, implementation of GIS tools in urban planning is more extensive. Urban planners use GIS software more commonly and so their results are based on expert analysis. Several examples of the application of GIS analytical tools for the urban environment are introduced by [3]. Case studies focused on for example crime pattern analysis, community-based planning, urban environmental planning or urban services and urban populations are described in this publication.

Another example is LUCIS (Land-use Conflict Identification Strategy) introduced by [4]. This is a strategy to explore optimal suitability to three broad land-use categories (agriculture, conservation and urban) and compared them to identify where conflicts among them exist. LUCIS is also introduced as a tool with potential for many other applications, including strategic conservation planning, real estate investments, infrastructure planning or general market analysis. The LUCIS model is a good example of the combination of GIS analytical tools into extension, accessible for urban planners. The free possibility of using GIS analytical tools through Geographic Resource Analysis Support System (GRASS) was used in research of [5] as a tool for urban planning.

2 Methods and procedures

2.1 Data collection and pre-processing

The aim was to acquire various types of background data which were subsequently used as input data in the process of finding solutions of various types of spatial operations, analyses and evaluation of changes in the development of permanent herbages (abbreviated in the article as "TTP").

2.1.1 Tabular data

The data originated from the project called "Motive Powers of Changes in Differentiation of Usage of Landscapes of the Czech Republic and Neighbouring Countries - Perspectives after Acceptance to EU". According to [6] the attribute table, based on the cadastral data from years 1845-1948-1990-2000, constitutes the groundwork of these data. Since the area of particular land registers changed, some land registers were formed and others ceased to exist, the land registers were therefore added to so-called the Basic Territorial Units, whose area was almost constant in the given years (i.e. the area changed within 1 % tolerance). In the tabular and map form, the stable land register represents well-established, detailed background for all procedures ending with the detailed knowledge on the development of the landscape structure. One can say that it is a comprehensive, up-to-date ultimately objective and precise piece describing quantitative and qualitative state of land reserves and economics in the Czech lands, Moravia and Silesia. For each time interval, an individual table was constructed characterizing the evolution of land exploitation in the particular cadastral territories in terms of hectares and percentages.

2.1.2 Satellite images
CORINE Land Cover (CLC) - We used data sets from two time periods, namely CORINE Land Cover CLC90 and CORINE Land Cover CLC2000. Both covers were in SHP data format and provided data on the whole territory of the Czech Republic. For further processing, it was necessary to modify these two covers with respect to the extent of interested territory with the use of ArcGIS program (function “Clip”). In order to have individual categories matched with the legend defined for tabular data, new categories of landscape exploitation were determined: woods, grasslands, non-forest green, arable land, gardens and vineyards and built-up area. By this process, two new covers were formed, which became a basis for following operations and analysis of changes in TTP areas.

LANDSAT – From the beginning of seventies of the 20th century, satellites of LANDSAT system and image data, which are produced by this system, are widely recognized as the most important source of information on natural sources of the Earth. For the need of our study, the satellite image was taken by a LANDSAT 7 satellite with an ETM+ (Enhanced Thematic Mapper Plus) sensor. The image was downloaded from the webpage belonging to Global Land Cover Facility (CLCF). The image is related to the time period in the year 2000.

In the working environment of the ArcGIS software program (using “Clip” function), the image was cut along to the outermost points enclosing the interested territory. We then worked only with these layers (covers).

Thanks to the high number of contained spectral zones, it is possible to visualize the interested territory in various combinations of spectral zones when each of these combinations brings a slightly different view and highlights certain properties of the land surface.

2.1.3 Vector data
The vector data comes from the Fundamental Basis of Geographical Data (ZABAGED®). ZABAGED® is a digital geographical model of the territory of the Czech Republic, which, with its characteristic accuracy and particulars of imaging of geographical reality, corresponds to the accuracy and particulars of the Basic Map of the Czech Republic with the 1:10000 scale [7]. These data were in the SHP data format and related to the year 2001. For finding the changes in the landscape, the second cover of ZABAGED® was created, this time for the year 2007 when it was updated by the combination usage of following programs: Janitor and ArcGIS. For subsequent comparison with the CORINE Land Cover data, the legend was reduced from 10 categories of land exploitation to seven categories.

2.2 Software and methods
The basic analytic procedure of used data lies in the analysis of the time series, which enables to judge the initial state of the landscape in comparison with the existing landscape state by means of monitoring a change in the exploitation of parcels, change in areas, change in arrangement of the landscape and change in natural and naturally close structures. In addition to the ArcGIS 9.x extended of Spatial Analyst we used two special extensions. For monitoring the changes in the exploitation of the landscape, “Change Detection” extension is used for satellite images, especially for CORINE Land Cover images. The resulting data are supplemented with maps, tables, graphs of state and development of permanent herbages and with a series of ecological indices, all acquired with the use of V-LATE and Patch Analyst extension. From LANDSAT satellite image, we find out information on a change in the areas in the landscape, vegetation and health state of vegetation by means of defined vegetation indices and ImageAnalysis/Spatial Analyst function.

2.2.1 Vector-based landscape analysis tools extension
Vector-based Landscape Analysis Tools (V-LATE) provides a set of the most frequently used metric functions (landscape indices) for the study and determination of the landscape structure. It can be freely downloaded in two versions, namely 1.0 version intended for ArcGIS 8.x program and 1.1 version for ArcGIS 9.x. As it is evident, the extension works with vector-based data [8]. V-LATE works only with polygons of shapefile data format. GRID and geodatabase files are not supported. The extension button is inactive until the polygon layer is loaded into the ArcMap project. The on-the-fly projection is not supported by this extension so far and it works only with the projected data. When working with a large amount of polygons (more than 1500 polygons), the process of calculation becomes significantly time consuming. If the appropriate classes are not explicitly expressed in the attribute table, they are automatically generated by the extension [8].

2.2.2 Patch Analyst

The Patch Analyst extension enables to perform spatial analyses of the landscape, supports modeling of standpoints, maintenance of biodiversity and woods management. The extension is available at the webpage of the Center for Northern Woods Ecosystems Research located at the Lakehead University. It is available in two versions, namely 3.12 version intended for the ArcGIS 3.x version program and 4.0 version for the ArcGIS 9.1 version program [9]. The menu of the 3.12 version Patch Analyst consists of 12 functions, which are divided into four thematic groups.

The first group involves the creation of new layers. Compared to V-LATE, this group offers two extra functions, namely "Intersect" function (crossing of polygons) and "Make Hexagon Regions" function (creation of regions of a regular hexagonal shape). The second thematic group deals with the setting of the parameters: Add/Refresh Area and Perimeter to shapefile and Parse Species Composition String (this function divides the column with the date of one attribute into a given number of columns), The third thematic group enables attribute modelling, which allows editing the attribute algorithms, i.e. questioning, searching and adding the information in the attribute table. The fourth thematic group works with the spatial operations: Neighbourhood mean (this function defines the landscape regions, where the polygons have similar values), Analysis by Regions (analysis of the individual categories, e.g. age analysis according to a given region) and Spatial Statistics.

At these points, it is worthwhile to mention following indices: Area Weighted Mean Patch Fractal Dimension – AWMPFD and Area Weighted Mean Shape Index – AWMSI belonging to the "Shape Index" group and Core Area Density – CAD from "Core Area Metrics" group [9]. These indices are present only in the Patch Analyst extension; they are missing in the V-LATE extension.

2.2.3 Study area

The Horňácko region is a small ethnical region that is situated in the eastern part of Moravia, close to the boundary with the Slovak Republic, in so-called the Moravian-Slovak borderland and at the foothill of Bílé Karpaty mountain range. The prevailing part of the model territory belongs to the CHKO Bílé Karpaty unit [10].

The total area of the territory is 14 312 hectares. The structure of the agricultural landscape of Horňácko region changes crucially during last one hundred years due to the political and economic changes, changes in the ownership and the transfer of the small-scale production to the mass production. The first stage of changes took place in the 1950s and 1960s due to the process of collectivization resulting in ploughing of balks and creation of large fields. The second stage of changes took place in the 1970s when more land was converted into arable land. This resulted in an increase of arable land at the expense of permanent herbages and entire environmental disturbance of the structure and function of the landscape. After 1989, there was a significant step towards development of permanent herbages when big parts of the arable lands got grassed [11].

The studied territory is unique for its characteristic landscape structure which, for the last 160 years, was not so devastated and disturbed by the process of intensification of agricultural production and process of collectivization compared to the other territories of the Czech Republic. Thus, one can say that the Horňácko region exhibits a so-called harmonic landscape [12].

3 Results

3.1 TTP development

A complete comparison of the acquired results is somewhat complex. The only one year, for which we have all the three types of data, is 2000 (or 2001 in the case of ZABAGED data if we assume that during one year, there was no significant change in the development of TTP areas). As far as the year 1990 is concerned, it is possible to carry out a comparison only within tabular data and CORINE Land Cover (CLC) data. Other values, i.e. those from the years 1845, 1948 and 2007, can be evaluated in dependence on assumed TTP development.

We encountered a problem in the case of the tabular data when the values of the land areas of the individual categories are related to the BTU (Basic Territorial Units) and do not carry any information on the number of lands and their distribution within the territory. Thus, from these data, it is impossible to evaluate any landscape-ecological indices except the index of change, the coefficient of ecological stability (KES) of territory and the absolute and relative presence of individual categories of land exploitation.

The whole period of 165 years is characterized by a decrease in the TTP area. In the years 1845-1948, almost 33 % of the total area of TTP was converted arable land (Table 1). The decrease in the TTP area continued also in the years

Table 1 Comparison of changes in the category of land use between selected years

Category of land use	ha	(%)	ha	(%)	ha	(%)	ha	(%)
	1845-1948		1948-1990		1990-2000		1845-2000	
arable land	1412.0	22.73	-1011.90	-13.27	-55.4	-0.84	334.7	5.55
permanent crops	-68.5	-16.84	396.6	117.23	11.1	1.51	339.2	83.38
TTP	-2012.50	-33.66	-385.7	-9.72	0.43	0.43	-2382.70	-39.85
forests	499.4	8.29	406	6.91	-52.8	-0.84	802.6	14.8
water surface	0	0	39.9	42.04	-0.7	-0.52	39.2	41.31
built-up areas	-4.9	-4.47	128.4	122.52	-1.1	-0.47	122.4	111.58
other areas	204.6	107.29	420.6	106.4	-16.4	-2.01	608.8	319.24
total	-19.9	-0.11	-6.1	-0.03	-99.8	-0.54	-125.8	-0.68

Table 2 Area of category of land use in the selected years

Category of land use	Area (ha)			
	1845	1948	1990	2000
arable land	6212.70	7212.70	6612.80	6557.40
permanent crops	406.80	338.30	734.90	746.00
TTP	5979.20	3966.70	3581.00	3596.50
forests	5432.80	5873.20	6279.20	6226.40
water surface	94.90	94.90	134.80	134.10
built-up areas	109.70	104.80	233.20	232.10
other areas	190.70	395.30	812.90	799.50
total	18417.80	18397.90	18391.90	18292.00

1948-1990, when the drop in the TTP area was not so striking (less than 10 %). From the year 1990, an increase in the TTP area is observed in the period from 1990 to 2000 (Table 2). For this increase, the values derived from the tabular data and CLC data differ, the trend of the increase is the same, but the change in the TTP area is 15.50 hectares (0.43 %) and 901.97 hectares (i.e. 2/3 increase) from the tabular data and CLC data, respectively. In the last monitored time interval from 2000 (or 2001) to 2007, the increase in the TTP area still persists, however, this increase is not so dramatic (about 44.90 hectares – 1.28 %) as in the case of the previous time interval.

If we concentrate on the resulting values of the area of the grasslands for the mentioned year 2000 (or 2001), one can see from Table 3 that the values of the tabular data and CLC data are very close to each other but are not similar with the ZABAGED data as the difference between them is approximately 823.13 hectares.

Table 3 Area of TTP in the Horňácko region from particular data in the year 2000 (or 2001).

Data	Area of TTP (ha)
Tabelar data	2679
CORINE Land Cover	2667.94
ZABAGED	3496.6

Such a trend evolution in the TTP area is also implied by the index of change when the lowest value (IZ = - 0.86) corresponds to the time interval from 1845 to 1948 which is period of the highest decline in TTP area at the expense of the arable land due to developing agriculture. In the years 1848-1990, IZ = - 0.30, signalizing further decrease in the TTP area. On the contrary, an increase in the TTP area is evidenced in the years 1990-2000 (IZ = 0.03 from the tabular data and IZ = 0.5 from CLC data). In the years 2000(or 2001)-2007, the value of the index of change decreased to IZ = 0.01, which confirms that in this time interval, there was not so significant change in the area of individual categories.

The evolution of the landscape-ecological indices is different comparing the time periods of 1990-2000 and 2001-2007. In both monitored periods, we see an increase in the TTP area at the expanse of the decrease in the area of the arable land, increase in the number of TTP parcels, increase in the index of mean size of the parcel (MPS), total length of edges (TE), density of parcel edges (ED), average shape of the parcel (MSI), Shannon index of diversity (SDI) and Shannon index of equilibrium (SEI), all being similar. The differences are observable for the index of mean parcel edge (MPE), fractal dimension (FD), dominance (D) and for other indices. According to the index of polygon shape (SI) [13], TTP are in a leading position, immediately after the category of non-forest greens over the CLC data and category of water areas over the ZABAGED data. This is

Table 4 Area of categories of land use of cadastral territories

Cadastral territory	Area in year 1990 (ha)						
	Arable land	*Meadows and pastures*	*Orchards and Vineyards*	*Forests*	*Non-forest vegetation*	*Built-up areas*	*Total (cadastal teritory)*
Hrubá Vrbka	660.24	287.17	2.26	207.25	105.63	46.71	1309.25
Javorník	693.48	295.14	0	1126.43	294.7	28.63	2438.38
Kuželov	531.53	161.77	0	250.67	13.08	58.4	1014.45
Lipov	1112.96	50.61	214.53	17.7	40.34	81.2	1517.34
Louka	770.75	17.82	25.2	78.99	2.54	59.54	954,84
Malá Vrbka	300.64	0.28	0	110.22	32.8	0	443.94
Nová Lhota	648.43	266.96	0	1394.06	279.25	32.22	2575.93
Suchov	480.11	195.93	0	492.22	253.32	27,83	1449.41
Velká nad Veličkou	1486.78	90.29	93.55	486.24	252.71	184.81	2594.39
Total absolute (ha)	6684.93	1365.97	335.54	4118.79	1274.37	518.33	14297.93
Total relative (%)	46.75	9.55	2.35	28.81	8.91	3.63	100

Table 5 Area of categories of land use of cadastral territories

Cadastral territory	Area in year 2000 (ha)						
	Arable land	*Meadows and pastures*	*Orchards and Vineyards*	*Forests*	*Non-forest vegetation*	*Built-up areas*	*Total (cadastal teritory)*
Hrubá Vrbka	619.88	327.53	2.26	207.25	105.63	46.71	1309.25
Javorník	594.42	394.2	0	1114.45	304.68	28.63	2438.38
Kuželov	531.53	161.77	0	250.67	13.08	57.4	1012.45
Lipov	1112.96	50.61	214.53	17.7	40.34	81.2	1517.34
Louka	770.75	17.82	25.2	78.99	2.54	59.54	954.85
Malá Vrbka	294.7	6.22	0	110.22	32.8	0	443.94
Nová Lhota	283.74	631.66	0	1349.06	279.25	32.22	2575.93
Suchov	347.55	328.5	0	429.22	253.32	27.82	1449.41
Velká nad Veličkou	1227.44	349.64	93.55	486.24	252.71	184.81	2594.39
Total absolute (ha)	5782.96	2267.94	335.54	4108.80	1284.35	518.33	14297.93
Total relative (%)	40.45	15.86	2.35	28.74	8.98	3.63	100

caused by the prevailing line character of the mentioned categories.

The number of types of changes in the land exploitation shows evidence of the accuracy and punctuality of the data of landscape structure of Horňácko region. The ZABAGEB data are recorded with more detailed landscape structure than those coming from CORINE Land Cover. Therefore, much more types have been recorded for the ZABAGEB data than for the CLC data when analyzing the change in the land exploitation. For CLC data, there are only three types of changes: non-forest greens to woods, woods to non-forest greens and arable land to TTP. For ZABAGED data, there are 11 types of changes recorded: woods to TTP, woods to arable land, TTP to woods, TTP to non-forest greens, TTP to arable land, non-forest greens to TTP, arable land to woods, arable land to TTP, arable land to non-forest greens, arable land to gardens and vineyards, and arable land to build-up area.

By analysis of the LANDSAT 7 satellite image, we defined the most suitable zone for detection of TTP in grey tones, i.e. zone No.4 and No.5. In the colour combination, the most suitable was a combination of zones No.4, No.3 and No.2. The majority of parcels with maximum density of vegetation are found in the highest altitudes, i.e. in the cadastral territory of Nová Lhota and Suchov. On the other hand, parcels with little vegetation or without vegetation are found in the cadastral territory of Lipov, Louka and in middle part of Horňácko region (Tables 4 and 5)

3.2 Evaluation of calculation accurancy

The landscape-ecological indices were possible to be applied only to CLC and ZABAGED data. Their calculations carried out in the Patch Analyst extension have been compared with the selected indices in V-LATE extension and their accuracy has been then evaluated. As one can see in Table 6 and 7, the values of indices from the CLC data are accurate within two decimal digits. The difference is only observed for the ZANAGEB data when the value of the index of density of parcel edges (ED) and the index of core land area (TCAI) differs by decimal digit. By this process, we confirmed the consistency and accuracy of the calculation of both extensions. When comparing the CLC and ZABAGED data, the resultant landscape-ecological indices are different from year other. The increase trend persists, the area of the TTP again slightly increases by a few percent in the time period of 2000(or 2001)-2007.

The resultant values of TTP indices are different when comparing the year 2000 (CLC) and 2001 (ZABAGED). Especially, the number of land parcels is several fold higher for ZABAGED data (more than 622 %). This value thus influences other landscape-ecological indices.

The reason lies in the primary processing of these data. CORINE Land Cover data are not so accurate compared to the ZABAGED data. The 1:100 000 scale is too small for a study of more detailed landscape structures. The CLC data consist predominantly of middle and larger land parcels but do not include small and line-shape land parcels as during the generation, the small land parcels have joined up the neighbouring larger categories. Here, the minimum area of the land parcel is 25 hectares with a minimum width of 100 meters. Therefore, for the CLC data, we do not register the category of water area and we only occasionally register the non-forest greens of a line character. This is also reflected in the update from the year 2000 when a plenty of errors were found out and a change in the land exploitation was registered if the change was higher than 5 hectares. This influences not only the number of land parcels but also other landscape-ecological indices.

Table 6 Comparison of accuracy of results of selected landscape indices derived from the CLC data.

Tool	Year	MPS	PSSD	ED	SDI*	TCAI
Patch Anal.	1990	65.05	68.34	6.73	1.36	93.05
	2000	81	76.76	10.18	1.44	93.65
V-LATE	1990	65.05	68.34	6,73	1.36	93.05
	2000	81	76.76	10.18	1.44	93.65

*SDI of all categories of land-use

Table 7 Comparison of accuracy of results of selected landscape indices derived from the ZABAGED.

Tool	Year	MPS	PSSD	ED	SDI*	TCAI
Patch Anal.	2000	17.31	55.59	29.42	1.35	89.78
	2007	15.33	51.8	30.91	1.36	89.54
V-LATE	2000	17.31	55.59	29.41	1.35	88.49
	2007	15.33	51.8	30.91	1.36	88.09

* SDI of all categories of land-use

On the other hand, for ZABAGED data, the structure of the landscape is detailed as a whole, the most detailed out of the mentioned data. Again, the scale plays an important role, but this time, it is ten times smaller than 1:10 000. This is then reflected in much more detailed landscape structure of individual categories and in the overall accuracy.

For further investigation, it would be suitable to also include the aircraft image from the time period of 1960-1970 in order to get a more comprehensive view on the development of the TTP area, or to also have the prepared CLC2008 data.

4 Conclusion

The resulting values, obtained from the used data, confirmed that the trend of the TTP development at the Horňácko region is identical with the trend of the TTP development in the Czech Republic. The TTP area was the highest in 1845, then the TTP area decreased in dependence on the expansion of the arable land until 1990 after when, thanks to the decline of the agricultural production mainly in the under-mountains regions, the renewal of the function of the grass growths takes place which is also reflected in the increase in the biological diversity of the whole territory. The most dramatic changes happened in the years 1845-1945 which was caused not only by the proceeding agricultural revolution but also duration length of the monitored period. This trend of decline continued in the following time interval of 1948-1990. In 1990, the mentioned turnover is observed in the development of the grasslands. From Table 3, one can see that the TTP values differ in the year 2000 (or 2001). The difference is 11.60 hectares between the tabular data and CLC data, which is not such a big discrepancy if we take into account the larger territory of BTU with a part of Uherské Hradiště district. However, in 1990, the acreage difference is more significant and is 2215.03 hectares (in favour of the tabular data, i.e. 62 % more compared to the CLC data). Inadequacy of the tabular data lies in the fact that they are related to the area of BTU and do not carry any information on the number of land parcels and their distribution within the studied territory. Therefore, for these data, it is not possible to evaluate other landscape-ecological indices except the fundamental ones, mentioned in the text.

For landscape-ecological indices, we observe an increase in the TTP area at the expanse of the arable land, increase in the number of land parcels, length of land parcels edges and their density, fractal dimension, shape of polygons, geological diversity (the Shannon indices). The usage of Patch Analyst and V-LATE extensions for the landscape-ecological studies and changes of the landscape structure represents a very suitable and powerful tool to get a comprehensive view on the landscape. It is obvious that the TTP state is getting much more better which is in a close connection with the structural changes within the agricultural land, support of grassing in the under-mountains regions, agro-environmental programs, support to local farmers and initiatives of Ministry of Agriculture and Ministry of Environment of the Czech Republic together with the grants of the European Union. Thanks to these financial supports, one can assume that the increase in the grass areas will continue in the forthcoming years.

The authors make available the detailed results together with the table appendices with the area of individual categories of the land exploitation and their changes, appendices with resulting landscape-ecological indices and map appendices documenting the TTP state and its evolution at the Horňácko region in the monitored time periods.

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