

“Ripple Effects 2026 – When Hillsides Move”

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Vermont Geological Survey
(VGS)

September 9, 2026



Photo Credit: J.
Kim

The Vermont Geological Survey

Ben DeJong, PhD



Jon Kim, PhD



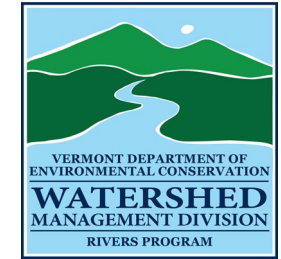
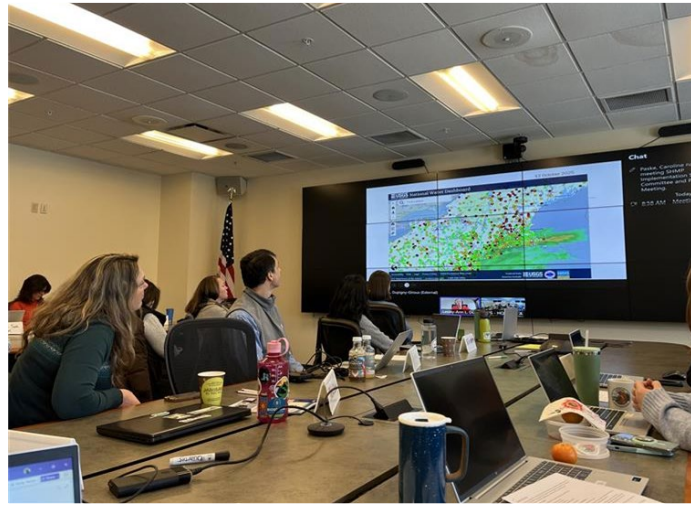
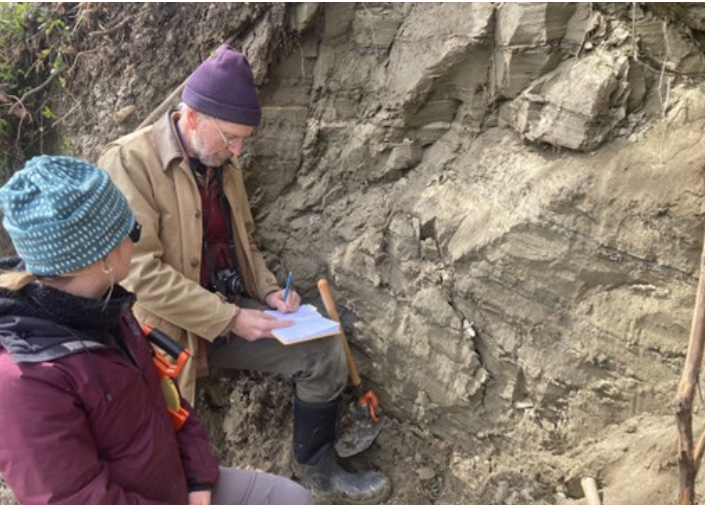
Emma Myrick, MS



Cora Deininger,
BS



...And our partners!



Middlebury



The VGS and landslide-related engagement

- **Field-based evaluations**
 - Emergency response & isolated inquiries
 - Guide mitigation planning or support governmental assistance applications
- **Statewide mapping and modeling**
 - LiDAR-based inventory
 - Slope failure susceptibility modeling
- **Outreach and Education**
 - Plain-language resources
 - Engagement with academic, state and community partners

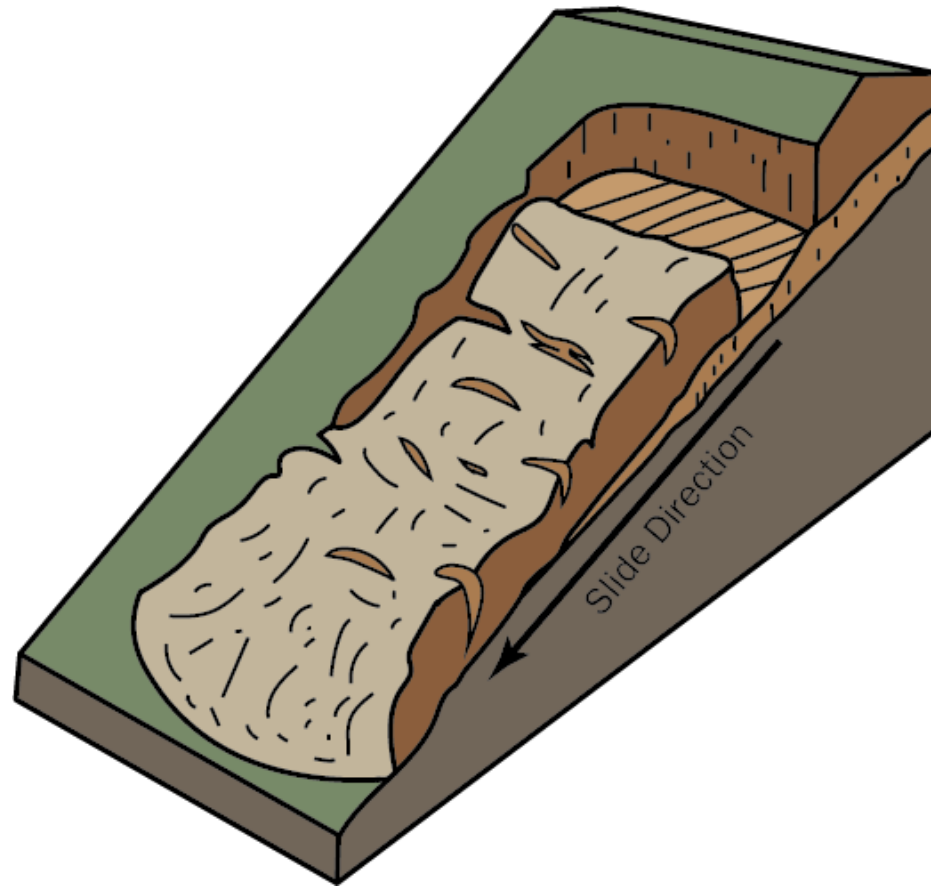


What is a landslide?

- The term “landslide” is broad and encompasses a range of slope failure mechanisms and rates of movement
- BUT..landslides can be complex and there are a variety of influences responsible for the conditions needed for a landslide to occur
 - Topography
 - Geology
 - Hydrology/Hydrography
 - Weather & Climate

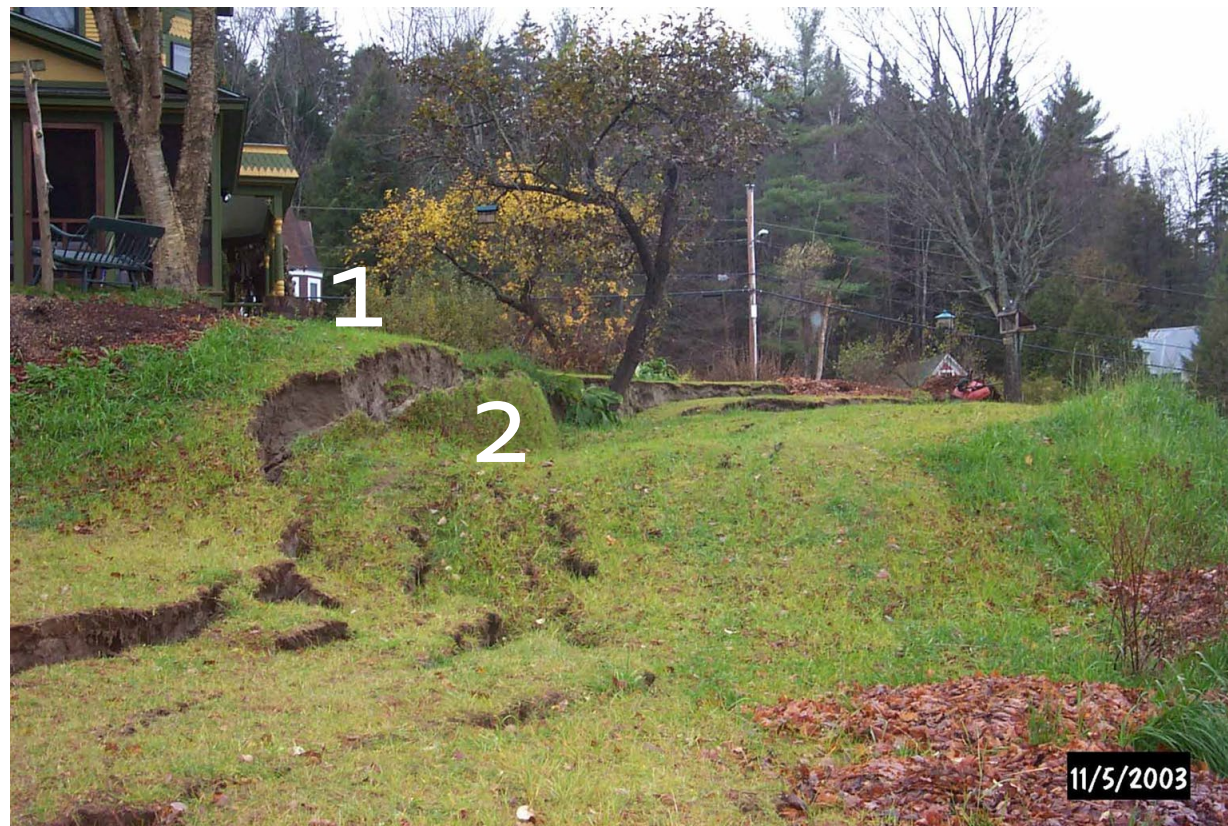
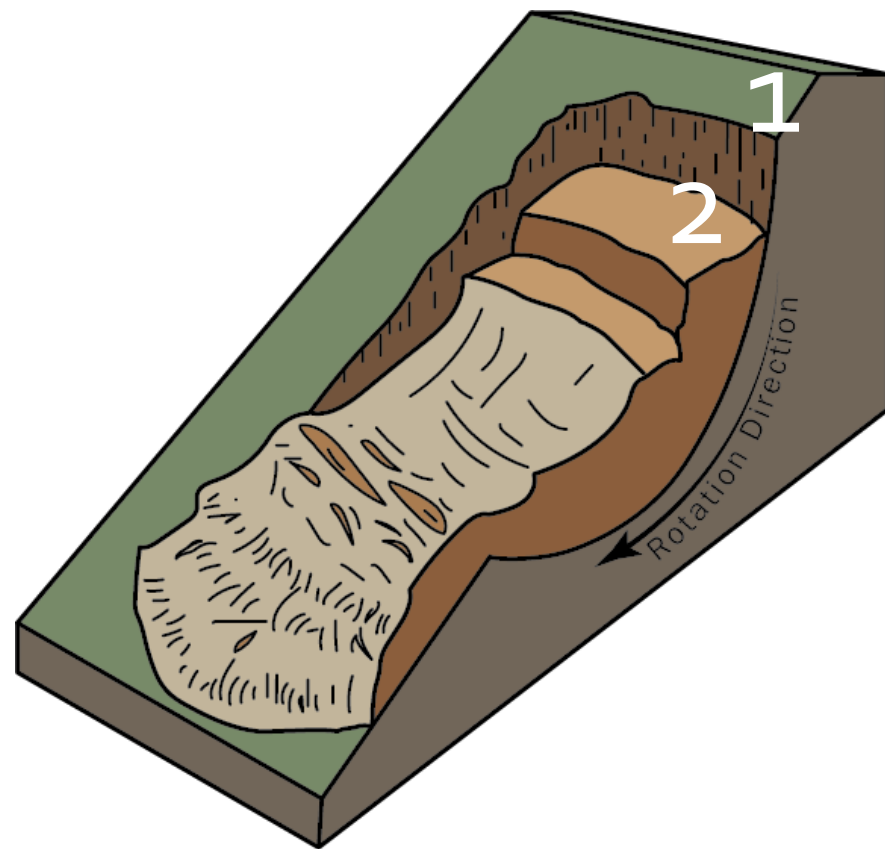


Translational Movement



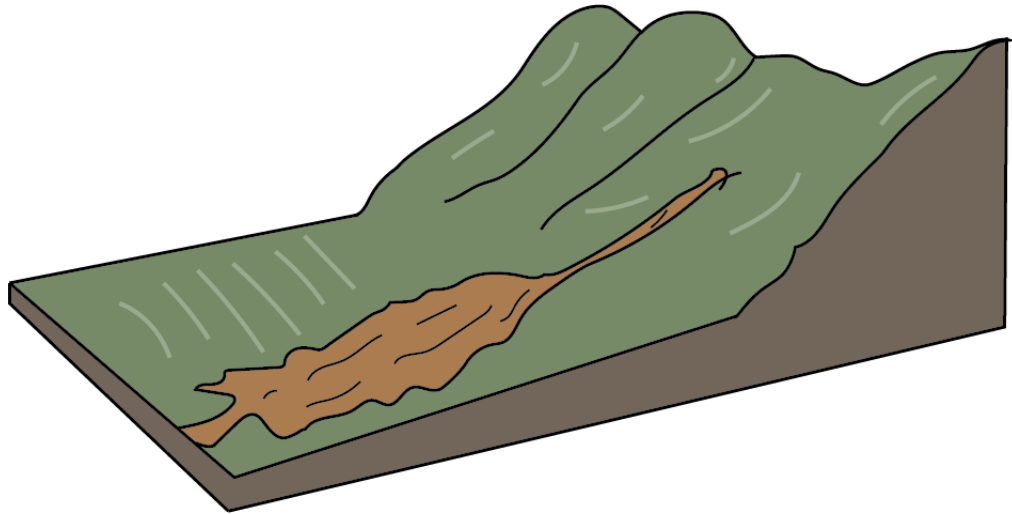
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Rotational Movement

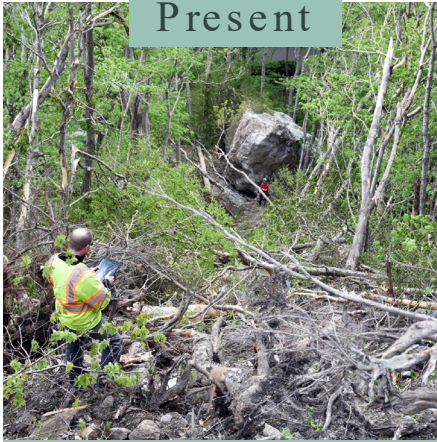


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Earth/Debris Flows

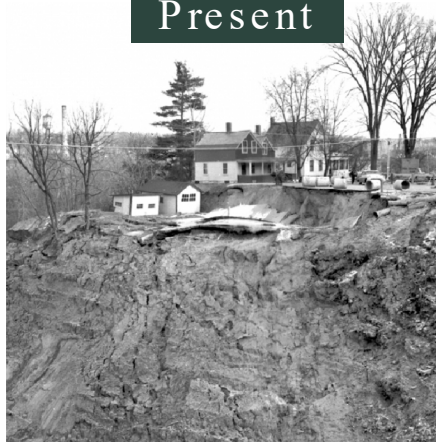


~1925 -
Present



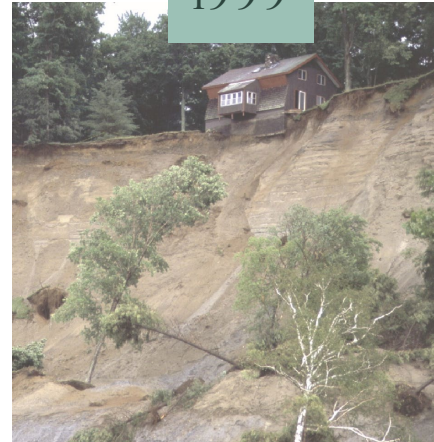
Smuggler's Notch, Mt.
Mansfield/Cambridge, VT

~1955 -
Present



Burlington, VT

1999



Jeffersonville, VT

2011



Tropical Storm Irene triggered
landslides throughout state

2019



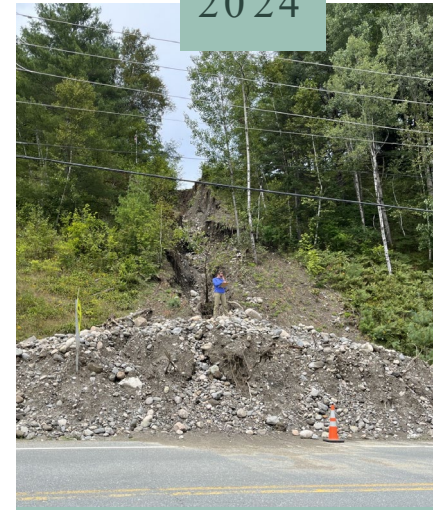
Cotton Brook Landslide,
Waterbury, VT

2023



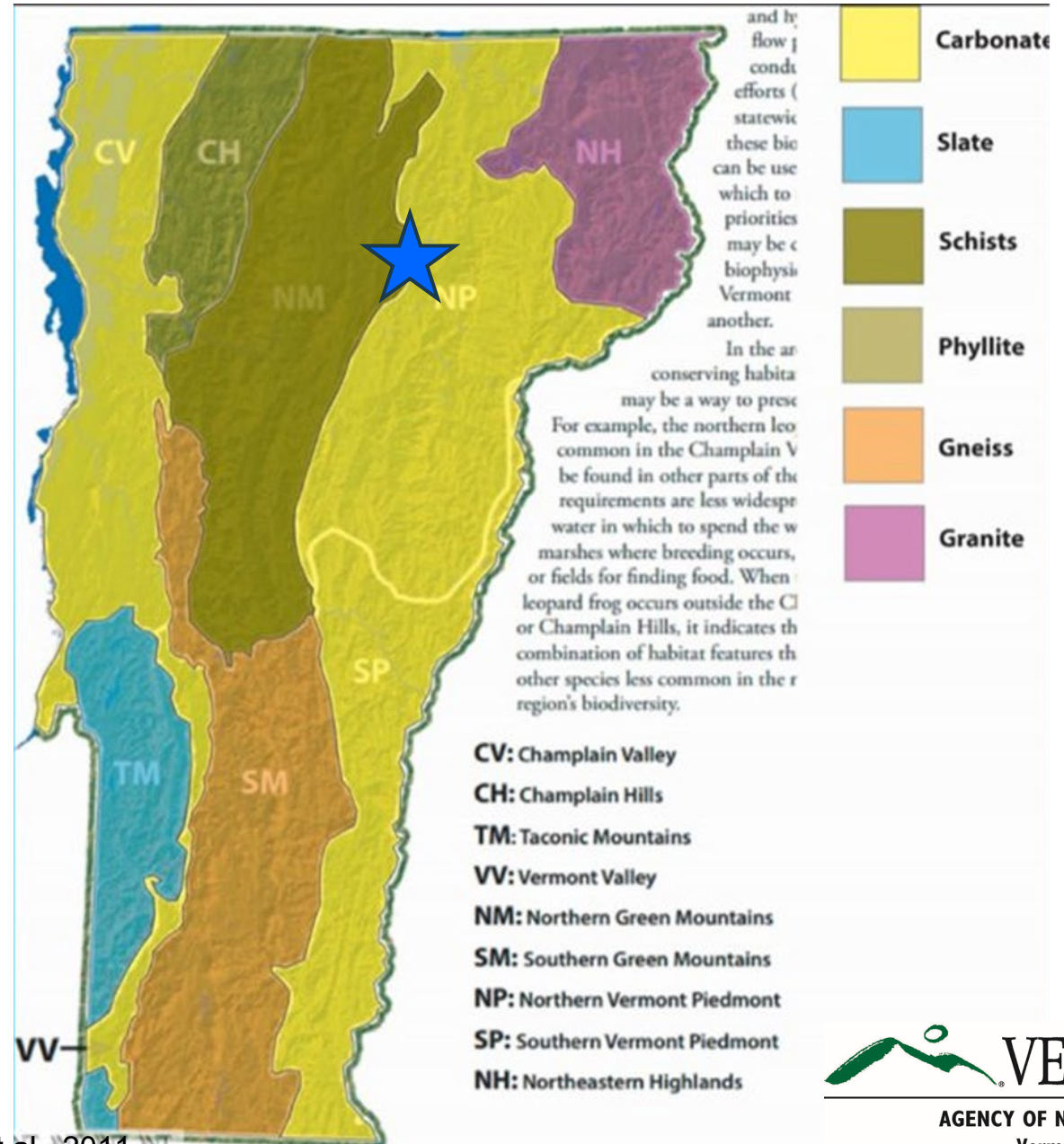
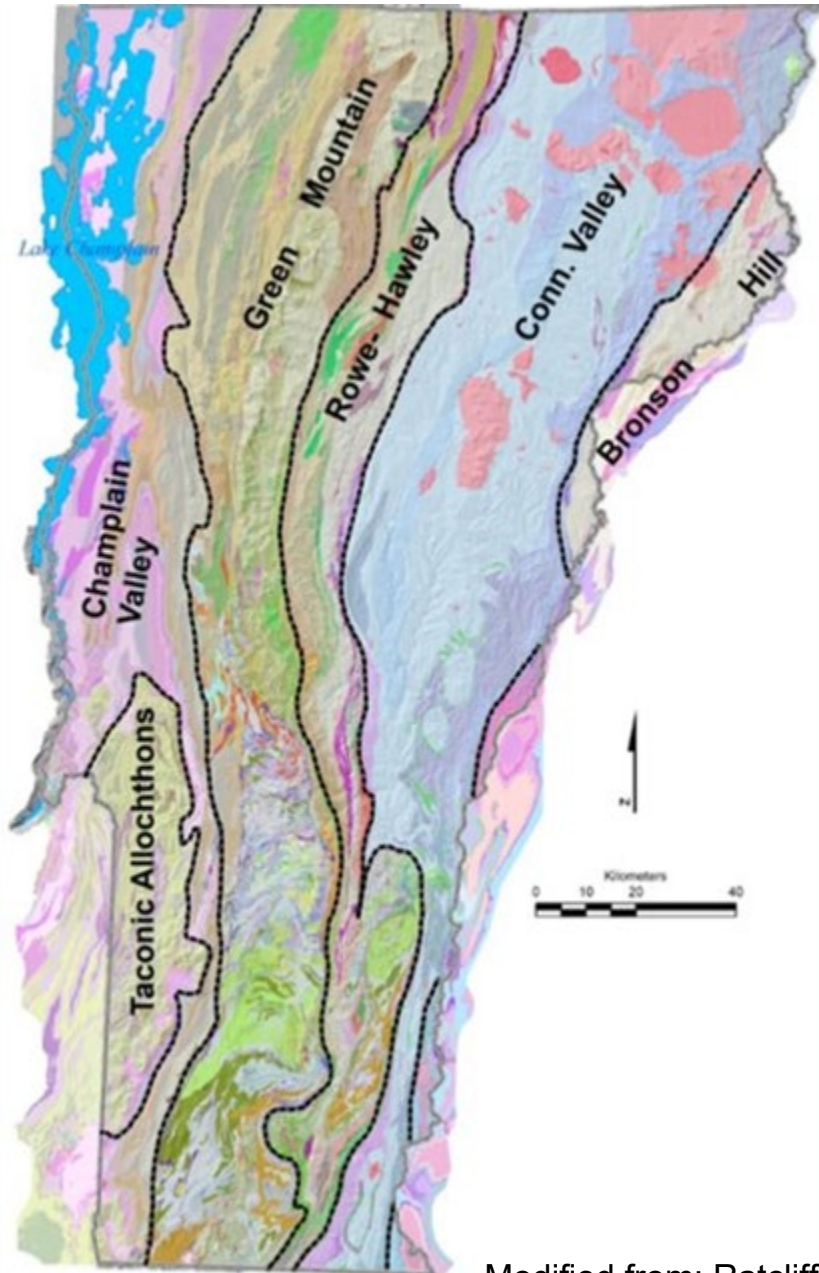
Extreme flooding event
triggered landslides
across VT

2024



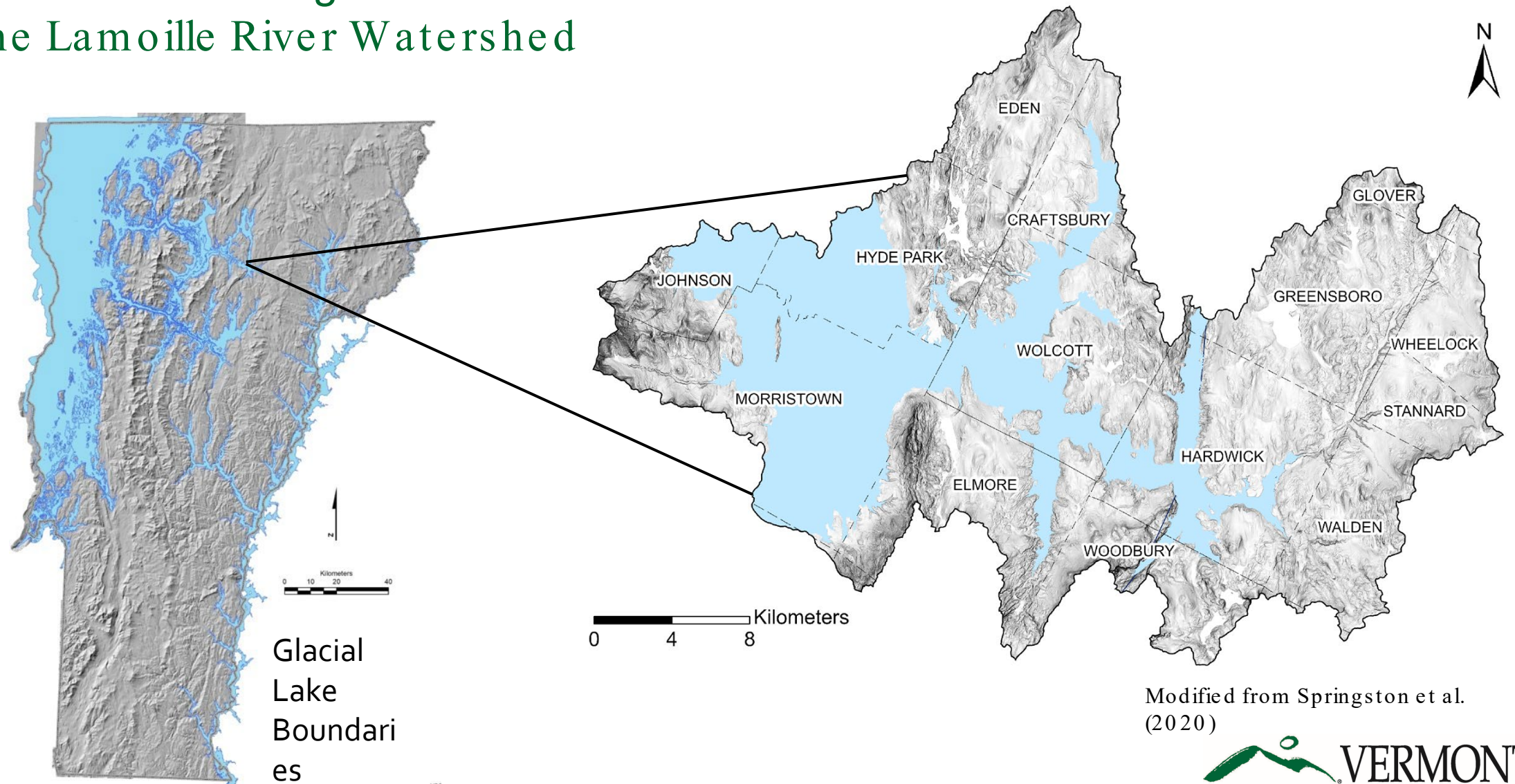
Extreme flooding event
triggered landslides across
central and northeastern, VT

*Full image sources in
presentation notes



Modified from: Ratcliffe et al., 2011

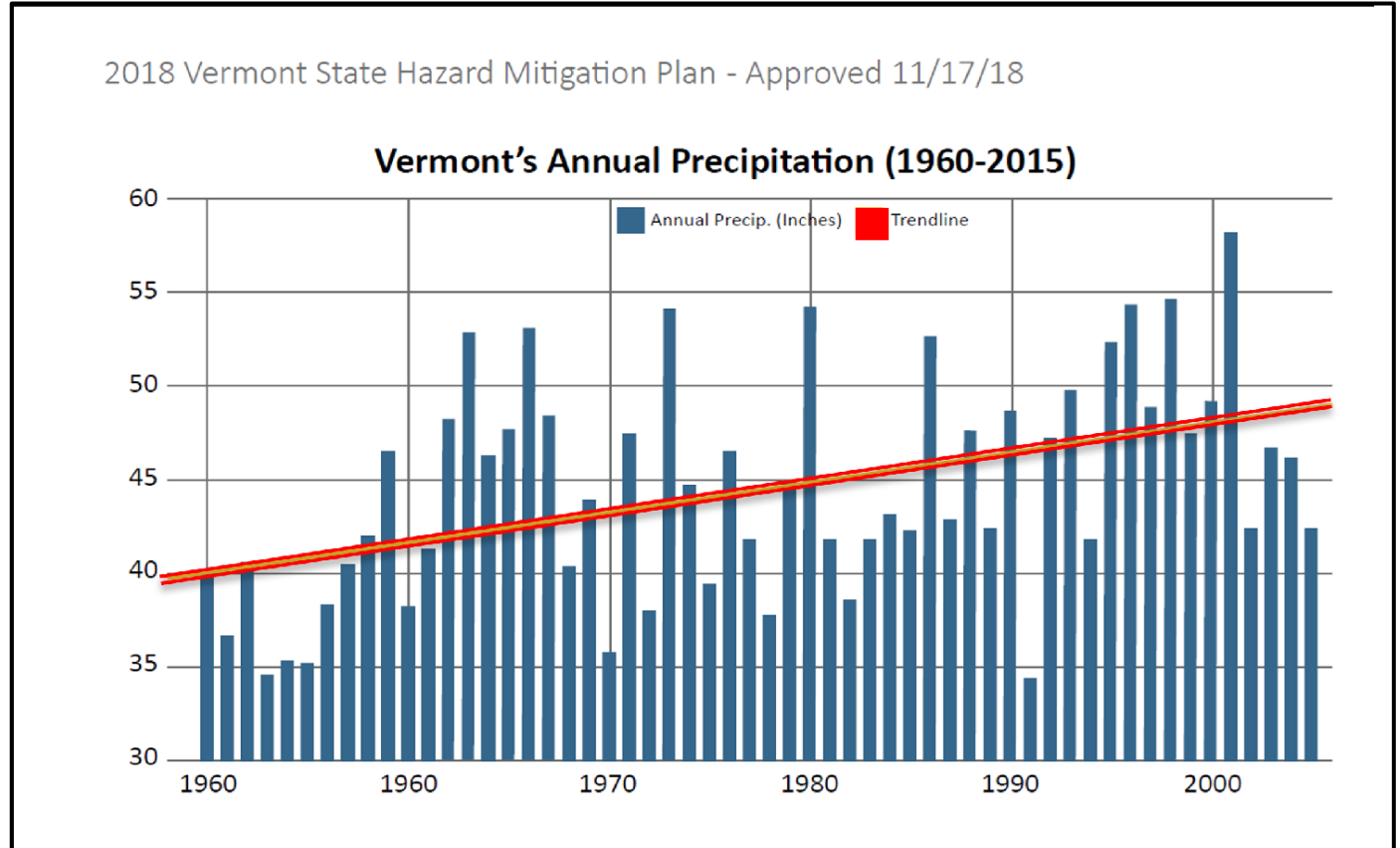
Glacial Lake Coverage in the Headwaters of the Lamoille River Watershed



Modified from Springston et al.
(2020)

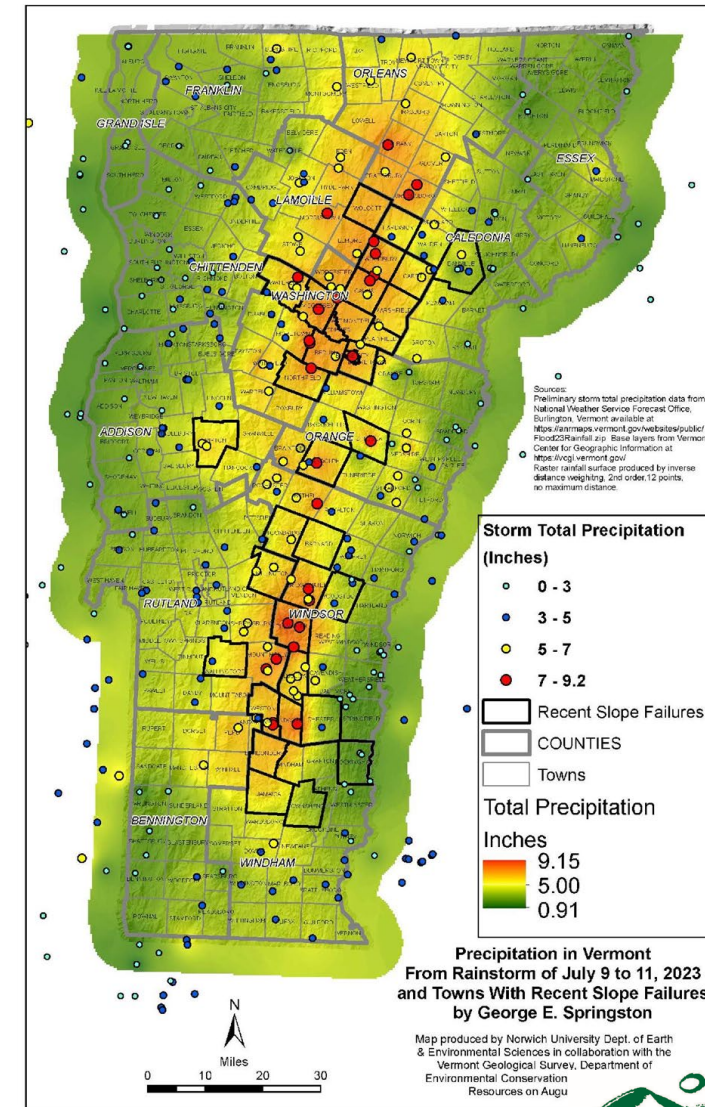
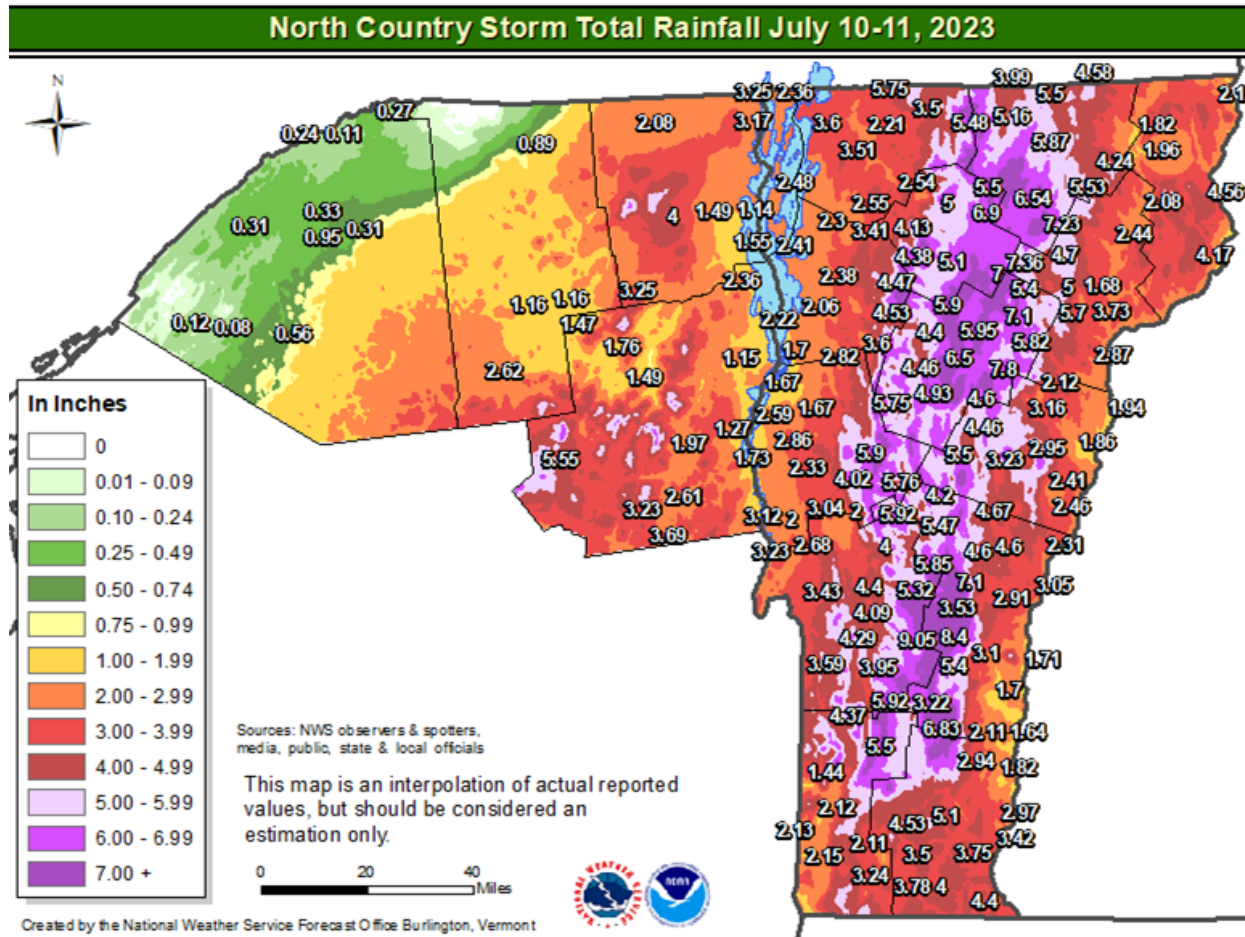
The influence of weather and climate

- Data indicate a warmer and wetter Vermont
 - average annual precipitation has increased by 21% or 7.5 inches since 1900 (Galford et al., 2021)
 - Average annual temperature has increased by almost 2°F since 1900 – winter temperatures are changing more rapidly when compared with other seasons (Galford et al., 2021)

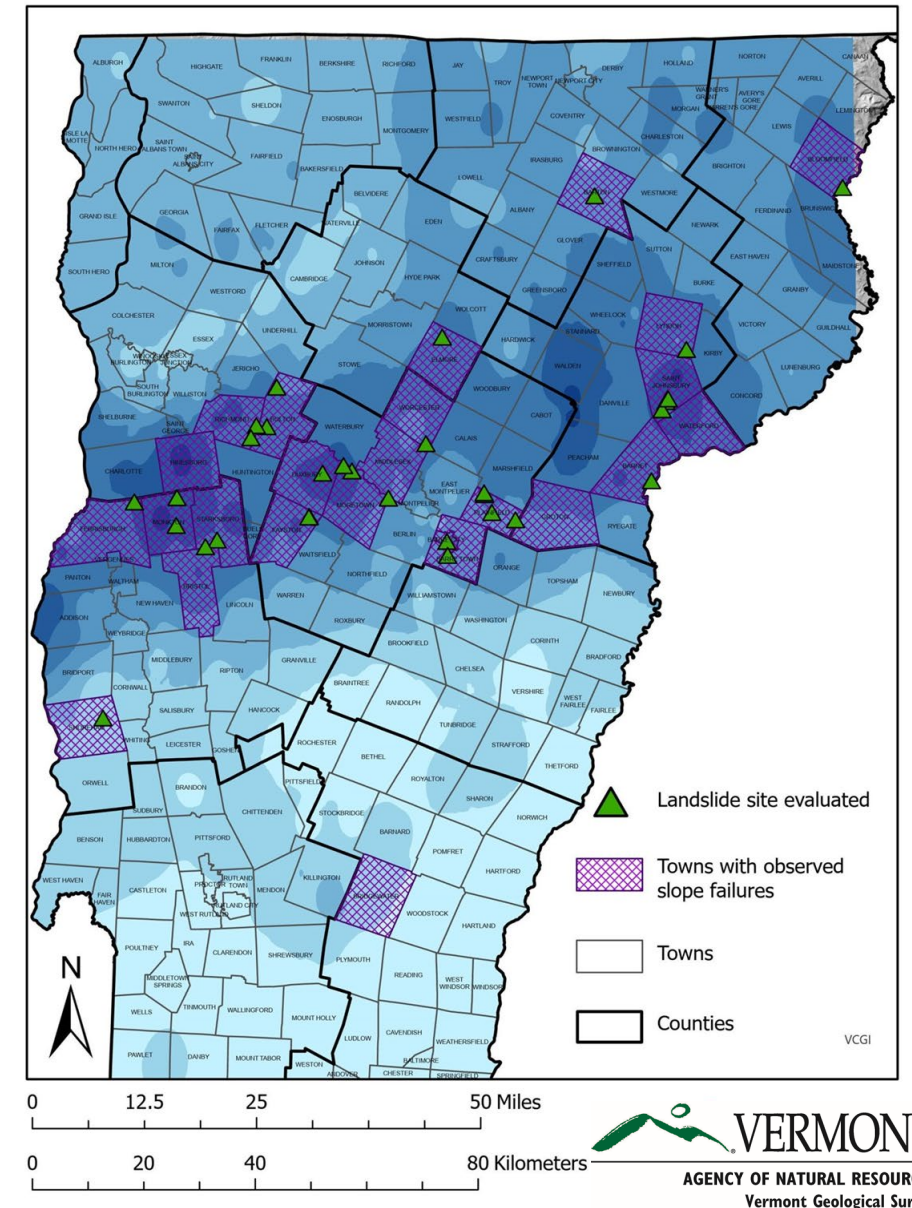
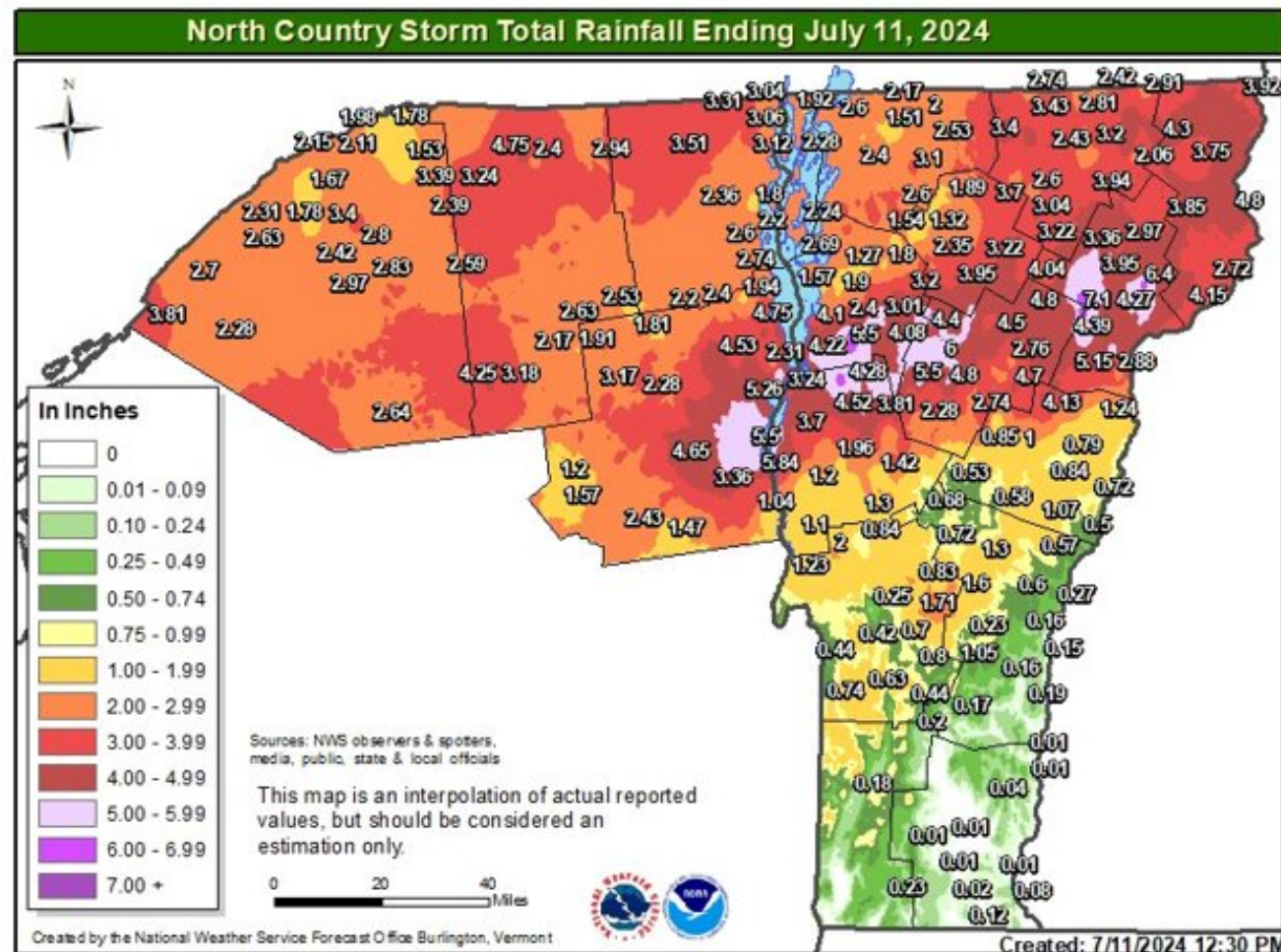


Source:
climatechange.vermont.gov

Extreme precipitation and landslide response – July 2022



Extreme precipitation and landslide response – July 2024



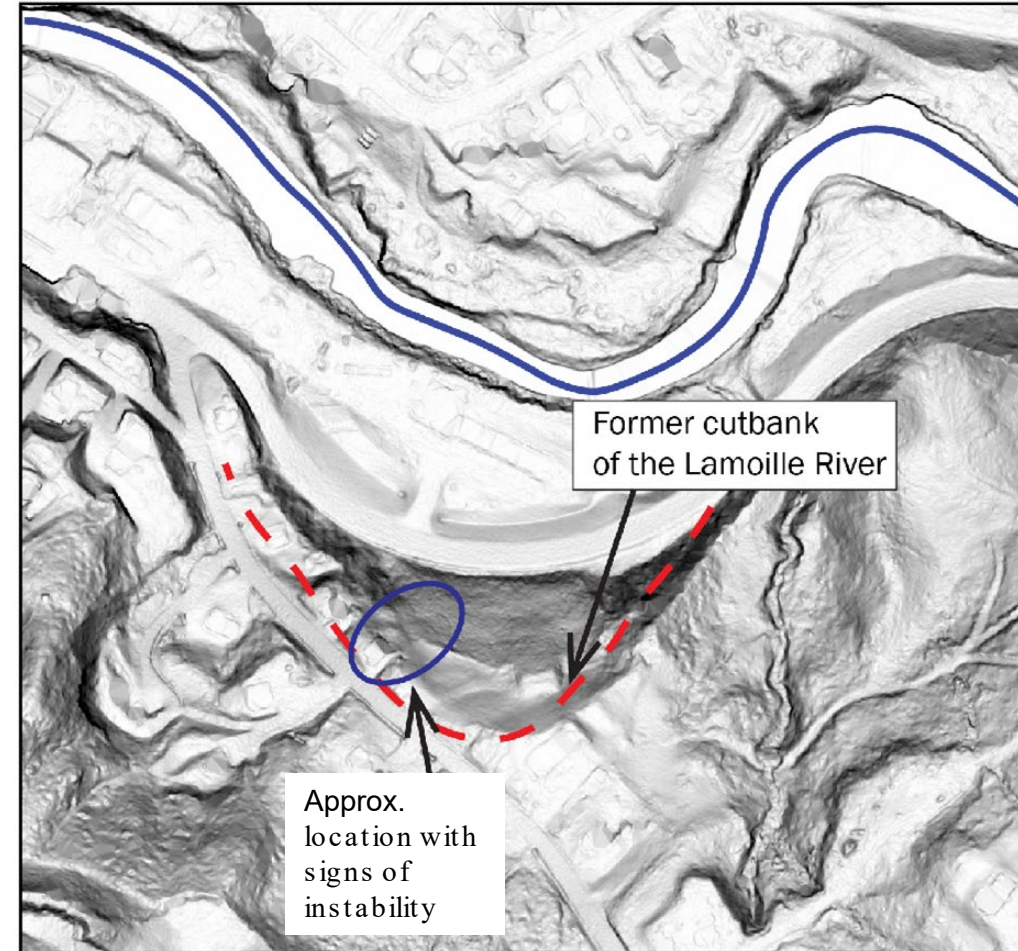
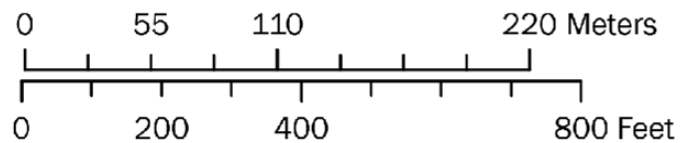
Hardwick Case Study

- Significant earth flow and rotational landslide events between November 2003 and April 2004
- Slope material is predominantly glacial till with a silt-rich matrix containing clasts ranging in size from pebbles to boulders
- Site demonstrated a variety of mechanisms of failure and risk factors at the time of 2003/2004 failure
- Extensive mitigation work by VTrans included the installation soil drains and removal of artificial fill observed at the crest of the slope

Springston (2021)



Photo by: George Springston



April 2004



Photograph by: Vermont
AOT

June 2026



Photograph by:
VGS

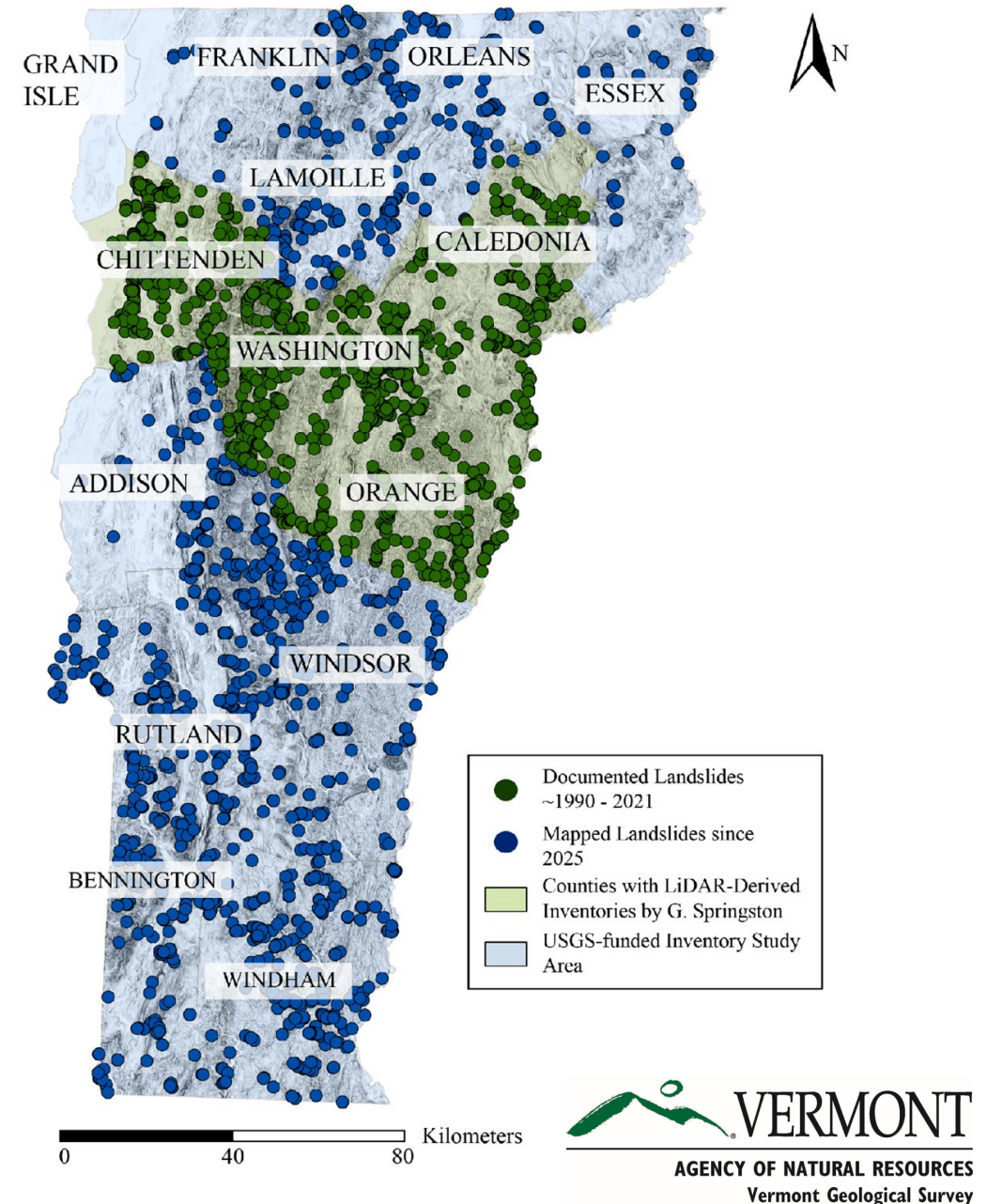
Updates to landslide information around Vermont

CURRENTLY...

- The VGS maintains a publicly available point-based dataset which includes:
 - LiDAR-based mapping in 4 counties (green)
 - Mass failures recorded during stream geomorphic assessments
 - Features identified during surficial geologic mapping
 - Select reported features and storm response locations

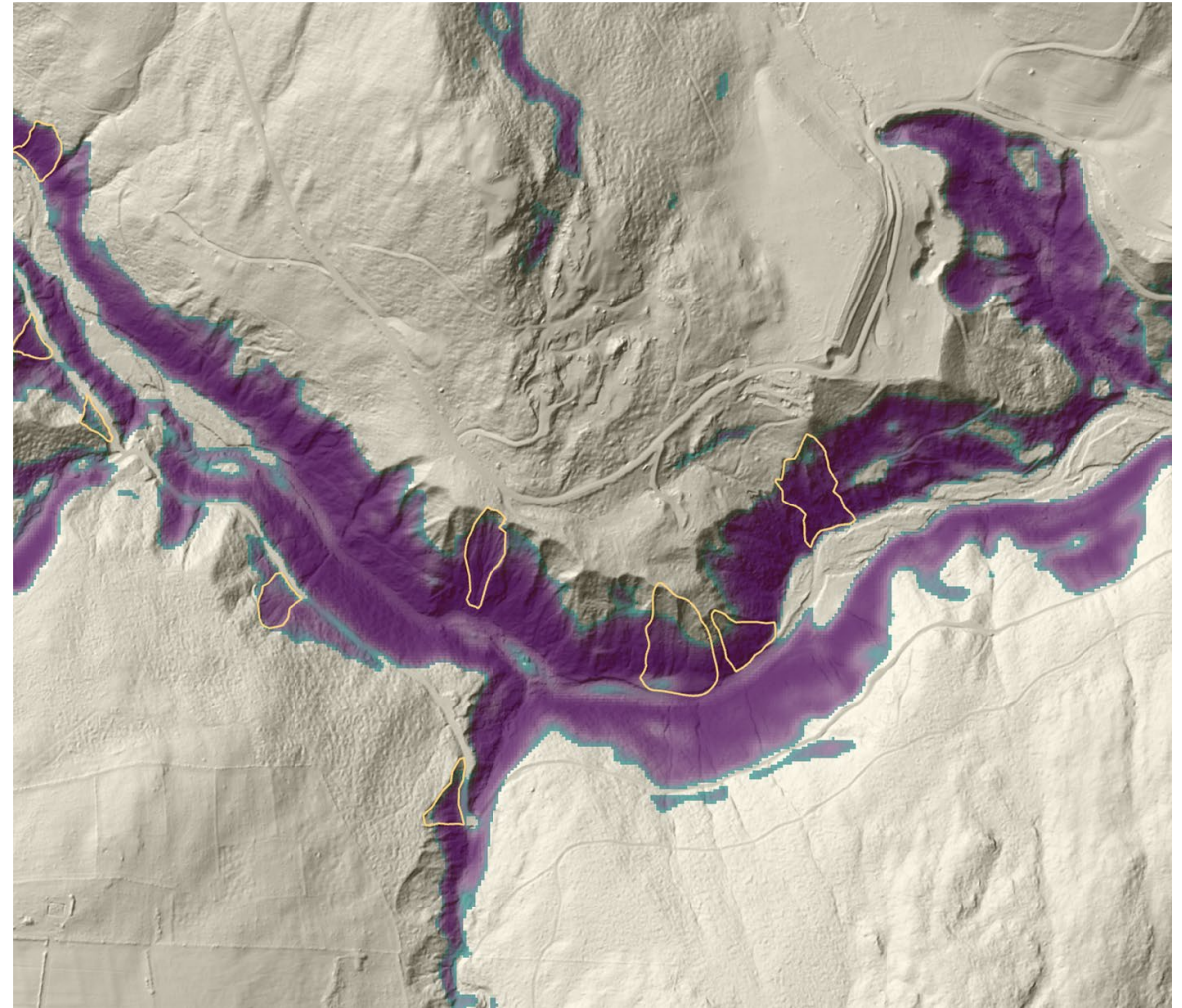
COMING SOON...

- We have expanded the spatial coverage to include 10 counties lacking systematic mapping (blue)
 - Funded by United States Geological Survey (USGS) Landslide Hazards Program
 - Leveraging 2023 statewide LiDAR



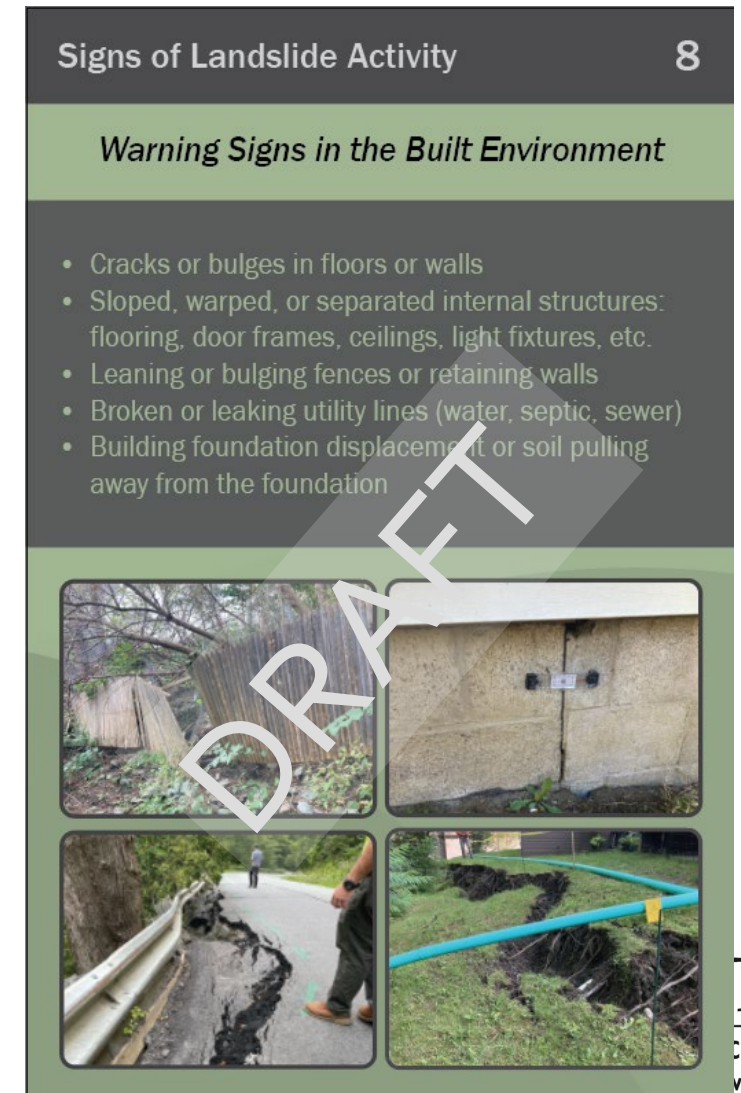
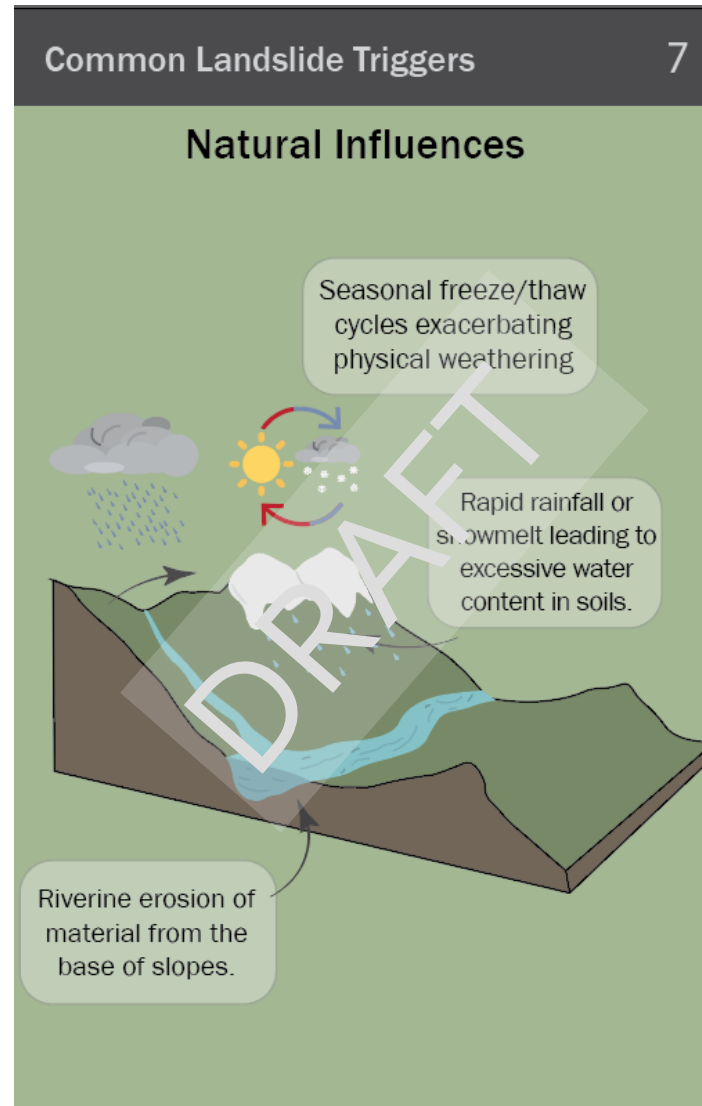
Landslide susceptibility analyses

- Funded by FEMA-BRIC Program in collaboration with landslide experts at Norwich University, the Vermont Center for Geographical Information and Vermont Emergency Management
- Informed by ongoing inventory mapping and incorporates geologic, topographic, hydrologic, and land use data as possible predictors of landslide occurrence
- Tool to inform 2028 State Hazard Mitigation Plan
- Provides opportunity to connect with interested parties about data accessibility and intended use



Preliminary results of model
developed by G. Springston and J.
VanHoesen

Improving emergency preparedness & landslide education





QUESTIONS?

2022 NOAA Climate Summary for VT

Key Message 1: Temps have risen 3 degrees F since the beginning of the 20th century

Key Message 2: Annual average precip has increased nearly 6" since 1960s

KEY MESSAGE 3

Extreme weather events, particularly floods and severe storms, are having a stronger impact on Vermont. At the same time, multiyear meteorological and hydrological droughts continue to pose challenges for water-dependent sectors. Extreme rainfall events are projected to become more frequent and intense in the future.

