

# Impacts of Tourism Load on the Mountain Environment (A Case Study of the Krkonoše Mountains National Park - the Czech Republic)

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**Abstract:** Krkonoše Mountains (the Giant Mountains in Czech) as the highest mountains of the Czech Republic belong to the most visited middle-european mountains as they are well facilitated for both summer and winter outdoor recreation. More than 8 million visitors within a year means very serious tourism load on the mountain landscape and ecosystems. Primary impacts (e.g. disturbing plants and animals by trampling and noise, soil erosion or cummulation of rubbish) together with secondary impacts of tourism development (a.g. arrising of accomodation capacity, impact on traditional landscape infrastructure by reebuilding of original small mountain chalets, nonsufficient disposal of waste, transport of allochtone organisms) create very cotraversional background for sustainable use of the mountains which are the oldest national park of the Czech Republic. Paper describes these impacts and suggests some forms of conflict solution between tourism development and statutes of the national park.

## FOREWORD

Mountains together with coastal areas represent doubtlessly the most attractive types of landscape for outdoor recreation. Both are highly sensitive and vulnerable to the large scale of human impacts. Therefore the harmonization of the relations between the nature environment and its conservation on the one side and the wide scale of its exploitation on the other side belongs to the basic problems and the most important management activities of the bodies responsible for sustainable development such areas. There are a lot of examples of hard conflicts between these two range of human interests from the Alps or from the Mediterranean countries. Many of middle-european mountains stand in the shadow of such famous areas for tourism industry but they have a lot of similar or even bigger problems because of smaller size and therefore higher pressure on the fragile mountain environment. **The Krkonoše Mountains**, culminating part of Hercynian middle-mountains, represent example of uneasily manageable conflicts between environmental conservation and contradictory demands for tourism and economic activities in mountain protected area.

## AREA DESCRIPTION

Lying astride the Czech and Polish boundary Republic, the mountains called the Krkonoše (the Giant Mountains in English, the Karkonosze in Polish), the highest mountains of the Czech Republic, belong to the Sudetes, a chain of

geologically old, non-calcareous middle-mountains shared by Czech, Poland and Germany.

The Krkonoše Mts. are about 40 km long and 20 km wide. Their georelief consists partly of an old denuded surface, partly deeply cut valleys that were sculptered by Pleistocene glaciers and nivation. The highest point Sněžka (1602 m a. s. l.) does not point out high-mountainous size, but the summit area of the Krkonoše Mts. (between 1300 and 1600 m a. s. l.) displays a landscape system with numerous elements of subarctic and high-mountain features such as alpine timberline, subarctic peatbogs, glacier corries, snow avalanches and landslides, tors, frost sorted grounds, relic plant and animal species and ecosystems.

Average annual temperature on the summits is between 0 °C and +1 °C only. Snowpack is sustained about 180 days per year, which corresponds to climatic regimes encountered in mountainous zone of Central Scandinavia. As a result of long-term multidisciplinary research and detailed analyses, the landscape of the topmost areas of the Krkonoše Mts. was described as an **arctic-alpine tundra** (Soukupová and others, 1995; Stursa, 1998).

However, the Krkonoše Mts. are not mountain range, whose long-term development was controlled by only natural laws. Their position in the centre of Europe meant that man has subdued nature here step by step since the 13<sup>th</sup> century and created in the highest Czech mountains an landscape, full of signs of the mutual coexistence of man and mountain nature in both positive and negative sense. Because of their unique natural richness and beautiful landscape with extremely

rich history and culture, the Krkonose Mts. were declared as the first Czech National Park in 1963 (total area is over 360 km<sup>2</sup>). On the northern Polish slopes the Karkonosze National park was created even earlier (in 1959, total area is over 55 km<sup>2</sup>). Both national parks (and also the **bilateral Biosphere Reserve** of UNESCO since 1992) are well-known and much frequented within the all-European context for their unique natural richness, landscape beauty, outstanding conditions for both winter and summer sports, wide offer of tourist and recreational facilities and easy accessibility from the foothills to the highest elevation.

### TOURISM IN THE KRKONOŠE MOUNTAIN

The characteristic landscape infrastructure of the Krkonose Mts. became during the period of farming in 17. and 18. centuries. Plenty of tree-less enclaves with mountain cottages are dispersed from the foothills till upper part of the mountains, created a significant bases for the later tourist utilization during the second half of 19<sup>th</sup> century. First visitors attended the mountains mainly in the summer but with the development of skiing, tourism extended throughout the winter months.

On the beginning of the last century only a few hundred thousands visitors from the large lowlands of Silesia, Germany and Bohemia came in the Krkonoše every year. Many villages slowly turned from small agricultural-industrial and woodworker's hamlets into tourism centers. Before

the end of the 20th century about 6 million visitors (hikers, skiers and holiday-makers) on the Czech side, and nearly 2,5 million visitors on the northern Polish side annually frequent the valleys and summits of the Krkonoše Mts. (Flousek J., 1994).

Thus the both Krkonose Mts. National Parks (abbrev. KRNAP resp. KPN) with **more than 8 million visitors** in a year belong undoubtedly between the most visited national parks in the Europe and perhaps according to their small area (the whole mountains around 630 km<sup>2</sup> only) to the most visited national parks in the world, unfortunately with all evidences of enormous pressure on very fragile mountain nature. Hotels, roads, ski lifts, ski hoists, downhill courses, skii slopes and other facilities serving tourism and sport activities (table 1.), bring about a lot of disturbance into the mountain environment of the Krkonose National Park .

### IMPACTS OF TOURISM

There are many direct influences of tourism on the mountain nature, e.g. picking up nice plants, disturbing of wild animals through the noise, soil erosion due to trampling of vegetation by short cutting ways, cummulation of rubbish, air pollution from the dense traffic etc. Beside these **primary impacts** which might be partly diminished by strict control activities of National Park staff or by some regulations, there are also **secondary impacts** of tourism development which are much serious.

	Czech side	Polish side
<b>Total area</b>	54 787 ha	5 564 ha
-core zone (1 <sup>st</sup> + 2 <sup>nd</sup> zone of NP)	8 432 ha	1 715 ha
- buffer zone (3 <sup>rd</sup> zone of NP)	27 925 ha	3 847 ha
-transition zone (buffer zone of NP)	18 430 ha	-
<b>Inhabitants</b>	26 700 = (48,7/km <sup>2</sup> )	90 = (1,6/km <sup>2</sup> )
- in core zone	300 = (3,6/km <sup>2</sup> )	50 = (2,9/km <sup>2</sup> )
- buffer zone	4 900 = (17,5/km <sup>2</sup> )	40 = (1,0/km <sup>2</sup> )
- transition zone	21 500 = (116,7/km <sup>2</sup> )	-
<b>Visitors in a year (estimate)</b>	6 000 000	2 500 000
<b>Total length of road network</b>	1 700 km	250 km
- tourist trails only	800 km	?
<b>Number of hotels and chalets on the National Park territory</b>	1 500	22
- core zone only	82	10
<b>Number of cableways + chairlifts</b>	6	2
„ „ <b>ski-lifts</b>	250	10
<b>Length of downhill courses/ski slopes</b>	139/112	10/17

Table 1. Selected data about bilateral Biosphere Reserve Krkonose/Karkonosze

They are connected with inadequate landscape infrastructure development and with step-by-step increasing of accommodation capacity, density of roads and traffic load, the water consumption, total amount of visitors etc. If there are well prepared land use plans with respect of the territorial carrying capacity, they could be guaranty of sustainable development or using of landscape and natural sources of the national park. They could be. Unfortunately these secondary symptoms of landscape deterioration are not visible immediately, so normal visitor of the National Park doesn't realize them and thus he doesn't feel to be responsible for such a harmful impacts. But in fact he is the primary subject of the improvement of tourism standards and busy activities of local enterprisers.

Some examples of secondary impacts:

*Rebuilding originally quite small mountain chalets* - that means

- - irreversible changes of the mountain landscape infrastructure character, a loss of historical and culture identity or originality by replacement old woody chalets by new hotels, without respect of local architecture style;
- - reducing of extent of species-rich mountain meadows in surrounding those reconstructed and mainly enlarged chalets (very serious impact because these meadows are essential source of biodiversity; a lot of rare, endangered or protected mountain plant and animal species are connected with existence of these semicultural non-forest ecosystems and with regular care for them; Krahulec and others, 1996).

Higher equipment and increasing of accommodation capacity connected with bigger consumption of drinking and household water and serious problems with generation, handling and disposal of sewage and waste-water or liquidation

of municipal solid waste - that means- large-scale eutrophization and acidifying of mountain habitats in surrounding of mountain chalets and consequently negativ trends in spatial and species succession of native plant communities, above all missing of rare and sensitive mountain species because of dispersion of some nitrophilous plants or anthropophyta which are strongly invasive (Rumex alpinus, Urtica dioica, Cirsium arvense etc).

*Extending of mountain roads and paths because the old construction is already not sufficient for higher moving of persons and for more dense traffic. For extending and repairing of roads are often used the geologically unsuitable material such as limestone, melaphyre, basalt or even asphalt, instead of native rocks* - that means

- changes of chemical properties of the soils in the vicinity of repaired roads and again the process of eutrophization and expansion of the weeds (Vitkova and others, 1999, Malkova and others, 1997) forcing out the natural ecosystems - threat to the genetic structure of native species ( table 2.). *Higher moving of people and tracks on mountain roads and paths* - that means (in synergism with the previous impact)
- an enormous transport of seeds of allochthonous plant species, especially weeds and their rapid and the highly succesful dissemination into the vicinity of roads and paths and consequently potential threat to the genetic structure because of uncontrolled hybridization of taxonomically simillar species (e.g. native *Viola sudetica* and allochtone *Viola tricolor*, some microspecies of genera *Hieracium*, *Taraxacum* etc.).
- Aproximately 30% of all vascular species of the Krkonoše Flora are allochthonous transported into the mountains during tle last two or three centuries - for imagination how big threat the transport of plant diaspors is (Stursa, 1996);

<b>Expansive and invasive anthropofytic species</b>	<b>Expansive apofytic species</b>	<b>Endangered native species</b>
<i>Alchemilla sp.div.</i>	<i>Calamagrostis villosa</i>	<i>Bartsia alpina</i>
<i>Alopecurus pratensis</i>	<i>Chaerophyllum hirsutum</i>	<i>Campanula bohémica</i>
<i>Cirsium arvense</i>	<i>Cirsium hellenioides</i>	<i>Epilobium alsinifolium</i>
<i>Dactylis glomera</i>	<i>Deschampsia caespitosa</i>	<i>Epilobium nutans</i>
<i>Epilobium adenocaulon</i>	<i>Filipendula ulmaria</i>	<i>Hieracium rubrum</i>
<i>Epilobium angustifolium</i>	<i>Hypericum maculatum</i>	<i>Juncus trifidus</i>
<i>Myrrhis odorata</i>	<i>Poa annua</i>	<i>Montia fontana</i>
<i>Phalaris arundinacea</i>	<i>Poa chaixii</i>	<i>Poa laxa</i>
<i>Rumex alpinus</i>	<i>Poa supina</i>	<i>Pulsatilla scherfelii</i>
<i>Rumex longifolius</i>	<i>Ranunculus acris</i>	<i>Swertia perennis</i>
<i>Tusillago farfara</i>	<i>Senecio nemorensis</i>	<i>Taraxacum alpestre</i>
<i>Urtica dioica</i>	<i>Taraxacum officinale agr.</i>	<i>Viola sudetica</i>

Table 2. The most expansive and invasive species of vascular plants and the serious endangered native species at the summit area of the Krkonoše Mts due to secondary tourism impacts

- changes in abiotic conditions and species composition of the vegetation along the paths influence undesirable changes in species structure of animals, even disturbance of the animal populations because of strong tourist traffic and too wide roads and therefore dividing of populations into small parts with consequences in genetic structure; the same impact is caused by fragmentation of complexity of mountain landscape with natural pattern of vegetation through too dense net of tourist trails;
- permanent stress for some sensitive species of mammals or birds and gradual disappearing such species like *Tetrao urogallus* or *Bonasa bonasia* from mountain forest ecosystems.

*Building of new alpine ski areas, building of new pistes or their extending* - that means

- - disturbing of forest stands complexity and consequently more rapid physiological damages, pest infestation and dying off mountain spruce forests which are under influence of air pollution (so called phenomena of emission forest's walls);
- - revegetation steep slopes after clear-cutting involves problem with appropriate seeds; there are the only seeds of cultivated sortes of grasses on the market, which are suitable for the revegetation of sportgrounds or stabilization of slopes along highways but not for the application within the protected areas with strict regime of species conservation. Using these grass cultivars (e.g. *Festuca rubra*, *Agrostis gigantea*, *Lolium* sp.div.) means later problem with genetic erosion because of potential threat of spontaneous hybridisation with autochtone population of the same taxa, regardless of conflict with the statute of the national park, where distribution of allochtone organisms is strictly prohibited.

Well, it is obvious that tourism exploitation can induce a lot of serious problems which are in contradiction with the main objectives of protected areas. On the other hand it is doubtless, that tourism sector is the only one potential source of prosperity of local people living inside and outside the national park territory, especially in the mountainous large-scale protected areas. These two antagonistic functions of the national park landscape evoke a strong confrontation atmosphere between the state administration and ecological bodies on one side and municipalities, indigenous people, entrepreneurs and investors in the area of recreation industry on the other side. Solution of this long-term conflict consists in working out of the proper management plan for the national park territory, respecting the natural stability of mountain ecosystems. That means to understand the basic principles of what is carrying capacity of the national park environment about.

## INDICATORS OF SUSTAINABILITY AND CARRYING CAPACITY

In spite of many definitions several types of carrying capacity and existence of many publications dealing in this topic (e.g. Ceballos-Lescuráin, 1996; Drdoš and Janik, 1995; Kreisel, 2001), to estimate or to evaluate carrying capacity in such a region like popular mountain national park is ever extremely difficult and results need not be expected by all stakeholders.

What is the right way to evaluate or to measure a carrying capacity? Which indicators can be used as a warning that the ecological impacts are too strong and the carrying capacity has been already overstepped. Could it be measurable by increased risk of footpath's erosion, or by speed of pauperization of biodiversity, by range of water pollution, or by extent of changes of soil's chemical properties? If we use such indicators, so how to quantify these features, how many degrees plus or minus we could put to single parameters to obtain their weightiness and which ecological impacts are synergistic with the others, etc. Finally we must be aware of absolutely different sensitivity of single mountain ecosystems which increases with their pauperization.

Therefore is necessary:

- to prepare an inventory of different types of stands or ecosystems of the protected area and to make a list according their sensibility or resistance to anthropogenic impacts,
- to recognize and well describe all types of primary as well as secondary anthropogenic impacts in the area during the process of environmental impact assessment taking into account cumulative effects (synergism),
- to carry out the proper long-term monitoring of these impacts; anyway the establishment of special monitoring network for objective way of later evaluation should be done,
- to attempt determine the differences not only in space but even in the time, that means to evaluate the dynamics of some negative impacts (e.g. to measure differences in sensitivity of the trails surface to the trampling not only during summer time but also in herbst or in early spring when there is some synergism with cryogenic factors). Thus, we will be able to realize more effective management activities protecting trails surface against soil erosion,
- to select a list of the most convenient indicators of sustainability and to open a monitoring such indicators.

We have started at the Krkonose Mts. National Park some investigation on **ecological carrying capacity** using recent mapping activities of actual non-forest vegetation and forest vegetation (Nováková and others, 1998) in the framework of Natura 2000 programme. Orthofotomaps are utilised for present field work, basic mapping unit

for the non-forest vegetation is the syntaxon on the alliance level ; approximately 30 basic mapping units (alliances) for non-forest vegetation from the submountain to the alpine zone. All syntaxons has been analysed and described according:

characteristic of species diversity, group of diagnostic plant species , occurrence of endangered and protected species, invasive plant species, significant animal species

altitudinal description (occurrence in the main vegetation belts

abundance (degree 1 – 5; one locality only, very rare, rare, disperse, common)

type of threat: (all types of both abiotic and biotic factors)

carrying capacity (5 degrees, see below)

management policy

*Degrees of carrying capacity:*

1. very low, high vulnerable ecosystem (high internal as well as external lability)
2. low, vulnerable ecosystem (high external lability, internal stability)
3. relatively stresstolerant ecosystem, both internal and external stability, vulnerable only through rough mechanical disturbances
4. stresstolerant ecosystem
5. high stresstolerant invasive (expansive) ecosystem

Using field vegetation mapping and above mentioned syntaxa description we prepared multicriterial analysis several GIS layers (for example density of tourist trail's network, construction and quality of trail's surfaces, density of tourist load, actual vegetation and dispersion of invasive plant species )which enabled us to evaluate how particular part of the national park is or will be sensitive to actual tourism load, if the potential carrying capacity still allows to increase some tourism activities and vice versa.

This is convenient way how to elaborate precise management plan which enables to harmonize both above mentioned functions of protected area (nature conservation as well as sustainable tourism). Anyway, detailed explanation and discussion of criteria for such a landscape evaluation with main stakeholders and land-use planners are extremely important and essential.

Another convenient indicator of sustainable use of mountain landscape seems to be **management of flower-rich mountain meadows**. They have several very important functions within the pattern of mountain landscape:

- biodiversity protection (species-rich habitats with high number of threatened and strictly protected plants and animals; altogether 450 plant species grow on mountain meadows 'more than 1/3 of total amount of vascular plant species recorded from the Krkonose Mts., Krahulec and other, 1996),

- agricultural function (ecofarming),
- high diversity of landscape character,
- recreational function (mountain chalets, skiing),
- cultural-historical heritage (local architecture of wooden houses/log cabins/, traditional practices lifestyles).

For keeping of all these functions appropriate system of funding and supporting from the state budget or from other bodies is absolutely needed. Recently there are two systematic grants in the Czech Republic (Ministry of agriculture and Ministry of Environment of the Czech Republic) using since 1994. As the National Park Administration is responsible for administration these state funds, results of implementation such state funding policy could be used as a convenient indicator of sustainable development of the National Park and Biosphere Reserve territory.

Therefore the Administration of KRNAP prepared a methodology of long-term monitoring such indicators of sustainability with three main objectives:

1. Evaluation of influence of various types of meadow management on biodiversity
2. Targeting of state support on most convenient parts of NP territory
3. Development of State policy of Landscape Care Funding if necessary according results of monitoring

Such monitoring could contribute to:

- better communication between NP Administration and indigenous people and local communities
- restoration of regular care for mountain meadows as a part of biodiversity protection
- supporting of landscape sustainability on the territory of the National Park and the Biosphere Reserve Krkonose

## PSYCHOLOGICAL CARRYING CAPACITY

Until NOW mainly aspects connected with evaluation of biological or environmental carrying capacity has been mentioned. However, it is very important to be aware, that visitor's behaviour and attitudes, their wishes and motivation for the visit of protected area, their knowledge what is unique, significant or typical for visited area, what types of visitor's rules are valid within the area, all these aspects can significantly influence amount of negative impacts of visitors in the protected area. Therefore is crucial to realize well prepared education and information programmes and also to increase our knowledges about feedback in visitor's behaviour, that means if visitors are satisfied or dissatisfied during their trip in protected area etc. These are very important information about the other type of carrying capacity - so-called the psychological carrying capacity.

To estimate this second type of carrying capacity is even more complicated than the first one. But if the psychological carrying capacity is overstepped - the consequences are also negative for the landscape. Many conflicts between visitors and nature and between visitors themselves. What more, these conflicts can overgrow within the conflicts between visitors and local people - thus advantages of the national park statutes become to be disadvantages for local people. It might be the beginning of misunderstanding between protected area's staff and indigenous people or municipalities.

Therefore the monitoring of visitor's behaviour, the evaluation of public opinion, permanent education of both local people and visitors and patient explanation what the sustainable tourism development is about, are so important. This is the only way for stimulation the indigenous people, local communities as well as visitors on the protection of valuable nature and landscape of the national park.

We have investigated some quantitative as well as qualitative aspects of tourism load in some hot spots of the Krkonose national park in 1996 (Cihar and other, 1998). Results are presented in other paper during this conference.

In spite a fact that there is a direct relationship between degree of our knowledges about both visitors and local people psychology and effectiveness of our management activities within protected areas, a lot of gaps still exist in this field. We need urgently to know more details about perception of nature or protected landscape by various groups of visitors in relations to their age, education, occupation or social standing, what's visitor attitudes to the rules, regulations and restrictions valid on territory of visited protected areas, etc. Very important tools for our communication with indigenous people and significant stakeholders consists in visible flux of incomes from tourism business as a clear economical benefits of the existence of protected area for local people.

## CONCLUSIONS

Having such real data about both ecological and psychological carrying capacity we might be able to prepare an adequate tourism management plan as an one chapter of the complete management plan for the national park. Main objectives such document, being prepared not only by conservationists but in cooperation with all targeted stakeholders, should be to define and to realize such management activities, which enable to keep up an equilibrium between sustainable use and the protection of natural sources in protected areas. Thus we should be able to make the right decision of what vision of the mountain landscape we will prepare - either busy scenery on figure 1. or romantic scenery on figure 2.

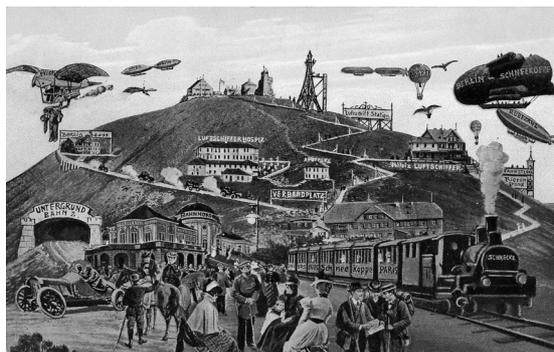


Figure 1.: Vision of Sněžka before the end of 20<sup>th</sup> century according stylized postcard from the beginning of the 20<sup>th</sup> century

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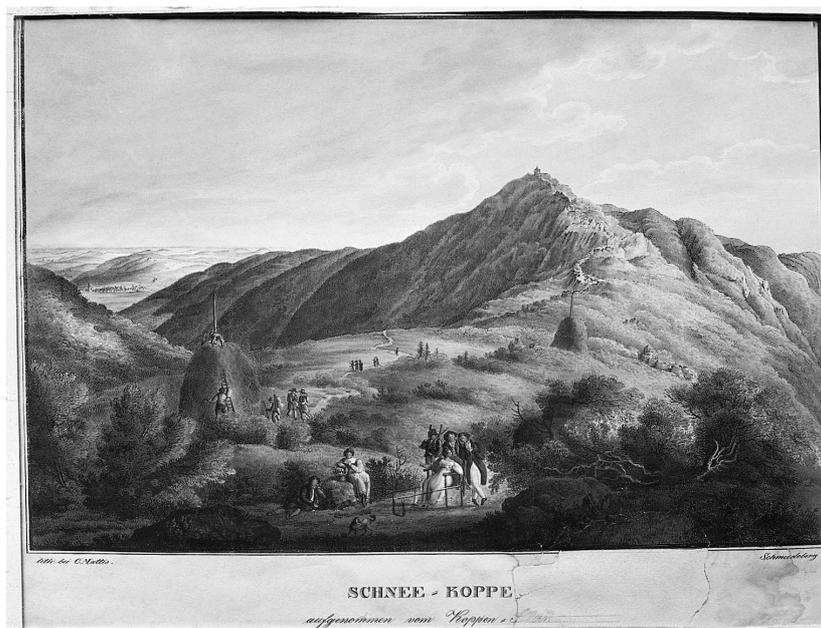


Figure 2.: Picturesque spirit of the landscape in the neighbourhood of Snezka on engraving of A. Matisse from the 19<sup>th</sup> century