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Downhill courses as significant landscape structure of the High Tatras Mts., Slovakia

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Abstract: Present state and changes of landscape's structures in high-mountain's environment requires rigorous scientific research. There the most intensive dynamic changes have started after wind throw disaster on the 19th November 2004 and intensification of new investment construction. Massive modifications of downhill courses of Solisko (above Štrbské pleso Lake) and in Tatranská Lomnica (under Skalnaté pleso Lake) have begun since 2008. The main task is anthropic influence's evaluation of downhill courses according to data's interpretation of relationship between exposed substrate and vegetation cover. Results introduced in article represent the state until the year of 2008 and consequently they will have historical value, concerning visible changes in studied areas. We comment scientific background of invested projects and possibilities of their more sensible design.

Key words: diversity, land surface structures, characteristic landscape appearance, anthropic influence

Introduction

Specific natural conditions of the High Tatras high-mountain's region in relation to recreational land utilization require individual approach. Not only in landscape ecology field, where we evaluate mostly capacity of abiotic and biotic conditions of landscape environs, ecological stability and hazards of biodiversity changes. There are landscape-aesthetical approaches achieved in the field of natural preservation, where research is concentrated on landscape character's attributes and on the impact of human activities on characteristic appearance of the landscape.

The object of research is the landscape of the High Tatras Mountains, especially localities in recreational-urban and forest high-mountain type of landscape, with sports-recreational and climatic function (landscape types are commented in more details in Table 1). Basic research localities are Solisko and Veľká Lomnica and comparative locality is Hrebienok (Table 2). The subject of research is characteristic landscape appearance (CHLA), in the

Table 1. Delimitation and characteristics of landscape types of studied downhill courses

Landscape types and vegetation altitude levels of downhill courses	Absolute altitude (m)
– cliff landscape in sub-nival level, – alpine level	1,800 (1,850)–2,655
–sub-alpine level; dwarf-pine above upper limit of forest;	1,500 (1,550)–1,800 (1,850)
– compact spruce forests, under upper limit of forest; – supra-mountain level, mountain type with recreational and sports use	1,200 (1,250)–1,500 (1,550)
– urban-recreational, mountain forest landscapes with compact spruce forests and forests, mountain level; – spa-recreational zone of bioclimatic region	700–1,200 (1,250)

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Table 2. Numeric parameters and shapes' characteristics of downhill courses of studied areas

Name of downhill course	Length (m)	Width (m)		Area (m^2)
		Interval min. – max. values	Average value of wide (m)	
Solisko	1,200	30–95	63	44,145
Hrebienok	475	7–110	59	12,705
V. Lomnica, part Skalnaté pleso štart	–	20–40–65	42	32,268

sense of European Landscape Convention, characteristic features of landscape (Kozová 2006), and stage of landscape surface's structures (LSS) of downhill courses, their biodiversity and abundance of species. The main task of our research is anthropic influence's evaluation of downhill courses with database's interpretation of relationship between exposed substrate and vegetation cover. We compare their change, which rises from building-up of down-hill course in altitude level of vegetation's associations. Results are concentrated on defining the set of factors consequent upon change of LSS's arrangement and abundance on downhill courses and changes of vegetation associations and shape characteristics of ones determining intensity of their visual impact on CHLA.

Analysis of problematic

Landscape type represents characteristic landscape signs. They provide the possibility to differentiate each landscape from another one, signs that "resemble" some landscapes, and on the other side, signs that are individual for each of landscapes, that means corporate signs which are typical and specific, individual (Jančura et al. 2006). Change of characteristic signs, which represent landscape, involve change of its landscape types. We can perceive these changes as disturbances, symptoms named visual impact, or as determinate process of landscape's degradation "un-functionality". Diversity of landscape types represents some value of the region. Correct incorporation of buildings to landscape, in our case downhill courses, underlie harmony of LSS's components in particular landscape type, arrangement of landscape structure's signs and that is why it is a useful instrument in landscape preservation. Preserved regions are regarded as the most attractive from the point of view of tourism. Their main function is ecosystems preservation, in which the primary ones are auto-regulation mechanisms, biological diversity of vegetation as well as animals and natural valuable and genetic resources localities. Preservation provides maintenance of species diversity and natural conditions for that diversity and it is presumption to inherency of attractive landscape. Landscape's attractiveness for tourism is based on its authenticity, visually attractive landscape and specifics of landscape character. Image of landscape for tourists' trade makes the "logo" for existing preserved area, or national park.

Terminology in context to existing legislation

The Act of National Council of the Slovak Republic No. 543/2002 Coll. on nature and landscape preservation introduces the term "characteristic landscape appearance" in §1–1., or landscape appearance in §2–1. According to the Act of National Council of the Slovak Republic No.50/1976 Coll., as amended by later regulation, in §39–3, in part about judgement of land-use is required when "terrain surface changing is practised, which lead to relevant change of landscape territorial system of ecological stability, landscape appearance, use of significant elements of the landscape".

A significant element of the landscape, according to the Act of National Council of the Slovak Republic No. 543/2002 Coll., base terms in §2 – section 2/c) – (1.), is defined as: "such a part of territory, which makes characteristic landscape appearance, or (2.) contribute to its ecological stability, mainly: forest, peat-bog, streamside stand, lake, wetland, rivers, cliff, gulley, block sea, sand-dune, park, alley, bound."

According to the Act of National Council of the Slovak Republic No. 50/1976 Coll. in §11, "allowable, delimited a forbidden land-use" is defined for local spatial plans. We cannot build in every place we would like to. In §12–2/g a concerning a zone spatial plan, it constitutes implementation of buildings to ambient landscape. In §13–3/c, §39–2/b provision harmony of urban and architectural solution with surrounding environment, mainly levelling and positional building location, and quotas of built-up area to un-built area from building land, requirements on design of its un-built areas inclusive are required.

Research of landscape diversity structures in context to the stage of influence

Firstly, we briefly describe geomorphologic situation of downhill courses which results from geological attributes and lithology. The High Tatras Mountains represent cambered asymmetry horst. There is higher amplitude in southern part, which leads to the prevalence of the highest peaks. Sub-soil consists mostly from granodiorite and quarter glacial and fluvioglacial deposits from granodiorite. They are situated mostly in slopes of south and south-east exposition. When we consider meso-relief forms, slopes are soft shaped, situated on the facet surface's forms. Soft shaping forms of slopes locally interfere with suffuse depressions in upper parts and concave objects formed by fluvial erosion in lower parts.

Presence and abundance of landscape types depends on diversity of landscape's components. We can talk about (a) structural diversity, abundance of several components of land-cover, as presence of forests, dwarf-pines, alpine meadows, roads, urban-recreational structures, (b) biological diversity: diversity of spatial arrangement of plant and animal species in landscape (Cochová 2008).

Landscape matrix is considered to be the prevailing component of LSS – generally vegetation cover in relation to zoned distribution in vegetation altitude levels in solved downhill courses areas consists mostly of forests or dwarf pines. There is immediately displayed any intervention in compact forest association in arrangement's change as fluctuation and fault. Change of the matrix compactness causes porosity of landscape matrix This is a statement of abiotic and biotic relation and risks in landscape. Corridors and plates in landscape matrix occur there (Forman & Godron 1993). From the landscape-ecological point of view, we talk about change of association and ecosystems, while appraisals in landscaping are concentrated on a visibly marked change of landscape textures (*paro* Daniš 2008). As texture we consider surface arrangement of elements in land-cover components (Jančura 2003). Forest's texture significantly differs from the texture of grass and grass-herby associations to uncover substrate. New forms in landscape originate there, and naturally compact vegetal cover is going to be more fragmented. Fragmentation of landscape structures is coming up. Those fragments in landscape have another attributes as natural biotopes. They pretend new land cover elements, generally with mono-functional anthropogenic concentration. There are visibly altered life conditions of organisms, which where those inhabited areas. Land-cover structure of individual downhill courses, and consequently their texture, consists of exposed substrate and vegetation cover. The vegetation cover has character of discontinuous and diffusive cover (Jančura et al. 2004). Relationship of exposed substrate and vegetation cover creates determining information about visual influence of some landscape area and its bio-ecological value. The most distinguished displays symptoms of vegetation cover's disturbance, when sub-soil and sub-roc is exposed. On the one hand, the impact is visual, on the other hand, there are risks of potential erosion and disturbances which arise from the exposed sub-soil and sub-rock with their light colour with strong visual intensity.

Preliminary thesis arises from building-up of downhill courses in high mountain landscape. Technical products transfer land-cover's arrangement. They form new land-cover composition. In case of downhill courses, there is concerned influence of landscape patterns in matrix, which leads to the formation of new landscape type with visibly sports-recreational and sports-entertainment function.

Methodology

Investigation of visual impact assessment on characteristic landscape appearance of downhill courses is proceeded in following steps: (1) in landscape environs we primary identify visual appearance shape of area and next (2.) disturbance of after-effects followed from vegetation cover removing.

Proceeding, assumptions verification and assignment of proposition:

1) Identification of landscape, landscape character assessment, characteristic landscape appearance (Jančura 2000, 2003).
2) Visual impact assessment (VIA) (Jančura 2003).
3) Stage of anthropic influence evaluation of chosen downhill traces. *Assumption verification – some stage of anthropic influence displays in characteristic landscape appearance as visual impact – anthropic influence of downhill courses express relationship between abundance of exposed substrate and vegetation cover.* Land surface structures (LSS) are classified according Jančura (2000) and were mapped in terrain research, which lasted from May to September 2004 and its method is described by Jančura et al. (2004).
4) Comparison of associations in downhill courses and their environs (natural associations) in altitude of 1,200–1,800 above the see level in spruce, dwarf-pine and sub-alpine vegetation level. Presumption verification – change of natural abundance of biotopes and associations' composition caused by anthropic influence on downhill courses. Ground-work for biotope's classification results from Stanová & Valachovič (2002) and further they were mapped, classified and interpreted by Pavlík in more details (2004).

Table 3. Interpretation of LSS' s abundance of downhill course Solisko

Square	1	2	3	
Abundance of landscape surface structures (LSS)				Average value of abundance
Area of downhill course in square	43.3%	8.7%	23.3%	
Exposed substrate	9.4%	38.2%	11.6%	15%
Cover I. discontinuous and difissive cover of vegetation	75.6%	57.8%	82.8%	77%
Cover II. Compact cover of vegetation	16.0%	2.0%	6.6%	8%

Ground materials for preparing and interpretation maps are ortho-photomaps of original scale 1:5000, part Poprad, no. 9.5, 9.6, 8.5, 8.6, 2.4, 2.5, 1.4, 1.5 (original source GEODIS s.r.o. 2003, provided by SAŽP, Banská Bystrica). We used software ArcGis 9.1 for their processing.

Results

The High Tatras Mountains are high mountain representatives of the Carpathian Mountains. In flat plan their occupancy is about 700 km^2 (at average 55 × 17 km). The landscape of the High Tatras represents high diversity of land structures of cliffs, rocky relief, water planes, dwarf-pines, compact forests and mountain meadows. Downhill courses are located in spruce and dwarf-pine and sub-alpine vegetation level, in altitude from 1,200 to 1,800 m a.s.l.

Visual impact

Downhill course represents in sense of comparative shape analogy in studied landscape types where organic forms prevail (Table 1) and traces have new shape – polygon with shape convergence to rectangle. Visual impact is supported not only by shaping of downhill course (Fig.1), but also by exposed sub-rock and sub-soil substrate on trace, which has different texture and vegetation cover (Fig. 2).

Evaluation of anthropic influence of selected downhill courses

There rises, from evaluation of abundance's proportion of exposed substrate to grass-herbal associations, prevailing abundance of exposed substrate (48%) to grass-herbal association, approximately in relation 1:1, in downhill course Veľká Lomnica – Skalnaté pleso (Štart) (Fig. 3). Cross-comparison of previous results leads us to assumption, that downhill course Tatranská Lomnica – Skalnaté pleso Lake with the highest stage of anthropic influence, causes the strongest visual impact on characteristic landscape appearance.

Downhill course Solisko, substructure analyse

IT appears from substructure of land-cover analyse that the proportion of abundance of uncovered substrate (Table 3) is similar to the relationship of those components of Hrebienok downhill course. Abounded discontinuous and diffusive vegetation cover is significant (at average 77%), which is not a suitably adequate vegetation form in the examined vegetation altitude levels, neither for its texture

Fig. 1. Area boundary of downhill course and land-cover

Fig. 2. Example from trace Skalnaté pleso – Tatranská Lomnica

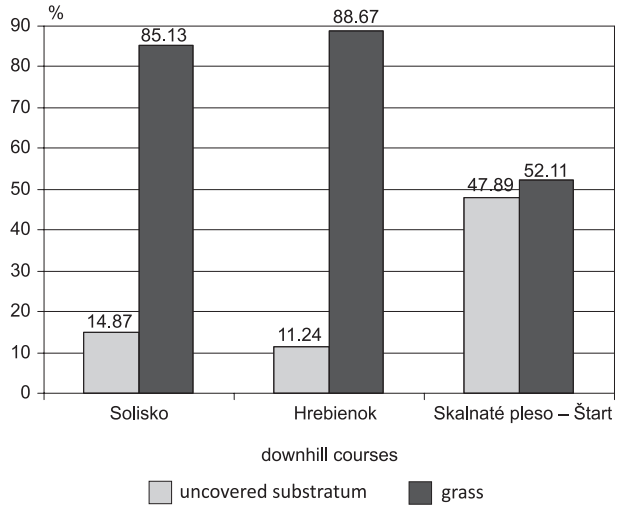

Fig. 3. Abundance of grassland associations and exposed substrate on the examined downhill courses

and colour, nor for weak functional ecological relations (apart from disturbances of biological function, that vegetation form is not suitable for substrate and micro-relief form stabilisation).

Downhill course Veľká Lomnica – Skalnaté pleso

Relation of ecological-forms classes of domain species to vertical gradient.

Destruction of vegetation on downhill trace cover presents approximately 48% and generally is supported by anthropic disturbances, which is non-homogeneous in space. It is influenced by walk-traces, terrain edges and pointed curves of downhill trace, contact follow of downhill trace with tourist walk-traces and terrain modifications of natural micro-relief (planar forms, cuts and fills). Vulnerability of vegetation cover increases with altitude level. Life forms of dominating species of plants, which are components of association, their habitus and strategy, are important to resistance of vegetation cover. From that point of view, form whole species spectrum were distinguished constant and domain species: 1- species of slip stands (S a S/R-strategies); 2 – wide-leaves grasses with high to 0.8 m (represented above by *Agrostis capillaris*) (C-S strategies) (Fig. 4); 3 – wide-leaves grasses with height of up to 1.2 m (represented above by *Calamagrostis arundinace, C. villosa*) (C strategies); 4 – narrow-leaved grasses with the height of 0.1 – 0.8 m (represented by vertical gradient of species: *Festuca rubra, Avenella flexuosa, Agrostis rupestris*) (C a S strategies); 5 – wetting-affinity species (represented by grasses like *Glyceria* sp. and *Deschampsia caespitosa*); 6 – chamaephyt (represented by species *Callua vulgaris, Vaccinium myrtillus a Vaccinium vitis-idaea*).

Downhill course Solisko

There are zoned association of species besides downhill trace and in locality of suggested variants of project, like fir and fir – spruce forests; spruce – bilberries forests; larch – limb forests; dwarf-pines. Presence of azonal alternatively intrazonal associations is supported by stagnant or flowing water. Azonal associations are connected with level of underground water and they create gradient according to the height of water level and successive state in the following order: oligotrophy to mesotrophy back waters; active high-bogs; peat-moss-limb forests + peat-moss spruce forests; water-logging spruce forests. Biotopes are of national and European value.

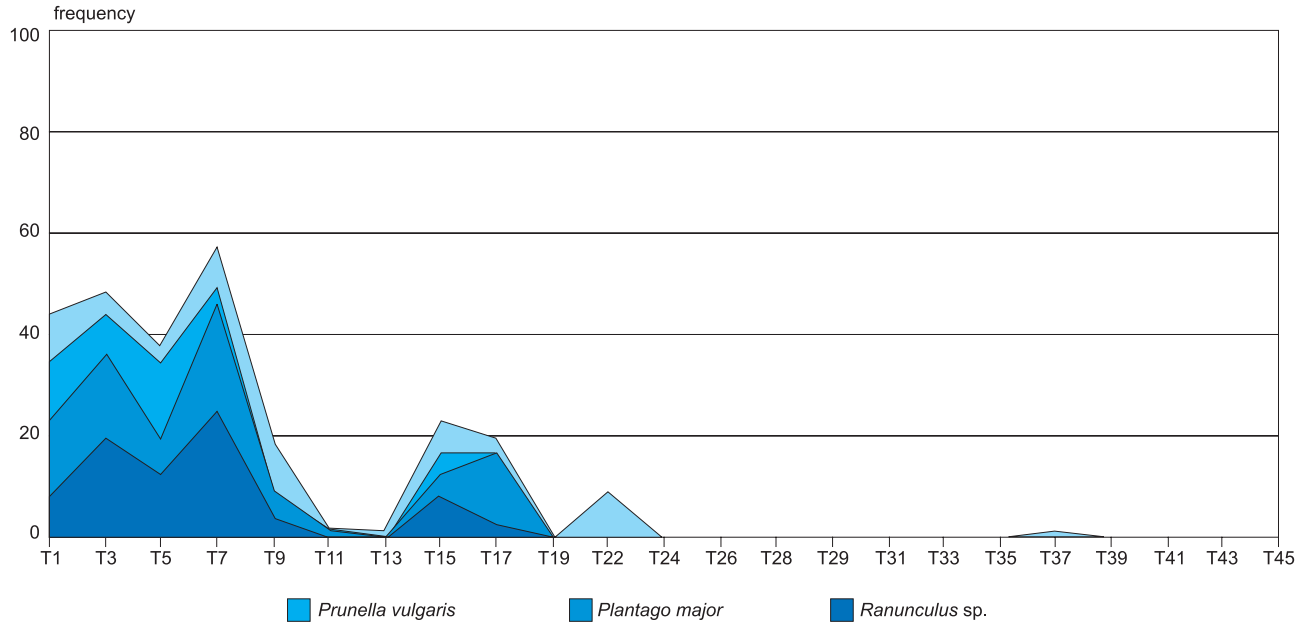

Fig. 4. Frequentation of abundance of ecological-forms classes in transects in relation to vertical altitude gradient

Comparison of associations

Downhill courses have not abounded woody level and they do not inlcude associations, which could naturally occur in studied vegetation level (Tab.1), or they occur apart from downhill trace. That is way downhill traces display with texture visibly different in surrounded forests of spruces level associations and in dwarf-pine level in altitude of 1,200 to 1,800 above see level. Here, forestry landscape with diffusive plates (fluctuations) prevail, generally of meadows' associations in landscape matrix in landscape space of Lomnický štít Peak, between Skalnaté pleso Lake and Tatranská Lomnica. Removing forest associations' forms in downhill courses also cause social detriment. Social value of biotopes is financially awarded in regulation no. 24/2003 Coll. Downhill courses are occupied by alternate grass-plant's associations. The way of winter hibernation, localisation of restoring buds and as well as life strategy of species is critical to the resistance of vegetation cover to anthropic pressure. Ecological-forms classes mentioned above (on downhill course of Tatranská Lomnica – Skalnaté Pleso Lake, Štart) create characteristic vertical gradient, beginning with associations of *Agrostis capillaris* and with high contribution of species of slip stands and meadows, at which follows zone with species of *Calamagrostis sp* kind, progressively altered by associations of chamaephyts (mostly *Calluna vulgaris* a *Vaccinium myrtillus*), there occur narrow-leaved grasses mainly in more attacking areas, in higher parts naturally, but also on the other hand, in consequence of artificial seeding.

Discussion and conclusion

Changes in term of natural mountain landscape's type are displayed not only in such a landscape, but also in far views on the one. Downhill courses are visually exposed areas with visibility of about 20–25 km. Downhill courses are foreign components with its content, shape and texture in frame of LSS's arrangement in landscape type of compact forests and dwarf-pine altitude level. The shape of component is visibly different from natural organic shapes of components and also to the ones in urban areas. They have line character with prevailing length over width and boundary as line is mostly situated on terrain edges whereas other boundaries are polygonal, with sharp edges. Texture of downhill trace has different visual attributes to natural landscape type.

We can identify important factor of downhill courses, which leads to visual impact, meanwhile we asses visual impact and confirm assumptions pronounced besides formulation of method. It is stage of anthropic influence, which rises from cross-relationship of proportion of exposed substrate and vegetation cover on downhill trace. The less vegetation cover is there, the more displays there are as a visual impact, as it is in case of downhill course of Tatranská Lomnica – Skalnaté pleso Lake (Štart) (Fig. 1, 2). There is absence of tree layer and its associations, with visibly changed texture and colour of surface in downhill course. Alternation of edifators and conditions on downhill trace lead to support of species variability of herb layer in lower part of trace, whereas in upper part species' variability is getting to equal, alternatively the number of species is lower – they consist of more resistant species of contact associations of the sub-alpine and alpine zone. Higher number of species in lower part of downhill trace is supported by immigration and conjunction of synantrophy meadow's species and species from slip stands, and that effect appears in the same manner in the surroundings of Štart startion.

Visual impact in the High Tatras Mountains is also caused by downhill course Solisko. The strongest influence on characteristic landscape appearance of that one is supported by combination of several factors: anthropic influence (at average 15% of exposed substrate and 77% of discontinuous vegetation cover), size of surface (it is the largest – 44,145 m^2), shape characteristics and trace's boundaries (convergence to rectangle, shape coefficient converges to regular geometric object). The most important are, first of all shape characteristics of downhill traces. With implementation of correct (determinate geo-ecological) design, using shape and ecosystem analogies, we can decrease level or eliminate visual impact. Intervention to landscape structures in relatively well-preserved natural associations causes also landscape-aesthetical and landscape-ecological relations, as well as financial detriment. It is related with potential assessment of unique characteristic landscape appearance of the High Tatras Mountains as demand for development of travel movement. When we consider that landscape space to be valuable and attractive from the perspective of its sports-recreation function, consequently present state requires sanation. The final state of landscape's quality requires using another shape characteristics and surface's texture of downhill trace. In particular – using curved lines and full-area plant's cover without uprising uncover substrate.

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