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Land-use of recreational high mountain landscape in Tatra National Park within the last six decades (case study from Belianske Tatry MTS., Slovakia)

Martin Boltižiar, Eva Michaeli, Monika Ivanová, Vladimír Solár

Abstract
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 Medodoly 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 and also tourists activities. The aim was to record changes in the landscape in two time series, starting since the year 1949 and 2013, 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 2013, was used and processed by GIS tools. The map outputs were processed digitally in vector format at the large-scale 1:1500.

Key words: landscape changes, tourist activities, high-mountain landscape, Belianske Tatry Mts.

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 Medodoly 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, 2013) are used for interpretation of LS changes (dynamics).

Materials and methods
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 (Faltan et al., 2011, 2000; Feranec, Oťahef, 2001; Feranec et al., 1996, 1997; Lipsky, 1995; Olah, 2003, Oťahef et al., 2003, Michaeli, Ivanová, 2005 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 ArcGIS 10.2 and included following operations:

- preparation of aerial photos and georeference of image from 1949 in module ERDAS Imagine 8.3 module Orthobase.
- 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 2013
- 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 (1949-2013) and its statistic (numeric and graphic) analysis

In 1949 was the whole territory of Slovakia taken aeril photographs by the Army of the SR. The so far last scanning of the Tatra area in 2013 was carried out by company EUROSENSE Ltd. Bratislava. As a result there are vertical aerial orthophotos at scale from 1:10 000 to 1:15 000 Individual homogeneous classes (their patterns) of LS were identified by analogue (visual) interpretation of the photos. The smallest identified polygon has area 5 m². 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, talus-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) 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 classes 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 (1949-2013) 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 comparison by historical and present terrestrial photos and by their evaluations with the help of graphic programmes.

Results

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 Međodoly 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 areas, 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 (Smarda, 1983). 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 forbidden. In this year was for example by Harvan (1965) 1970 sheep on south slopes of Belianske Tatry grazed.

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 Kopske saddle (south-east slope of Jahnači 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 areas, which arise was mostly conditioned by sooner mentioned factors (4 %). Smaller parts took debris talus (to 2 %).

Changes of landscape structure in 1949-2013
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 (2013) 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 processes 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 areas 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 quicher erosion and big changes in vegetation (Baranček, 1996).

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, Boltziar, 2001), that have not long-termed character, but strong relative short-termed morphodynamic disturbances (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 disturbance (Forman, Godron, 1993).

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 social-economic interests (mining, pastures), social 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.

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

Fig. 2: Graph of classes area (in ha) in the selected part of Predné Međodoly in 2013.

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

Fig. 4: Map of landscape structure in the selected part of Predné Međodoly in 2013.
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