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Protection forest stand formation – soil temperature effects on interlinked root growth and slope stability

Alexander Bast (1), Frank Graf (1), Peter Bebi (1), and Holger Gärtner (2)

(1) WSL Institute for Snow and Avalanche Research SLF, Mountain Ecosystems, Davos Dorf, Switzerland (alexander.bast@wsl.ch), (2) Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Dendrosciences, Birmensdorf, Switzerland

Well-structured forests in mountainous areas are pivotal to ensure protection against natural hazards. The protective functions of forests are becoming increasingly important not just, but primarily as far as superficial slope failure is concerned since torrential rainfalls or forest disturbances modify or even override the protective function. To reclaim the protection potential against shallow landslides, eco-engineering is often applied, first and foremost to initiate and promote the development of roots as an indispensable prerequisite for soil re-stabilisation. Although such practice is common, many knowledge gaps exist and little is known on the effects of soil temperature and (fine) root development related to soil or slope stability. Thus, our contribution addresses soil stability of the initial succession steps, starting from a site-adapted plant and seed mixture, aiming at the natural climax forest association, with respect to soil climate and plant root development.

The study was conducted in the Arieschbach catchment, eastern Swiss Alps, where mild winters and temperate summers characterise the climate. Cambisols, Luvisols, and Regosols developed under a fir-spruce forest. On an erosion-prone slope (37° to 50° inclination, ∼1300m a.s.l., skeletic Leptosol) we set up hedge layers on two sites with a total of 2400 saplings (mainly Alnus spp. and Salix spp.) to establish a first vegetation cover and, thus, the initial stage of succession. One site was mycorrhizal treated. At the end of three subsequent growing seasons, 36 soil cores were taken from both stabilised and a control site to analyse fine root development (RLD = root length density) and soil aggregate stability (ASC). From July 2010 to September 2013, soil temperature and volumetric water content were logged.

In 2011, RLD and ASC decreased at all sites. Weather and soil climatic data were similar for the growing periods in 2011 and 2012, but differed for the dormancy phase. In the dormant periods 2010/11 and 2011/12, average soil temperature was 0.9°C and 1.7°C, respectively. Moreover, the dormant period 2010/11 showed 91 days below 1°C compared to 43 days in 2011/12. The cumulative snow fall was 88cm in the dormant period 2010/11 and 266cm in 2011/12, indicating that the warmer soil temperatures are, particularly, caused by the insulating snow cover.

The amount of fine roots plays a key role in soil aggregation and, therefore, in the stabilisation progress related to succession stages, especially under coarse grained soil conditions. The initiation and cessation of root growth is regulated by soil temperature. Following our results, we conclude that interannual climatic variations have an influence on root growth and, thus, soil stability. Soil temperatures during the dormant period have an important impact on root development and may even leading to the very fine root's die off. Thereby, snow cover regulates the energy balance between atmosphere and pedosphere and, hence, modify soil temperatures. Notably, in mountain environments, these conditions may increasingly altering as a result of a changing climate. Conclusively, danger from shallow landslides is correlated to interannual climatic variations and needs to be considered in an integrated management approach.