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ENVIRONMENTAL IMPACTS IN SERBIAN SKI RESORTS

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Abstract: Construction or improvement of Serbian ski resorts produced numerous negative effects to surrounding environment, endangering even the functionality of the built objects. Investigation involved the analysis of disturbing activities by phases, and consequential environmental impacts. Clear cuttings, trunk transport, machine grading of slopes, huge excavations, and access road construction, caused the strongest pressure to the environment. Follow up activities during skiing and non skiing periods: skiing, usage of snow groomers, moving of vehicles and tourists, forestry activities and overgrazing. Consequential environmental impacts are clearly noticeable through intensive erosion processes, changes of hydrological conditions and forest fragmentation. The most affected ski runs were surveyed (scale 1:1000), all damages were mapped and classified during the summers of 2007-2010. Development of rills and gullies was measured at experimental plots (100x60 m), integrating survey data into GIS application. Changes of hydrological conditions were estimated on computations of maximal discharges before and after the construction of ski resorts, as well as using local hydrological records. Forest fragmentation is studied on the basis of detailed survey and field work.

Key words: ski resort, soil erosion, hydrological conditions, forest fragmentation, environmental impacts.

1. INTRODUCTION

The environmental impacts in traditional Serbian ski resorts (Kopaonik, Zlatibor) as well as in the new ones (Stara Planina; Divchibare) are very strong, leading to landscape degradation and functionality losses of built objects. Construction or improvment works comprised areas in headwaters of local streams, very fragile to any modification of the established natural conditions. First victims of changes were trees in old growth forests and topsoil, like in similar enterprises around the world (Tsuyuzaki, 1994; Balaganskayaa & Malinen, 2000). It is followed by the loss of typical, rare and endangered species living in mountain areas (Geneleti, 2008). After the completion of activities ski run soils are highly vulnerable and susceptible to erosion, with significantly transformed hydrolic-hydrological parameters such as surface roughness, velocity of surface runoff and retention capacity (Nondedeu et al., 2006; Ristić, 2006; Frepazz et al., 2002; Fattorini, 2001). Some activities such as clear cuttings, trunk transport, access road construction and large excavations on steep slopes accelerate erosion processes. Lithological properties of the exposed material and characteristics of precipitation have strong impact on the development of erosion processes (Kasanin-Grubin, 2006; Kasanin-Grubin & Rork, 2007, Dragićević, 2007). Erosion control decreases the intensity of erosion processes (Grismer & Eliss, 2006; Ristić & Macan, 1997), but its lack especially between April and October, results in various forms of land degradation such as rills, gullies, landslides, debris from rock weathering and solifluctions. Mismanagement in ski areas produces unfavorable composition of surfaces (land use) in the headwaters of local streams, with unavoidable consequences: more frequent appearance of torrential floods and bed-load deposition in downstream sections.

2. STUDY AREA

In the former development of mountain areas a few ski resorts were built (Fig. 1). The major and the oldest ski resort in Serbia is located on the Kopaonik

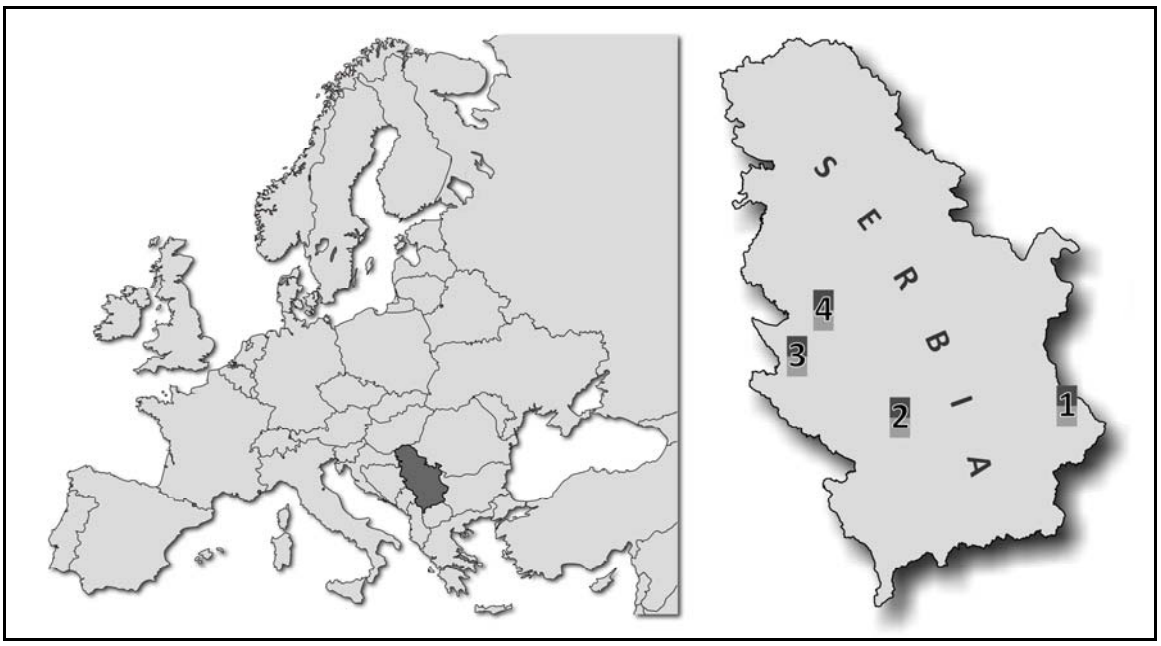

Figure 1. Disposition of studied ski resorts in Serbia: 1-Stara planina; 2-Kopaonik; 3-Zlatibor; 4-Divchibare

Table 1. Physical characteristics of the investigated ski runs

		Parameters					
Ski resort	**Ski run**	**Area km^2**	**Peak point m.a.s.l.**	**Lowest point m.a.s.l.**	**Length of ski run km**	**Mean slope of ski run %**	**Exposition**
Stara planina	Konjarnik 1	0.049	1548	1230	1.134	28.04	NW
	Konjarnik 2	0.025	1554	1355	0.469	42.43	NW
	Sunchana dolina	0.039	1724	1544	0.566	31.80	NE
Kopaonik	Pancicev vrh	0.051	1968	1721	1.599	15.45	N-NW
	Karaman greben B	0.044	1898	1730	1.134	14.81	W-SW
Zlatibor	Zmajevac	0.043	1474	1190	0.856	33.18	N-NE
	Tornik	0.035	1472	1274	0.680	29.12	NW-N-NE
	Chigota	0.043	1260	1111	0.741	20.11	NE
Divchibare	Crni vrh	0.042	1091	910	0.790	22.91	N

mountain, in the area of the National Park. This ski resort offers about 50 km of ski slopes for alpine skiing, about 18 km of ski slopes for cross-country skiing, interconnected with 24 chairlifts and ski lifts. The total investment in the construction of new ski runs and chairlifts, between December 2004 and June 2010, amounts to about 27000000 €.

Ski resort Stara planina is being built on the biggest mountain in East Serbia - Stara planina, which runs along the Serbian-Bulgarian border (Fig. 1). Three ski slopes of 3700 m in length and appropriate installations (water reservoir for artificial snow making, 10000 m^3; 3 km of pipeline, snow guns) were completed during the first construction phase. In December 2007, a new detachable quad chair lift and one ski lift were started up. Total value of these investments surpasses 20000000 €. Ski resort Zlatibor was renovated in period 2006-2009, with 7 km of ski runs and a new detachable six chair lift (Fig. 1). Construction of another new ski slope has been started in the proximity of the locality Divchibare on the Maljen mountain in 2006 (Fig. 1). By the end of 2006 a construction of one 850 m long ski slope with double chair lift had finished, totaling to approximate 1500000 € investment. Main physical characteristics of investigated ski runs are presented in table 1.

3. STUDY METHODS

The most affected ski runs were surveyed (scale 1:1000), as the basis for detailed mapping carried out during the summer seasons 2007-2010.

All damages, both resulting from skiing activities during previous winters or caused in non skiing periods, were mapped and classified in order to estimate their impact to the environment. Forest fragmentation is studied on the basis of detailed survey and field work.

The rill and gully initiation was surveyed from the beginning of April until the end of August, 2007 (when the restoration of ski runs started), at the most endangered spots (ski resorts Stara planina and Zlatibor). Development of rills and gullies was measured at experimental plots (100x60 m). Measurements were usually taken weakly and after each rainfall event and finished with the beginning of the process of restoration, in September 2007. Observation of rill network transformation into gullies was based on the integration of survey data into GIS application in order to present the intensity of the process. Survey data were integrated by raster method (cell size 0.7x0.7 m). Area sediment yield and intensity of erosion processes were estimated on the basis of the "Erosion Potential Method" (EPM). This method was created, developed and calibrated in Serbia (Gavrilovic, 1972), still in use in all countries originated from former Yugoslavia, with high degree of reliability of calculation of sediment yield, transport and reservoir sedimentation.

Computation of maximal discharge, in hydrological conditions before and after construction of ski resorts, was done using a synthetic unit hydrograph theory and SCS methodology (SCS, 1972). This is the most frequently used procedure in Serbia for computations of maximal discharges at small, unstudied watersheds, enriched by regional analysis of lag time (Ristic, 2003), internal daily distribution of precipitation (Jankovic, 1994) and classification of soil hydrologic classes (Djorovic, 1984). Computation was carried out for AMC III (Antecedent Moisture Conditions III-high content of water in soil, and significantly reduced infiltration capacity).

The aim of this investigation is to show how bulky activities, such as ski resorts construction in headwater landscapes, can cause various and strong environmental impacts.

4. RESULTS OF INVESTIGATION

Environmental impacts in the studied ski resorts are the consequence of disturbing activities that could be classified according to three characteristic phases (Fig. 2): construction of ski runs, ski lifts and access roads (I phase); skiing activities (II phase); ski runs maintenance (III phase). In this phase of development of Serbian ski resorts, the following environmental impacts are dominant and involved in this investigation: erosion processes, changes of hydrological conditions and forest fragmentation.

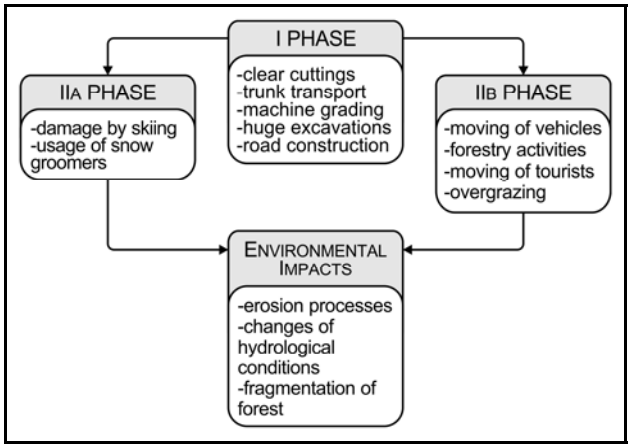

Figure 2. Disturbing activities in Serbian ski resorts and consequential environmental impacts

4.1. Construction of ski runs, ski lifts and access roads (I phase)

This phase has started in summer 2006 with massive clear cuttings, trunk trunsport, machine grading of ski slopes, huge excavations (for the fundaments of ski lift posts; electric supply; water supply), access road construction and finished in autumn of the same year. Clear cuttings in ski resort Stara planina involved about 26 ha of forest (*Fagus moesiaca*, *Picea abies*; average age 80 years; 7800 m^3 of wood mass), 11 ha in ski resort Zlatibor (*Pinus nigra*; average age 70 years; 4730 m^3 of wood mass) and 3.35 ha in ski resort Divchibare (*Pinus nigra*, *Pinus silvestris*, *Betula verrucosa*; average age 60; 1190 m^3 of wood mass). Clear cuttings in ski resort Kopaonik involved more than 10 ha, in the period 2006-2010. After removal of trees and undergrowth, the stumps were cut off at ground level, with roots remaining in the soil, but during reshaping of ski runs, numerous stumps were dug from the ground, inducing further disturbance of soil. Trunk transport caused total destruction of the topsoil and the remaining vegetation (grass and shrubs), especially from steep sections of the terrain (over 20%) to the nearest forest roads (average transport distance amounts to 174 m). Machine grading of ski slopes and reshaping of terrain were carried out mostly until the parent rock, at 11.3 ha at ski resort Stara planina, 7.8 ha at ski resort Zlatibor, 4.7 ha at ski resort Divchibare. Only 2.4 ha of ski slopes were machine graded in ski resort Kopaonik due to favorable morphological conditions. Machine grading and reshaping of ski slopes completely

changed the local relief, and among others, comprise following activities: leveling of small ridges; filling up of hollows; widening of ski runs at narrow sections (optimal width amounts from 45 to 60 m); modifying particularly difficult ski run sections and attenuation of extremely steep slopes. These activities are followed by the removal of topsoil with vegetation and disturbance of natural soil stratification. The newly created conditions are favorable for the development of erosion processes and fast surface runoff forming.

Network of access roads was built to enable transport of material during construction of fundaments of ski lift posts. Roads have been built without asphalt cover and water evacuation structures (road culverts and channels), and helped concentration of fast surface runoff, as well as sediment transport from gravitating surfaces to the ski runs or local streams. Density of access roads network amounts to from 1.8 $km \cdot km^{-2}$ (Divchibare) to 6.79 $km \cdot km^{-2}$ (Stara planina).

4.2. Skiing activities and ski runs maintenance during skiing season

Damage by skiing happens when skiers are forced to stop or to turn on very steep or narrow sections of ski runs. Skis edges frequently cut into the topsoil or they cut the grass, especially if snow layer is thinner than 15 cm. Narrow sections at ski runs (width 30-35 m) are burdened with 7000-12000 passes of skiers daily. Patches with disturbed topsoil and removed or damaged grass have changed heat balance, fastening the snow melting process thus creating unfavorable conditions for skiers. Duration of snow cover at ski run sections with preserved grass cover was 2-5 days longer, than at the sections with disturbed topsoil and grass.

Favorable skiing conditions require usage of snow groomers at ski runs to provide uniform distribution of snow (natural or artificial). Ski slopes at studied ski resorts, at altitudes lower than 1500 m, require more frequent usage of snow groomers (2-4 passes daily, at least), in order to eliminate the effects of temperature fluctuations and snow melting. If transport and leveling of snow happens at depths below 20 cm, metal bars (10-12 cm) in snow groomer chains (type "Kassbohrer", models PB 300 and 500) take out grass sods from the ground or hardly damage the topsoil. The most affected spots are sections where a very steep slope of ski run alter its form into a gentle slope, and where snow groomers change direction.

4.3. Ski runs maintenance during non skiing season

During the period without snow (May-October), ski runs become places for diverse, undesirable activities such as passing (illegal) of vehicles (tracklaying vehicles; motorcycles; SUV; tractors), uncontrolled forest activities (logging and transport of timber from nearby forest stands) or uncontrolled hiking of tourists. 32-157 tourists daily were registered at ski run "Crni vrh", in the period July-August 2010 (64 on average).

Local farmers have herds of cows and sheep, that freely move around, and overgrazing leads to the soil compaction or degradation of previously damaged vegetation, thus creating favorable conditions for soil erosion. At highly graded ski runs (more than 50% of the total surface) reestablishing of grass cover is very slow („Konjarnik 1", „Konjarnik 2", "Sunchana dolina", "Tornik", "Zmajevac", "Crni vrh"). Restoration works started in autumn of 2007 and finished in the autumn of 2008, but intensive grazing during summer periods 2007-2010, partly destroyed the newly established grass and accelerated erosion processes. During the summer period of 2010 (25th of June-15th of September), at ski runs "Sunchana dolina" and "Konjarnik 1" a total of 3-12 cows were registered per day (7 on average). At ski runs "Zmajevac" and "Tornik" a total of 14-52 sheep were registered per day, in the same period (21 on average).

4.4. Environmental impacts

4.4.1. Erosion processes

Strong pressure on surfaces on steep slopes provoked development of various erosion forms: sheet erosion, networks of rills and gullies, debris flows and solifluctions. The destruction of vegetation and topsoil influenced the microclimatic regime often triggering solifluction. Frequent solifluctions (November-March), with patchy distribution (3-7 m in diametar), accelerated sliding of shallow (0.3-0.7 m deep), surface soil layers. Ski runs sections exposed to wind strikes (snow is blown away and deposited on distance of 30-100 m), frequent movement of skiers and snow groomers, on the very steep slopes, with disturbed topsoil and grass cover, have severe erosion.

Area sediment yield and intensity of erosion processes were calculated (Tab. 2) on the basis of "Erosion Potential Method" (EPM).

The process of rill network transformation into gullies was very intensive at the ski run „Konjarnik 2" (ski resort Stara Planina): at the and

of the May 2007. (Fig. 3a) rill network (0.1-0.5 m deep) comprised 264 m^2 (3.7% of the total area of experimental plot); at the end of June (Fig. 3b) rill network and embrions of gullies (0.5-0.8 m) comprised 509m^2 (11.6% of the total area); at the end of July (Fig. 3c) gullies (0.8-1.2 m) comprised 818 m^2 (18.6% of the total area); at the end of August (Fig. 3d) gullies and deep gullies (>1.2 m) comprised 1193 m^2 (27.12% of the total area). Sediment yields in the zone of deep gullies (A=6000 m^2) was measured by survey methods (longitudinal and cross section profiles), from April 1st 2007 until September 1st 2007, when the restoration of ski run started. By the end of summer 2007 gully bottom reached parent rock (green schist or granite). Total volume of the eroded material from gullies amounts to E_p=744.93 m^3

Table 2. Review of basic characteristics of erosion processes at investigated ski runs.

Ski resort	Erosion forms	Specific annual sediment yield [$m^3 \cdot km^{-2}$]	Parent rock	Soil type
Stara planina	• deep gullies • solifluctions • sufosion • systems of rills • debris flows • sheet erosion • road erosion	5174.9	• red sandstones • green-schist • granite	• skeleton red sandstone soil • humus-silicate soil
Kopaonik	• systems of rills • sheet erosion • road erosion	350.4	• porphyroide granodiorite • granite • chlorite-sericite schist • metamorphosed sandstone	• humus-silicate soil formed on granite • rocky-gravel brown acid soil formed on shale
Zlatibor	• shallow gullies • systems of rills • debris flows • sheet erosion • road erosion	4741.3	• harzburgite	• humus-silicate soil
Divchibare	• systems of rills • debris flows • sheet erosion • road erosion	1711.1	• harzburgite	• humus-silicate soil

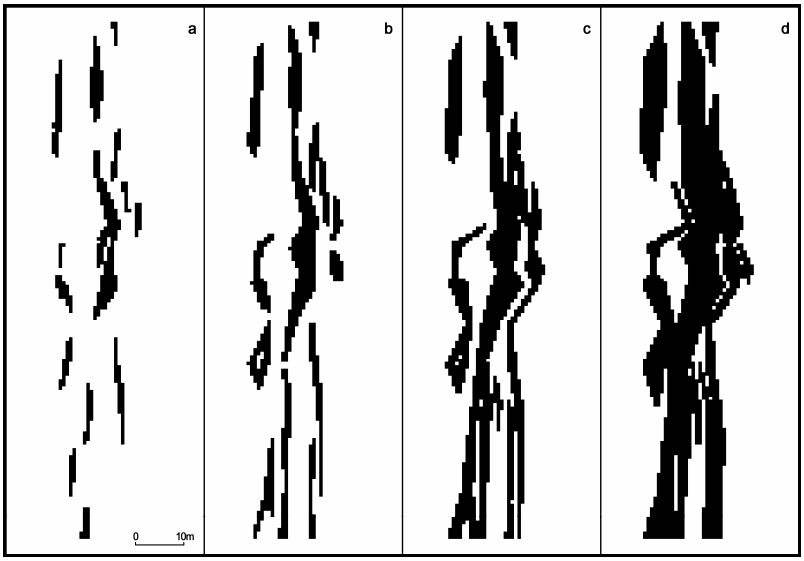

Figure 3. Development of erosion process on experimental plot at the ski run „Konjarnik 2“ (May-August 2007).

4.4.2. Changes of hydrological conditions

Land use directly affects the surface runoff intensity by creating ″losses″ of precipitation, through the processes of interception, depression storage, evaporation, transpiration and infiltration. Construction of ski runs, ski lifts and access roads damaged huge surfaces of topsoil and vegetation on steep terrain, in the headwaters of local streams, and changed the existing hydrological conditions. It is illustrated by hydrological analysis in the watershed of Stankovic stream, in the ski resort Zlatibor.

From May 15th until October 12th 2007, Stankovic stream flooded four times, damaging the local road, the bridge and the houses. Local records reveal that the last time when Stankovic stream flooded was in the summer of 1973. This is a clear indication that the construction of ski resort influenced the hydrological regime in the Stankovic stream headwaters. The effect of hydrological changes was estimated by computation of maximal discharge under conditions before (summer 2006) and after the construction (summer 2007) of the ski resort Zlatibor.

Until the summer of 2006, Stankovic stream headwater was covered with stable forest on 1.708 km^2 (73.62% of the total surface). One year later the forest cover amounted to only 1.47 km^2 (63.36% of the total surface). At the same time anthropogenic bare land enlarged from 0.012 km^2 (0.52% of the total surface) to 0.238 km^2 (10.26% of the total surface) in the summer of 2007 (Fig. 4). Deforestation influenced significant reduction of the interception effect (Ristić & Macan, 2002), exposing the soil to the impact of raindrops „bombing“, which accelerated surface runoff. Maximal daily precipitation data were provided from neighboring rain-gauge station Zlatibor (46 years of observations).

Computed values of maximal discharge (for control profile P_1, at the Stankovic stream headwater outlet), are presented in Fig. 5, as hydrographs for different probabilities (p= 0.5, 1 and 2%). Values of maximal discharge $Q_{max\text{-}AMCIII\ (2\%,\ 2007)}$=9.65 $m^3 \cdot s^{-1}$ (after constructing) and $Q_{max\text{-}AMCIII\ (0.5\%,\ 2006)}$=9.45 $m^3 \cdot s^{-1}$ (before constructing) are similar, indicating the decrease of the recurrence interval from 200 years (p=0.5%) to 50 years (p=2%), as a direct consequence of land use changes. At the same time, other significant parameters such as physical characteristics of the headwater (magnitude, mean slope of terrain, mean slope of stream bed) remained the same.

4.4.3. Forest fragmentation

Forest clear cutting is the dominant anthropogenic disturbance inducing mature forest loss, fragmentation and strong impact on wildlife (St-Laurent et. al., 2009).

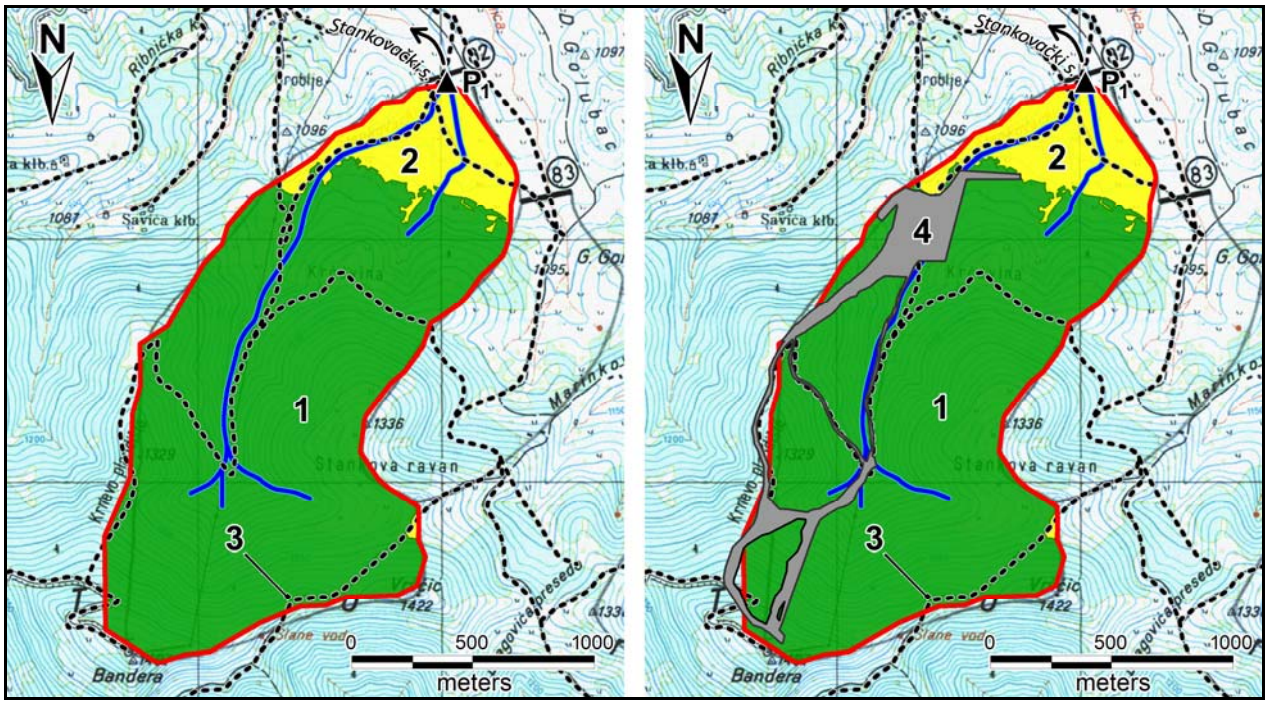

Figure 4. Land use in the Stankovic stream headwater before (bc) and after construction (ac):
1-forest; 2-meadows; 3-forest roads; 4- ski runs, top and bottom stations of ski lift, ski lift corridors, constructing sites, access roads, parking lot and urbanized spots (anthropogenic bare land);
P_1- control profile at the Stankovic stream headwater outlet

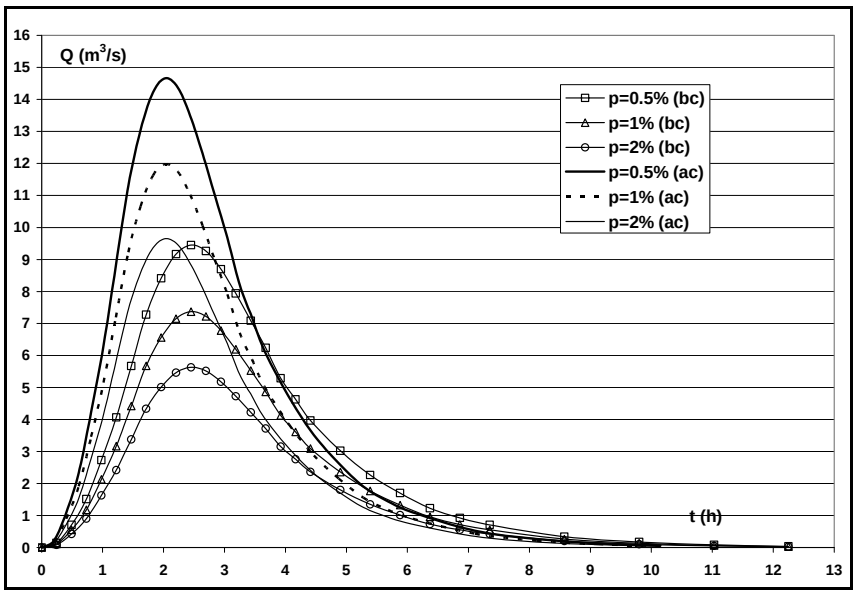

Figure 5. Hydrographs of maximal discharge in hydrological conditions before (bc, 2006) and after construction (ac, 2007) of ski resort „Tornik", for probabilities p=0.5, 1 and 2%.

In Serbian ski resorts, forest fragmentation is the consequence of clear cuttings carried out before construction activities. Fragmentation starts when ski runs, ski lift corridors, access roads, water and electric power supply instalations penetrate into old growth or mature forest, dividing large surfaces into small elements, changing their habitat conditions.

Fragmentation is followed by habitat loss that seriously endangers forest wildlife. Changes of forest microclimate are noticable up to 60 m from fragment edges (Kapos, 1989). Altered radiation, wind, water, and nutrient regimes create new habitat conditions, inducing tree mortality in fragments and strong influence on forest dynamics and structure (Laurance et al., 1998).

Native mature forests have been extensively fragmented in the Serbian ski resorts, but remarkable example was recorded in ski resort Stara Planina, where clearing of the forest began in the July of 2006 and proceeded until the October of 2006. Destruction of 26 ha of native mature forest created two fragments (Fig. 6), mostly surrounded by meadows, cattle pastures and rock outcrops. After ski resort construction, buzzard (*Buteo rufinus*) disappeared from the area (IUCN Red list of threatened species, 2006), and populations of skylark (*Alauda arvensis*, IUCN Red list of threatened species, 2008) and Eurasian Woodcock (*Scolopax rusticola*, IUCN Red list of threatened species, 2008) were significantly reduced. Fragmentation endangered local endemic species *Campanula calycialata* (found only in the proximity of ski resort Stara planina), and *Senecio pancici*, (stenoendemic of the Central Balkans), as well as the neighboring peat bog.

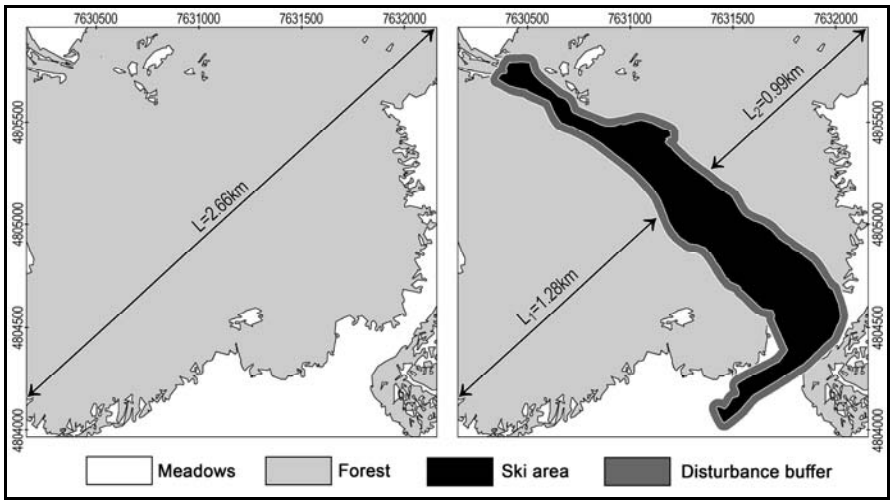

Figure 6. Example of forest (habitat) fragmentation in ski resort Stara planina.

5. DISCUSSION

Serbian ski resorts were formed on the very steep terrains in the headwaters of local streams (Stara planina, mean slope of terrain Sm=47.6%; Kopaonik, Sm=40.4%; Zlatibor, Sm=28.6%; Divchibare, Sm=23.7%), after massive construction activities. Clear cuttings, trunk transport, access road construction and large excavations on steep slopes produced very strong pressure on the environment. Among many consequences are the compaction of surface soil layer, the reduction of infiltration capacity, destruction or degradation of vegetation cover, intensifying of surface runoff and development of erosion processes. Removal of the topsoil and vegetation during construction of ski runs, exposing to precipitation and temperature extremes, later utilization in skiing and non skiing periods, caused various forms of erosion such as rills, gullies, landslides, debris from rock weathering and solifluctions. Also, legal nature-protection standards were poorly implemented in Serbian ski resorts. Some activities such as clear cuttings in National Parks (Kopaonik) and Parks of Nature (Stara planina, Zlatibor) are contradicted to the two main objectives of the management of the protected areas: conservation of ecosystems and preservation of biodiversity.

In the region of Stara Planina, sediment yields were nearly 10 times bigger (5174.9 $m^3 \cdot km^{-2} \cdot year^{-1}$) on disturbed granitic ski run soil than on undisturbed green schists soil in the surrounding (native) beech forest (520 $m^3 \cdot km^{-2} \cdot year^{-1}$). Similarly, in the ski resort Tornik: 4741.3 $m^3 \cdot km^{-2} \cdot year^{-1}$ of sediment was produced on disturbed humuse silicate ski run soil on harzburgite and 417.5 $m^3 \cdot km^{-2} \cdot year^{-1}$ on undisturbed soil in the surrounding, mature pine forest. Lithological properties of the exposed material, characteristics of precipitation and changed hydrological conditions caused intensive rill and gully erosion, especially in the ski resort Stara planina, with gullies up to 4 m deep, and specific sediment yield at experimental plot E_{psp}=124155 $m^3 \cdot km^{-2}$. Also, lack of erosion control activities in ski resorts, during construction (between June and October 2007), increased the intensity of degradation processes.

Mismanagement in ski areas changes hydrological conditions, reducing capability of the soil to store water from short, strong rain events and snow melting. Anthropogenic bare land (ski runs, top and bottom stations of ski lift, ski lift corridors, constructing sites, access roads, parking lot and urbanized spots), mostly poorly permeable surfaces with compacted surface soil layer, was from more than 20 times (ski resort Zlatibor) to more than 10 times (ski resort Stara planina) enlarged, in the period summer 2006-summer 2007. The construction of ski resorts destroyed or destructed natural drainage network and enhanced surface runoff, especially on ski runs and access roads, with unavoidable consequences: more frequent appearance of torrential floods and bed-load deposition in downstream sections of local streams. Torrential floods were recorded three times in the ski resort Stara planina and four times in the ski resort Zlatibor, from May to October 2007, damaging local roads, bridges and houses.

Maintenance in the skiing period is very important to provide functionallity of ski runs with favorable skiing conditions. Usage of snow groomers, for transport and leveling of natural or artificial snow, is reasonable at snow depths >30 cm, or provokes topsoil and grass damage, inducing faster melting process. Meanwhile, the greatest problems now affect the period without snow (May-October), when the ski runs become places for diverse, undesirable activities. Consequently, it is necessary to introduce some administrative bans and guidelines, regarding the sustainable capacity of ski runs for different activities: usage of snow groomers and skiers frequency in the winter period; level of maximum load (tourists, vehicles, cattle) and application of BMPs (Best Management Practices) in the exploitation of the surrounding forest, in non skiing periods. Also, stuff should be trained to recognize diverse problems and solve them in accordance with defined administrative measures and BMPs guidelines.

The restoration and erosion control measures were carried out in period October 2007-October 2008, under conditions of high terrain degradation. They were the first of their kind at ski runs in Serbia, but they are not discussed in detail in this study. The onset and completion of main restoration and erosion control activities occurred in the period May-October 2008, in accordance with basic restoration principles (Krautzer et al., 2004, 2006). Technical works were finished until the end of September, biotechnical until the middle of October (Ristić et. al., 2010). Lack of restoration and erosion control, during and immediately after basic construction, produced high expenses. The completion of the restoration and erosion control works was successful, significantly altering the general condition and appearance of the endangered ski runs.

6. CONCLUSIONS

The environment in Serbian ski resorts is highly endangered by disturbances through construction, skiing activities, maintenance in skiing

and non skiing periods. The strongest pressure on landscape was recorded during the construction of ski runs, ski lifts and access roads. Mismanagement provoked severe erosion processes on the headwaters of local streams, huge sediment yield, and more frequent appearance of torrential floods on downstream sections. Clear cuttings led to forest fragmentation, habitat loss and endangering of rare and typical species.

Effective prevention of investigated environmental impacts (erosion processes, changes of hydrological conditions and forest fragmentation) has to be based on carefull considerations of impact assesment of land use changes in ski areas at all levels of planning and constructing, in accordance to legal nature-protection standards. Restoration and erosion control works have stopped degradation processes and helped reestablish vegetation and rehabilitate landscape appearance and functions. They renovated the ability of soil to absorb water from rainstorms and snowmelt without generating fast surface runoff, and obtained higher resistance to erosion. Environmental impacts in skiing and non skiing periods could be minimized with defined sustainable capacity for different activities. Consequently, it is necessary to issue regulations (BMPs guidelines and some administrative bans) and provide trained stuff for practical application.

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