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Changes in Vegetation Structure along Four Tourist Trails from Kasprowy Wierch, Tatra Mountains

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Abstract: In this paper there is a new method to asses tourist impact on vegetation cover presented and tested in four locations, which have a different tourist traffic magnitude. Research area is Kasprowy Wierch surroundings in Tatra Mountains. It is a specific place in Tatra Mts., because it can be reached either by cable car or five tourist trails, being the most visited summit in the Polish Carpathians. Each year, there are about 500 thousand people reaching Kasprowy Wierch with a cable car and thousands of walking people. High tourist impact causes many vegetation injuries. Methods used in this research is based on average daily and monthly magnitude of tourist traffic and geobotanical method, which based on a plant species registration and its' surface coverage estimation using Daubenmeir scale. The results attest that some species are resistant to the pressure and other not. In this regard, the species composition and species percentage can be suitable indicator to measure vegetation changes due to the tourist impact.

Key words: *tourist impact, Tatra Mountains, vegetation damage*

1. Introduction

Kasprowy Wierch is a specific place, which tourists can reach either by cable car or five different tourist trails and that's why it is the most visited summit in the Polish Tatra Mts. During summer cable car can take about two thousand people a day, which is a really impressive number for a summit area of 2.8 hectares. This is the area, where conflicts: people – nature has happened since cable car was built - 1935. State Board of Nature Protection (Państwowa Rada Ochrony Przyrody) resigned due to this fact at the time. About 70 years later, because of cable car renovation in 2006-2007, protests have increased once more. Polish Cable Railways decided to carry out monitoring of Kasprowy Wierch area (Kozłowska and Rączkowska, 2010). During monitoring works it was found, that there hasn't been developed a uniform method for measuring vegetation cover damages in the mountainous areas. There were some works dealing with a synanthropic or anthropogenic species in Tatra Mountains (Piękoś-Mirkowa and Mirek 1982; Balcerkiewicz, 1984), but these kinds of species don't appear in a high mountain vegetation. It was observed, that the higher above sea level, the more native

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species appear on a vegetation patches affected by a human impact (Holeksa, Holeksa 1987). But, there are different species responses on trampled areas. Species under human pressure are reduced in cover and height and there are some compositional responses (Cole, 2002). Some species increase in abundance, some other do not tolerate trampling and disappear as well as a new plant communities are formed (e.g. community with *Deschampsia flexuosa*, Holeksa, Holeksa, 1987). Using species composition as an indicator to measure vegetation changes due to the tourist impact is a non-invasive tool for protected areas. In this paper some method to analyze vegetation cover damage is suggested and tested. The aim of this research is to present differences between vegetation's structures in four localizations in the area of Kasprowy Wierch and find some connections between vegetation structure and a different tourist impact in these locations.

2. Research Area

Research area was located in Poland, Tatra Mountains, in the alpine zone (1800 – 2300 m a.s.l.) and includes four touristic trails and nearby vegetation along Kasprowy Wierch (1987 m a.s.l.) area. These four trails are named: Hala, Goryczkowa, Myślenickie Turnie and Beskid (Figure 1).

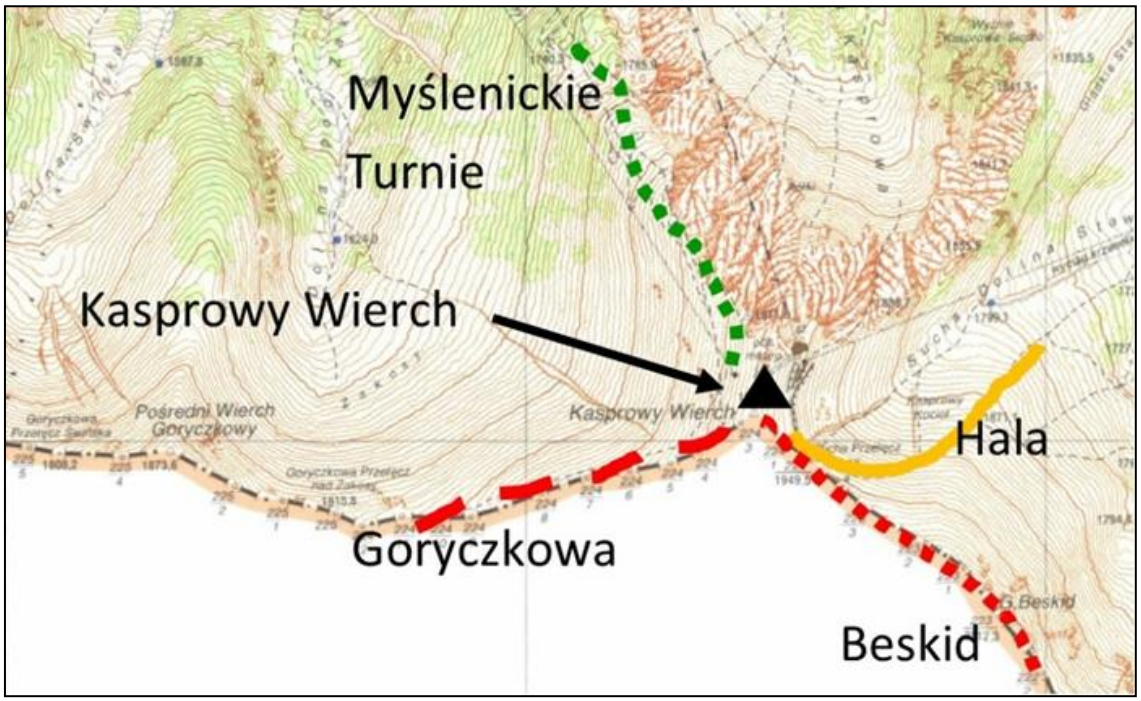

Figure 1. Geographical location of the four researched touristic trails (own elaboration)

3. Methodology

There were two measures of tourist impact chosen for this research. The first one was a relationship between tourist impact intensity and a distance from the touristic trail, namely: the closer to the touristic trail, the higher is the tourist impact intensity. Moreover, each of the researched trails has a different tourist impact. There was a monitoring of a tourist traffic carried out in 1991- 1994 (Czochański and Szydarowski, 2000), 2011 (Janczy, 2012) and in 2012 (own research in cooperation with Tatra Mountains National Park).

Data collected has been divided into two groups: average daily and monthly magnitude of tourist traffic. The first group shows some tendencies in tourist traffic in the area of Kasprowy Wierch. It shows that the highest tourist traffic is connected with the red tourist trail on a Beskid summit and in a year 2012 there was a significant number of people reaching Kasprowy Wierch with a green tourist trail (Myślenickie, Figure 2). The second group of data collected shows average monthly (in August) magnitude of a tourist traffic and is more representative for the Kasprowy Wierch area (Figure 3). On this graph there is a profound difference between tourist traffic magnitude on the way to Beskid and Hala in 1991-94 and 2011. This fact is supposed to be connected with a different tourist traffic monitoring points localization. As far as tourism monitoring in 2011 is concerned, it doesn't include a number of people reaching Kasprowy Wierch by cable car and walking on Beskid on foot, because tourist traffic monitoring points were located behind Beskid summit. Generally it is observed, that trail Kasprowy-Beskid is the most influenced by trampling area. Tourist traffic from Myślenickie Turnie and Hala is also high, but not as much as on Beskid. The least trampled by tourist area is Goryczkowa.

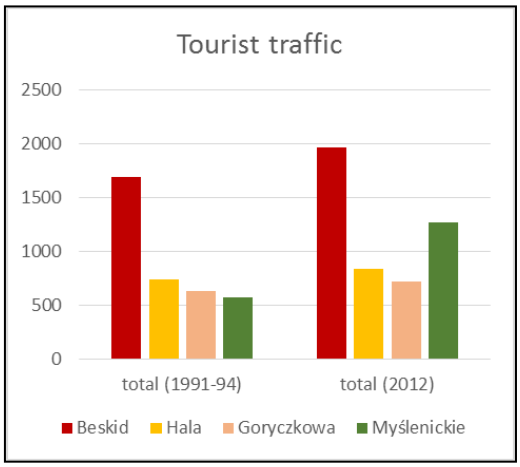

Figure 2. Average daily magnitude of the tourist traffic in four localizations around Kasprowy Wierch (own elaboration based on Czochański, Szydarowski, 2000 and own research)

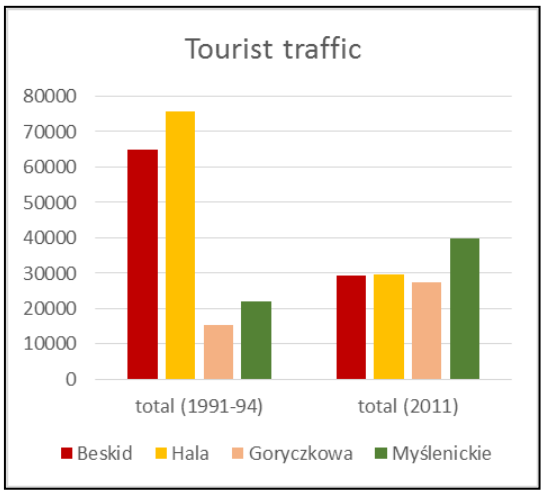

Figure 3. Average monthly magnitude of the tourist traffic in four localizations around Kasprowy Wierch (own elaboration based on Czochański, Szydarowski, 2000 and Janczy, 2012)

Research on grasslands was carried out using geobotanical method, which based on a plant species registration and its' surface coverage estimation using Daubenmeir scale (Frankenberg, 1982). This research was conducted in August 2012 on 24 transects, which were perpendicular to the tourist trail (Figure 4). On each of the four tourist trails there were 6 transects. They were 10 meters long and 0.5 meter wide, but the basic area of plant species registration was 0.25 x 0.25 m. The small size of basic area was designed to do some tests and register plant structure in a micro scale. Research area has been selected randomly in order to gather objective data. All transects are located in the area, where vegetation cover is represented by one plant community called *Oreochloo distichae-Juncetum trifidi.* These are alpine swards that are typical for acidic, granite base.

From the data obtained during field work there were two groups of areas chosen for this paper: areas located 0 – 1 and 9 – 10 meters from the tourist trail (see: Fig. 4). For these areas there was average coverage in percentage calculated and presented in a Table 1. Species with an average coverage less than 2% were gathered in "other" group. This group comprises of the following species: *Hieracium alpinum, Salix herbacea, Soldanella carpatica, Primula minima, Poa laxa, Tanacetum alpestre, Geum montanum, Polygonum viviparum, Anthoxantum odoratum, Doronicum clusii, Campanula alpina, Mutellina purpurea, Potentilla aurea, Avenula versicolor, Carex sempervirens, Vaccinium gaultheroides.*

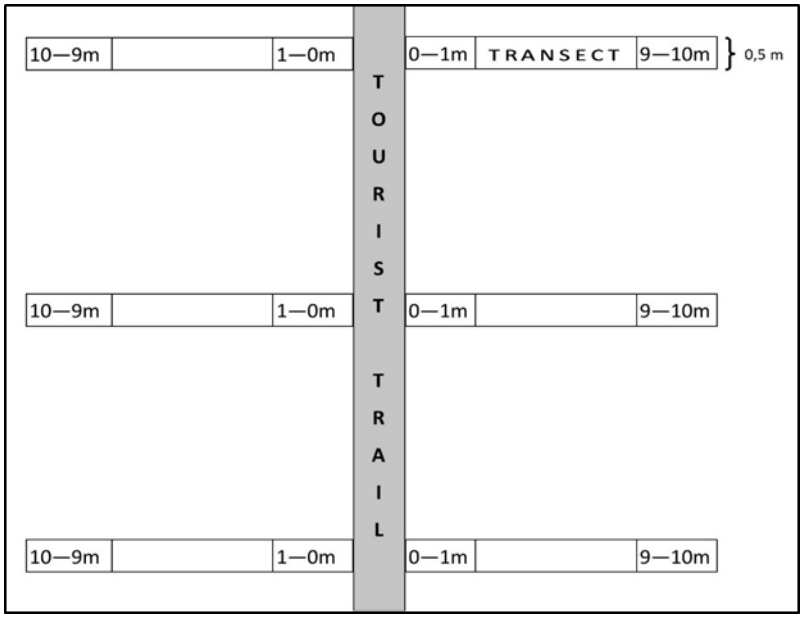

Figure 4. Research methodology scheme

2. Research Results

Data presented in a Table 1 shows, that on each location there is a different species composition. Dominant species on transect in Hala localization is *Agrostis rupestris*.

Table 1. Average species coverage in four localizations and two different distances from the trail

Species name	Hala		Goryczkowa		Myślenickie		Beskid	
	0-1m	9-10m	0-1m	9-10m	0-1m	9-10m	0-1m	9-10m
Luzula alpinopilosa	18.8	3.7	0.1	2.9	3.3	0.4	5.8	1.5
Agrostis rupestris	16.8	20.7	14.0	8.3	9.4	1.3	37.3	13.2
Deschampsia flexuosa	3.8	13.2	2.2	4,4	3.4	0.3	1.0	10.0
Juncus trifidus	2.4	4.4	3.8	7.7	9.4	18.7	0.0	9.1
Homogyne alpina	2.1	9.2	0.3	1.8	0.1	0.3	0.7	7.1
Festuca airoides	1.1	0.8	2.6	5.1	4.8	7.1	6.8	1.3
Oreochloa disticha	0.8	2.4	0.7	4.7	0.8	12.1	2.6	3.5
Festuca picta	0.4	0.4	5.8	1.1	19.2	12.9	1.7	0.1
Vaccinium vitis-idaea	0.1	0.2	8.8	3.3	0.1	8.0	0.0	0.0
Vaccinium myrtillus	0.0	5. 9	2.6	11.9	0.4	4.5	0.3	5.7
Nardus stricta	0.0	0.0	6.1	8.7	0.0	0.1	0.0	0.0
other	4.3	19.4	9.1	12.7	1.9	2.9	6.4	22.5

Source: According to the author's calculations

For the areas one meter distant from the trail there is also a big percentage of *L. alpinopilosa*, whereas on the areas located ten meters from the trail this species covers only 3.7 % of the area, but simultaneously greater shares of *Deschampsia flexuosa* and *Homogyne alpina* appears. In Goryczkowa there is a significant share of *Agrostis rupestris* and two *Vaccinium* species. Moreover *Nardus stricta*, which is connected with grazed grasslands appear there with a percentage of 6.1 and 8.7. In Myślenickie there is a considerable share of typical species for tall grass vegetation observed - *Festuca picta* and *Juncus trifidus* as well. Beskid is profoundly dominated by *Agrostis rupestris* on the areas one meter distant from the trail. Further, that is 10 meters from the trail, *Agrostis rupestris, Deschampsia flexuosa* and *Juncus trifidus* (each) covers about 10 % of the area.

To calculate a difference between areas located on the two different distances from the trail there were percentages on the areas ten meters from the trail subtracted from the areas one meter from the trail (Table 2). The biggest difference is observed for *Agrostis rupestris* on Beskid and for *Luzula alpinopilosa* on Hala. These two differences are positive, so it means, that there are greater shares of them on the areas one meter distant from the trail. There are also positive differences for *Agrostis rupestris* along Goryczkowa and Myślenickie trail. It means that this species can be connected with trampled areas.

Table 2. Differences obtained by subtracting species share on the areas of one meter and ten meters from the trail

Species name	difference Hala	difference Goryczkowa	difference Myslenickie	difference Beskid
Luzula alpinopilosa	15.1	-2.7	2.9	4.3
Agrostis rupestris	-3.9	5.7	8.1	24.1
Deschampsia flexuosa	-9.4	-2.2	3.1	-8.9
Juncus trifidus	-2.0	-3.9	-9.3	-9.1
Homogyne alpina	-7.1	-1.6	-0.2	-6.5
Festuca airoides	0.4	-2.5	-2.3	5.5
Oreochloa disticha	-1.7	-4.0	-11.4	-0.8
Festuca picta	0.0	4.7	6.3	1.6
Vaccinium vitis-idaea	-0.1	5.4	-7.9	0.0
Vaccinium myrtillus	-5.9	-9.4	-4.0	-5.4
Nardus stricta	0.0	-2.6	-0.1	0.0

Source: According to the author's calculations

Taking into account localizations with the biggest number of positive differences, there are two of them, which are the most trampled by tourists with four such results, respectively: *Agrostis rupestris*, *Festuca airoides*, *Luzula alpinopilosa* and *Festuca picta*

on Beskid and *Agrostis rupestris*, *Festuca picta*, *Deschampsia flexuosa* and *Luzula alpinopilosa* on Myślenickie. Finally, there are no species with all the positive results.

The highest negative difference is noted for *Oreochloa disticha*. The species, which had negative difference in all four locations, were*: Juncus trifidus, H*omogyne *alpina, Oreochloa disticha* and *Vaccinium myrtillus.* These can be the most sensitive to trampling species.

The lowest differences in species percentage (between 0.1 and 5%) are noted for eight species on Goryczkowa, six species on Myślenickie, five on Hala and three on Beskid. In the second group of percentages, which is 5-24.1% there are six species from Beskid, five species from Myślenickie, four from Hala and three from Goryczkowa. It shows that the least rapid changes in vegetation structure is noted on Goryczkowa and the highest – on Beskid.

Conclusions

Data presented in this paper shows mosaic nature of the alpine grasslands. Although research was conducted in a one plant community (*Oreochloo distichae-Juncetum trifidi*) there are lots of types of it and it is hard to find the same vegetation patches. Moreover, there was a difference between the vegetation's structures on the two distances from the monitored trail. The highest difference has been noted for *Agrositis rupestris* on Beskid, which is the most visited trail in the area of Kasprowy Wierch. Also the number of the species, which are connected with the lower (0-5%) and higher percentages (5-24.1%) indicates that areas on transects from Beskid are more disturbed (there is a bigger number of species with greater shares) and from Goryczkowa are the least disturbed. It is supposed to be connected with a magnitude of the tourist traffic.

Moreover there is a one species, *Agrostis rupestris*, which appears with a higher percentages on the three locations next to the trail and this could meant, that this species is resistant to trampling. To the same conclusion came Balcerkiewicz (1984). There were also positive differences for a following species: *Luzula alpinopilosa*, *Festuca picta*, *Festuca airoides* and *Deschampsia flexuosa*, but the research results are not so clear for them. For this reason, these species should be taken into account during further studies to examine, if they indicate vegetation damages due to the human pressure.

Species composition can be considered as an indicator of a tourist impact. But, in fact, searching for a connection between tourist impact and vegetation structure is a big challenge and needs further studies. It seems that carrying out experimental trampling could give some better measurable results, but it is difficult to use such methods in a national park.

References:

1. Balcerkiewicz, S., 1984. Roślinność wysokogórska Doliny Pięciu Stawów Polskich w Tatrach i jej przemiany antropogeniczne, Wydawnictwo Naukowe UAM.
2. Cole, D., N., 2002. Trampling disturbance of High-Elevation Vegetation, Wind River Mountains, Wyoming, U.S.A., *Arctic, Antarctic and Alpine Research.* Vol. 34 (4), p. 365-376.
3. Czochański, J., Szydarowski, W., 2000. Diagnoza stanu i zróżnicowanie przestrzenno- czasowe użytkowania szlaków turystycznych w TPN [in:] Czochański, J., Borowiak, D. (red.), *Z badań geograficznych w Tatrach Polskich*, Wyd. Uniwersytetu Gdańskiego, Gdańsk.
4. Frankenberg, P., 1982. *Vegetation und Raum*, Wyd. UTB, Schöningh, p.52.
5. Holeksa, J., Holeksa K. 1987. Zbiorowiska roślinne miejsc wydeptywanych w Babiogórskim Parku Narodowym – Plant communities of trampled sites in the Babia Góra National Park (Western Carpathians), *Fragmenta Floristica et Geobotanica.* Vol. 31-32, p. 247-259.
6. Janczy, Ł., 2012. Liczenie na Kasprowym*, Tatry.* Vol. 3 (41).
7. Piękoś – Mirkowa H., Mirek Z. 1982, Flora synantropijna w otoczeniu obiektów turystycznych, *Studia Naturae, Seria A.* Vol.22, p. 133-196.
8. Rączkowska, Z., Kozłowska, A., 2010. Wpływ turystyki na rzeźbę i roślinność przy ścieżkach w otoczeniu Kasprowego Wierchu [in:] Krzan Z. (red.), *Nauka a zarządzanie obszarem Tatr i ich otoczeniem. T. 3. Człowiek i środowisko. Materiały IV Konferencji „Przyroda Tatrzańskiego Parku Narodowego a Człowiek"*, Zakopane, 14-16. października 2010, Zakopane, Tatrzański Park Narodowy, p. 21-28.