



Recurrence intervals and rainfall intensity–duration thresholds for extensive shallow landslide occurrence in granitic mountains of Japan

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Heavy rainfalls are major triggers of shallow landslides in Japan. Establishing rainfall thresholds is important for assessing future landslide occurrences. This study examined recurrence intervals of heavy rainfall and rainfall intensity–duration (I–D) thresholds for shallow landslide occurrence at two granitic mountains that have different climatic conditions and topography in Japan. Mt. Ichifusa, located in southwestern Japan, has mean annual precipitation of more than 3,000 mm. Shallow landslides have occurred frequently since the 1960s after clear-cutting was conducted on the mountain. The Abukuma Mountains in northeastern Japan, experience mean annual precipitation of about 1,500 mm. Extensive rainfall-induced shallow landslides occurred there in 1971. We interpreted the orthorectified aerial photographs from the 1950s. This study calculated the mean rainfall intensity (I, mm/h) and duration (D, h) of all rainfall events from the 1950s at Mt. Ichifusa, and from the 1970s in the Abukuma Mountains. Rainfall events were separated by the absence of rainfall for 24 h. We then examined the I–D thresholds of extreme rainfall events for extensive shallow landslide occurrences in each period of aerial photographs. We used a quantile-regression method and assumed that the threshold curve is a power law $I = \alpha \times D^{\beta}$, where α and β are constants, to determine the I–D threshold. Finally, we estimated recurrence intervals for rainfall thresholds using a Gumbel distribution.

Results for Mt. Ichifusa show that few shallow landslides occurred at the beginning of clear-cutting, and that shallow landslides occurred frequently after clear-cutting, such as during periods of 1976–1980, 1980–1985, and 1990–1995. The I–D thresholds after the clear-cutting declined to one-third of those at the beginning of clear-cutting. These thresholds roughly correspond to return periods of longer than 10 yr and shorter than 1 yr, respectively, before and after clear-cutting. In the Abukuma Mountains, the I–D thresholds for the extensive shallow landslide occurrences correspond to a return period of longer than 10 yr. These results are expected to be important for landslide hazard assessments and for future forest management. They should be verified in other granitic mountains in Japan.