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Keefer's law revisited: A new law for coseismic landslide volume prediction.

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We present a new empirical law relating the total volume of seismically triggered landslides to seismic moment for shallow, continental earthquakes. 12 comprehensive inventories of landslides caused mainly by thrust fault earthquakes, but also strike slip and normal fault earthquakes with magnitudes between 5.7 to 7.9 were used to constrain this relation. We used an empirical area-volume relationship, corrected for runout and deposition area, and differentiated between soil and bedrock landslides. Our inventories were screened for amalgamation, that is the merging of several adjacent landslides into a single map polygon, and artefacts were corrected to avoid volume overestimation. We show that a significant part of the scatter in the relation between landslide volume and seismic moment correlates with the steepness of the epicentral topography, captured, for example, by modal slope. Some scatter can also be accounted for by seismic wave attenuation through geometric spreading. Hence, we relate steepness-normalized landslide volume to distance-normalized seismic moment over more than 3 orders of magnitude in each dimension, with a precision of about a factor of 2. A simple correction for topographic steepness brings most published landslide volume estimates in good agreement with our prediction. This suggests that our updated landslide law can be used to generate estimates of the amount of landsliding in the epicentral area of an earthquake as soon as first constraints on the magnitude, mechanism and location of that event are available. It could also be used to assess landslide risk for realistic earthquake scenarios, or integrated in a landscape evolution model to explore the effects of seismically triggered erosion.