Data-driven shallow landslide connectivity analysis to reduce sediment delivery to streams

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# ABSTRACT

To achieve national freshwater goals and reduce sedimentation, more detailed data on sediment delivery by rainfall-induced shallow landslides to streams are needed. Data-driven landslide connectivity analysis can be used to address this by identifying areas where future landslides are more likely to enter streams. To tackle this issue, we extended the morphometric connectivity modelling approach of Spiekermann et al. (2022) by accounting for land cover and lithology in combination with additional morphometric variables and an expanded landslide inventory.

We mapped shallow landslide source areas and debris deposits across a ca. 3,000 km² study area in northern Hawke's Bay, which was affected by intense rainfall in March 2022 that produced over 35,000 landslide features. We used stream networks derived from a LiDAR DEM with a range of channel initiation thresholds as landslide targets. A set of binary logistic regression models with automated variable selection was trained on the dataset.

Our results revealed a strong dependency of connectivity on the overland flow distance to the target (DownDist). Results obtained from this single-variable model exhibited similar predictive performance to more complex, multi-variable models. This single variable model showed good spatial transferability when applied to an independent dataset from the Greater Wellington region. However, further improvement in performance was achieved by combining landslide runout distance (RD) and DownDist in a single model. The RD is only obtainable post hoc, whereas for use in future prediction (i.e., prior to a landslide occurrence) we developed a stochastic simulation approach by sampling RD values from a theoretical distribution. For every landslide scar, we created a set of 1000 realizations, i.e., multiple equiprobable models of connectivity. We achieved significant improvement in predictions of landslide-to-stream connectivity by representing the variability in landslide runout distance.

The data-driven landslide connectivity model can be used with susceptibility analysis to identify areas where future landslides are likely to connect to the stream network. This can help better target mitigations to more cost-effectively reduce landslide erosion and sediment delivery to streams.

# REFERENCES

Spiekermann, R. I., Smith, H. G., McColl, S., Burkitt, L., Fuller, I. C., 2022. Development of a morphometric connectivity model to mitigate sediment derived from storm-driven shallow landslides. Ecological Engineering, 180, 106676. https://doi.org/10.1016/j.ecoleng.2022.106676