



A new landslide area-to-volume relationship, and its application to the evaluation of landslide volumes in the Collazzone area, Central Italy

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Landslides are complex phenomena influenced by multiple factors. Knowing the number, area, and volume of landslides is important to determine landslide hazard and risk, for ecological studies, and to evaluate the long-term evolution of landscapes dominated by mass-wasting processes. The number and area of individual landslides and the total landslide area in a region can be computed from accurate landslide inventory maps. Determining the volume of a landslide is a more difficult task that requires information on the surface and subsurface geometry of the slope failure, information difficult to collect. Determining the volume of slope failures for large populations of landslides is an even more challenging task that, at present, can only be achieved adopting empirical relationships to link the volume of individual landslides to geometrical measures of the landslides, chiefly landslide area. Through a worldwide literature search, we compiled a catalogue of 5582 landslides for which measures or estimates of the area (in square meters) and the volume (in cubic meters) are known. From this large catalogue, 591 mass movements of the slide type were selected, and used to determine a relationship linking landslide area to landslide volume. The new relationship takes the form of a power law with a scaling exponent $\alpha = 1.449$. The relationship holds for 8 orders of magnitude of landslide area and 11 orders of magnitude of landslide volume, and is in reasonably good agreement with the few published area-to-volume relationships. The result suggests that the relationship between the volume and the area of landslides of the slide type is essentially geometrical, and not influenced sig-

nificantly by the geological characteristics of the slope or the mechanics of the trigger. We exploited the new relationship to evaluate the volume of landslide material produced in the Collazzone area, Central Italy, in the period from about 1937 to 2005. The study area extends for 78.9 square kilometres, and a detailed multi-temporal landslide inventory map of the area, covering the period 1937-2005, shows 2543 landslides, for a total mapped landslide area of $10.43 \cdot 10^6$ m². Using the landslide information and the new area-to-volume dependency, we calculated the total volume of landslide material, $V_L = 4.89 \cdot 10^7$ m³, corresponding to an average landslide mobilization rate of $7.09 \cdot 10^5$ m³ yr⁻¹, or $8.89 \cdot 10^{-3}$ m³ m⁻²yr⁻¹.