

## An Inventory and Analysis of the Grand Mesa Landslides, Colorado, USA: Insights to High-Volume, Hypermobile Mass-Wasting Events

Chapter 2 will be submitted to *Landslides Journal* with the following author list:

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### Abstract

The deadly and massive<sup>1</sup> 2014 West Salt Creek Landslide (WSCL) on Colorado's Grand Mesa prompted an investigation into the recurrence interval of such events. Grand Mesa formed in response to the late Cenozoic incision of the upper Colorado River system and now stands ~1580 m above the local base level. We inventoried 781 landslides<sup>2</sup> via GIS<sup>3</sup> techniques and field verification and analyzed using correlation and regression tree analysis for up to 33 variables per slide. We found 31 landslides in the inventory on the scale of WSCL. Over the last ~15 ka, events on the scale of the WSCL (>20 Mm<sup>3</sup>) occur, on average, about once every 500 years. The late Holocene (last ~5 ka) landslide activity rate averages one landslide every ~17 years, with the ~Holocene Epoch (last ~15 ka) landslide activity rate slightly less frequent at one landslide every ~22 years. The ~late Pleistocene (>15 ka < 30 ka) activation rate slowed to an average of one

<sup>1</sup> Volume = 41 Mm<sup>3</sup>

<sup>2</sup> The database threshold value was a landslide deposit area > 1400 m<sup>2</sup>.

<sup>3</sup> GIS is the abbreviation of Geographic Information Science (or Systems)

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I think you also need to briefly describe in the Abstract how the study was conducted and how you came up with the age estimates. This should be one to two sentences each.

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landslide every ~152 years. The late Quaternary, or "background" (last ~30 ka) landslide activity rate averages one landslide every ~40 years. The ~middle Holocene (<15 ka >5 ka) rate nearly doubles the background rate at one slide every ~26 years, on average. Landslide activity has been relatively stable during the Holocene, with a slight pulse in the late Holocene, but significantly more activity than in the late Pleistocene. Landslide age estimation primarily utilized geomorphic techniques (McCalpin, 1984; Wegmann, 2006), augmented by surface roughness analysis (LaHusen et al., 2016) and selective radiocarbon sampling. The flanks of the mesa generated 52 hypermobile (mobility index  $\geq 9$ ) and 163 high-mobility (mobility index  $\geq 6 < 8.99$ ) landslides during the late Quaternary. In all, 122 landslides have higher mobility indices than the WSCL. The Green River Formation sandstone produces 65% of the high-volume and 37% of the hypermobile landslides while cropping out beneath only 28% of the entire Grand Mesa study area. The dominance of the Green River Formation in producing landslides is likely the combination of the stratigraphic elevation on the Grand Mesa and the varied lithography of the many members. The Wasatch Formation produced the most, 42%, of the hypermobile landslides, likely the same reasons.