

Land-use changes in the selected part of the Tatry biosphere reserve in 1772–2003

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Introduction and theory

The landscape, as an open system created by the synergy of both natural and anthropogenic factors, is the leading subject of the landscape ecology research in the last decades. However, this phenomenon proves a constant development, subjected to changes and therefore, we can specify its latent state only with difficulties. According to Feranec et al. (1997), Chrastina (2005, 2009) Pucherová (2004, 2008) Petrovič (2005), Šolcová (2009), Michaeli, Ivanová, Juhaščíková (2009): Mišovičová (2007, 2008) and the others, the analysis of changes in the landscape is significantly important for the evaluation of natural and socio-economic processes (their dynamics, causes and stability of the current situation), but especially it is necessary for the prediction of the possible trends of further development.

People have always looked for the best places (the best conditions) to meet their needs within the landscape. It was divided according to special characteristics to suitable areas, less suitable areas and areas unsuitable for certain activities. At first, they started to utilize the most suitable places, later used even the less suitable (a demand for the land, new management, etc.). Looking to the past, it is typical to find cyclically alternating periods of a high anthropogenic pressure on the landscape (when even less suitable sites are used) and periods with more or less major downturn (abandoning of less suitable sites) in the same place. Particularly, in the area with such a diverse relief as the territory studied, it is possible to assume a strong link between the land use and the man-made relief. Another phenomenon of the investigated area is the outbreak and expansion of the recreational land use (especially in the recent decades), hence the studied territory has a very high, even an outstanding potential for tourism (Midriak, 2003).

The aim of this article was to identify the land use development in the selected part of the Tatry Biosphere Reserve (BR) in the years 1772–2003; to determine the intensity of its changes, and to analyze the relationship between the areas with a different intensity of changes in the land use and the basic morphometric characteristics of relief.

The investigated territory of the Tatry BR represents a rectangle of 32.5 x 15.1 km (Fig. 1) with an area of 49,000 ha, which is situated on the transition between the Popradská kotlina basin and the High Tatras Mts. The altitude range lies between 600–2,655 metres above the sea level.

Methodology

The methodological procedure consisted of the following steps:

1. The identification of land use in the different time horizons using historical and temporal military maps (from the years 1772, 1822, 1900, 1956 and 1988) in the scale of 1:25,000 – 28,800 (more in: Olah, 2003) and aerial orthophotographs from the years 1949, 1990 and 2003 (more in: Boltížiar, 2005) in the GIS environment.

Considering the diversity of categories (forms) of land use, identified on the underlying maps and aerial photographs in the given time horizons, some forms of land use have been merged and the following categories created: forests (managed forests, special designation forests and protection forest – L), transitional shrublands (LK), non-forest tree and shrubbery vegetation (bank vegetation and shaws – NSKV) permanent grasslands (meadows and pastures – TTP), permanent crops (orchards – HM), fields (large and small arable land), urban areas (settlements, houses with gardens, industrial sites, landfills, roads, traffic areas – UP), water (VP), wetlands (ZP), excavated subsoils (rock walls and cliffs, areas of mining and quarrying, construction areas – OP), rubble (rubble covered slopes – S), alpine meadows (AL), scrub (K).

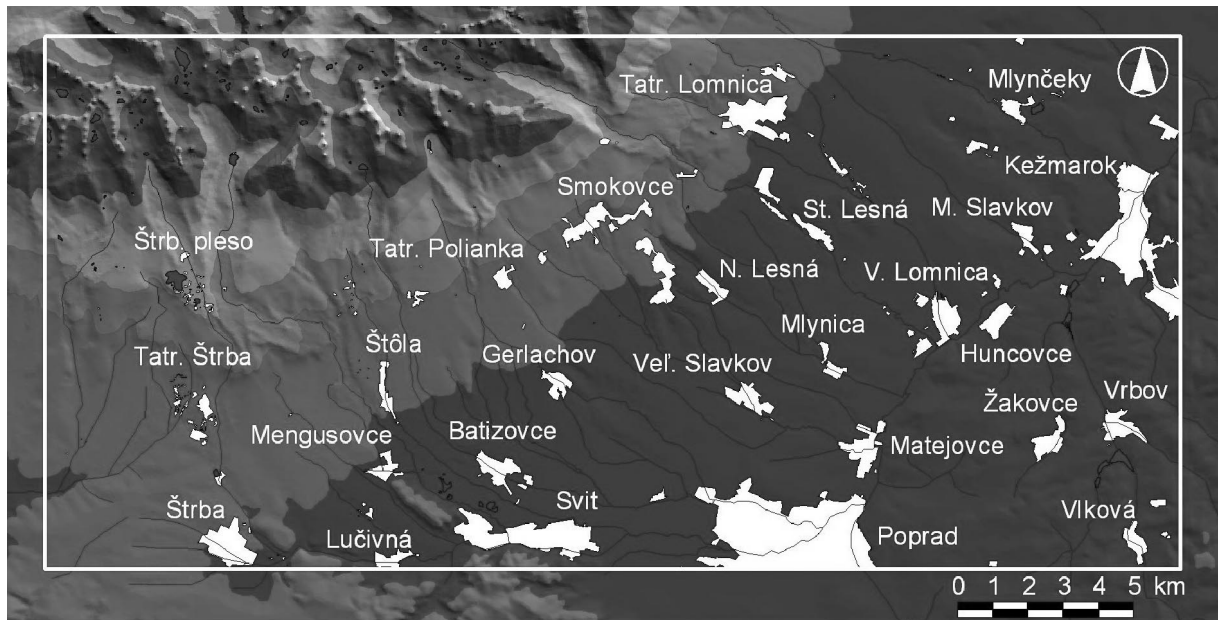


Fig. 1. The investigated territory of the Tatry BR

Changes of land use were identified by the superposition of layers of the investigated time horizons. We have identified these areas:

- **without a change of use** (the most stable areas with the regard to land use)
- **with a land use change in each time horizon** with or without a repetition of land use forms (the least stable areas)

Changes in the forms of land use were evaluated using the superposition of data. Most of the current forms of land use acquired by the interpretation of the aerial photographs were verified directly by the field mapping.

2. The intensity of land use changes (relative and absolute) was calculated as the arithmetic difference of land use intensity coefficients for individual forms: **1** forests, **2** transitional shrublands, non-forest tree and shrubbery vegetation, wetlands, **3** permanent grasslands (meadows and pastures), **4** fields and permanent crops (orchards and vineyards), **5** urbanized areas, excavated subsoils as a result of mining or construction (more in: Olah, Boltžiar, Petrovič, Gallay, 2006).

The total **relative intensity** of land use changes was expressed as the sum of partial changes. If the resulting number was positive, the intensity increased (the intensification of land use), if negative, the intensity was reduced (the extensification of land use).

The **absolute intensity** of land use changes reflects the sum of changes, which took place in the examined area, regardless to its direction (intensification or extensification). It represents the sum of absolute values of the partial (relative) changes between the individual time horizons.

The socio-economic development process of the investigated territory was elaborated mostly by using available literary sources. The population development was

prepared on the basis of data acquired from the Statistical Office of the Slovak Republic and further information from the municipalities.

Results

Although the studied territory had been settled already in the Pleistocene, the process of creating a cultural landscape began only in the Holocene. According to the plants pollen findings, it can be concluded that synanthropical vegetation started to expand during the Subboreal period. This fact indicates the presence of an agricultural landscape in the Popradská kotlina basin in the Neolithic age. Anthropogenic erosion also influenced the landscape at that time.

The natural landscape of the mountains was disturbed by mining of different ores in the Middle Ages. The wood consumption of mining industry had been satisfied from the local forests, which were significantly affected by wood cutting. Further negative changes in the landscape structure were caused by lowering of the upper forest boundary and by scrub burning for the acquisition of new areas to expand grazing activities (Plesník, 1971).

Since the late 20th century a new wave of the human impact on the landscape started in the Tatras Mts., intensified especially from the 60s to 80s in the form of tourism. The expansion of man into the mountains is nowadays accompanied by the waste pollution, a destruction of vegetation and soil, a retreat of indigenous plants and animal species, the expansion of synanthropic processes and so on. (Drdoš, 1990).

Land use in the year 1772

In the year 1772 (Fig. 2) almost 40% of the investigated territory was used as fields, which represented an area of

nearly 20 thousand ha. One third of this territory (33.7%) was covered by continuous forests with an area of 16,746 ha. Larger areas of permanent grasslands covering approximately 3,500 ha were located mainly along the river Poprad, in the southwestern and in the eastern part near Kežmarok. Non-forest tree and shrubbery vegetation represented only 1.1% of the total studied area in the year 1772. Transitional shrublands were located north from Batizovce and Gerlachov in the present region of Tatranská Polianka. This form of land use was identified in the western part of the territory as well. The consequence of its occurrence might have been also more extensive deforestation due to either anthropogenic or natural causes. Transitional shrublands covered only 2.6% of the area. According to historical maps, 43 residential units were classified in the year 1772, with mostly traditional characteristics of the High Tatras villages. The largest established settlement, documented by the data from census in the year 1787, was Kežmarok (Kaysmark) with 4,170 inhabitants. Nevertheless, settlements covered only up to 1.3% of the area.

Land use in the year 1822

According to maps of land use from this year, a rapid increase in the percentage of permanent grassland is visible in the territory covering over 10,200 hectares (Fig. 3), which represented more than 20% of the investigated area. Enlarged areas of this category are found primarily in the northeastern and southwestern parts of the territory. An increase in the area of permanent grasslands had been conducted mostly at the expense of forests, its share was decreased by 9.7%. This comprises a decline of more than 4,700 ha of forests. Deforestation in such a scale took place due to the expansion of pasturin-

shepherding in the High Tatras Mts., which existed here since the 13th century (Pigeon-Pacewiczova, 1931). The biggest boom of mountain shepherding was experienced in the 18th and 19th century (Boltžiar, 2007). According to sporadic statistical data, the grazing culminated in the year 1815. Mostly, the settlements of Spišská Belá and Kežmarok together with Rakúsy (Midriak, 1983) participated on the grazing of these pastures. We have to point out the enlarged areas of permanent grasslands in the territory of (nowadays) Smokovec, Tatranská Lomnica and Tatranské Matliare, which previously belonged to the grazing areas. The settlements covered over 1% of the total area. For the first time we observed a creation of the new settlement (Starý Smokovec) in a large forest territory, associated with the boom of iron ore mining (Olah, Boltžiar, Gally, Oláhová, Petrovič, 2005).

Land use in the year 1900

Fields represent the category of land use covering the greatest area in the year 1900 (Fig. 4), with the size of over 18 thousand ha (37.4%). A small increase occurred in the area of forest land use, we can compare the year 1822 with the increase about 2.8% to almost 14 thousand hectares in the year 1900. This was achieved by reforestation of the extensive areas of permanent grasslands. Larger forest complexes in agricultural landscape were created east from Batizovce and Gerlachov (Olah, Boltžiar, Galai, Oláhová, Petrovič, 2005). The reforestation of permanent grasslands meant a decrease in the size of TTP in nearly 4,000 ha. An area of settlements increased in the year 1900 to a value of 2.6%, which is twice the value of the formerly mentioned year. The area occupied by the settlements was 1,258 ha. Smaller scattered settlements

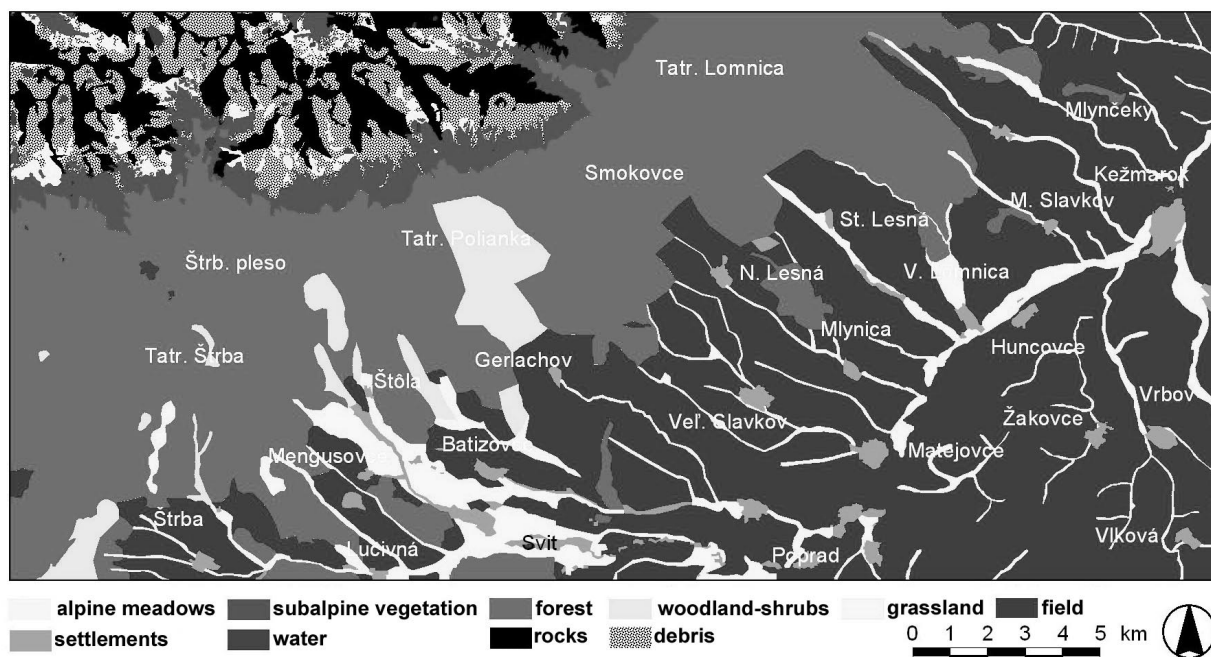


Fig. 2. Land use of the investigated territory of the Tatra BR in 1772

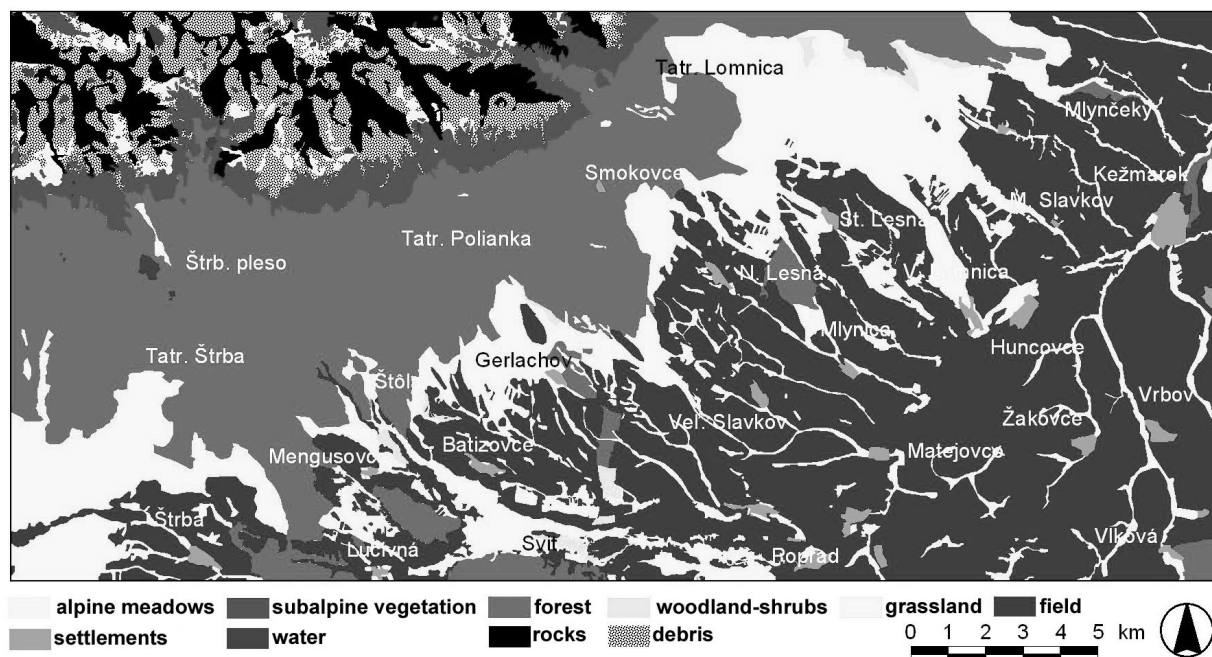


Fig. 3. Land use of the investigated territory of the Tatry BR in 1822

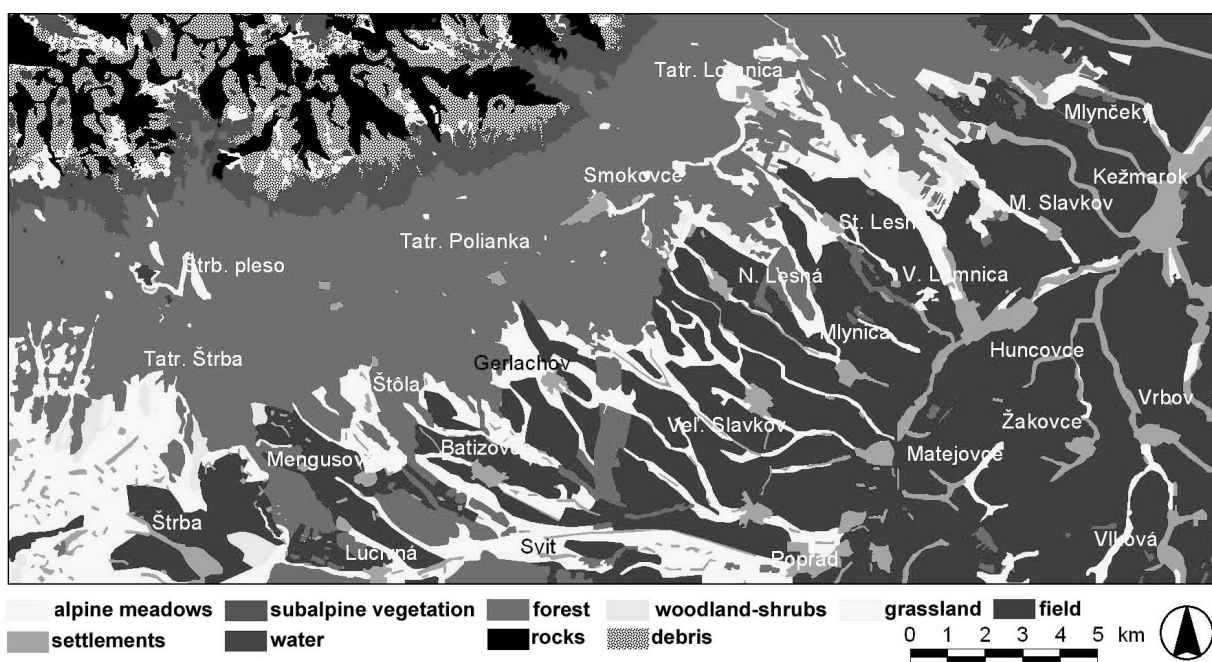


Fig. 4. Land use of the investigated territory of the Tatry BR in 1900

were situated northwest from Štrba in the examined area, these can be considered for sheepfolds and shepherds settlements. Kežmarok remained the largest settlement. The settlements like Tatranská Lomnica, Smokovce and Polianka emerged in mostly uninterrupted forest complexes.

Land use in the year 1956

The most interesting changes in land use in the investigated territory include a decline of permanent grasslands

area. In the year 1956 (Fig. 5) permanent grasslands covered 4,460 ha (9.1%). The share of non-forest tree and shrubbery vegetation had been partially raised to 3.4% of the total area. However, a gradual reforestation of TTP had occurred due to the decrease in the intensity of their management. The decline was brought about by the industrialization of the Popradská kotlina basin. The end of shepherds in the western part of this territory is dated from the year 1895, when the prince of Hohenlohe bought the shooting-ground in Vyšné Hágy (Vološčuk, 1994). In spite of this, grazing continued in some parts of the Tatras

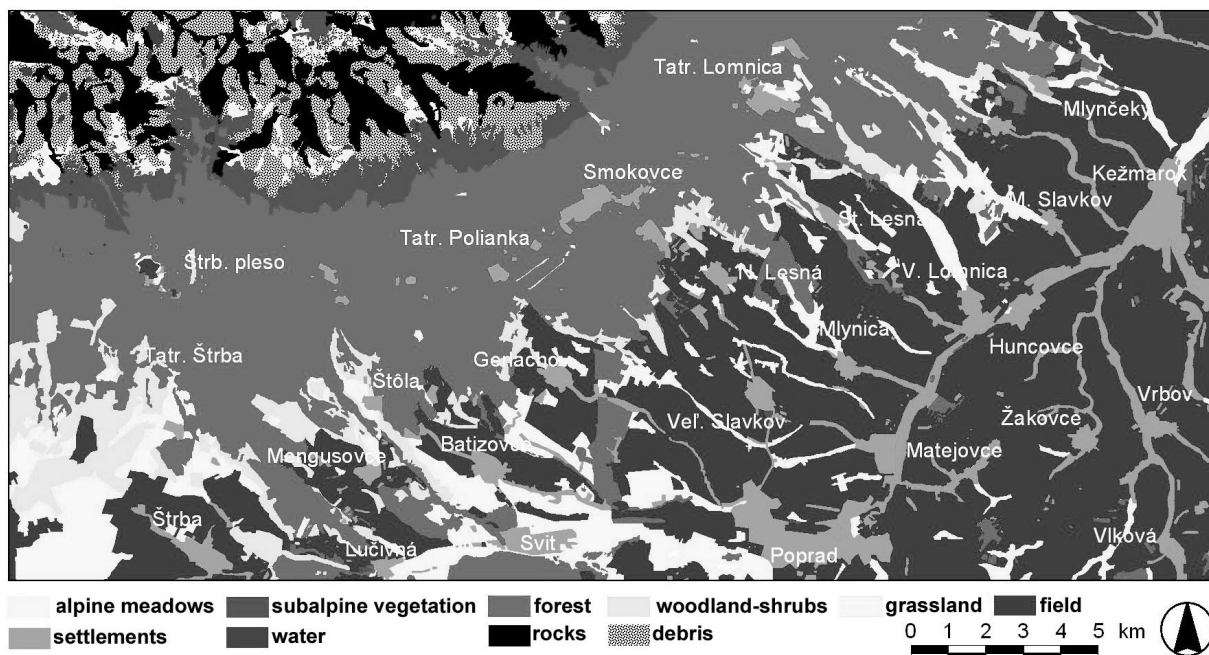


Fig. 5. Land use of the investigated territory of the Tatra BR in 1956

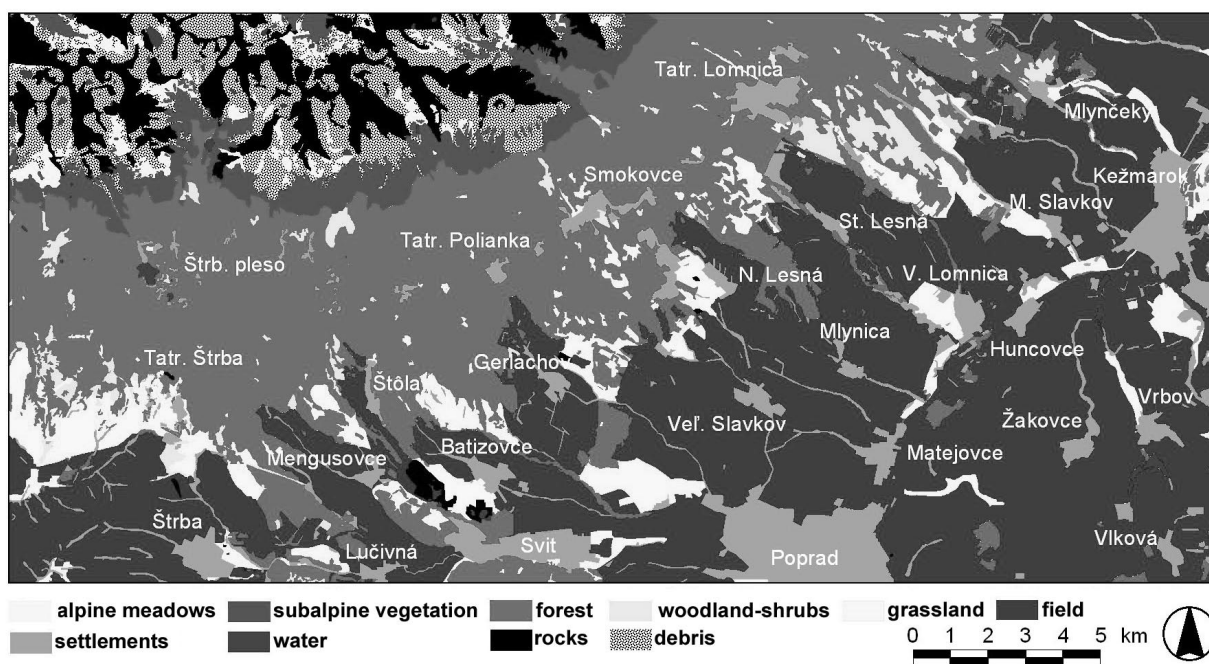


Fig. 6. Land use of the investigated territory of the Tatra BR in 1988

even after the announcement of the Tatra National Park in 1948. Many municipalities have arbitrarily continued sending their herds to grass illegally. The expansion of shepherds really culminated in the year 1954 that represented the last period of grazing. In the investigated area, sheepfolds were located northwest of Štrba, near Štola and Batizovce until the year 1952, whereas sheepfolds in the northeastern part disappeared in the year 1952. According to the map of land use from the year 1956, a scene of fire was recorded on the southern slope of the Slavkovský Peak dated from the year 1928, sacrificing

at least 60 ha of scrub vegetation and a part of the upper forest boundary (Boltižiar, 2004). This fire was not totally uncommon, because similar natural events worth mentioning occurred also over the Jamské lakes in the year 1921, leaving approximately 150 ha burned down. Moreover, a big fire in Vyšné Hágy caused by visitors of the Tatra national park was documented in the year 1953, when 100 ha of young forest was damaged (Midriak, 1998).

From a demographic perspective, a continuous expansion of settlements occurred in the High Tatras, followed

by the subsequent increase of 2,036 ha (4.2%) covering the settled. Population of Starý Smokovec was consequently raised up to more than 3,000 inhabitants and Tatranská Lomnica increased to more than 1,900 inhabitants in the year 1956. A large expansion took place in Poprad, which together with the municipality Velká achieved a population of almost 10,000. The town of Svit expanded as well. There were no significant modifications in the land use of fields (33%) and forests (30.6%).

Land use in the year 1988

Fields have become the category of land use with the largest representation (Fig. 6). Their share jumped to 37.6% that covers an area over almost 18 thousand ha. Fields formed a relatively homogenous part of the landscape around Žakovce, Vrbov, Štrba and Poprad. Forests were the second largest form of land use covering 30% of the area. The area of non-forest tree and shrubbery vegetation has decreased to 2%, what was caused by the changes of utilisation and gradual reforestation. The trend of settlements increase continued also in the year 1988, when they represented more than 6% of the total area examined. Poprad became the largest settlement and the center of this area too, with a population of 29,375 inhabitants in the year 1982. Increased urbanization due to the building of therapeutical spa and recreational settlements emerged especially in this period (Midriak, 1998). It is visible from the maps of land use around Štrbské Pleso, Smokovce and Tatranská Lomnica. A larger area of transitional shrublands was identified near the Euro-camp FICC on the map from the year 1988. Their total area was over 900 ha. The occurrence of this form can be attributed to the recent wind calamities. Two major

should be happened there. A whirlwind with a speed of nearly 180 km.h⁻¹ occurred on the 22nd and the 23rd of October 1971, exaggerated from Vyšné Hágy to Kežmarské Žlaby (94 thousand m³ of timber fell for the victim). Moreover, a calamite caused by wind speeds from 120 to 165 km.h⁻¹ took place in Tatranská Lomnica on the 2nd and the 3rd of November 1981, damaging 295 thousand m³ of timber. The increase of water surface area of approximately 52 ha is a result of the small water reservoirs construction. Concretely, three of them are situated near Vrbov municipality and two near the former state property located southwest from Kežmarok.

Land use in the year 2003

In the year 2003, fields represented the largest category in terms of land use (almost 17 thousand ha), covering more than a third of the investigated territory (Fig. 7). Forests still maintained a large area with over 14 thousand ha and the total share of 30%. The permanent grasslands occurred mainly in the contact area between forests and fields and their size increased to 4,341.5 ha, similarly to the category of transitional shrublands. Further development of the settlements was reflected in a further increase of their size to 3,436.3 ha. Areas above the upper forest boundary were used like in the last two time horizons because of the fact that this territory is a part of the national park and is used only for recreational purposes.

Land use changes in the years 1772–1822

The transformation matrix of forms of land use between the years 1772 and 1822 is documented by the

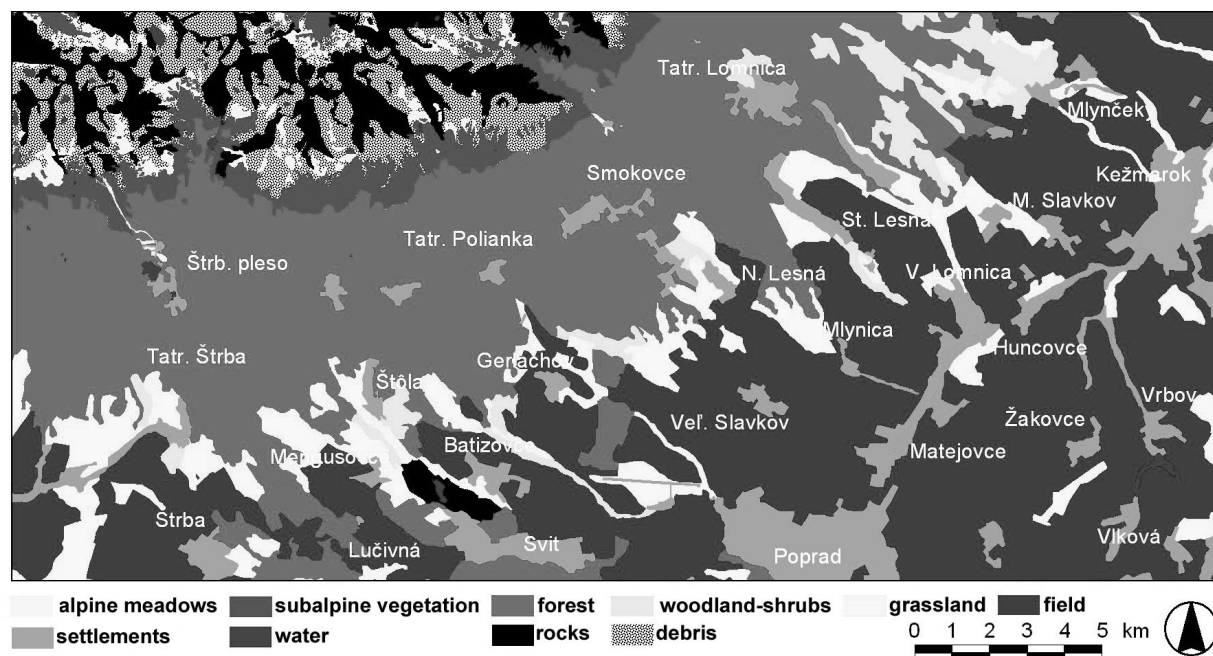


Fig. 7. Land use of the investigated territory of the Tatra BR in 2003

table 1. Changes in land use are apparent at first sight. The area of permanent grasslands increased until the year 1822, in comparison to the year 1772, by nearly 7,400 ha. TTP had been started to be used mostly at the expense of forests, because deforestation caused the transformation of 5,122 ha of forests into permanent grasslands. TTP had increased its size rather dramatically, and by the conversion of fields to this form of utilization, the original area of fields had been diminished by 2,801 ha. New fields had been excluded from areas originally used as permanent grasslands and forests. Around the year 1822, significant area of forest suffered a decrease of more than 4700 ha compared to the year 1772. Transitional shrublands occurring north from Gerlachov and Batizovce in the year 1772, had slowly created coherent forests and were partially converted to permanent grasslands depicting the dominant form of land use in the 1st half of the 19th century.

Land use changes in the years 1822–1900

The table 2 shows the change of land use between the years 1822 and 1900. As the share of TTP increased in the previous time horizon, there was a significant de-

crease in the area of permanent grasslands of more than 4,000 ha at the end of the 19th century. Some areas of TTP (1,453 ha) were gradually reforested and converted into forest plantation. On the one hand, a partial area of permanent grasslands was transformed into fields, on the other hand, some portion of fields had been changed to TTP too. Consequently, the total area of fields fell by more than 2,000 ha, mainly due to conversion into forests, permanent grasslands and NSKV. The area of NSKV reached a value of 1,482 ha by the year 1900 because of the transformation of fields and the gradual overgrowing of unused TTP. Settlements, respectively built-up areas, had more than doubled size at the expense of fields (421 ha), grasslands (257 ha) and forests (96.4 ha), as a result of the origin of the High Tatras settlements: Tatranská Lomnica, Tatranská Polianka and Smokovce in the forest complex.

Land use changes in the years 1900–1956

The table 3 depicts the change of land use between the years 1900 and 1956. The category of TTP retained its downward trend, because its size was reduced by more than 1,830 ha, caused by non-utilization of these

Table 1. The transformation matrix of land use changes in the investigated area of the Tatro BR between the years 1772–1822 (without Alpine meadows, scrubs, excavated subsoils and rubbles)

| In | Ha 1772 | | | | | | | |
|-----------------|---------|--------|---------------------|-------------------------|---------|--------------------|-----------------|---------|
| | forests | LK | woodland/ shrubs | permanent grasslands | fields | urbanized areas | water bodies | sum |
| 1822 | | | | | | | | |
| Forests | 10768,7 | 821,8 | 19,1 | 224,1 | 589,9 | 5,9 | | 12429,8 |
| Woodland-shrubs | 104,3 | 6,2 | 32,6 | 36,7 | 58,7 | 0,7 | | 239,2 |
| Grasslands | 5121,5 | 418,2 | 161,1 | 1680,8 | 2801,1 | 69,9 | | 10252,6 |
| Fields | 737,1 | 135,5 | 114,8 | 1456,1 | 15544,1 | 238,6 | | 18226,1 |
| Urbanized areas | 5,7 | | 3,2 | 46,2 | 150,2 | 339,9 | | 545,1 |
| Water bodies | 8,4 | | | | | | 97,5 | 105,8 |
| Sum | 16745,6 | 1381,7 | 330,7 | 3444,0 | 19144,0 | 655,6 | 97,5 | 49000,1 |
| % | 34,2 | 2,8 | 0,7 | 7,0 | 39,1 | 1,3 | 0,2 | |

Table 2. The transformation matrix of land use changes in the investigated territory of the Tatro BR between the years 1822–1900

| In | Ha 1822 | | | | | | |
|-----------------|----------------|---------------------|-------------------------|----------------|--------------------|-----------------|---------|
| | forests | woodland/ shrubs | permanent grasslands | fields | urbanized areas | water bodies | sum |
| 1900 | | | | | | | |
| Forests | 10996,2 | 167,2 | 1453,2 | 1177,4 | 4,3 | 9,3 | 13807,6 |
| Woodland/shrubs | 137,1 | | 306,7 | 100,7 | | | 544,5 |
| Trees/bushes | 42,7 | 0,3 | 646,3 | 789,9 | 3,0 | | 1482,2 |
| Grasslands | 714,8 | 41,8 | 3859,5 | 1656,6 | 15,2 | 2,9 | 6290,9 |
| Fields | 438,1 | 29,8 | 3730,0 | 14080,5 | 39,9 | | 18318,2 |
| Urbanized areas | 96,4 | | 257,0 | 421,0 | 482,8 | 0,3 | 1258,2 |
| Water bodies | 4,5 | | | | | 93,3 | 97,9 |
| Sum | 12429,8 | 239,2 | 10252,6 | 18226,1 | 545,1 | 105,8 | 49000,1 |
| % | 25,4 | 0,5 | 20,9 | 37,2 | 1,1 | 0,2 | |

areas and their subsequent over-growing. A considerable part of the TTP was gradually changed by such a process into NSKV (283.7 ha) and forest plantations (38.9 ha). A part of fields had been converted into TTP, however, TTP had vice versa been gradually converted to fields; and these gained an area close to 1,400 ha at the expense of permanent grasslands. In this time horizon, built-up area continued to increase its size especially at the expense of the fields (579.7 ha) and TTP (287.8 ha). Forest areas did not overcome a major change, but new and larger findings of forests emerged in the areas of former permanent grasslands and fields. Non-forest tree and shrubbery vegetation covered more than 1,600 ha in the year 1956.

Land use changes in the years 1956–1988

The table 4 deals with the changes of land use in the period between the years 1956 to 1988. Fields became the dominant form of land use over the period of 1988, increasing their area by 2,240.6 ha since 1956. The categories of NSKV (965.9 ha) and permanent grasslands

(2,463 ha) have suffered mostly by their conversion to fields. This process is associated with the intensification of agricultural activities in the territory. Nevertheless, there was a partial increase in the share of TTP to the value of 3,434 ha in the year 1988 at the expense of forests and fields, but mainly due to the re-conversion of NSKV into permanent grasslands. During the years 1956–1988, the size of settlements increased by more than 1,000 ha. Built-up area covered 700.1 ha of fields, 242.7 ha of forests, and 291.2 ha of grasslands. Moreover, the incidence of transitional shrublands was recorded with a total area of 687 ha, including the largest part located near Tatranská Lomnica.

Land use changes in the years 1988–2003

Changes of land use in the period of the years 1956 to 1988 are documented by the table 5. The size of forests category is identical in both time horizons. However, its change had a qualitative-spatial character. An area of transitional shrublands was increased by 1% due to overgrowing of fields and grasslands. Deforestation caused

Table 3. The transformation matrix of land use changes in the investigated territory of the Tatry BR between the years 1900–1956

| In | Ha 1900 | | | | | | | |
|-----------------|----------------|---------------------|------------------|-------------------------|----------------|--------------------|-----------------|---------|
| | forests | woodland/ shrubs | trees/ bushes | permanent grasslands | fields | urbanized areas | water bodies | sum |
| 1956 | | | | | | | | |
| Forests | 11828,5 | 130,2 | 38,9 | 937,2 | 1975,8 | 47,0 | 7,3 | 14977,5 |
| Woodland/shrubs | 559,1 | 200,1 | 73,7 | 1028,5 | 455,7 | 27,7 | | 2344,8 |
| Trees/bushes | 56,6 | 2,1 | 426,1 | 283,7 | 854,0 | 52,6 | | 1675,1 |
| Grasslands | 421,3 | 133,2 | 279,0 | 2205,6 | 1392,8 | 27,6 | | 4459,5 |
| Fields | 769,6 | 78,2 | 596,7 | 1522,1 | 13050,5 | 161,8 | | 16178,9 |
| Urbanized areas | 159,7 | 0,7 | 67,8 | 287,8 | 579,7 | 937,5 | 2,3 | 2035,7 |
| Water bodies | 10,5 | | | 3,0 | 0,2 | 0,5 | 77,9 | 112,6 |
| Wetlands | 1,5 | | | 18,2 | 4,9 | | | 24,5 |
| Sum | 13807,6 | 544,5 | 1482,2 | 6290,9 | 18318,2 | 1258,2 | 97,9 | 49000,1 |
| % | 28,2 | 1,1 | 3,0 | 12,8 | 37,4 | 2,6 | 0,2 | |

Table 4. The transformation matrix of land use changes in the investigated territory of the Tatry BR between the years 1956–1988

| In | Ha 1956 | | | | | | | | |
|-----------------|----------------|---------------------|------------------|-------------------------|----------------|--------------------|-----------------|----------|---------|
| | forests | woodland/ shrubs | trees/ bushes | permanent grasslands | fields | urbanized areas | water bodies | wetlands | sum |
| 1988 | | | | | | | | | |
| Forests | 12819,1 | 697,1 | 70,4 | 404,4 | 466,7 | 160,3 | 8,2 | 2,6 | 14650,9 |
| Woodland/shrubs | 691,3 | 121,2 | 1,8 | 56,6 | 30,1 | 4,2 | | 4,3 | 909,4 |
| Trees/bushes | 104,3 | 94,0 | 203,4 | 180,1 | 401,4 | 15,4 | 0,4 | | 998,9 |
| Grasslands | 656,5 | 636,6 | 233,9 | 912,4 | 950,2 | 40,5 | | 2,5 | 3434,0 |
| Fields | 411,7 | 677,6 | 965,9 | 2463,0 | 13596,7 | 291,2 | 0,3 | 10,5 | 18419,5 |
| Urbanized areas | 242,7 | 78,4 | 165,6 | 407,7 | 700,1 | 1521,4 | 0,5 | 4,6 | 3131,0 |
| Water bodies | 12,7 | 5,4 | 31,4 | 8,3 | 13,7 | 2,1 | 82,7 | | 165,7 |
| Sum | 14977,5 | 2344,8 | 1675,1 | 4459,5 | 16178,9 | 2035,7 | 112,6 | 24,5 | 49000,1 |
| % | 30,6 | 4,8 | 3,4 | 9,1 | 33,0 | 4,2 | 0,2 | 0,1 | |

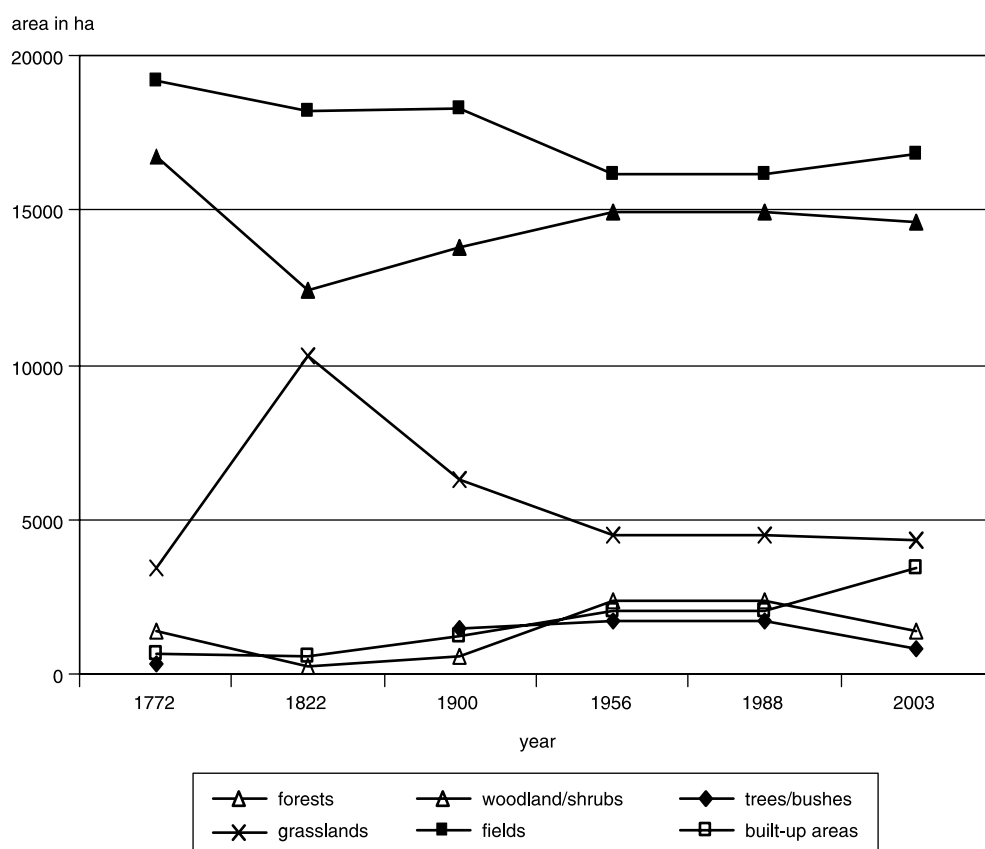
Table 5. The transformation matrix of land use changes in the investigated territory of the Tatry BR between the years 1988–2003

| In | Ha 1988 | | | | | | | |
|-----------------|----------------|---------------------|------------------|-------------------------|----------------|--------------------|-----------------|---------|
| | forests | woodland/ shrubs | trees/ bushes | permanent grasslands | fields | urbanized areas | water bodies | sum |
| Forests | 12709,5 | 530,0 | 105,6 | 706,5 | 416,0 | 170,1 | 6,2 | 14648,3 |
| Woodland/shrubs | 793,2 | 312,5 | 14,3 | 131,5 | 147,2 | 22,0 | | 1420,7 |
| Trees/bushes | 230,2 | 4,1 | 100,9 | 138,6 | 334,7 | 23,9 | 15,0 | 847,3 |
| Grasslands | 363,4 | 34,7 | 206,6 | 1537,6 | 2063,0 | 114,2 | 5,6 | 4341,6 |
| Fields | 198,9 | 16,3 | 545,8 | 681,3 | 15006,7 | 334,4 | 12,3 | 16805,2 |
| Urbanized areas | 327,1 | 11,8 | 25,3 | 188,4 | 415,5 | 2466,3 | 1,4 | 3436,3 |
| Water bodies | 0,3 | | 0,5 | 0,1 | 14,6 | 0,1 | 115,5 | 139,5 |
| Sum | 14650,9 | 909,4 | 998,9 | 3434,0 | 18419,5 | 3131,0 | 165,7 | 49000,1 |
| % | 29,9 | 1,9 | 2,0 | 7,0 | 37,6 | 6,4 | 0,3 | |

a slight increase in the proportion of grasslands (of about 2%). Urbanized areas increased mainly at the expense of fields (334.4 ha), forests (170 ha) and TTP (114.2 ha). The transformation of agriculture influenced the overall reduction of fields in the investigated territory by more than 3%, because of the increase in the size of TTP and NSKV. The territory above the upper forest boundary (alpine meadows, scrubs, bare subsoils, debris, water bodies) maintained the same utilization, as a part of the TANAP national park.

The overall conduct of the representation of different land use forms in the investigated area of the BR Tatry is documented in the chart 1. Some important changes occurred in the first three time horizons. Since the year 1956 the land use has been considerably balanced, but with significantly greater increase in the share of urban areas in the year 2003.

Areas of the unchanged land use represent 51% of the investigated territory of the BR Tatry (Fig. 8); 36.9% of this portion is created by the fields, and 33.2% by the

**Chart 1.** Representation of land use forms in the investigated area of the Tatry BR (1772–2003)

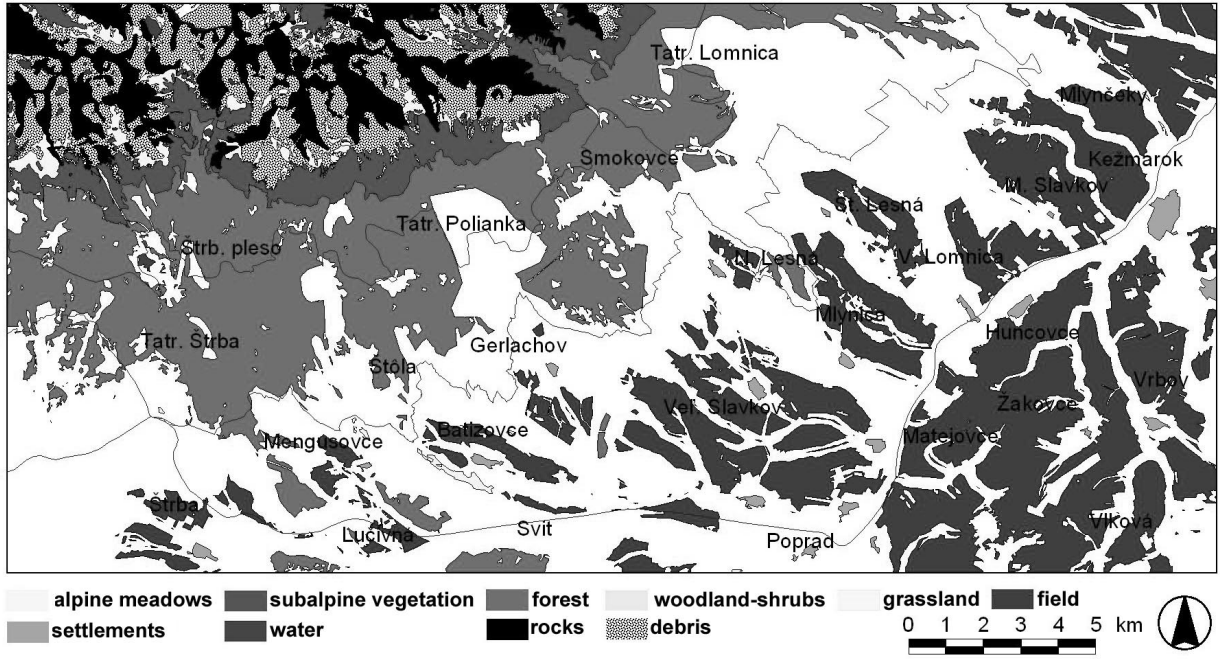


Fig. 8. Areas without land-use changes in the investigated territory of the Tatry BR in 1772–2003

forests. Almost one third of the most stable areas belongs to alpine areas of the landscape (scrub zone, Alpine meadows, lakes (tarns), slopes covered in rubble, and rock walls). Permanently urbanized areas cover 1.1% and only 0.2% is represented by TTP.

The unchanged areas of forests and Alpine landscape prevail largely in the nuclear zone of the Bio-

sphere Reserve. White areas (with at least one change in use) have only an insular distribution near the settlements in the High Tatras (Štrbské Pleso, Tatranská Lomnica and Smokovce) and around the documented calamites (fire scene under the Slavkovský peak). Large white areas are situated around Tatranská Polianka and Tatranská Lomnica (created as a consequence of large

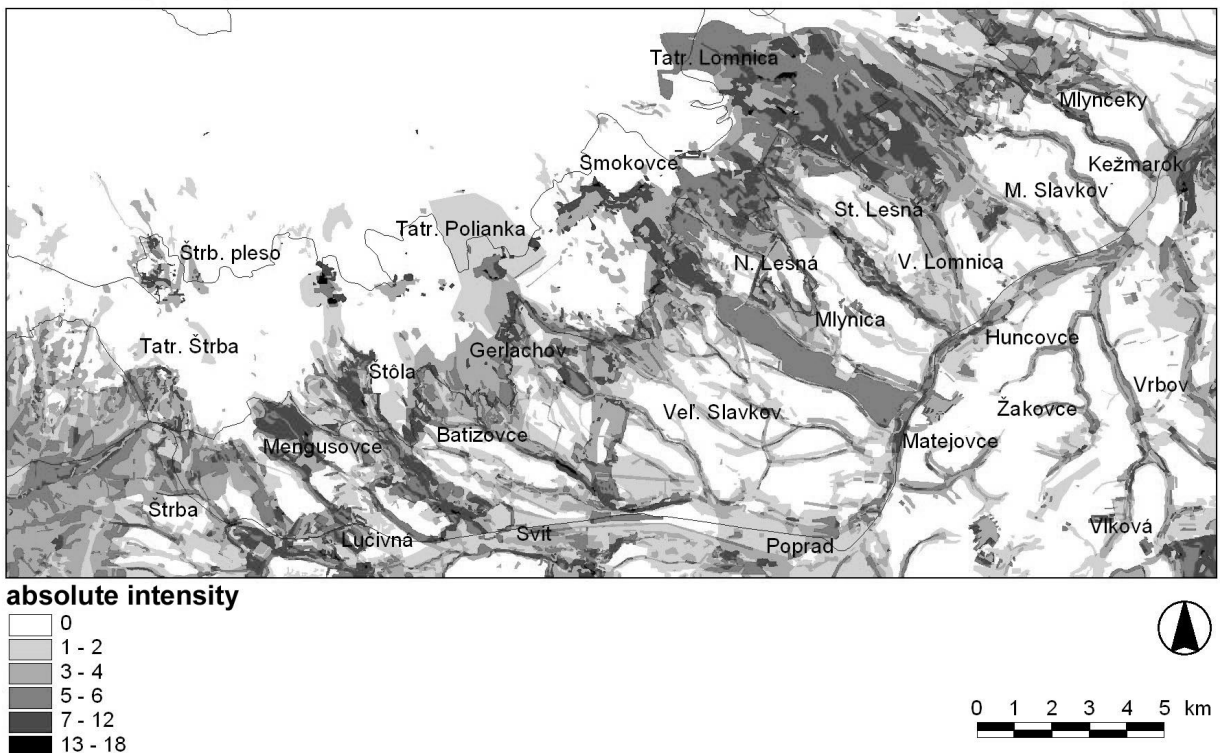


Fig. 9. Absolute intensity of land use changes in the investigated territory Tatry BR in 1772–2003

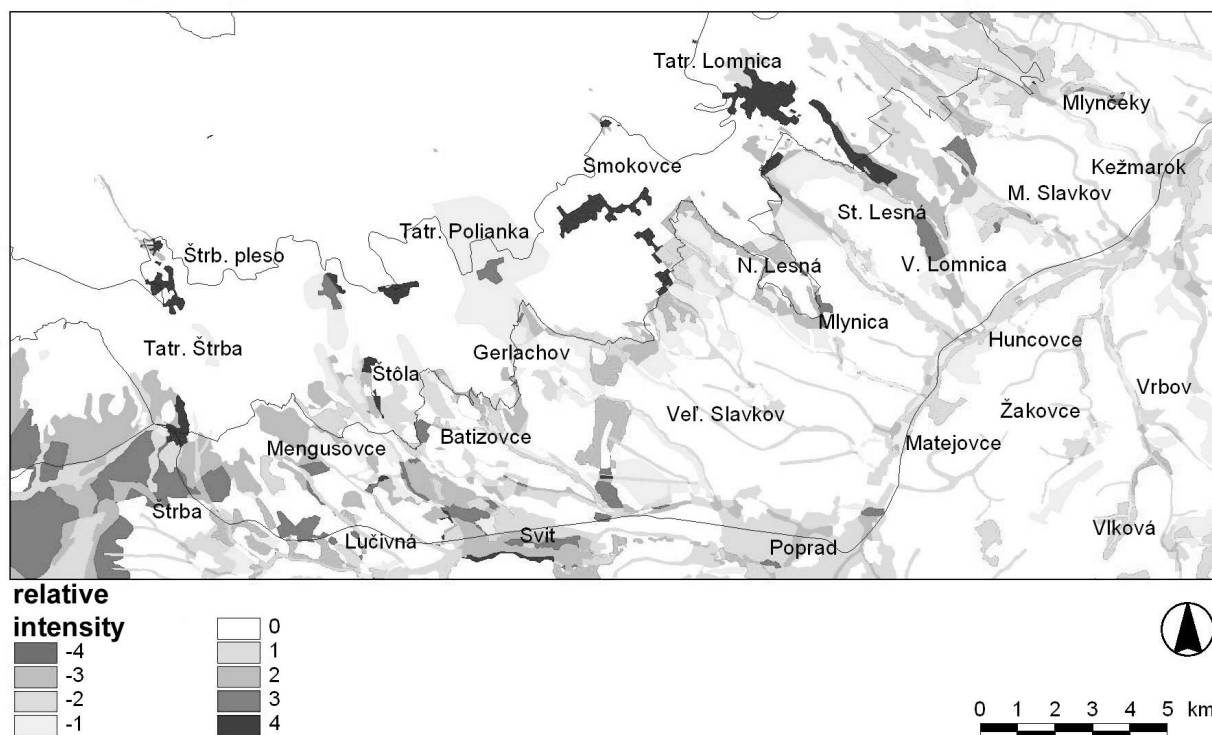


Fig. 10. Relative intensity of land use changes in the investigated territory of the Tatra BR in 1772–2003

deforested areas in the 18th and 19th century). On the maps considering the absolute (Fig. 9) and relative (Fig. 10) changes of the land use intensity is shown that the nuclear zone of the BR Tatry has experienced only a minimum of changes over the past 234 years. About a half of the buffer zone is covered by permanent forest, the second half consists of areas with modified land utilization. As for the number of changes made, the most intensely changed part is stretched from Tatranská Lomnica to Smokovce, from Gerlachov to Tatranská Polianka, from Štôla to Vyšné Hágy and in the surroundings of Štrbské Pleso. Another interesting observation is the occurrence of areas with the most intensive changes along the border of the buffer and transition zones. According to the direction of these changes, they alternatively represent a retreat to a original form of land use (zero changes), or extensification (a shift to forests) as well as intensification (a shift from forests to grasslands) of land use. Large changes and intensification of the settlements in the High Tatras (dark red to brown areas), mainly Tatranská Lomnica and Smokovce, are alarming.

Intensive changes of land use continue in the northern part of the transition zone, connected to the boundary of the buffer zone. Next, many changes occur around mountain villages in the High Tatras and along the roads and streams in the basin area. The intensification of land use is manifested in the area near Velká Lomnica and in the strip from Malý Slavkov to Tatranská Lomnica, around Svit, Batizovce, Mengusovce and in Poprad. Large red areas in the southwest part of the investigated area (a part of Liptovská kotlina basin) have been created as a result

of deforestation and conversion into grasslands since 1772.

Conclusions and discussion

In the presented work we have evaluated the evolution of land use of the Biosphere Reserve Tatry based on historical maps, aerial photographs and field surveys. We have identified areas without any change of use, which represent the most stable areas. By the attaching of weight coefficients to individual forms of land utilization, we have determined areas with different intensity of land use change: absolute (the size of changes was monitored, regardless to their direction), as well as relative (we have stipulated the direction and the intensity – intensification, or extensification of use).

On the basis of our results, the landscape of the BR Tatry could be characterized by stable agricultural utilization at the bottom of the basin; associated with the expansion of settlements (especially Poprad, Kežmarok and Svit) and by essentially unchanged mountain landscape. The most significant changes occurred on the transition between the basin and mountain landscape (the zone of continuous changes among forests, permanent grasslands and fields); and the emergence and continuous expansion of settlements in the High Tatras in the 20th century. Recurring wind calamities also contributed to the total change of the landscape (last, while the largest, in the year 2004). These have been documented since the late 19th century, but according to our results, we can express the hypothesis that larger calamities took

place in the territory even before years 1772 (areas of transitional shrublands in Tatranská Polianka) and 1822 (large grasslands areas reaching from Malý Slavkov to the current Tatranská Lomnica in 1900 are reforested again).

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Summary

Land use development of the Tatra BR was identified considering historical and temporal military maps, aerial orthophotographs and field mapping (2000–2005). The identified land use changes were judged according to the intensity of the change. Land use forms were given intensity coefficients and using a simple addition, we analysed a absolute land use change intensity (with the regard only to the amount of changes) or arelative land use change intensity (with the regard to the change orientation, the increase in intensity – intensification, the decrease in intensity – extensification).

In BR Tatra was a very stabilised basin bottom (with larger towns and villages and agricultural land use) and an alpine part of the Tatra Mts. However, the growth of urbanised areas in the national park was alarming almost in the last 50 years.

Land-use changes in the selected part of the Tatra Biosphere Reserve in 1772–2003

The paper presents results of the survey considering the land use development and its changes in the Podtatranská kotlina basin and the High Tatra Mts between 1772 and 2003. The land use was identified according to historical military maps and aerial orthophotographs. The intensity of land use changes (absolute and relative) was assessed as a sum of partial changes during studied time horizons (1772, 1822, 1900, 1956, 1988, 2003). The study area of the Tatra BR is characterised by highly stabilised basin bottom (with fields and settlements and rapidly developing towns) and in fact unchanged high mountain landscape. The main changes occurred on the transition of basin to mountains and since 1900 the continuously growing tourism centres. As very significant land use factors can be considered the periodical wind calamities (the oldest identified areas from historical maps were before years 1772 and 1822, in following years again reforested).

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