

Multi-scale interactions between disturbances and ecological and socioeconomical changes – case study High Tatra Mts. (Slovakia)

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Introduction

The case study is located in the highest part of Carpathian mountain range, in High Tatra Mts. (Slovakia, Central Europe). High Tatra Mts. are crossed by the Slovak-Polish borderline and thus divided in two parts, the case study area is in Slovak part only. The main mountain ridge is 26 km long, the highest point (Gerlach 2665 m) is located in the southern side-ridge.

The study area represents the Tatra National Park (TANAP) and its buffer zone. Its boundary corresponds to the Tatras Biosphere Reserve. TANAP area is 741,11 km² and its buffer zone 1.106,85 km². Dimensions of the whole area are: 42 km in east-west direction and 17 km in south-north direction.

The study area has outstanding nature values: unique alpine rocky relief carved by ancient glaciers; high amount of glacier lakes (tarns); high number of Carpathian endemic species of plants and animals; the largest alpine vegetation belt in Western Carpathians; precious plant communities of cembra pine (*Pinus cembra*), mugo pine (*Pinus mugo*) and common larch (*Larix decidua*); well-preserved native and natural forest ecosystems of the Norway spruce (*Picea abies*) belt. The present flora of TANAP is represented by ca 1 300 species of higher plants, 900 species of algae, 700 species of lichens, over than 500 species of mosses and numerous blue-green algae. The endemic species belong to specific features of the area: here grow 30 species endemic to Carpathians, endemic species of West Carpathians (e.g. *Saxifraga wahlenbergii*, *Delphinium oxysepalum*, *Dianthus nitidus*), but also 50 taxa endemic to Tatra Mts., including e.g. *Thalictrum minus* subsp. *carpathicum*, *Cochlearia tatrae*, *Ranunculus altitatreensis*, *Hieracium pseudobupleuroides* and 36 species of genus *Alchemilla*. Regarding animals, 290 species of vertebrates live in the area. The most important habitats, e.g. those of chamois, marmot, brown bear, lynx and wolf are at the same time the most anthropically threatened. The model area ranks among top five nesting areas for forest gallinaceous birds, Golden Eagle (*Aquila chrysaetos*), Peregrine Falcon (*Falco peregrinus*) and forest owls.

The area has a specific role in the network of protected areas; TANAP is the oldest national park in Slovakia. The most valuable sites benefit from the status of small-size protected areas under highest levels of protection (4th and 5th degree). There are 27 National Nature Reserves, 24 Nature Reserves, 2 Protected Territories, 1 National Nature Monument and 2 Nature Monuments with the total area of 37.551,63 ha that represents 50,7% of TANAP. The whole area of TANAP lies in 3rd degree of protection, its buffer zone in the 2nd degree. Levels of protection represent certain environmental regulations of the development in the area as they control the land-use in accordance with requirements of nature and natural resources protection. With growing level of protection there also grows the amount of restrictions for land-use.

The Administration of TANAP in Tatranská Štrba and the Research station of the TANAP Forest Service covers the nature management and research in TANAP. In 1943 there was founded the Astronomic Observatory in Skalnaté pleso. It obtained the status of an Astronomic Institute in 1953. Gradually there were founded further facilities of the Institute: the coronary station (solar and stellar telescopes) on the Lomnický Peak and the new

headquarters of the Institute in Stará Lesná. Besides these organizations located directly in TANAP, research in the territory is done by scientists from many research organizations across Slovakia and from abroad. Well-developed research of nature started already in Tatra Mts. already in the 18th century.



Figure 1. Study area and its division to core area and buffer zone

The study area has also other outstanding values and importance: very favorable climatic conditions for health-care and rehabilitation activities; significant socio-economic potential for health-care and recreation development (hosting already many facilities and services situated in the high-mountain environment); recreation resort of international importance in the High Tatra Mts.

The study area is located in two the administrative regions (NUTS III) of Žilina and Prešov and it belong to the districts (NUTS IV) of Tvrdošín, Liptovský Mikuláš, Poprad and Kežmarok. In the study area are the town of Vysoké Tatry and the village of Tatranská Javorina. The town was established in 1990 by fusion of local settlements, it consists of 15 municipal units connected within a 60 km long chain and covering the area of 398 km². Other 4 towns and 23 villages are located in the buffer zone of the national park. As for the functional categorization, in the core of the study area dominate the nature-conservation, health-care, sport-recreational and partially residential functions, while in the buffer zone the residential-agricultural function prevails.

The study region consists of 29 settlements with 128.908 inhabitants (01/01/2004), 73,9% of them living in towns. Mean density varies between 2 people/km² (Tatranská Javorina) by 1.499 people/km² (Svit). During last 30 years, number of inhabitants in the region grew by about 59,33% till 2001(Figure 2). This trend is specific to the region, different from the overall tendency in Slovakia (decreasing population growth and continuous ageing mainly due to the decreased natality). Slight population decrease was recorded in 2001-2003, the bigger decrease was recorded in 2004, caused by migration. Since whole area is protected as national park, barriers for socio-economic development are evident (e.g. building restrictions,

barriers of spatial expansion), what negatively influence potential immigration. High seasonal occupancy of the region (weekly or daily tourism) influences the functional utilization of the area, putting priority on nature conservation, medical-recreational and sport-tourist activities. Based on the employment structure in individual sectors of economy, 2 sub-regions could be distinguished: 1) **core Tatra-region** representing TANAP with a high employment in the health-care sector (26,8%), in hotels and restaurants (14,1%) and very low employment in agriculture (0,3%); and 2) **Tatra-basin region** consisting of settlements of the TANAP buffer zone with higher employment in industry (15,45%) and in agriculture (6,89%). In summary, the population working in industry, health-care sector, hotels and services dominates in region. Employment in agriculture and in forestry is lower, in spite of the fact that the region has high forest coverage. Forests in the region have especially non-production functions (climate, health-care, soil protection etc.) what is reflected in a low level of employment in the forestry. Figure 3 presents the economic activity by sectors.

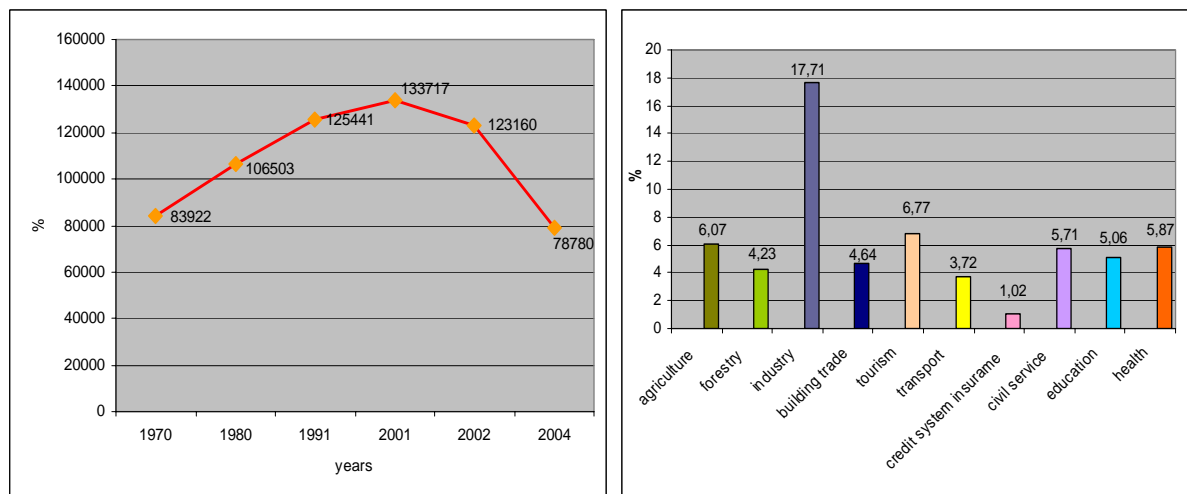


Figure 2 and 3. Population development and economic activity by sectors

The study area is affected by the air pollution – both from remote and local sources. The local sources are represented by several large- and medium-size sources of air pollutants located in surrounding towns and by traffic pollution. The water quality is predominantly satisfying, underground water in core zone of the Tatras Biosphere Reserve is generally clean, locally with insignificant pollution. The waters in the buffer zone are locally affected by high concentration of pollutants.

History

The region (especially the foot of the mountains) had been inhabited continuously already since the prehistoric period. Similarly in Bronze and Iron Ages, there was a relatively dense population of various cultural groups. During the 12th century the area became a part of the Hungarian Monarchy. In the 13th century, new settlements were founded at the foot of the mountains. Some of them, with long and narrow cadastral areas extended up to the mountain ranges, started to exploit the natural environment of the Tatras. In the 15th century, new towns were developed along the important trade roads close to the study area (Liptovský Hrádok, Spišská Sobota and Kežmarok).

In that time, the agriculture - especially grazing, breeding cattle, flax and hemp growing - was the main source of income. Part of population was concerned with mining and processing of raw materials provided by the natural environment, by wood processing, cartage and textile production. There were several sawmills in the region, processing the wood from nearby forests, as well as brickfields and ironworks. A significant development of the craft industry started in the 17th century when many important and internationally respected craftsmen

corporations were established. Since the 18th century the small-scale craft production was gradually replaced by manufactories in the vicinity of the study area. The increasing interest in the Tatra Mts. induced the construction of the first tourist and accommodation capacities and later on of sanatoria. Based on them, the individual settlements were built inside of the study area. The first one was Starý Smokovec, founded in 1793. The great impulse for the region development arose in 1871 when the construction of the railway connecting cities Košice and Bohumín (Czech Republic) was finished. Besides its importance for the economy and industry, the railway contributed substantially to expansion of the tourism and recreation in the region. Most of settlements were built in 80's and 90's of the 19th century, the last one, Nová Polianka, was built in 1956 as the therapeutic center. During the first Czechoslovak republic (1918-1939) the low-cost accommodation capacities were build and their number increased rapidly. The construction of the cableway to the Lomnický Peak induced the formation of a tourist and skiing center. Development of spa health-care can be dated to 1885 when the settlement Štrbské Pleso was certified for health-care spa. Since that time the intensive growth of new sanatoria, especially for tuberculosis and respiratory diseases, continued. Many sanatoria appeared after World War II.; this process culminated during the socialism period (1948-1989) with mass recreation of workers and free of charge spa care.

The summer tourist activities (especially hiking and mountaineering) have long tradition, winter recreation and sports progressed in the 20th century. Accommodation capacities were markedly extended particularly during the preparation of World Championship in Skiing in 1970. The construction of new accommodation and alimentation facilities as well as the reconstruction of road and railway network were affected the whole Tatras' region. The transport infrastructure was enhanced by rebuilding of funicular from Starý Smokovec to Hrebienok, construction of cableway from Tatranská Lomnica to the Skalnaté lake (1973), cog railway from Štrba to Štrbské Pleso and construction of a new airport near Poprad.

After the World War II., displacement of the Carpathian Germans from the eastern part of the Tatra region as well as the collectivization of agriculture markedly affected the physiognomy and utilization of landscape. Narrow fields were merged and a monotone and mono-functional landscape was created in southern part of the region. The collectivization process negatively impacted the social sphere by compulsory surrender of individual farms, resettlement and displacement of the population etc. A strong industrialization of the urban areas below the Tatras was characteristic for that period as well, the towns Poprad, Svit, Liptovský Hrádok and Kežmarok became industrial centers of the region, attracting the young people to work in factories and live in new large housing estates. The establishment of the Tatra National Park in 1948 (first NP in Slovakia) represented important milestone for the nature conservation and protection of natural resources, but also certain regulation for economic activities and development of the region. In 1993, the area was included into the world network of the MaB Biosphere Reserves.

The study area was significantly impacted by the large disturbance of forests by windstorm in November 2004. On the area of 12.000 hectares, trees of around 2.7 million cubic meters of wood were broken or uprooted. This event also induced broad discussion about zonation of the National Park and way of the management of damaged area. The



wind damage influenced (mainly in negative way) almost all ecosystem functions of this area.

The Tatra Mts. Multiscale Approach

The three embedded scales are considered: plot level, landscape level and regional level.

Plot level: at the finest scale (site level) we focus on the site damaged by windstorm in 2004, this site was used for establishment of long-term research for study of ecosystem processes of forest ecosystems damaged by the catastrophic disturbance.

Landscape level: at the intermediate scale (landscape level) we treat the forest zone of the National Park and issues that are typical for this zone (residential function, recreation, sport, health care – climatic spa, nature protection). Quite large part of the forest zone was affected by the windstorm.

Regional level: at the coarsest scale (regional level) we deal with the whole area of the National Park and its buffer zone. This level contains both mountain and alpine zone with close-to-nature state of ecosystems and part of surrounding basins. The basins represent the hinterland of the National Park connected to its core zone by many interactions.

For each of the investigated scales, we developed specific versions of the generic LTER model. The baselines for the concept of the Tatra Mts. case study are the generic questions from the ISSE framework:

- Q 1:** How do long-term press and short-term pulse disturbances interact to alter forest ecosystem structure and function?
- Q 2:** How the changed structure of the forest ecosystem influence ecosystem function and dynamics?
- Q 3:** How do altered ecosystem dynamics affect ecosystem services?
- Q 4:** How do changes in vital ecosystem services feed back to alter human behavior?
- Q 5:** Which human actions influence the frequency, magnitude, and form of press and pulse disturbance regimes within and across ecosystems?

Level 1: Field plots

Narrative: On 19 November 2004, the extreme windstorm impacted the Tatra National Park. The wind reached speed 140-180 km/hour, the highest measured speed was above 200 km/hour. In the area affected by the wind almost all trees were destroyed – either broken or uprooted. This disturbance had crucial effect to ecosystem structure and functioning, on the other hand it represented unique opportunity for study of ecosystem restoration. Therefore the research site was established with 4 sub-sites; 3 of them are in impacted area: in one plot timber was left, in second plot the timber was removed, in third plot the removal of timber was followed by fire. The last plot is located in undisturbed area serving as control. It was expected that as a consequence of disturbance, there will be changes in the surface run-off (higher risk of flooding in lower areas, higher soil erosion), micro- and mezo-climate, nutrient flows, flora and fauna composition.

On studied plots, the former continuous forest habitat was replaced by ecosystem similar to glade, with big amount of dead timber. The timber was from two plots partially removed and partially burned on the place, but still thick layer of raw humus remained on the site – bigger amount that can be utilized by soil-forming processes in short time. The research sites were left for natural reforestation. In the next years after disturbance, quite big changes in vegetation were recorded. The open habitats were invaded by the fireweed (*Epilobium angustifolium*) accompanied by tall grasses and especially in burned area also by ruderal species.

Site level research questions:

- Q 1:** How can long-term climate changes (temperature, precipitation) interact with the short-term pulse disturbances (windstorms, fires, pest outbreaks) to alter forest ecosystem and function?
- Q 2:** How will altered ecosystem structure influence ecosystem functions and vice versa?
- Q 3:** How do altered ecosystem dynamics affect provision of ecosystem services?
- Q 4:** How do changes in vital ecosystem services feed back to alter human behavior?
- Q 5:** Which human actions influence the frequency, magnitude, and form of press and pulse disturbance regimes within and across ecosystems?

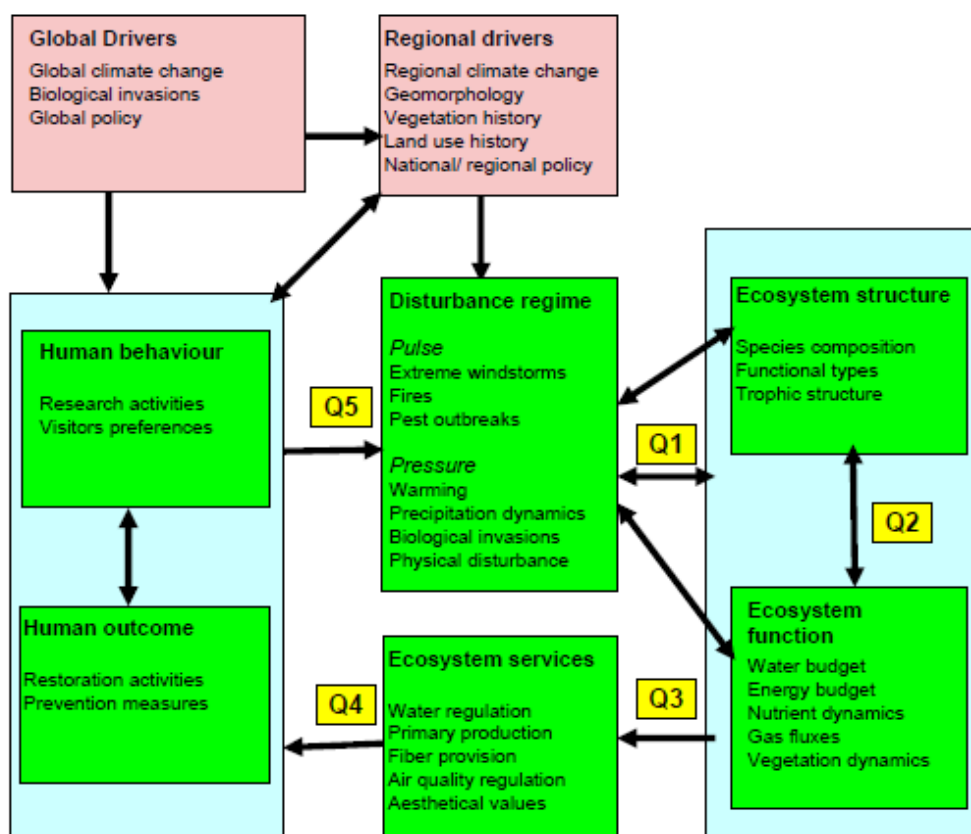


Figure 4. Site level socio-ecological system

Level 2: Landscape level

Narrative: The wind heavily damaged forest in area of 12.600 ha – almost all trees in this territory were either displaced or broken. Affected were mainly spruce forests that were in the early 20th Century artificially planted after similar disturbance, but operating in smaller (ca 60%) area. In short time after storm, the wood was processed in large part of the damaged area: till end of May 2006, nearly 1.9 million meter cubic of timber was excavated. This had significant impact to local and regional economy: on one hand, high amount of people found job in the wood processing operations in the area, on the other hand, the surplus of spruce timber led to decrease of wood price. The tree branches, bark and non-utilizable parts of trunks were burned directly in the place. The burning resulted in rapid increase of air pollution. This relatively short-term, but intensive decrease of the air quality had significant impact to therapeutic function of the forest zone (many spa building creating „climatic spa“ are located in the damaged zone). After end of burning period, the air quality improved, but

the large-scale removal of continuous forest ecosystem changed micro- and mezo-climate for long period with permanent consequences to therapeutic function of the area.

All settlements and majority of hotels in the Tatra Mts. are located in the damaged area. There were recorded significant damages to infrastructure: damaged were buildings, roads and mountain railway. These losses were within a few months removed, but significant concerns about reduction in number of tourists visiting the territory remained as the local economy is based especially on tourism. These fears have proved only partially justified – the number of tourists has decreased slightly, but their behavior changed: instead of medium-term stays (week to two weeks) started to outweigh one-day or weekend visits.

The restoration of the damaged forests is managed by the state forestry service (State forests of TANAP): the natural reforestation occurred on area of 1608 ha while the artificial restoration was applied on area of 1640 hectares. The forestry service attempts to respect natural conditions as much as possible in order to reach mixed stands of uneven age with species composition corresponding to local conditions.

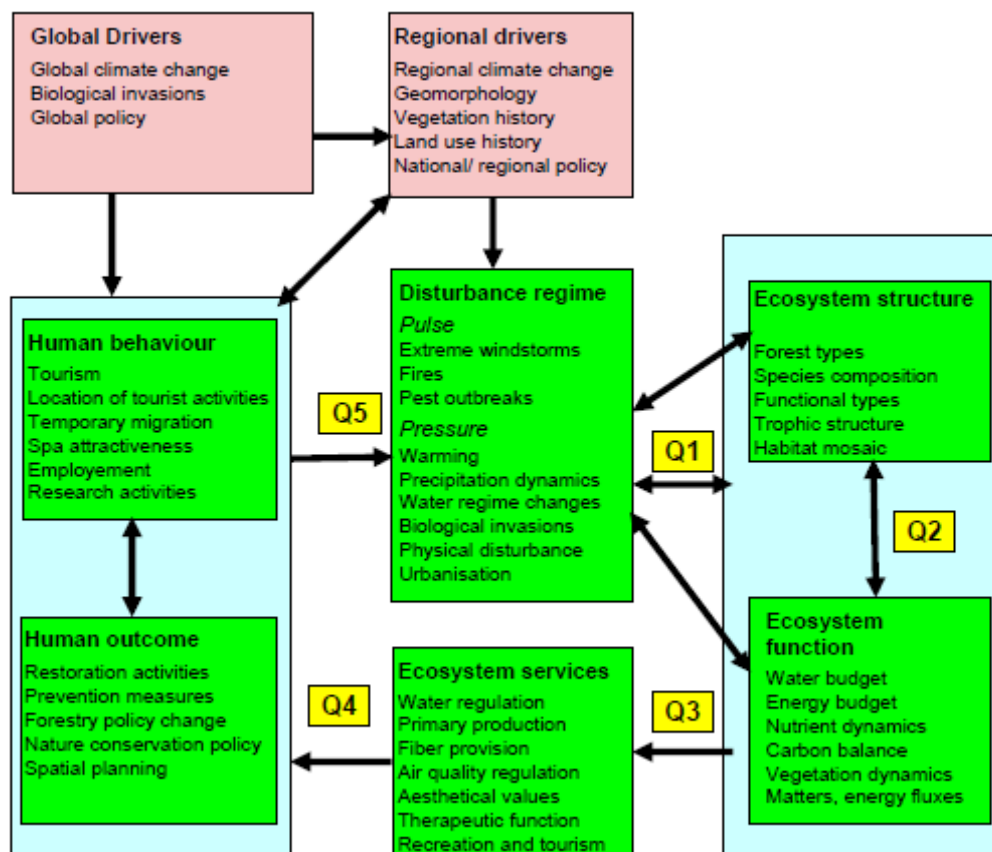


Figure 5. Landscape level socio-ecological system

Landscape level research questions:

Q 1: Are there differences in impact of long-term climate changes (temperature, precipitation) and short-term pulse disturbances (windstorms, fires, pest outbreaks) to ecosystem structure and dynamics of different forest types?

Q 2: How the altered mosaics of ecosystems influence ecosystem functions and horizontal relationships in the forest zone?

- Q 3:** How do altered ecosystem dynamics affect ecosystem services provision by forests in Tatra Mts?
- Q 4:** Which human interventions/measures will induce changes in ecosystem services provision and how the behavior of local population and visitors will be influenced?
- Q 5:** Which human actions influence the frequency, magnitude, and form of press and pulse disturbance regimes within and across ecosystems?

Regional level

Narrative: The development of the area of Tatra Mountains is under influence of different interest groups: environmentalists, owners or tenants of land and forests, local inhabitants, visitors, tourism businessmen and developers (among others). The windstorm damage intensified contradictions between these groups and induced changes in the management of the region. The zonation of the National Park was prepared several years ago, but not approved and discussion about it started again. The state nature conservancy ordered to keep the biomass of more than 580.000 m³ of wood in area of higher (3-5) conservation degree. In the second year after damage the political influence impacted area when the government sent machines to process wood in protected valleys. The environmentalists protested against this practice and the conflict exacerbated. In third year, the bark beetle invasion occurred and large areas of before not damaged forests was destructed; the damage was estimated at €289 millions. The enlargement of damaged area by bark beetle impact further restricted area of territory that is attractive for visitors and the recreation potential of whole Tatra Mts. decreased.

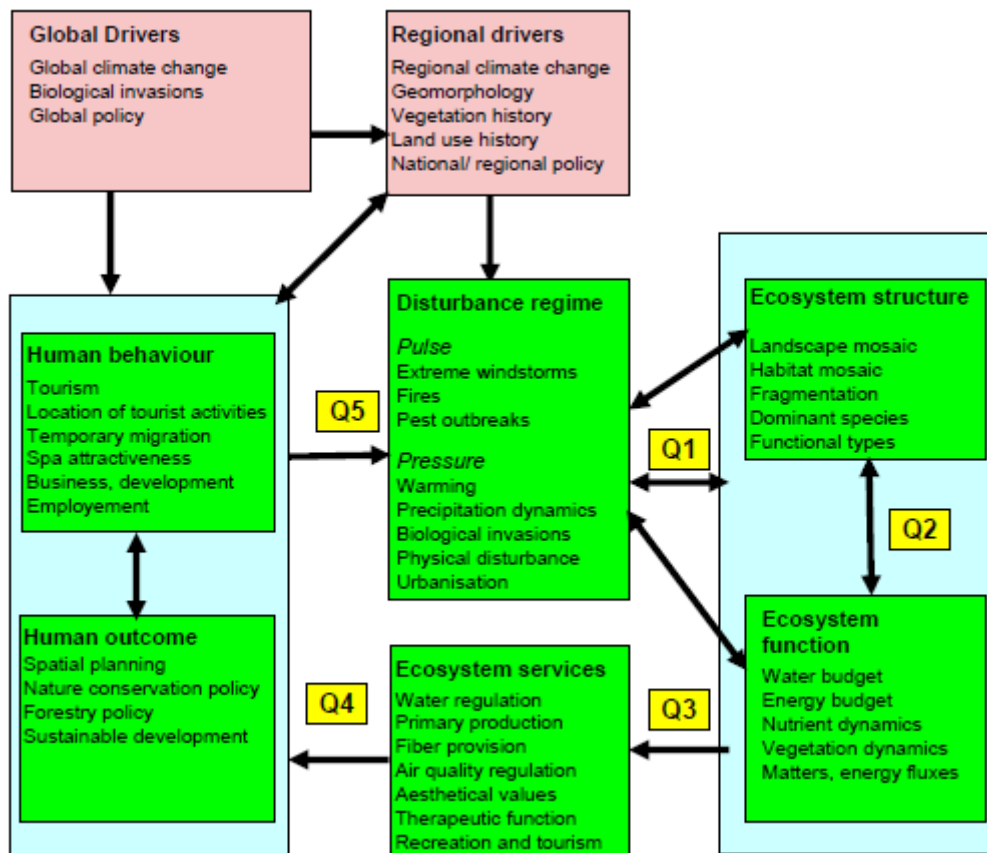


Figure 6. Regional level socio-ecological system

When the situation after the windstorm calmed down a bit, step up the activities of investors and developers who were interested to expand their business activities in the national park arguing that they try of the Tatras to build a modern resort. They were quite successful in promoting their interests in recent years and alongside investment in existing facilities they began also to generate new projects. The biggest impact on the nature of the National Park had reconstruction of the downhill trail from Skalnaté Pleso to Tatranská Lomnica.

Regional level research questions:

- Q 1:** Are will the long-term climate changes (temperature, precipitation) and short-term pulse disturbances (windstorms, fires, pest outbreaks) impact the structure and dynamics of different vertical zones of mountains and their interaction?
- Q 2:** How the altered landscape mosaics influence ecosystem functions and horizontal relationships in the mountain system?
- Q 3:** How do altered ecosystem dynamics affect ecosystem services provision on regional level?
- Q 4:** Which will the society modify its behavior in reaction to changed provision of ecosystem services?
- Q 5:** Which human actions influence the frequency, magnitude, and form of press and pulse disturbance regimes within and across ecosystems?

Regime shifts and interactions

We summarized the most important regime shifts by scales and by domains. Inside the blocks, the arrows stand for the present time changes. The arrows between the blocks can be considered research questions: a few of them have been investigated, while most of them are worth to investigate.

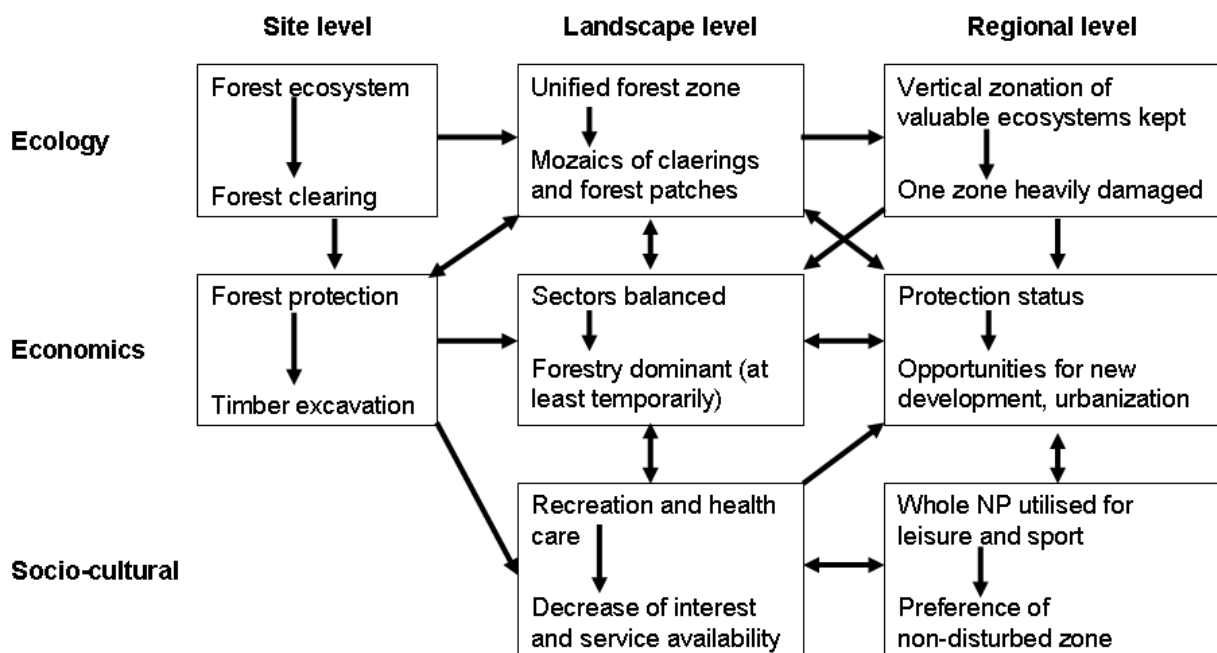


Figure 7. Interactions between regime shifts in Tatra Mts.

Ecosystem services and interactions between them

The case study area has relatively high variability of natural conditions related to the geological background, distribution of geological formations, relief diversity and a wide range of climatic and soil conditions. This variability is clearly reflected in the land-use and ecosystem services. The selected ecosystem services are discussed below, the summary of all studied ecosystem services is provided in table 1.

Provisioning Services

Despite high natural values of the area, also the provisioning services remain important. The core zone of the area has high coverage of forests, therefore especially provision of fiber is potentially important. However, the fiber excavation is limited because of the special regime applied to the forests. Majority of them are reserved for protection and special-function purposes. Forests of the Biosphere Reserve are owned in 54,6% by the state, 33,7% by associations of private owners, 9,8% by municipalities and 1,9% by individuals, churches and other subjects. The main part of forests is managed by the State Forests of TANAP in Tatranská Lomnica. Their activities are focused to protective measures (e.g. against the calamity of wood parasite insects), the calamity wood processing and the afforestation and some further activities, including management of the hunting ground in the core area of TANAP (42 164 ha - so-called exempt hunting ground where hunting is regulated by the state).

Food provision. Agriculture has long tradition in the region, the area was typically used for breeding of sheep and cattle and their grazing. The region was renowned for cheese production and for the special kind of soft cheese called bryndza even abroad. After the World War 2, the broad transformation of agriculture occurred. The nationalization and fusion of parcels started and cooperatives were created. Collectivization and socialization of agricultural production took place mainly in the southern part of the area where a mono-functional agricultural land with prevailing arable land was created. After the national park declaration, the agriculture was almost completely eliminated in the NP area and moved to the buffer area.

The internal part of the NP is important for other provisioning function – water provision. The mountains are called also „towers of water“ and this is true also for Tatra Mts. where important sources of water exist. In addition to significant reserves of underground water, the area counts 13 water-supply courses and 26 other important watercourses. The mountain-foot area is rich in geo-thermal springs and there are also several sources of mineral water mostly of local and regional rank.

Regulating Services

In the study area is important especially air quality regulation, regulation of the natural risk and hazards, such as floods, avalanches, slopes, erosion-accumulation processes, gravitation processes, etc. and regulation of climate. The area abounds with the forest and water resources. The category of forests with protection function prevails (23.346 ha), focused mainly on water and soil protection and the erosion and avalanches prevention. For the air quality regulation, especially high coverage of forest in the territory is important.

Table 1. Review of ecosystem services at the case study site

Ecosystem Service	Important at site?	Direction of change	Primary drivers of change	Public awareness of service	Institutions that manage this service
Provisioning Services					
Food	Yes	About the same		Medium	Ministry of Agriculture, local farmers
Fiber	Yes	Degrading	Wind damages, pests	High	Forest Service
Fuel	None				
Genetic Resources	Yes	About the same	Not known	Low	National Park Administration
Biochemicals & pharmaceuticals	None				
Fresh Water	Yes	Degrading	Wind damages, soil erosion	High	Water authority
Ornamental resources	None				
Regulating Services					
Air quality regulation	Yes	Degrading	Wind damages	Medium	NP Administr.
Climate regulation	Yes	Degrading	Wind damages	Low	Not known
Water regulation	Yes	Degrading	Wind damages, logging, illegal landfills, soil erosion, intensive tourism	Medium	Water authority
Erosion regulation	Yes	Degrading	Wind damages and pests-forest damage	Low	NP Administr.
Water purification and waste treatment	Yes	Degrading	Wind damages and pests-forest damage	Low	?
Disease regulation	Yes	Not known		Low	?
Pest regulation	Yes	Degrading	Wind damages	Medium	Forestry Service
Pollination	None				
Natural hazard regulation	Yes	Degrading	Climatic change, air pollution	Low	?
Cultural Services					
Cultural diversity	No				
Spiritual and religious values	Yes	Degrading	Wind damages	Medium	?
Knowledge systems	No				
Educational values	Yes	About the same	Not known	Medium	?
Inspiration	Yes	About the same	Not known	Low	?
Aesthetic values	Yes	Degrading	Wind damages	High	?
Social relations	No				?
Sense of place	Yes	Degrading	Wind damages	Low	
Cultural heritage values	Yes	Degrading	Urbanisation, insufficient management	Medium	Local administration, owners
Recreation and ecotourism	Yes	Degrading	Wind damages, natural hazards – avalanches, noise	High	Local and regional administration
Therapeutic service	Yes	Degrading	Wind damages, air pollution, noise	Medium	Local administration, Ministry, owners
Supporting Services					
Soil formation	Yes	About the same			NP Administration
Photosynthesis	Yes	Degrading	Wind damages, pests	Low	Forest Service
Primary production	Yes	Degrading	Wind damages, pests	Medium	Forest Service
Nutrient cycling	Yes	Degrading	Wind damages, pollution	Low	?
Water cycling	Yes	Degrading	Wind damages	Low	?

Legend: most important ecosystem services are highlighted

Cultural Services

The study area provides different cultural services, the most important ones are recreation and tourism, aesthetic value and therapeutic service.

Recreation and tourism. The first visitors of the Tatra Mts. were recorded already since the second half of the 16th century (written records). In the 19th century climbing activities emerged and in the second half of the century almost all of the Tatra peaks had been already conquered. Development of winter recreation in the area started in the beginning of the 20th century when the first ski-slope and cross-country tracks, ski-jumping facilities, sledge and bobsleigh tracks were built. As an important scenic mountain trail, Tatranská Magistála was created that is currently 46,2 km long. Annually, there are held many home and international ski competitions in the region; the World Championship in Classic Skiing were held here in 1935 and 1970 in Štrbské Pleso. In spite of intensive development of winter sports in the region, the summer tourist activities prevail. The tourists centers build in basins around the study area in last period reduce the load on the high-mountain zone of the Tatra Mts.

Table 2. Most important ecosystem services and their perception

Service	Trend	Public perception
Provisioning: Fiber	Recently increased	High
Provisioning: Fresh water	Decreasing	High
Regulating: Air quality	Decreasing	Medium
Cultural: Aesthetic	Decreasing	High
Cultural: Recreation	Decreasing	High
Supporting: Primary production	Decreasing	Medium – low

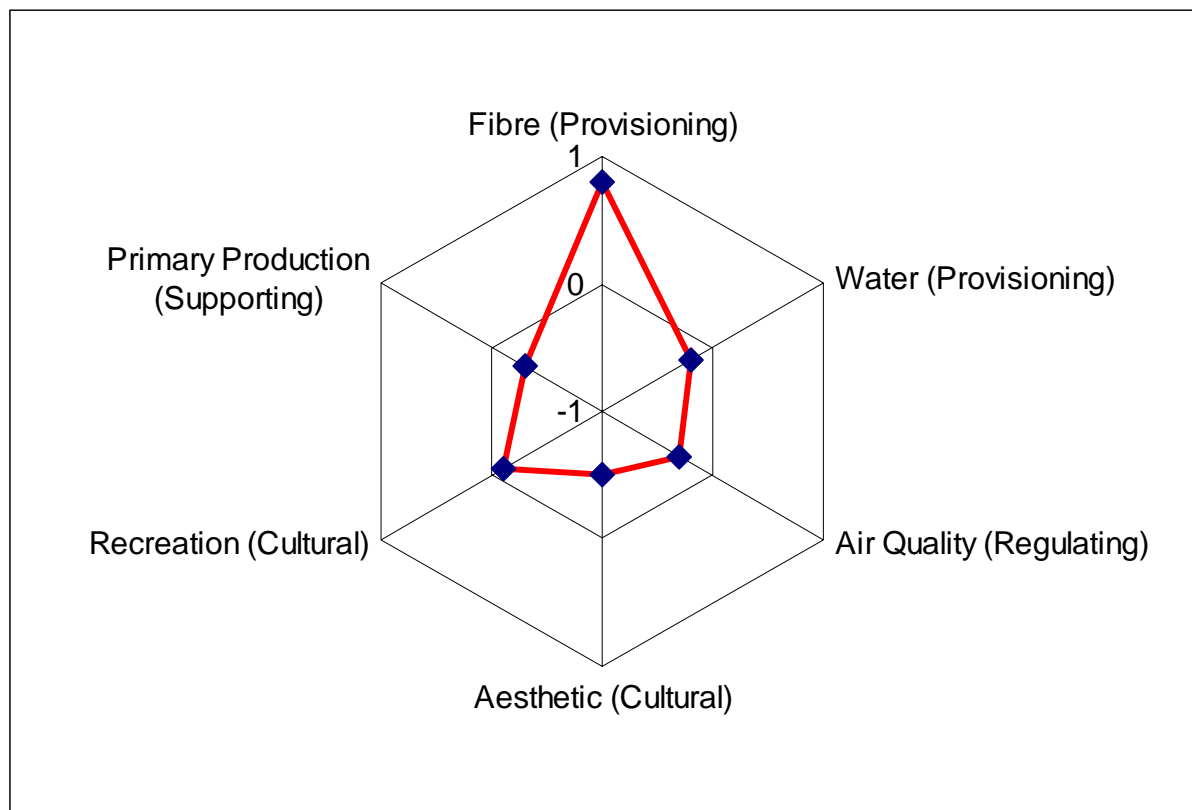


Figure 8. Trend of crucial services change

0 – stable; positive values: increasing trend; negative values: decreasing trend

Therapeutic function. In the region are favorable climatic conditions that support health care. The development of spas in the region started in the 19th century. Its bases were laid down together with foundation of the oldest Tatra settlement Starý Smokovec in 1793. Further settlements with therapeutic-recreational facilities were gradually founded later, before the World War I. The character of a noble atmosphere of therapeutic spas was emphasized not only by high-quality architecture of spa houses, but mainly by the landscape and park arrangement of the surrounding area naturally interlinked with the mountain landscape. After the World War I, cheaper family boarding-houses and sanatoria were needed what stimulated foundation of new settlements and after constitution of Czechoslovakia (1918), large therapeutic complexes were built and this trend continued also after World War 2. Spa activities were focused mainly on treatment of respiratory tract diseases and tuberculosis. The changes in the society after 1989 led to decrease of number of patients as a result of abolition of the state-supported recreation stays and health-care system, as well as the total decline of socio-economical situation of families, reduction of expenses for recreational-therapeutic purposes as a result of insolvency of companies etc. A negative influence had also windstorm in 2004, which significantly damaged the therapeutic and health-care potential of the High Tatra Mts.

From other cultural services, very important is the aesthetic value of the area, for which especially typical mountain landscape, natural habitats and ecosystems are crucial. The cultural functions are supported by existence of many museums, exposition places in the region representing natural, cultural and historic values of the area

Supporting Services

The supporting services are usually less perceived by public, but they are very important, as they are crucial for existence or quality of provision of many other services depending on them. The whole array of supporting services could be found in the study area: soil formation, photosynthesis, primary production, nutrient cycling and water cycling.

We tried to characterize and quantify interactions between crucial services that are listed in table 2. The results are presented in table 3 and figures 9.

Table 3. Interaction between crucial services

TO	FROM					
	Fiber (p)	Fresh water (p)	Air quality (r)	Aesthetic (c)	Recreation (c)	Primary production (s)
Fiber (p)	x					3
Fresh water (p)	-2	x			-1	
Air quality (r)	-2	1	x		-1	2
Aesthetic (c)	-3	2	2	x	-2	2
Recreation (c)	-1	2	3	3	x	1
Primary production (s)	-2	3	2		-1	x

Legend: 1 = weak, 2 = medium, 3 = strong, -1 = weak negative, -2 = medium negative, -3 = strong negative

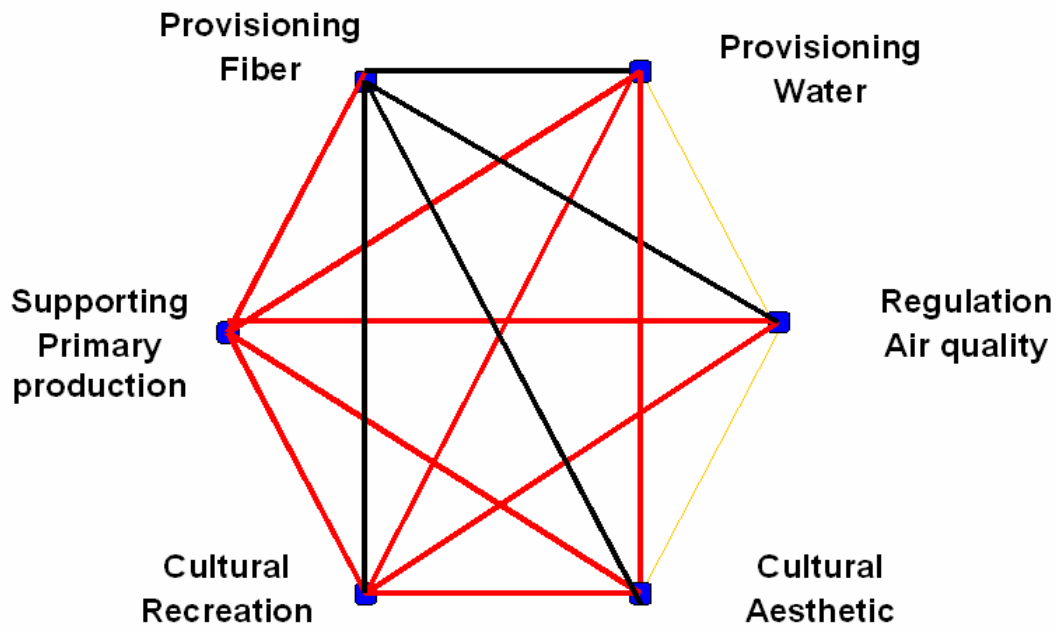


Figure 9. Interaction between crucial services

Black: negative interaction; red – positive interaction; yellow: no interaction