# SLOPE MOVEMENTS AND SLOPE MOVEMENT DEPOSITS MAP OF GRAYSON COUNTY, VIRGINIA

Holly E. Mangum and Anne C. Witt

2026

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF ENERGY
DIVISION OF GEOLOGY AND MINERAL RESOURCES

GEOLOGIC HAZARDS MAP SERIES 4
SLOPE MOVEMENT HAZARDS MAP OF
GRAYSON COUNTY, VIRGINIA
VERSION: September 28, 2026

## EXPLANATION

### MAP FEATURES

**Slope movements**
- Landslide track
- Weathered landslide

Initiation zones
- Debris or earth blowout
- Debris or earth flow
- Debris or earth slide and flow
- Debris or earth slide

**Slope movement deposits**
- Debris deposits
- Relict landslide

**Roads**
- Primary roads
- Secondary roads
- Blue Ridge Parkway

**Rivers**
- Rivers and Streams
- Lakes

**Political Boundaries**
- County boundary
- State boundary

**Modifiers**
- Green halo indicates slope movement or slope movement deposit was field verified

### SLOPE MOVEMENT DEFINITIONS

**Materials**

**debris** - A soil that contains a significant proportion of coarse material; 20 to 80 percent of the particles are larger than coarse sand (0.08 inches or 2 millimeters), with the remainder finer than 0.08 inches of 2 millimeters.

**earth** - A soil in which more than 80 percent of the particles are smaller than 0.08 inches (2 millimeters).

**rock** - An aggregate of one or more minerals or undifferentiated mineral matter.

**Mechanisms**

**blowout** - A type of slope failure in which water and soil bursts forth from the ground and then proceeds downslope as overland flow. These are possibly caused by excessive pore water pressure.

**flow** - A type of slope movement in which the water content in the displaced mass is sufficient for the material to liquify and behave as a viscous fluid.

**slide** - A type of slope movement failure in which the material is displaced along a well-defined, typically planar or curvi-planar failure surface. Where the geometry of the failure surface is not known, the term slide is applied. Where known, the slide is classified as rotational or translational.

### SLOPE MOVEMENT DEPOSIT DEFINITIONS

**Debris deposits** - A type of slope movement deposit consisting of accumulations of clay-, silt-, and sand-sized particles with gravel-to-boulder-sized rock clasts in various stages of weathering and decomposition (AASHTO, 2025). These features are a result of multiple slope movement processes and events of various ages from prehistoric to modern times.

**Relict landslide** - A slope movement deposit identified by its hummocky appearance, indistinct lateral edges, and lack of a headscarp. These may represent the weathered remnants of rockfalls of unknown ages.

**Note:** Definition of blowout from Hack and Goodlett (1960); unless referenced otherwise, the above definitions are in general accordance with Cruden and Varnes (1996) and Jackson (1997).

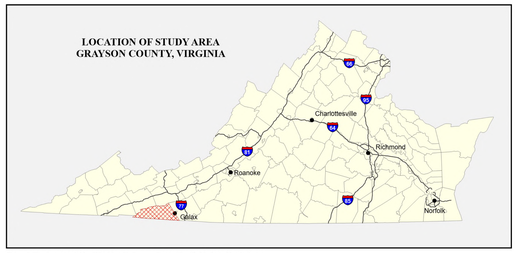
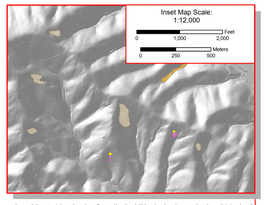



**Figure 1.** The Commonwealth of Virginia with Grayson County identified in the red hatched area.




**Inset Map 1**. Map showing five relict landslides in the Grassy Creek and Mouth of Wilson quadrangles. The underlying bedrock is within the Proterozoic-aged Elk Park Plutonic Group and is primarily composed of a quartz monzonite gneiss (Witt et al., 2021). These features are representative of relict landslides found in Grayson County; 19 out of the total 50 relict landslides mapped in the county are found within the bounds of these two quadrangles, and 23 of 50 are underlain by the quartz monzonite gneiss.

**Inset Map 2**. Copernicus Sentinel-2 satellite imagery from October 7th, 2024 showing a multi-headed debris slide generated by Hurricane Helene along Rt. 21. The image above is representative of the visual resolution of the imagery dataset, and it is the only aerial imagery available immediately post-Hurricane Helene. This debris slide was only visible in post-Helene imagery (Copernicus Sentinel-2, 2024) and appears to have obstructed the roadway with sediment. The imagery is 10-meter resolution (therefore a low level of detail), so the post-storm landslides identified from this imagery are based on the visible sediment in the roadway and field verification. Figure 2 shows the erosion control put in place within three of the four slide bodies after the storm.

**Figure 2**. A portion of a multi-headed debris slide generated by Hurricane Helene along Rt. 21, the major access route in Grayson County. The bodies of three out of the four heads of the slide have been filled with riprap for erosion control, and the road was re-paved. Copernicus Sentinel-2 imagery (Inset Map 2) was used early in the mapping process to identify this feature.

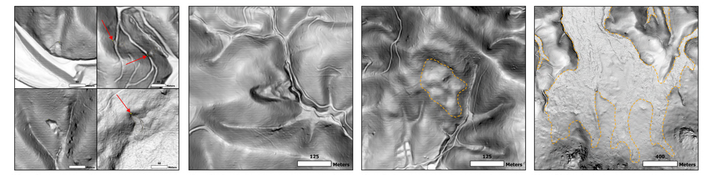
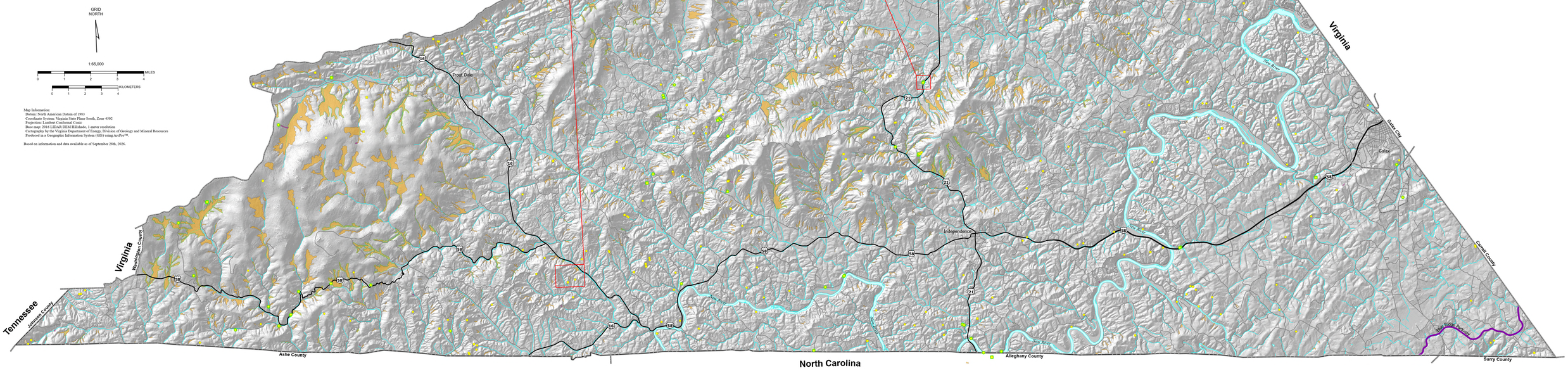



**Figure 3a**. Four examples of modern debris slides and flows in high-resolution 1-meter lidar. These modern features can occasionally be associated with a particular storm event. These examples are representative of the predominantly short and small landslides that exist in Grayson County. Red arrows indicate headscarps.

**Figure 3b**. An example of a weathered landslide in 1-meter lidar. The headscarp and lateral edges are rutted but identifiable. These weathered landslides often exhibit an indistinct, curved shape upslope that is the weathered headscarp and have a hummocky or lumpy topography within the flow path. Weathered landslides cannot be associated with a particular storm event.

**Figure 3c**. An example of a relict landslide in 1-meter lidar. The deposit has a slight hummocky appearance with no headscarp and indistinct lateral edges. Many of these features in Grayson County are underlain by a quartz monzonite gneiss and may be the remnants of prehistoric debris or rock slides.

**Figure 3d**. An example of several composite debris deposits in 1-meter lidar. These features are composed of accumulations of unconsolidated rounded to subrounded cobbly and bouldery sediment resulting from several generations of slope movements over geologic time.



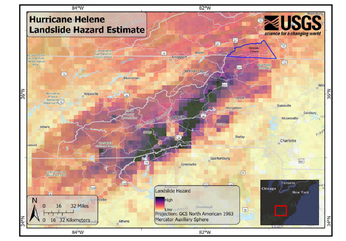




**Figure 4**. A map of the relative landslide hazard from Hurricane Helene. This map was created by the U.S. Geological Survey immediately after Hurricane Helene to aid emergency response and landslide mapping (Martinez et al., 2024). It is based on cumulative precipitation estimates (NWS Greenville-Spartanburg from September 24-28, 2024) and the USGS National Landslide Susceptibility Map (Mirus et al., 2024). Areas in dark purple indicate the highest landslide occurrence. Grayson County, outlined in blue, is on the northern extent of the high hazard area.

GRID NORTH

1:65,000

0 1 2 3 4 MILES

0 1 2 3 4 KILOMETERS

Map Information:
Datum: North American Datum of 1983
Coordinate System: Virginia State Plane South, Zone 4502
Projection: Lambert Conformal Conic
Base map: 2016 LiDAR DEM Hillshade, 1-meter resolution
Cartography by the Virginia Department of Energy, Division of Geology and Mineral Resources
Produced in a Geographic Information System (GIS) using ArcPro™.

Based on information and data available as of September 28th, 2026.

**Figure 5**. A debris slide that occurred during Hurricane Helene near the New River in southern Grayson County. This landslide was initially identified in the Preliminary Landslide Inventory for Landslides Triggered by Hurricane Helene (Burgi et al., 2024). Photo 5a, taken by Susan Caudell Adams and shared on social media (Adams, S.C., 2024), shows sediment and woody debris that was pushed onto Old River Lane by flood waters. Photo 5b shows the headscarp of the same debris slide over a year after Helene. Subsidence occurred along the headscarp, and the property's septic system (septic tank visible) as well as a utility pole along the road were damaged. The main body of the slide contains subangular cobbles and boulders of biotite gneiss. The underlying Ashe Formation bedrock foliation dips southeast downslope.

**Figure 6**. A debris slide with two headscarps that occurred during Hurricane Helene along Old River Lane in southern Grayson County. This landslide was identified in the Preliminary Landslide Inventory for Landslides Triggered by Hurricane Helene (Burgi et al., 2024) and is visible in the Copernicus Sentinel data, October 7th, 2024. The contact between the displaced material and main scarp (white dotted line) is the initiation zone of the landslide.

## OVERVIEW OF THE SLOPE MOVEMENTS AND SLOPE MOVEMENT DEPOSITS MAP

### Background and Purpose

The Virginia Department of Energy's Division of Geology and Mineral Resources (DGMR) has produced a slope movements and slope movement deposits inventory map for Grayson County (Figure 1) in response to the numerous landslides and extensive flooding initiated by Hurricane Helene in September 2024 (Figure 4). Preliminary rainfall estimates from the National Weather Service indicate that Grayson County received between 8 to11 inches of rain during a 72-hour period ending on September 28, 2024. No regional landslide hazard maps exist for this part of Virginia, so landslide risk was entirely unknown. The intention of this landslide inventory map is to begin to understand geological and topographic factors that influence landslide initiation and the risk to public safety from landslides in southwestern Virginia. During a second phase of this project, a susceptibility model and inundation model will be created to further investigate these factors and safety risks.

This printed map is a smaller scale representation of digital spatial data that has been created for use in a Geographic Information System (GIS).

### Slope Movements and Slope Movement Deposits Map

This map consists of data from the Virginia Slope Movement Geodatabase and is color-coded by entry type (slope movement or slope movement deposit). Definitions and descriptions of slope movements and slope movement deposits are provided in the Explanation. Slope movements are classified in general accordance with Cruden and Varnes (1996). The Virginia Slope Movement Geodatabase and this map are compilations of information on slope movements and slope movement deposits derived from numerous sources including field observations by DGMR geologists. New information or future mapping may identify additional slope movement features not currently shown on this map.

DGMR geologists mapped features using direct field observations; Copernicus Sentinel-2 post-Helene satellite imagery acquired September 22nd, 2024, October 7th, 2024, and October 12th, 2024 (Copernicus Sentinel-2, 2024); 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2001, 2002, 2007, 2011, 2015. 2019, and 2023 orthophotography; the Preliminary Landslide Inventory for Landslides Triggered by Hurricane Helene (Burgi et al., 2024); and a digital elevation model (DEM) derived from a 1-meter resolution lidar dataset collected in 2016. DGMR geologists conducted fieldwork from December 2025 through April 2026 and collected data at 595 field locations.

The only lidar available for the study area was flown between 2015-2016, meaning there was no post-Hurricane Helene lidar for comparison. While the lidar was sufficient for inventory mapping of landslide features initiated before 2016, the USGS Preliminary Landslide Inventory, VDOT reports, social media, new reports, Copernicus imagery, and field observations were relied upon for identifying landslides caused by Helene. Only 16 landslides were identified as definitely resulting from Helene, most initiating on modified slopes. The process for mapping landslide features was as follows:

1. Identify and draw potential features visible in ArcGIS Pro at a scale of 1:6,000 using the 1-meter resolution lidar DEM and substantiate with aerial imagery if available.

2. Field check drawn features using ArcGIS Field Maps application to collect data.

3. Update database based on observations made in the field.

Individual point and map unit data types included on the map are described below.

1. **Slope Movement Initiation Zones.** These locations identify the upslope starting point (Figure 3a and Figure 6) of slope movements from entries in the Virginia Slope Movement Geodatabase. Data points that identify these zones are symbolized by type of slope movement process.

2. **Landslide Tracks.** These map units outline the areal extents of recent individual debris flows and slides, including those caused and re-activated by Helene (Inset Map 2, Figures 5a and 5b), and older weathered landslides (Figure 3b) which cannot be associated with a known storm event. The landslide tracks in Grayson County have a mean length of ~330 feet. These tracks are notably shorter than those mapped in Albemarle and Nelson County, Virginia in which the mean track length is ~1,050 feet.

3. **Slope Movement Deposits.** These map units show older landslide features with indistinct lateral edges and hummocky geomorphology (relict landslides, Figure 3c), and the areal extents of significant volumes of earth, debris, and rock that have accumulated because of past debris flows and debris slides (Figure 3d).

**Debris Deposits**. Debris deposits mainly occur in valleys and grade upslope into debris flow, debris slide, and rock slide deposits in steep source areas. These mapped slope movement deposits are typically composite features that formed from multiple slope movements over time. The bulk of the deposits are likely prehistoric in age, but their depositional ages have yet to be verified by age-dating. Areas mapped as debris deposits meet two or more of the following criteria: 1) exhibit an elongate, lobate or fan shape and are visible at a scale of 1:6,000 using the 1-meter resolution lidar DEM; 2) have an adequate upslope source area where past slope movements could have initiated; 3) were verified in the field to contain gravel-to-boulder-sized clasts or other textures and depositional structures that characterize deposits produced by slope movements (i.e. matrix supported or imbricated clasts, or scour and fill structures). In general, coarse-grained deposits east of the Little Wilson Creek Wilderness area tend to accumulate further upslope. From initial interpretations based on contours and the texture of the 1-meter lidar, the deposits in this portion of Grayson County appeared to be further downslope. According to observations made in the field, however, the deposits tend to transition into fine-grained material downslope while maintaining a fan-like morphology. This indicates that the more recent material was confined upslope near the source areas, allowing this material to be a likely origin of future downslope movement. These eastern-Grayson County deposits tend to be sparse and cover the slope in a thin veneer of sub-angular to sub-rounded cobbles and boulders, typically less than 2 feet thick at depth (Soil Survey Staff, 2026). Deposits are more widespread and thicker, about 5 feet thick at depth (Soil Survey Staff, 2026), in the higher elevation areas of Whitetop Mountain, Mt. Rogers, and Pine Mountain in the west, and Buck Mountain and Point Lookout Mountain in the center of Grayson County. These thicker deposits accumulate larger boulders with a grain size up to 4 feet in diameter, and are typically sourced from the porphyritic rhyolite, phenocryst-poor rhyolite, graywacke conglomerate, and augen and porphyritic gneiss rock units (Witt et al., 2021).

**Relict Landslide**. These features form from a heterogeneous mixture of clay-, silt-, sand-, and gravel-sized particles. Numerous to few rounded boulders may be found within the body of the landslide. Compared to weathered or modern landslides, these features are less apparent in the field as they are the remnant of a slope movement that occurred 1,000+ years ago. It is possible for these features to be re-activated and produce modern slope movements. An indicator of re-activation can be the presence of surrounding trees with the lower part of their trunks curving downslope, called pistol butted trees. Relict landslides are most often found in upland areas underlain by a quartz monzonite gneiss in the southern part of Grayson County (Inset Map 1). They are identified by their hummocky appearance in the field and in 1-meter resolution lidar (Figure 3c). They are assumed to be the remnants of prehistoric debris or rock slides based on their geomorphology.

### References Cited

AASHTO, 2025, Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. M145-91. American Association of State Highway and Transportation Officials, Washington DC.

Adams, S.C., 2024, photograph, Old River Lane, Grayson County, Virginia. Retrieved from https://www.facebook.com/photo/?fbid=10230419921435639&set=pcb.10230419859074080.

Burgi, P.M., Toney, L.D., Collins, E.A., Murphy, C.R., Ellison, S.M., Schmitt, R.G., Allstadt, K.E., Bedinger, E.C., Belair, G.M., Bilderback, E.L., Dunlap, L.R.C.C., Cuttanach, B., Crawford, M.M., Einbund, M.M., Fitzpatrick, F.A., Frost, D. J., Grant, A.R.R, Hageman, S. J., Hartman, C., Heckert, A.B., Hoch, O.J., Johnson, B., Jones, E.S., Jurgevich, J., Karanitsellis, E., Korte, D., Martinez, S.N., Merschat, A.J., Miles, C.P., Sas, R., Schaefer, L.N., Scheip, C., Soobitsky, R., Trantham, B., Witt, A., 2025, Preliminary Landslide Inventory for Landslides Triggered by Hurricane Helene (September 2024): U.S. Geological Survey data release, https://doi.org/10.5066/P14CHGKS.

Copernicus Sentinel-2, 2024, European Space Agency, Available online: https://browser.dataspace.copernicus.eu/.

Cruden, D.M. and Varnes, D.J., 1996, Landslide types and processes, in Turner, A.K., and Schuster, R.L., eds., Landslides: Investigation and Mitigation: Transportation Research Board Special Report No. 247, National Research Council, National Academy Press, Washington, D.C., p. 36-75.

Hack, J.T. and Goodlett, J.C., 1960, Geomorphology and forest ecology of a mountain region in the central Appalachians: U.S. Geological Survey Professional Paper 347, 66 p.

Martinez, S.N., Stanley, T., Allstadt, K.E., Baxstrom, K.W., Mirus, B.B., Einbund, M.M., Bedinger, E.C., and the National Weather Service Greenville-Spartanburg Forecast Office, 2024, Preliminary Landslide Hazard Models for the 2024 Hurricane Helene Landslide Emergency Response (version 2.0, April 2025): U.S. Geological Survey data release, https://doi.org/10.5066/P134EBB9.

Mirus, B.B., Belair, G.M., Wood, N.J., Jones, J., and Martinez, S.N., 2024, Parsimonious High-resolution Landslide Susceptibility Modeling at Continental Scales: AGU Advances, v. 5, p. e2024AV001214, https://doi.org/10.1029/2024AV001214.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic Database (SSURGO). Available online: https://arcg.is/0fiIDqG, accessed 22 June 2026.

Witt, A.C., Heller, M.J., Occhi, M.E., Spears, D.B., Lang, K.E., Berquist, C.R. Jr., and Prince, P.S., editors, 2021, Statewide Geologic Map Database of Virginia: Virginia Department of Energy, Geology and Mineral Resources Program, Open-file report 2021-12, scale 1:250,000.

### ACKNOWLEDGEMENTS

This material is based upon work supported by the U.S. Geological Survey under Grant No. G25AP00227-01. The federal funding under this grant agreement was $109,088.52. We thank the Grayson County Government for their cooperation, Grayson County residents who provided personal stories about their experiences during Hurricane Helene and allowed access to their property, Dr. Arthur Merschat and Haley Gunnon for additional field support, and Wendy Kelly for assistance in the office. We also acknowledge the authors of the Preliminary Landslide Inventory for Landslides Triggered by Hurricane Helene for their contributions to the dataset.

### DISCLAIMER

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey. This map product is not intended to be a substitute for a detailed, site-specific analysis by a qualified geologist or engineer.