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Cover photo:
left: Establishing bench terraces for orchards in Igriste/South Morava River Basin, South Serbia (photo: Ratko Kadoovic, 1989)
right: Conservation of unused and erosion-prone land into productive Oblacinska Cherry in Igriste (Photo courtesy of Porecje Company/Porecje-Vucje/South Morava River Basin, South Serbia)



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# Restoration of Eroded Surfaces in Ski Resorts of Serbia

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## Abstract

The construction works at ski resorts involve numerous environmental violations. Massive clearing measures in the mountain zones of Serbia have been undertaken since the 2006, for the creation new ski-runs and enlarge existing. This caused serious problems with soil erosion and surface runoff, with ecological and economic consequences. In order to solve these problems, especially on ski-runs, a special strategy was created, for restoration and protection of eroded surfaces, which includes technical, biotechnical and administrative measures. This was applied to ski-runs on mountains Stara planina and Maljen. Restoration and erosion control works have stopped degradation processes and helped reestablish vegetation and rehabilitate landscape appearance and functions.

**Keywords:** Restoration, erosion control, ski runs, technical and biotechnical structures.

## Introduction

The construction of new and improvement of existing ski resorts is a very attractive activity in the transition societies of Balkan region (Serbia, Montenegro, Bulgaria), but involves numerous environmental violations during and after work (Ristić, 2007; Perović, 2007/2008; "For Earth" 2007; Fattorini, 2001). The logging and construction works, large excavations, erosion, noise and water pollution constantly impact the environment (Geneletti, 2007; Riess, 1996). Sediment yields can be 10 times greater from ski-run soils than from neighboring, undisturbed sites (Grismer and Eliss, 2006). The process also leads to severe fragmentation of the remaining old-growth forests, endangering future subsistence.

This study tackles two Serbian ski resorts „Stara Planina" and „Divčibare", which were created without thought to erosion control projects. Building activities in the ski resort "Stara planina" started in summer 2006, and the first skiers were recorded in winter season 2006/2007. This ski resort is located on

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the biggest mountain in East Serbia – Stara planina, which runs along the Serbian-Bulgarian border (Fig. 1). Three ski-slopes of 3.700 m in length and associated installations were completed during the first construction phase. In December 2006, a new detachable quad chair lift and one ski lift were added. The total value of these investments was about 4.000.000 €.


*Fig. 1: Location of ski resorts Stara Planina (1) and Divčibare (2)*

Construction of the ski-run „Crni vrh" in the proximity of the locality Divčibare, on the Maljen mountain (West Serbia), started in summer 2006 (Fig. 1). By the end of 2006, the construction of one 850m long ski-slope with double chair lift had begun. On completion, in 2007, totaling investment was approximately 1.000.000 €.

## Erosion processes and degradation of landscape

After massive clearings and machine grading of slopes, the surface soil layer became vulnerable to erosion, thus creating a source of sediment that was easily transported into local streams (Macan et al., 1997; Ristić et al., 2005). Disturbances caused degradation of the unique mountain landscape, leading to functional and aesthetic problems, along and around all the newly-built ski-slopes (Ristić et al., 2007).

The logging, large excavation activities, construction works on the steep slopes, caused the appearance of rills, gullies, debris flows and shallow land slides (Fig. 2, 3). The shallow soil coverage on the steep slopes started to be stripped away with every onset of intensive rainfall or snowmelt.

*Fig. 2: Ski run „Konjarnik I" (Stara Planina, August 2007)*

*Fig. 3: Ski run „Crni vrh" (Divčibare, August 2007)*

In the region of Stara Planina, sediment yields ranged from 6460 $m^3 \cdot km^{-2} \cdot year^{-1}$ on disturbed surfaces (ski run „Konjarnik 1", Zubska river catchment), to 450 $m^3 \cdot km^{-2} \cdot year^{-1}$ on undisturbed surfaces (Repuški stream catchment) (Ristić et al., 2008b). Sediment production was calculated using a method of „Erosion Potential" (method prof. Gavrilović). Sediment yields were nearly 14 times greater from red sand and granite ski-run soils than from undisturbed (native) sites (Ristić et al., 2008b). Consequences of mismanagement on ski-runs are noticeable in downstream sections of river beds, causing bed-load deposition, especially on Stara planina.

## Restoration and erosion control works

Work carried out from May-October, 2008, was done in accordance with basic restoration (Krautzer et al., 2006; Peratoner, 2003) and erosion control works principles (Ristić et al., 2007; Nondedeu and Bédécarrats, 2007). Although the problems encountered in the ski resorts „Stara planina" and „Divčibare" proved to be extensive and diverse, the following treatments were all carried out during 2008 (Ristić et al., 2008a, 2008b):

a) **Technical works**
- stream reclamation (by cleaning and deepening to prevent flooding and meandering) nearby ski-run „Konjarnik 1";
- building two check dams to stop bed-load sediment in Zubska river bed;
- forming of stabilization-drainage constructions (Fig. 7);

b) **Biotechnical works**
- restoration of vegetation, with adopted grass and leguminous mixtures (Fig. 4);
- usage of mulch cover, with netting (Fig. 4);
- installing of contour barriers (CB) against surface runoff (Fig. 5). CB's are manufactured from reed or straw that can be wrapped in tubular form (with or without plastic netting). They are approximately 150-250mm in diameter, 2-4m long. CB's are placed and staked along the contour of newly constructed or disturbed ski-slopes. CB's are intended to decrease velocity of surface runoff, capture and keep sediment on the slopes. They are useful to temporarily stabilize slopes by reducing soil creep, sheet and rill erosion until permanent vegetation can get established. Installed, contour barriers shorten the slope length, thereby interrupting the raveling and riling processes, and reduce the slope steepness. They catch soil material that moves down the slope by the freeze/thaw processes. Organic matter and seeds are trapped behind the barriers, which provide a stable medium for germination. CB's trap retains moisture from rainfall, which aids in growth of seed mixture sown along the upslope. CB's last an average of one to two years. Straw or reed, or other organic material, becomes incorporated into the soil with time, adding organic material to the soil. CB's are laid in small trenches and staked with wooden or iron stakes (Fig. 5);
- forming of surface drainage systems (Fig. 6).

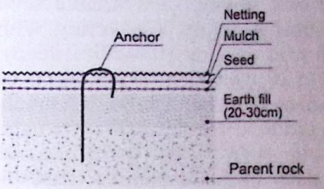


*Fig. 4: Reestablishing soil and vegetation cover (Divčibare, October 2008)*

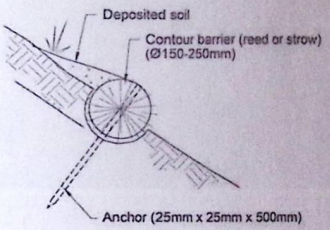


*Fig. 5: Contour barrier against fast surface runoff (Divčibare, October 2008)*

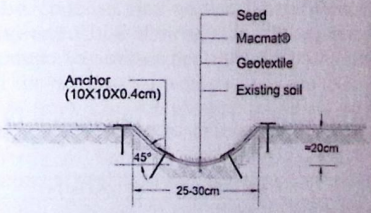


*Fig. 6: Surface drainage system (Stara planina, October 2008)*

The restoration of vegetation on eroded surfaces on ski-runs was carried out in steps (Fig. 4): earthfill (0.2-0.3m) with fertile soil; sowing of available seed mixtures (20gr/m$^2$; 200kg/ha) and mulching (strow, 0.5kg/m$^2$); covering with synthetic or biodegradable nettings, fixed with iron anchors (0.4-0.5m deep); contour barriers installing (on distance from 8 to 20 meters, in dependance of steepness of terrain; Fig. 5); construction of surface drainage system (channels with slope 3-5%, with linning; Fig. 6); installing of SDC (stabilization-drainage constructions) for prevention of shallow land slides, and collecting of underground water by numerous springs, especially on Stara planina (SDC is new construction, for the first time ever used in restoration of ski runs, combination of gabion baskets and drainage trench; Fig. 7).

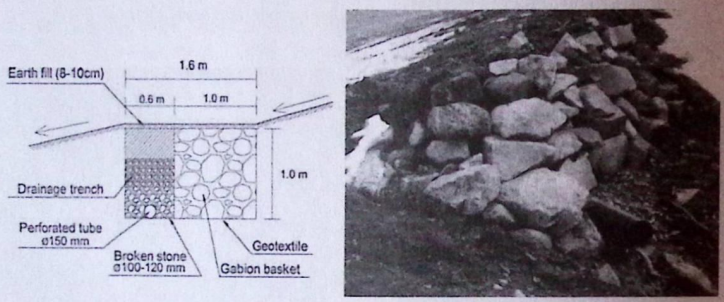


*Fig. 7: Stabilization and drainage construction (outflow; Stara planina, October 2008)*

Surface drainage systems on ski-runs are protected with MacMat (a three-dimensional geomat applied as an erosion control mat for sloped embankments, channel linings and soil-veneer applications). It is a geocomposite manufactured with a reinforcement (generally a double twisted steel wire mesh) inside the geomat, to provide either tensile mechanical strength and a stronger form of erosion protection, better ensuring the stability of the top-soil on the sliding surfaces (polymeric geomembranes), drainage ditches, channels and other areas susceptible to erosion damages. MacMat is lied down on the surface of channels and staked with iron stakes (Fig. 6).

*Table 1: Site specific species and commercial seed mixture (grasses and leguminouses) used on Stara planina*

| Site specific species | Commercial seed mixture |
|---|---|
| 1. *Anemone ranunculoides* | 1. *Festuca rubra* (30%) |
| 2. *Verbascum sp.* | 2. *Agropyrum repens* (15%) |
| 3. *Lusula silvatica* | 3. *Festuca arundinacea* (10%) |
| 4. *Taraxacum officinale* | 4. *Agrostis alba* (15%) |
| 5. *Sesleria sp* | 5. *Trifolium repens* (10%) |
| 6. *Gentiana asclepiadea* | 6. *Festuca ovina* (20%) |
| 7. *Rumex sp.* | |
| 8. *Viola tricolor* | |

*Table 2: Site specific species and commercial seed mixture (grasses and leguminouses) used on Divčibare*

| Site specific species | Commercial seed mixture |
|---|---|
| 1. *Sesleria rigida* | 1. *Festuca rubra* (40%) |
| 2. *Muscari botrioides* | 2. *Agropyrum repens* (15%) |
| 3. *Asteraceae* | 3. *Festuca arundinacea* (25%) |
| 4. *Daphne blagayana* | 4. *Poa pratensis* (5%) |
| 5. *Vaccinium myrtilus* | 5. *Lolium perene* (5%) |
| 6. *Brachipodium silvaticum* | 6. *Lotus corniculatus* (5%) |
| 7. *Luzula sp.* | 7. *Trifolium repens* (5%) |

Restoration works were carried out with commercial seed mixtures (Tables 1, 2), because sufficient quantity of site specific seed mixtures was not available on Serbian market.

## Results of restoration and erosion control activities

The onset and completion of all activities fell within one construction season (May-October, 2008.): technical works were finished until the end of summer, biological and biotechnical until the middle of autumn. Vegetation cover was established just 20 days after sowing, and care measures continued until the end of summer 2009.

The completion of the restoration and erosion control works significantly changed the general condition and appearance of the ski-runs "Konjarnik 1" and "Crni vrh" (Fig. 8, 9). These restoration and erosion control works at the ski-resorts "Stara planina" and "Divčibare" were the first activities of their kind in Serbia. In the past there was a lack of planned and organized erosion control activities during design, construction, improvement or maintenance stages for ski areas in Serbia. Legal nature-protection standards were poorly implemented in Serbian ski areas.

However, neglecting investment for erosion control works, immediately after basic construction works, caused costs of 300.000,00 € - Divčibare, ski-run "Crni vrh"; 1.000.000,00 € - Stara planina, ski-run "Konjarnik 1". For the sake of an initial investment of just 3-5% of total costs in erosion control work, the bill for restorative works was as much as 20-25% of total costs.

Meanwhile, the greatest problems now affect the period without snow (May-October), when the ski-runs become places for diverse, undesirable activities: moving of vehicles (tracklaying vehicles; motorcycles; SUV; tractors); cattle grazing (local farmers have herds of cows and sheeps, that freely move around); uncontrolled forest activities (logging and transport of timber from nearby forest stands); uncontrolled moving of tourists.

Among many consequences are the compaction of surface soil layers; the reduction of infiltration capacity; degradation of vegetation cover; intensifying of surface runoff; decreasing of resistance on erosion. Consequently, it was necessary for the restoration programme to issue some administrative bans and guidelines, concerning the sustainable capacity for different activities: level of

maximum load (tourists, vehicles, cattle); apllication of BMP's in exploitation of forest; guidelines for sustainable management with controll mechanisms, etc.

*Fig. 8: Ski run „Konjarnik 1" (Stara Planina, October 2008)*

*Fig. 9: Ski run „Crni vrh" (Divčibare, October 2008)*

In addition, the plan had to ensure that the new measures were adequately maintained. Stuff was trained to recognize the critical points on ski-runs. Their work included:

- Inspecting the surface drainage systems and CB's after significant storms (drainage channels have to be cleaned of deposited soil, and it must be ensured that their protective mat remains in close contact with the soil);
- Repairing any furrows promptly;
- Reseeding vegetation if necessary, until the slope is stabilized.

## Conclusions

The environmental impacts of the ski resorts "Stara Planina" and "Divčibare" were very severe, leading to environmental degradation and functionality losses. Construction works degraded topsoil and native vegetation, enhanced erosion and sediment yield. Other impacts included: forest clear cuttings; trunk transport down the slope; road construction and large excavations. Restoration and erosion control works have stopped these degradation processes and helped reestablish vegetation and rehabilitate landscape appearance and functions.

The successful restoration and erosion control works in ski resorts „Stara planina" and „Divčibare" were constructed on several principles:

- ✓ preservation of the ability of soil to absorb water from rainstorms and snowmelt, without generating fast surface runoff;
- ✓ prevention of disturbed soil erosion by either decreasing the velocity of overland flow, or by diverting it into forest stands or local streams;
- ✓ stabilization of endangered sections of ski-runs and evacuation of underground water;
- ✓ restoration of vegetation on eroded surfaces;
- ✓ protection and reclamation of disturbed areas within same constructing season, in accordance with natural ambiance.

Further projects in ski areas of Serbia need careful assessments of the impact of the land use changes at all levels of planning (spatial, urbanistic, regulation) and design.

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