

# Assessment of changes in landuse development in the Magura and the Eastern Tatras in the years 1772 - 2003

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**Abstract:** Assessment of changes in landuse development in the region of Magura and East Tatra Mts. between 1772 and 2003 was performed by remote sensing (RS) and geographic information systems (GIS), on the basis of historical maps and aerial orthophotographs. Individual landcover structures, historical development of landuse and changes in the intensity of landuse were analyzed using collected data. Quantitative indicators of landscape quality were evaluated on the basis of selected landscape characteristics such as ecological stability and human impact. Our results have shown similarities between the development of study areas with the development of four biosphere reserves in Slovakia. In mountain and piedmont areas of Slovakia, the percentage of forest cover has increased, agriculture and shepherding has declined especially in steeper and higher located slopes, which presently experience the development of secondary plant succession due to the financial unsustainability of more intensive landuse forms.

*Key words:* Landuse development, remote sensing, GIS, landscape change, historical mapping

## Introduction

In recent decades many parts of the Slovak territory have undergone extensive changes in landcover due to the increasing number of inhabitants, growing socio-economic demands of the society, industrial development and other changes related to the development of society. The reflection of these changes can be observed all the way from the piedmont to the alpine zone. Identification of land changes provides information on the historical development of the landscape and potential impact of human activity. Historical and current map data on the landscape structure can be analyzed using geographical information systems (GIS) in order to identify development of landscape changes. Our aim in this work was to map the secondary landscape structure (SLS) in four time horizons (1772, 1822, 1984, 2003) and analyze the changes and development of landuse in respect to the natural conditions. We compared our results with other regions in Slovakia and foreign countries. The representativeness of the selected areas has great

influence on the comparison outcome. Since we were concerned with protected areas, we expected to find high quality natural environment. Areas of the High Tatras, Magura, East Carpathians and Slovak Paradise partially belong to national parks but in this case also the more populated basin areas were included in the assessment, which are more influenced by human activity. For the assessment of landscape quality we used selected indicators of landscape characteristics through their quantitative representation, since we could not measure the quality of individual landscape features in the field.

## Materials and Methods

The first phase of our work was concerned with the acquisition of historical map data, which was then analyzed and processed in GIS environment. ArcView 3.3 and ArcGIS 9.2 GIS environments were used for map processing and geographical analysis of data. Maps of the 1<sup>st</sup> and 2<sup>nd</sup> military survey were provided by the State Archive/Military Archive in Vienna.

Topographic maps of 1:10,000 scale from the 1980's in raster format were provided by the Geographical and Cartographical Institute of the SR. Topographic military maps from the 1980's in 1:50,000 scale were rasterized by the Military Topographic Institute in Banská Bystrica and then georeferenced according to the S-42 coordinate system. Recent colour aerial images from 2003 were provided, orthorectified and transformed to the JTSK coordinate system of the Slovak Base Map System at 1:5,000 scale by the EUROSENSE Ltd. and GEODIS Slovakia Ltd. companies.

Historical maps from the 1<sup>st</sup> Military Survey were georeferenced in the ArcGIS 9.2 environment. Churches, road junctions, stream junctions, river beds and altitude points were used as reference points. Because of original source of error contained in these aged maps, the mean deviation was about 50m in villages and 100m at the streams. Maps from the 2<sup>nd</sup> Military Survey, which were far more accurate were processed in ArcGIS 9.2, using churches, stream junctions, lakes, bridges and roads as reference points. We reached a mean deviation of less than 30 total RMS error, which was mainly due to high elevations. At least 15 reference points were selected in each map. The exact coordinates were identified using orthophotomaps.

Topographical maps from the 1980's were georeferenced using map divisions at the scale of 1:10,000 using four corners of the map as reference points. Maximum deviation reached 3m in the mountain

areas. All map materials were digitally processed in order to obtain geographic data in the same coordinate system (S-JTSK).

Background information on the landscape, landscape structure, landcover and landscape ecology were derived from the works of Forman and Godron (1993), Ružička (2000), Ružička and Mišovičová (2006). The topics of landcover were also discussed by Feranec (1996), Feranec and Oťaheľ (2001), and Pucherová (2007).

Methods and study of secondary landscape structure - historical landscape structure have been studied by Pucherová (2007) in her methodical handbook for landscape mapping, as well as in the works of Boltížiar (2003, 2004, 2006, 2007), Petrovič (2005) and Olah (2003), who studied the secondary landscape structure in protected areas and high mountain landscape. Their work has provided us with basic information on the methods of analysis and evaluation of secondary landscape structure. As particularly important has to be considered the publication of Olah *et al.* (2006), which describes an area neighbouring to our study area and which is concerned with the development of landuse in the Biosphere reserve High Tatras. Methods of secondary landscape structure mapping have been also developed by Ružička and Ružičková (1973), Feranec (1997), Lipský *et al.* (1999). Similar landscape changes and landuse development were studied in North America by Farrow and Winograd (2001), Schmucki *et al.* (2002), Fitzsimmons (2003) and Griffith *et al.* (2003). Nagasaka and Nakamura (1999) and Nüsser (2001) have studied the same topic in Asia. In Europe, several works have been published in Norway such as Hamre *et al.* (2007), Great Britain (Swetnam 2007), Italy (Falcucci *et al.* 2007), Spain (Romero-Calcerrada and Perry 2004), Germany (Bender *et al.* 2005) and Estonia (MacDonald *et al.* 2000). During our study, we followed the geomorphological classification by Mazúr and Lukniš (1972). Geology and geomorphology was derived from the geological map of Spišská Magura and Poprad basin, Hornad basin from the map of Levočské vrchy (1:50,000) and from the legend to the geological map of Spišská Magura (Janočko 2000). Data on the historical development were derived from the work of Beňko (1972) and Podoliak (1972). Historical development of Zamagurie region was studied by Griger (1988). Development of settlement and historical development in the Tatra piedmont areas was studied by Bohuš (1972, 1994) and Roth (2000). Background information about the development of agriculture and industries in the Spiš region was taken from the work of Némcová (1977) and the history of mines and smelters were studied by Bohuš (1963).

#### Mapping units

According to Pucherová (2007), mapping and evaluation of the SLS is performed as:

Classification of landscape features, or categories of landscape features in the selected area.

The legend used for the analogous interpretation of the SLS was based on the methodology of LANDEP (Landscape Ecological Planning) by Ružička (2000), CORINE Land Cover (Feranec and Oťaheľ 2001), Secondary Landscape Structure (Handbook of map-

ping methods; Pucherová 2007). The total number of features reflecting landscape development were reduced to 14. Original 11 features: alpine meadows, dwarf pine, forest, scrub, non-forest tree and bush vegetation, permanent grasslands, fields, urban areas, water surfaces, denuded substrate, screes as defined by Oláh *et al.* (2006) were supplemented by 3 features - water streams, agriculture and industry and traffic features. This classification is more detailed and provides better representation of contemporary landuse.

#### Identification of individual components of secondary landscape structure

Analogue (visual) recognition was used for the identification of individual landscape features on the orthophotographs. The identification of individual landuse forms was based on the monograph of Prikryl (1977), analyzing the development of cartographic visualization of the Slovak territory in the past and present. We also based our work on the results and experience of Žigrai (1995), Oláh (2006), Petrovič (2005) and Boltížiar (2004, 2006), Pucherová (2007), CORINE Land cover (Feranec and Oťaheľ 2001).

#### Assessment of ecological stability and anthropic impact on the landscape

The coefficient of ecological stability  $Kes_2$ , defined by Miklós (1986) was used for the assessment of ecological stability of the studied area.

$$Kes_2 = (\sum p_i k_i) / p$$

( $p_i$  - surface of *i*-form of land use,  $k_i$  - weight coefficient of the *i*-form,  $p$  - total surface area).

Human impact on the landscape was evaluated using the coefficient of landscape human impact  $Kao$  proposed by Kupková (2001).

$$Kao = V / N$$

( $V$  - areas with higher intensity of use,  $N$  - areas with lower intensity of use).

#### Changes in the intensity of landuse

Changes in the intensity of landuse were evaluated according to the methodology by Oláh *et al.* (2006), where the individual forms of landuse were aggregated and classified by coefficient on the scale of 1-5. The relative intensity of landuse change was calculated according to the following formula:

$$I_R = i_1 + i_2 + \dots + i_n$$

( $I_R$  - relative intensity of landuse change,  $i_1$  - partial intensity of change between the 1. and 2. time horizon). Absolute intensity of the landuse change is calculated as the sum of absolute values of partial intensity of landuse change.  $I_A = \sum \text{abs } i_1; i_2; \dots; i_n$ .

#### Study area

The studied area (Fig. 1) is situated in the north of central Slovakia, in the Prešov region (counties Poprad, Kežmarok, Stará Ľubovňa). The largest part of the area belongs to the region of Spišská Magura, part of the area reaches into the eastern part of Podtatranský basin, northwestern part of Levočské Mountains, High and Belaer Tatra. The highest point of the area is Gerlachovský peak with

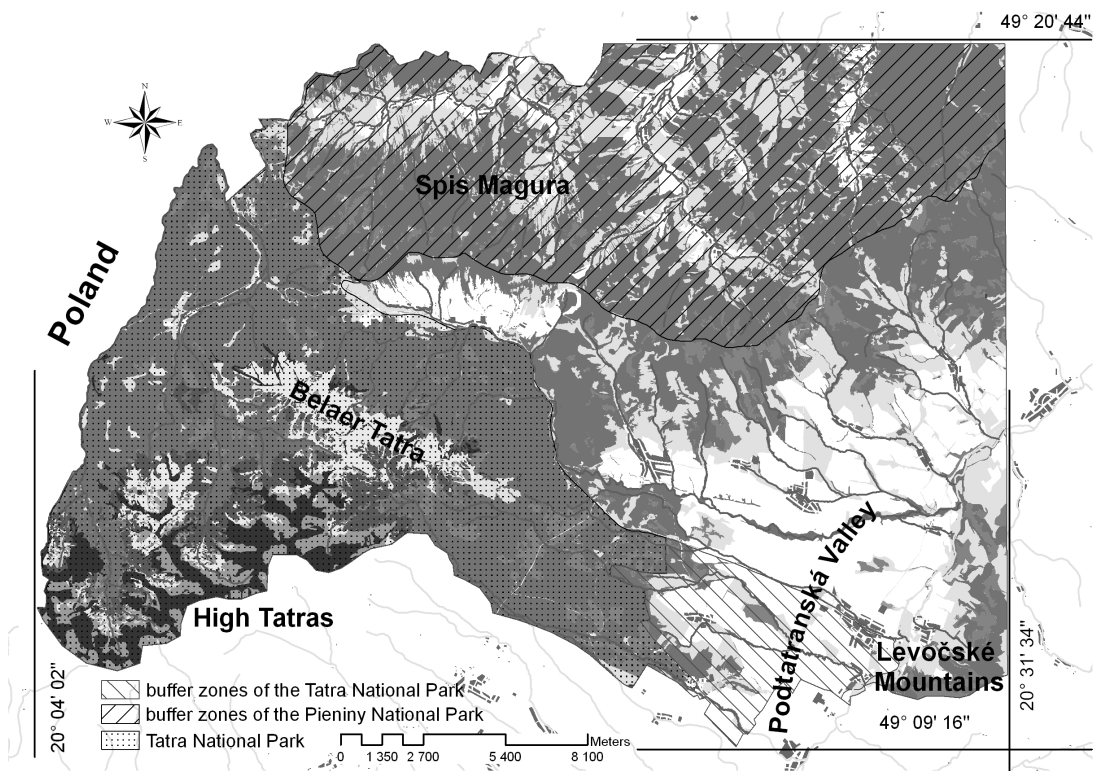


Fig. 1. Study area.

2,655m a.s.l. and the lowest point is the Lesniansky creek in the village Haligovce at 530m. The mean altitude reaches 1,315m a.s.l. The studied area extends over 55,433 ha. 69% of the area belong to the buffer zones of the Tatra National Park and Pieniny National Park.

## Results

### *Landuse development between 1772-2003*

#### *Colonization of the area*

The studied area was colonized between the 13<sup>th</sup> to 18<sup>th</sup> and 19<sup>th</sup> Century. The colonization of this area was based on the German right and was part of the so called Šoltýs colonization. Thanks to the help of German settlers, several villages in the Northeast and East of the area were established: Mlynica, Toporec, Výborná, Lendak, Spišská Stará Ves, Hanušovce, Matiašovce, Rešov, Veľká Lesná, Haligovce, Veľká Franková a Veľký Lipník. Villages established by settlement colonization: Osturňa, Malá Franková, Jezersko, Hágy, Zálesie located in the Magura region. The last group comprises villages that were detached from the large estates, such as Havka and Matiašovský potok, the latter presently forming a part of the village Matiašovce.

Colonization and establishment of Ždiar - in the 16<sup>th</sup> Century first seasonal sheep folds were founded on the slashed and burnt clearings. They aggregated into the village of Ždiar during the 17<sup>th</sup> Century. In 1759 the proceeding colonization allowed the establishment and formation of the village Javorina (Table 1).

	Surface area [ha]			
Alpine meadows	1,712.89	1,714.07	1,712.42	1,718.50
Scrubs	898.21	947.6	2,072.59	3,676.05
Non-forest tree and bush vegetation	896.86	576.48	1,264.27	1,320.85
Fields	1,5646.3	19,682.81	7,353.83	7,815.72
Agriculture and industries	1.40	1.89	117.73	126.92
Traffic features		122.60	244.34	240.03
Permanent grasslands	8,435.43	6,083.32	12,018.39	8,649.31
Urban areas	242.45	515.95	723.73	931.21
Water bodies	32.91	40.66	47.20	45.72
Water streams	244.37	221.49	208.00	209.01

Table 1. Ratio of individual landuse forms in the studied area in different time horizons.

### 1772

The most sub-tatran villages lived of grazing sheep on piedmont pastures, as well as seasonal grazing on the cleared mountain grasslands. For several centuries, raising sheep, goats and cattle was the main and essential occupation of the local population.

In 1772 41% of the area (22,781 ha) was covered with forests. More than a quarter of the area (28%) was covered with fields, mainly located in the Southeast and North of the area around the villages Osturňa, Malá and Veľká Franková. The most inaccessible steep slopes were used for cattle grazing. Southeastern part of the area was the most populated with the highest number of villages. In 1772 there

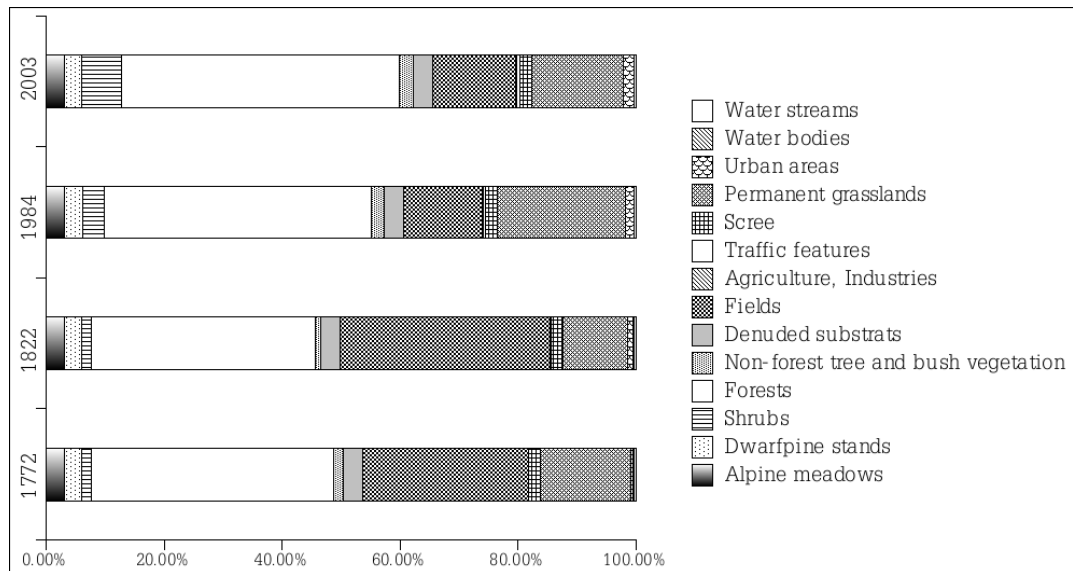


Fig 2. Development of Land use between 1772 - 2003.

were 20 piedmont settlements covering 0.44% of the area. The largest settlement was Spišská Belá, which already possessed town rights by then. Surroundings of the settlements were characterized by fields lined on the periphery with permanent grasslands, covering a total area of 84,288.966 ha. Scrubs were identified between Lendak, Rakúsy and close to Vojňany, covering 1.62% of the surface area. The occurrence of these landscape features can be attributed to a more intensive human-induced or natural deforestation. The third most common feature was permanent grasslands, covering 15.23% of the total area (Fig. 2, Table 2).

### 1882

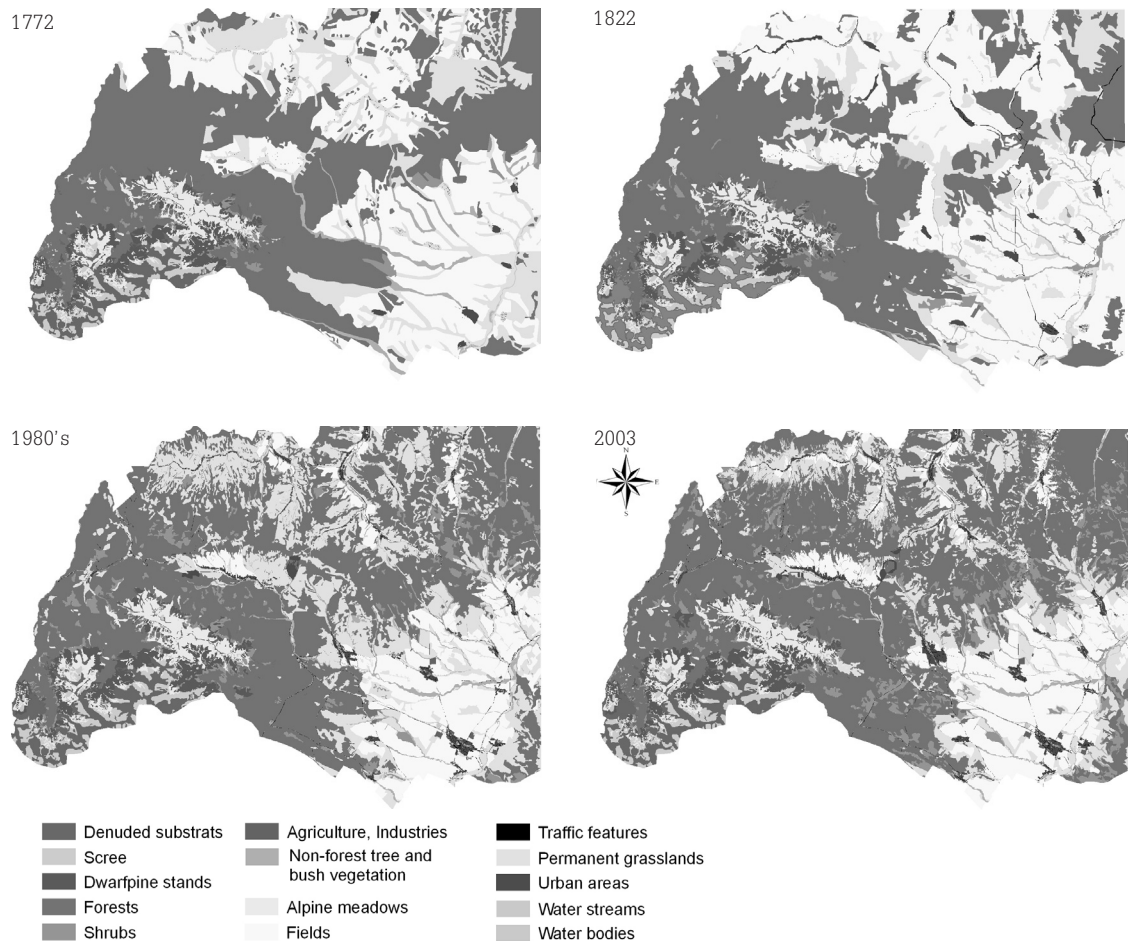
The expansion of road system at the expense of forests, fields and permanent grasslands found in the historical maps can be seen in the cross table of changes between 1772 – 1822 (Appendix 1).

In this period several food companies started to operate such as the liquor factory in Spišská Belá (1875), potato starch and sugar factory (1878) and tobacco factory. The expanse of forests decreased by 3% (1792 ha). Nevertheless forests remained the dominant landuse feature covering 37.89% of the total area. The surface area of fields grew by 10% from 1772, expanding by 3,982 ha. This expansion was reflected in diminishing area of permanent grasslands. The map of landuse (Fig. 3) and the cross table (Table 3) show clearly the expansion of fields in the vicinity of rivers, leading to the reduction of permanent grasslands. Permanent grasslands shifted to higher altitudes at the expense of forests. In this period we can observe an expansion of urban areas by 100% which most probably has led to the expansion of fields around the urban areas and shift of the permanent grasslands towards the originally forested areas.

	Surface area [ha]			
	1772	1822	1984	2003
Alpine meadows	1,712.885	1,714.071	1,712.418	1,718.497
Dwarfpine stands	1,598.117	1,594.064	1,711.451	1,664.92
Scrubs	898.211	947.6	2,072.592	3,676.051
Forests	22,781.632	20,989.913	25,006.318	2,6071.758
Non-forest tree and bush vegetation	896.86	576.478	1,264.272	1,320.849
Denuded substrats	1,791.468	1,791.468	1,796.314	1,798.332
Fields	1,5646.3	19,682.808	7,353.832	7,815.723
Agriculture and industries	1.396	1.885	117.726	126.918
Traffic features		122.601	244.344	240.027
Scree	1,121.586	1,121.568	1,126.296	1,135.549
Permanent grasslands	8,435.433	6,083.321	12,018.391	8,649.309
Urban areas	242.451	515.948	723.727	931.213
Water bodies	32.908	40.66	47.2	45.719
Water streams	244.366	221.486	208.991	209.007

Table 2. Cross table of land use change between 1772 - 1822.





**Fig. 3.** Map of land use change in the east section of High Tatras and Magura.

### 1984

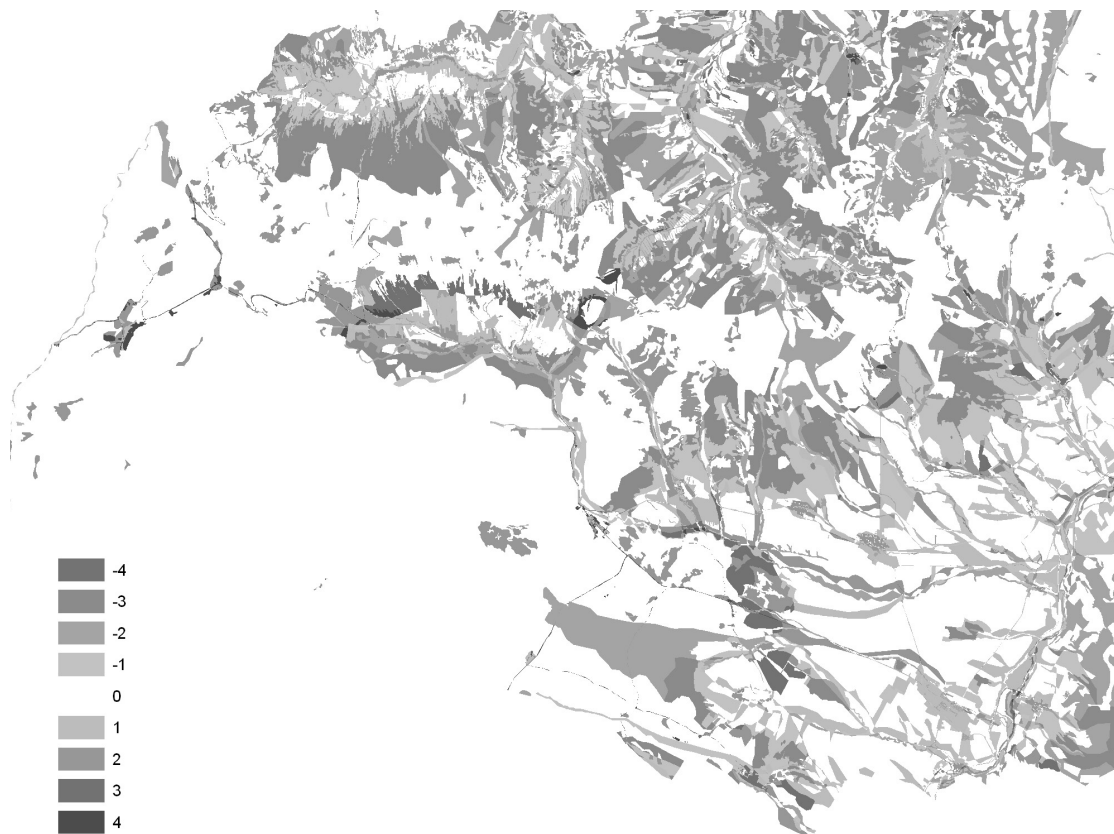
In this time horizon we can observe the emergence of new settlements. In the middle of the 19<sup>th</sup> Century, forestry station and later a saw mill was built, leading to the formation of the village Podspády. The town of Spišská Belá constructed a summer tourist facility on its grounds as a starting point for the Belianske Tatra Mts. and the Belianska Cave. The new settlement was called Tatranská Kotlina (1882). In 1884 Matej Loisch founded the village Tatranské Matliare, constructing a hunting chalet and later a hotel.

In 1984 the largest surface area was covered with forests, reaching 25,006 ha (45% of the total area), 4,790 ha of fields changed into forests (Appendix 2). Minor increase of permanent grasslands to 21% with a total cover of 12,018 ha could be observed. The comparison of the maps from 1822 and 1984 shows a massive change of fields into permanent grasslands and a change of grasslands into forests. Among other causes this was influenced by the collectivization of agriculture, transformation of crop production to sheep farming in this area and change of less suitable steeper fields into permanent grasslands. The development of landcover in this period was also influenced by the implementation of nature protection and founding of the Tatra National Park (18 December 1948) and Pieniny National Park (16 January 1967). 1,172 ha increase of scrubs was to certain extent caused by the improved accuracy of mapping procedure. Scrubs are most frequently

observed as disturbed forest growths. By then the policy was to increase the surface area of forests, therefore we can put forward the hypothesis that the expansion of scrubs solely at the expense of forests could be caused by periodic repetition of windthrows. During this period we can observe a minor spread of traffic features caused by railway construction. The surface area of the main roads also grew, as the paved roads in the urban parts of the villages were built. This has also induced growth of agriculture and industries by 0.21%, extending over the area of 117 ha. The railway construction has promoted the development of food and wood processing industries in Spišská Belá. Urban area expanded to 723 ha due to the growth of the tourist industry, urban development, population growth and general development of towns and villages almost to the extent known today.

### 2003

In 2003 the largest part of the landscape was covered by forests (47%; 26,072 ha). We observed a decrease of permanent grasslands. As can be seen in the (Appendix 3) permanent grasslands declined with the growth of forests. Fields, non-forest tree and bush vegetation have not undergone any significant changes from 1984. Urban surface area kept growing and covered 1.68% of the total area in 2003. We observed the development of a whole group of urban and recreational facilities. The surface area of urban landscape grew mainly at the expense of arable land.



**Fig. 4.** Relative intensity of land use changes.

A growth of almost 3% (1,662 ha) in surface area was observed in scrubs. We could observe a growth of scrubs in relation with windthrows, which destroyed forest stands northwestern of Ždiar and forest stands of Spišská Magura, which were located in the middle of the studied area. The decrease in surface area of the road system was caused by a more accurate vectorization of the roads, otherwise road system followed a trend of expansion.

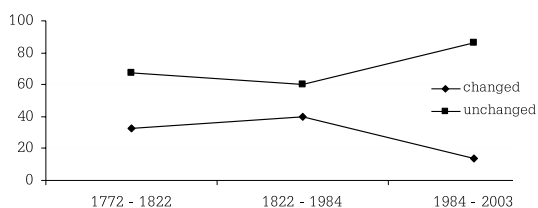
*Absolute and relative intensity of landscape change*

The total relative intensity of land use change (Fig. 4) was expressed as the sum of partial changes. If the result was positive, the intensity of use increased (intensification) and if negative, the intensity of use decreased (extensification). The absolute intensity (Fig. 5) of change is expressed as the sum of changes, which have occurred at a given location without considering the direction of change (intensification or extensification). The absolute intensity of change is the sum of absolute values of partial (relative) changes between the studied time horizons (Olah *et al.* 2006).

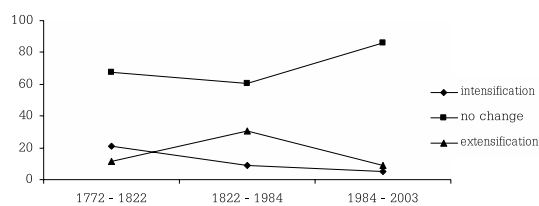
The ratio of areas with zero partial intensity of landscape change (Fig. 6) reached from 67.6% to 85.9%. This indicates that the total ratio of changed areas did not reach over 40% in any time horizon. The greatest intensity of change occurred between 1822 and 1984. The smallest intensity of change occurred since 1980's to present time.

The measures of extensification (Fig. 7) and intensification are almost equal only in 2003. Greater extensification due to the decline of agriculture can be observed. Closer image of the development of landscape use can be seen in Fig. 3, which shows the expansion of agricultural structures until 1882 and the following decline of agriculture after 1984. This trend can be seen in the map of absolute intensity of landscape changes (Fig. 5).

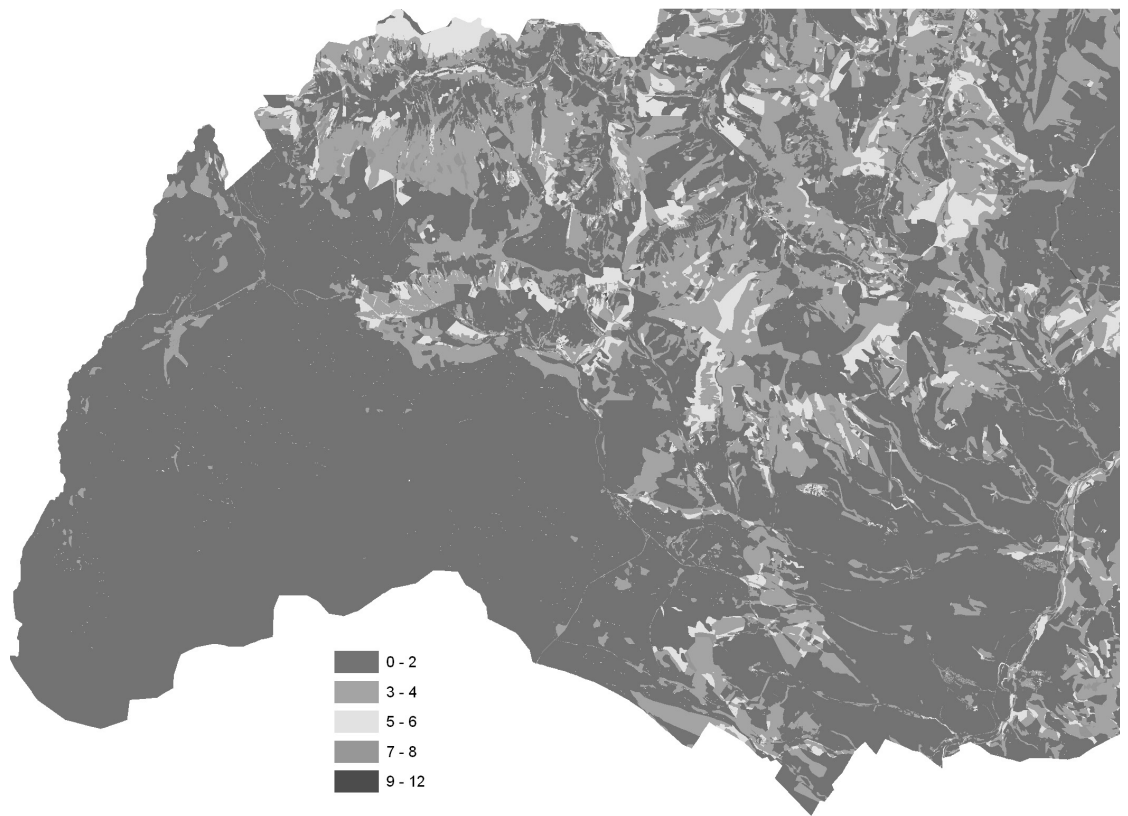
In 1822 the greatest human impact (Fig. 8) on the landscape can be seen due to deforestation, expansion of the existing villages and emergence of new settlements. In the same period we can observe the lowest coefficient of ecological stability of the landscape. This testifies marked



**Fig 6.** Ratio of changed and unchanged parts of the landscape.



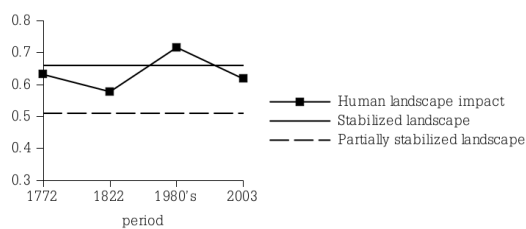
**Fig 7.** Percentage of land use intensification and extensification.



**Fig 5.** Absolute intensity of land use changes.



**Fig. 8.** Degree of human landscape impact.



**Fig. 9.** Degree of ecological stability.

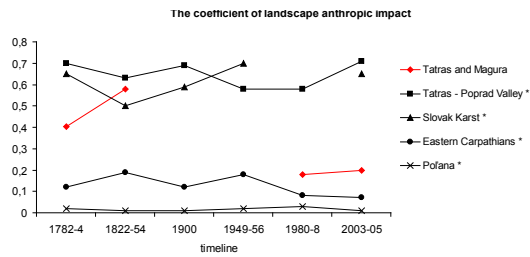
human impact on the landscape. Among other causes, the founding of the TANAP (1949) could influence the increase of ecological stability and decrease of human impact on the landscape in the 1980's and the development of agricultural machinery which has led to the decline of traditional agricultural methods. Steeper and higher located fields were not cultivated anymore. The last period is characterized by a decline of ecological stability (Fig. 9) associated with changes of socio-economic conditions. The demands of the society have become superior to the protection of nature and landscape.

## Discussion

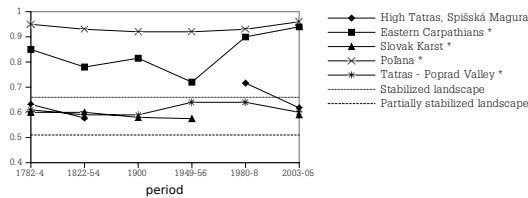
In order to achieve cross-comparison of different areas within Slovakia, information from several works about the development of Slovak UNESCO Biosphere reserves (Olah *et al.* 2006) were used. Several different areas with different geological composition, natural conditions and socio-economic characteristics were compared. We compared the coefficients of ecological stability and human impact (Fig. 10-11) of the respective areas. Coefficients calculated using the same method allow the comparison of landuse development in several ecologically significant areas of Slovakia. Coefficient of ecological stability is increasing and human impact is decreasing with the proportion of forest stands against the more intensively used land features. Increase in proportion of arable fields and urban areas leads to the deterioration of ecological stability (Olah *et al.* 2006).

The areas with the lowest density of inhabitants in Polana and East Carpathians display the highest ecological stability (Fig. 11). Human impact coefficient fluctuates in the range between 0.1-0.2, indicating an ecologically highly stable natural landscape (Fig. 10). In the Polana area, the intensive forms of landuse are located beyond the borders of the protected areas. The area is covered mainly with forest stands with patches of grasslands, which presently undergo natural succession because a more intensive form of landuse is not profitable. The development of landscape in the East Carpathians was influenced by their marginal position (located along the state border) with a number of closed valleys, which has led to the formation of smaller settlements with





**Fig. 10.** Comparison of human landscape impact (HLI) in selected areas of Slovakia (Olah *et al.* 2006).



**Fig. 11.** Comparison of ecological stability of selected areas in Slovakia (Olah *et al.* 2006).

predominantly agricultural-horticultural landuse. One of the important factors was associated with the relocation of seven villages and the consequent secondary succession. Slovak Karst can be generally described as largely stabilized landscape. This area is characterized by a fertile basin bottom, xerothermic southern slopes of the plain Horný vrch and ruderalized forest soils due to past deforestation and grazing. The greatest changes can be seen in the fertile basin bottom, where wetlands and grasslands have been changed to ponds and fields. The landscape of the southern side of the Tatras and Poprad basin was by several authors described as being characterized by stabilized agricultural landuse in the basin, associated with the growth of settlements (especially of the towns Poprad, Kežmarok and Svit) and at higher elevations by largely unchanged high mountain landscape. The most altered zone could be found in the piedmont area at the transition from the basin to the high mountain landscape, where especially in the 20<sup>th</sup> Century wide emergence and growth of settlements has taken place.

The eastern part of High Tatras and Magura is characterized by great elevation differences (530-2,656m a.s.l.) and diverse geological structure. High Tatras are mainly composed of granitoids (granodiorites and tonalites) Belianske Tatra Mountains with limestones, dolomites, quartzites, sandstones, radiolarites and marls. The Magura Region is composed mainly of schists which change into sandstones in Levočské Mountains and Tatra basin. The natural and socio-economic conditions and specific distribution of settlements have greatly influenced the development and current shape of the landscape. Areas at higher elevations (Magura, Belianske Tatra Mountains, Zadné Meďodoly) were in the past influenced by sheep grazing.

The greatest intensity of landscape changes was recorded between 1772 and 1822. In this time period we can see the greatest oscillation of human impact (Fig. 11) which results in later settlement of the area in comparison to other observed areas. These changes were associated with wide-ranging deforestation of the landscape.

Similarly to other areas, there was a decline of traditional agricultural techniques during 1980's and abandonment of areas which were not profitable for agricultural landuse.

The most significant changes, similar to the southern slopes of the Tatras could be seen on the transition from the basin to the high mountain areas. The region of eastern Tatra Mountains and Magura could be characterized as ecologically stabilized landscape. The bottom parts of valleys and basins were more influenced by agricultural activity.

The human impact coefficient was in the 1980's and in 2003 very similar to the HIC of Poľana and East Carpathians (Fig. 10). This similarity was not so apparent in ecological stability. This is mainly caused by higher proportion of permanent grasslands in the region. Since 1980's we have observed increased human activity associated with the development of tourist industry in the High Tatras.

Between 1772 and 2003 we have observed an increase in relative forest cover from 41% to 47%, along with a decrease of field surface area by 14%. Slight increase in the surface of urban areas could be seen. The greatest changes could be seen especially in steep remote areas that are very labor demanding for agricultural use. This trend was caused by changes in agricultural techniques and gradual decrease of grasslands and pastures from 1980's to present.

The agricultural use of less profitable areas was abandoned. Shepherd grazing that was once typical for this region was completely abandoned. Areas with heterogenous landscape mosaic of fields, grasslands and pastures are subjected to secondary succession today. Great changes in landcover were induced by periodic windthrow events in the regions of High Tatras and Spišská Magura.

Different authors prefer various methods of data processing and evaluation (Tasser *et al.* 2009), therefore it's not feasible to make a direct comparison of data from different studies. Differences between procedures complicate or impair the possibilities for comparison of development in different places in the world. This is caused by differences in the source data, different types of indicators and indices for landscape assessment. The choice of map and map unit size, as well as other processing methods depend upon the study aim. Most works are concerned with urban agricultural land. Slovak authors studying the landscape, mapping of historical changes and analysis of landuse changes (Feranec 1998, 1997, Feranec *et al.* 2005; Ružička 2000; Feranec and Oťaheľ 2001; Boltížiar 2003, 2004, 2006; Petrovič 2005; Cebecauerova and Cebecauer 2005; Oláh *et al.* 2006; Pucherová 2007; Mišovičová 2008; Maniak and Oláh 2008) use similar methods of mapping analysis and assessment of landscape-ecological indicators. Their methods are characteristic for the so called Slovak and Central European Landscape Ecology School. Other authors around the world have used different map sources including aerial photographs and orthophotographs (Nagasaki and Nakamura 1999, Schmucki *et al.* 2002) and topographic maps (Fitzsimmons 2003, Palang *et al.* 1998) or Landcover maps (Griffith *et al.* 2003, Swetnam 2007). However, similarities can be found in the interpretation of these studies. The development of landscape in the studied area has experienced significant changes, which are reflected both in ecological stability and biodiversity of the landscape.



Similar trends can be seen in other parts of Slovakia and Europe. Changes in the system of agriculture, political and socio-economic situation are reflected in landscape changes. Presently, the greatest changes occur because of the ongoing extensification of agriculture. Traditional agricultural techniques are declining and the surface area of pastures is decreasing in the whole of Europe. Many farmers quit using traditional agricultural practices and agricultural production is concentrating at lower elevated areas. MacDonald *et al.* (2000) compared the works of 24 authors, concerned with agriculture of mountain parts of Europe and concluded that the abandonment of agricultural land and of traditional farming practices is continuing to occur in the mountain areas of Europe. While the socio-economic driving forces are ubiquitous, the environmental impacts are spatially diverse. However, environmental indicators are not well developed for biodiversity and landscape change, nor are interpretations of change always unambiguously positive or negative.

In Italy, the history of landuse in Italy was studied by Faluccci *et al.* (2007). The land was classified into macro-regions: Alps, Italy and Sicily. The macro-region of the Alps has experienced a 3% decrease of agricultural land, grasslands by 6% and increase of forests by 18%. These changes have occurred in the time horizon between 1600-2000. The Alps and Apennines have experienced a significant increase in forest cover due to the abandonment of agricultural land and pastures. However, the abandonment of soils leads to the decline in biodiversity and depending on elevation, the diversity of landscape features changes. In contrast to this, the lowland seaside regions of Sardinia and Sicily experience an increase in surface area of agricultural land. The human presence and increase in tourist activities leads to a rapid deterioration of shepherding, which used to be a strong tradition in this region.

In Norway, Hamre *et al.* (2007) recorded a change from 30,9% in 1865 to 0,6% in 2002. At the latter date, pastures were the dominant type of landcover with a total cover of 36%. Abandoned land (23.8%) was the second most dominant type of landcover. Abandoned land was mainly present in the most remote parts of the country. From 61.2 % of grasslands in 1865 remained only 36.0%. Similar changes have been recorded also in other parts of west Norway (Lundberg *et al.* 1996).

In Estonia, the relative forest cover has tripled between 1986 and 1988 (14% to 42%), whereas the percentage of agricultural land decreased from 65% to 30% (Palang *et al.* 1998).

In Uper Franconia in 1850 (Bavaria, Germany), a rather densely populated part of the country, the landscape was almost exclusively covered by agricultural land. Forests only covered 18% of the total surface area. Pastures and abandoned land covering approximately 9% of the area were used for grazing. During the first half of the 20<sup>th</sup> Century, the forest cover increased markedly and agricultural landscape decreased to less than 50%. Pastures which were typical for this region almost disappeared during this period (Bender *et al.* 2005).

Similarly to other mountain regions in Europe the traditional mosaic landscape structures are disappearing from the region of High Tatras and Spišská Magura. This leads to the decrease of biodiversity. The increase in forest cover has not been reflected in

a great improvement of ecological stability. Tourist industry replaces traditional agricultural practices and the development of tourism and urban structures exerts great pressure on the landscape. Both public and political incentives will be needed to preserve valuable landscape structures.

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	1822														
	Alpine meadows	Dwarfpine stands	Scrub	Forests	Non-forest tree and bush vegetation	Denuded substrats	Fields	Agriculture, Industries	Traffic features	Scree	Permanent grasslands	Urban areas	Water bodies	Water streams	sum
1772	1,712.742	0.143	0	0	0	0	0	0	0	0	0	0	0	0	1,712.885
	1,128	1,591.413	0.984	0	0	0	0	0	0	0	0	0	4.628	0	1,598.117
	0	2,527	560.148	100.534	10.196	0	117.254	0	1.336	0	106.216	0	0	0	898.211
	0	0	122.126	17,298.494	77.062	0	2,653.542	0.222	40.957	0	2,579.208	9.414	0	0.607	22,781.632
	0	0	9.112	155.554	1.686	0	577.16	0.389	3.672	0	140.273	5.072	0	3.942	896.86
	0	0	0	0	0	1,791.461	0	0	0	0.017	0	0	0	0	1,791.468
	0.201	0	60.951	1,588.901	364.288	0	11,487.523	0.698	37.948	0	1,895.118	182.215	0	8.457	15,646.3
	0	0	0	0.05	0.027	0	0.958	0.145	0	0	0.116	0.096	0	0.004	1.396
	0	0	0	0	0	0	0	0	0.259	0	0	0	0	0	0.259
	0	0	0	0	0	0.017	0	0	0	1,121.539	0	0	0	0	1,121.586
	0	0	183.384	1,830.745	117.246	0	4,704.866	0.335	35.634	0	1,324.043	210.873	3.124	25.183	8,435.433
	0	0	0	2,639	2.663	0	106.152	0.096	2.795	0	20.077	108.079	0	0	242.451
	0	0	0	0	0	0	0	0	0	0	0	0	32.908	0	32.908
	0	0	10.895	2.996	1.1383	0	25.353	0	0	0	18.27	0.249	0	0	183.293
	1,714.071	1,594.064	947.620	20,989.913	576.478	1,791.468	19,682.808	1.885	122.601	1,121.588	6,083.321	515.948	40.66	221.486	244.366

	1984														
	Alpine meadows	Dwarf pine stands	Scrub	Forests	Non-forest tree and bush vegetation	Denuded substrats	Fields	Agriculture, Industries	Traffic features	Scree	Permanent grasslands	Urban areas	Water bodies	Water streams	sum
1822	1,669,742	1,048	17,899	24,175	0	0,416	0	0	0,001	0,57	0,201	0	0,019	0	1,714,071
	1,111	1,582,639	0,21	9,469	0	0,273	0	0	0	0,346	0,003	0	0,013	0	1,594,064
	0,679	57,260	427,043	136,470	61,468	0,039	63,599	0,233	1,697	0,01	194,64	0,317	0,001	4,154	947,600
	36,592	69,951	1,056,461	16,881,241	208,590	4,979	139,381	2,927	54,15	0,004	2,503,392	31,394	0,357	0,494	20,989,913
	0	0	7,465	79,831	1206,351	0	188,319	4,132	6,876	0	165,549	16,423	0	152	576,478
	0,425	0,252	0,136	0,093	0	1,789,963	0	0	0	0,597	0	0	0,003	0	1,791,468
	0	0	334,161	4,790,482	600,448	0	6,167,466	92,32	108,762	0	7,217,424	351,975	7,848	11,922	19,662,808
	0	0	0,018	0,001	0,447	0	0,429	0,146	0,06	0	0,578	0,206	0	0	1,865
	0	0	1,605	35,041	12,802	0	21,865	1,053	8,635	0	29,967	11,234	0	0,379	122,601
	0,498	0,276	0,007	0,009	0	0,641	0	0	0	1,120,116	0	0	0,021	0	1,121,568
	3,361	0,006	227,528	3,041,339	192,486	0	704,432	10,826	31,35	0	1,764,509	94,751	5,574	7,159	6,083,321
	0	0	0,069	6,525	70,070	0	55,889	6,069	31,662	0	128,327	217,317	0	0	515,948
	0,010	0,019	0	1,449	0	0,003	0	0	0	4,653	1,162	0	33,364	0	40,660
	0	0	0	0,193	11,598	0	12,452	0	1,151	0	12,619	0,11	0	183,363	221,486
	1,712,418	1,711,451	2,072,592	25,006,318	1,264,272	1,796,314	7,353,832	117,726	244,344	1,126,296	12,018,391	723,727	47,200	208,991	



	2003														
1984	Alpine meadows	Dwarfpine stands	Scrubs	Forests	Non-forest tree and bush	Denuded substrats	Fields	Agriculture, Industries	Traffic features	Scree	Permanent grasslands	Urban areas	Water bodies	Water streams	sum
	1,669.743	1,107	0.127	36,558	0	0.423	0	0	0	0.502	3,948	0	0.01	0	1,712.418
	1,052	1,582.639	56,996	69,951	0	0.253	0	0	0	0.273	0.269	0.001	0.017	0	1,711.451
	17,898	0.206	693.609	1,251.57	4,655	1.021	5,964	0.004	0.138	0.087	97.374	0.064	0.002	0	2,072.592
	24,174	80,328	2,374.268	21,591.622	20,076	1,828	21,485	2,300	0,826	2,535	862,218	24,672	0.251	0.005	25,006.318
	0	0	3,032	52,98	1,166.070	0	7,645	1,098	1,714	0.462	13,294	17,894	0.002	0.081	1,264.272
	0.418	0.275	0.037	4,828	0	1,790.110	0	0	0	0.641	0.003	0	0.002	0	1,796.314
	0	0	25,044	61,937	121	0	6,187.757	3,894	2,803	0.004	977,064	83,302	0	0.017	7,353.832
	0	0	0.498	1,144	0.026	0	0.023	112.032	0.036	0.004	3,947	0.016	0	0	117.726
	0	0	0.193	1,705	2,006	0	1,836	1,457	224,298	0.003	10,801	2,022	0	0.023	244,344
	5,191	0.348	0.01	0.004	0	0.591	0	0	0	1,120.126	0	0	0.026	0	1,126.296
	0	0.003	522,234	2,982,931	114,549	1,527	1,574,215	5,979	6,547	10,890	6,636,409	163,038	0.048	0.021	12,018.391
	0	0	0.002	15,098	1,351	2,576	16,788	0.424	3,661	0	43,624	640,202	0	0.001	723,727
	0.021	0.014	0.001	1,43	0.004	0.003	0	0	0.001	0.022	0.343	0	45.361	0	47,200
	0	0	0	0	0.102	0	0.01	0	0.003	0	0.015	0.002	0	208.859	208,991
sum	1,718,497	1,664,920	3,676,051	2,6071,758	1,320,849	1,798,332	7,815,723	126,918	240,027	1,135,549	8,649,309	931,213	45,719	-	209,007