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Landslide Inventory of Caledonia County, Vermont

George Springston
Norwich University Department of Earth and Environmental Sciences
108 Harmon Drive
Northfield, VT 05663
802-485-2734
gsprings@norwich.edu

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On the cover: Landslide on Route 15 in Hardwick. Photo taken May 4, 2004 by George Springston.

Executive Summary

Landslides, gullies, and associated features were inventoried in Caledonia County in northeastern Vermont. Over 300 features were identified using a combination of field investigations and remote sensing using lidar (light distance and ranging) topographic data and recent, high-resolution orthophotos from the Vermont Center for Geographic Information.

Most of the landslides are located on steep slopes close to streams at sites of active streambank toe erosion. The greatest concentrations of landslides, landslide-gully complexes, and mass failures are seen along unstable reaches of Calendar Brook in Sheffield and Burke, Stannard Brook in Stannard (and an unnamed tributary to it in Walden), Morrill Brook and Water Andric in Danville, and Peacham Hollow Brook in Peacham and Barnet.

The landslides that have been mapped in this study are generally in locations that have also experienced slope failure in the past. This means that by mapping the present locations of landslides we can predict many of the locations where slopes will fail in the future.

Most of the actively eroding gullies in the county are within the level of glacial Lake Hitchcock and appear to be closely associated with stormwater runoff from roads and developed areas. There is also a scattering of unstable gullies along the terraces adjacent to the Connecticut River.

The principal causes of the slope failures appear to be the over-steepening of slopes due to fluvial erosion of banks and stream beds during floods and decreases in shear strength of soils due to increases in soil water pore pressures due to the heavy rainfall.

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Introduction

This report presents the results of a detailed study of the existing landslide, gullies, and other slope instability indicators in Caledonia County in northeastern Vermont (Figure 1). This study is intended to provide an accurate basis for local, State, and Federal hazard planning in the area.

The current State Hazard Mitigation Plan identifies mapping of landslides gullies, and other slope instability hazards as an important component of hazard mitigation efforts in Vermont (http://vem.vermont.gov/plans/SHMP). This inventory of Orange County is based on the Phase 1 inventory method outlined in Clift and Springston (2012).

The inventory was undertaken using a variety of sources. Sources of locations of existing landslides and other features included:

1. Landslide Protocol study conducted for the Vermont Geological Survey (VGS) by Clift and Springston (2012).

2. Surficial geologic mapping projects produced for the VGS.

3. Data from individual site visits conducted by the author for the VGS.

4. Data from the stream geomorphic assessment data provided by the Vermont Rivers Program. Of critical importance is the Phase 2 field data on mass failures and eroding banks derived from the Feature Indexing Tool (FIT).

Lidar (light distance and ranging) topographic data from the Vermont Center for Geographic Information was an essential component of the study. Lidar is very detailed airborne laser topographic mapping. Trees, buildings, and other structures have been removed in the processing in order to show the shape of the land surface. The data was used both as an accurate source for determining elevations and heights of features, and as the basis for calculating the steepness of slopes. In the slope maps shown in this report steep slopes are shown as black, intermediate slopes are gray, and flat areas are shown as white. The slope data was also classified to produce a GIS layer showing ranges of slope: 0 to 33%, 33-50%, 50-73%, 73-100%, and greater than 100%.

Interpretation of slope instability features was undertaken by viewing existing site data in combination with the coded lidar slope map, streams (1:5,000 surface waters from the Vermont Hydrologic Dataset), and recent high-resolution orthophotos.

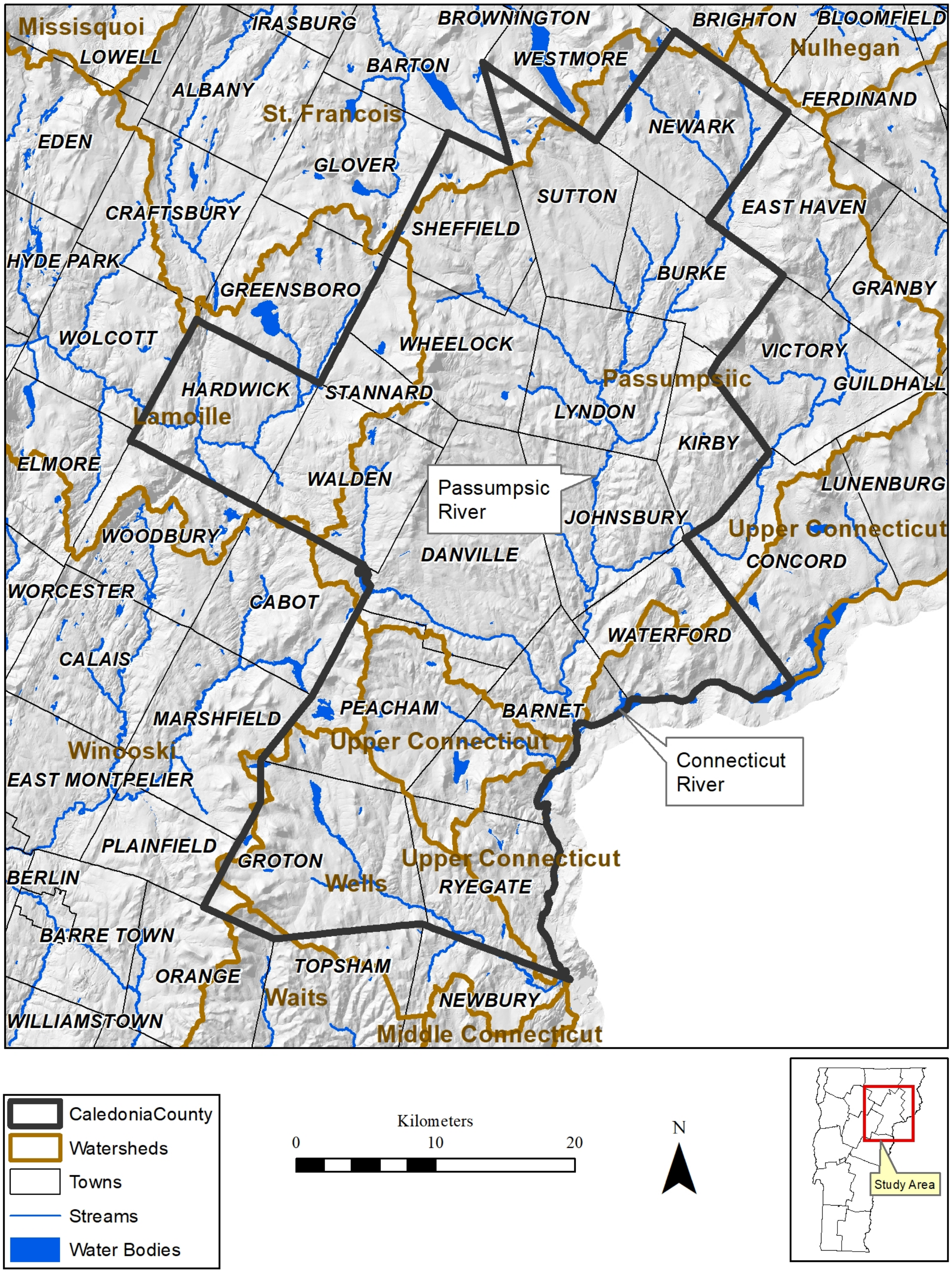

Figure 1. Location map.

Previous Work

Although there have been many studies of landslides and associated slope instability hazards in Vermont, most were focused only on small areas or specific sites and a detailed inventory that is useful for hazard planning has been lacking. A detailed chronology of the earlier studies up through 2011 is given in Clift and Springston (2012) and is summarized and updated below.

A USGS study of slope stability issues in Vermont, undertaken in cooperation with the VGS, resulted in several publications that contain useful information on slope stability. Much of this work is summarized in Baskerville and others (1993) and Baskerville and Ohlmacher (2001).

Several studies of debris flows and/or debris avalanches in the mountainous terrain of Vermont and surrounding states have been undertaken in recent decades, including Flaccus (1958), Kull and Magilligan (1994), and Milender (2004) in New Hampshire, Bogucki (1977) in the Adirondacks, and Dethier and others (1992) on Mount Greylock in Massachusetts. Springston conducted a detailed analysis of rockfall and debris flow hazards in Smugglers Notch in northwestern Vermont (Springston, 2009).

The close association between landslides and stream erosion has been investigated in a number of recent studies. Barg and Springston (2001), Springston and Barg (2001) and Springston and Barg (2002) studied the fluvial geomorphology and surficial geology of the Great Brook watershed in central Vermont. This work included mapping of over 20 large landslides. Springston and others (2004) conducted a detailed analysis of a large rotational slump in lacustrine sediments on the Mad River in Waitsfield. Since approximately 2000, extensive studies of fluvial geomorphology in Vermont watersheds have been undertaken by the River Management Program of the Vermont DEC. Some of the results of these studies are summarized in Kline and Cahoon (2010). These assessments include mapping locations of mass failures that can be seen walking along the stream and will be utilized extensively in this protocol. Springston (2010) summarized existing knowledge of bank stability issues in Vermont and included a literature review of previous landslide studies in the state.

Landslide activity in the wake of Tropical Storm Irene (August 2011) has been the subject of many studies. Observations by Springston and others (2012) suggested that many pre-existing landslides were reactivated during the flooding. Dethier and others (2016) undertook an extensive inventory of landslides in the southern half of Vermont and provided abundant evidence that this was the case. Their study showed a dramatic increase in both the erosion rate and the input of large wood into stream channels due to Tropical Storm Irene. They conclude that infrequent, large-magnitude stream-flows have more influence on landscape evolution than has previously been recognized in the region.

The present study is part of a series of landslide inventories that the Vermont Geological Survey is currently (Springston, 2017, 2018, 2019; Springston and Gale, 2018).

Landslide Inventory

The inventory is shown in detail on Plate 1 and includes landslides, gullies, and other slope instability hazards. A much-reduced version of the inventory is shown in Figure 2. A landslide is a feature formed by the downslope movement of rock and/or soil under the influence of gravity. A good general discussion of landslides is given in Highland and Bobrowsky (2008). The term "landslide" as used in this report includes a wide variety of falls, slides, and flows. The material can range from rock, through debris, to earth (predominantly <2 mm). A classification of slope movements based on the general type of movement and type of material is shown in Table 1. A further subdivision of the earth slides and earth slumps into rotational and translational types is shown in Figure 3 and the terminology used to describe the geometry of a typical landslide is shown in Figure 4. A landslide is commonly identified by the presence of steep slopes and/or evidence of soil movement and surface or subsurface erosion. A large translational earth slide in dense glacial till is shown in Figure 5. Most originate near streams, although they may extend quite far from the streams. The mass failures identified during stream geomorphic assessment studies are landslides.

Table 1 - Simplified classification of slope movement types.
Modified from Varnes (1978). Types common in Vermont are in bold.

Type of Movement	Type of Material		
	Bedrock	Engineering Soils	
		Predominantly coarse	Predominantly fine
Falls	**Rock fall**	Debris fall	**Earth fall**
Topples	**Rock topple**	Debris topple	**Earth topple**
Slides*	**Rock slide**	**Debris slide**	**Earth slide or slump**
Spreads	Rock spread	Debris spread	Earth spread
Flows		**Debris flow**	**Earth flow**
Complex	**Combinations of two or more types of movement**		
Creep	**Several types**		

*Slides may be subdivided into rotational and translational types. Rotational slides in relatively homogeneous materials are commonly called "slumps". The term "rotational slump", although somewhat redundant, will be used here to emphasize the distinction from translational slides.

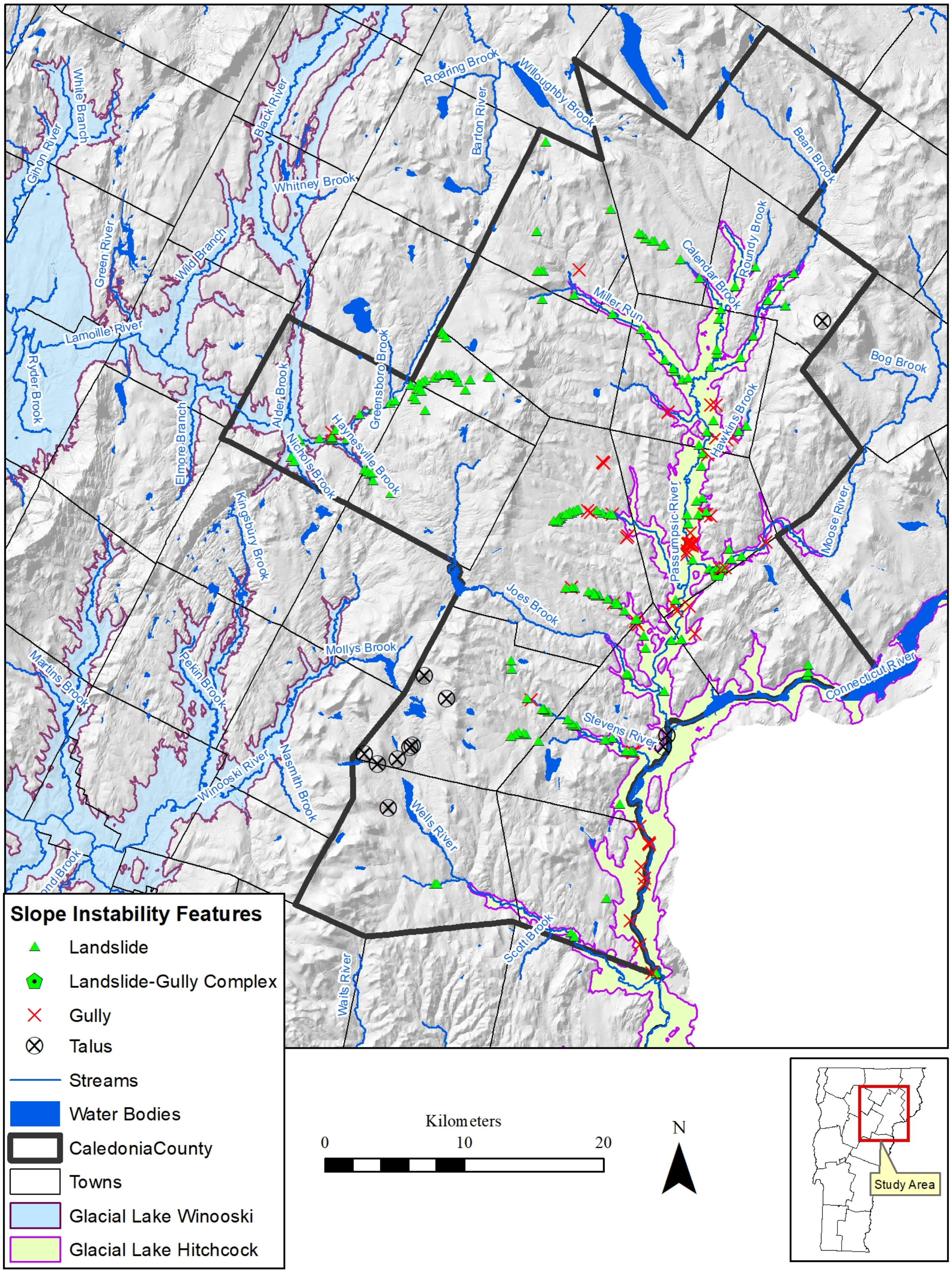

Figure 2. Generalized map of all slope instability hazard sites. These include landslides, landslide-gully complexes, gullies, and talus slopes. These are shown at a larger scale on Plate 1.

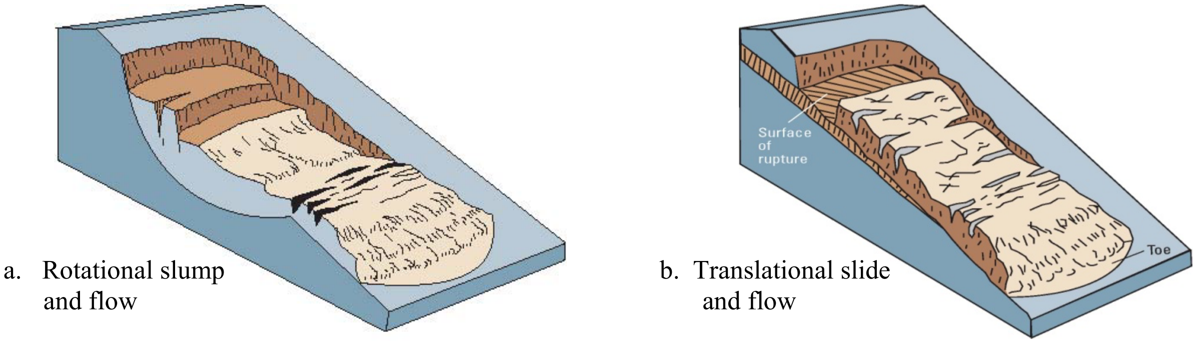

Figure 3. Two common types of landslides in Vermont. a) rotational slump and flow, b) translational slide and flow. From Highland and Bobrowsky (2008).

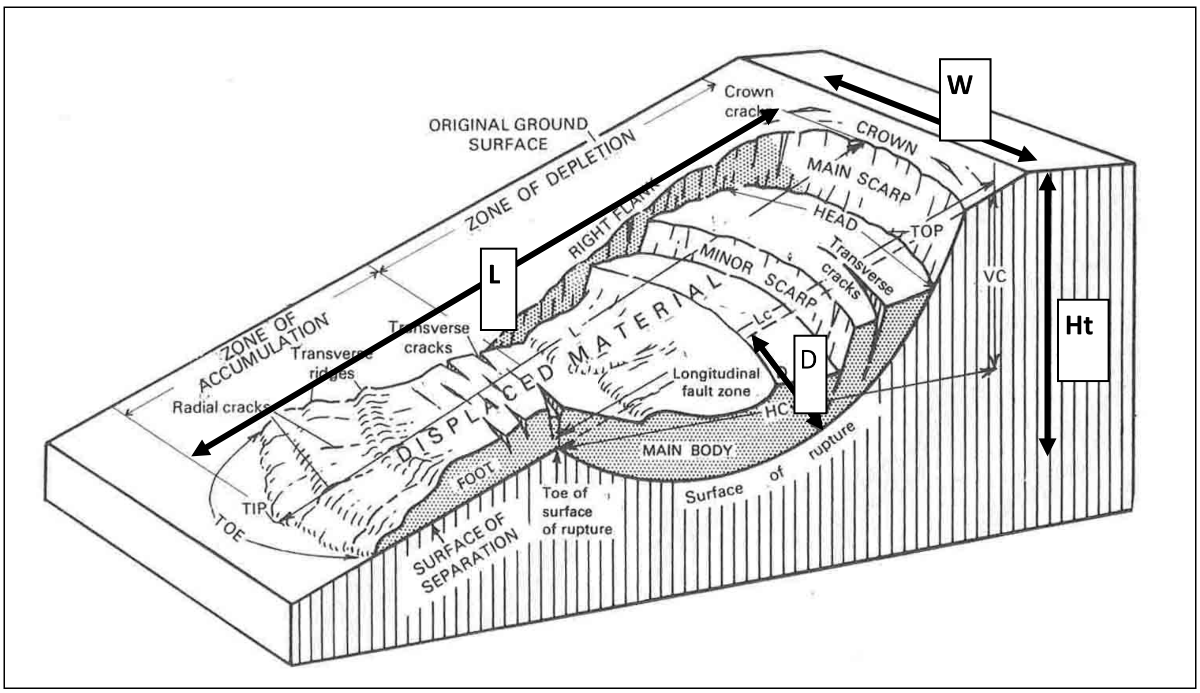

Figure 4. Generalized complex rotational slump/flow. Landslides with this overall form are common on clayey to sandy lacustrine deposits throughout Vermont. In many cases the displaced material has been at least partially eroded away by stream flow. Length (L) refers to the total slope length from crown to the tip of the toe. Width (W) refers to the width of the feature measured across the slope at the location of greatest width. Depth (D) is measured in a vertical plane and perpendicular to the original slope. Height (Ht) refers to the vertical height from the toe up to the top of the slide. Modified from Cruden and Varnes (1996, Figure 3-3).

A typical large landslide in dense glacial till is shown in Figure 5. This is one of several identified along the banks of Stannard Brook in Stannard. This landslide has been active for many years. The failure mechanisms may be complex. Certainly an important mode of failure has been shallow translational sliding, but observations by the author over many years suggest that during large floods there may be deep erosion of the landslide toe due to fluvial shear and subsequent collapse of the over-steepened slope. See Springston and Thomas (2018) and the section in this report entitled *Patterns of Slope Failure on Till Slopes* for a more detailed discussion.

Figure 5. Large translational earth slide in dense glacial till on the south side of Stannard Brook in Stannard. Photo courtesy of Jack Carlson, September, 2020.

Eroding banks are common along many of the streams in the county but are not included in this inventory. Eroding banks are formed by the same mechanisms as landslides, but a cutoff has been set at about 4 meters in height, with eroding banks being below that height and landslides above it. A typical example is shown in Figure 6. Although the distinction may seem arbitrary, it is commonly the case that eroding banks are forming on the sides of low terraces that are themselves subject to inundation flooding. In contrast, landslides are generally high enough that they are not going to have their tops flooded (at least during normal floods of short recurrence intervals). Thus, the landslide hazard may be more of a fluvial erosion hazard than an inundation hazard.

Figure 6. Eroding bank of the Dog River, Northfield, Vermont. Shovel and notebook for scale. Flow is away from observer. Sandy alluvium has been undercut during recent high flows and is in the process of collapsing. Photo by George Springston, April, 2007.

A gully is a steep, narrow channel incised into surficial deposits. The stream is usually a first-order stream and the flow in the bottom is usually intermittent. Unstable gullies have very steep sides and commonly show signs of fresh erosion in the bed or at the gully heads. The heads of gullies have been indicated for many of the unstable gullies. These serve to give some idea of the extent of the features. A landslide-gully complex includes one or more gullies with associated landslides.

A talus deposit is a fan or apron of fallen rock at the base of a cliff. Talus deposits are mapped in order to indicate the presence of unstable rock slopes that are prone to failure. In Caledonia County limited talus deposits are present on the flanks of some of the taller peaks and on cliffs above the Connecticut River. These are shown on Figure 2 and Plate 1.

A typical streamside landslide is shown in Figures 6 and 7. This site is on the east side of the Second Branch of the White River in East Randolph and although it is not in the current study area, it will serve as a good example. The landslide exposes an alluvial terrace deposit of sand and gravel overlying glaciolacustrine silt and silty clay interpreted to have been deposited in glacial Lake Hitchcock. The landslide appears to have been driven largely by toe erosion.

Figure 7. Landslide in alluvial terrace deposits overlying lacustrine silt-clay deposits on Second Branch of White River in Orange County. Photo by George Springston, 2006.

Figure 8. Close-up view of alluvial sand and gravel overlying grey lacustrine silt and silty clay in landslide scar shown in Figure 7. Photo by George Springston, 2006.

Unstable gullies are mostly concentrated in lowland areas underlain by glacial Lake Hitchcock deposits in the more densely populated towns of Lyndonville and St. Johnsbury. They are uncommon in the more sparsely populated uplands. As the lowland areas are often the sites of the larger towns, it is somewhat uncertain whether the unstable gullies are more due to the increased density of population, roads, and buildings or to the highly erodible sand and silt/clay deposits that underlie these areas.

A typical unstable gully from Orange County is shown in Figures 8 and 9. The gully is part of a landslide-gully complex on the southwest bank of the Ompompanoosuc River in Thetford that has eroded into about 20 feet of loose, coarse-sandy boulder cobble gravel overlying 11 feet of dense fine-sand to silt-matrix till over bedrock. The culvert outfall shown in Figure 12 drains onto the slope. In this particular case it appears that road runoff has contributed significantly to the formation of the gully.

Figure 9. Looking down at a typical unstable gully near the Ompompanoosuc River in Thetford.

Figure 10. Looking up the center of the gully at highly erodible gravel deposit.

Case Study: Landslide in Hardwick in 2003 and 2004

As an example of the type of damage that can result from even a moderate-sized landslide, the following case study is presented: In November of 2003 the Vermont Agency of Transportation (VTrans) alerted the VGS that a landslide was developing on the outer face of a high terrace above VT Route 15 in Hardwick (Figure 11). Site visits on November 10 and 21 revealed an area of active slope movement on a wooded slope south of the highway. Many of the trees on parts of this slope outside the present landslide had curving trunks, indicating at least some previous down-slope movement has occurred. The slope appears to be an ancient cut-bank formed by the Lamoille River, which presently is located to the north of the road. The area of sliding was about 400 feet long, about 105 feet high, and had an overall slope angle of 28 degrees. A general view of the slide as it was in November of 2003 is shown in Figure 12. Using the landslide classification of Cruden and Varnes (1996), this is an active, complex landslide consisting of several rotational earth slumps and a central earth flow. This flow can be seen in Figures 12 and

13. From observations at the slide, along Glenside Avenue, and in the stream valley to the east, there does not appear to be bedrock near the surface. Field observations confirmed that most of the slope is underlain by glacial till containing angular pebbles, cobbles, and boulders in a silt-rich matrix. The materials are best exposed on the fracture surfaces and are described further below.

The owner of one of the properties reported that the slope below their house had long been unstable and that they had been placing fill below their house for “about 20 years”.

Fresh fracture surfaces were exposed at three locations:

1. The lowest of the three failures is partway up the wooded slope. The top of this fracture is about 57 feet above the highway. This failure was in glacial till. The till has a silt-rich matrix with angular pebbles, and cobbles. The material had a loose to medium density. Glacial boulders up to several feet in diameter were scattered sparsely throughout the woods. Although a few may have been dumped over the edge from above as part of artificial fill activities, most of the boulders on the slope appeared to be from the underlying glacial till.
2. A second failure surface was located at the base of the concrete foundation wall of a house on the west side of the landslide, approximately 81 feet above Route 15. Movement on this fracture surface had removed material from the north (downhill) side of the Wiggins foundation. This failure was partly in glacial till and partly in what appeared to be artificial fill. At the closest point, the fracture was about 50 feet from the north side of Glenside Avenue.
3. Near the top of the slope at the Holmes residence there is sandy artificial fill that has settled, leaving a prominent steep scarp approximately 3 feet high (Figures--). The top of the scarp was about 105 feet above Route 15. The scarp extended westward onto natural ground and there cut into approximately 1.5 feet of sand over till. This sand appeared to be a natural deposit of lake sand.

Movement of soil blocks and active flows of mud were observed over the course of November, 2003. The site appeared largely stable over the winter, but a visit on April 2, 2004 showed extensive failure of soil blocks (Figure 14). A major event on the morning of April 19 blocked Route 15. Eyewitnesses report that the slope failure was rapid (less than 30 seconds). Figure 15 shows the site on April 22 after the highway was reopened. Figure 16 shows the site on May 5.

Investigations showed that a large amount of fill had indeed been placed on the top of the slope. Scarps developed in this material are shown in Figures 17 and 18. Although the main failure surface was coated with a thin layer of silt and clay (Figure 19), scraping revealed that much of the slope was underlain by dense glacial till (Figure 20). Although the landslide was not immediately adjacent to the Lamoille River, a large quantity of fine-grained sediment from the slope failure was delivered to the river via culverts. VTrans subsequently undertook a major remediation project involving removal of fill that had been placed on the upper part of the slope, installation of soil drains, and an engineered buttress at the base of the slope. The slope is currently believed to be stable.

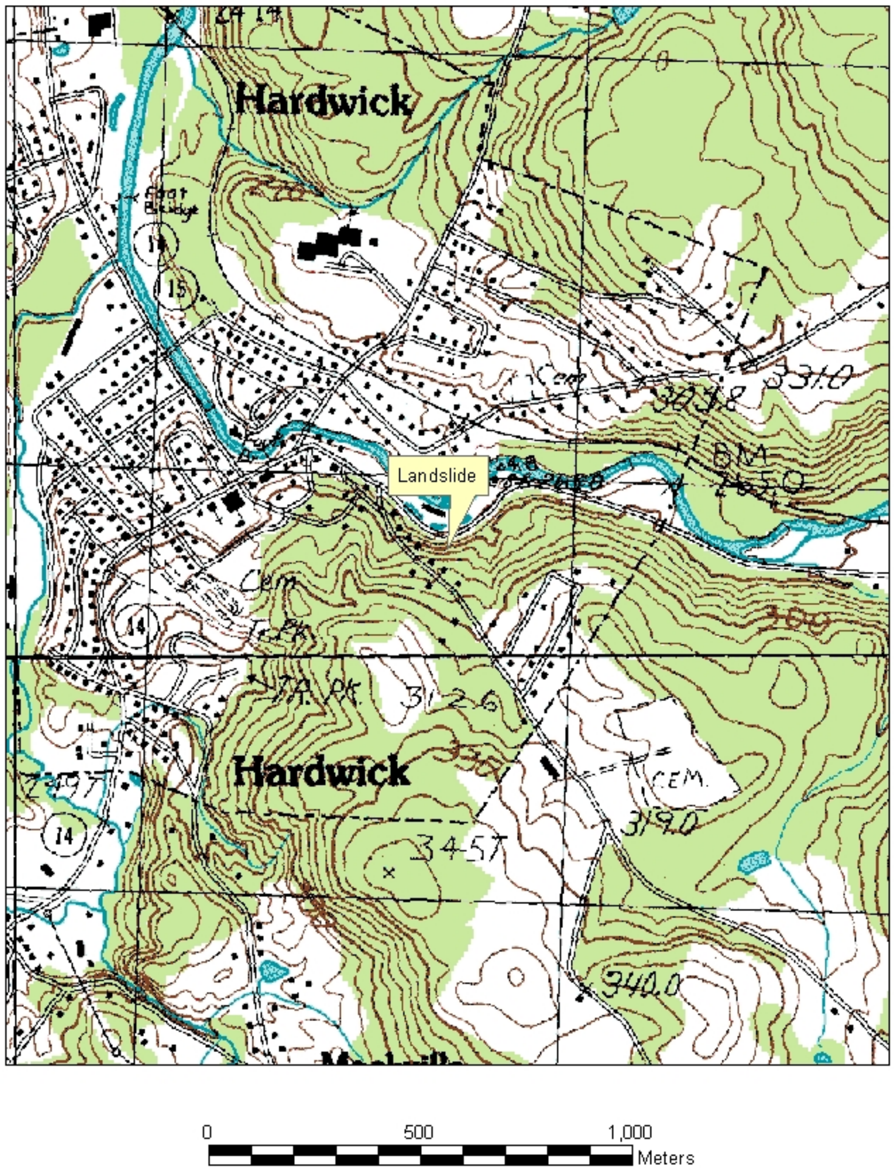

Figure 11. Map showing location of the Hardwick landslide. From U.S. Geological Survey Caspian Lake 7.5 minute quadrangle. Contour interval 6 meters.

Figure 12. Landslide viewed from below. View looking south-southeast from far side of Route 15. November 10, 2003. Photo by George Springston.

Figure 13. Earth flow originating in central part of slide and flowing down to culvert on east side of State Route 15. November 10, 2003. Photo by George Springston.

Figure 14. Site on April 2, 2004, prior to major failure. Note changes from Figure 12. Photo by George Springston.

Figure 15. Site on April 22, 2004, 3 days after a major slope failure occurred. Road has been cleared of landslide deposit. Photo by George Springston.

Figure 16. Site on May 4, 2004. Photo by George Springston.

Figure 17. View looking east along fracture surface in artificial fill at Holmes residence. November 10, 2003. Photo by George Springston.

Figure 18. Uppermost scarp in artificial fill at top of landslide. View looking southwest. November 5, 2003. Photo courtesy of VTrans. Much of this material was subsequently removed by VTrans in order to reduce loading on the slope.

Figure 19. Looking directly down landslide. Note surface of landslide is striated by sliding debris. May 4, 2004. Photo by George Springston.

Figure 20. On the landslide failure surface. The area in the center (to the right of the shovel) has been scraped to reveal the underlying dense glacial till. April 19, 2004. Photo by George Springston.

Figure 21. Looking down the landslide at Route 15 as material is being cleared out of roadside ditch. April 22, 2004. Photo by George Springston.

Rock Slope Failures and Debris Flow Hazards

Rock slope failures and debris flows are two types of landslide that occur on steep, bedrock-dominated terrain in Vermont. Rock slope failures are not included in this inventory. Debris slides and debris flows have not been identified in Caledonia County, but they have been identified in the more mountainous parts of the state, including Smugglers Notch (Springston, 2009).

Patterns of Slope Failure on Till Slopes

Many of the landslides in Caledonia County originate in glacial till deposits. A typical landslide in till is shown in Figure 22. Observations of the landslides here and elsewhere in Vermont suggest the following as a common sequence of events on till-dominated slopes in response to catastrophic flood events (Springston and Thomas, 2018). Note that the events described below will not always take place in a sequence of discrete steps. For example, a translational slide on the upper part of a landslide may be occurring at the same time that the base is being undercut by flood waters. The model is illustrated in Figure 24.

- Fluvial shear results in erosion of the bank and/or bed, over-steepening the slope and, if bed erosion occurs, increasing the effective height of the slope (Figure 23). Dense till and lacustrine diamict typically are detached as irregular blocks. Loose materials typically are detached as single grains. At sites where the material is very strong, the stream may undercut the bank, leaving an overhang. Infiltration of rainfall results in an increase in pore-pressure in the surficial material, reducing the effective shear strength of the material.
- Translational slides occur off the upper slope, commonly carrying blocks of soil and trees, with depths of 1.5 to 5 feet (0.5 to 1.5 meters). Parts of the sliding blocks may break up into flows. A rotational slump may occur in place of or following a shallow translational slide. This type of slope failure is more common in lacustrine or ice-contact or stream terrace deposits than in till, but a few examples of rotational slumps have been observed in dense till deposits that were severely undercut by catastrophic flooding.
- Material reaching the base of the slope may either be swept away by the stream or accumulate to form a toe deposit.
- The water level of the stream recedes, perhaps leading to additional slope failure as the support of the water on the lower face is removed.
- Overhangs begin to fail and translational slides and flows remove material from the upper parts of the landslide.
- With the passage of time, mass-wasting and weathering processes begin to alter the deposits. Material continues to fall, topple, slide, or flow off of the upper slopes. Weathering of the fresh deposits becomes evident after the first winter, with the outer 0.5 to 1 inch (1 to 2.5 cm) of even the densest till beginning to soften. Rills begin to dissect parts of the upper faces and the toe deposits. Even after only a single year, pioneer vegetation such as coltsfoot and horsetails begin to colonize the slopes.

Figure 22. A typical large landslide in till. Site JP602 on Morrill Brook in Danville, Vermont. Note orange pack at base for scale. Photo taken in 2016 by George Springston.

Figure 23. Evidence of fluvial shear at base of landslide shown in Figure 22. A weathered till surface is seen in the upper right. The shovel rests on a fresh till surface exposed due to fluvial shear from a recent high-streamflow event. This corresponds to Stage 2 in Figure 24. Photo taken in 2016 by George Springston.

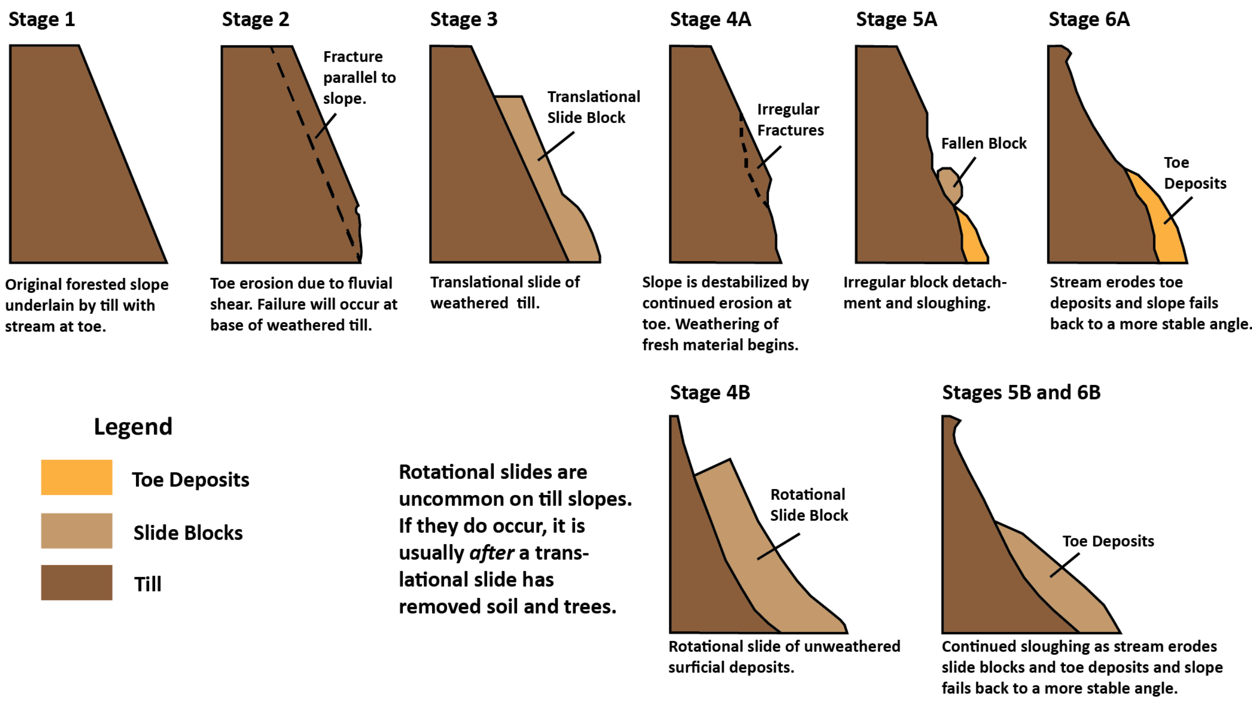

Figure 24. Model for landslides on till slopes originally developed in Springston and Thomas (2018). The initial stages of failure of a wooded streambank by a translational failure are shown in Stages 1 to 3. Stages 4A to 6A show the continued failure of the slope by the detachment of irregular blocks of till. Stages 4B to 6B show an alternate style of rotational failure in till that may occur after heavy stream erosion.

Discussion and Future Work

The present study has identified numerous landslides, unstable gullies, and other features related to unstable slopes in the county. As only limited field works was undertaken, it is undoubtedly only a partial inventory. However, the features included are believed to be representative of the population of unstable slope features in the county.

A review of Plate 1 shows that the greatest concentrations of landslides, landslide-gully complexes, and mass failures are seen along unstable reaches of Calendar Brook in Sheffield and Burke, Stannard Brook in Stannard (and an unnamed tributary to it in Walden), Morrill Brook and Water Andric in Danville, and Peacham Hollow Brook in Peacham and Barnet.

Most of the actively eroding gullies in the county are within the level of glacial Lake Hitchcock and appear to be closely associated with stormwater runoff from roads and developed areas. There is also a scattering along the terraces adjacent to the Connecticut River. Although it is true that the areas where gullies are concentrated are also within the level of glacial Lake Hitchcock, this pattern of unstable gullies in areas of increased road density and population density has been observed in each of the county inventories cited above. In Orange County the population centers were smaller, and thus despite the extensive glaciolacustrine lowlands, the unstable gullies were somewhat limited. By contrast, unstable gullies were common in the more developed portions of Washington County that were within the limits of glacial Lake Winooski and widespread within the erodible deposits of glacial Lake Vermont and the Champlain Sea in Chittenden County.

This inventory of slopes that are presently unstable can be the basis for producing a model of potentially unstable slopes within the county. An important step toward this was made by Carlson (2021) who produced GIS models of potentially unstable slopes in the study area. Carlson worked on a Senior project at Norwich University (mentored by the present author and Dr. John Gartner) to analyze a variety of landslide characteristics and environmental variables for known landslides in eastern Vermont (808 sites) and then used the results to develop weighted overlay models in GIS for Caledonia County. The final variables chosen by Carlson were proximity to streams, slope, presence of highly erodible soils, distribution of bedrock outcrops, and land cover. The resulting maps show a good correlation between known landslides and the areas predicted to be unstable (Figure 25). The new data produced during this Caledonia County inventory can now be added to that available to Carlson and will be used to create a refined landslide susceptibility map that should result in even better agreement between the model and reality.

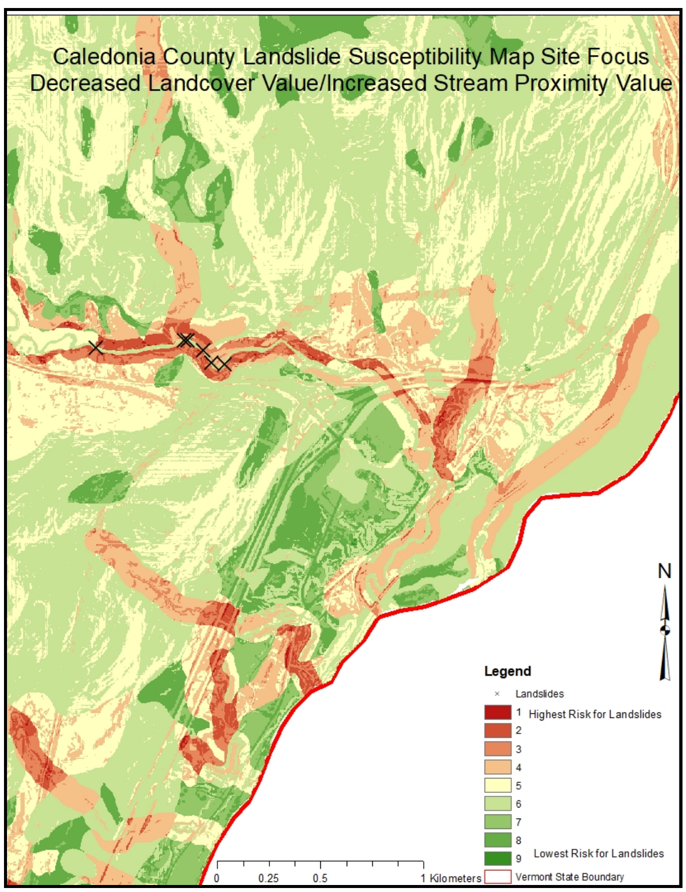

Figure 25. Portion of final landslide susceptibility map from Carlson (2021). Red areas have highest susceptibility and green areas have lowest. Black X symbols indicate known landslides.

The work on the landslide susceptibility map with Jack Carlson identified an important future data requirement: Most of the known landslides currently exist only as point locations in the landslide database. This limits the types of geographical queries that can be undertaken. If future studies can develop polygons for even a modest number of typical landslides in eastern Vermont (say 200-300), then there will be a much richer set of geographic data available for input into landslide susceptibility models.

Conclusions

This study identifies over 300 unstable slope features in Caledonia County. The maps are sufficiently accurate to help landowners and planners consider slope instability hazards.

As in the recent studies in Washington, Chittenden, and Orange counties (Springston 2017, 2018, 2019), the current lidar topographic data was successfully used to produce an accurate and cost-effective landslide inventory.

As shown by Springston (2017, 2018, 2019), and Springston and Thomas (2014, 2018), most of the landslides are located on steep slopes close to streams at sites of active streambank toe erosion. When long-term data is available, the landslides are generally in locations that have been failing for a long time (Springston and others, 2012; Dethier and others, 2016). Thus, by mapping the locations of present landslides we are identifying sites that are likely to fail in the future.

Most of the actively eroding gullies in the county are within the level of glacial Lake Hitchcock and appear to be closely associated with stormwater runoff from roads and developed areas. There is also a scattering of unstable gullies along the terraces adjacent to the Connecticut River.

The principal causes of the slope failures appear to be the over-steepening of slopes due to fluvial erosion of banks and stream beds during floods and decreases in shear strength of soils due to increases in soil water pore pressures due to the heavy rainfall.

The detailed (Phase 2) stream geomorphic data from the Vermont Rivers Program is critical to understanding the patterns of stream channel adjustment that are underway in the river corridors. The mass failure locations the river studies compared very well with site location from geologic field work and from lidar. It would be highly desirable to have similar Phase 2 data available for the streams in any areas where landslide mapping is to be undertaken.

Acknowledgements

Support for this work was provided by the Vermont Geological Survey through a series of contracts and grants running from 1999 to the present. Funding was largely from the Emergency Management Division of the Vermont Department of Public Safety.

Thanks to Jack Carlson and Dr. John Gartner for many stimulating discussions on landslides in general and those in Caledonia County in particular. I think we all learned a lot together.

Geologist Julia Boyles of the Vermont Geological Survey has played a critical role in managing the landslide data as it is produced and coordinating file exchanges with the Landslide Inventory Geoform (available at https://vtanr.maps.arcgis.com/apps/GeoForm/index.html?appid=505af0d19dd44faaa912ef3d5c80a3b6).

I extend my deep appreciation to Acting State Geologist Jonathan Kim and former State Geologists Marjorie Gale and Laurence Becker for their consistent and enthusiastic funding over many years for the landslide inventory work.

This work would also not be possible without the far-sighted work of the current and former staff of the Vermont Rivers Program, until recently headed by Mike Kline. Special thanks go to Mike, Barry Cahoon, Shayne Jaquith, Sacha Pealer, Staci Pomeroy, and Gretchen Alexander.

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