LAND USE CHANGES IN THE VESELOVIANKA RIVER CATCHMENT IN THE HORNÁ ORAVA REGION

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Abstract

Špulerová J.: Land use changes in the Veselovianka river catchment in the Horná Orava region. Ekológia (Bratislava), Vol. 27, No. 3, p. 326–337, 2008.

The research of the landscape structure and its changes was carried out in a part of the Horná Orava region. Landscape structure was studied and compared in 2 periods (1958 and 2001). Two types of changes were identified: anthropogenic and succession. Succession processes were spontaneous, anthropogenic-conditioned or successive, which were linked with land use changes, reduction of traditional management of non-forest vegetation (mowing, grazing) and consequent climax succession. Recultivation of meadows was the most extensive anthropogenic process (88%) linked with disposal of hedges, bank vegetation, floodplain woods, changes of mosaic of arable fields and semi-natural meadows to intensively utilized meadows. Evaluation of ecological significance of land use changes pointed out, that the target area became most homogenous landscape during the last fifty years. Statistics and the synthesis of historical and present land use maps refer to a reduction of the number of land use elements, increase of their size, decrease of mosaics due to interface of plots and succession of non-forest habitats as well as the decreasing trend of porosity.

Key words: succession, land use changes, anthropogenic changes, landscape element

Introduction

The present landscape is the result of several development factors – agriculture and collectivisation, urbanisation, transport requirements, economy etc. Man and their activities became the most important and dynamic landscape factor. The results of these activities are the changes in the aspect, structure and functions of the landscape.

The main object of the research was to identify the character of changes of landscape structure during the historical evolutionary processes on the basis of the analysis of land use changes in 2 periods (1958 and 2001) of mapping with special attention to antropogenic changes and succession processes. The impact of these changes was evaluated on the basis of landscape ecological features, which are the indicators of landscape microstructure.

Material and methods

The research was carried out in the model area of the Veselovianka river catchment situated in the NW part of the Protected Landscape Area (PLA) Horná Orava. According to soil, climatic and relief conditions the study area belongs to the mountain and sub-mountain region. The area of 9 154.95 ha lies in 3 municipalities: Oravská Jasenica, Oravské Veselé and Mutné. Natural potential of the area is mostly conditioned by abiotic terms. The Veselovianka river and its affluents (Pasečí potok creek, Mútnik, Riečka and Vahanový potok creek) comprise the hydrological network. Morphologically the area is a very multiple highland.

Methodological steps:

- processing of historical view of formation of landscape structure in the settlement period
- comparison of land use in 2 periods: historical land use (maps from 1958) and present land use mapped in 2001
- determination of land use changes: anthropogenic and succession. Two sorts of succession processes were differentiated (Moravec, 1969):
  - spontaneous, anthropogenically conditioned: when the ecosystem is disturbed, the secondary succession becomes as a spontaneous regeneration of ecosystem.
  - successive changes, which are linked with land use changes, reduction of traditional using (grazing, cutting) and next climax succession to the forest. If conditions of habitats are changed, they became more suitable for new habitats.
- assessment of changes according to landscape ecological characteristics: changes in the number of landscape elements and their average size, position, connection, porosity, tessellation and landscape stability (Forman, Godron, 1986).

Tessellation – is given by the rate of the number of landscape elements to the size of the study area and reflects the degree of horizontal landscape division. Tessellation was calculated by two variants:

- variant No. 1: rate of the number of all landscape elements (arable field, meadows, pastures, forest, etc.) in the given year to the complex study area (or areas of single municipalities)
- variant No. 2: rate of the number of landscape elements without arable fields and area of settlements to the complex study area (or areas of single municipalities) reduced by the area of arable fields and settlements.

Matrix tessellation – is given by the rate of the number of landscape elements without arable fields to the size of landscape matrix area. Area of the settlement and arable fields were purposely excluded, in order to compare the changes of landscape tessellation in the open countryside.

Porosity – is given by the rate of number of landscape elements in the landscape matrix to area unit (ha).

Connectivity – is a measure expressed the level of the continuity of the corridor or matrix. Connection of changes of the most important ecological elements – meadows, pastures and forests was compared between two periods (years): 1958 and 2001.

Landscape stability – is expressed by the coefficient of ecological stability, which takes note of ecological significance of landscape elements (Miklós, 1986):

$$K_{ES} = \frac{p_a . k_{pn}}{P},$$

where p_a – area of landscape elements, P – area of municipality, k – coefficient of ecological significance of landscape elements (floodplain woods – 1; forest – 0.8; pastures with trees – 0.68; pastures – 0.62; semi-natural meadows – 0.62; reclaimed meadows – 0.4; narrow-strip mosaic of arable fields – 0.2; mosaic of arable field, grassland and woods – 0.4; large-block arable land – 0.1; settlement – 0).

Results

Historical evolution and land use changes

Analysing the land use changes the evolution of land use was followed in the agricultural landscape in the Veselovianka catchment from the beginning of the settlement.
The view of forming and planning of land use during the process of colonization and the impact of man on vegetation was compiled on the basis of literature concerned the study area. The colonisation of the upland in the Veselovianka catchment and village foundations began in 1558 and was realized only on the basis of Walachian colonisation. The primary land cover of the area was forest; according to the vertical segmentation there were several typological units of forest. The result of deforestation of the landscape is semi-natural meadows and pastures characterised with great species richness (Ružičková, Kubíček, 1999). The outstanding feature of the landscape from the 16th century was their high biodiversity because of the heterogeneity of forms and blanket, relief segmentation, variety of farming products. The most important interventions in the landscape started in the second half of the 20th century. Intensification of agriculture was linked with collectivisation and removing of hedges and riparian vegetation, decreasing of mosaic of arable field, grassland and woods. Small plots were changed to large fields due to joining them. After 1990 the landscape was partly retrospectively diversified by virtue of land restitution. Although the decline of traditional use of farmed land is noticeable in Slovakia, especially grazing of meadows and pastures, local inhabitants of the Orava region are strongly linked with traditional land use.

In spite of many negative interventions in the landscape in the second half of the 20th century during the period of intensification of agriculture, considerable part of the study area did not lose the shape of a cultural-historical countryside. Land-use changes of farmed land were studied in detail during the last fifty years. The object of the research was the historical and present land use, where the most interactions between man and landscape were held. The map of historical land use was elaborated on the basis of maps from 1958 and there were isolated the following landscape elements: forest, shrubs, floodplain woods, overgrown pastures (coverage of woods more than 30%), pastures (coverage of woods less than 30%), semi-natural meadows; narrow-strip mosaic of arable fields and permanent grass stands, mosaic of arable fields, grassland and woods and settlement. New categories of the present land use (2001) were: reclaimed meadows and large-block arable fields, as consequence of large-scale management of agricultural landscape.

Changes of the elements of historical and present land use

Typisation of land use changes is the outcome of the synthesis of historic (1958) and present (2001) land use (Fig. 1). Syntheses refer to landscape homogenisation. The most homogenous large areas were reclaimed meadows and extensive forests, altered by succession processes from mosaics of forests, pastures and shrubs. Two sorts of changes were identified: anthropogenic and succession. Anthropogenic changes refer 17% and succession processes almost 14% of the whole study area (Fig. 2).

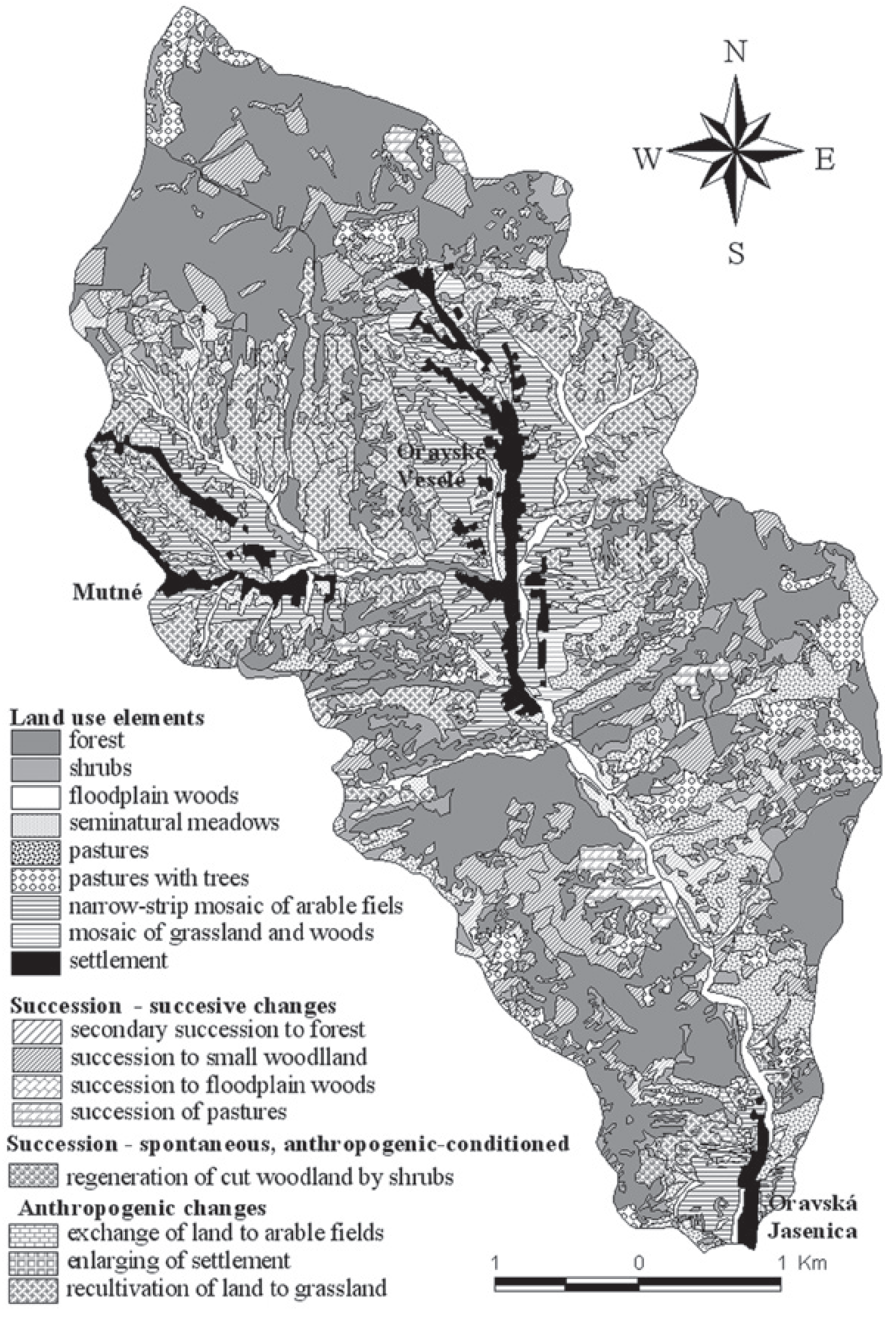

Fig. 1. Changes of historical land use to (1958) to present land use (2001).

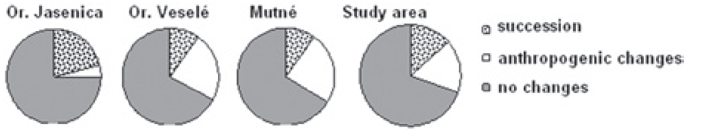

Fig. 2. Proportion of land use changes in the individual municipality.

Succession processes

When man stops to affect the area, spontaneous successive changes are activated. According to the analysis of historic and present land use, succession processes presented 13.6%, the highest proportion was in Oravská Jasenica municipality. Two types of succession processes were differentiated: spontaneous, anthropogenic-conditioned and successive changes (Table 1).

Man's disturbing activity conditioned spontaneous changes. After woodland cutting, the secondary succession with shrubs started as a spontaneous regeneration of the deforested ecosystems.

Succession changes were connected with land use changes and reduction of traditional use (grazing, cutting) and next climax succession to the forest. Leaving the outlaying grassland non-used, the area of shrubs and trees was increased and next climax succession leads to the forest.

T a b l e 1. List of succession processes of historical land use elements (1958) to present land use elements (2001).

Type of succession processes	Area		Total area	
Succession – spontaneous, anthropogenic-conditioned	(ha)	%	(ha)	%
Woodland cutting			**15.08**	**1.19**
Regeneration of cut woodland by shrubs	15.08	1.19		
Succession – successive changes				
Secondary succession to forest			**852.64**	**67.54**
Succession of shrubs to forest	446.05	35.33		
Succession of pastures with trees to forest	250.20	19.82		
Succession of pastures to forest	154.18	12.21		
Succession of meadows to forest	2.21	0.18		
Succession to small woodland			**207.38**	**16.43**
Succession of pastures with trees to small woodland	72.80	5.77		
Succession of pastures to small woodland	90.76	7.19		
Succession of meadows to small woodland	25.8	2.04		
Succession of mosaic of arable field, grassland to small woodland	18.02	1.43		
Succession to floodplain woods			**22.49**	**1.78**
Change of pastures with trees to floodplain woods	1.07	0.08		
Change of pastures to floodplain woods	13.7	1.09		
Change of meadows to floodplain woods	3.99	0.32		
Change of abandoned fields to floodplain woods	3.73	0.30		
Succession of pastures			**164.79**	**13.05**
Succession of pastures to pastures with trees	154.34	12.23		
Change of semi-natural meadows to pastures	10.45	0.83		
Total			**1262.38**	**100**

This kind of changes made up 68% of all succession processes. The second most spread process was succession of grassland and changes to small woodland (16.43%). Expansion of floodplain woods is other positive process, because this vegetation was often reduced and shaped just as narrow lines along the streams in the past. Soft increase of these changes was noticed for the period from 1958 to 2001, by exchange of surrounding meadows, pastures or arable fields.

Succession processes threaten many habitats important for nature conservation, as meadows and pastures with occurrence of many rare and endangered species, therefore it is necessary to provide suitable management, as regular use as grazing and mowing is (Špulerová, 2004).

Anthropogenic changes

The results of human interventions and activities are anthropogenic changes. Man makes decisions about land use, changes and selects crops and agricultural products etc. The highest proportion of anthropogenic changes was taken down in the Mutné municipality. Intensification of agriculture was held in the area of all three municipalities in the second half of the 20th century, which was from ecological aspect very unsuitable, because of high relief diversity (Holec, 1992). Meadows reclamation was the most significant change in the landscape (93% of all anthropogenic changes – Table 2) linked with removing of hedges, floodplain woods

T a b l e 2. List of anthropogenic changes of historical land use elements (1958) to present land use elements (2001).

Type of anthropogenic changes	Area		Total area	
	(ha)	%	(ha)	%
Reclamation of land to grassland				
Reclamation of mosaic of arable fields and meadows to pastures	51.86	3.42		
Change of forest to reclaimed meadows	8.60	0.57		
Change of shrubs to reclaimed meadows	142.44	9.40		
Reclamation of pastures with trees to reclaimed meadows	18.50	1.22		
Reclamation of pastures to reclaimed meadows	79.37	5.24		
Reclamation of semi-natural meadows to reclaimed meadows	228.19	15.07		
Reclamation of mosaic of arable fields and grassland to reclaimed meadows	898.05	59.29	**1427.01**	**94.21**
Change of land to arable fields				
Change of shrubs to mosaic of arable fields and grassland	4.38	0.29		
Change of pastures to mosaic of arable fields and grassland	9.22	0.61		
Change of semi-natural meadows to arable fields and grassland	6.22	0.41		
Change of mosaic of arable fields and grassland to large-block arable field	19.04	1.26	**38.86**	**2.57**
Enlarging of settlement				
Change of shrubs to settlement	4.17	0.28		
Change of semi-natural meadows to settlement	9.78	0.65		
Change of mosaic of arable fields and grassland to settlement	32.91	2.17		
Change of mosaic of arable fields, grassland and woods to settlement	1.95	0.13	**48.81**	**3.22**
Total			**1514.68**	**100**

and change of mosaic of arable fields and semi-natural meadows to intensively utilized meadows.

A consequence of these changes is the decline of landscape biodiversity (diversity of cultural landscape) as well as biodiversity of habitats and their fauna and flora. The largest area of reclaimed meadows is situated in Oravské Veselé municipality.

Other outcome of agricultural reclamation is large-block arable fields, which are the most threatened by erosion and considered as the least stable elements of the landscape. Ecological stability and auto-regulation was shattered in consequence of reclamation and intensification of agriculture, manifested by increased soil erosion, air pollution and water contamination (Podstavek, 1991).

Evaluation of land use changes on the basis of landscape ecological features

Land use changes between two periods (historical land use – 1958 and present land use – 2001) were evaluated on the basis of landscape ecological features, which are considered to be the indicators of landscape microstructure and affect the processes in the landscape substantial. Changes in the number of landscape elements and their average size, placing, connection, porosity, tessellation and stability of landscape were studied; unlike to summary of land use categories, e.g. changes in proportion of arable fields etc.

Characterisation of spot of land use elements – Every spot of element is specified by their boundary and characterised by type of land use element, shape, size, number of elements in the study area. Figs 3 and 4 expressed the changes in the number of elements and their size.

Graphs refer to the decrease of the number of land use elements almost for all categories, which shows the reduction of landscape diversity. The number of settlements and floodplain wood elements stayed stable, just the area of these elements slightly increased. Reclaimed meadows and large-block arable fields are new elements in present land use, which markedly changed the character of the landscape. Decrease of shrubs, semi-natural meadows and pastures was evaluated also as a negative trend of landscape evolution. Changes of average size of spots (Table 3) pointed out homogenisation of the landscape structure.

Tessellation reflects the degree of horizontal division of the landscape on the basis of spots density. The tessellation was calculated in two variants (Table 4). Comparing the changes of land use, the decrease of tessellation was recorded between two periods (1958 and 2001), mainly as a consequence of joining of landed estate and succession of non-forest habitats. The highest tessellation was achieved in the Mutné municipality (17%). Second calculation variant demonstrates, that tessellation of historical land use was by 5% higher than in present land use. Although narrow-strip mosaic of arable field segments of landscape structure, because of the map scale (1: 25 000), they were mapped as unified polygons.

Matrix tessellation was assessed for more detailed comparison. Three sorts of landscape matrix were divided in the study area: forest country (FC), grassland country (GC) and agricultural country (AC). The most considerable decrease of matrix tessellation was

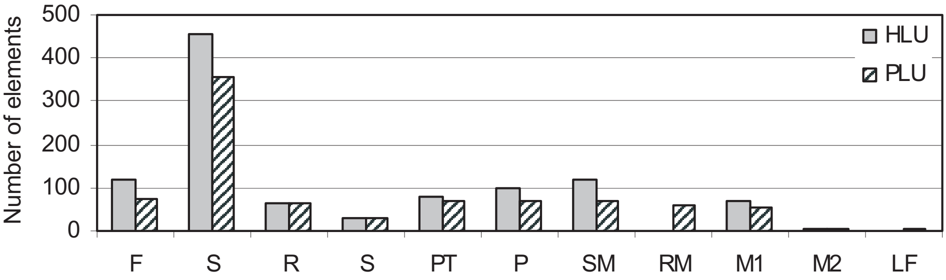

Fig. 3. Number of land use elements.

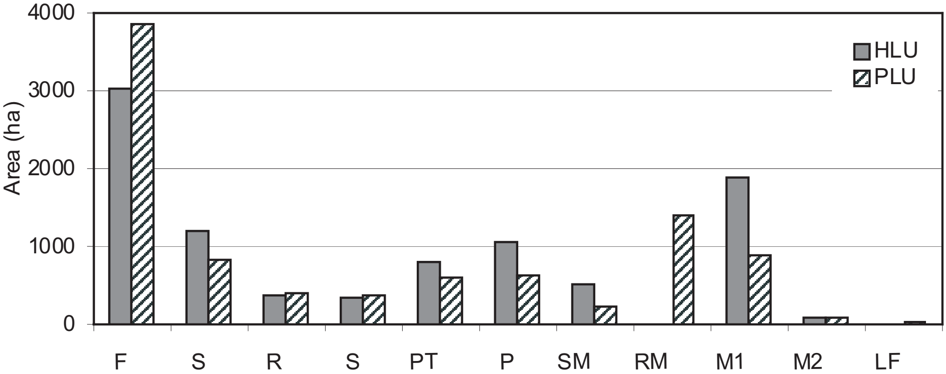

Fig. 4. Size of land use elements.

Legend: F – forest; S – shrubs; R – floodplain woods; S – settlement; PT – pastures with trees; P – pastures; SI – semi-natural meadows; RM – reclaimed meadows; M1 – narrow-strip mosaic of arable fields; M2 – mosaic of arable fields, grassland and woods; LF – large-block arable field; HLU – historical land use; PLU – present land use

taken down in the forest country as the subsequence of succession of non-forest habitats and abandoned fields or afforestation. Decrease of tessellation was expressed in Oravská Jasenica municipality, what is related to joining of landed estate.

Porosity is the structural characteristics given by the rate of landscape elements in the landscape matrix to area unit (ha). The falling tendency of porosity of forest, settlement, pastures and meadows shows Table 5. Porosity reduction is related to decrease of pastures and meadows area in consequence of succession and change of mosaic of forest and non-forest habitats to extensive forest area as well as reclamation of mosaic of grassland, arable fields and shrubs to large-block reclaimed meadows. Moderate increase was taken down in porosity of arable fields and shrubs (also floodplain woods) in Oravské Veselé and Mutné municipalities, which is linked with the decrease of the area of these elements and maintaining the number (minor decrease) of spots.

T a b l e 3. Average size of spots (ha).

	Forest	Shrubs	Floodplain woods	Pastures with trees	Pastures	Semi-natural meadows	Reclaimed meadows	Narrow-strip mosaic of arable field	Mosaic of arable field, grassland and woods	Large-block arable field	Settlement
HLU	25.53	2.61	5.64	9.9	10.48	4.23	–	27.20	12.65	–	11.47
PLU	50.54	2.29	5.90	8.48	9.10	2.98	23.05	16.90	10.22	6.35	13.21

Notes: HLU – historical land use; PLU – present land use

T a b l e 4. Tessellation and matrix tessellation in municipalities of the study area.

Characteristics		Oravská Jasenica	Oravské Veselé	Mutné	Study area
Tessellation (var. 1)	HLU	0.13	0.1	0.13	0.11
	PLU	0.08	0.08	0.09	0.09
Tessellation (var. 2)	HLU	0.13	0.14	0.17	0.14
	PLU	0.08	0.08	0.1	0.09
Matrix tessellation (HLU)	FC	0.09	0.09	0.06	0.08
	GC	0.16	0.11	0.36	0.16
	AC	0.26	0.12	0.12	0.13
Matrix tessellation (PLU)	FC	0.05	0.04	0.02	0.05
	GC	0.15	0.12	0.36	0.16
	AC	0.2	0.1	0.12	0.12

Notes: HLU – historical land use; PLU – present land use; FC – forest country; GC – grassland country; AC – agricultural country

T a b l e 5. Porosity of land use.

	Forest	Shrubs	Settlement	Pastures	Meadows	Arable fields
Oravská Jasenica						
HLU	0.052	0.408	0.137	0.087	0.225	0.094
PLU	0.013	0.292	0.088	0.084	0.152	0.071
Oravské Veselé						
HLU	0.036	0.308	0.082	0.110	0.227	0.029
PLU	0.018	0.359	0.069	0.091	0.052	0.052
Mutné						
HLU	0.032	0.332	0.069	0.181	0.267	0.48
PLU	0.014	0.336	0.064	0.179	0.101	0.071

Notes: HLU – historical land use; PLU – present land use

Connection is important functional characteristics of land use, which reflects the level of connection (steadiness) of corridor or matrix. Connection changes of the most important ecological elements – meadows, pastures, and forest, were compared between two periods (years): 1958 and 2001. Meadows in historical land use appear along the river and streams (fluvial plain) and together with the pastures formed an important biocorridor. After collectivisation, reclaimed meadows create continuous united matrix. Drained semi-natural wet meadows, many endangered and rare species were lost, and at present they constitute only isolated spots. Isolation of outlying meadows and pastures in the matrix of forest country led to succession of these habitats and the connection of woodland increased. Woodland is an important biocorridor for beasts. Narrow-strip mosaics of arable fields are connected to settlements and create joined mosaic. Floodplain woods, which were often left as woodland remnants in the cultural landscape, form a continuous network of biocorridors and are significant habitats for many animals.

Ecological landscape stability is expressed by the coefficient of ecological stability (K_{es}). Results of K_{es} are quite similar and not too differential (Table 6). The highest calculation of K_{es} was recorded in the Oravská Jasenica municipality, where forests cover 51% of the area. Positive increase of ecological stability was found out by comparison of land use changes between 2 periods, in consequence of increase of woodland and grassland. Calculation of K_{es} does not exactly express the changes in internal spatial configuration of elements in agricultural landscape and destruction of their tessellation by creating units of large-block arable fields and reclaimed meadows. To follow the course of landscape microstructure, perimeter was compared between the elements of historical and present land use. Shortening of the perimeter of all land use elements indicates the decrease of landscape diversity (Table 6).

T a b l e 6. Coefficient of ecological stability (K_{es}) and perimeter (m) of land use elements.

	Oravská Jasenica	Oravské Veselé	Mutné	Study area
K_{es} – HLU	0.69	0.56	0.54	0.60
K_{es} – PLU	0.71	0.58	0.56	0.62
Perimeter – HLU	460162.70	794032.31	287684.43	1541879.11
Perimeter – PLU	543712.51	668701.22	262067.10	1474481.31

Notes: HLU – historical land use; PLU – present land use

One of the most significant elements of diversification of land use was shrubs and hedges. While they covered 13.1% of the study area in 1958, in 2001 it was by 5% less. Concerning their spreading in the matrix, the area of shrubs has increased in the forest and grassland country, on other hand their area decreased in agricultural country.

Discussion and conclusion

Studying the land use changes, it is necessary to perceive the human impact on environment in term of history, as well as the evolution of human intellect, their working tools, materials and equipments (Dobrovodská, 2006).

The result of land use development is different and unique in every area at the level of the country or region as well as the level of habitats, as it was showed on the example of land use changes in the study area. Statistics and synthesis of maps of historical and present land use refer to increasing homogenisation of the landscape through the decrease of numbers of land use elements, increase of their size, decrease of mosaic due to uniting of landed estate and succession of non-forest habitats.

Following the land use between 2 periods, two types of changes were determined: anthropogenic, which refer 17% and succession, which refer 14% of the whole study area. The recultivation of meadows constituted the highest proportion of anthropogenic changes, linked with removing of hedges, floodplain woods and change of mosaic of arable fields and semi-natural meadows to reclaimed meadows. The consequence of intensification is the decline of landscape biodiversity, destruction of important biodiversity hotspots, microclimatic changes etc. Anthropogenic changes alter the landscape character, structure and function and on the other hand they cause other unwanted processes, as erosion, succession, floods etc. (Lipský, 2000).

By abandonment of outlaying grassland started non-used, successive succession processes. This kind of changes made up 68% of whole succession processes. Climax succession and increasing area of forest seem to be a positive process in the country. If forests are still managed by man with economic interests, conflicts in biodiversity conservation and increasing forestry emerge, because the habitats of grassland and shrubs with many protected species are threatened by succession or forestry plantation. It is useful to have knowledge about the value and richness of these habitats and this fact should be taken into account in landscape management.

Translated by the author and K. Kis-Csáji

This work was supported by Research and Development Support Agency under the contract No. APVT-51-037202 "Integrated Landscape Management".

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