THE METHODS OF PREVENTING TRAIL EROSION ON THE EXAMPLES OF INTENSIVELY USED FOOTPATHS IN THE TATRA AND THE BABIA GÓRA NATIONAL PARKS

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Hiking impact has a great influence on the mountain environment and is a big concern for managers of protected areas. Most of negative effects of trampling, such as soil erosion and vegetation loss, result in a permanent trail erosion and relief transformations.

The study presents the existing and possible ways of mitigation of trail deterioration and methods of theirs maintenance on the example of two popular footpaths located in the Tatra and in the Babia Góra National Parks. Authors present four groups of trail maintenance practices, namely: trails barriers, drainage structures, vegetation protection and supplementary structures.

Prevention of trails erosion can be achieved by preparing theirs surface and application of drainage structures. Application of trails maintenance practices should be preceded by complex geomorphic mapping in different weather seasons.

Key words: Tatra Mts., Babia Góra Mt., trampling impact, trail maintenance, anti-erosion development

INTRODUCTION

Tourism attractiveness of mountain regions is undeniable, given their significant differences in elevation and diverse relief. For this very reason, mountain areas received a lot of tourist traffic, which exceeds the tourist capacity and might be observed in significant deterioration of hiking trails. The mechanical impact of tourist traffic directly affects the condition of trail surface. In the absence of proper trail design and maintenance we observed gradually trails erosion, which leads to the destruction of soil cover. Furthermore, vegetation found near tourist trails is destroyed or altered as a result of the succession of non-native species in trails vicinity. These result in the deterioration of forest ecosystems and relief transformation. In order to minimize the destruction caused by visitors impact and tourist traffic, it is possible to pursue preventive structures along trails and apply effective trail development techniques.

The problem of the negative effects of hiking in mountain areas has been extensively studied by a number of researchers including MACIASZEK and ZWYDAK (1992), ŁAJCZAK (1996), KOPEĆ and GOŁĄB (2002), PRĘDKI (2002), GORCZYCA (2000), TRACZ (2004), KRZEMIEŃ and GORCZYCA (2005), and FIDELUS (2007). Advanced research on the impact of tourism on plant cover in the Tatra Mountains was performed by a number of researchers including PIĘKOŚ-MIRKOWA and MIREK (1982), HOLEKSA (1993), SKAWIŃSKI (1993), MIREK (1996) or CZOCHAŃSKI and SZYDAROWSKI (1996). The issue was also studied in Babia Góra National Park by BOGACZ (1974), CELIŃSKI et al. (1976) or HOLEKSA and HOLEKSA (1981). There is, however, a dearth of studies devoted to the prevention of this type of damage as well as studies recommending effective trail development techniques such as man-made structures and protective plant cover. Keeping in mind maintenance efforts designed to keep trails in a state where plant cover and soil cover are not damaged, it is important to consider effective maintenance practices for preventing their erosion and deterioration.

STUDY AREA

The trails selected for analysis are the most frequently used within their mountain groups –

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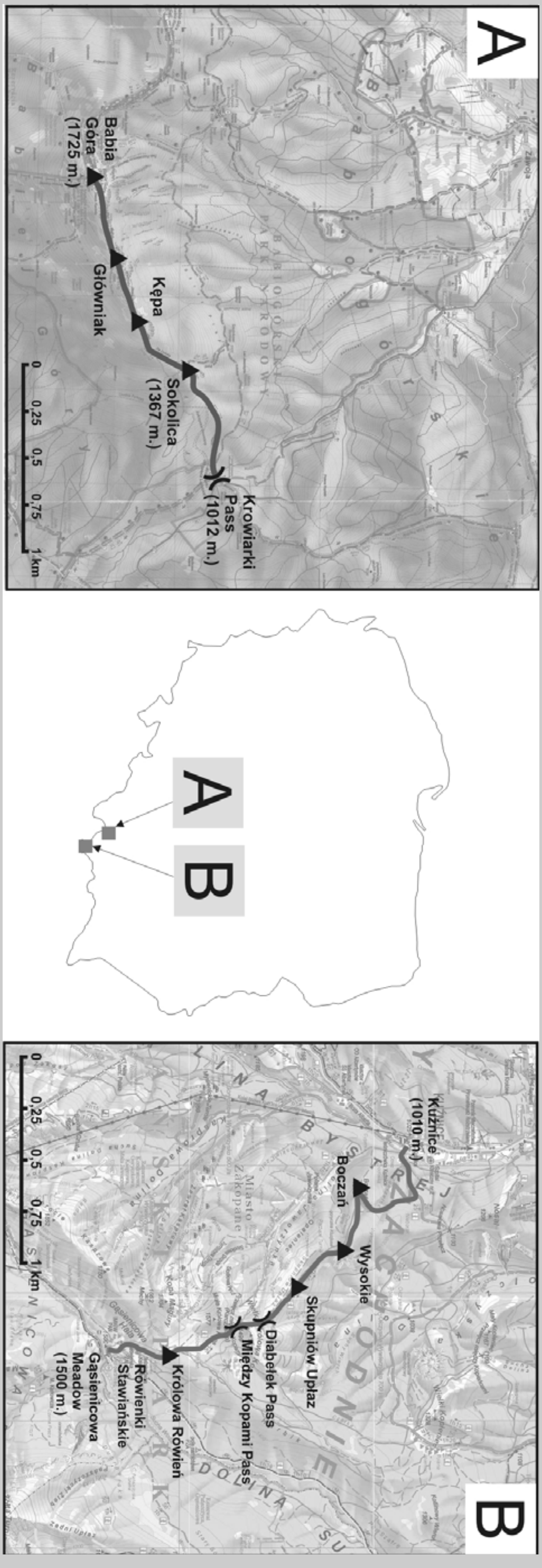

Fig. 1 Studied hiking trails in the Babia Góra (A) and the Tatra (B) National Parks (maps layout: (c) Sygnatura – Polkart)

the result of this being substantial trampling impact. The trail from Kuźnica to the Murowaniec shelter, via Skupniów Upłaz, is an important tourist route heading into the Gąsienicowa Valley and farther destinations in the High Tatras (**Fig. 1B**). The lithology of the trail consists of sedimentary rocks, which are mostly limestone, dolomite, and shale. At higher elevations, postglacial and moraine sediments can be found. The trail runs across three vegetation zones: 1) a lower forest zone, 2) an upper fo-rest zone featuring spruce forest, and 3) a sub-alpine zone featuring dwarf pine. In 2005, the number of tickets sold at the starting point of the trail was about 155,000, which makes this point of entry the fourth most popular in the Tatra Mountains (TNP 2005).

The second investigated hiking trail leads from Lipnicka Pass (Krowiarki) to Babia Góra Mountain and is part of the Main Beskid Trail (**Fig. 1A**). The highest section of the trail is located on Babia Góra Mountain (1725 m a. s. l.) a massif formed of flysch rocks. The trail features Carpathian beech as it runs across lower vegetation zones, spruce forest across upper vegetation zones, dwarf pine across the subalpine zone, and turf across the alpine zone. In Babia Góra National Park, the largest number of tickets is sold at the Krowiarki Pass. Over 46,000 tourists entered the trail during the 2005 summer season (May – Oct.) (BGNP 2005).

EROSION ALONG HIKING TRAILS – THE NATURE OF THE PROBLEM TRAIL

MAINTENANCE TECHNIQUES

Tourist traffic in national parks only moves along marked hiking trails, which creates linear zones of tourist impact. The zones, devoid of plant cover, experience the action of natural morphogenetic processes that induce the soil loss. The first effect of tourist foot traffic on the slope system is the trampling of trail shoulders, which expand in locations devoid of dense plant cover.

For this very reason, it is important that trails should be marked in a way that is unambiguous and does not leave tourists wondering what the limits of the hiking trail zone are. Trail zones can be marked with the help of structures that act as a sort of fence: stone or wooden kerbs, wooden logs, rope lines, or simply dense vegetation. Trail shoulders, devoid of dense plant cover and characterized by less porous soil cover, do not favour sprouting and overall plant development.

Soils experiencing trampling pressure are characterized by a reduced ability to absorb precipitation, which may lead to intense erosion (MACIASZEK and ZWYDAK 1992). This is especially true during high intensity precipitation. In order to minimize the damage inflicted by hiking activity, the two key goals are to effectively channel the flow of tourist traffic and make it difficult for tourists to wander off trails and trample vegetation near trails and vantage points. Therefore four main trails maintenance practices were distinguished, namely: trails barriers, drainage structures, vegetation protection and supplementary structures (**Fig. 2**).

DRAINAGE STRUCTURES. TRAILSIDE ANTI-EROSION DEVELOPMENT

Main process that damages trail surfaces, especially along steeper sections of trail, is water erosion. Water appears on trails due to precipitation as well as the ablation of snow cover. For this reason, drainage structures are the second type of anti-erosion development used along hiking trails. The purpose of such structures is to limit the effects of water erosion along trails. In order to reduce the amount of time water remains on trails running across slopes, slight grading can be applied to trail surfaces (**Fig. 3**). It is best if trail surface grades conform to the slope line. This ensures that water flows down the slope, as expected.

When optimal grading is applied, the magnitude of soil erosion along trails is reduced. A 3 – 5º grade has been accepted as optimal for ground forest roads (KOCZWAŃSKI 1995). This ensures that, absent any barriers to runoff, water can freely flow off the trail and onto the shoulder. In some cases, local topography makes it necessary to design trail grades inconsistent with the slope's line. In such cases, water flows onto the slope-side shoulder, which should have a drainage ditch made of stone under the best of circumstances. The ditch should direct water to the nearest culvert or drain.

The best way to remove water from the soil layer of forest roads and hiking trails is via drains and culverts, which allow water to drain off the entire surface of the road or trail (**Fig. 4**). Drains can be made of many different materials including wood, concrete, and metal. They are widely used on properly constructed forest roads (KOCZWAŃSKI et al. 1994, KOCZWAŃSKI 1995). Proper placement of drains as well as barriers such as wooden thresholds effectively minimizes the soil wash-out and loss from trail surfaces (GRAB and KALIBBALA 2008). It is, however, important to remember to systematically unclog drainage structures.

Ideas on what types of anti-erosion development to use along a trail, being a sort of

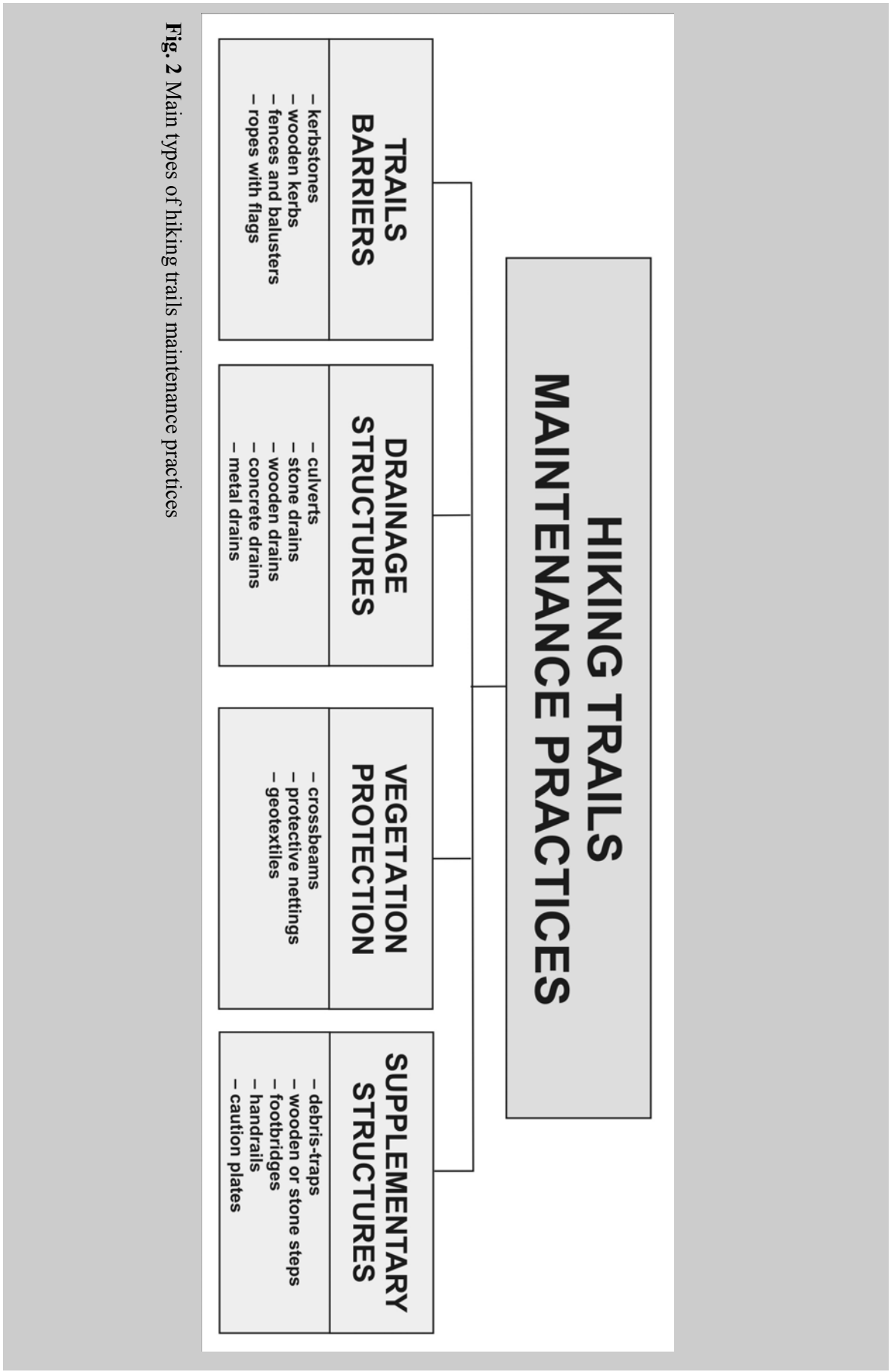

Fig. 2 Main types of hiking trails maintenance practices

Fig. 3 The example of slight grading applied on the hiking trail within the Skupniów Upłaz (Tatra National Park)

an example of a ground road, can be applied from forest road construction and maintenance manuals. The number of drains along a trail should be large enough (usually every 40 – 50 m in the case of forest roads) that water is effectively diverted off its surface, keeping in mind the grade of the trail surface. The steeper the trail, the more drains it should have.

When water remains on a trail surface, even for a short period of time, temporary depressions tend to form and widen the trail, as tourists bypass them and trample the shoulder area. This leads to the deterioration of natural vegetation on shoulder surfaces. Special attention needs to be paid to places where trails run across streams. Trails ought not serve as temporary streams. This often happens when trailside drainage structures are not maintained properly (mud-filled drains, blocked culvert entrances). Maintenance problems tend to reinforce the erosion along trails and increasing of theirs incision. When culverts are blocked by rocks and woody debris, lateral erosion may also become more destructive in stream channels during intensive rainfalls or the melting of snow.

One of the more effective ways of minimizing threats resulting from water erosion along hiking trails is reducing the grade of the trail. This leads to a slower flow of water, which reduces slope erosion. Most planning work ought to be performed at the trail design stage. However, the research area in this case includes trails that were marked intuitively. Some follow former hunting trails, mining trails (e.g. in the Tatras), and pastoral paths.

Damaged trail surfaces are most often observed along steeper sections of hiking trails. Topography permitting, it would be a good idea to consider redesigning trails away from areas characterized by significant erosion potential. Trails ought to run along traverses or along a path slightly skewed with respect to

Fig. 4 The wooden drains limit the effects of water run-off and reduce soil loss form the trail surface (Markowe Szczawiny, Babia Góra National Park)

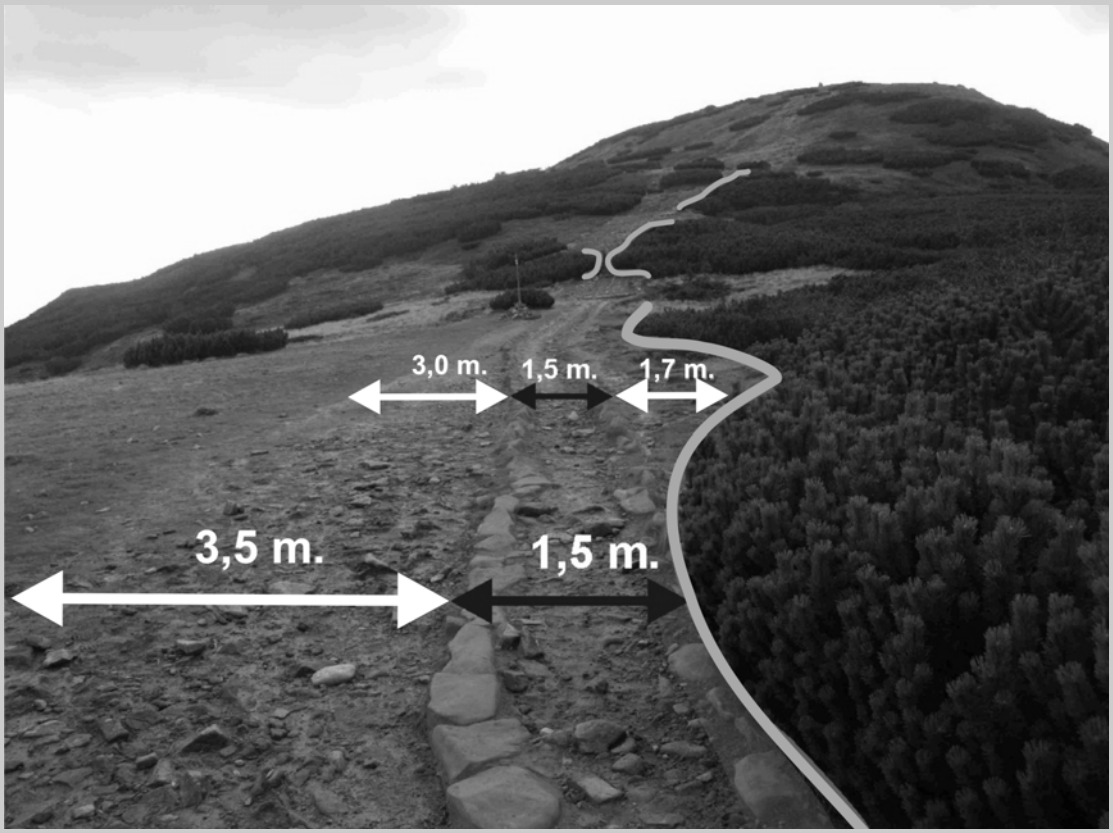

Fig. 5 The kerbstones delimit trial width (1.5 m), however wide (3.0 – 3.5 m) surface (left side) is under trampling impact. The dwarf mountain pine growing on the trailside strictly limits trail deterioration (trail section between Sokolica and Babia Góra; Babia Gora National Park)

contour lines. The largest potential for erosion exists along steep sections of trail running perpendicularly to contour lines. Trails should not include steep sections where the soil is prone to erosion. Trail grade should not exceed 10º. If a trail must include steep sections, then the construction of supplementary structures such as wooden or stone steps should be given consideration.

TRAMPLING TRAIL SHOULDERS. STRUCTURES THAT PROTECT VEGETATION COVER ALONG TRAILS

Trampling is a process that favors the formation of bare surfaces susceptible to erosion along trail shoulders and theirs vicinity. The landforms that result from trampling lead to the widening of marked trails, an increase in the human pressure zone, and encourage the exploration of surrounding areas, which leads to the destruction of plant cover (**Fig. 5**).

It is particularly recommended that shortcuts and social trails of all types be avoided along trails. The most common preventive measure used in this case is the installation of wooden or stone kerbs. This form of protection is even more effective while at the same time vegetation protections are used. The species that resists trampling pressure best is dwarf pine. This species, when planted along a hiking trail, is very effective at protecting trail shoulders from tourist exploration (Skupinów Upłaz, the Tatras).

Vegetation protections are also an effective means of trail shoulder reclamation. It must be noted that planted areas should be surrounded by fencing and not trampled over. Wooden barriers such as crossbeams are simple and effective means of providing such protection. This results in the channeling of tourist traffic along a given trail and its shoulder areas are able to experience plant succession.

OTHER TRAILS MAINTENANCE PRACTICES. SUPPLEMENTARY STRUCTURES

The effects of hiking impact can be minimized via the use of artificial trail surfaces, trail drainage systems, and erosive cuts reclamation. The types of anti-erosion structures

Fig. 6 Debris-traps along the trail within the Skupniów Upłaz as the example of an effective supplementary trail maintenance structures (Tatra National Park)

listed above are often aided by the use of supplementary structures. For example, debris-traps can be used to stop loose material from falling off the sides of steep sections of trail (**Fig. 6**).

Sections of trail running across natural streams are unique in a different way. Such sections need to be equipped with stable footbridges, usually made of wood.

Still another issue is the management of vantage points, which are a natural magnet for tourists wandering off trails. Some of the more common means of protecting trails are handrails or warning signs and caution plates instructing tourists not to wander off marked trails. The effectiveness of trails maintenance practices is strictly related to the ecological awareness level of tourists, which helps in the accomplishment of protection goals to a greater or lesser degree. Many hikers, however, are unaware of the extent of the damage they cause by trampling. Hence, it seems most appropriate for protective structures to be taken in conjunction with educational measures.

CONCLUSIONS

Trail surfaces must be safe for tourists and their maintenance is the responsibility of Park authorities. The use of trails maintenance practices ought to be preceded by thorough geomorphological mapping of hiking trails in different seasons. Each trail should be checked following snowmelt season, so that any sections of trail damaged by erosion can be repaired – primarily in terms of stabilizing their surface. Special attention ought to be paid to sections of trail that run parallel to ski tracks.

Well-designed trails result in fewer problems associated with their maintenance, while being user-friendly at the same time. Properly maintained trails do not allow the formation of trampling zones and other types of trails deterioration. This, in turn, results in a decreased need for repairs. Efforts designed to minimize trail damage result in reduced overall environmental damage and reduced trail maintenance costs. It is not possible to stop natural denudation processes, however, their effects can be attenuated via proper trail routing and effective anti-erosion development.

The design and installation of anti-erosion structures that minimize soil loss and vegetation damage along hiking trails need to be well thought out. What should not happen is a situation where structures designed to protect the environment lead to further damage instead. In light of different local trail conditions (slope aspect, lithology, density of hydrographic net-

work, soil properties, plant cover resistance, trail vicinity, etc.), each section of trail should be analyzed separately without resorting to any standardized solutions.

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