Evolution of an earth flow controlled by gully incision in the Mangaehu Catchment, North Island, New Zealand

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Mass movement and gully erosion are widespread processes on slopes in the East Coast Region, North Island, New Zealand. Both processes have been analyzed in previous studies, but understanding of their process combination is not sufficient. In this study an active earth flow in the 1.2 km^2 large Mangaehu Catchment on the North Island of New Zealand is analyzed for 73 years to develop a model on the evolution of earth flows influenced by gully incision.

The study area is prone to earth flow and gullying, because the area is composed of Cretaceous, crushed and sheared mudstones and sandstones and because native forest was removed at the beginning of the 20th century for pastoral farming. Aerial photography taken in 06.1939, 04.1957, 09.1971, 06.1988, 05.2005, and 01.2012 were analyzed to map the evolution of an earth flow and gullies.

On the earliest photography of 1939 an incipient gully eroded along the foot of an 810m long earth flow. Shallow slides were initiated in the deposit due to undercutting of the gully walls. The evacuation of the foot material lead to reactivation of the earthflow which propagated along the foot upstream. Gully channels were destroyed by infill of successive failures, but re-incision occurred at the earthflow-distant gully wall. This relocation of the channel reached up to 74m leading in turn to undercutting of the opposing slope causing there slides and gullies supplying additional sediment into the gully. The gully eroded high sediment volumes, as branch number and gully length increased continuously during the study period. The earth flow was recharged by slumping at the head scarp keeping the sediment throughput high.

These findings indicate that gully erosion causes reactivation of earth flows as well as rapid reworking of earth flow deposits on decadal scale. The gully-controlled evolution of such earth flows may be masked when phases of infilling and re-incision of gullies cannot be detected. Because gully incision coupled the earth flow with the river system, incipient gullies need to be treated before dormant earth flows are reactivated to reduced off-site damage.

Keywords: earth flow, gully incision, New Zealand

