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The effect of large scale clear cutting on infiltration conditions in experimental upland catchments in the Chilean Coastal Range, Bío-Bío Region

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Favorable climatic and hydrological conditions make Chile one of the leading timber and cellulose exporting nations with one of the biggest growing rates worldwide. Forest operations mainly concentrate in the 2.3 million hectares of plantations established with exotic fast growing species. Chile has targeted some additional 2.5 million hectares to be planted in the next years to increase the offer of forest products and to generate biomass from intensive managed woody crops to reduce the country's dependence of imported fuel. Large scale forest operations increase hydrological and morphological risks, especially during extreme rainfall events and after extensive clear cuttings enhancing surface runoff with increased erosive processes and intensified sediment fluxes. In this scenario process based research on runoff generation is becoming essential. In this study we present patterns and mechanisms of runoff generation effected by a large scale clear cutting during winter rainy season in the Coastal Range of South-central Chile. The study is conducted on two spatial scales: a self-designed rainfall simulator on micro-scale to identify runoff sources and at-risk areas and small experimental upland catchments under different forestry use. In the latter, paired catchment analyses complete process-based models where plot-sized-data is used for parameterization to put the process knowledge into a general, transferable and quantifiable context.

A total of 97 rainfall simulations with different rainfall intensities (10, 20, 40 mm-h) were conducted under dry soil conditions, 36 experiments prior and 61 after the clear cutting. To identify the influence of soil properties, post clear cutting experiments were carried out on both soil types. The steady state infiltration rates are highly variable in space and time, both, prior and post the clear cutting. The final infiltration capacity remains unchanged in all of the precipitation classes in the course of the timber harvest. Parametric statistics and a random forest model identify rainfall intensity as the dominant determinant. A delayed rainfall-runoff response indicates filling of the accentuated micro depressions caused by soil disturbance by heavy machinery. The lasting ponding intensifies superficial water storage facilitating infiltration in the compacted soil. Qualitative and quantitative application of Dye tracer identifies infiltration by preferential flow along (former) roots systems and macro pores due to (former) harvest action as the far dominant process.

In contrast to the expected increase of streamflow discharge a decrease occurred immediately after the timber harvest during rainy season in August 2009. The relation reversed in October 2009 in favor the treatment catchment. A superior streamflow discharge was observed in the following months most intensively during summer base flow conditions. This observation corresponds with the plot scale experiments and indicates reinforced infiltration by intense ponding due to accentuated microtopography, increased macroporosity and removed hydrophobic organic layers. The enhanced infiltration fortifies the groundwater recharge until complete saturation is reached. The removal of forest cover inhibits high transpiration rates and leads to elevated base flow discharge since water consumption is less and soil moisture higher as water balances show.

Additionally sediment transport is monitored. During single events, sediment transport increased by one order of magnitude after clear cutting. Ongoing work includes the analysis of erosion processes and sediment yield, too. In this case, reestablishment of vegetation will be considered.