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Long-term impacts of ski-runs construction and management on alpine soils

Michele Freppaz, Gianluca Filippa, and Ermanno Zanini

Università degli Studi di Torino, Di.Va.P.R.A. - Chimica Agraria e Pedologia - LNSA NatRisk (Research Centre on Natural Risks in Mountain and Hilly Environments) michele.freppaz@unito.it

In mountain regions, the traditional use of lands is nowadays combined with surfaces devoted to recreational activities because of increasing tourist demand for winter sports. Construction and operation of ski-runs may have a large impact on soil resilience as their construction with machine-grading, which is the process of smoothing the slopes by the removal of topsoil, boulders, and vegetation, involving the use of heavy earth-moving machinery, induces many environmental transformations. Further, the evolution of skiing to a mass sport has increased the demand for wide smooth ski-runs because of their large capacity for skiing and easy slope preparation with artificial snow and snow grooming. All these operations may induce geomorphologic hazards, increase of flow and sediment loads, soil erosion and interferences with flora and fauna. Also the snow management during the ski season may strongly influence the soil characteristics of the ski-slopes, by snow density changes due to grooming and use of artificial snow. Previous studies have mainly focused on local effects of machine-grading or of artificial snow inputs on vegetation, while only few studies have investigated the impacts of these treatments on soils. Moreover little is known about the trends of these impacts over time. The present study therefore aimed to evaluate the impacts of graded ski-runs on soil properties over a ten year time period (1999-2008). The study was based on a pair-wise design of permanent plots situated on and next to ski runs located in an Italian ski resort. The study was carried out in the Susa Valley (NW-Italy), along ski runs located at elevations between 1330 m and 2000 m asl. Soil samples were collected in 4 transects. In each of the select sites a soil profile was dug within the ski-run, while another one was excavated at the same elevation and aspect, but in an undisturbed site. In each site the soil samples were collected at different depths (0-5 cm, 5-20 cm, > 20 cm). Soil samples were analyzed for texture, pH, electrical conductivity (CE), organic carbon (TOC), total nitrogen (TN) and CaCO3 content. The aggregate stability was evaluated by wet sieving for different time lengths and a simple exponential model was fitted to the data, to quantitatively evaluate aggregate breakdown. The soils sampled in 2008 were characterized by a constant loss of aggregates at all the depths, while in 1999 it was greater in the deepest soil horizons. Moreover the influence of the organic matter on the soil aggregate stability resulted less evident in comparison to the samples collected in 1999. Globally, in the most part of the ski-runs evaluated in this study, an increase of the aggregate breakdown was found in the upper horizons, while at greater depth no significant changes were found. The increase of soil vulnerability could be related to the interventions carried out on the ski-runs in the last 10 years, particularly before the Winter Olympic Games, for the realization for example of artificial snow equipments. Therefore it derives the need of a careful management of these anthropogenic soils, with a regular input of organic matter combined to a correct restoration of all the interventions realized on the ski-runs surfaces with the purpose to guarantee a favorable evolution of the soil chemical and physical properties.
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