



Comparing landslide rates in the northern and central Apennines, Italy

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In Italy, landslides occur every year in response to meteorological and geophysical triggers, including intense or prolonged rainfall, rapid snow melting, and earthquake shaking. Despite the considerable number of landslides triggered every year, the rate of landslide occurrence remains largely undetermined in Italy. In an attempt to fill this gap, we obtained and compared the rates of landslide occurrence in selected study areas. We selected three study areas in the northern and the central Apennines of Italy, including: (i) the Staffora River basin that extends for 275 square kilometres in the southern Lombardy region, (ii) the Collazzone study area that extends for 79 square kilometres in the central Umbria region, and (iii) the Teramo study area that extends for 590 square kilometres in the central Abruzzo region. For each study area we prepared detailed multi-temporal landslide inventory maps through air-photograph-interpretation (API) and field checks. The multi-temporal landslide maps were prepared by interpreting different sets of aerial photographs (from 2 to 5 sets) taken in the period from 1941 to 2000, and field surveys conducted in the period from 1998 to 2004. When interpreting each set of aerial photographs and during the field surveys, care was taken in the identification of the areas where landslides had changed (i.e., landslide reactivations), or where new landslides had occurred. To determine the rates of landslide occurrence in each study area, we quantified the differences between the individual temporal layers (landslide period) that compose the multi-temporal landslide inventory maps. For the purpose, we devised and performed six simple tests. The first test consisted in comparing the number, total extent, and descriptive statistics of landslide areas occurred during a landslide period. The second test consisted in measuring the spatial persistence of landslides mapped during a specific landslide period with respect to the old and very old landslides mapped in the study area. The third test consisted in comparing all the landslides occurred in any landslide period

with the ensemble of landslides of the older slope failures, including the old and very old landslides. The fourth test was similar, and consisted in comparing all the landslides occurred in any landslide period with the ensemble of landslides of the older slope failures, not including the old and very old landslides. The fifth test consisted in determining and comparing the amount of new landslide area generated during each landslide period. The sixth test consisted in comparing the extent of landslides mapped during a specific landslide period with the extent of landslides in the immediately preceding landslide period. Systematic comparison of the single temporal landslide layers that compose the multi-temporal inventory maps allowed obtaining measures of landslide spatial persistence and of landslide rates of occurrence in each study area. Cross comparison of the obtained measures for the three study areas allowed estimating general rates of landslide spatial persistence and of landslide occurrence in the central and the northern Apennines of Italy.