EVALUATION OF THE TOURIST PATH CARRYING CAPACITY IN THE BELIANSKE TATRY MTS

PETER BARANČOK, MÁRIA BARANČOKOVÁ

Institute of Landscape Ecology of the Slovak Academy of Sciences, Štefánikova 3, P.O.Box 254, 814 99 Bratislava, Slovak Republic; e-mail: peter.barancok@savba.sk, maria.barancokova@savba.sk

Abstract

Barančok P., Barančoková M.: Evaluation of the tourist path carrying capacity in the Belianske Tatry Mts. Ekológia (Bratislava), Vol. 27, No. 4, p. 401–420, 2008.

The aim of the study is to contribute to the knowledge of the path carrying capacity in the Belianske Tatry Mts and to propose the tourism regulation. We determined the criteria for the evaluation of the path carrying capacity and we created the limits and proposals for the using. This led to the criteria determination for general landscape use, which can be potentially used for the territory landscape ecological regionalization and optimization.
We evaluated 3 tourist paths localized in the territory of the fifth (the strictest) degree of protection, which are in use during the tourist season (since 16th June till 31st October). Each path was divided into separately evaluated parts. There were: a) path from the Javorina village to the Kopské sedlo saddle (educational path), b) path from the Monkova dolina valley through the Široké sedlo saddle to the Kopské sedlo saddle (educational path) and c) path through the Dolina Siedmich prameňov valley.

Key words: carrying capacity, tourist path, tourism regulation, degrees of significance, weight coefficient, limits and proposals

Introduction

The natural environment of the Belianske Tatry Mts is one of the most valuable regions in Slovakia. The Belianske Tatry Mts environment has faced much human interference, which the nature is still coping with. In the past, it was especially cattle and sheep breeding linked with deforestation, lowering of the timberline, burning of dwarf pines, devastation and erosion of alpine meadows and plains. Another negative phenomenon nowadays being in bloom again is presented by tourism. Excessive number of the tourists hiking the region causes devastating of its natural values, destroying vegetation not only on path surroundings but also on the remote sites.

Dense network of the tourist paths contribute to accelerated sheet erosion, rill erosion, wind erosion and widened cryogen processes, too. These phenomena are supported by the

fact, that the paths are not kept, stabilized and drained sufficiently. Tourist activities cause trampling of the vegetation and soil directly on the tourist paths as well as in their surroundings. There are formed new paths, the soil-conservation function of the vegetation weakens, hydrophysical soil characteristics worsen the vegetation biomass production change, etc.

Materials and methodology

Carrying capacity and attendance of the tourist paths in the Tatry Mts were evaluated especially by Havran (1970), Dubovský (1977), Drdoš (1989), Strnka, Petro (1983) and Repka (1989). Šomšák et al., (1981), Šoltésová (1982), Šoltés (1982) and Barančok (1996) studied the trampling impact on vegetation of tourist path surrounding in the Tatra Mts. Limits and tourist path carrying capacity were studied by Hrnčiarová, Altmanová (1999) and Midriak (1989). Drdoš (1982) and Repka (1982) studied the landscape synthesis and urbanization impact in the model region of the Tatranská Lomnica village. Šoltés (1985) and Šoltés, Šoltésová (1989) dealt with the carrying capacity of path surroundings. Destruction and regeneration of tourist path surface was studied by Midriak, Tomagová-Rendeková (1993) and Varšavová, Barančok (1994). Studies of Hrnčiarová, Altmanová (1982), Barančok, Varšavová (1994, 1995, 1996a, b) were focused on tourist path ecological evaluation and tourism impact on Tatra Mts environment. Some information on alpine landscape and morphodynamic process impact on the landscape is to be found in the studies of Boltižiar (2007), Hreško et al. (2003) and Hreško, Boltižiar (2001).

To evaluate the tourist path carrying capacity we took into account their selected properties as well as properties of their surroundings, which affect the carrying capacity essentially. Following criteria, which are possible to evaluate by complex reconnaissance, were taken into account: inclination of the tourist path (Table 1), inclination of the terrain relief (Table 2), resistance of rocks (Tables 3), soil erodibility (Tables 4), type of path surface (Table 5), potential for the path leaving (Table 6), damage to the surrounding vegetation – the damage was observed up to 1m from the path (Table 7), evaluation of potential erosion (relates to the surface of the tourist path, Table 8) and evaluation of resistance (understood as resistance to water or atmospheric erosion and to trampling, Table 9).

For all criteria, five degrees of significance were determined (or 5 possibilities of the criteria used for the evaluation of the path carrying capacity). Individual degrees were evaluated by the scale from 1 to 5 (value 1 = high carrying capacity, 5 = low carrying capacity). It is a numerical expression of the criteria, not absolute value of the carrying capacity.

Each criterion was assessed by weight coefficient in scale from 0.1 (the least significant criteria) to 1.0 (the most significant criteria). These evaluations of criteria emphasize the total importance of the evaluation of carrying capacity of the tourist paths. Weight coefficients were created by multi-criterial assessment.

For weight coefficient from 0.6 to 1.0, for significance degree exceeding value 4, limiting value (LV) was evaluated (i.e. value increasing overall point evaluation). Degree of significance exceeding value 4 is the criterion limiting path use, as its carrying capacity is decreasing. Therefore, along path carrying capacity value, also limiting value was taking into account, i.e. criteria value is affected by the following values:

Weight coefficient	Point evaluation (degree of significance)	Value impacting the total point evaluation
0.8 or 0.9	4 up to 4.4	**0.5**
0.6 or 0.7	5	**1.0**
0.8 or 0.9	4.5 up to 5	**1.5**
1.0	4 up to 4.4	**1.5**
1.0	4.5 up to 5	**2.0**

Another step in the evaluation of path carrying capacity comprised evaluation of path carrying capacity rate according to Dubovský (1977), taking into account only path parameters as length, width, duration of ascent in min., duration of start hike in min., daily turnout, attendance, not biotic and abiotic properties of its surroundings.

$$UD = d : t.Dt.s.N : 10000 = \frac{d.Dt.s.N}{t.10000}$$

d – length of the path in m, s – width of the path in m, t – duration of ascent in min., Dt – duration of start hike in min., UD – daily turnout (number persons), N – attendance: exceptional attendance (500/1000 persons for 1 ha of functional area), middle tolerable attendance (250/500 persons for 1 ha of functional area), tolerable attendance (100/200 persons for 1 ha functional area) and theoretical maximum (1250/- persons for 1 ha of functional area).

The daily turnout (UD) and attendance (N) were calculated as follows:

1) determining all path parameters (length, width, etc.);
2) on the base of accessible data (data on attendance since 1976 to 1999 – provided by TANAP, published and original data) average daily turnout (UD_p) was estimated followed by calculation of attendance (N) per functional area of the path (P) – formula A;

$$\text{A} \qquad N = \frac{UD_p.t.10000}{d.Dt.s}$$

3) determining of tolerable daily turnout (UD_{PR}) according to the criteria in Tables 1–9 and by comparison with Drdoš (1989) and Midriak (1989). Hereby, limits (L) of person per functional path area were determined. Each part of the path has its limit to preserve recreation value and nature protection (by the computation of tolerable daily turnout N = L) – formula B;

$$\text{B} \qquad UD_{PR} = \frac{d.Dt.s.L}{t.10000}$$

Following criteria for tourist paths were set:

T a b l e 1. Inclination of the tourist paths.

Weight coefficient	Marking	Category	Verbal evaluation	Degree of significance (point evaluation)
1.0	a)	0–7°	low inclination	1
	b)	7°1´–12°	middle inclination	2
	c)	12°1´–17°	great inclination	3
	d)	17°1´–25°	very great inclination	4
	e)	over 25°	steep inclination	5

T a b l e 2. Inclination of the terrain relief.

Weight coefficient	Marking	Category	Verbal evaluation	Degree of significance (point evaluation)
0.8	a)	0–7°	low inclination	1
	b)	7°1´–12°	middle inclination	2
	c)	12°1´–17°	high inclination	3
	d)	17°1´–25°	very high inclination	4
	e)	over 25°	steep inclination	5

T a b l e 3. Resistance of the rocks.

Weight coefficient	Marking	Category – verbal evaluation	Degree of significance (point evaluation)
0.6	I.	very strongly resistant rocks Baboš Quartzites (*Jurassic-Sinemurian*), conglomerates, quartzose sandstones, quartzites (*Triasic-Scythian*)	1
	II.	strongly resistant rocks glaciofluvial and glaciogene deposits (*Pleistocene*), Muráň Limestones (*Cretaceous-Lower Aptian*), red bedded to thick-bedded nodular limestones (*Jurassic-Lower Tithonian*)	2
	III.	medially resistant rocks light-coloured pelitic limestones and spotted marls (*Tthonian-Cenomanian*), radiolarites, radiolarian limestones (*Bajocian-Kimmeridgian*), Allgäu Member (*Sinemurian-Lower Bajocian*), Kopienic Member (*Upper Rhetian-Sinemurian*), Fatra Formation (*Rhetian*), Ramsau Dolomites (*Ladinian-Carnian*), Gutenstein Member (*Anissian*), coarse conglomerates and breccias (*Paleogene*)	3
	IV.	little resistant rocks Werfenian Formation (*Upper Scythian*), Paleogene flysch Formation, Quarternary deluvial-proluvial sediments	4
	V.	very little resistant rocks Carpathian Keuper (*Norian-LowerRhetian*), claystone lithofacies with rare sandstones and fine conglomerates, deluvial loams, talus, slopes	5

T a b l e 4. Soil erodibility.

Weight coefficient	Marking	Category – verbal evaluation	Degree of significance (point evaluation)
0.7	I.	very highly erodible soils Eutric Fluvisols (FMm), Stagno-gleyic Cambisols (KMg)	1
	II.	highly erodible soils Cambic Podzols (KMp)	2
	III.	medially erodible soils Eutric Cambisols (KMm) Eutric Cambisols (KMv), Lithic Leptosols (LIm), Histi-Lipthic Leptosols (LIo), Haplic Podzols (PZm), Foli-Skeletic Leptosols (RNo), Foli-Rendzic Leptosols (RAo)	3
	IV.	easily erodible soils Calcaric Cambisols (PRk), Calcaric Cambisols (PRm), Cambi-Eutric Leptosols (RNk), Skeletic Leptosols (RNm), Umbric Leptosols (RNp), Rendzic Leptosols (RAk), Rendzic Leptosols (RAq), Rendzic Leptosols (RAm), Skeli-Rendzic Leptosols (RAj)	4
	V.	very easily erodible soils Anthropic Regosols (KTk, KTm)	5

T a b l e 5. Type of path surface.

Weight coefficient	Mark-ing	Category – Verbal evaluation	Degree of significance (point evaluation)
0.9	a)	adjusted path surface (solidified, asphalted)	1
	b)	adjusted path made of great stones	2
	c)	deeper bared soil with a higher stoniness	3
	d)	shallow bared stony soil	4
	e)	bared soil with vegetation rests and stone admixture	5

T a b l e 6. Potential for the path leaving.

Weight coefficient	Marking	Category – verbal evaluation	Degree of significance (point evaluation)
0.1	a)	terrain configuration does not allow to leave the path	1
	b)	path leaving hardly possible	2
	c)	path leaving possible but limited	3
	d)	easy path leaving	4
	e)	terrain configuration attracts to leave the path	5

T a b l e 7. Damage to the surrounding vegetation.

Weight coefficient	Marking in degrees	Category – verbal evaluation	Degree of significance (point evaluation)
0.6	1	vegetation is not damaged by trampling	1
	2	vegetation is damaged up to 25% by trampling	2
	3	vegetation is damaged up to 50% by trampling	3
	4	vegetation is damaged up to 75% by trampling	4
	5	total devastation of the plant cover	5

T a b l e 8. Evaluation of potential erosion.

Weight coefficient	Marking in degrees	Category – verbal evaluation	Degree of significance (point evaluation)
0.3	1	very low potential erosion	1
	2	low potential erosion	2
	3	middle potential erosion	3
	4	high potential erosion	4
	5	very high potential erosion	5

Potential erosion (water and wind) is linked only to the path (or, in the case of erosion caused by path shortening, to its surrounding). We evaluated it on the base of path and relief inclination as stated in Hrnčiarová, Altmanová (1982), where sheet, linear and lateral erosion are taken into account. Potential erosion is classified into 5 degrees, where degree 1 refers to very small potential erosion, while that of 1 to the very intensive erosion.

T a b l e 9. Evaluation of resistance.

Weight coefficient	Marking	Category – verbal evaluation	Degree of importance (point evaluation)
0.4	1.	very low resistance	5
	2.	low resistance	4
	3.	middle resistance	3
	4.	intensive resistance	2
	5.	very intensive resistance	1

Resistance is immunity to the external impact and it is understood as one of the stability types. We evaluated path surrounding vegetation resistance to water and wind erosion and trampling. Resistance was classified into 5 degrees, where degree 1 refers to very low resistance (weak vegetation stability), while degree 5 to the very intensive resistance (high vegetation stability).

To evaluate the erosion, we used the study of Midriak (1978), who used 6-member scale (erosion intensity 0–15 mm/year). Property as inclination, substrate, soil, precipitation, altitude, wind, vegetation cover, type of plant communities etc. are taken into account.

On the basis of this, we determined the scale of the path carrying capacity. Values to the individual categories were divided evenly from the range 5.4–27.0. Individual categories were set as follows: path with very high carrying capacity (5.40–9.72 points), path with high carrying capacity (9.73–14.04), path with middle carrying capacity (14.05–18.36), path with low carrying capacity (18.37–22.68) and path with very low carrying capacity (22.69–27.00). Such evaluation presents only mechanical calculation. For total path evaluation it is necessary to take into account limiting factors and total possibility of the paths use.

Overall rate of tolerable load was evaluated as follows:

- very high carrying capacity – tolerable daily turnout (UD_{PR}) 300 up to 500 persons/day;
- high carrying capacity – tolerable daily turnout (UD_{PR}) 150 up to 300 persons/day;
- middle carrying capacity – tolerable daily turnout (UD_{PR}) 100 up to 150 persons/day;
- low carrying capacity – tolerable daily turnout (UD_{PR}) 50 up to 100 persons/day;
- very low carrying capacity – tolerable daily turnout (UD_{PR}) 50 persons/day.

We divided the paths into several parts that were evaluated individually. It follows the fact that every part has similar character and properties (surface, width, slope, surrounding, etc.)

Results and discussion

Nowadays, there are used three tourist paths in the Belianske Tatry Mts (during the tourist season since June, 16th till October, 31st) located in the territory with fifth degree of the protection (Fig. 1):

- path from the Javorina village trough the Zadné Meďodoly valley to the Kopské sedlo saddle (1750.2 m a.s.l.) – blue tourist sign;
- path from the Ždiar village trough the Monkova dolina valley, the Široké sedlo saddle (1825.5 m a.s.l.) to the Kopské sedlo saddle (1750.2 m a.s.l.) – green tourist sign;
- path from the Tatranská Kotlina village through the Dolina Siedmich prameňov valley to Plesnivec hut (1290 m a.s.l.) through the Biele pleso tarn to the Kopské sedlo saddle (1750.2 m a.s.l.) – green and blue tourist signs.

Fig. 1. Tourist paths in the Belianske Tatry Mts.

Fig. 2. Path quality on the locality of the Poľana pod Muráňom.

a) Path Javorina village (1000 m a.s.l.) – Kopské sedlo saddle (1750.2 m a.s.l.)

Javorina village (1000 m a.s.l.) – Poľana pod Muráňom locality (1083.3 m a.s.l.) – Zadné Meďodoly valley (1397.8 m a.s.l.) – Kopské sedlo saddle (1750.2 m a.s.l.)

In 2007–2008 it undertook reconstruction and it serves as an educational tourist path since June 18, 2008.

This path leads from the Javorina village to the Poľana pod Muráňom locality (Fig. 2) concurrently with the path to the Javorová dolina valley. Tourists use this path part during all tourist season and without limitation.

Quarternary sediments create the path from Poľana pod Muráňom locality to Bránky gorge. They are characteristic by high permeability creating suitable conditions for infiltration of atmospheric precipitations. Unfavourable conditions for accumulation of the underground water cause that infiltrated water flows quickly through glaciogene and talus sediments in the form of the overground flow and it appears on the surface again as the springs (1100 m a.s.l.). Gutenstein limestones create the path from the Bránky gorge. They

Fig. 3. Path quality in the Zadné Meďodoly locality.

have high carrying capacity and they are strong and very little compressible in the untouched form. They are weatherproof, but soluble, so they are subjected to carstification.

From the altitude of about 1500 m a.s.l. the path enters to varied and characteristic territory of the Belianske Tatry Mts (Fig. 3). Initial part of the path is created by Werfenian sediments (variegated loamy shales, sandstones, marly shales, limestones). In the intact form they resist the water impact however after being weathered and water saturated, they easily disintegrate and get properties of the plastic pelites. Werfenian sediments are resistant weakly, quickly weathering and creating the erosion furrows. These sediments build the depression of the Kopské sedlo saddle (Figs 4, 5).

Evaluation of surface carrying capacity of this path and determination of the limits

The length of the path is 8800 m. We divided it into four separately evaluated parts (Table 10):

Fig. 4. The end of the path under the Kopské sedlo saddle (1750.2 m a.s.l.).

Fig. 5. Kopské sedlo saddle (1750.2 m a.s.l.).

- 1 – the Javorina village (1000 m a.s.l.) – Poľana pod Muráňom locality (1083.3 m a.s.l.), length 2200 m;
- 2 – Poľana pod Muráňom locality (1083.3 m a.s.l.) – spring in the Zadné Meďodoly (1397.8 m a.s.l.), length 3700 m;
- 3 – spring in the Zadné Meďodoly (1397.8 m a.s.l.) – Predný žľab groove (1525 m a.s.l.), length 1800m;
- 4 – Predný žľab groove (1525 m a.s.l.) – Kopské sedlo saddle (1750.2 m a.s.l.) length 1100 m.

T a b l e 10. Criteria for the evaluation of the Javorina village – Kopské sedlo saddle path.

Part of path	Evaluation of the path by Tables 1–9								
	1.	2.	3.	4.	5.	6.	7.	8.	9.
1	a	a	II.	I.	a	c	1	1	4a, 5b, 4c
2	b	B–c	III.	I.–III.	b	d	1	2	3a, 4b, 4c
3	b	B–c	IV.	II.–III.	c	d	1–2	3	3a, 4b, 3c
4	b–c	d	III.–IV.	III.–IV.	d	c	1–2	4	3a, 4b, 2c

Point evaluation

1. part = 1x1.0 + 1x0.8 + 2x0.6 + 1x0.7 + 1x0.9 + 3x0.1 + 1x0.6 + 1x0.3 + 1.7x0.4 + LV = 6.48 point + 0 = **6.48 points (path with very high carrying capacity)**
2. part = 2x1.0 + 2.5x0.8 + 3x0.6 + 2x0.7 + 2x0.9 + 4x0.1 + 1x0.6 + 2x0.3 + 2.3x0.4 + LV = 11.52 point + 0 = **11.52 points (path with high carrying capacity)**
3. part = 2x1.0 + 2.5x0.8 + 4x0.6 + 2.5x0.7 + 3x0.9 + 4x0.1 + 1.5x0.6 + 3x0.3 + 2.7x0.4 + LV = 14.13 point + 0 = **14.13 points (path with middle carrying capacity)**
4. part = 2.5x1.0 + 4x0.8 + 3.5x0.6 + 3.5x0.7 + 4x0.9 + 3x0.1 + 1.5x0.6 + 4x0.3 + 3x0.4 + LV = 17.45 point + 1.0 = **18.45 points (path with low carrying capacity)**

Note: LV – limiting value

To evaluate the rate of the path carrying capacity we followed the computation of Dubovský (1977). The path was divided into three parts as each part has different carrying capacity and parameters (length, width, etc.). Individual parts do not reach 1 ha of functional area, so attendance was calculated for available functional area. Total area of the path is 1.25 ha.

Limits of number of persons and tolerable daily turnout were determined as follows: UD_P – average daily turnout since 1976 to 1999, N – attendance calculated according to Dubovský (1977) for 1 ha of functional area and N_P – attendance calculated for given paths functional area (Table 11).

Generally, high attendance can be stated, particularly in the alpine part reaching not acceptable values from nature protection point of view.

On the base of the criteria (Tables 1–9) and the conditions set for the carrying capacity keeping we determined the limits for number of visitors per corresponding path functional area. From this limit, overall tolerable daily turnout is derived (Table 11).

T a b l e 11. Limits of number of persons and tolerable daily turnout for the Javorina village to the Kopské sedlo saddle path.

Quantity		1. part	2. part	3.–4. parts
UD_p	average daily turnout	620	370	280
N	attendance for 1 ha of functional area	51	89	282
Np	attendance for path area	28	49	41
L	proposed limits	14–23	20–40	15
UD_{PR}	daily turnout – tolerable	308–506	150–300	103
UD_{PR}	adjusted	300–500	150–300	100

From the calculated values results, that tolerable daily turnout in the first part of the path can be 300 up to 500 persons per day. This number is often overstepped, especially in the tourist season (during nice and sunny days). This part of the path is used by the tourists aiming to the Javorová dolina valley and by those hiking to the Poľana pod Muráňom locality and returning to the Javorina village.

For the second part of the path the tolerable daily turnout can be 150 up to 300 persons per day. This number is overstepped too, especially during nice and sunny days. The tourist intensity is uneven. The highest load is during the morning.

Third and fourth parts (from the Zadné Meďodoly locality by spring to the Kopské sedlo saddle) present the limit for all paths. Third part of the path yields middle carrying capacity while the fourth low carrying capacity. For both parts tolerable daily turnout of 100 persons per day was estimated. It presents very vulnerable and sensitive part situated to the alpine environment.

It is improbable that some of the tourists, who reach the end of the second part, will come back. Therefore, we propose to keep their number for the first part and to reduce it for the second to the value of 50 (maximum 100 persons per day).

b) Path Monkova dolina valley – Široké sedlo saddle (1825.5 m a.s.l.) – Kopské sedlo saddle (1750.2 m a.s.l.)

Ždiar village (896 m a.s.l.) – Monkova dolina valley – Široké sedlo saddle (1825.5 m a.s.l.) – Kopské sedlo saddle (1750.2 m a.s.l.)

This path leads from the Hotel Magura in the Ždiar village up the Monkova dolina valley to the Široké sedlo saddle (Figs 6, 7) and through the south slope of the Hlúpy vrch peak up to the Kopské sedlo saddle. It is an educational tourist path, open since July 1, 1993 as one-direction tourist path. Its length is 6250 m and superelevation 1033 m. To use the path, operation rules and limits were declared at its opening.

The path begins in the fluvial deposits of the Rígeľský potok stream and continues through the glaciofluvial sandy coarse of the narrow terrace. These sediments are characteristic by high permeability, accumulation of the groundwater and low distribution of the material. It is followed by Ramsau Dolomites. This path part has a steep terrain and trampled vegetation. During high precipitation, denudation of the slope materials occurs.

Fig. 6. Široké sedlo saddle (1825.5 m a.s.l.).

Fig. 7. The path to the Monkova dolina valley.

Fig. 8. Sedlo pod Hlúpym saddle (1933.5 m).

Passing large talus cone, path substratum is replaced by light-coloured pelitic limestones and Muráň Limestones.

The base of the Široké sedlo saddle and the Sedlo pod Hlúpym saddle (Fig. 8) is formed by Carpathian Keuper (variegated shales and sandy shales, sandstones, quartzites, fine conglomerates, yellowish dolomites, carbonate conglomerates). This variegated formation is very sensitive to the exogenous atmospheric factors and predisposed to depression formation. Slopes have low stability and considerable inclination to landslides. This formation is water impermeable and water flow on the surface creates erosion rills. Both saddles are attended very frequently (dispersal of the tourists and creation of the parallel paths).

The path from the Široké sedlo saddle continues through Fatra Formation, Kopienec Member and Baboš Quartzites. The part formed by Baboš Quartzites has unstable scree character. It is damaged by avalanches, water, landslides, erosion as well as trampling.

Evaluation of path surface carrying capacity and determination of the limits

The length of the path is 6250 m and we divided it into four separately evaluated parts (Table 12):

- 1 – Hotel Magura (900 m a.s.l.) – Strednica locality (920 m a.s.l.), length 1100 m;

- 2 – Strednica locality (920 m a.s.l.) – Široké sedlo sadle (1825.5 m a.s.l.), length 3750 m;
- 3 – Široké sedlo saddle (1825.5 m a.s.l.) – Sedlo pod Hlúpym saddle (1933.5 m a.s.l.), length 625 m;
- 4 – Sedlo pod Hlúpym saddle (1933.5 m a.s.l.) – Kopské sedlo saddle (1750.2 m a.s.l.) length 775 m.

T a b l e 12. Criteria for evaluation of the Monkova dolina valley – Široké sedlo sadle – Kopské sedlo saddle path.

Part of path	Evaluation of the path by Tables 1–9								
	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	a	a	III.	I.	b	d	1–2	1	4a, 5b, 4c
2.	c–d	c–e	II., III., IV.	I., II., III.–IV.	c–e	c	2	5	3a, 4b, 2c
3.	c	d	V.	III.–IV.	d–e	c, e	2–3	4	3a, 4b, 2c
4.	c–d	c–d	III., V.	III.–IV.	d–e	d–e	2	4	3a, 4b, 3c

Point evaluation

1. part = 1x1.0 + 1x0.8 + 3x0.6 + 1x0.7 + 2x0.9 + 4x0.1 + 1.5x0.6 + 1x0.3 + 1.7x0.4 + LV = 8.38 point + 0 = **8.38 points (path with very high carrying capacity)**
2. part = 3.5x1.0 + 4x0.8 + 3x0.6 + 3.4x0.7 + 4x0.9 + 3x0.1 + 2x0.6 + 5x0.3 + 3x0.4 + LV = 18.68 point + 1,0 **= 19.68 points (path with low carrying capacity)**
3. part = 3x1.0 + 4x0.8 + 5x0.6 + 3.5x0.7 + 4.5x0.9 + 4x0.1 + 2.5x0.6 + 4x0.3 + 3x0.4 + LV = 19.73 point + 3,0 = **22.73 points (path with very low carrying capacity)**
4. part = 3.5x1.0 + 3.5x0.8 + 4x0.6 + 3.5x0.7 + 4.5x0.9 + 4.5x0.1 + 2x0.6 + 4x0.3 + 2.6x0.4 + LV = 19.09 point + 1.5 = **20.59 points(path with low carrying capacity)**

Note: LV – limiting value

To estimate the rate of the path carrying capacity, we followed the computation of Dubovský (1977) again. The path was divided into three parts, as every part has different carrying capacity and parameters. The area path is 0.4225 ha.

On the base of the criteria (Tables 1–9) and the conditions set for the carrying capacity keeping we determined the limits for number of visitors per corresponding paths functional area. From this limit, overall tolerable daily turnout is derived (Table 13).

T a b l e 13. Limits for number of persons and tolerable daily turnout for the path Monkova dolina valley – Široké sedlo saddle – Kopské sedlo saddle.

Quantity		1. part	2. part	3.–4. parts
UD_P	average daily turnout	220	130	130
N	attendance for 1 ha of functional area	67	195	174
Np	attendance for path area	11	37	12
L	proposed limits	15	14–28	5 (9)
UD_{PR}	daily turnout – tolerable	300	50–100	53 (96)
UD_{PR}	Adjusted	300	50–100	50 (100)

At the preparation and opening (in 1993) of this path, limits for daily turnout of the tourists were set. This limit was 100 persons per day and later on it was adjusted to 150 persons per day. This was set on the assumption of increased care of tourist path (especially their surface). This limit is not kept and daily turnout reaches over 200 persons per day. It is a very high number and it is not acceptable concerning the character of the natural environment, importance of all territory or path properties.

Therefore we propose to limit the high-mountain environment attendance here to the value of 50 or at maximum to 100 persons per day. Daily turnout 50 persons are based on assumption that there will be no high tourist concentration impacting the territory fauna (especially marmots and chamois).

During rainy days the susceptibility of the paths to mechanic degradation is increased. Various erosion impacts of the flowing water are expressed and the parallel paths or short cuts are formed. The most obvious devastation takes place in the Široké sedlo saddle and the Sedlo pod Hlúpym saddle. These sites encounter high concentrations of the tourists as it offers impressive landscape views having negative impact on a wider surrounding.

c) Path through the Dolina Siedmich prameňov valley

Tatranská Kotlina village (760 m a.s.l.) – Šumivý prameň spring (856.9 m a.s.l.) – Plesnivec hut (1290 m a.s.l.) – Veľké Biele pleso tarn (1612 m a.s.l.) – Predné Kopské sedlo saddle (1835 m a.s.l.) to Kopské sedlo saddle (1750.2 m a.s.l.)

This path leads from the Tatranská Kotlina village through the Šumivý prameň spring to the Plesnivec hut. Then is goes on along the Veľké Biele pleso tarn up to the Predné Kopské sedlo saddle and it ends in the Kopské sedlo saddle.

The path begins in the glaciofluvial coarse, continues through deluvial-fluvial (slope wash) loams and sandy loams, but also deluvial-proluvial loamy-gravelly sediments with abundant debris (periglacial-dejection cone). From the Šumivý prameň spring the path narrows down, crosses the glade and enters to the wood. Path severity is relatively low as it copies the line level. There are Werfenian Formation, Ramsau Dolomites, Carpathian Keuper, Kopienic Member (gray organodetrital limestones, dark-gray marly shales, calcareous sandstones, sandy-crinoidal and oolitic limestones) and Baboš Quartzites.

The Plesnivec hut (1290 m a.s.l.) is situated on the Allgäu Member (siliceous spotted limestones, gray spotted marly limestones, marls and shales with spongolites) under the Skalné vráta peak (1619.8 m a.s.l.). Then the path passes through the Rakúska poľana locality, the Valley of Napájadlový potok and enters to the Dolina Bielych plies valley. This area is created by periglacial-dejection cone, Allgäu and Kopieniec Members and the Dolina Bielych plies valley is located on the glaciogene moraine sediments. From this place the path continues to the Kopské sedlo saddle (1750.2 m a.s.l.)

Evaluation of path surface carrying capacity and determination of the limits

The path length is 11500 m and we divided it into six separately evaluated parts (Table 14):

- 1 – Tatranská Kotlina village (760 m a.s.l.) – Šumivý prameň spring (850 m a.s.l.), length 1300 m;
- 2 – Šumivý prameň spring (850 m a.s.l.) – Plesnivec hut (1290 m a.s.l.), length 4950 m;
- 3 – Plesnivec hut (1290 m a.s.l.) – Rakúska poľana locality(1410 m a.s.l.), length 1400 m;
- 4 – Rakúska poľana locality (1410 m a.s.l.) – Biele pleso tarn (1615.4 m a.s.l.), length 2600 m;
- 5 – Biele pleso tarn (1615.4 m a.s.l.) – Predné Kopské sedlo saddle (1778 m a.s.l.), length 950 m;
- 6 – Predné Kopské sedlo saddle (1778 m a.s.l.) – Kopské sedlo saddle (1750.2 m a.s.l.), length 300 m.

T a b l e 14. Criteria for the evaluation of the Dolina Siedmich prameňov valley path.

Part of path	Evaluation of the path by Tables 1–9								
	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	b	b	II.	III.	b	c	1	2.	3a, 4b, 4c
2.	b–c	c–d	III.–V.	III.–IV.	c–d	b–c	2	3	3a, 4b, 4c
3.	c–d	d	III.	II.–IV.	c–d	b	1	3	3a, 4b, 3c
4.	b	b	II.	II.–IV.	c–e	d	2	2	4a, 5b, 3c
5.	c–e	d–e	III.	III.–IV.	d	c	2	4	2a, 4b, 2c
6.	a	a–b	IV.	III.–IV.	d–e	d–e	2–3	5	2a, 4b, 1c

Point evaluation

1. part = 2x1.0 + 2x0.8 + 2x0.6 + 3x0.7 + 2x0.9 + 3x0.1 + 1x0.6 + 2x0.3 + 2.3x0.4 + LV = 11.12 point + 0 = **11.12 points (path with high carrying capacity)**
2. part = 2.5x1.0 + 3.5x0.8 + 4x0.6 + 3.5x0.7 + 3.5x0.9 + 2.5x0.1 + 2x0.6 + 3x0.3 + 2.3x0.4 + LV = 16.57 point + 0 = **16.57 points (path with middle carrying capacity)**
3. part = 3.5x1.0 + 4x0.8 + 3x0.6 + 3.2x0.7 + 3.5x0.9 + 2x0.1 + 1x0.6 + 3x0.3 + 2.6x0.4 + LV = 16.63 point + 0.5 = **17.13 points (path with middle carrying capacity)**
4. part = 2x1.0 + 2x0.8 + 2x0.6 + 3x0.7 + 4x0.9 + 4x0.1 + 2x0.6 + 2x0.3 + 2x0.4 + LV = 12.80 point + 0.5 = **13.30 points (path with high carrying capacity)**
5. part = 4x1.0 + 4.5x0.8 + 3x0.6 + 3.5x0.7 + 4x0.9 + 3x0.1 + 2x0.6 + 4x0.3 + 3.3x0.4 + LV = 19.47 point + 3.5 = **22.97 points (path with very low carrying capacity)**
6. part = 1x1.0 + 1.5x0.8 + 4x0.6 + 3.5x0.7 + 4.5x0.9 + 4.5x0.1 + 2.5x0.6 + 5x0.3 + 3.6x0.4 + LV = 15.99 point + 1.5 = **17.45 points (path with middle carrying capacity)**

Note: LV – limiting value

To estimate the rate of the path carrying capacity, we followed the computation of Dubovský (1977) again. The path was divided into three parts, as every part has different carrying capacity and parameters. The area path is 1 ha.

On the base of the criteria (Tables 1–9) and the conditions set for the carrying capacity keeping we determined the limits for number of visitors per corresponding paths functional area. From this limit, overall tolerable daily turnout is derived (Table 15).

T a b l e 15. Limits of number persons and tolerable daily turnout for the path Dolina Siedmich prameňov valley.

Quantity		1.–2. parts	3.–4. parts	5.–6. parts
UD_P	average daily turnout	220	200	250
N	attendance for 1 ha of functional area	67	176	250
Np	attendance for path area	33	35	16
L	proposed limits	15–30	15–30	3 (7)
UD_{PR}	daily turnout – tolerable	100–200	85–170	48 (112)
UD_{PR}	adjusted	100–200	90–170	50 (110)

For the first two path parts it is necessary to regulate the number of visitors to 170 up to 200 per day. This number is necessary to control and to respect because there are sites where number of tourists should be decreased even more. The highest concentration is in the surrounding of the Biele pleso tarn and former Kežmarská chata hut (burn out in 1973). This site is important as several paths meet here.

The part between the Biele pleso tarn and the Kopské sedlo saddle is another site with high tourist concentration. Considering its state and properties the number of tourists should be reduced to 50 per day. Actual number is much higher - during summer days it exceeds that value 12 times. Therefore, this part is decisive for planning of the tourist activities in this territory and for tolerable daily turnout.

Conclusion

The length of tourist paths in the Belianske Tatry Mts is 26.5 km. Estimating their carrying capacity we found that 3300 m (12.4%) is classified into the category "very high carrying capacity" with proposed attendance 500 persons/day at maximum. 7600 m (28.6%) belong to the category "high carrying capacity" and we propose the maximal attendance 300 persons/day. 8450 m (31.8%) present category "middle carrying capacity" and there we propose max. 150 persons a day. The rest comprises path parts with low and very low carrying capacity (7200 m, 27.2%). In these cases we propose the attendance of about 50 or at the maximum 100 persons/day. Respecting of such proposals is essential concerning the Belianske Tatry Mts nature protection and regeneration.

Translated by J. Kollár and the authors

Acknowledgements

The work was supported from the grant GP No. 2/6081/26 Phytocoenological and ecological characteristic of the timberline forests of the Western Carpathians high mountains – Swiss stone pine – spruce forests).

References

Barančok, P., 1996: Changes in the representation of the selected plant species on the trampling sites of the surrounding of tourist path in the Belianske Tatry Mts (in Slovak). In Eliáš, P. (ed.), Plant population biology IV. SEKOS, Nitra-Bratislava, p. 90–92.

Barančok, P., Varšavová, M., 1994: Ecological evaluation of the potential impacts by the opening of educational tourist path in the Belianske Tatry Mts (in Slovak). In Machová, Z. (ed.), Prírodná časť krajiny, jej výskum a návrhy na využitie. Zborník referátov z konferencie, Katedra fyzickej geografie Prírodovedeckej fakulty UK, Bratislava, p. 79–81.

Barančok, P., Varšavová, M., 1995: Ecological impacts of the opening of the educational tourist path on the environment of the Belianske Tatry Mts (in Slovak). In Kovář, S., Härtel, H. (eds), Zprávy ČBS 30, Materiály 12 (Využití terénní botaniky v ekologii krajiny), Praha, p. 141–143.

Barančok, P., Varšavová, M., 1996a: The influence of tourism on the natural environment of the Belianske Tatry Mountains investigated on an educational hiking path situated in the locality Monkova dolina Kopské sedlo and its near surroundings. Ekológia (Bratislava), *15,* 4: 469–473.

Barančok, P., Varšavová, M., 1996b: Impact of tourism on the nature environment of the Belianske Tatry Mts on the educational hiking path Monková dolina valley–Kopské sedlo saddle and its near surroundings (in Slovak). In Hrnčiarová, T. (ed.), Celostnosť-syntéza-ochrana. ÚKE SAV, Bratislava, p. 83–84.

Boltižiar, M., 2007: Structure of Tatra Mts high-mountain ladscape (large-scaled mapping, change analysis and estimation applying remote sensing data) (in Slovak). Fakulta prírodných vied Univerzity Konštantína Filozofa, Nitra, 248 pp.

Drdoš, J., 1982: Landscape synthesis for modeling solution of the Tatranská Lomnica and its hinterland (in Slovak). Zborník prác o Tatranskom národnom parku: *23*: 233–256.

Drdoš, J., 1989: Tolerable load of visiting frequency in the Tatra National Park (in Slovak). Zborník prác o Tatranskom národnom parku, *29*: 191–237.

Harvan, L., 1970: Carrying capacity of the natural environment from the viewpoint of its using by tourism in the Tatra National Park (in Slovak). Zborník prác o Tatranskom národnom parku, *12*: 267–274.

Hreško, J., Boltižiar, M., 2001: The influence of the morphodynamic processes to landscape structure in the high mountains (Tatra Mts.). Ekológia (Bratislava), *20*, Suppl. 3: 141–148.

Hreško, J., Boltižiar, M., Bugár, G., 2003: Spatial structures of geomorphic processes in high-mountain landscape of the Belianske Tatry Mts. Ekológia (Bratislava), *22*, Suppl. 3: 341–348.

Hrnčiarová, T., Altmanová M., 1982: Ecological evaluation of the tourist paths in central part of the Nízke Tatry Mts (in Slovak). ÚEBE CBEV SAV, Bratislava, 26 pp.

Hrnčiarová, T., Altmanová M., 1999: Impact of the high-mountains landscape by localization of the tourist paths (in Slovak). In T. Hrnčiarová, Z. Izakovičová (eds), Krajinnoekologické plánovanie na prahu 3. tisícročia. Ústav krajinnej ekológie SAV, Bratislava, p. 240–247.

Midriak, R., 1978: Potential erosion intensity in the Tatry Mts (in Slovak). Zborník prác o Tatranskom národnom parku, *20*: 93–114.

Midriak, R., 1989: Load limits on tourist footpaths in the Tatra National Park with regard to the destruction of their surface (in Slovak). Zborník prác o Tatranskom národnom parku, *29*: 239–251.

Midriak, R., Tomagová-Rendeková, R., 1993: Destruction and regeneration of the surface of a high-mountain tourist path in Belianske Tatry Mts (in Slovak). Zborník prác o Tatranskom národnom parku, *33*: 87–110.

Repka, S., 1982: Study of urbanization effects on the nature of the Tatranská Lomnica model territory (in Slovak). Zborník prác o Tatranskom národnom parku, *23*: 257–294.

Repka, S., 1989: Urbanistic-landscape bases for determining a tolerable visiting frequency for TANAP (in Slovak). Zborník prác o Tatranskom národnom parku, *29*: 335–358.

Strnka, M., Petro, I., 1983: Recording of visiting frequency at the TANAP on August 6 through 8, 1981 (in Slovak). Zborník prác o Tatranskom národnom parku, *24*: 189–240.

Šoltés, R., 1982: Anthropogenic effects on Bryophytes in the model territory of Tatranská Lomnica (in Slovak). Zborník prác o Tatranskom národnom parku, *23*: 107–121.

Šoltés, R., 1985: Bearing capacity of the environs of tourist paths in the High Tatras from the aspect of the vegetation cover (in Slovak). Zborník prác o Tatranskom národnom parku, *26*: 97–152.

Šoltés, R., Šoltésová, A., 1989: Bearing capacity of the environs of tourist paths in the Tatra National Park from the aspect of the vegetation cover (part II). Zborník prác o Tatranskom národnom parku, *29*: 253–334.
Šoltésová, A., 1982: Treading by visitors and its effects on the selected vegetation of the south-eastern slope of the Lomnický peak (in Slovak). Zborník prác o Tatranskom národnom parku, *23*: 77–105.
Šomšák, L., Kubíček, F., Jurko, A., Háberová, I., Šimonovič, V., Majzlánová, E., Šoltésová, A., Šoltés, R., Rybárska, V., 1981: The influence of trampling on the vegetation in the environment of Skalnaté pleso and Hrebienok in the High Tatras (in Slovak). Zborník prác o Tatranskom národnom parku, *22*: 145–292.
Varšavová, M., Barančok, P., 1994: Surface d estruction of the high-mountain educational path in the Belianske Tatry Mts (in Slovak). In Méres, Š. (ed.), Geochémia na Slovensku: história, súčasnosť a budúcnosť. Abstrakty. GÚDŠ, Bratislava, p. 77.