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CHANGES OF HIGH MOUNTAIN LANDSCAPE STRUCTURE IN THE SELECTED AREA OF THE PREDNÉ MEĎODOLY VALLEY (BELIANSKE TATRY MTS) IN 1949–1998

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Abstract

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The paper is focused on mapping, analyse and evaluation of the landscape structure changes in high-mountain environment within 50 year time period, with a special respect on subalpine and alpine belt of the selected part of the Predné Meďodoly valley in the Belianske Tatry Mts, belonging to the Tatra National Park. The territory was strongly influenced by humans till 1954, especially by means of cattle and sheep grazing. The aim was to record changes in the landscape in two time series, starting since the year 1949 and 1998, as well as to evaluate them qualitatively and quantitatively. Another aim was to analyse causes of these changes with the exploration of human and natural factors as well. For this purpose a set of aerial photographs scanning the study area, namely from the year 1949 and 1998, was used and processed by GIS tools. The map outputs were processed digitally in vector format at the large-scale 1:1500.

Key words: high mountain landscape structure, changes, Belianske Tatry, remote sensing, GIS

Introduction

Landscape as an open system, created by synergy of natural as well as anthropogenic factors, belongs in the last decades among important objects of landscape-ecological research. However, this phenomenon is under continual development and changes, so it is difficult to specify his latent state. According to Feranec et al. (1997) the analysis of landscape changes is especially important from the viewpoint of evaluation of natural as well as socio-economical processes, their dynamics, reasons and stability of up-to-date state, but above all of possible trends of further development. Land use by humans means always its certain

destabilisation. This phenomenon is strikingly observable not only in the most intensively used parts of the Slovak lowlands, but also in such types of landscape where as a consequence of historical but partly also current anthropogenic impact we observe during the last 50 years relatively increased intensity of changes of various elements of landscape structure. To a such type of landscape we range also the Tatra high-mountain landscape where environment above the upper timber line have been in the past commercially used (mining activity, pastures, logging of dwarf pine to gain tanin oil a.o.) till the declaration of the Tatra National Park (TANAP). The landscape is currently used only for recreation.

Landscape structure (LS – meant as secondary landscape structure) is composed of landscape elements – basic spatial and at the same time mapping units. According to a methodology of landscape planning LANDEP (Ružička, Miklós, 1982) elements are selected following the way of lands use and in the case of high mountain landscape primarily on the base of characteristic physiognomy. Considering analogy of LS with land cover, besides physiognomic there is significant also visible morpho-structural (content) character or biophysical substance.

In this paper we are giving partial results of mapping and evaluation of changes of landscape structure of high mountain landscape in the selected part of the Predné Meďodoly valley in the Belianske Tatry Mts, belonging to the TANAP. The aim of this work is to map and evaluate state of landscape elements in this area in the past as an example of disturbed landscape (pastures and with it connected drastic intervention into landscape structure) and to compare it with the current state. Aerial photos from two time periods (1949, 1998) are used for interpretation of LS changes (dynamics).

Methodology

Parts of current development in the field of geoinformation technology are remote sensing (RS) and geographic information systems (GIS), which belong to the most progressive alternatives of mapping of LS and its changes in different scales – from global to local (Feranec et al., 1997). Its particular manifestation are mapping and multitemporal analysis applied in works of different scales and orientation (Falťan, 2000; Feranec, Oťaheľ, 2001; Feranec et al., 1996, 1997; Lipský, 1995; Olah, 2003a, b; Oťaheľ et al., 2003, e.g.).

Preparatory stage included obtaining and study of aerial photos as well as preliminary recognoscation of terrain. Production of large-scale thematic maps of LS of study area was carried out by PC software ArcView GIS 3.1 and included following operations:

- preparation of aerial photos and georeference of image from 1949 in module ImageWarp
- identification of individual classes of LS by means of analogue (visual) interpretation of aerial photos
- digitising of spatial data by method "*on screen*" – creation of thematic maps of LS (1:1500) from 1949 and 1998
- creation of flexible database, in which are saved all relevant information and which will enable to realise all further needed operations
- evaluation of LS changes by overlay method and comparing of vector thematic maps from individual time periods and subsequent statistic processing
- creating of database of changes of individual classes of LS (1949–1998) and its statistic(numeric and graphic) analysis

- cartographic figuration of information layers in analogue output form – thematic maps of LS from 1949 and 1998.

In 1949 was the whole territory of Slovakia taken aerial photographs by the Army of the SR. The Tatry area was scanned on different photographic material than other territories. As a result there are large-scale panchromatic aerial photos (size 23x23 cm) made from slides with high resolution (50 cm/pixel), scanned from the absolute altitude 4500 m at scale 1:10 000. Stereoscopic longitudinal overlap of the photos is 60% and lateral overlap is 30%. The Military Topographic Institute provided for us slides in digital format (*.tif) scanned with resolution of 1200 dpi. Each of them was rectified in desired projection by means of identical points, locations of which were possible to define both on the photo and on the orthophoto from 1998 as well, that already had appropriate cartographic projection. By the means of module ImageWarp was by method of affinity transformation "image-to-image" found more than 4000 identical joint points (ground control points - GCPs) for each photo. Root Mean Square (RMS) achieved was acceptable. Method of nearest neighbour was used for resampling. Photos were subsequently adjusted regarding colour balance and contrast and cut off to the size of study area.

The so far last scanning of the Tatra area in 1998 (2002–2003 is currently in process) was carried out by company EUROSENSE Ltd. Bratislava. As a result there are vertical infrared aerial photos in format of coloured slides (size 23x23 cm) on Kodak Aerochrome II, 2443, film, which were scanned from the absolute altitude about 5200 m at scale from 1:10 000 to 1:15 000 by aerial measuring camera Leica Wild RC 30, equipped for this purpose with lens f = 21 cm. Stereoscopic longitudinal overlap was done by the above mentioned company and transferred into standard projection of topographic maps of S-JTSK system.

Individual homogeneous classes (their patterns) of LS were identified by analogue (visual) interpretation of the photos. The smallest identified polygon has area 5 m^2. Digitisation of spatial data – individual elements of LS was carried out manually by method "*on screen*" at scale 1:1000 to 1:1500, because aerial photos from both time periods present very high resolution and thereby also good readability. Resultant vector maps of LS are at scale 1:1500 (Fig. 3, 4) without any generalisation, while readability of map is sufficient. Thereby we pursue maintenance of the all spatial attributes of LS, respectively its individual elements. We ranged them into 7 classes: scrub, dwarf-pine stands, tallus-herbaceous stands, debris cover, rocks, disturbed areas, water areas and settlements (huts, sheepfolds). Content characteristics of the majority of the classes is obvious, so we won't deal with it in more detail. We will focus only on the class of disturbed areas – we mean by them physiognomically remarkable areas (in terrain as well as on panchromatic or infrared photo), that differ also morphostructurally from other classes mainly by different composition. According to works of Midriak (1972, 1983) they are mainly uncovered soil-mantlerock stricken by various types of destruction, which arose under influence of anthropozoogenic factors as well as by intensive activity of natural geomorphic processes in extreme environment of Tatra high mountain landscape (avalanches, debris shift, eolic, nivation and fluvial erosion a.o.).

By evaluation of changing landscape structure we used method "overlay" of creating thematic maps from individual time periods on the basis of analysis and comparation of areal changes (in ha and %) of individual landscape structure clasess and present results through GIS in map and numeric (statistic) form together with brief evaluation of landscape development in context of social-historical changes.

In this paper we are giving just partial results of analysis and evaluation of changes of landscape structure (1949–1998) in chosen square (80 ha), that part of studied territory – south slopes under Zadné Jatky (2019.8 m n.m.) and Predné Jatky (1950.4 m n.m.)

We registered changes of landscape elements also by direct methods, concrete throught interpret schemes, which we found out by comparation by historical and present terrestrial photos and by their evaluations with the help of graphic programms. Because we wanted to catch also detail spatial and capacity changes of individual elements (most of all tallus-herbaceous stands) on the topic level, we established seven pernament monitored plots (size 4x4 m). Research is aimed on long-termed observation of vegetation quality changes in relation with geomorphological processes and georelief qualities in mezo and micro-scale of landscape. Geomorphological proceses seams to be in high-mountain landcape like key factors, that determine besides also spatial distribution of vegetation, respectively its individual types or total character of stands fragmentation. Vegetations data are collected one time per year (in July) with standard seven degree combined Braun-Blangquet method. By using phytocoenological records, that are later submitted multivariate gradient analyse (PCA, DCA). Every year we also draw species spatial distribution and hereby there are realised intensity measurements of geomorphological proceses.

Landscape structure till 1949

From the very beginning had smooth south slopes of Belianske Tatry attract attention because of their great condition for pasture. By Holub-Pacewiczowa (1931) were here from 13th century pastures. It existed here several sheepfolds (in Predné Meďodoly valley: 3 Belianske, 3 Kežmarok, 1 Rakusy). Here has been mostly grazed sheep, cattle, but also horses and sows. From those days became to expressive changes of land structure and area of individual elements. It was influence of deforestation, wood-cutting, burning of dwarf-pine (lowering of upper timberline for about 200–300 m) because new pastures, new paths for people, sheep, cattle and the obtaining of tanin oil. This is why the area expressive lowered at the other hand erosion accelerated and also arised new disturbed areals, which were influenced with different forms of destruction (by water, wind, frost and so on). Deforestation in a upper timber-lines had influence on more frequency avalanches. Pastures had influence on changes of species composition of talus-herbaceous stands (Šmarda, 1963). It came to arise of sheep paths and dense network of paths in the surroundings of watering places and to trampling of soil. This state was lasting until year 1954, when was pasture in TANAP forbiden. In this year was for example by Harvan (1965) 1970 sheep on south slopes of Belianske Tatry grazed.

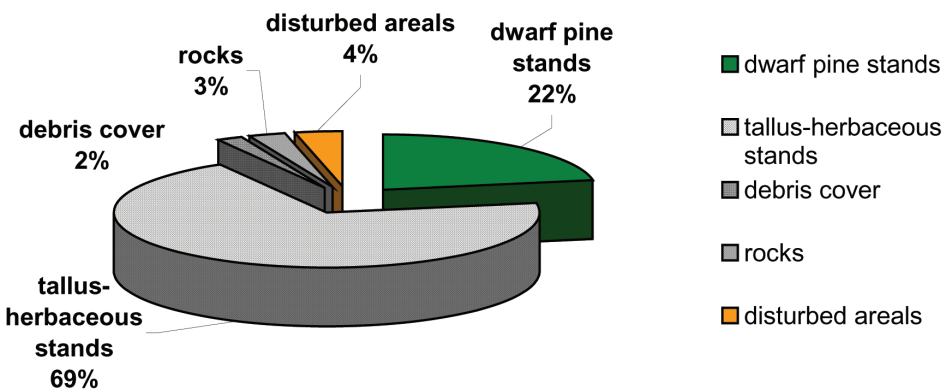

Fig. 1. Graph of classes area (in ha) in the selected part of Predné Meďodoly in 1949.

Another factor that influenced landscape structure from 15th century was mining (copper, silver, gold). That also played role in destruction of surface (vegetation and soil), especially in area of Kopské saddle (south-east slope of Jahňací peak, Belianska kopa peak) Jatky peak.

During few centuries until of establishing of TANAP economical human interests without respect of natural laws, caused extence of changes. Intensity of anthropogeneous influence as follows changed the whole character of Belianske Tatry landscape.

By visual and following statistic analysis of chosen square in thematic maps of landscape structure from 1949 (Fig. 1, 3) we came to these conclusions. The biggest part took talus – herbaceous stands areas (69%). They covered more than half of selected area. Relatively big area took dwarf-pine stands, respectively rest of them (22%). Much smaller area (under 10%) took rocks (3%) and disturbed areals, which arise was mostly conditioned by sooner mentioned factors (4%). Smaller parts took debris talus (to 2%).

Changes of landscape structure in 1949–1998

Landscape structure of Belianske Tatry Mts, respectively arranging of landscape structure elements in last century was determined by a lot of natural and partly also anthropogenic factors. After the pastures were in 1954 prohibited started the stands to regenerate and come to native communities. But a lot of native communities were replaced with poor secondary stands. Natural succesion of dwarf-pine and also her planting on several places caused again incease of ecological stability of landscape system and deceleration of destruction processes.

At present (1998) in our researched square is area of dwarf-pine stands (30.2 ha – that is 38% of our analysed square) (Fig. 2, 4, 5). Change opposite to year 1949 makes 13 ha, which is biggest difference from all observationed classes. Area of talus – herbaceous stands had lessed 10 ha and has value 45.5 ha (56%). Like a consequence of succesion proceses of vegetation had debris cover class lessed 0.1 ha. Area of rocks formations did not change, they are relatively the most stable element of our area. Very favourable is, that for the area of disturbed areals had lessed for 3% (2 ha). Part of it is consequence of economical utility and also of negative influence of hiking, for example destroying paths and as follows quiclier erosion and big changes in vegetation (Barančok, 1999).

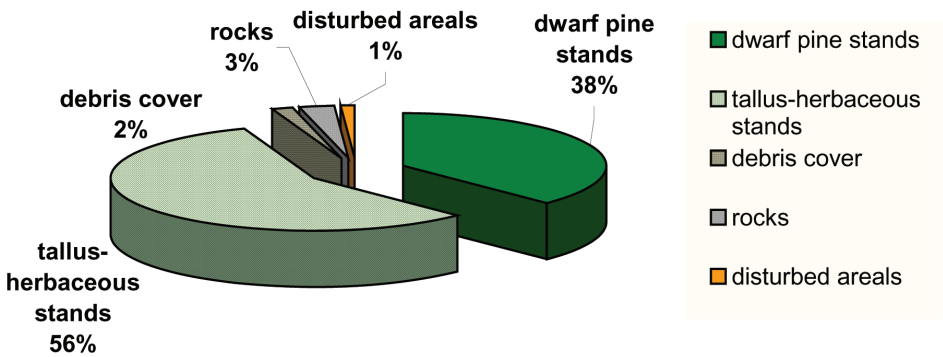

Fig. 2. Graph of classes area (in ha) in the selected part of Predné Meďodoly in 1998.

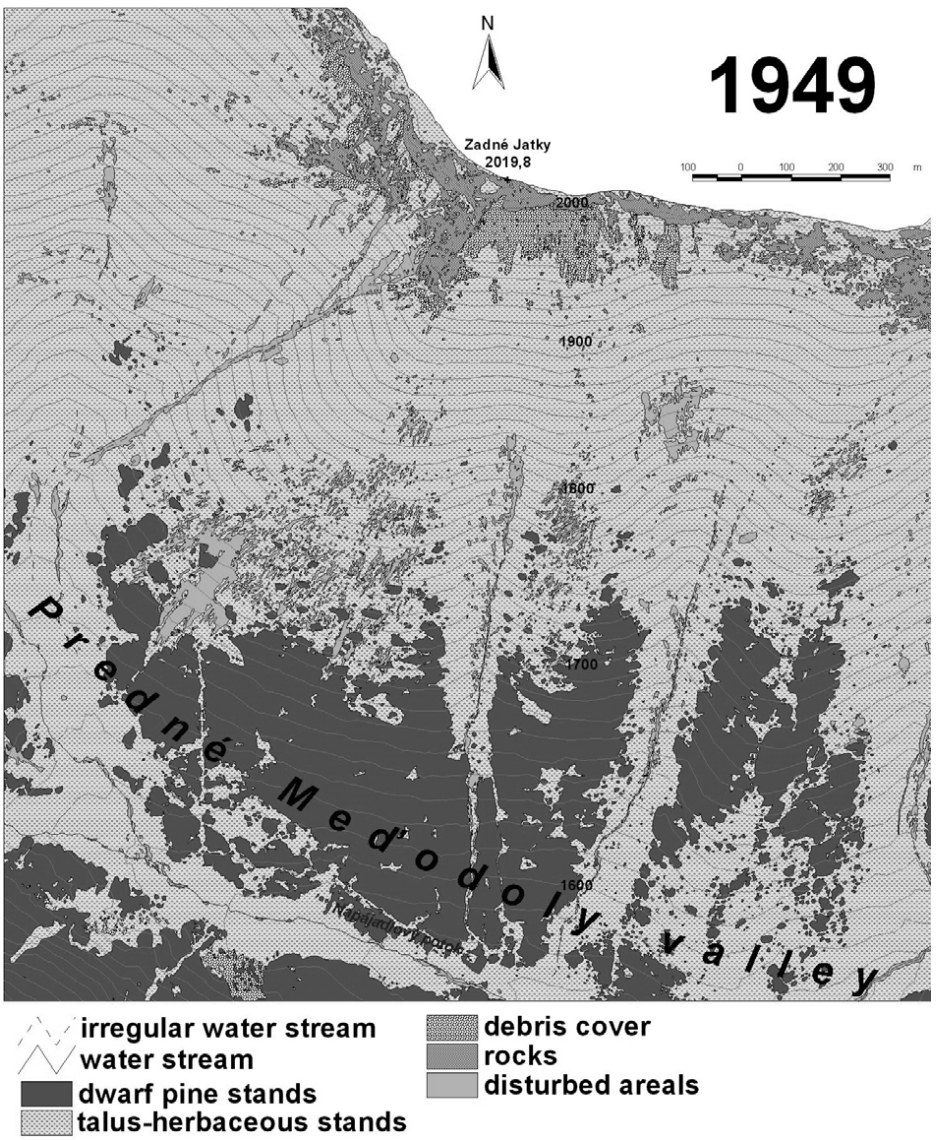

Fig. 3. Map of landscape structure in the selected part of Predné Meďodoly in 1949.

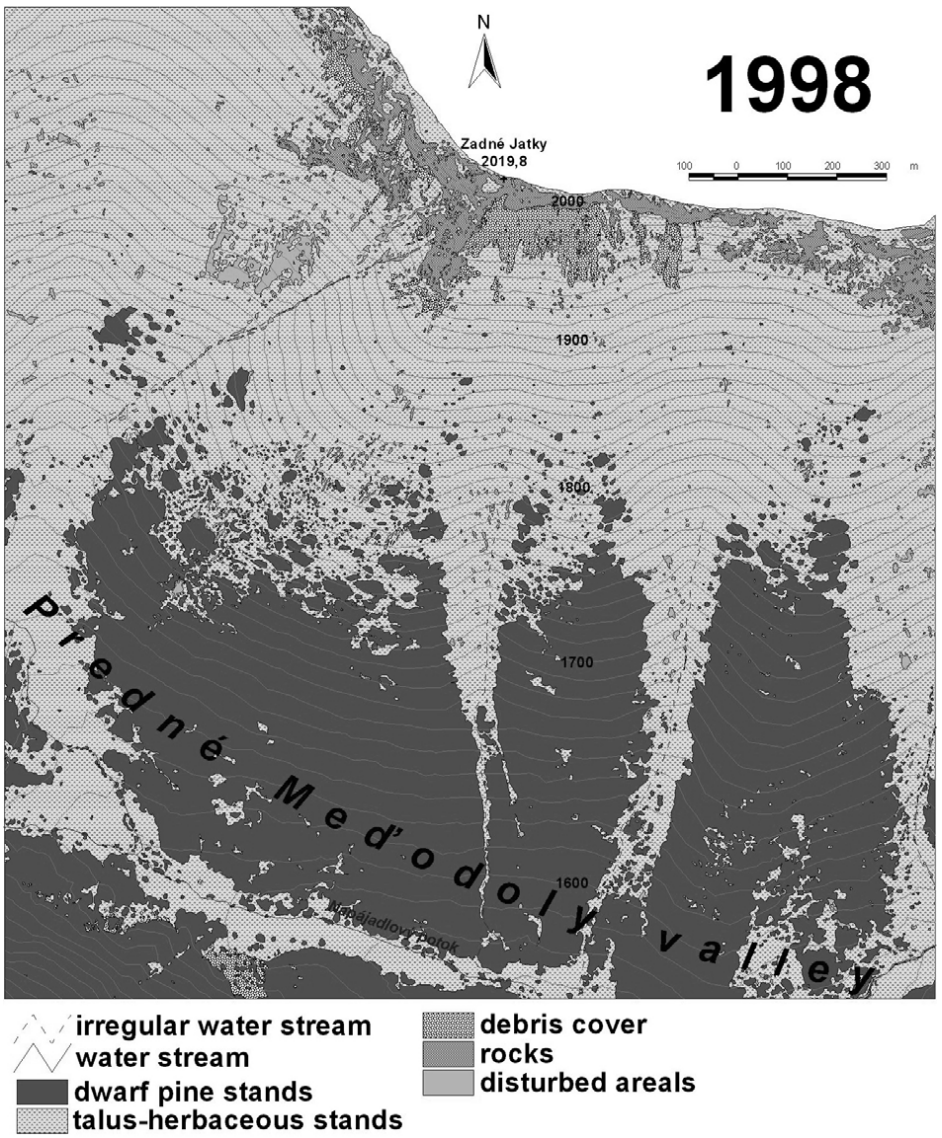

Fig. 4. Map of landscape structure in the selected part of Predné Meďodoly in 1998.

Landscape structure at present is not constant. There are unconstitutional changes in time, that depend on changing of seasons, but also on phenomena of absolute altitude and with it connected phenomenous (temperature, precipitation, evolution of soils, changes of relief and e.g.). By our present terrain observations plays the key role geomorphic processes (Hreško, Boltižiar, 2001), that have not long-termed character, but strong relative short-termed morphodynamic disturbations (avalanches, debris flows). Landscape structure is so in state of dynamic stability, this means, that it is an object of two against each other comming powers – evolution and disturbation (Forman, Godron, 1993).

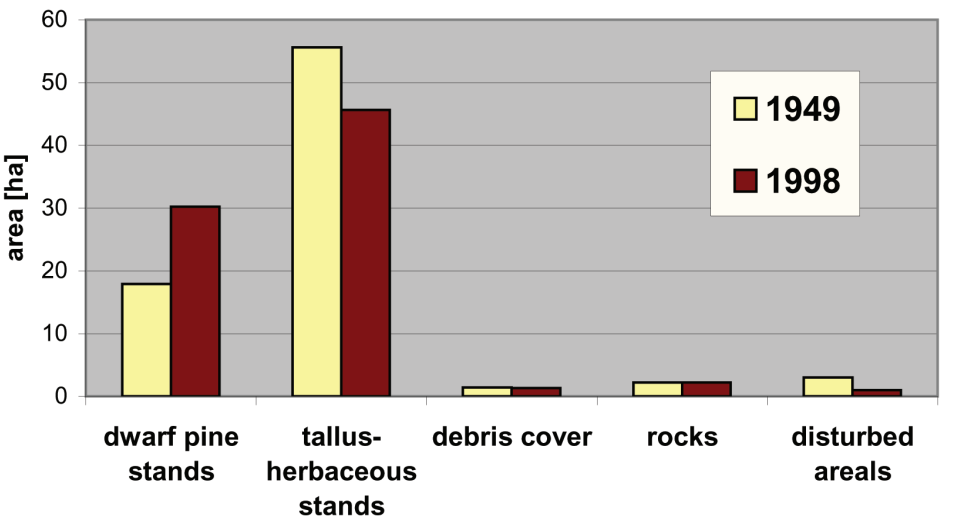

Fig. 5. Graph of areas change of landscape classes in 1949–1998.

Conclusion

The aim of this paper was to document possibilities that come with used of historical and present aerial photos, that can be used for identification of landscape by application of GIS and to present them in forms of large scale thematic maps (1:1500), tables and also in graphic forms.

Analysis of landscape structure changes, maps from this analysis and also statistic evaluation document expressive dependence between individual classes (especially vegetation) and socio-economical interests (mining, pastures), socio-legislation changes (establishment of TANAP) and also with natural factors influence-geomorphic processes. This type of analysis helps by respecting of landscape structure-ecological principles, to improve solitude of high mountain Belianske Tatry landscape. In this sence can information from this research bring important contributions for development, management and planning.

Althought there are few works about Belianske Tatry Mts, mostly there can be founds only fragmented information and we are missing detailed study of these type of changes and their causes, connected with mapping at the large-scale (1:1500). In next stage of research we are going to focus on detailed analysis of these changes in connection with detailed diagnostic of natural conditions, in our fall mostly of relief (hypsometry, slopes, orientation, genetic geomorphologic forms), that seems to play key role or of abiocomplexes (Falťan, 2002). We suppose, that this way focused research will bring not only proofed statistic – spatial information about changes of individual elements of landscape structure, but also has a importance in point of view human influence on high-mountain landscape.

At end we can state that RMS presented mostly by aerial photographs large-scale photographs, respectively orthophotos bring really valuable information for the evaluation of landscape structure changes in such a extreme environment like high-mountain landscape of Tatras, which are, when we lay stress upon exactness and topicality, with terrain research and mapping practically unattainable.

Translated by the author

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Boltižiar M.: **Zmeny krajinnej štruktúry vysokohorskej krajiny vo vybratej časti doliny Predných Meďodolov (Belianske Tatry) v rokoch 1949–1998.**

V príspevku dokumentujeme možnosti využitia historických i súčasných leteckých snímok na identifikáciu zmien krajinnej štruktúry v prostredí GIS a prezentovať ich v podobe ukážok veľkomierkových tematických máp ako aj pomocou tabuľkového a grafického aparátu.

Analýza zmien krajinnej štruktúry a jej mapové vyjadrenie ako aj štatistické vyhodnotenie dokumentujú výraznú závislosť zmien jednotlivých tried (najmä vegetácie) od spoločensko-hospodárskych a vlastníckych záujmov (baníctvo, pastierstvo) ako aj od spoločenskej legislatívnej zmeny (vyhlásenie TANAP-u) a v neposlednom rade aj od vplyvu prírodných činiteľov – geomorfologických procesov. Takýto typ analýz umožňuje na základe rešpektovania krajinnoekologických princípov riešiť ďalšie smerovanie starostlivosti o vysokohorskú krajinu Belianskych Tatier a v tomto zmysle sa získané informácie stávajú významným prínosom pre jej ďalší vývoj, manažment a plánovanie.

Záverom možno konštatovať, že údaje DPZ reprezentované najmä leteckými veľkomierkovými snímkami, resp. ortofotomapami predstavujú veľmi cenné údaje aj pre hodnotenie zmien krajinnej štruktúry vo veľkých mierkach i v takom extrémnom prostredí, akým je i vysokohorská krajina Tatier a ktoré sú, so zreteľom na presnosť a aktuálnosť, terénnym mapovaním prakticky nedosiahnuteľné.