A Physiology and Ecology Based Model of Lateral Root Reinforcement of Unstable Hillslopes

Finn Krogstad

Abstract

Shallow lateral roots interweave extensively, forming a reinforcing mat which spans unstable sections of a hillslope and prevents failure. After major stand disturbances such as fire, windstorms, or timber harvest, these roots decay, reducing slope stability until the roots of the young trees grow enough to replace them. Studies of root reinforcement have commonly focused on deep roots anchoring the soil to the slope by wedging into bedrock cracks, but these basal roots may not be significant where the soil is deep, the roots are shallow, or the bedrock is not fractured.

In this thesis, the mechanical strength of the lateral root mat is calculated using the pipe-model theory to relate the distribution of fine roots to the cross-sectional area of roots crossing the failure boundary. Simplifying assumptions about the distribution of roots around the stem and the distribution of stems in the stand are used to derive the strength of root mat as the product of the strength of the root wood, the stand sapwood basal area, the average spread of the root systems, and two dimensionless terms which describe root distribution and orientation. The constant leaf biomass following crown closure and the functional equilibrium between leaf and root biomass are used to define stand sapwood basal area and root spread in terms of more easily measured stand spacing and foliage biomass. The resulting model is simple and provides estimates of the physical forces that the root network can provide under alternate harvest options.

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