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Monitoring landslide erosion in dependence on land cover using advanced remote sensing techniques at multiple scales

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During the 19th and 20th centuries, much of the Manawatu catchment in New Zealand was cleared of its original indigenous forest cover and converted to pastoral farmland which now covers around 70 % of the catchment. In the years following forest clearance, a succession of major storm events saw an increase in shallow landsliding. Most landslides occur during infrequent storm events that last a day or more and bring total rainfalls exceeding 100 mm. A severe landslide-triggering rainfall event in February 2004 led to the introduction of the Sustainable Land-Use Initiative in 2006 aimed at reducing accelerated hill country erosion. Mitigations included space-planted trees (mainly willows and poplars) and afforestation, which are the most commonly used practices for controlling shallow landsliding, gullying, earthflows, and bank erosion in New Zealand.

There is currently no objective, quantitative methodology for quantifying the effectiveness of erosion mitigation works in pastoral hill country across multiple spatial and temporal scales. This knowledge gap is related to a lack of relevant spatial data. For example, monitoring the effectiveness of bio-physical erosion control requires a woody vegetation data layer covering regular intervals and of adequate precision. In New Zealand, there are currently two main sources of woody vegetation cover: 1) a Landsat TM-classified woody vegetation layer, and 2) the 2012 New Zealand Land Cover Database (LCDB v.4.1), which – despite being more recent – has a minimum mapping unit size of one hectare and is therefore also not suited for identifying the locations of individual space-planted trees. LiDAR-derived canopy height models can be useful, though coverage, whilst improving, is currently limited in New Zealand. While landslide inventories exist for individual study areas, these have limited spatial extent. The New Zealand landslide database generally does not include shallow landslides in pastoral hill country.

Therefore, we develop an object-based image analysis (OBIA) method to overcome some of these existing challenges surrounding the ability to accurately locate tree crowns and erosion features at catchment scale. Landslides and woody vegetation are mapped using regional aerial photography for 2005, 2010/11, 2015/16 covering an area of approximately 15,000 ha in the Pohangina Valley in the central North Island of New Zealand. Initially, woody vegetation is mapped using the most recent 4-band optical imagery, and for subsequent imagery each object classified as woody vegetation in 2015/16 is queried as to whether vegetation was already present in 2010/11, and again in 2005. In this way, the age of the vegetation can also be estimated and changes in land cover quantified. Results are aggregated to different scales (paddock, sub-catchment, land cover classes). Landslide density with respect to woody vegetation cover and other environmental factors (slope, landform) is statistically evaluated. Finally, an accuracy assessment is carried out for the landslide mapping using manually mapped landslides as reference for a subset of the study area. Results show that agreement between manual and object-based landslide mapping is acceptable while dependent on the scale and precision of landslide delineation.