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Landsliding after Earthquakes

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The Chi-Chi earthquake solicited years of unexpectedly intense landsliding and sediment transport in the mountain area most affected by strong ground motion. This compromised the recovery of the epicentral area and inspired a search for the mechanisms and time scales of post-seismic surface effects and their dissipation. Rates of landsliding remained higher than normal in the Chi-Chi epicentral area for about four years after the earthquake, falling progressively to background levels. In this time, excess erosion caused a 35% reduction of the co-seismic surface uplift. Other earthquakes have induced similar transient episodes of intense mass wasting. The amount and extent of co-seismic landsliding can be predicted with a model including the influences of seismic ground acceleration, fault length, earthquake source depth, and seismic moment, and the modulating effect of topographic steepness. The transient pulse of landsliding after earthquakes has been harder to explain. It is not related to external forcing such as rainfall or aftershocks, and has instead been attributed it to the reduction and subsequent recovery of ground strength, also termed relaxation. This phenomenon has been observed in a wide class of materials after straining perturbations but its duration after earthquake ground shaking has not been constrained. In most landscapes, relaxation is convolved with transient hydrological effects. To eliminate the influence of ground water, we have studied two large earthquake and aftershock sequences in arid northern Chile, and analyzed their effects on ground properties using estimates of seismic velocity from ambient noise interferometry. We have found that the relaxation time scale is a function of the state of the substrate at the time of seismic perturbation, rather than the intensity of ground shaking. This highlights the predictability and tractability of earthquake damage dynamics in the shallow subsurface. 25 years after the Chi-Chi earthquake, patterns and rates of co-seismic landsliding can be predicted with confidence, and the duration of the post-seismic phase of elevated mass wasting appears to be within grasp. Earthquake disaster management in mountainous epicentral areas can be pursued in this quantitative framework.