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Predicting Patagonian Landslides: Roles of Forest Cover and Wind Speed

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Many of Earth's steepest, wettest, and rapidly denuding landscapes are covered by dense temperate rainforests. Chilean Patagonia hosts some of Earth's largest swaths of temperate rainforests where landslides frequently strip hillslopes of soils, rock, and biomass.

The susceptibility to shallow landslides can increase following deforestation because of limited root reinforcement, altered soil infiltration, and permeability rates. The wind is a common driver of forest disturbance. While anchoring soils, trees also transfer dynamic-wind force as a turning moment (torque) to the soil mantle via the tree bole, causing tree throw or even shallow slope failure. Despite the above, inquiries into the role of wind in landslide initiation have been anecdotal and unclear about cause and effect.

Assuming that wind loads on trees cause slope instability, we explore the role of forest cover and wind disturbances in promoting such landslides using a hierarchical Bayesian logistic regression model that predicts from crown openness and wind speed the probability of detecting landslides terrain. To control for effects of local terrain steepness, our multi-level model admits different landform types such as channels, ridges, or valley floors.

We find that higher crown openness and wind speeds credibly predict higher probabilities of detecting landslides regardless of topographic location, though much better in low-order channels and on midslope locations than on open slopes. Wind speed has less predictive power in areas that were impacted by tephra fall from recent volcanic eruptions, while the influence of forest cover in terms of crown openness remains.

Distinguishing between landforms in a hierarchical model context improves an otherwise moderate average performance of the classification, but highlights topographic locations for which the prediction needs to be refined.

Our study is the first of its kind in one of the windiest spots on Earth and encourages further inquiry into the rarely investigated role of wind speed in promoting slope instability in southern Chile and densely forested mountain regions elsewhere, especially with weather and wind extremes being on a projected rise in a warming world.