Seasonal hydrological impacts of land use on hillslope stability

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SESSION 11 – HYDRO-GEOMORPHIC PROCESSES

Keynote – David Polster

SBEE73 - Soil Bioengineering for the Treatment of Drastically Disturbed Sites

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Soil bioengineering is the use of living plant materials to perform an engineering function. Soil bioengineering can be used to establish vegetation on steep and unstable sites. The use of pioneering species in soil bioengineering treatments initiates the natural successional processes that will ensure the site remains vegetated. Soil bioengineering systems work with natural processes to restore drastically disturbed sites. Treatments such as wattle fences and modified brush layers can be used on over-steepened slopes (average slope up to 70 degrees). Where excess moisture is causing slope instabilities, live pole drains can be installed to drain the moisture. Shoreline erosion can be solved in most cases by taking the energy out of the moving water, either waves or stream current. Dense live staking can be used to protect shorelines as can dense plantings of emergent aquatic vegetation. Live silt fencing uses this same principle to remove sediment from water. Slowing the flow allows sediment to be deposited and by using live cuttings to do the slowing, a dense shrubby wetland can be constructed. Live gravel bar staking can be used to remove excess sand and gravel from rivers that would otherwise cause avulsions. The plants used in live gravel bar staking can tolerate stem burial while continuing to grow. This creates a condition where the gravel bar continues to collect sediment while the vegetation starts the process of succession. This will result in rich alluvial forests on the floodplain. There are a variety of techniques that can be used to re-build riparian vegetation including joint and pocket planting and live palisades. Soil bioengineering systems provide an excellent tool for the restoration of damaged sites. By using native species, these treatments can build ecosystem resilience.

SBEE33 – Seasonal hydrological impacts of land use on hillslope stability

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Shallow landslides can pose a major threat to human lives and infrastructure over significant portions of the global land surface and occur primarily from weakened soil shear resistance due to water infiltration. Although there is growing interest in using vegetation to stabilize hillslopes against landslides, we noted the scarcity of studies examining temporal variations in slope stability, particularly with regard to different land uses. In three tropical and temperate landslide-prone regions (Laos, Costa Rica and France), we combined soil moisture monitoring to 1.2-1.8 m depths in the field, soil shear resistance measurements and numerical modeling to compare slope stability under competing land uses for 2-3 years. Slope stability tracked temporal changes in soil moisture, with smaller contributions from root mechanical reinforcement. Land uses with denser vegetation had greater stabilizing impacts than those with sparser vegetation, which lasted for six to twelve months per year and coincided temporally with growing or rainy/dry seasons. Greater stability under denser land use persisted into wet seasons in one of the sites and were minimized or reversed in the other two sites. Site-specific factors such as climate, soil and species may explain these differences in the vegetational control on slope stability. A review of the data in the literature found that woody vegetation increased slope stability

and decreased temporal variation in stability compared to herbaceous vegetation. However, while variations in slope stability decreased in increasingly humid climates, indicating that the largest fluctuations in stability, and hence potential to improve slope integrity with land-use changes, will be found in arid to sub-humid regions. Our results show that dense vegetation provides greater stability and protection against landslides from rainfall. Land managers need to take into account this biological control on hydrology when managing vegetated slopes. Incorporating the vegetation-driven deep soil moisture dynamics will also improve predictive utility of models of specific events.

SBEE41 – A proxy to quantify the hydrological effect of vegetation against landslides

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The quantification of the hydrological effect of vegetation against landslides is challenging and scarce in the scientific literature. Relatively high soil matric suctions induced by plant evapotranspiration could enhance significantly the slope stability conditions from a hydrological aspect. However, plant-soil-water interactions are far from being clear and there is no consensus upon how the vegetation's hydrological effect can be included within slope stability analyses. In this sense, the suction stress characteristic function (SSCF), accounting for all the soil inter-particle stresses, could be used as a proxy to quantify the vegetation's hydrological effect against shallow landslides.

In the present study we aim to set the basis for defining a simple, reproducible and straightforward laboratory protocol to obtain the suction stress characteristic function of the soil by means of direct shear tests. Additionally, we explore SSCF deviations induced by vegetated soil and the possibility of inclusion of these results in an integrated model that would account for the effects of vegetation on slope stability. The results from our investigation will shed light on the potential use of the SSCF as a proxy to quantify the hydrological effect of vegetation against landslides and will enhance our understanding on the topic.