# Federal Advisory Committee on Landslides

## April 1st–2nd, 2025

# Engagement Considerations

- Raise your hand (in person and online)
- State your name and organization before speaking
- Virtual attendees—feel free to keep cameras on
- Meeting notes will be shared publicly

# Welcome and Introductions

Godt

(3) RECOMMENDATIONS.—

(A) IN GENERAL.—The Advisory Committee shall submit to the Committee recommendations for the implementation of the program, including recommendations regarding—

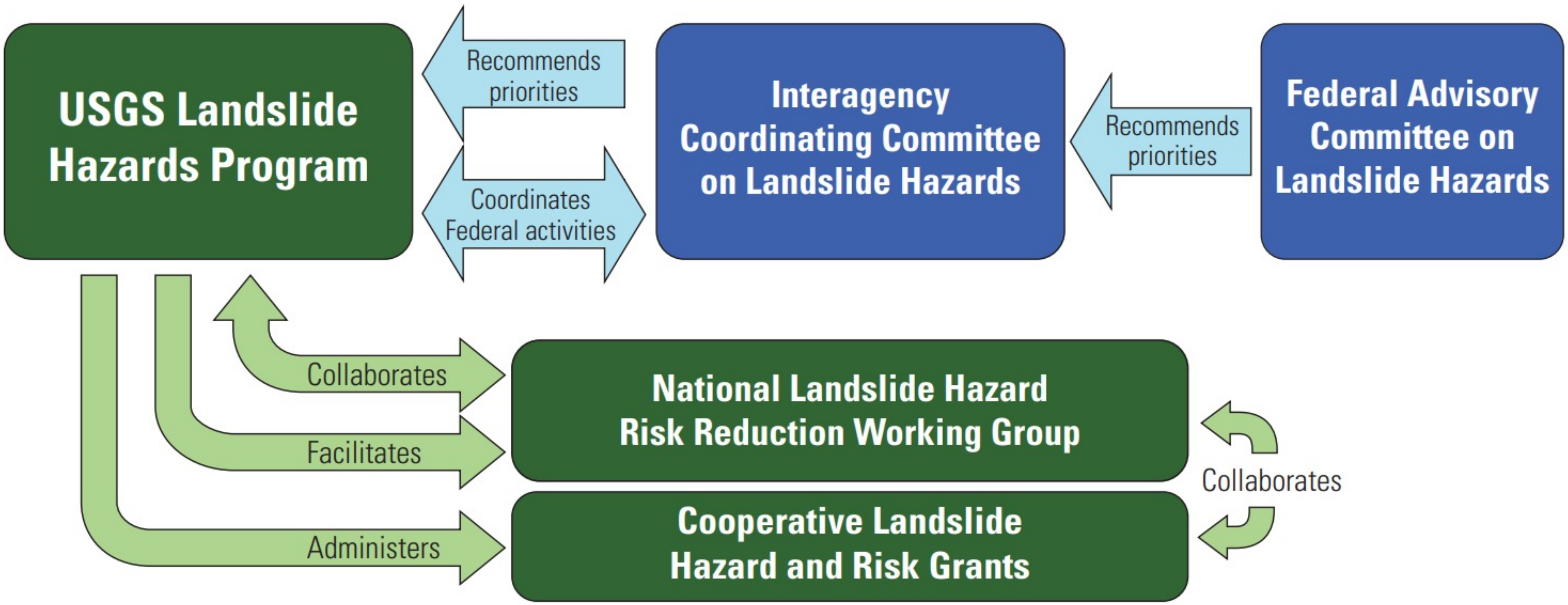
(i) landslide hazard and risk reduction and planning;

(ii) tools for communities;

(iii) research; and

(iv) such other topics as the Advisory Committee determines appropriate.

**Goal 2 –** Coordinate landslide hazard mitigation, preparedness, response, and recovery efforts



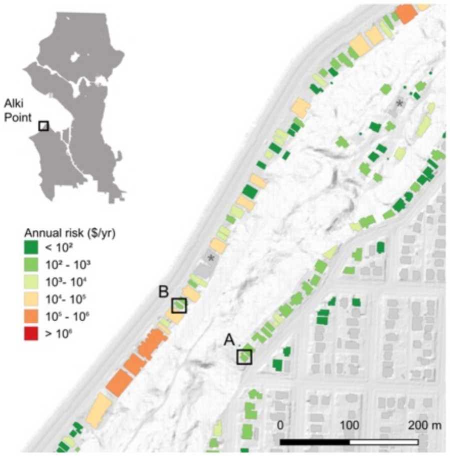
# Member Introductions

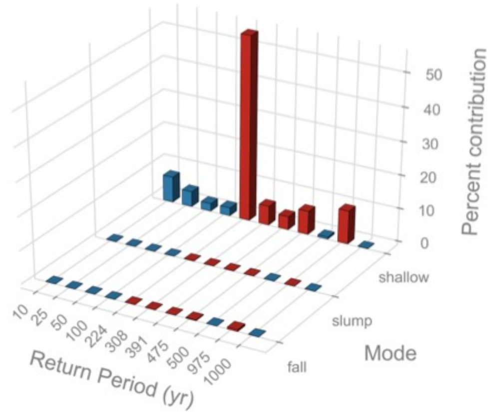
All

# Joe Wartman
# University of Washington

PROFESSOR OF CIVIL ENGINEERING; AND DIRECTOR, RAPID FACILITY

5 YEARS IN PROFESSIONAL PRACTICE + 20 YEARS IN ACADEMIA




Research on regional-scale landslide hazard and risk assessment

The RAPID Facility enables transformative research by providing investigators with the instrumentation, software, and support needed to collect, process, and analyze perishable data from natural hazard events and from disasters.


# Landslide and Hazard Experience

- Teach the graduate-level course “Landslides and Slope Stability” at the University of Washington

- Advise federal, state, and local government officials, non-governmental and non-profit organizations, and public authorities; additional geotechnical consulting experience.

- Conduct research on a range of topics related to landslides

# Work with the USGS

- USGS research program grantee (NEHRP)
- USGS panel reviews
- Interacted with USGS on major landslides events

# Why Advisory Committee on Landslides?

- Contributed to and helped shape landslide bill (via Rep. S. DelBene and Senator P. Murry; WA)
- Solicited professional society endorsements of Bill (AGU, ASCE, EERI)
- …. I strongly believe in the tenets of the Landslide Act!

# Gabriel Taylor
# Washington State Department of Transportation

ASSISTANT STATE ENGINEERING GEOLOGIST

AT WSDOT SINCE 2005, IN THIS ROLE SINCE 2018

# My work

**Emergency Response**

Answer the phone at all hours and respond rapidly to transportation-related geohazards. Most emergency responses are for winter-related landslides, rockfall, debris flows, and erosion.

Conduct geologic reconnaissance and evaluate risks to public and infrastructure. Provide immediate short-term recommendations (closures, barriers, repairs) and generally follow up with long-term recommendations. Documentation.

**Geotechnical design**

Programmed and emergency projects typically include geotechnical design for slope stabilization, earthwork, and fish passage.

Most projects include desk study, subsurface investigation, geotechnical design, documentation, development of contract plans and specifications, and construction support.

**Inventorying and Monitoring**

Maintain a statewide inventory of unstable slopes (USMS) and implement monitoring systems where necessary and possible.

**Research**

Some State and/or Federally funded research (i.e., aggregate mapping, hydraulic scour, stabilization systems, InSAR)

**Management**

Manage and develop a small team of engineering geologists.

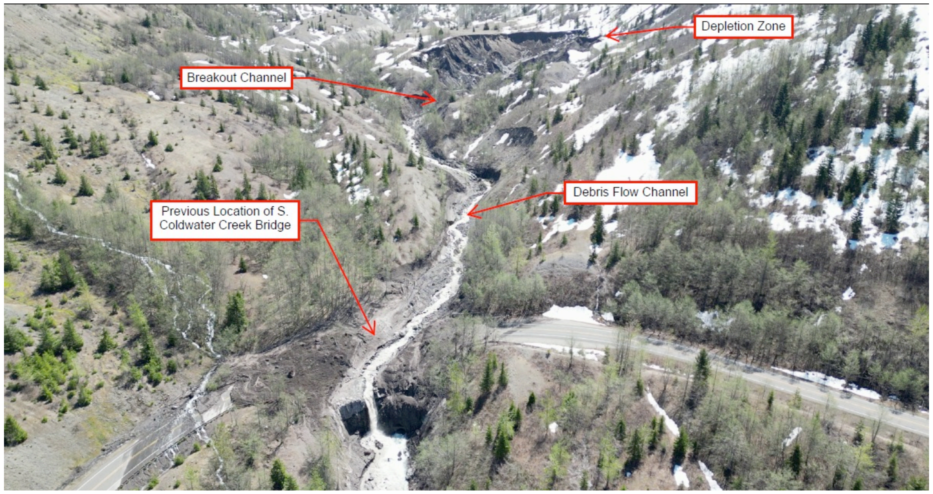
# Landslide and Hazard Experience

- **Field work:** Emergency response, mapping, characterization, data collection, sampling, drilling, instrumentation, monitoring, boots in the mud!
- **Analysis:** Laboratory testing, materials characterization, cross-sections, 3D modeling, limit-equilibrium analysis
- **Construction**: verification of conditions, field adjustments, documentation.

# Work with the USGS

Just a little…

- Some interaction with CVO during the 2023 SR 504 South Coldwater Creek Debris Flow




and

- We were recently awarded a USGS Landslide Hazard grant to study some landslide-prone corridors in Washington State with InSAR

# Why Advisory Committee on Landslides?

I am excited to contribute my applied engineering geology background to the Committee.

I represent a State Agency and can share my thoughts on capabilities and resources of similar agencies.

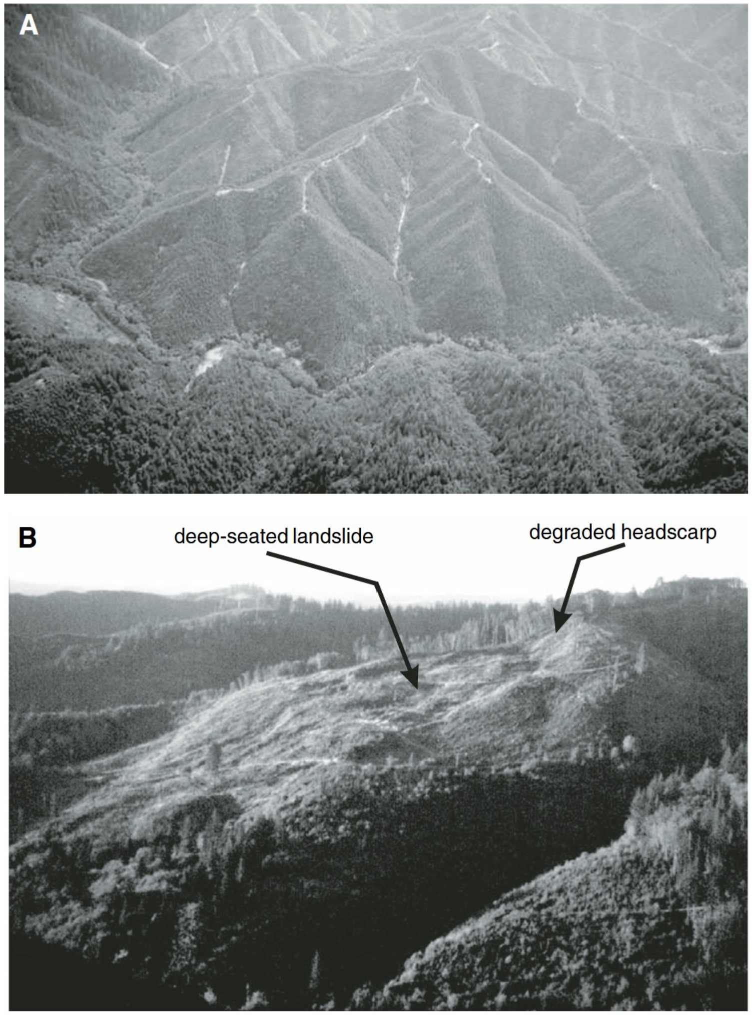
I hope to learn about new monitoring and mapping technology and the development of landslide-related policy from the experience.

I am honored to be here!

Josh Roering
University of Oregon

PROFESSOR

25 YEARS



# My Work

1. **Research**: geomorphology, landscape evolution, hillslope processes, landslides, geomorphic controls on soil organic carbon
   - ***Research tools*****:** field observations and sensors, computer simulations, analog experiments, topographic analysis, remote sensing
   - ***Field areas:*** Western Oregon, SE Alaska, New Zealand, Northern California, Taiwan
   - ***Funding***: NSF, NASA, USGS, Oregon Dept of Transportation, Binational Science Foundation (Israel)
2. **Teaching**:
   - Environmental Geology, Hillslope Geomorphology, Tectonic Geomorphology
   - Earth & Environmental Data Analysis, Field Methods in Geology
3. **Service** *(*current)*:
   - *Independent Research & Science Team (Oregon Private Forest Accord), UNAVCO Board of Directors, NSF EAR Committee of Visitors
   - *Sponsored Research Advisory Committee, Department Head

# Landslide and Hazard Experience

How does **your research group** interact with landslides, landslide hazards, or other natural hazards in your professional capacity?

- Perform basic research on geomorphic and landslide processes in an array of landslide-prone settings
  - 1996 (Western Oregon): Forestry impacts on debris flow initiation following storms and fatal slides
  - 2010 (California, New Zealand): Mechanics and kinematics of slow-moving landslides
  - 2020 (Cascadia): Chronology of landslide-dammed lakes to decipher climate and coseismic forcing
  - 2023 (SE Alaska): Hydrologic and geomorphic controls on fatal Wrangell landslide initiation and runout
- Developing tools for mapping and characterizing landslides with lidar and remote sensing
- Developed community-led landslide warning system in Sitka, Alaska (*sitkalandslide.org*)
- Translating fundamental geoscience knowledge for risk reduction in 6+ SE Alaska communities

# Work with the USGS

Describe your history of working with the USGS, if any.  **A few highlights:**

- 1995: Mapping Highway 50 (California) landslide complex (Mark Reid)
- 2010s: Integrating instrumental and remote sensing analysis of earthflows (Bill Schulz)
- 2018: Assessing post-fire debris flow susceptibility (Francis Rengers, Jason Kean)
- 2020: Machine learning for hydrologic response on steep hillslopes (Ben Mirus and Matt Thomas)
- 2021: Coupled slope stability and hydrologic modeling (Jon Perkins)
- 2025: Characterization of deep-seated landslide chronology for soil organic carbon inventory (Sean Lahusen)

# Why Advisory Committee on Landslides?

Describe your interest in serving on the Federal Advisory Committee on Landslides.

- Strong interest in improving how we translate fundamental scientific discoveries for mitigating risk in landslide-prone communities, e.g., development & proliferation of susceptibility maps and early warning systems
- Interested in informing national and regional research priorities and funding mechanisms
- Interested in facilitating and expanding collaborations between academia, agency, and industry scientists, e.g., improve models and data for the insurance industry
- Interested in improving how we communicate with communities in landslide-prone regions

# Nina Oakley
# California Geological Survey

GEOHAZARDS CLIMATOLOGIST

2 YEARS

# My Work

I am an applied meteorologist and climatologist with expertise in extreme precipitation from small (mesoscale) to large (synoptic) scale

I support people within and outside my field to utilize weather/climate information in decision making and understanding of geohazards (landslides/debris flows)

Most of my career has been in academia conducting research and publishing on atmospheric conditions driving extreme precipitation and landslides/postfire debris flows in CA/western US

# Landslide and Hazard Experience

~10 years applied research on landslides and postfire debris flows

Part of CA Watershed Emergency Response Teams, identify/evaluate postfire hazards, develop report, and communicate hazards

Postfire instrumentation and monitoring for flood/debris flow responses, forecasting and evaluating characteristics of storms producing responses

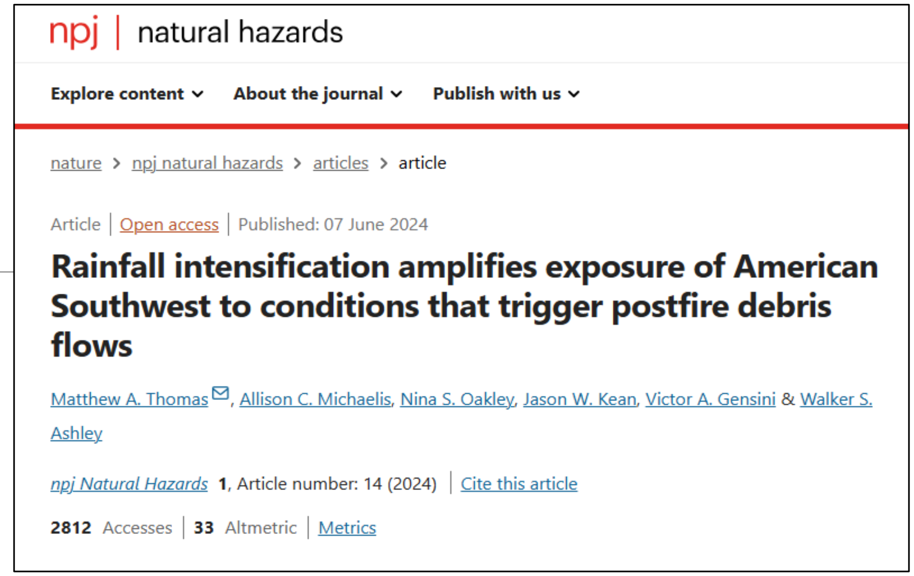
# Work with the USGS

Continuous collaboration on postfire hazard monitoring, “geometeorology” monthly meetings

Worked with USGS (LHP, GMEG) on applied research, previously funded under IPA award while at UCSD

Many research papers with USGS coauthors

Led USGS-funded project to host a conference on postfire debris flows in 2024, with USGS team member


npj | natural hazards

Explore content ⌄ About the journal ⌄ Publish with us ⌄

nature › npj natural hazards › articles › article

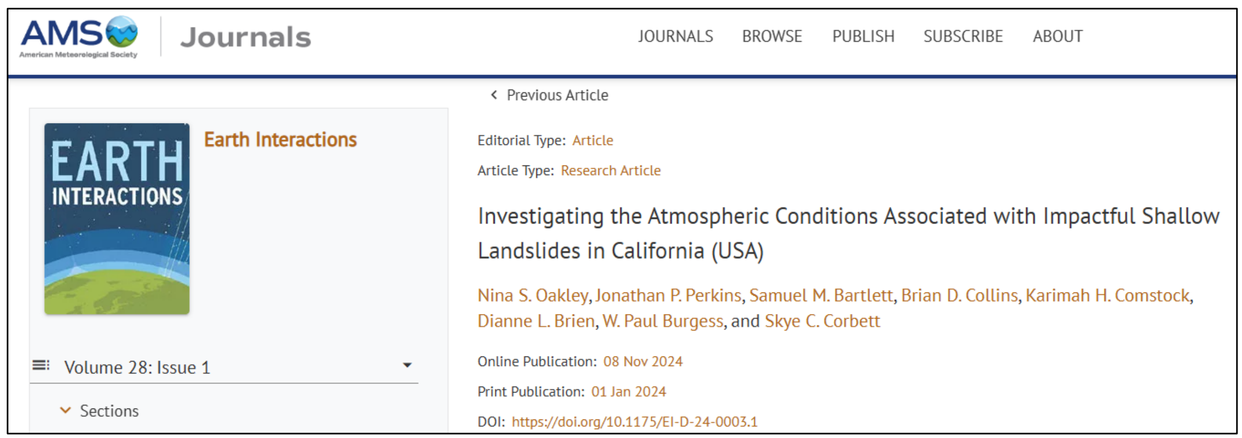
Article | Open access | Published: 07 June 2024

**Rainfall intensification amplifies exposure of American Southwest to conditions that trigger postfire debris flows**

Matthew A. Thomas, Allison C. Michaelis, Nina S. Oakley, Jason W. Kean, Victor A. Gensini & Walker S. Ashley

*npj Natural Hazards* **1**, Article number: 14 (2024) | Cite this article

**2812** Accesses | **33** Altmetric | Metrics


AMS American Meteorological Society | Journals

JOURNALS BROWSE PUBLISH SUBSCRIBE ABOUT

‹ Previous Article

Earth Interactions

Volume 28: Issue 1

⌄ Sections

Editorial Type: Article

Article Type: Research Article

Investigating the Atmospheric Conditions Associated with Impactful Shallow Landslides in California (USA)

Nina S. Oakley, Jonathan P. Perkins, Samuel M. Bartlett, Brian D. Collins, Karimah H. Comstock, Dianne L. Brien, W. Paul Burgess, and Skye C. Corbett

Online Publication: 08 Nov 2024

Print Publication: 01 Jan 2024

DOI: https://doi.org/10.1175/EI-D-24-0003.1

# Why Advisory Committee on Landslides?

Landslide hazards are an interdisciplinary problem! I can offer a weather/climate perspective and support interdisciplinary collaboration for science advancement

Interested in helping guide landslide science and application/communication of it to protect life, property, and infrastructure


Leslie Jones
Alaska Geospatial Office, DGGS

# Lorna G. Jaramillo Nieves, Ph.D.
# University of Puerto Rico, Río Piedras

PROFESSOR

20 YEARS

# Academia

## Teaching (Current semester)

- Undergraduate science courses to science and non-science students
  - Geologic Processes, Disasters, and their Effects on Society (CIFI 4065)
  - Undergraduate Research in Physical Sciences (CIFI 4996)

## Research

- Current Projects
  - Building Geological Hazard Capacity in Puerto Rico (2025-2026)
  - Construction of 1918 Puerto Rico Tsunami Flooding Maps Based on Primary References

## Other Academia Responsibilities

- Personal Committee Coordinator- Adjunct and Tenure Track Personnel Evaluation and Mentorship
- Science Outreach (Conferences, Radio and TV)
- University Life and Service

# Landslide and Hazard Experience

Teaching

- Geologic Processes, Disasters, and their Effects on Society (CIFI 4065)
  - Site visits as case studies:
    - Villa España, Bayamón
    - Cerca del Cielo, Ponce
    - Cañaboncito, Caguas
    - PR-10, Utuado
    - Unibón; Morovis

- Risk and Natural Hazards (PLAN 6003), Graduate Planning School, University of Puerto Rico, Río Piedras

Research

- Building Geological Hazard Capacity in Puerto Rico (2025-2026)

Hazard and Risk Outreach

- Publishing materials for the general public (two books)

# Work with the USGS

1999-2003 Graduate student contract (GS-09), USGS Southwest Field Office, Tucson AZ. Supervisor- Floyd Gray

- Described surficial deposits affected by erosion from active mine areas, enabling subsequent pollution and water quality studies.
- Identified alteration zones in the Silver Bell Mountains, Arizona using remote sensing techniques in the visible and infrared regions.
- Refined and added identification criteria into database regarding alteration spectra in watersheds associated with mineralized and mined regions for environmental assessment.

2020 USGS and the Puerto Rico Seismic Network Liaison

- Served as an expert advisor in the response and recovery phase resource meetings with the Government of Puerto Rico after the seismic sequence of December 2019 and January 2020.

2020-2024 Volunteer

# Why Advisory Committee on Landslides?

Contribute to a safer society.

Learn from experts working in other fields and states.

Taking up a new challenge.

# Kelly Hubbard
# County of Santa Barbara

Director, Office Of Emergency Management

5.5 Years

# Emergency Management

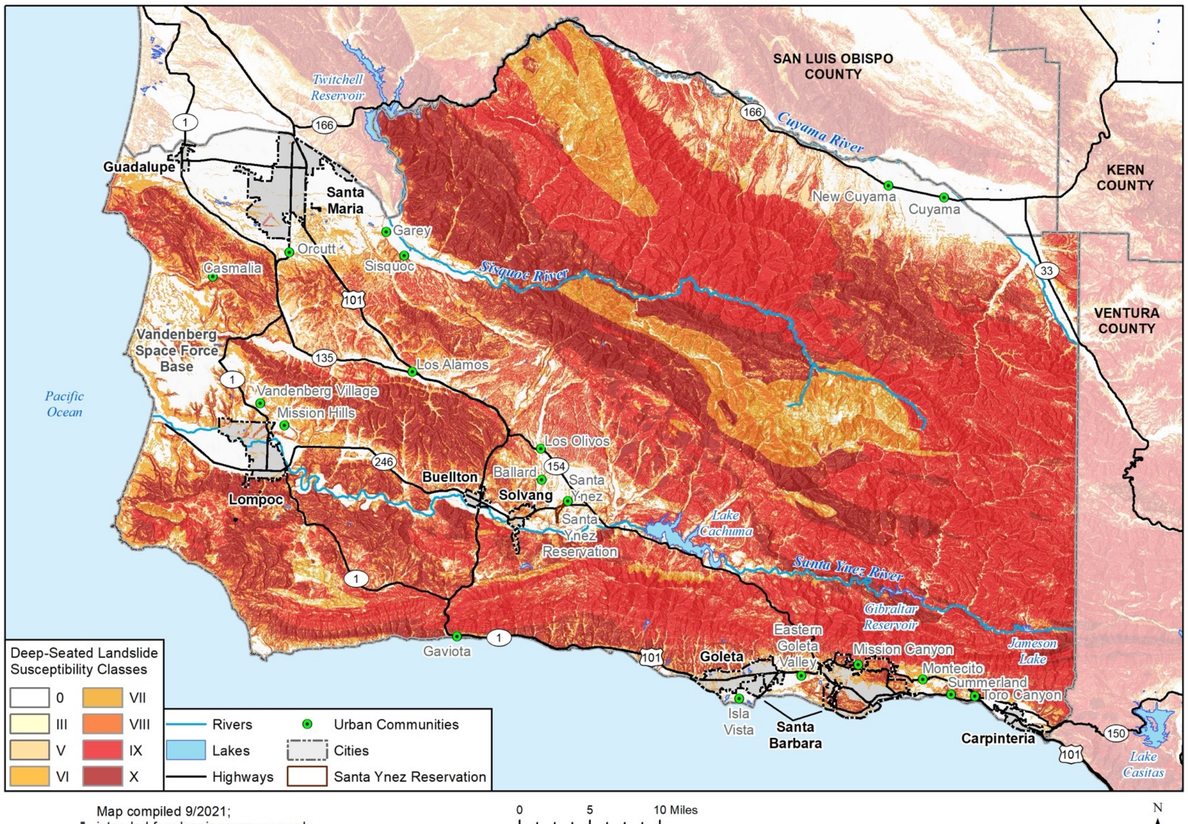
## What I do…

- Collaboration in blue skies
  - Prevention, Mitigation, Preparedness
- Disaster Response
  - Information – briefings, situation status reports
  - Support – resources, coordination
  - Liaison – to the incident, state, federal partners
- Disaster Recovery
  - Regional support resources (i.e. Local Assistance Center)
  - Coordination and collaboration

## Who I do it for…

- County Government
  - 23 departments
- Unincorporated County Residents
  - Est 140,000 residents
- Operational Area
  - All governmental agencies within County boundaries
  - 120+ agencies

# Santa Barbara County Deep-Seated Landslide Susceptibility




wood.

Map compiled 9/2021;
intended for planning purposes only.
Data Source: Santa Barbara County,
Department of Conservation, California Geological Survey

COUNTY OF SANTA BARBARA CALIFORNIA
one COUNTY one FUTURE

READYSBC.org
SIGN-UP • PLAN • UNDERSTAND

# Landslide and Hazard Experience

- 24 years in Emergency Management
- Types of Agencies:
  - City
  - Special District (Water & Wastewater)
  - County
- Santa Barbara County
  - 4 Wildland Fires with Debris Flow Risk
  - Storm Risk Decision Teams
  - Evacuations, damages and recovery

- Types of Disasters:
  - Wildfires
  - Earthquakes
  - Severe Floods, Winter Storms, Debris Laden Flows
  - Rerouted River
  - Tsunamis
  - Mass Casualty
  - Elections
  - Power Outages
  - Extreme Cold/Heat
  - Infrastructure Failures

READYSBC.org
SIGN-UP • PLAN • UNDERSTAND

# February 2025 Storm


READYSBC.org
SIGN-UP • PLAN • UNDERSTAND

# Work with the USGS

- 4 Burn Area Emergency Reports (BAER)
- USGS Earthquake Sensor @ Emergency Operations Center
- Congressional Research Service Presentation with USGS (Dec 2023)
- Montecito 2023 Storm Response analysis

# Why Advisory Committee on Landslides?

- An opportunity to serve my community through greater research, data, tools, educational resources and coordination.
- Lack of:
  - Data on how to evaluate landslide risk
  - Educational resources
  - Recommendations on protective actions

one COUNTY one FUTURE

READYSBC.org SIGN-UP • PLAN • UNDERSTAND

# Casey Hanell
# Washington State Department of Natural Resources

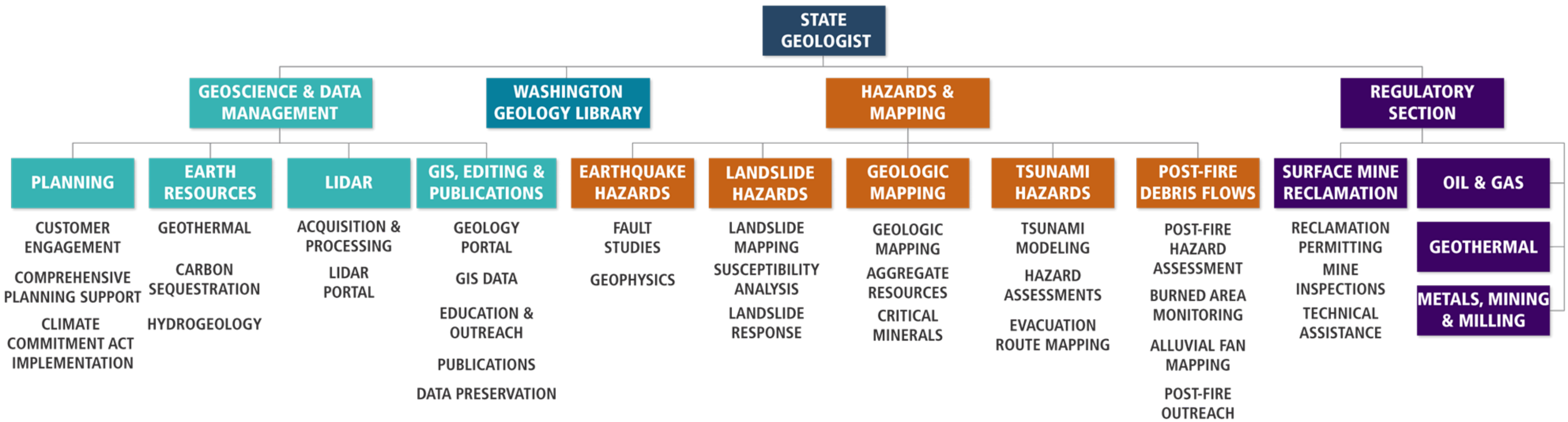
STATE GEOLOGIST AND DIRECTOR, WASHINGTON GEOLOGICAL SURVEY

SINCE OCTOBER 1, 2019

# State Geologist

## Lead and manage the Washington Geological Survey (WGS)

Geology for a safe, resilient, and prosperous Washington



# Landslide and Hazard Experience

## COMMUNICATE LANDSLIDE HAZARD TO THE PUBLIC

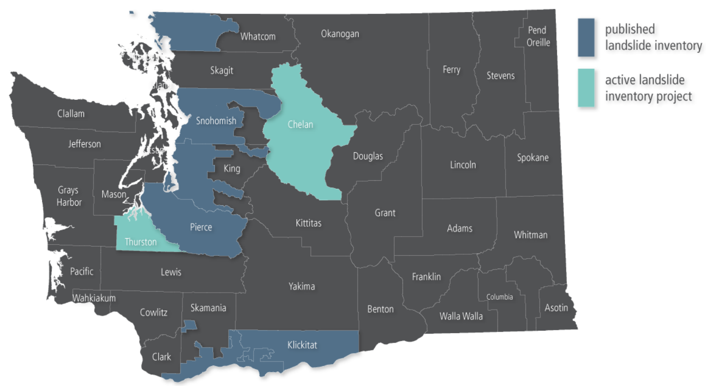
The Washington Geological Survey works to increase public and scientific understanding of landslide hazards in Washington State. Please visit our Geologic Information Portal and Geologic Hazard Maps page for the most up-to-date listing of all of our hazard maps.



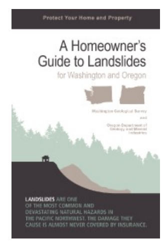
Consider subscribing to our blog, Washington State Geology News, to receive notifications when new information is published. Also check out Ear to the Ground, published by the Department of Natural Resources.

The information on this webpage is also contained in two factsheets: Landslide Hazards in Washington State and What Are Landslides And How Do They Occur?

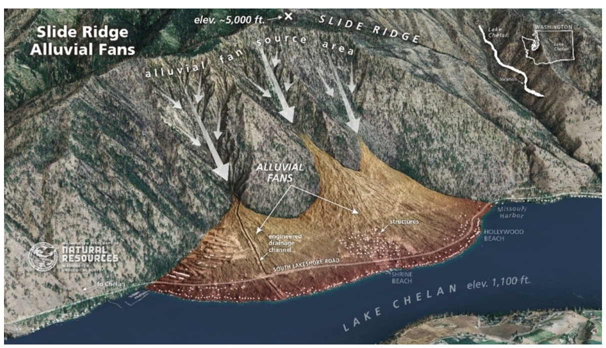
Website: https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/landslides




(Left) Counties in Washington that have completed or in progress landslide inventories. Inventory work has only been completed for 14% of the state and 34,683 landslides have already been mapped.



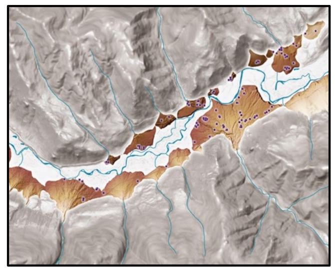


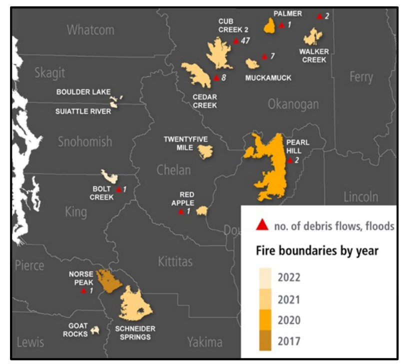


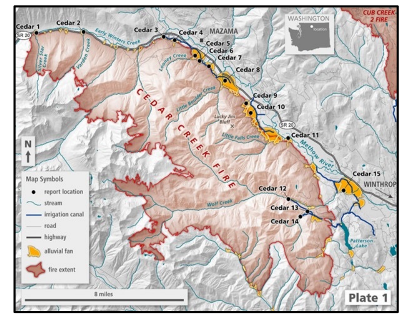
# Work with the USGS

## Landslide Inventory

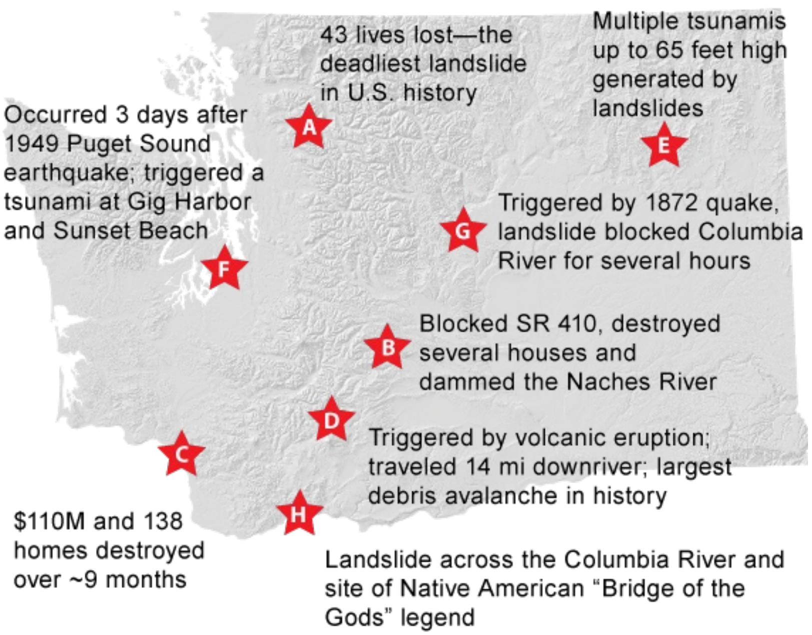

## Post-wildfire debris flows






# Why Advisory Committee on Landslides?




| Some historic landslides in Washington State | |
|---|---|
| **Slide or area name** | **Date** |
| (A) SR 530 (aka Oso or Hazel) | Mar. 2014 |
| (B) Nile | Oct. 2009 |
| (C) Aldercrest–Banyon | Feb–Oct. 1998 |
| (D) Mount St. Helens | May 1980 |
| (E) Lake Roosevelt | 1944–1953 |
| (F) Tacoma Narrows | Apr. 1949 |
| (G) Ribbon Cliffs | Dec. 1872 |
| (H) Bonneville | mid-1400s |

# Bill Haneberg
# William C. Haneberg, LLC

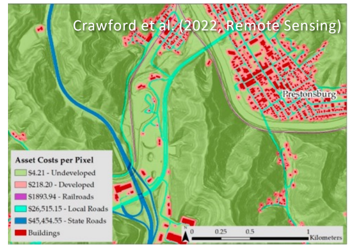
GEOLOGICAL AND GEOHAZARDS CONSULTANT

2023-PRESENT

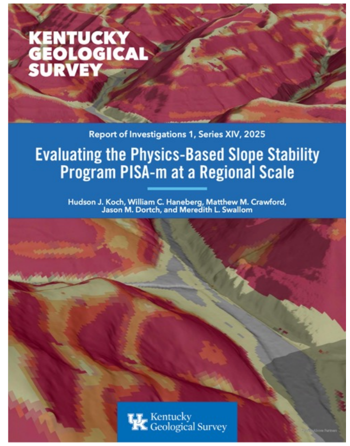
# My work

**Consulting at the geohazard-climate-policy nexus**

- Combining applied research and professional practice
- Using digital terrain modeling for geohazard assessment
- Developing and applying GIS-based susceptibility, hazard, and risk models
- Applying machine learning to surficial geologic and geohazard mapping (including a US patent)
- Understanding the influence of geology, climate, and human activity on past, current, and future landslides
- Supporting policy and management decisions by contextually interpreting and translating geoscience information





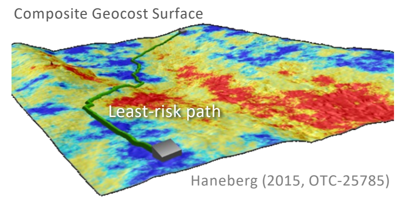

KENTUCKY GEOLOGICAL SURVEY

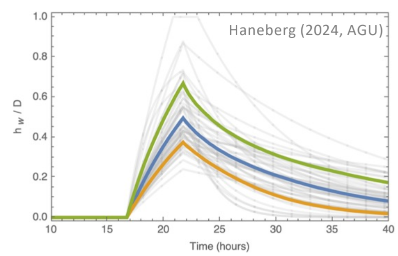
Report of Investigations 1, Series XIV, 2025

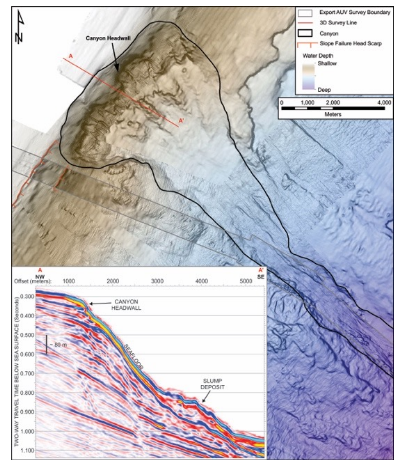
Evaluating the Physics-Based Slope Stability Program PISA-m at a Regional Scale

Hudson J. Koch, William C. Haneberg, Matthew M. Crawford, Jason M. Dortch, and Meredith L. Swallom

Kentucky Geological Survey




Martin et al. (2015, OTC-25938)

# Landslide and Hazard Experience

| | |
|---|---|
| **1986 - 1989** | **University of Cincinnati**<br>PhD research on rainfall-induced pore pressure changes in a landslide-prone slope along the Ohio River. Cincinnati Infrastructure Commission. |
| **1989 - 1999** | **New Mexico Tech (New Mexico Bureau of Geology & Mineral Resources)**<br>Senior engineering geologist and assistant director. Landslides, debris flows, land subsidence, and other geohazards. Faults and subsurface fluid flow. Basin-scale aquifer system characterization. Water resources and seismic hazards policy advising. |
| **1999 - 2011** | **Independent Geologic and Geohazards Consultant (Haneberg Geoscience)**<br>Early adopter of airborne lidar and digital photogrammetry for landslide and rock slope discontinuity mapping. Development of map-based probabilistic slope stability models. Himalayan landslide and geomorphological research. Jahns distinguished lecturer in engineering geology. |
| **2011 - 2016** | **Fugro Geoconsulting**<br>Senior consultant and quantitative geohazards team leader. Integrated geological-geophysical-geotechnical deepwater site investigation and hazard assessment. Regional probabilistic submarine slope stability modeling. Deepwater pipeline route optimization and risk minimization. |
| **2016 - 2023** | **University of Kentucky (Kentucky Geological Survey)**<br>Research professor, state geologist, and survey director. Established KGS DEAL lab to leverage statewide lidar and 1:24K geologic map coverage. Lidar change detection, machine learning for landslide susceptibility and surficial geologic mapping. Geologic controls on indoor radon. Stakeholder engagement and scicomm. Policy advising including KY GIAC and NGAC. |
| **2023 - ?** | **Independent Geological and Geohazards Consultant (William C. Haneberg, LLC)**<br>Digital terrain modeling for geohazard assessment. Development of efficient GIS-based landslide and debris flow models. Effects of logging and mountaintop removal coal mining on flood severity. Private sector advising on landslide, land-use, and climate policy issues. |

# Work with the USGS


USGS in-kind support

Multi-agency city-state-federal co-op

USGS co-op agreement G20AC00416

USGS award 14-08-0001-G2108

USGS NEHRP award 04HQGR0035

# Why Advisory Committee on Landslides?

- Belief in the inherent value and practical utility of publicly funded science and science-based policy decisions
- Combination of private sector and state geological survey applied research, professional practice, and policy insight
  - Deep-water seafloor mass transport events to prehistoric Himalayan mega-landslides
  - Small residential projects to major multi-hundred-million-dollar capital expenditure and asset integrity projects
- Previous rewarding experience on the National Geospatial Advisory Committee and state advisory bodies

# William (Bill) Burns
# Oregon Department of Geology & Mineral Industries (DOGAMI)

LANDSLIDE TEAM LEAD

21 YEARS @ DOGAMI)

# Landslide Risk Reduction

Risk reduction projects with communities (cities, counties) in Oregon ranging from lidar-based inventory to susceptibility, risk, and risk reduction.

Lead author on landslide method papers: SP-42 Inventory, SP-45 Shallow Suscep, SP-48 Deep Suscep, SP-53 Debris Flow Suscep, SP-55 Serial Lidar

Create public data: Lidar, lidar-based landslide inventories, historic landslide inventories, geology…encourages collaborative research on tough questions.

Collaborative research:  USGS, Universities, and other state agencies: Dating landslides to try and find a Jan 1700 coseismic, understanding post-fire debris flows in the PNW, student internship mapping landslides for 15 years, debris flow modeling, rainfall/soil water/landslide monitoring, landslide losses.

Outreach/Education: Landslide warnings=Bill on TV, lots of talks/presentations, digital items

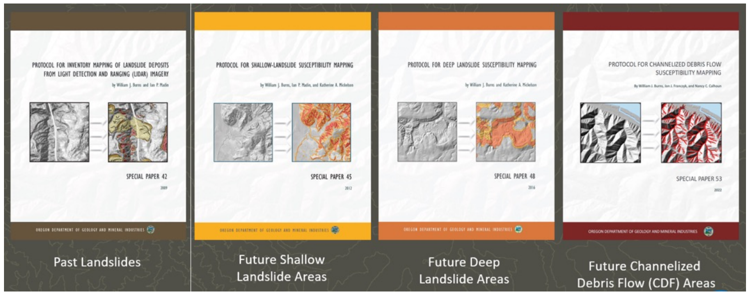



Table 4. Summary of permit based loss and landslide repair valuation data for 1996 and 2000-2013.

| | Number of Landslides | Mean | Range |
|---|---|---|---|
| 1996 | 39* | $89,300 | $1,300-$1.08M |
| 1996 With corresponding exposure data | 17 | $99,100 | $1,300-$256,700 |
| 2000-2013 | 60* | $93,100 | $113-$1.46M |

*Number of landslides with permit data.

# Landslide and Hazard Experience

PSU Scott Burns Landslide Master's Student – 1996-1997 storms ~10,000 landslides. Was part of several research teams collecting data.

Engineering Geologist at Consulting Firm in Portland ~8 years. Lots of site-specific evaluations, drilling, stabilization design, and construction monitoring.

DOGAMI, 21 years. Landslide Team Lead: Regional mapping with remote sensing data as primary method. A lot of computer/GIS analysis.

Collect data as landslides occur. Internet, field checks. Remote sensing data and field campaign if widespread.

Friends of the landslide inventory (2007), GSA EEGD Landslide Committee (brother to AEG landslide workgroup).

# Work with the USGS

USGS Statemap: Annual, they map Qls, Qfan, add to SLIDO.

USGS LHP: 5-year collaborative landslide research in Oregon 2006-2011. Helped DOGAMI immensely and still helping today!

USGS CVO: Multihazard risk analysis of Mt Hood.

USGS Earthquake: Landslide inventory mapping in the Portland metro.

USGS Earthquake: NEHRP collaborative research with UO (Roering) dating landslides to Jan 1700.

USGS LHP: Initiation and monitoring. Portland hills monitoring site + landslide inventory.

USGS LHP: 5-year collaborative research on post-fire debris flows in Oregon.

USGS LHP NLRRP: Y1 and Y2 successful proposals.

# Why Advisory Committee on Landslides?

I proposed the idea of a National Landslide Hazard Risk Reduction Program in my talk at the 2015 AEG Landslide Forum, Time to Face the Landslide Hazard Dilemma: Seattle, WA, 1-year after Oso conference.

A national landslide inventory and some day (frequency/magnitude) hazard maps, has always been a dream of mine.

I love to work as close to the cutting edge as possible. Serial lidar, modeling debris flow hazard and risk.

I have a wide range of experience (site-specific, research, methods, risk reduction) which helps see the entire range of the landslide risk reduction landscape.

I think some of the risk reduction actions we need and can accomplish are not hard science, but adjacent, such as education/awareness, guidelines/standards, national meteorological monitoring network.

# Jennifer Bauer, P.G.
# Appalachian Landslide Consultants, PLLC

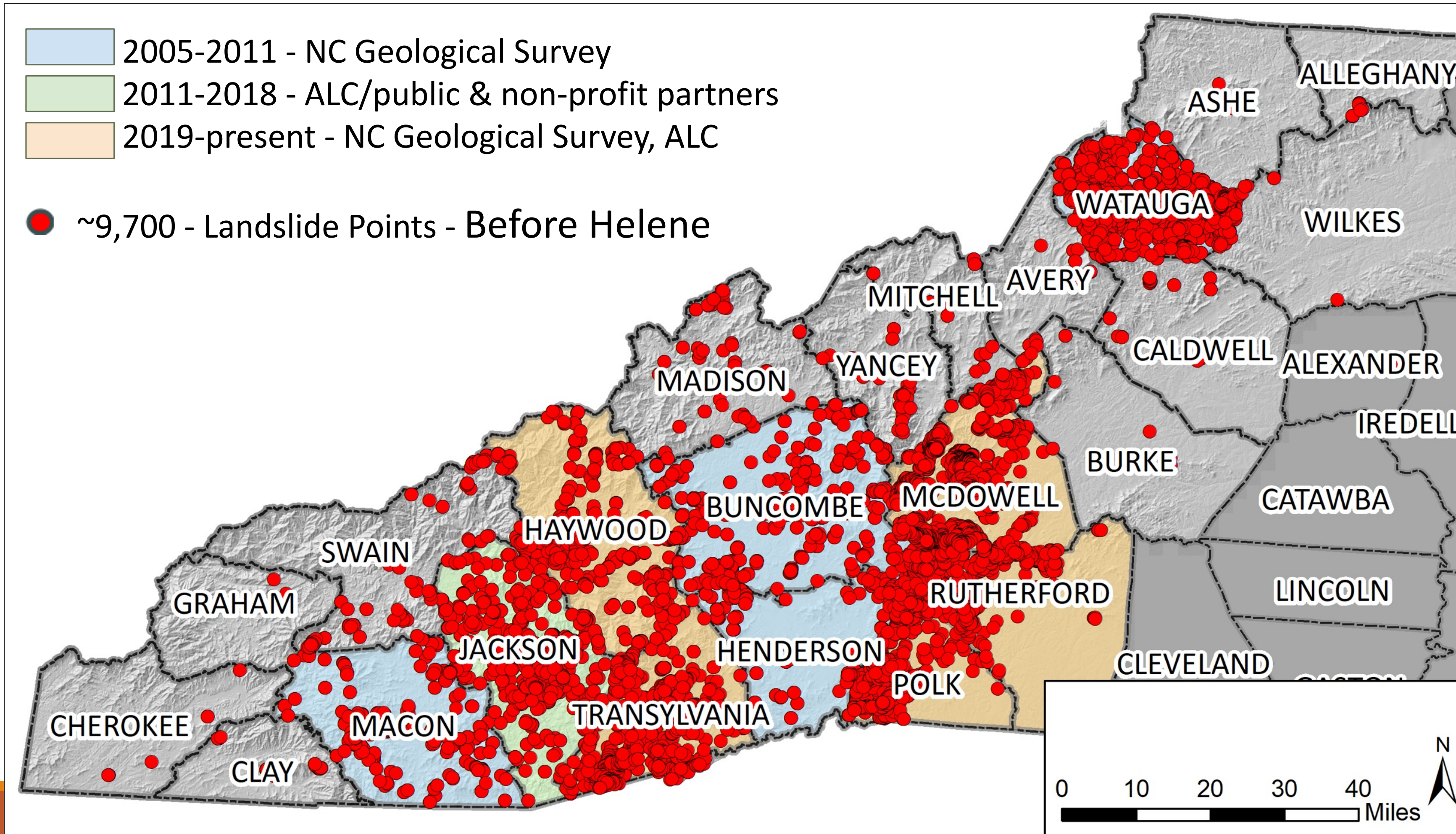
CO-OWNER/PRINCIPAL GEOLOGIST

13+ YEARS

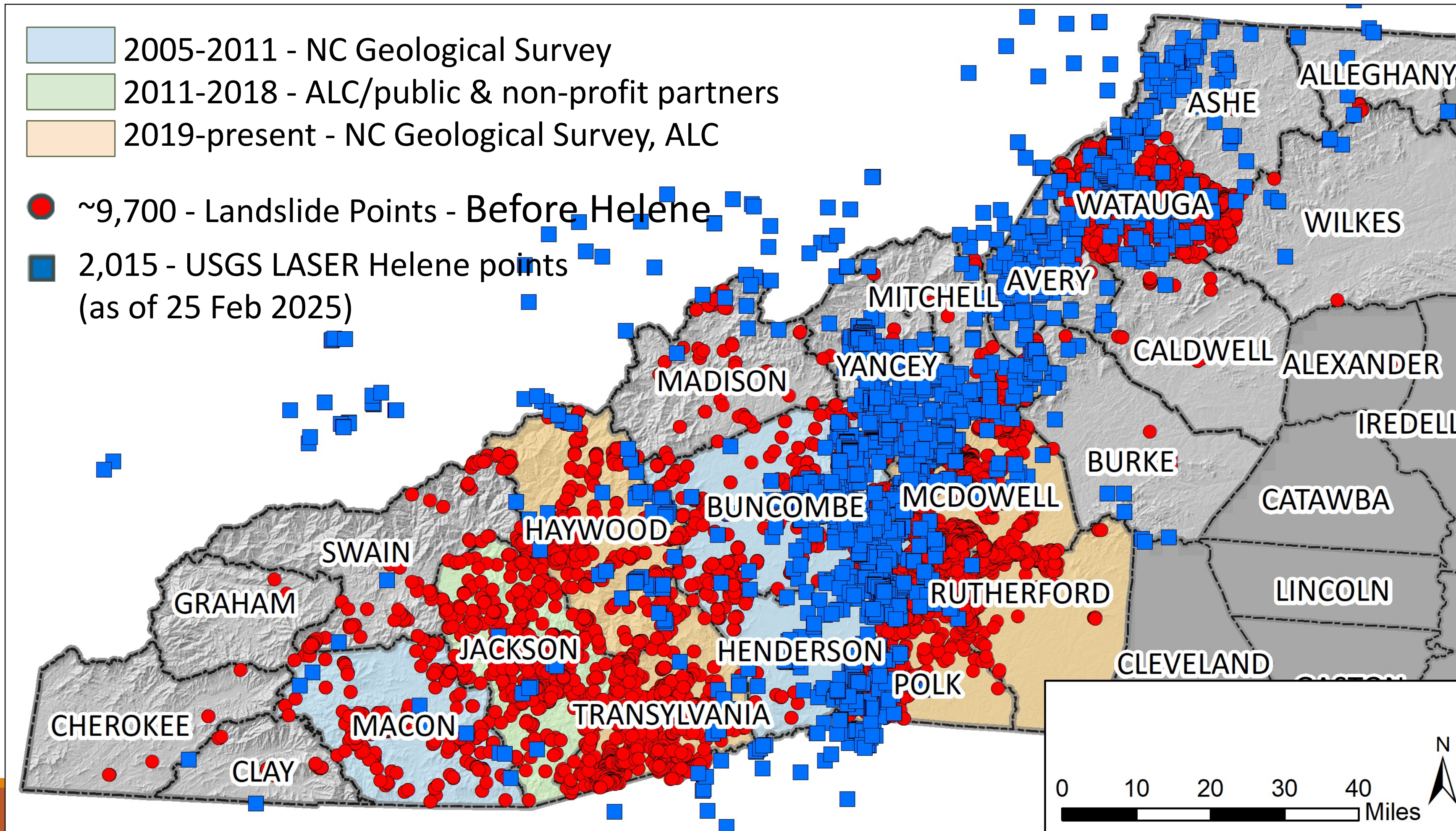
# Landslide Consultant

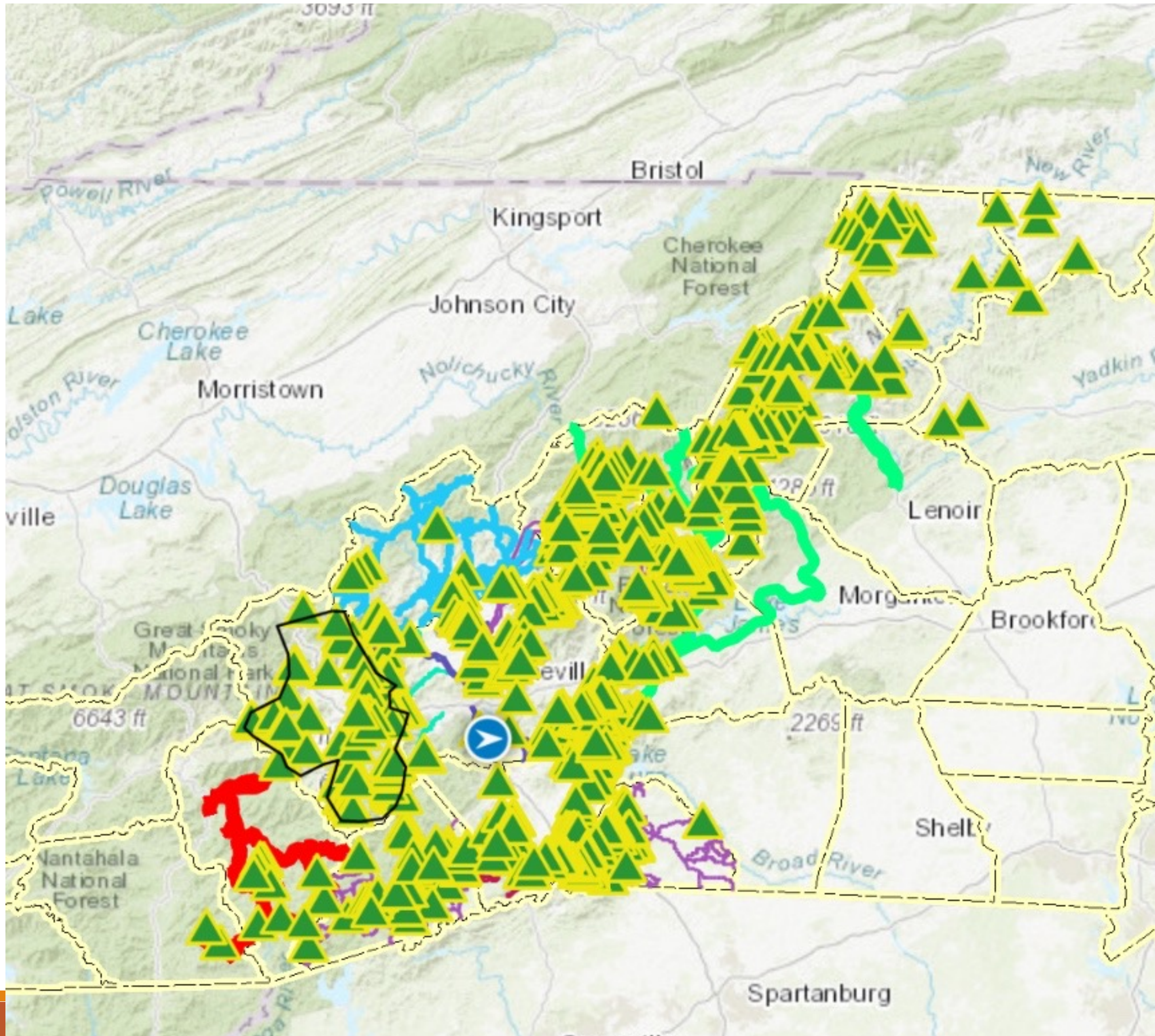
- Landslide mapping (NCGS, utilities)
- Rock and soil slope ratings for Geotechnical Asset Management (DOTs)
- Property evaluations (private landowners, buyers, HOAs)
- Landslide characterization and monitoring (commercial, private, transportation, utility clients)

# NC Landslide Mapping



# NC Landslide Mapping

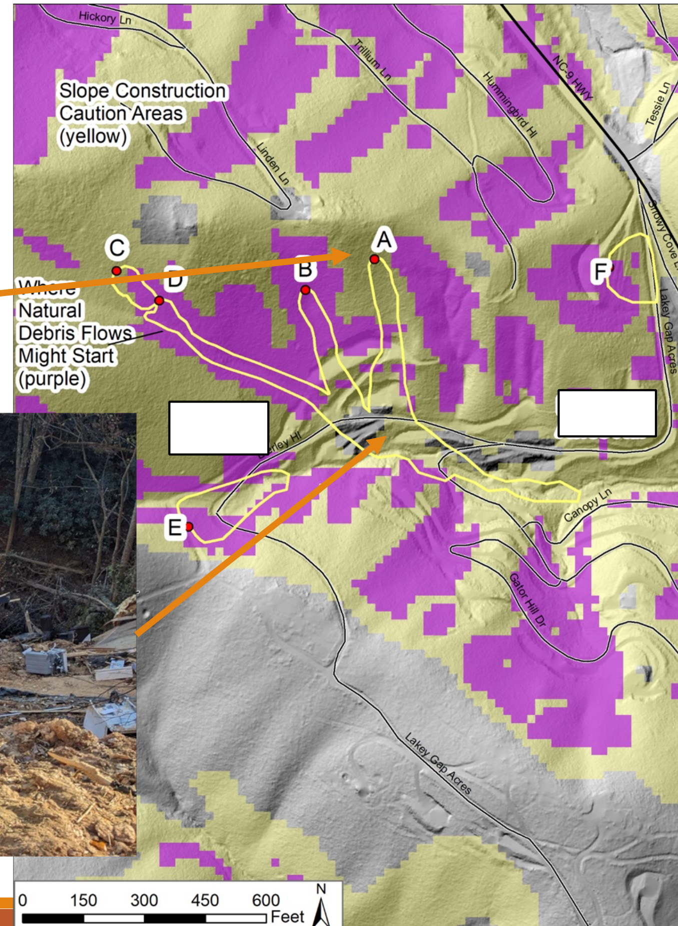





NCDOT GAM Slope Ratings – Helene

Colored lines indicate covered ground

# Helene Landslide Evaluations



# Landslide and Hazard Experience

How do you interact with landslides, landslide hazards, or other natural hazards in your professional capacity?

- Contract with the NCGS to map landslides
- Communicate with local governments about landslides
- Use the landslide maps to assist clients when purchasing property, deciding on homesites, or educating them about hazards
- Identify potential unstable slopes along roadways or along utility corridors or properties prior to construction or mitigation

# Work with the USGS

- Work with NC Geological Survey on one of the Cooperative Landslide Hazard Mapping and Assessment Grants for Haywood County, NC
- Spoken at sessions for congressional staffers about landslide hazards.
- Weekly calls post-Helene

# Why Advisory Committee on Landslides?

# Email from a client post-Helene

October 2, 2024

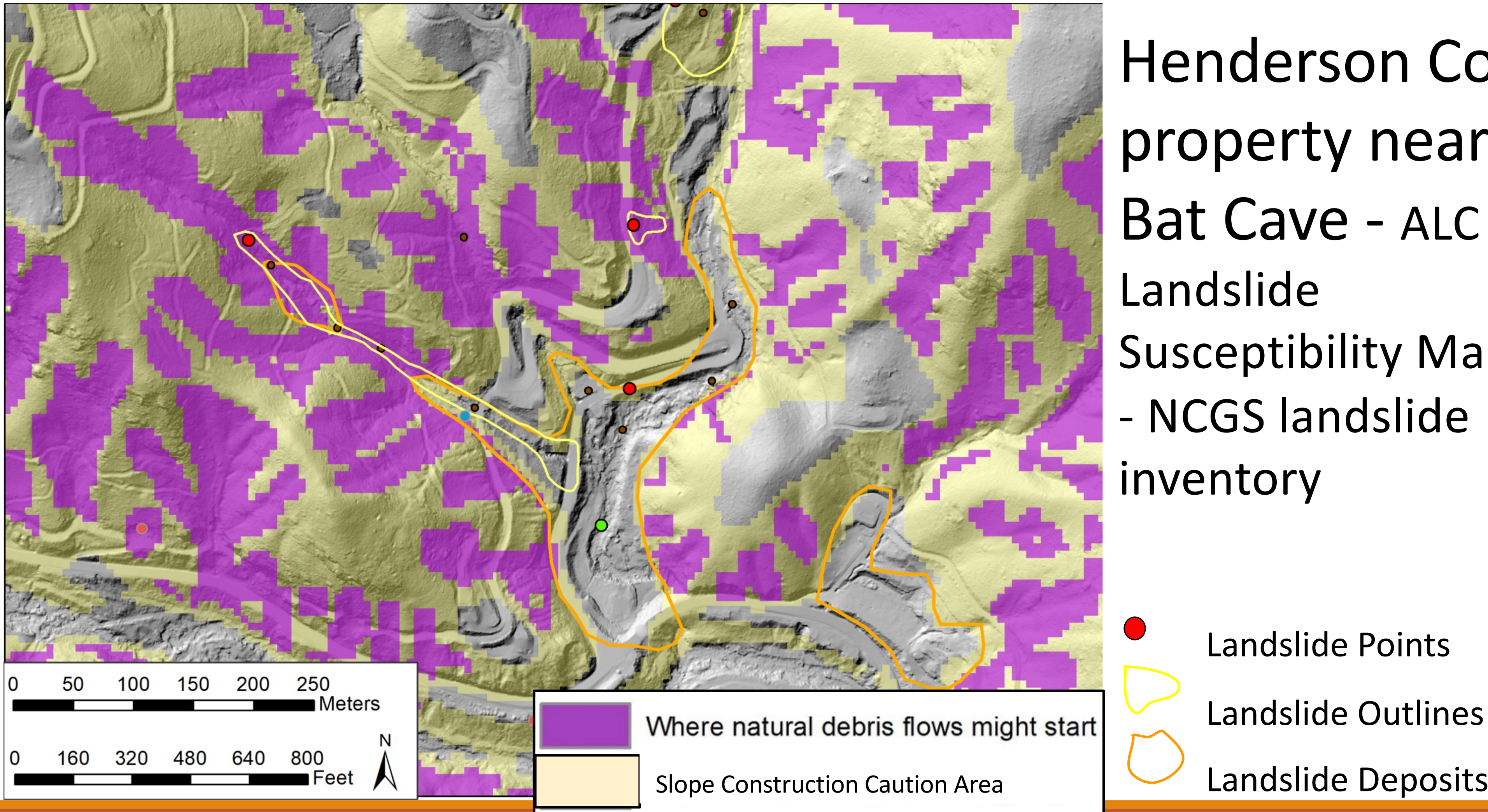
“I just wanted to say thank you for both for your expertise 3 years ago when I asked you to provide help as I was buying properties in the Blue Ridge.

Our house, and our family, were safe even though Burnsville had many catastrophic mudslides and floods. So many of the properties I had been wanting to purchase (that you steered me away from) had cataclysmic results, or are completely gone now. I cannot thank you enough - you truly saved us. Your work is important, and even if it’s only accentuated in big events like these, the daily tasks you do have long-lasting impacts.”

-P.A.

Henderson Co. property near Bat Cave in 2021 - video from P.A.

# Henderson Co. property near Bat Cave - ALC Landslide Susceptibility Map - NCGS landslide inventory

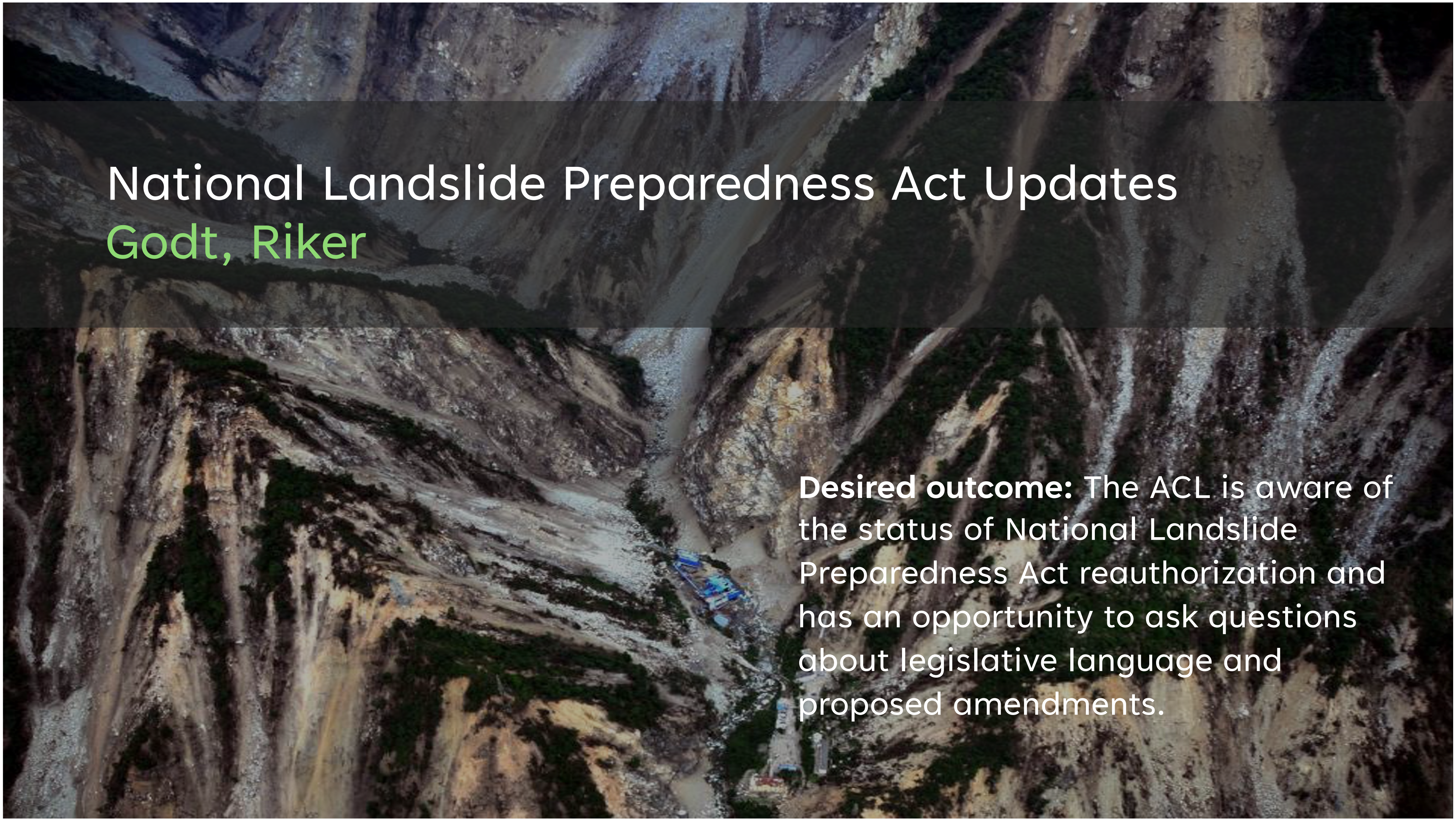


Henderson Co. property near Bat Cave in 2025 - video from P.A.

# Why Advisory Committee on Landslides?

- I want to help move the needle in the right direction and I think the Strategies laid out in the National Strategy for Landslide Loss Reduction are the path to do so.

- I have personal stories of how having landslide information has saved peoples lives. This can work if scaled up.

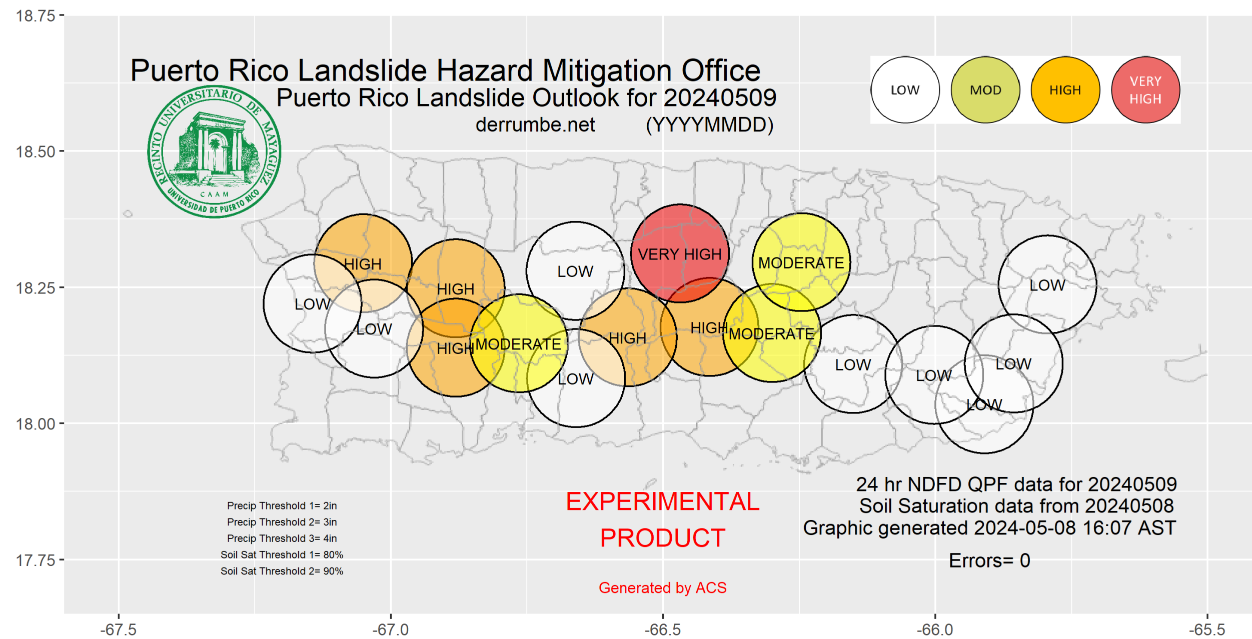

National Landslide Preparedness Act Updates
Godt, Riker
**Desired outcome:** The ACL is aware of the status of National Landslide Preparedness Act reauthorization and has an opportunity to ask questions about legislative language and proposed amendments.

**National Landslide Preparedness Act reauthorization 118th Congress**

H.R. 2250

- Added NASA to the Interagency Coordination Committee on Landslide Hazards
- Extended authorization to 2029
- Cleaned up a few typos and other bits
- Added definitions of "Atmospheric River Flooding Event" and "Extreme Precipitation Event" (5-year return period)
- Directs Interior and Commerce to include an assessments of ARs and Extreme Precipitation Events to the National Strategy
- National Landslide Hazards Database to identify areas in need of additional hazard and risk assessment
    - Hydrologic changes such as erosion and drought
    - AR and Extreme Precipitation Events
    - Geologic activity such as volcanic eruptions, earthquakes, or tsunami
    - Data-poor areas or poorly monitored areas
- Addition of Native Hawaiian Communities to the list of partners and stakeholders
- Directs the Secretary of the Interior to establish in each region of high landslide hazard a *Regional Partnership* with institutions of higher education
    - To leverage applicable expertise
    - Coordinate long-term landslide research
    - Align interagency monitoring efforts
- Expands grant program to Hawaiian Communities and Institutions of Higher Education
- Increases USGS budget authorization to $40 million with $15 million for landslide early warning

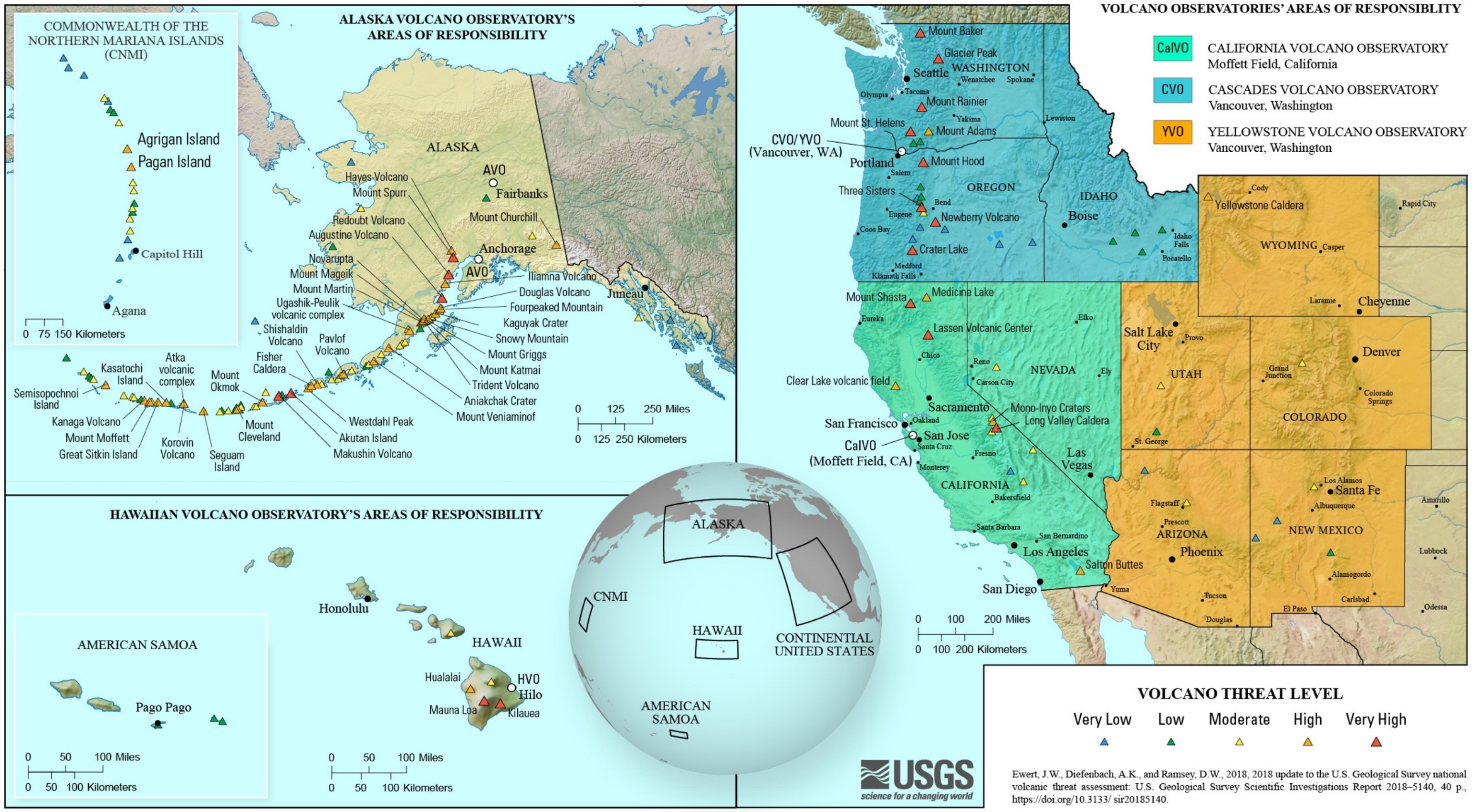
# Regional partnership with the University of Puerto Rico Mayagüez



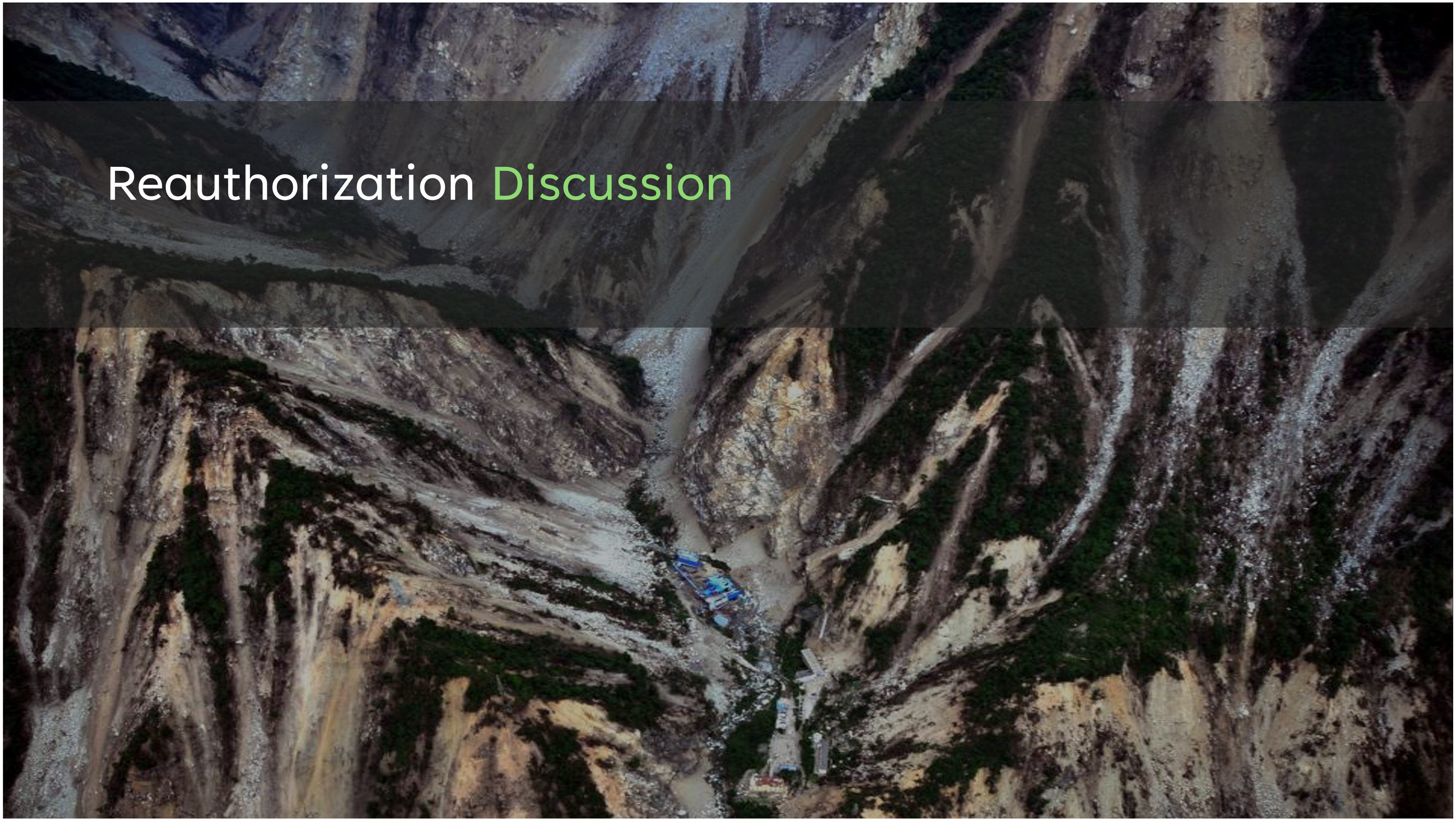
## Concept for a regional landslide observatory in Southeast Alaska

- Several deadly, rainfall-induced landslides over the previous 15 years have generated substantial interest in landslide early warning as a risk-reduction strategy.
- Vast geography, complex topography, and isolated nature of communities present significant challenges to maintaining and operating a monitoring network.
- Relatively poor observational record and understanding meteorologic and geologic conditions that lead to landslide initiation compared to other parts of the US.
- Expansion highlights need for integrated IT infrastructure for display, interpretation, and alarming of landslide monitoring data.

# USGS Volcano observatories as a model for landslides?




Ewert, J.W., Diefenbach, A.K., and Ramsey, D.W., 2018, 2018 update to the U.S. Geological Survey national volcanic threat assessment: U.S. Geological Survey Scientific Investigations Report 2018–5140, 40 p., https://doi.org/10.3133/ sir20185140.


Reauthorization Discussion


Regional Landslide Partnerships and Monitoring
Godt, Riker, Hughes, Staley, All

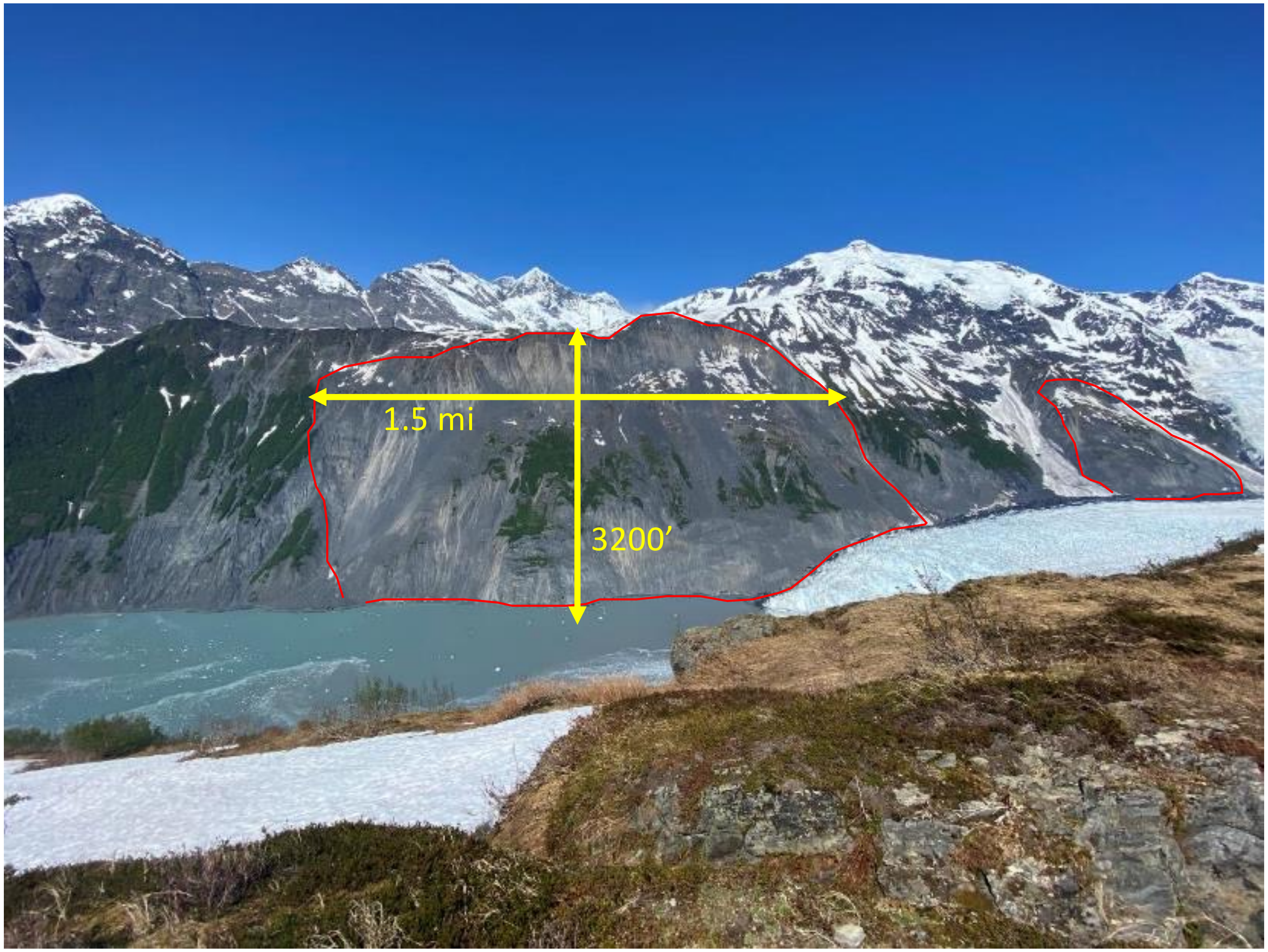
# Alaska Landslide Hazards Project Overview

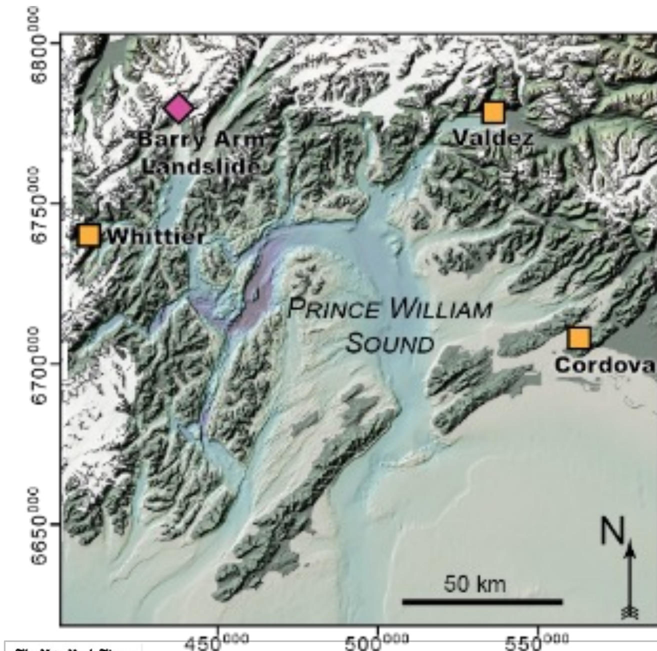

**Dennis M. Staley**

*U.S. Geological Survey*

*Alaska Volcano Observatory, Anchorage AK*


# The Barry Arm Landslide




The New York Times

*'It Could Happen Anytime': Scientists Warn of Alaska Tsunami Threat*

A retreating glacier is increasing the risk of a catastrophic landslide and tsunami within a few decades, researchers say.

By Henry Fountain

Mr. Fountain is a science writer and the author of "The Great Quake," about Alaska's deadly 1964 earthquake.

Published May 14, 2020 Updated May 15, 2020

A The Atlantic Sign In

SCIENCE

## The Alaska Tsunami That Can't Be Stopped

Melting ice has left one small town on the brink of disaster.

VICTORIA PETERSEN AND HIGH COUNTRY NEWS NOVEMBER 15, 2020

# Primary Science and Operational Objectives

In 2021, Congress authorized the USGS to work in Prince William Sound* with federal, state, and local partners to:

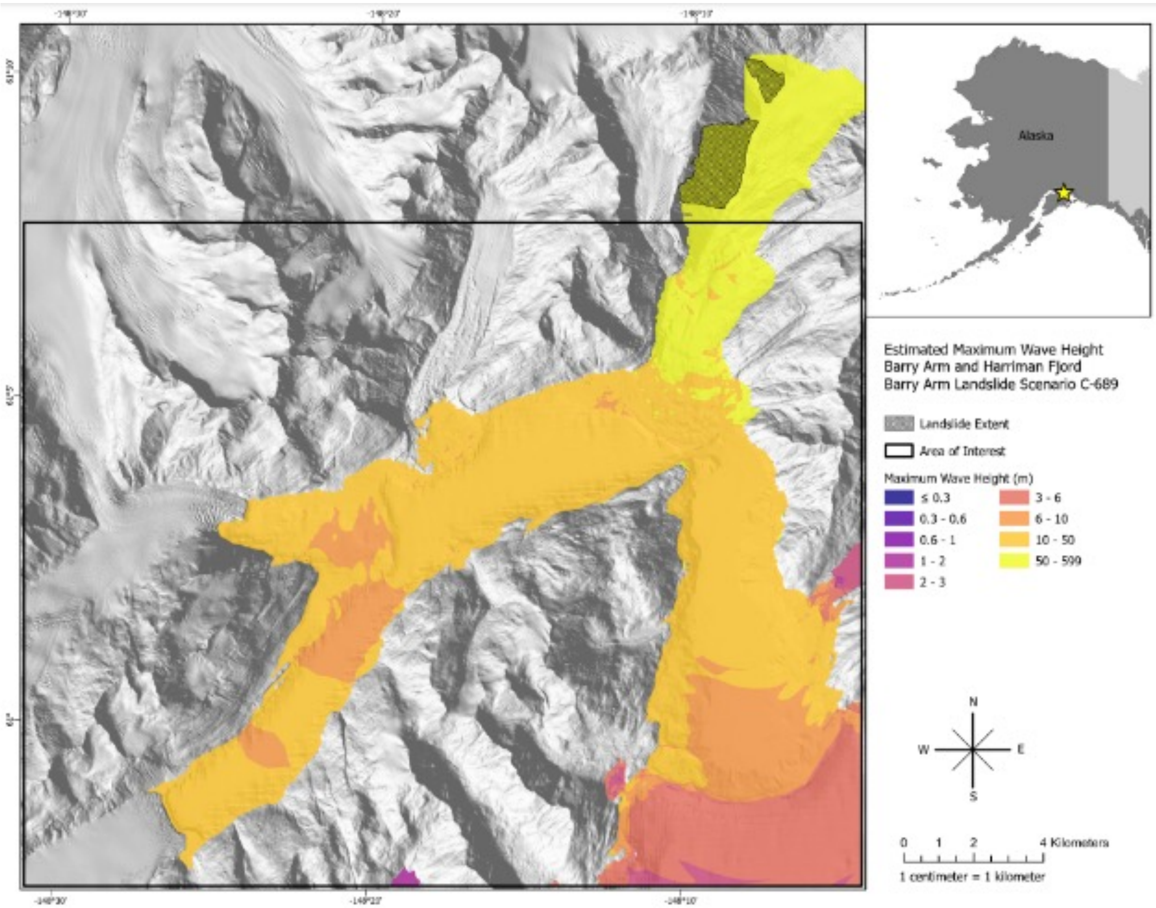
- conduct **data collection and analysis** to develop a site-specific landslide **hazard assessment**
- provide recommendations to support a **long-term monitoring strategy**
- **develop a warning system** to alert of an impending or actual landslide that could result in a tsunami.

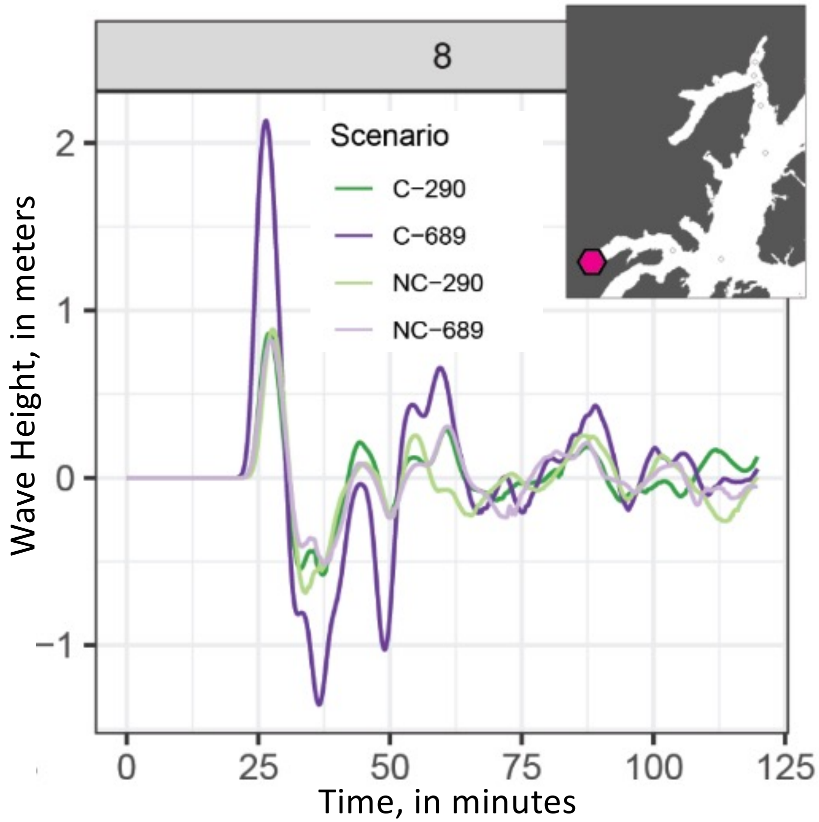
Since then, SE AK has become a primary area of concern:

- provide actionable information to NWS and partner agencies/organizations about landslide triggering conditions, landslide susceptibility, and landslide hazards in southeast Alaska

** There are ongoing and complementary efforts in Glacier Bay*

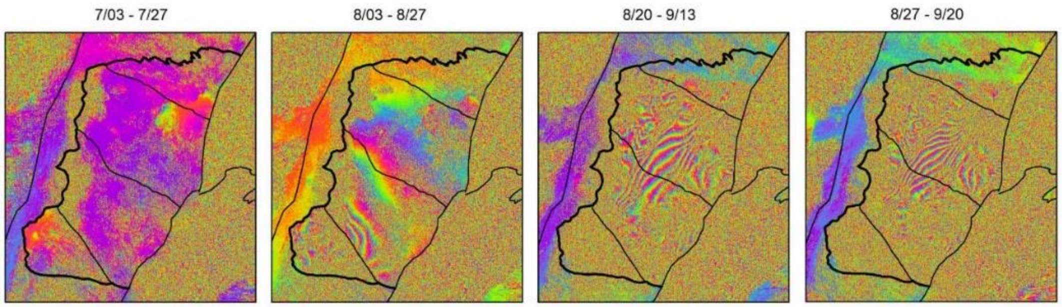
# Landslide-Generated Tsunami Hazard Assessment

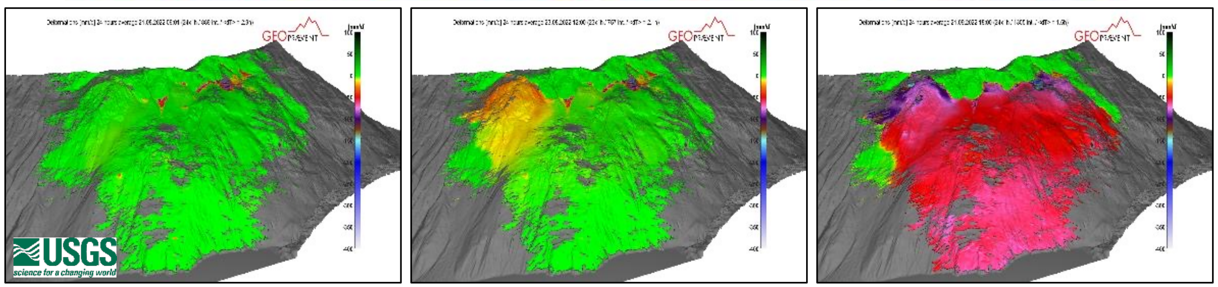


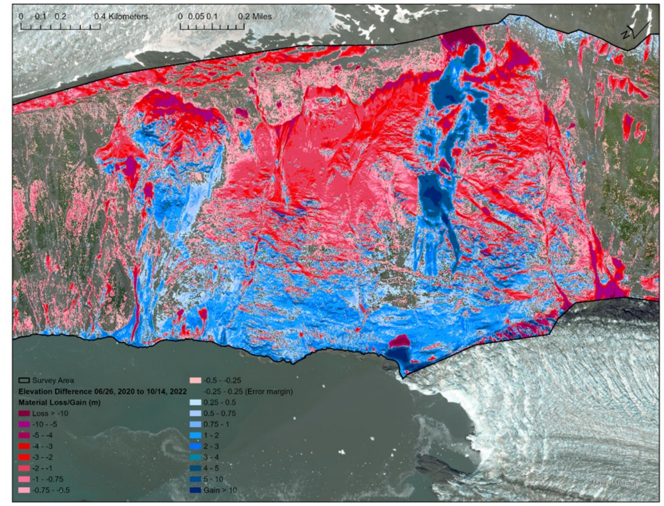



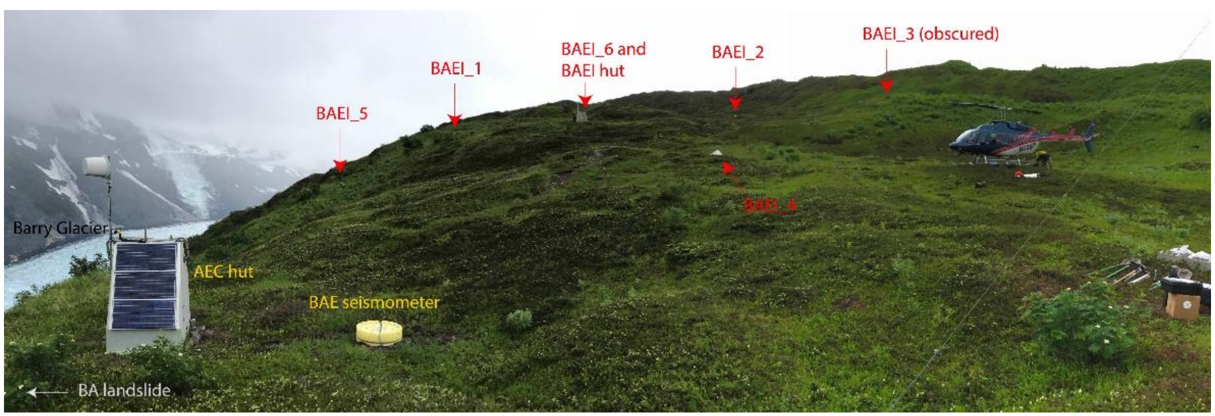

From Barnhart et al., 2021, U.S. Geological Survey Open-File Report 2021–1071, https://doi.org/10.3133/ofr20211071

# Landslide Surveillance



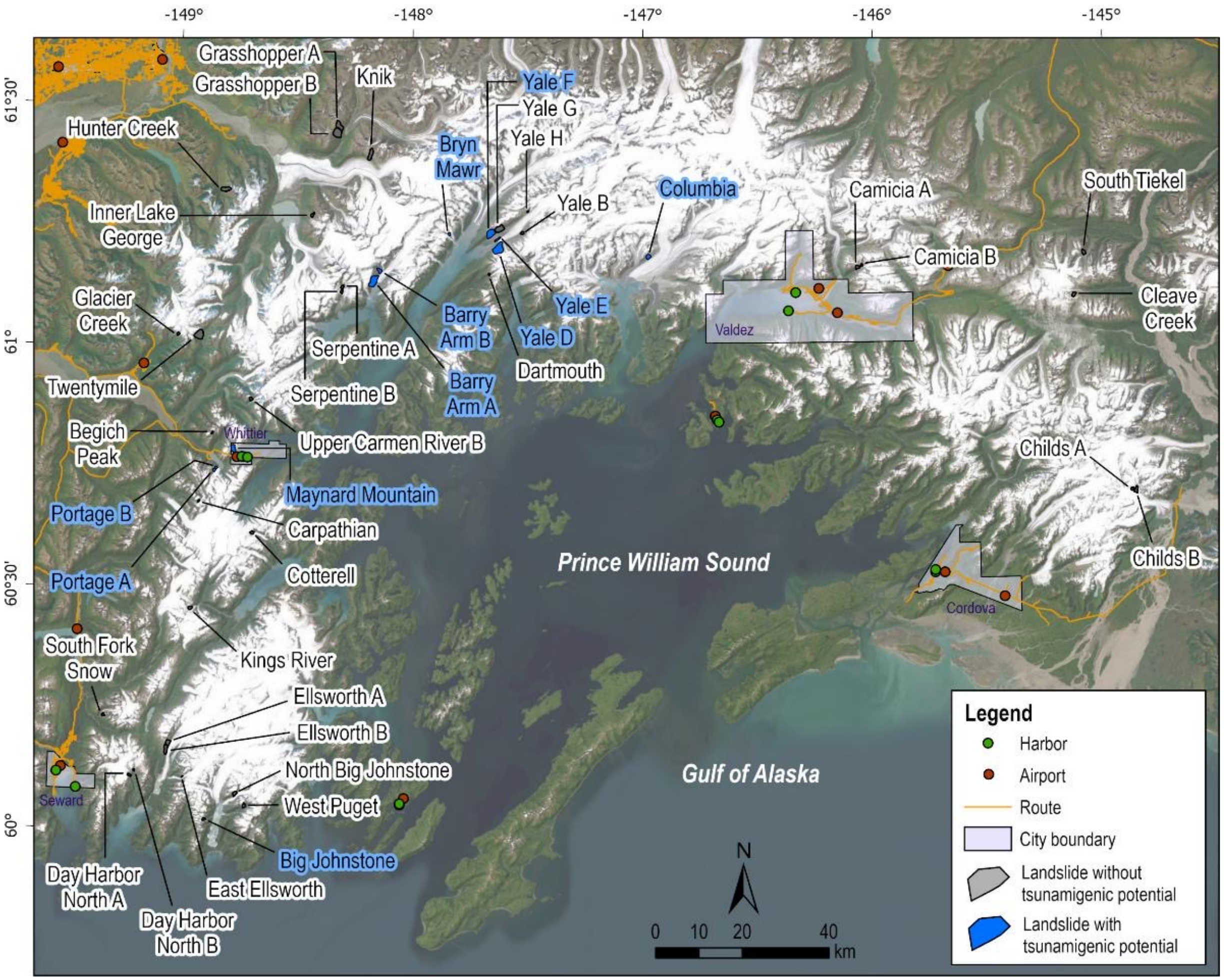






# Experimental Warning System

# Data Collection and Analysis – Landslide Inventory




SAR (displayed here): **43 landslides**

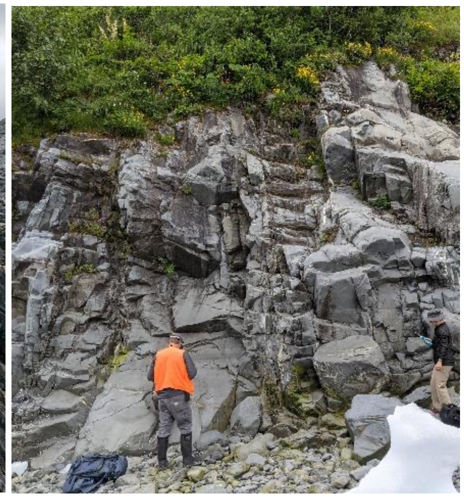
Optical imagery (northwestern PWS): **61**

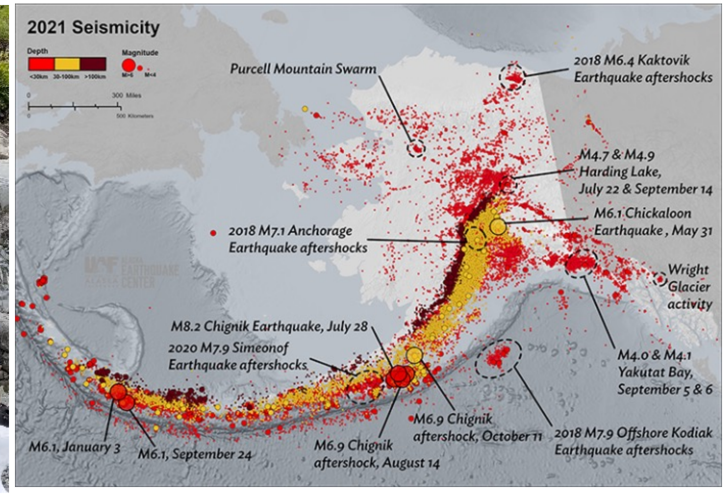
Overlap: **14**

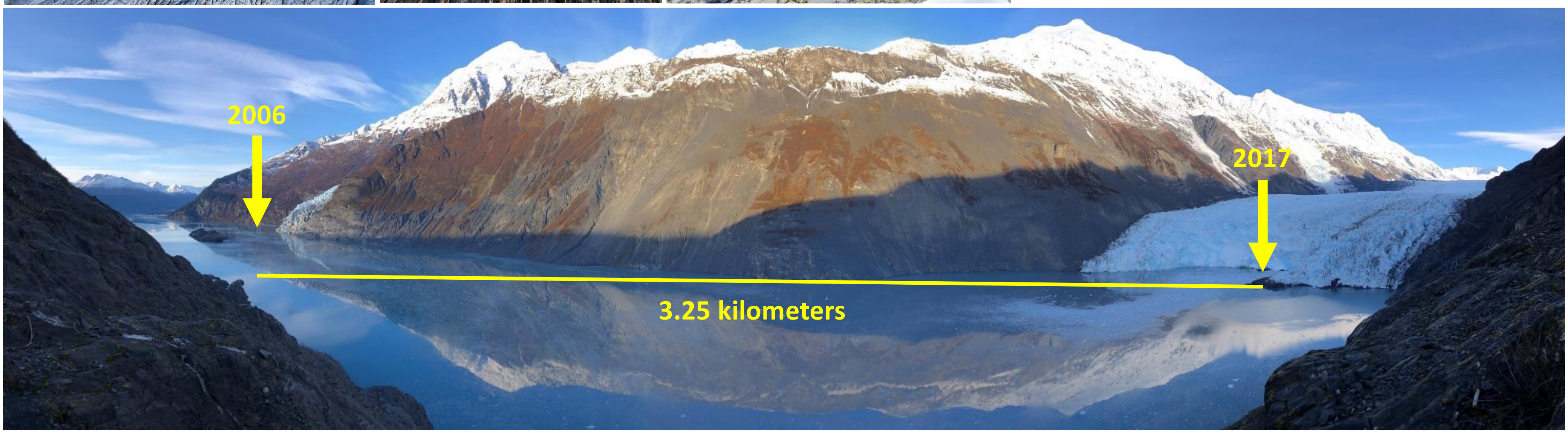
= **90 large, slow-moving landslides**

From Schaefer, et al., 2024, U.S. Geological Survey Open-File Report 2023-1099. https://doi.org/10.3133/ofr20231099

# Data Collection and Analysis - Inheritance and Conditioning





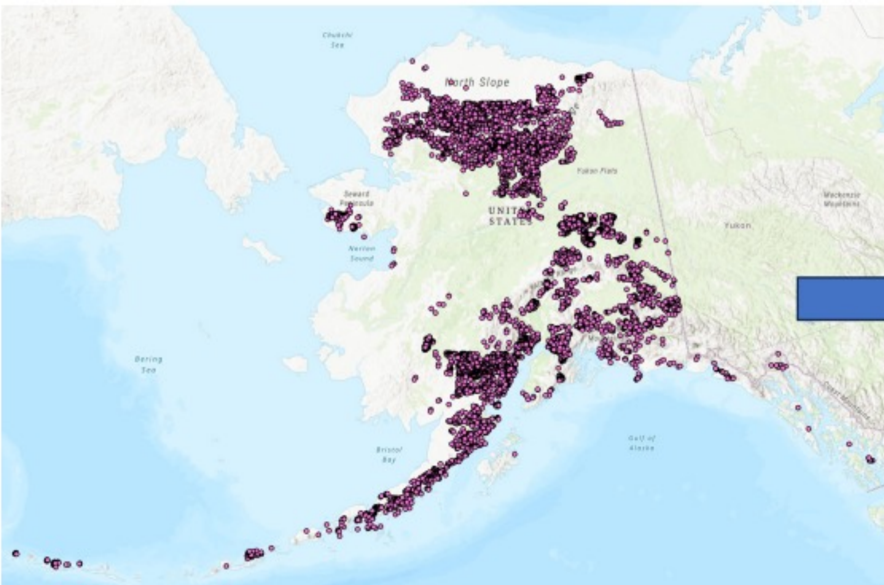
# Primary Objectives - SEAK

- Targeted research into the hydrometeorological conditions that contribute to landslide initiation in southeast Alaska.
- Near real-time availability of data from monitoring sites via NWIS.
- Scientific support of hazard awareness and messaging at NWS Juneau through interpretation of monitoring data and event reconstruction.
- Complement ongoing efforts at DGGS, SSSC, CCTH, and Kuti Project to identify, download, and analyze geospatial and hydrometeorological data that support monitoring network expansion, landslide inventories, and hazard assessment.
- In partnership with DGGS, formulate plan for strategic and sustainable short- and long-term monitoring in SEAK.

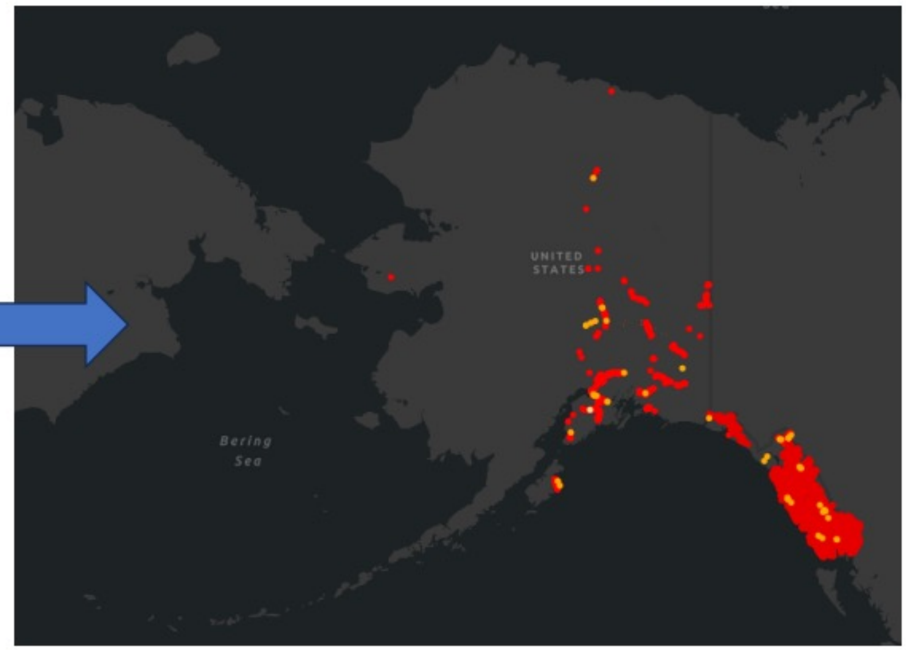

*Photo by B. Salisbury (DGGS)*

# Data Collection – Landslide Inventory

**Division of Geological & Geophysical Surveys**
**Alaska Landslide Inventory**




**U.S. Geological Survey**
**U.S. Landslide Inventory**

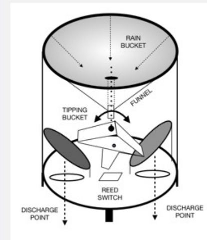


# Monitoring

**Soil Moisture Content**

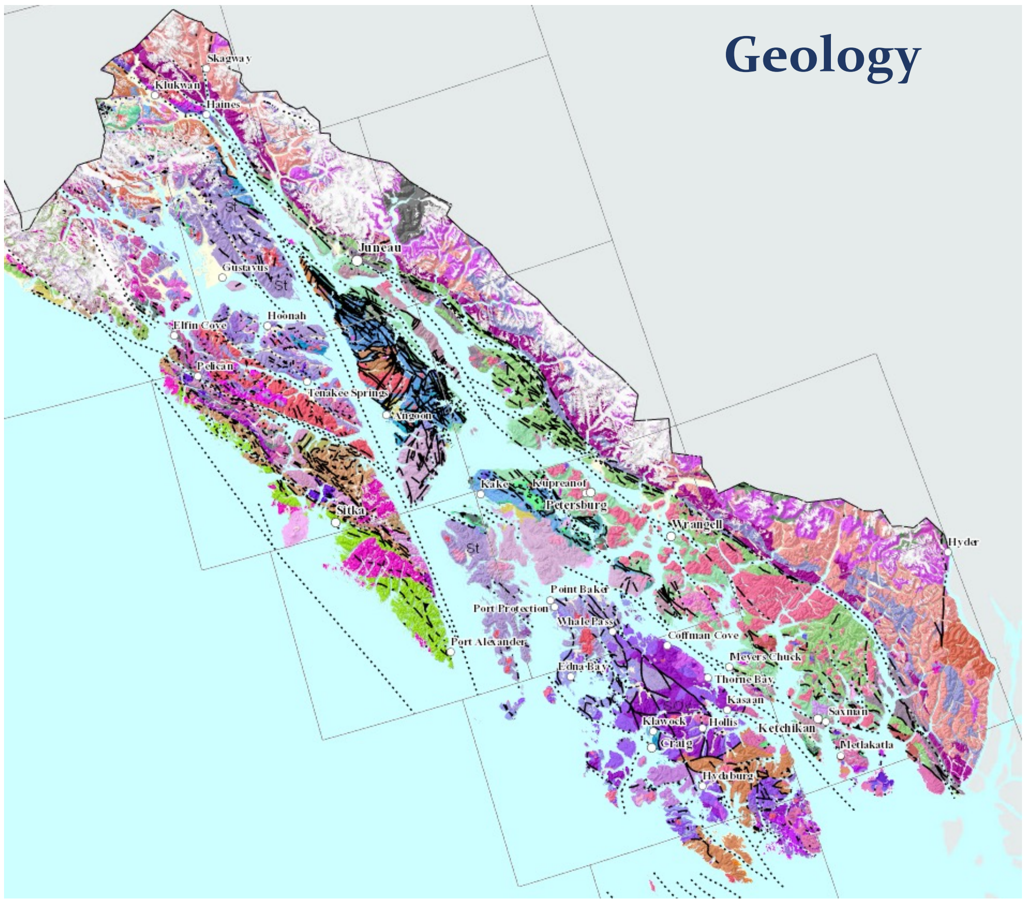
**Pore Pressure**

**Precipitation**

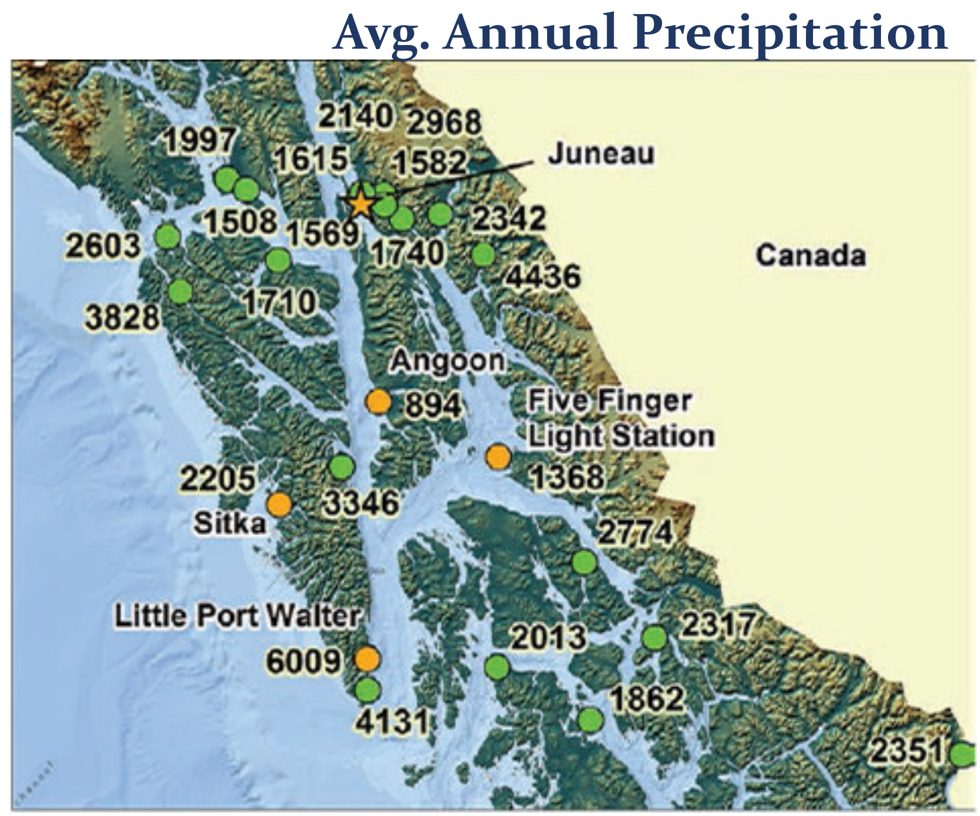



**Wind and Pressure**

# Challenges: Regional Variability and Representativeness




From Wilson Et al. (2015) Geologic Map of Alaska, Scientific Investigations Map 3340

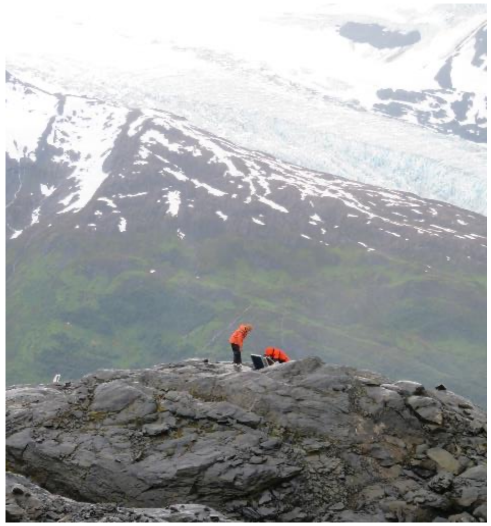



From Brettschneider and Trypaluk, 2016. Bull. Am. Met. Soc. 95, 1249-1256.

# Challenges: Local Variability and Representativeness

# Challenges: Data Availability and Access

# Questions?



USGS
science for a changing world

State of Alaska
Division of Geological & Geophysical Surveys

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

UAF
University of Alaska Fairbanks
Alaska Earthquake Center

Forest Service
U.S. Department of Agriculture

NRCS
Natural Resources Conservation Service

United States Coast Guard 1790

State of Alaska
Division of Homeland Security and Emergency Management

Transportation & Public Facilities
State of Alaska

Central Council of Tlingit & Haida Indian Tribes of Alaska
1935

Sitka Sound Science Center

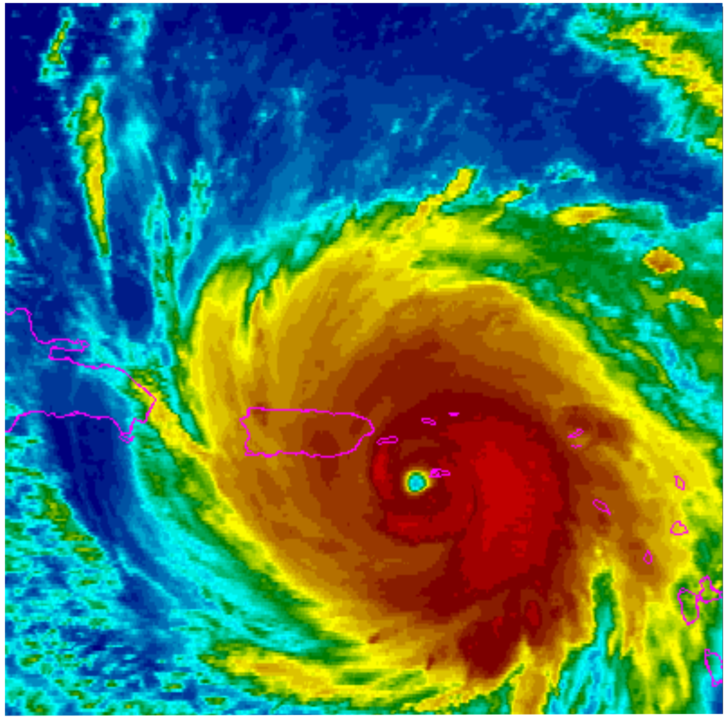
City of Whittier Alaska

City of Valdez, Alaska
Opportunities in Every Season

City & Borough of Juneau
Alaska's Capital City
Unified July 1, 1970

AEL&P
since 1893
Alaska Electric Light & Power Co.

# Puerto Rico Landslide Hazard Mitigation Office



01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Who are we?

Puerto Rico Landslide Haz. Mitigation Office at the Univ. of P.R. Mayaguez

- **Mision:** To conduct ongoing research and community engagement activities related to landslide hazards in Puerto Rico.

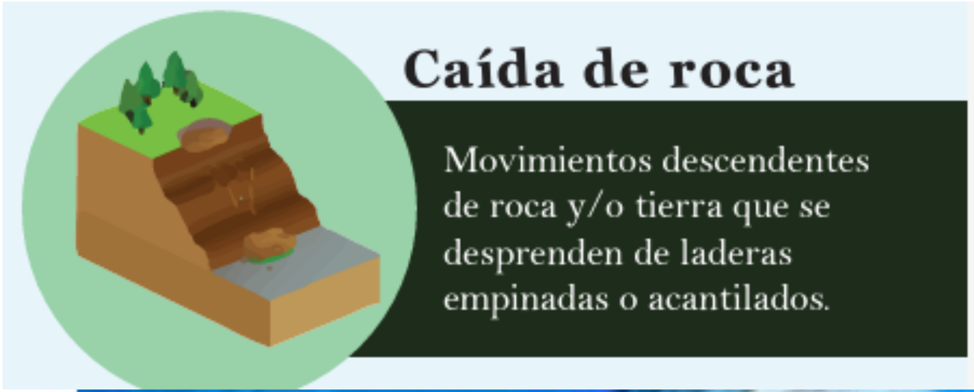
- **Vision:** To provide science and preparedness for landslide hazards in Puerto Rico.

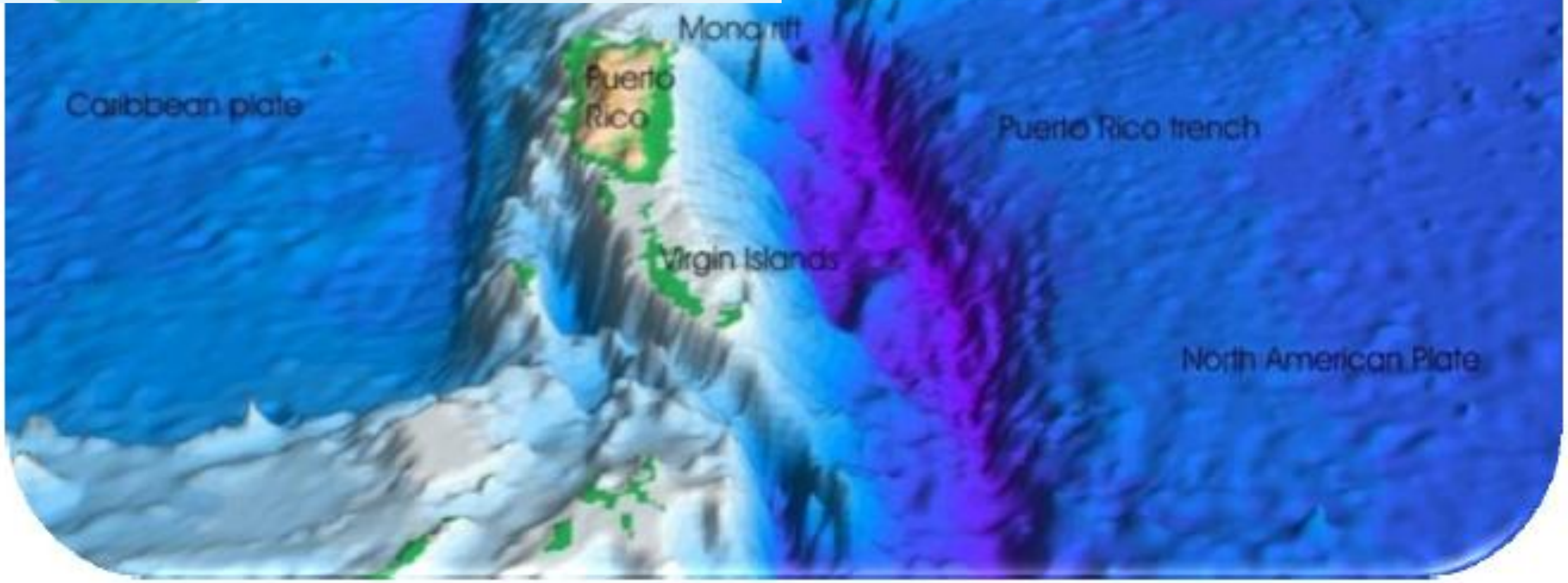
# Creation of the Puerto Rico Landslide Hazard Mitigation Office

- Landslides in Puerto Rico are common, and their severity ranges from nuisance to life-threatening.
- There was no local organized effort to carry out landslide science or monitoring, or to train communities in landslide hazard assessment, preparation, and response.
- SLIDES-PR Project launched after Hurricane Maria in 2017.

ure 2. Headscarp and body of the large block landslide in 1985 at Mameyes, Ponce, Puerto Rico (18.024, –66.619). Photograph taken October 1985 by Ja
versity of Puerto Rico at Mayagüez, used with permission. View is looking west.

# Landsliding in Puerto Rico




- Rockfall
- Much more common during seismic events
- More common in our limestone geological formations

Derrumbe.net




Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Landsliding in Puerto Rico


PR-2
Ponce/Peñuelas, PR
January 2020

- **Rockfall**
  - Much more common during seismic events
  - More common in our limestone geological formations

Derrumbe.net




Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Landsliding in Puerto Rico


- Debris Flow
  - Much more common during atmospheric events
  - More common in our volcanic/sedimentary geological formations

Derrumbe.net



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Landsliding in Puerto Rico

- # Debris Flow
- Much more common during atmospheric events
- More common in our volcanic/sedimentary geological formations

Derrumbe.net



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Landsliding in Puerto Rico

Rio Grande de Manati
September 2017

Lago Dos Bocas
September 2017

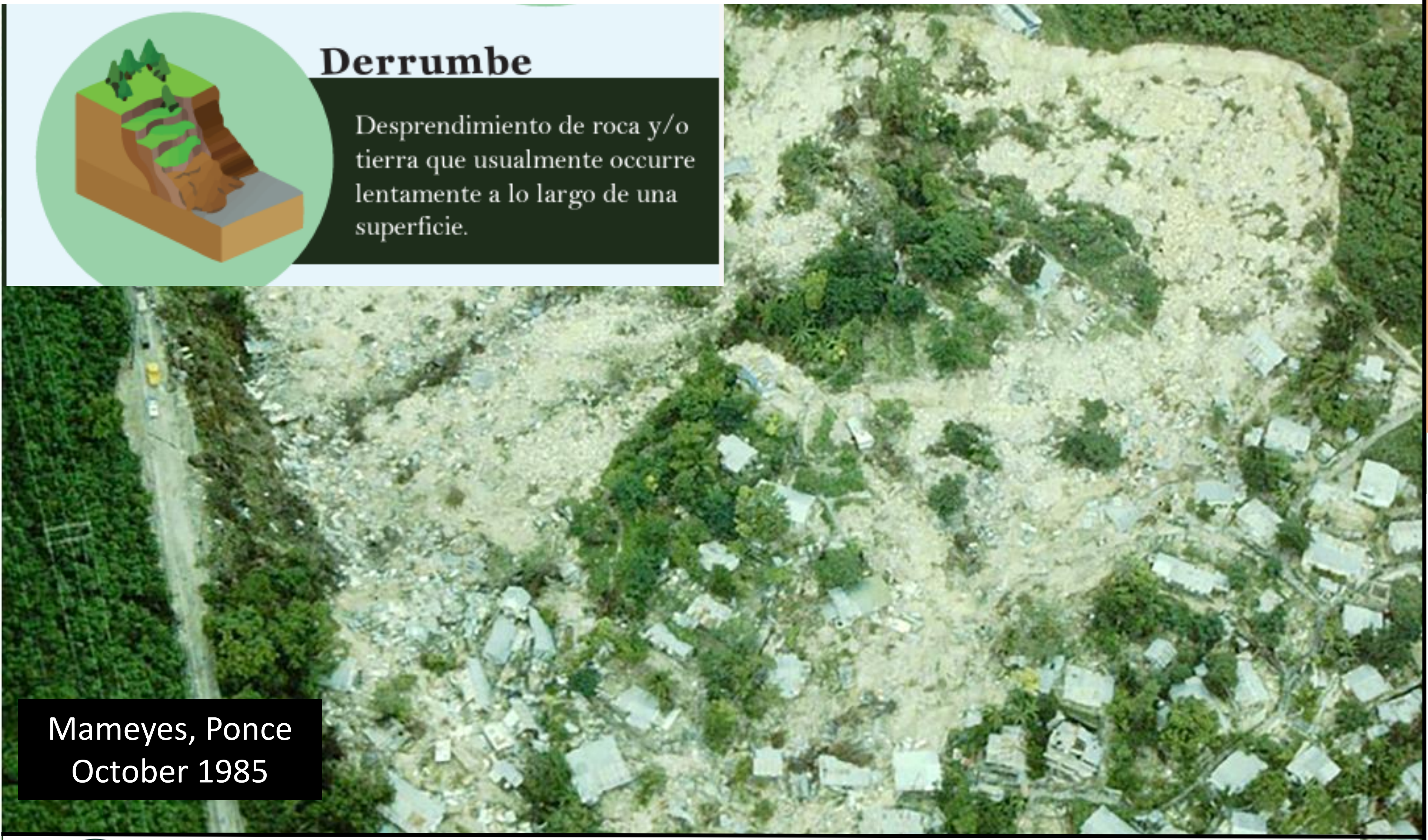
- **Debris Flow**
- Much more common during atmospheric events
- More common in our volcanic/sedimentary geological formations

Derrumbe.net



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Landsliding in Puerto Rico




Mameyes, Ponce
October 1985

- Landslide
  - Can be deeper
  - They can limit access to communities, communications, services, water, electricity

Derrumbe.net



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

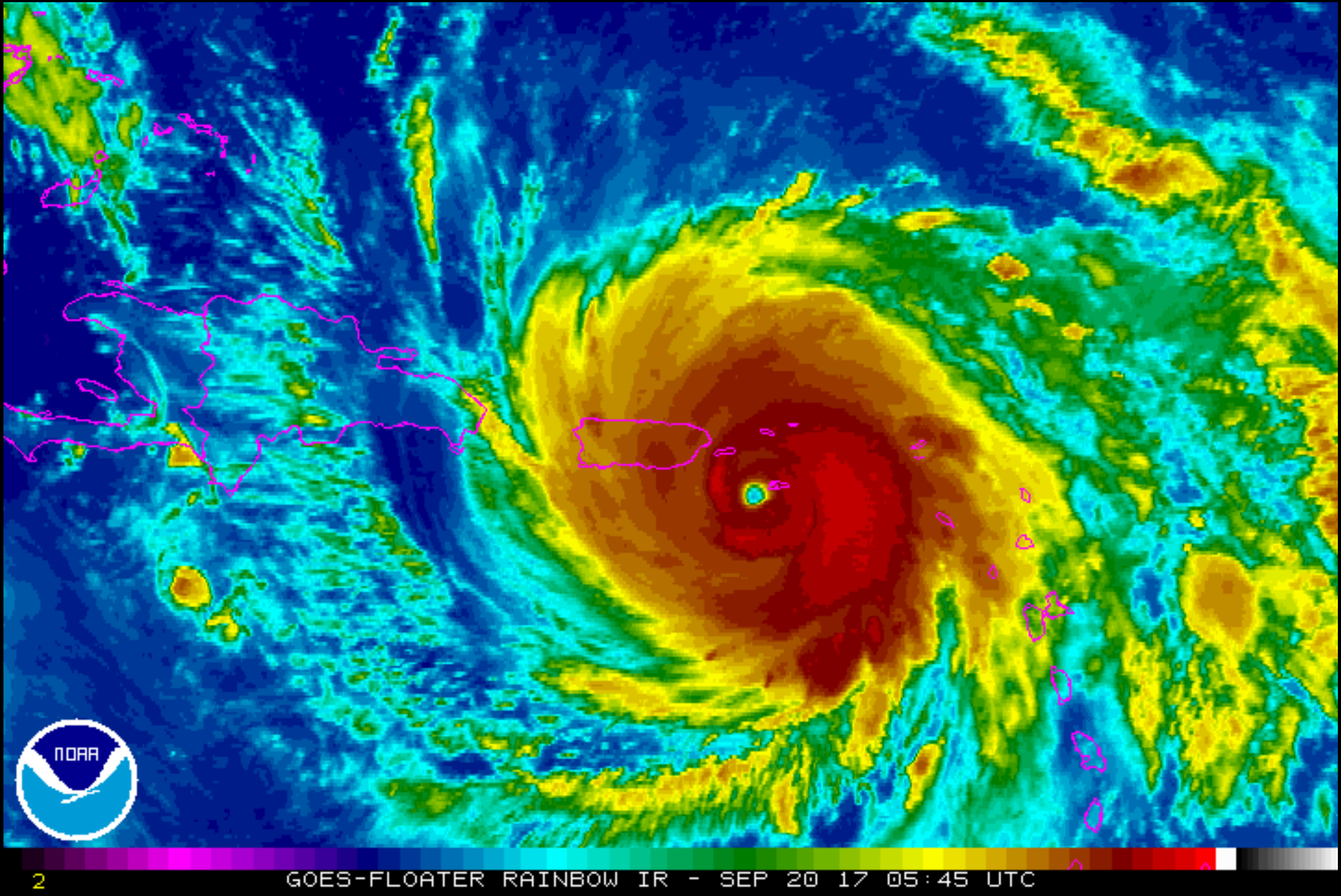
# Landsliding in Puerto Rico


- **Landslide**
- Can be deeper
- They can limit access to communities, communications, services, water, electricity

Derrumbe.net



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez


NOAA
2
GOES-FLOATER RAINBOW IR - SEP 20 17 05:45 UTC

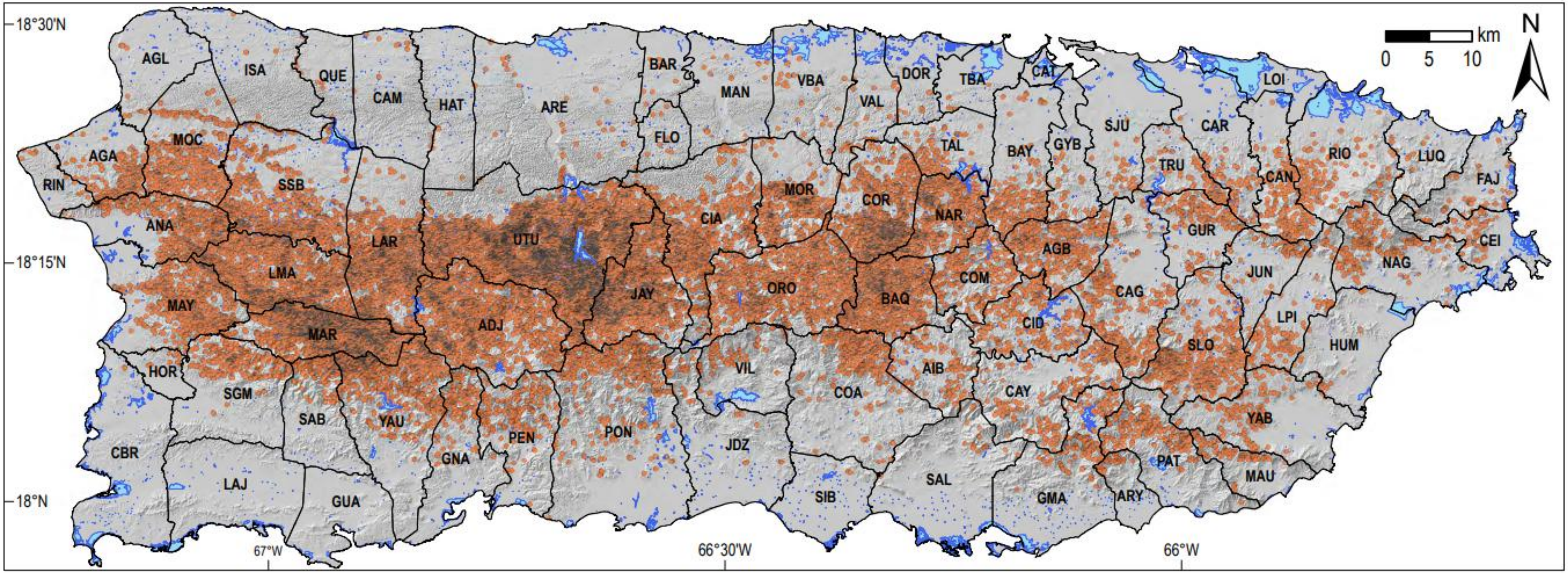



**Figure 12.** Hurricane María event slope failure inventory (Hughes and others, 2019). Each small circle represents one landslide site. There are 71,431 sites in the inventory. Explanation of municipality abbreviations can be found in appendix 1. (km, kilometer)

Hughes, K.S., Bayouth García, D., Martínez Milian, G.O., Schulz, W.H., and Baum, R.L., 2019, Map of slope-failure locations in Puerto Rico after Hurricane María: U.S. Geological Survey data release, https://doi.org/10.5066/P9BVMD74.

USGS
science for a changing world

RECINTO UNIVERSITARIO DE MAYAGÜEZ
UNIVERSIDAD DE PUERTO RICO

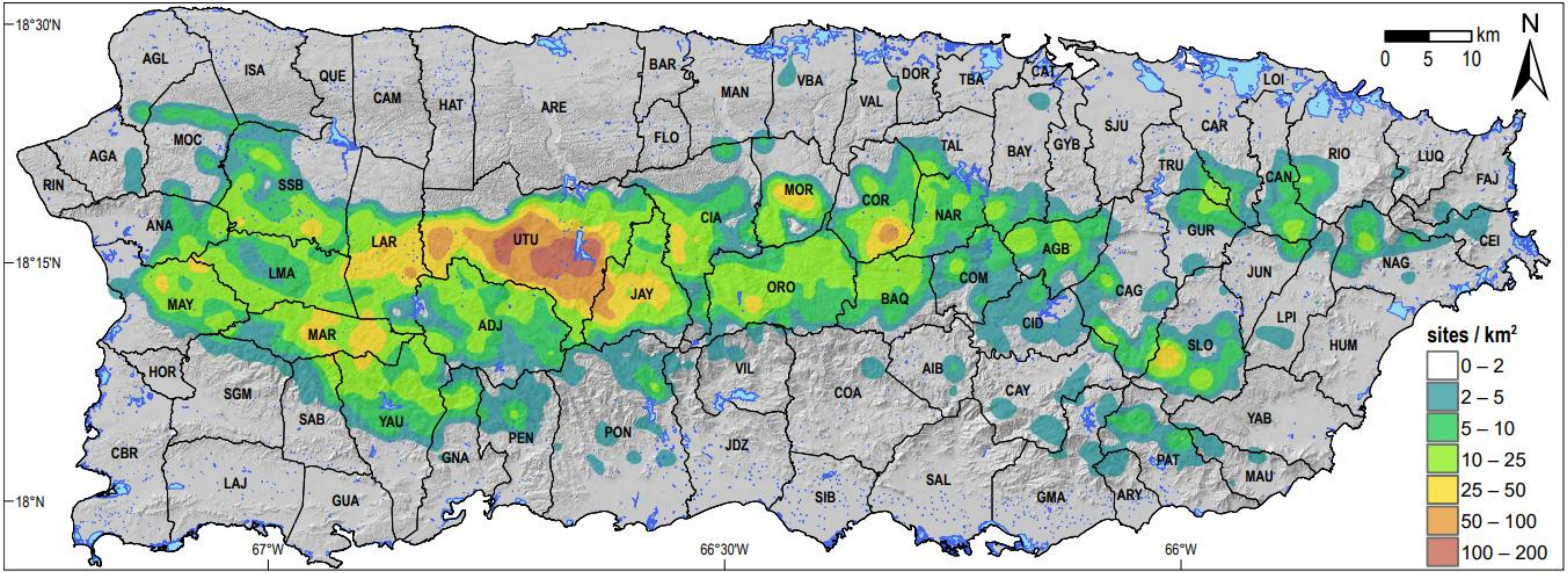


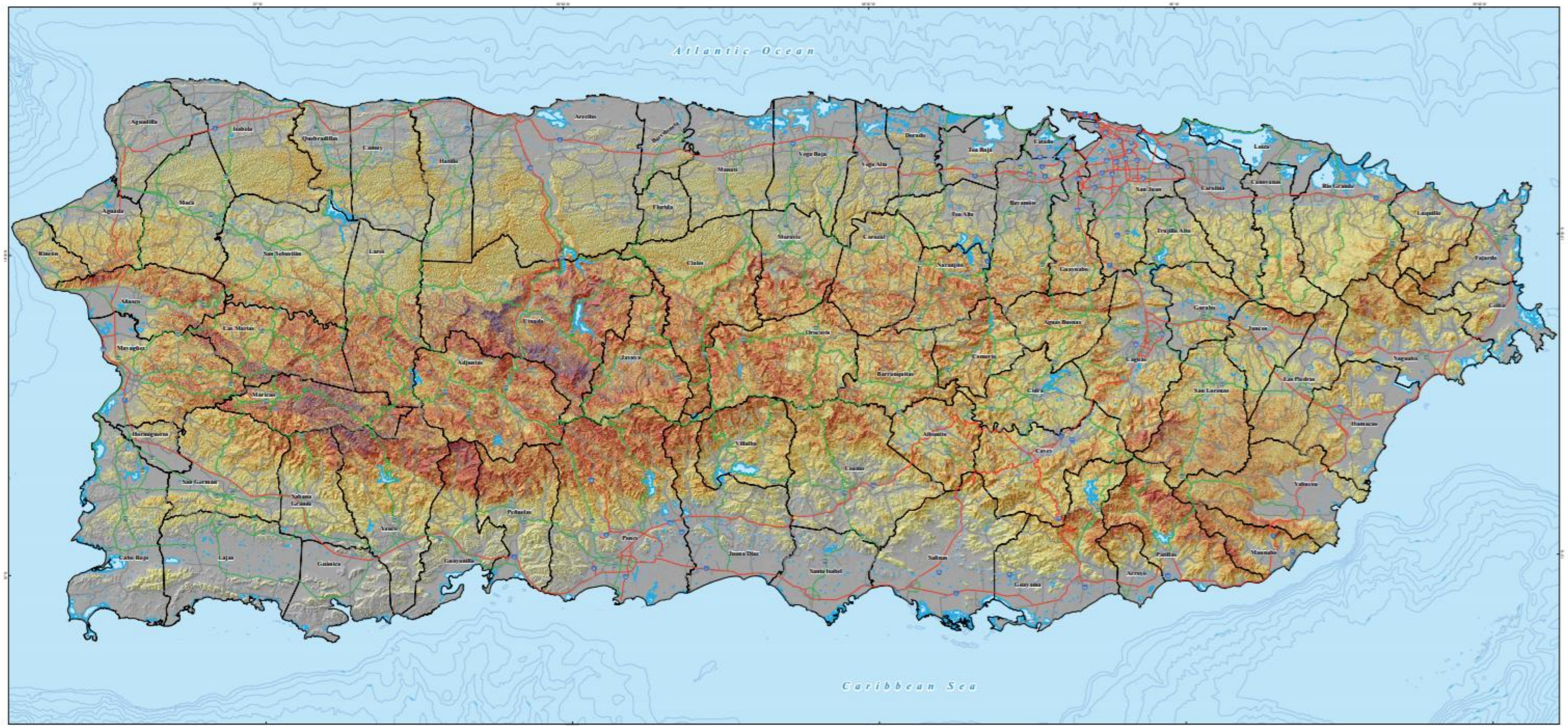

**Figure 13.** Density of landslide sites from the Hurricane María event inventory. Point data from Hughes and others (2019) were used to determine the spatial density of the points, which is shown in the figure. The figure was created with kernel density technique using a 2-km-diameter window. Explanation of municipality abbreviations can be found in appendix 1. (km, kilometer; km$^2$, square kilometer)

Hughes, K.S., Bayouth García, D., Martínez Milian, G.O., Schulz, W.H., and Baum, R.L., 2019, Map of slope-failure locations in Puerto Rico after Hurricane María: U.S. Geological Survey data release, https://doi.org/10.5066/P9BVMD74.

USGS
Open-File Report
2020-1022

Replaces 1979 hand-drawn susceptibility map for Puerto Rico.

U.S. Department of the Interior
U.S. Geological Survey




# Map Depicting Susceptibility to Landslides Triggered by Intense Rainfall, Puerto Rico

By

K. Stephen Hughes[1] and William H. Schulz[2]

2020

science for a changing world

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez


USGS
Open-File Report
2020-1022

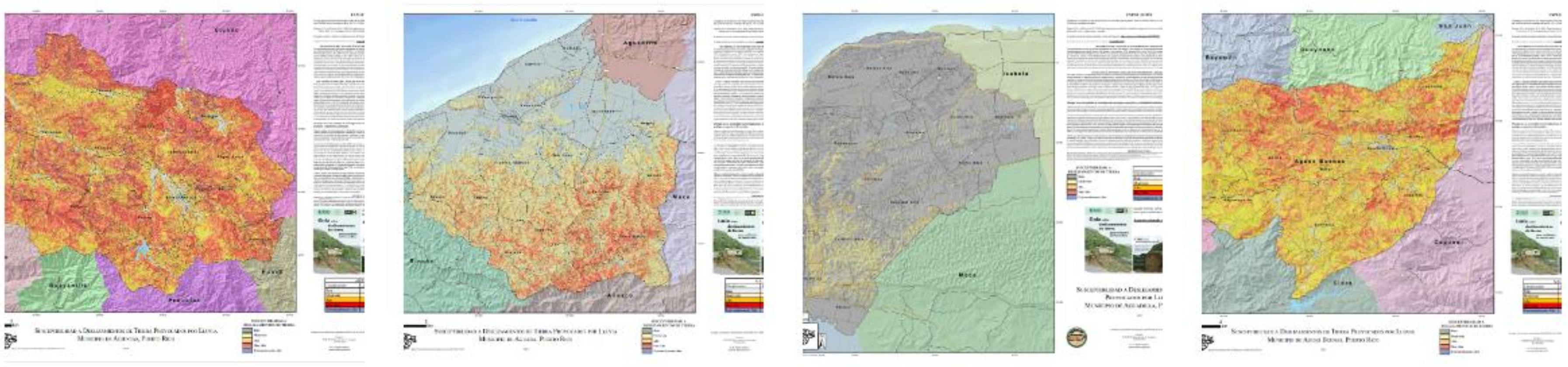
Replaces 1979 hand-drawn susceptibility map for Puerto Rico.

Derrumbe.net

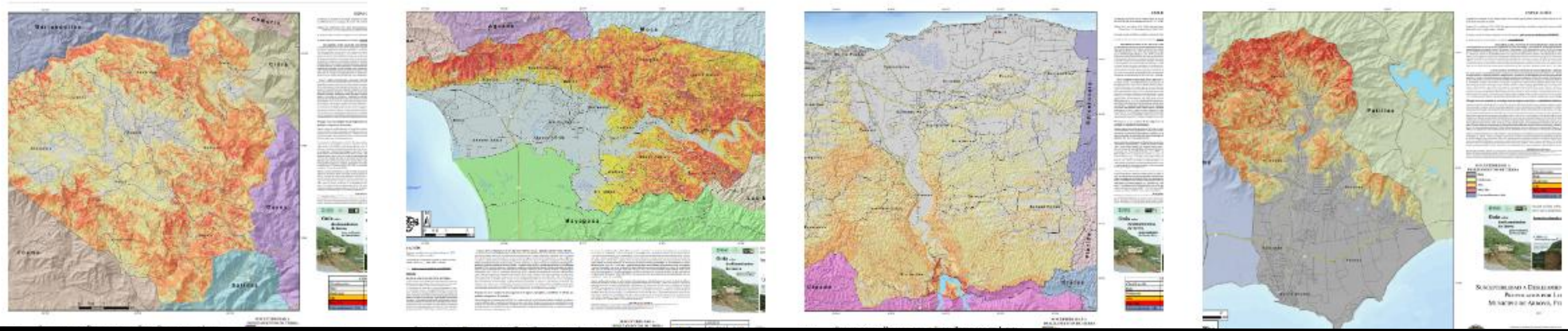
01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Municipal maps
# Interactive online map



Adjuntas Aguada Aguadilla Aguas Buenas



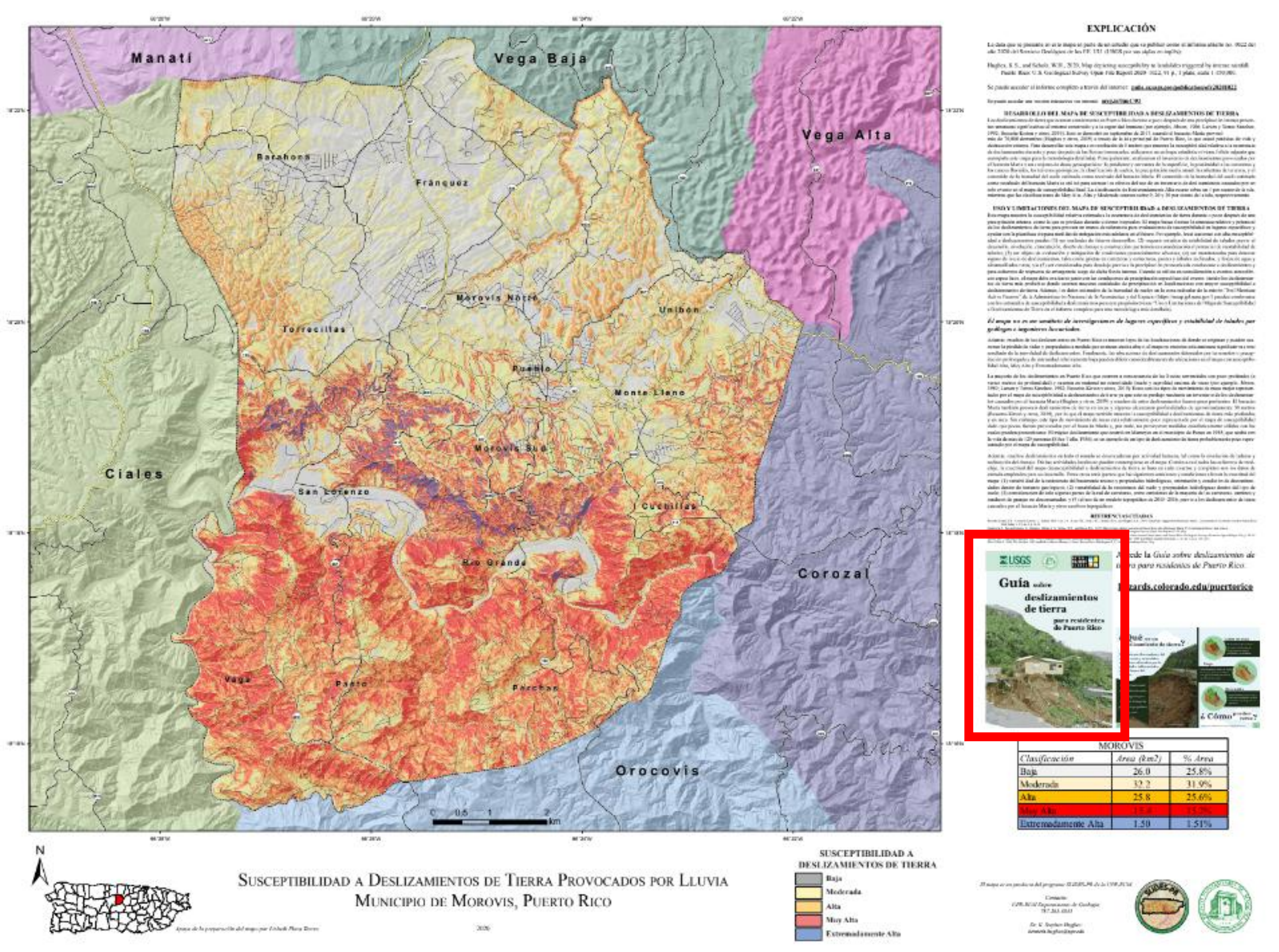
USGS
Open-File Report
2020-1022

Replaces 1979 hand-drawn susceptibility map for Puerto Rico.

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

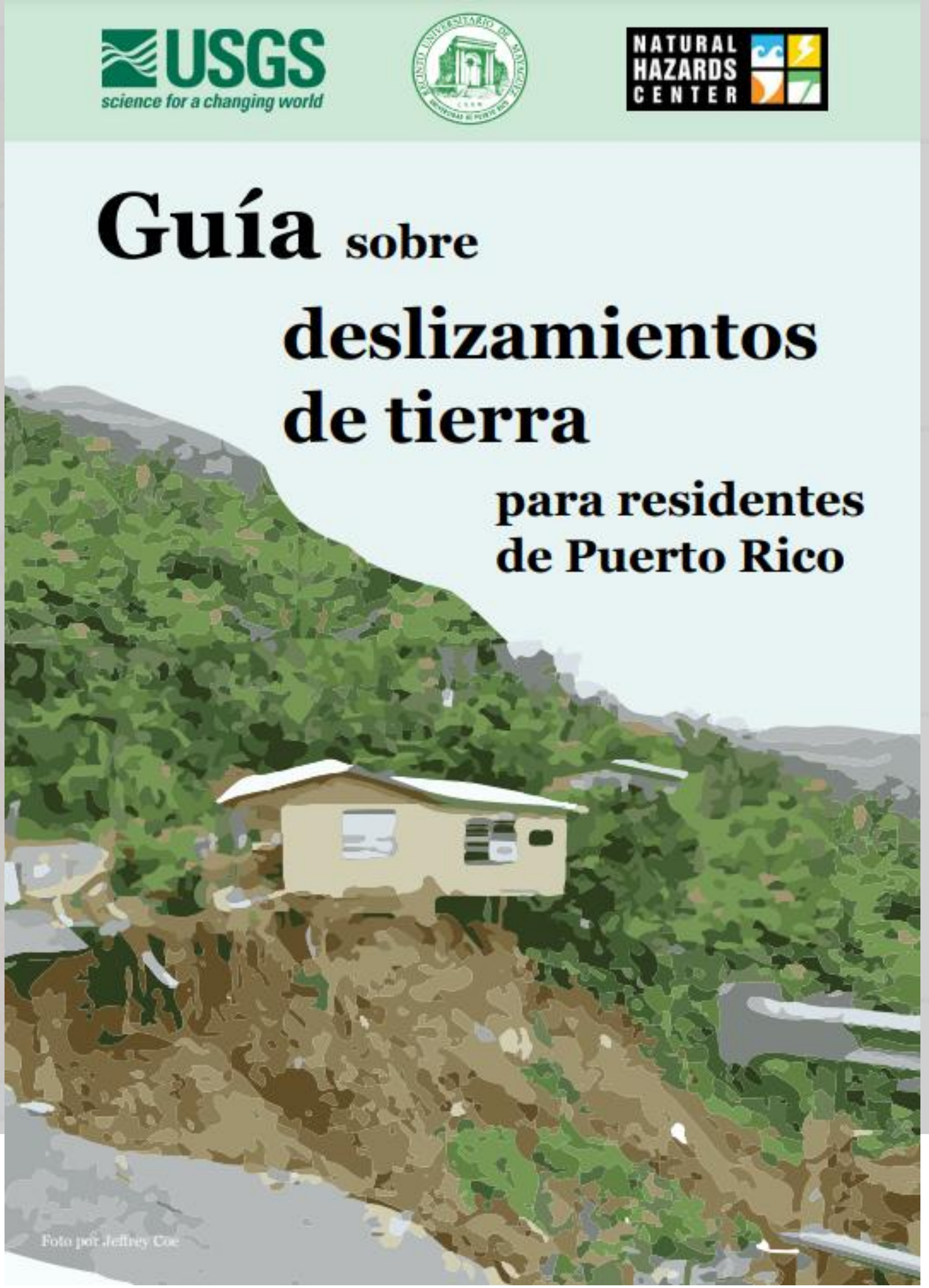
Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez




USGS
Open-File Report
2020-1022

Replaces 1979 hand-drawn susceptibility map for Puerto Rico.

Derrumbe.net




Landslide Guide about landslides for residents of Puerto Rico

UPRM/USGS/CU-Boulder

Lindsay Davis, Jocelyn West, Raquel Lugo, Yahaira Alvarez

Derrumbe.net

Received: 25 February 2020 | Accepted: 12 August 2020
DOI: 10.1002/hyp.13885

RESEARCH ARTICLE

WILEY

# Hillslopes in humid-tropical climates aren't always wet: Implications for hydrologic response and landslide initiation in Puerto Rico

Matthew A. Thomas | Benjamin B. Mirus | Joel B. Smith

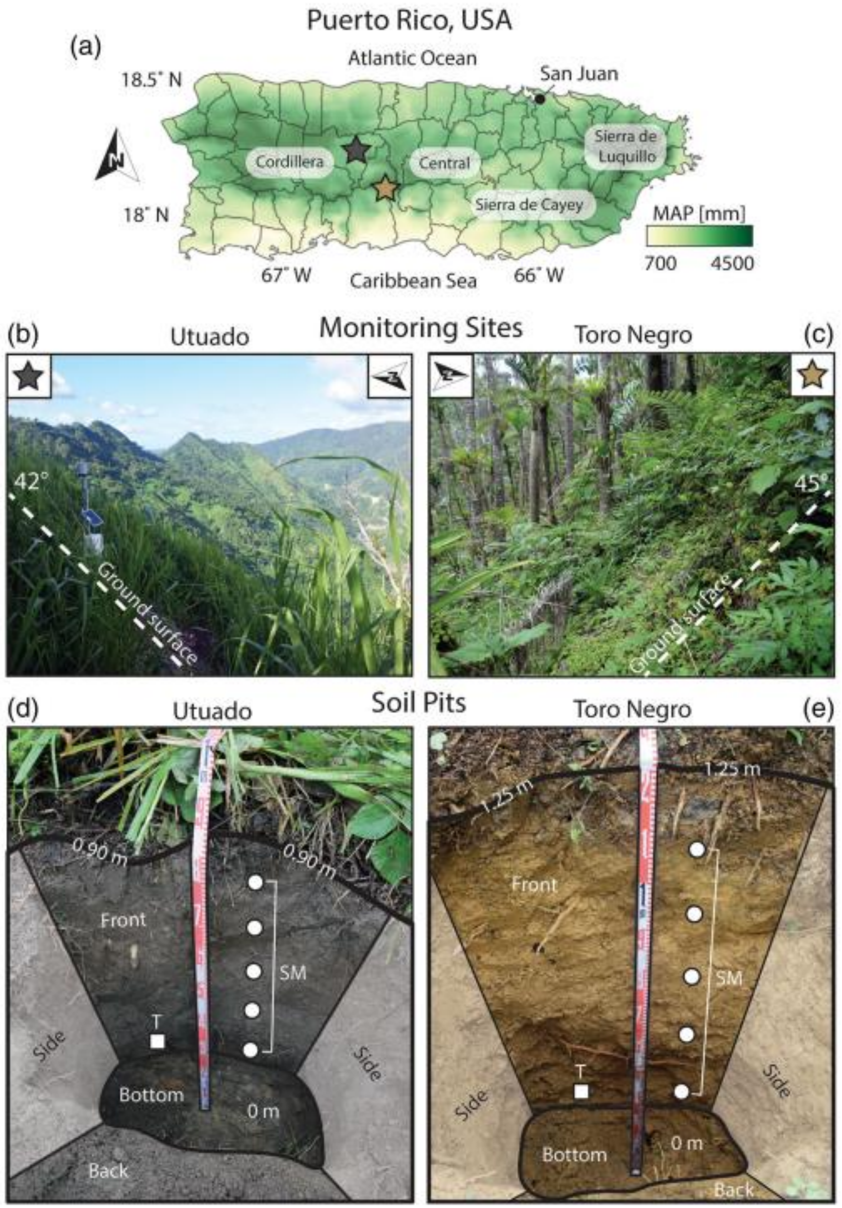
Geologic Hazards Science Center, U.S. Geological Survey, Golden, Colorado

**Correspondence**
Matthew A. Thomas, Geologic Hazards Science Center, U.S. Geological Survey, Box 25046, Denver Federal Center, MS 966, Denver, CO 80225.
Email: matthewthomas@usgs.gov

**Abstract**

The devastating impacts of the widespread flooding and landsliding in Puerto Rico following the September 2017 landfall of Hurricane Maria highlight the increasingly extreme atmospheric disturbances and enhanced hazard potential in mountainous humid-tropical climate zones. Long-standing conceptual models for hydrologically driven hazards in Puerto Rico posit that hillslope soils remain wet throughout the year, and therefore, that antecedent soil wetness imposes a negligible effect on hazard potential. Our post-Maria in situ hillslope hydrologic observations, however, indicate that while some slopes remain wet throughout the year, others exhibit appreciable seasonal and intra-storm subsurface drainage. Therefore, we evaluated the performance of hydro-meteorological (soil wetness and rainfall) versus intensity-duration (rainfall only) hillslope hydrologic response thresholds that identify the onset of positive pore-water pressure, a predisposing factor for widespread slope instability in this region. Our analyses also consider the role of soil-water storage and infiltration rates on runoff generation, which are relevant factors for flooding hazards. We found that the hydro-meteorological thresholds outperformed intensity-duration thresholds for a seasonally wet, coarse-grained soil, although they did not outperform intensity-duration thresholds for a perennially wet, fine-grained soil. These end-member soils types may also produce radically different stormflow responses, with subsurface flow being more common for the coarse-grained soils underlain by intrusive rocks versus infiltration excess and/or saturation excess for the fine-grained soils underlain by volcaniclastic rocks. We conclude that variability in soil-hydraulic properties, as opposed to climate zone, is the dominant factor that controls runoff generation mechanisms and modulates the relative importance of antecedent soil wetness for our hillslope hydrologic response thresholds.

KEYWORDS
flooding, hillslope hydrology, humid-tropical climate, in situ monitoring, landslides, thresholds




USGS Hydrometeorological Monitoring in Puerto Rico

Two stations

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

Received: 25 February 2020 | Accepted: 12 August 2020
DOI: 10.1002/hyp.13885

RESEARCH ARTICLE

WILEY

# Hillslopes in humid-tropical climates aren't always wet: Implications for hydrologic response and landslide initiation in Puerto Rico

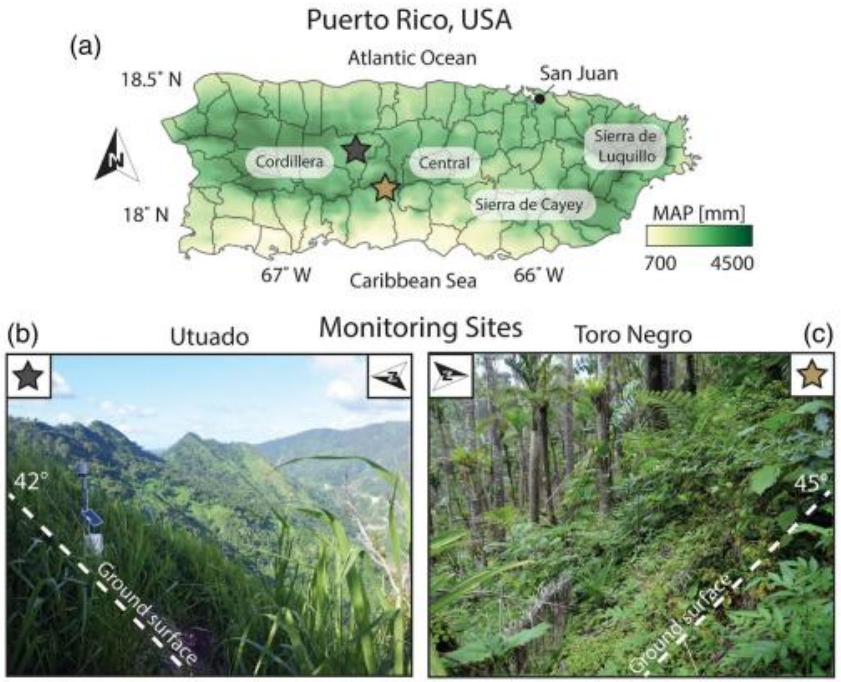
Matthew A. Thomas | Benjamin B. Mirus | Joel B. Smith

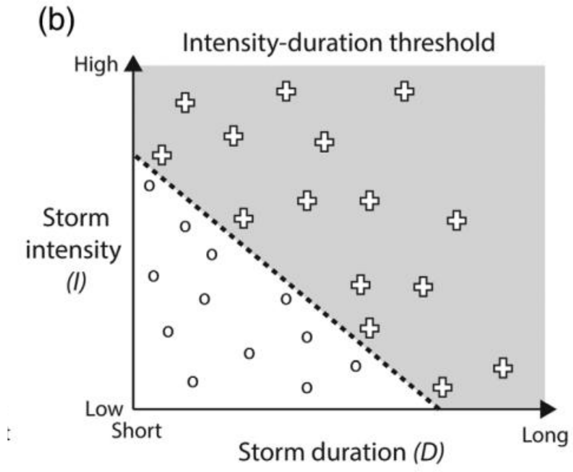
Geologic Hazards Science Center, U.S. Geological Survey, Golden, Colorado

**Correspondence**
Matthew A. Thomas, Geologic Hazards Science Center, U.S. Geological Survey, Box 25046, Denver Federal Center, MS 966, Denver, CO 80225.
Email: matthewthomas@usgs.gov

**Abstract**
The devastating impacts of the widespread flooding and landsliding in Puerto Rico following the September 2017 landfall of Hurricane Maria highlight the increasingly extreme atmospheric disturbances and enhanced hazard potential in mountainous humid-tropical climate zones. Long-standing conceptual models for hydrologically driven hazards in Puerto Rico posit that hillslope soils remain wet throughout the year, and therefore, that antecedent soil wetness imposes a negligible effect on hazard potential. Our post-Maria in situ hillslope hydrologic observations, however, indicate that while some slopes remain wet throughout the year, others exhibit appreciable seasonal and intra-storm subsurface drainage. Therefore, we evaluated the performance of hydro-m
duration (rainfall only) hillslop
of positive pore-water pressu
in this region. Our analyses al
rates on runoff generation, w
that the hydro-meteorologica
for a seasonally wet, coarse-
duration thresholds for a per
types may also produce radic
being more common for the
infiltration excess and/or sa
volcaniclastic rocks. We co
opposed to climate zone, is
mechanisms and modulates
our hillslope hydrologic respo

KEYWORDS
flooding, hillslope hydrology, hum




USGS Hydrometeorological Monitoring in Puerto Rico

Two stations

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

Received: 25 February 2020 | Accepted: 12 August 2020
DOI: 10.1002/hyp.13885

RESEARCH ARTICLE

WILEY

# Hillslopes in humid-tropical climates aren't always wet: Implications for hydrologic response and landslide initiation in Puerto Rico

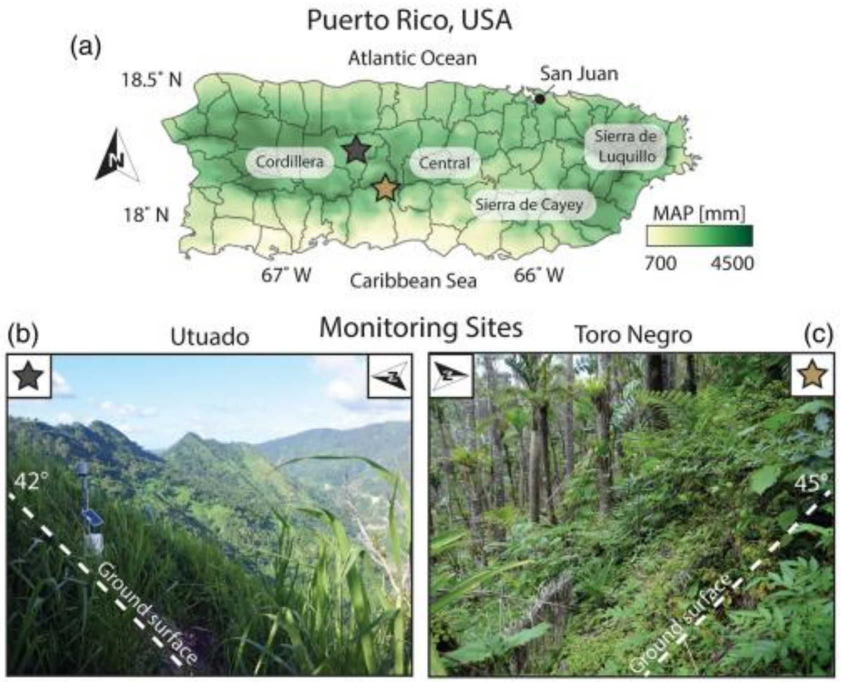
Matthew A. Thomas | Benjamin B. Mirus | Joel B. Smith

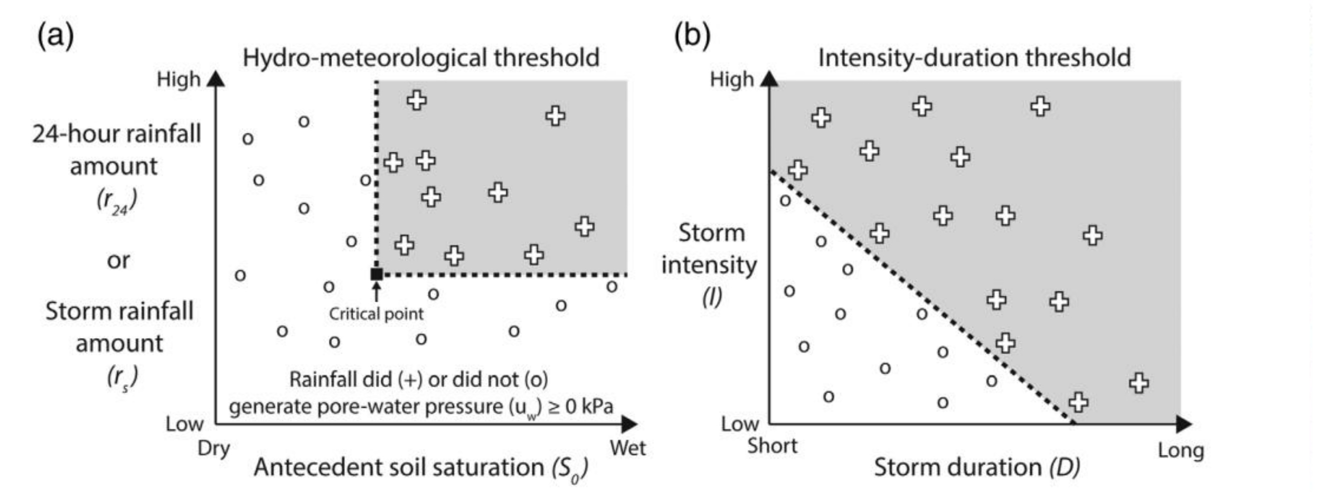
Geologic Hazards Science Center, U.S. Geological Survey, Golden, Colorado

**Correspondence**
Matthew A. Thomas, Geologic Hazards Science Center, U.S. Geological Survey, Box 25046, Denver Federal Center, MS 966, Denver, CO 80225.
Email: matthewthomas@usgs.gov

**Abstract**
The devastating impacts of the widespread flooding and landsliding in Puerto Rico following the September 2017 landfall of Hurricane Maria highlight the increasingly extreme atmospheric disturbances and enhanced hazard potential in mountainous humid-tropical climate zones. Long-standing conceptual models for hydrologically driven hazards in Puerto Rico posit that hillslope soils remain wet throughout the year, and therefore, that antecedent soil wetness imposes a negligible effect on hazard potential. Our post-Maria in situ hillslope hydrologic observations, however, indicate that while some slopes remain wet throughout the year, others exhibit appreciable seasonal and intra-storm subsurface drainage. Therefore, we evaluated the performance of hydro-m
duration (rainfall only) hillslop
of positive pore-water pressu
in this region. Our analyses al
rates on runoff generation, w
that the hydro-meteorologica
for a seasonally wet, coarse-g
duration thresholds for a per
types may also produce radic
being more common for the
infiltration excess and/or sa
volcaniclastic rocks. We co
opposed to climate zone, is
mechanisms and modulates
our hillslope hydrologic respo

KEYWORDS
flooding, hillslope hydrology, hum




# USGS Hydrometeorological Monitoring in Puerto Rico

Two stations

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

REGISTRO DE CONTRATOS
TOMO 31 PAGINA 40
CONTRATO NUM. 2022-000088

LETTER OF AGREEMENT

BETWEEN

THE LANDSLIDE HAZARDS PROGRAM
OF THE
UNITED STATES GEOLOGICAL SURVEY
OF THE
DEPARTMENT OF THE INTERIOR
OF THE
UNITED STATES OF AMERICA

AND

THE UNIVERSITY OF PUERTO RICO MAYAGÜEZ

PURPOSE

This Letter of Agreement (LOA) serves to outline and facilitate the development of a long-term hydrological soil monitoring network project in Puerto Rico and the U.S. Virgin Islands between the **U.S. Geological Survey (USGS) Landslide Hazards Program (LHP)** represented by its Coordinator Jonathan Godt, of legal age, married, and resident of Colorado, and the **University of Puerto Rico Mayagüez (UPRM),** an institutional unit of the University of Puerto Rico, a Public Corporation created by Puerto Rico Public Law Number 1 of January 20, 1966, as amended, represented by its Chancellor, Agustín Rullán Toro, of legal age, married, and resident of Cabo Rojo, Puerto Rico (hereinafter referred to as "Party" or "Parties"). The project is associated with the Storm-induced Landslide Impact Dynamics on Environment and Society in Puerto Rico (SLIDES-PR) research endeavor of the Department of Geology (GEOL) at UPRM, and with USGS LHP efforts to reduce landslide hazards in Puerto Rico. The project is intended to support collaborative hydrological soil monitoring, results from which may be used to aid development of hydrologic thresholds for the onset of widespread landsliding.

BACKGROUND

Landslides are a common occurrence in Puerto Rico and often impact property, infrastructure, and human life. The combination of the island's geology, topography, and geographic setting make for a landscape that is especially susceptible to mass wasting. Landslides can be secondary effects of other major natural phenomena like earthquake shaking or intense rainfall, often associated with tropical cyclones. In the absence of a state-level geological survey, most landslide hazard science in the island has historically been carried out by the USGS; however, in recent years, the USGS LHP has successfully partnered with the UPRM GEOL SLIDES-PR project to further advance landslide science and public outreach in the territory. This collaboration has included the publication of a digital inventory of over 70,000 landslide sites triggered by Hurricane Maria in 2017 (Hughes et al., 2019), a new landslide guide for residents of Puerto Rico, and a new high-resolution landslide susceptibility map for the island (Hughes and Schulz, 2020).

1 of 5

NOTICE OF AWARD

1. DATE ISSUED MM/DD/YYYY 07/28/2023
1a. SUPERSEDES AWARD NOTICE dated except that any additions or restrictions previously imposed remain in effect unless specifically rescinded
2. CFDA NO. 15.808 - US Geological Survey
3. ASSISTANCE TYPE Cooperative Agreement
4. GRANT NO. G23AC00479-00
Originating MCA #
5. TYPE OF AWARD Research
4a. FAIN G23AC00479
5a. ACTION TYPE New
6. PROJECT PERIOD MM/DD/YYYY From 08/01/2023 Through MM/DD/YYYY 07/31/2026
7. BUDGET PERIOD MM/DD/YYYY From 08/01/2023 Through MM/DD/YYYY 07/31/2024

AUTHORIZATION (Legislation/Regulations)
Title Organic Act of 1879, 43 U.S.C. 31, 43 U.S.C. 36c, 43 U.S.C. 36d, 43 U.S.C. 1457b

8. TITLE OF PROJECT (OR PROGRAM)
Puerto Rico Landslide Hazard Reduction Project 2023-2026

9a. GRANTEE NAME AND ADDRESS
UNIVERSITY OF PUERTO RICO
259 Blvd Alfonso Valdes
Mayaguez, PR, 00680-6475

9b. GRANTEE PROJECT DIRECTOR
Mr. K. Stephen Hughes
259 BLVD ALFONSO VALDES
MAYAGUEZ, PR, 00680-6475
Phone: 787-832-4040 ext2706

10a. GRANTEE AUTHORIZING OFFICIAL
Mrs. Brunilda Negron-Garcia
259 BLVD ALFONSO VALDES
MAYAGUEZ, PR, 00680-6475
Phone: 787-832-4040 ext5250

10b. FEDERAL PROJECT OFFICER
Amber Brazil
National Center 12201 Sunrise Valley Drive
Reston, VA, 20192-0001
Phone: 703-648-7477

ALL AMOUNTS ARE SHOWN IN USD

11. APPROVED BUDGET (Excludes Direct Assistance)
I Financial Assistance from the Federal Awarding Agency Only
II Total project costs including grant funds and all other financial participation — II

| | | |
|---|---|---|
| a. Salaries and Wages | $ | 41,153.00 |
| b. Fringe Benefits | $ | 2,283.00 |
| c. Total Personnel Costs | $ | 43,436.00 |
| d. Equipment | $ | 55,297.00 |
| e. Supplies | $ | 81,699.00 |
| f. Travel | $ | 3,000.00 |
| g. Construction | $ | 0.00 |
| h. Other | $ | 2,500.00 |
| i. Contractual | $ | 0.00 |
| j. TOTAL DIRECT COSTS | $ | 185,932.00 |
| k. INDIRECT COSTS | $ | 64,068.00 |
| l. TOTAL APPROVED BUDGET | $ | 250,000.00 |
| m. Federal Share | $ | 250,000.00 |
| n. Non-Federal Share | $ | 0.00 |

12. AWARD COMPUTATION

| | | |
|---|---|---|
| a. Amount of Federal Financial Assistance (from item 11m) | $ | 250,000.00 |
| b. Less Unobligated Balance From Prior Budget Periods | $ | 0.00 |
| c. Less Cumulative Prior Award(s) This Budget Period | $ | 0.00 |
| d. AMOUNT OF FINANCIAL ASSISTANCE THIS ACTION | $ | 250,000.00 |
| 13. Total Federal Funds Awarded to Date for Project Period | $ | 250,000.00 |

14. RECOMMENDED FUTURE SUPPORT
(Subject to the availability of funds and satisfactory progress of the project):

| YEAR | TOTAL DIRECT COSTS | YEAR | TOTAL DIRECT COSTS |
|---|---|---|---|
| a. 2 | $ | d. 5 | $ |
| b. 3 | $ | e. 6 | $ |
| c. 4 | $ | f. 7 | $ |

15. PROGRAM INCOME SHALL BE USED IN ACCORD WITH ONE OF THE FOLLOWING ALTERNATIVES:
a. DEDUCTION
b. ADDITIONAL COSTS
c. MATCHING
d. OTHER RESEARCH (Add / Deduct Option)
e. OTHER (See REMARKS)

b

16. THIS AWARD IS BASED ON AN APPLICATION SUBMITTED TO, AND AS APPROVED BY, THE FEDERAL AWARDING AGENCY ON THE ABOVE TITLED PROJECT AND IS SUBJECT TO THE TERMS AND CONDITIONS INCORPORATED EITHER DIRECTLY OR BY REFERENCE IN THE FOLLOWING:
a. The grant program legislation
b. The grant program regulations.
c. This award notice including terms and conditions, if any, noted below under REMARKS.
d. Federal administrative requirements, cost principles and audit requirements applicable to this grant.

In the event there are conflicting or otherwise inconsistent policies applicable to the grant, the above order of precedence shall prevail. Acceptance of the grant terms and conditions is acknowledged by the grantee when funds are drawn or otherwise obtained from the grant payment system.

REMARKS (Other Terms and Conditions Attached - ● Yes ○ No)
See next page

GRANTS MANAGEMENT OFFICIAL:
Sherri Bredesen, Chief, National Grants Branch
National Center 12201 Sunrise Valley Drive
205
Reston, VA, 20192
Phone: 703-648-7485

17. VENDOR CODE 0070093934 — 18a. UEI GZRNJ1GZDBM1 — 18b. DUNS 175303262 — 19. CONG. DIST. 00

| LINE# | FINANCIAL ACCT | AMT OF FIN ASST | START DATE | END DATE | TAS ACCT | PO LINE DESCRIPTION |
|---|---|---|---|---|---|---|
| 1 | 0051034622-00010 | $125,000.00 | 08/01/2023 | 07/31/2024 | 0804 | Base Award |
| 2 | 0051034622-00020 | $125,000.00 | 08/01/2023 | 07/31/2024 | 0804 | Base Award |
| | | | | | | |

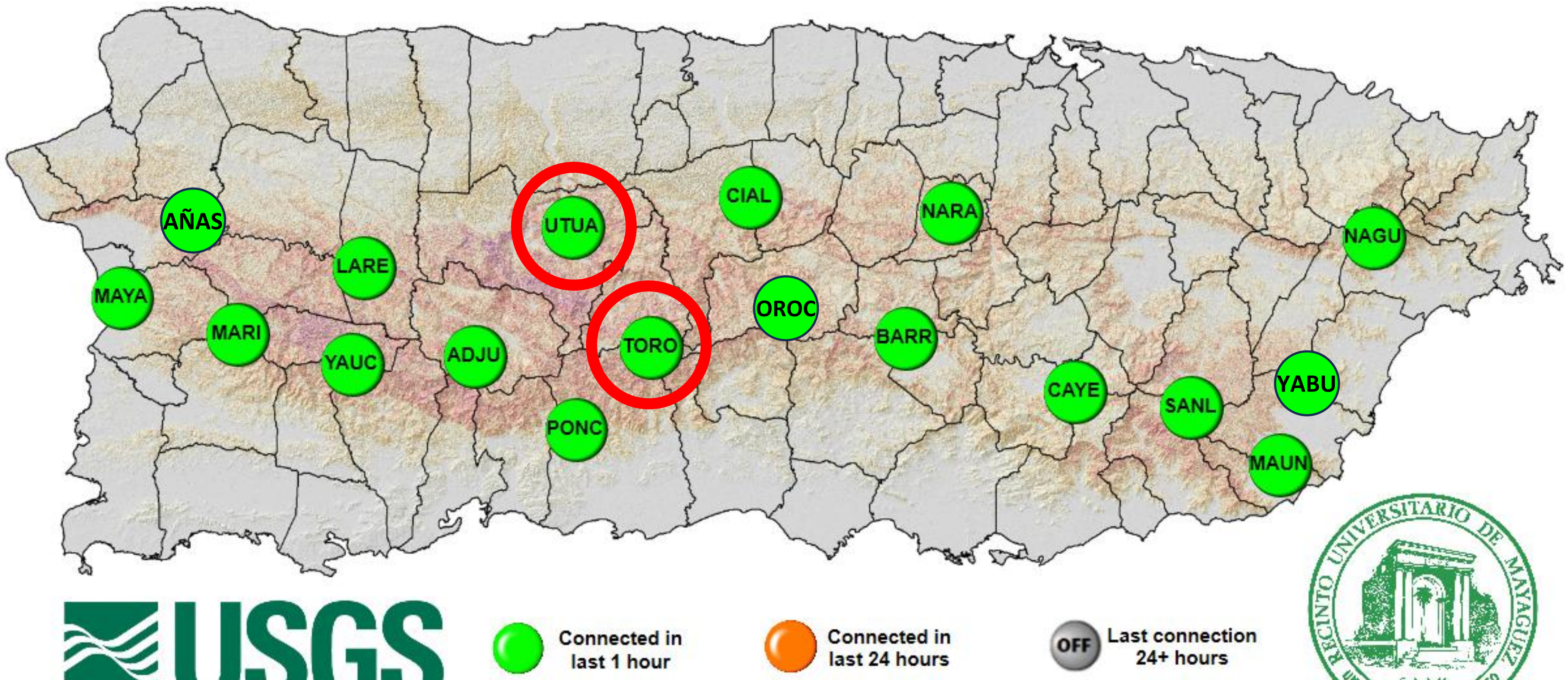
2021 Letter of Agreement (Monitoring Stations)

2023 Collaborative Agreement (Landslide Forecast)

2024 Collaborative Agreement (LandslideReady Program)

Derrumbe.net

# Puerto Rico Hydro-meteorological Stations




Puerto Rico Hydro-meteorological Monitoring Network

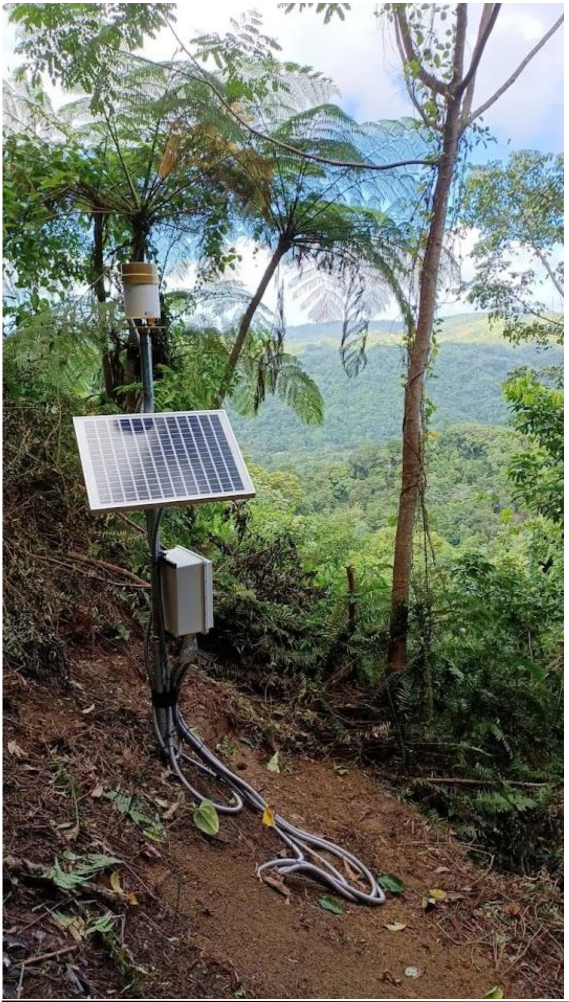
18 stations

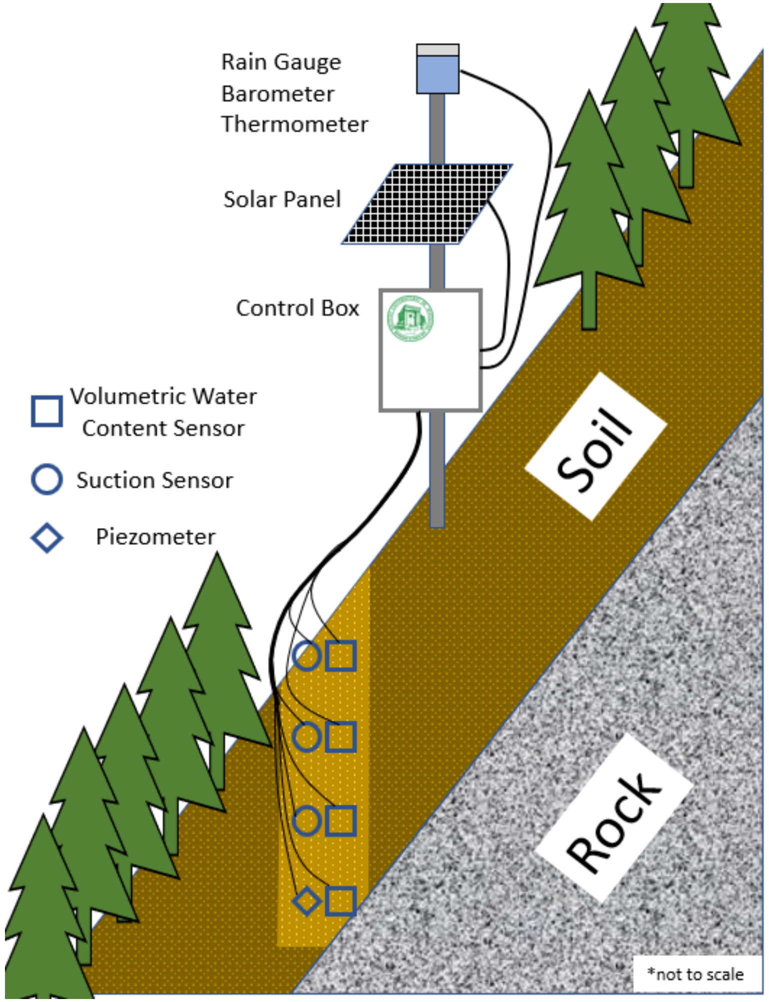
Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides


Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Puerto Rico Hydro-meteorological Stations






Puerto Rico Hydro-meteorological Monitoring Network

18 stations

Distinct soil types

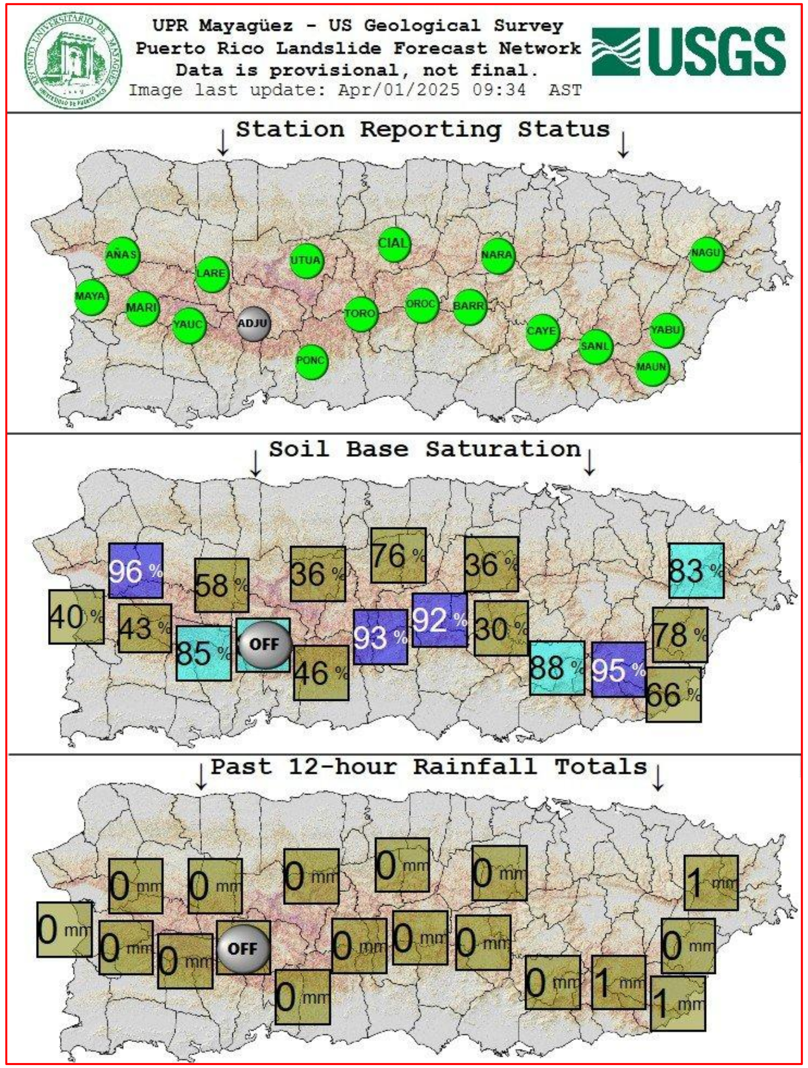
Maintenance challenges

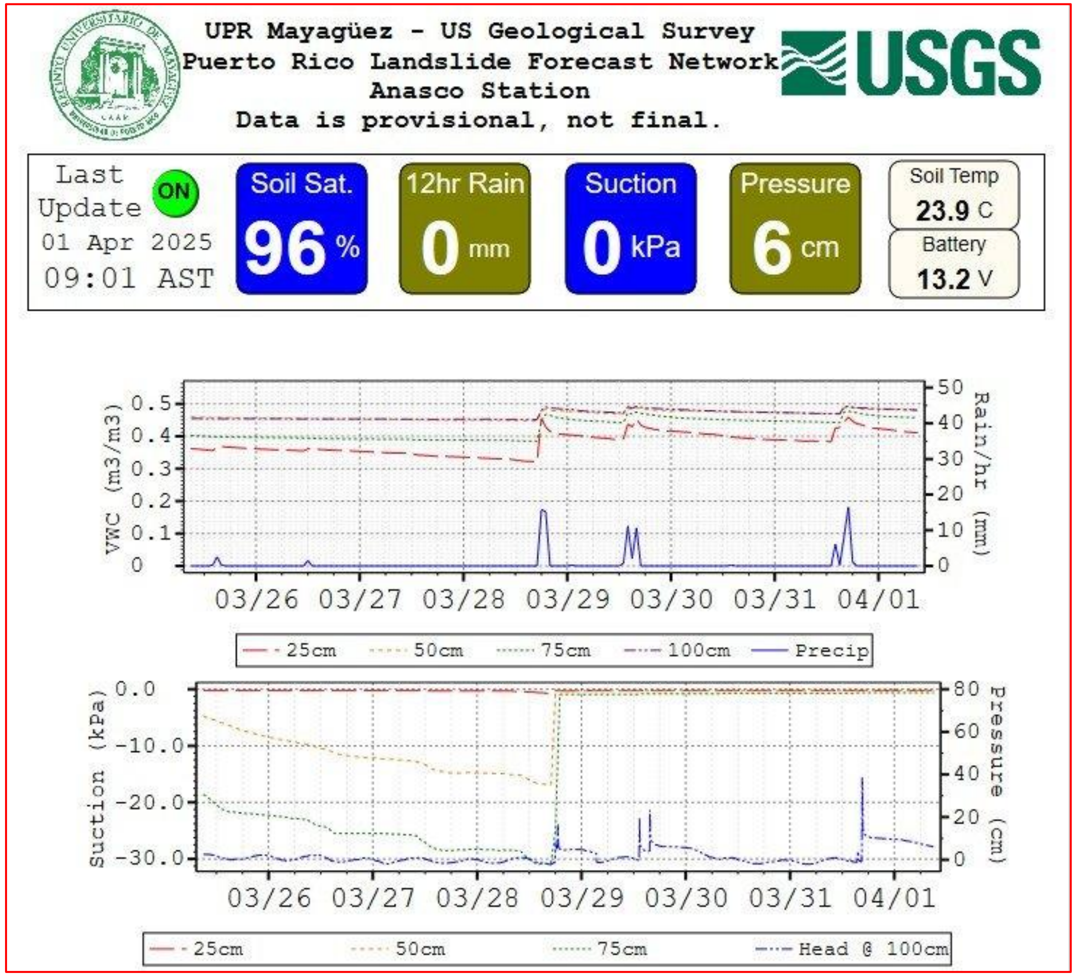
Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides


Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Puerto Rico Hydro-meteorological Stations




Monitoring station data always available via Derrumbe.net.

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Puerto Rico Hydro-meteorological Stations


Monitoring station data shown on local news outlets with regards to flooding or landslide concerns.

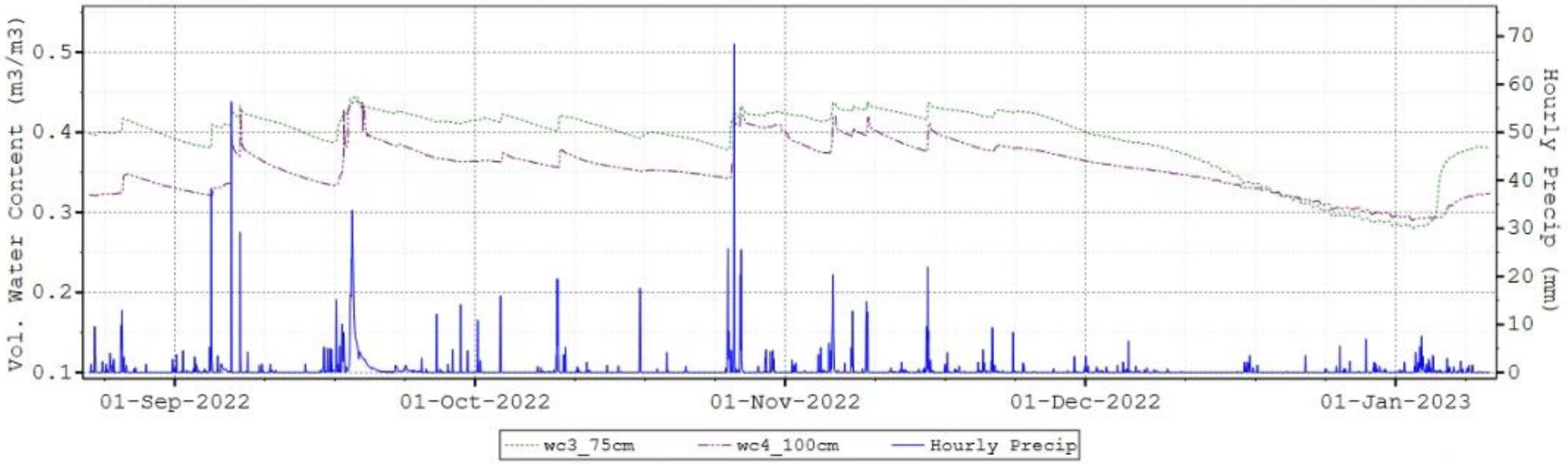
Derrumbe.net

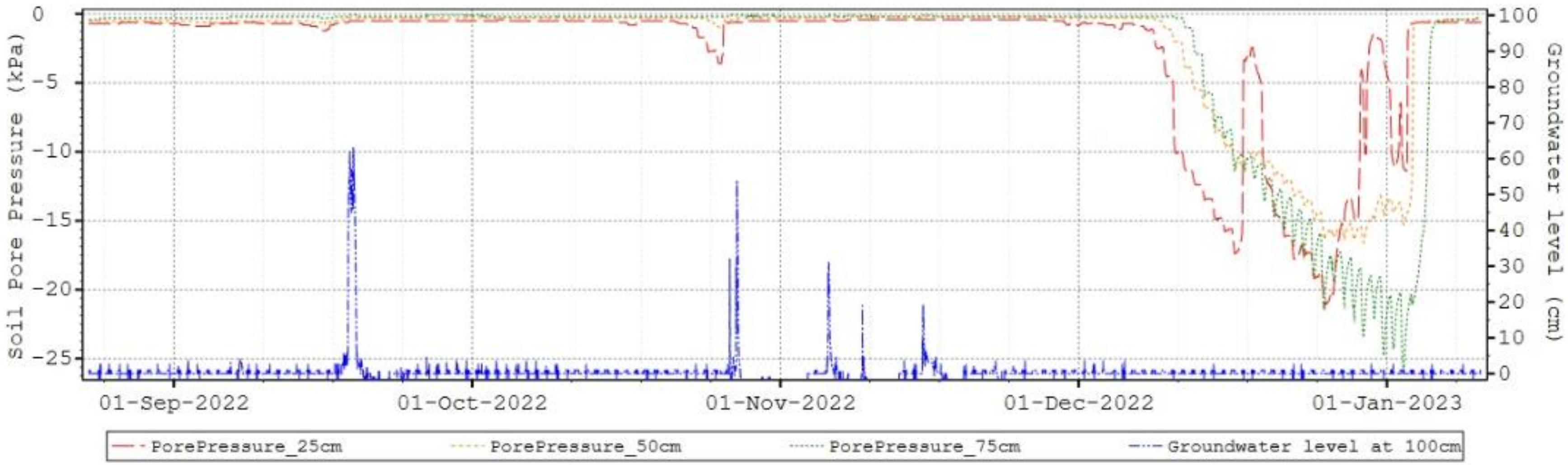


Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

UPR Mayagüez - US Geological Survey
Puerto Rico Landslide Forecast Network
Naguabo Station
Data is provisional, not final.

USGS
science for a changing world



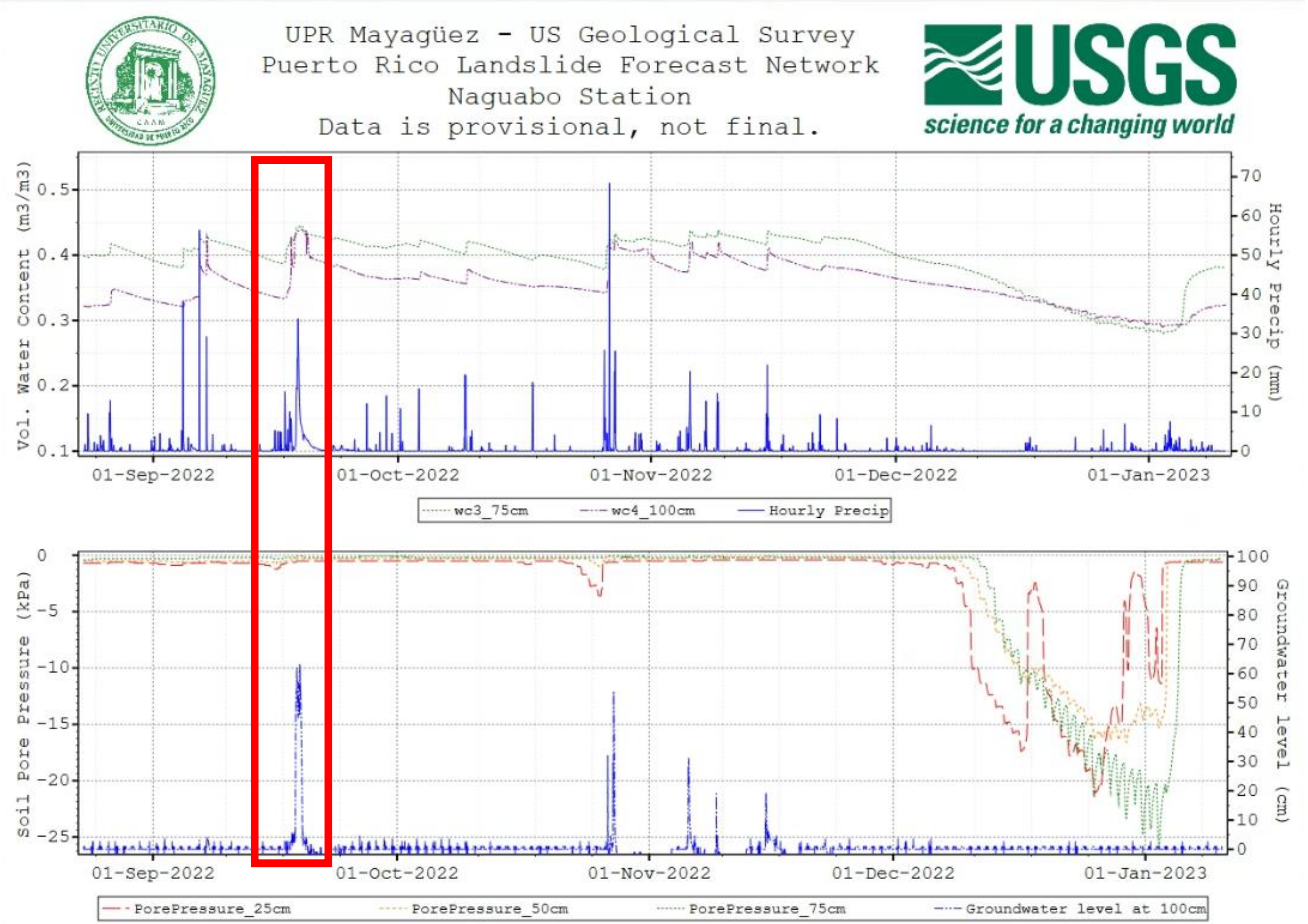

# Puerto Rico Hydro-meteorological Monitoring Network

## Experience in Hurricane Fiona (2022)

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides


Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez




# Puerto Rico Hydro-meteorological Monitoring Network

# Experience in Hurricane Fiona (2022)

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez


# Puerto Rico Hydro-meteorological Monitoring Network

## Experience in Hurricane Fiona (2022)

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez


# Puerto Rico Hydro-meteorological Monitoring Network

## Experience in Hurricane Fiona (2022)

Derrumbe.net



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

wapa.tv en Puerto Rico

PROGRAMAS NOTICIAS TU TIEMPO MUPR DEPORTES SHOPPERS

# Nueva tecnología podría ayudar a salvar vidas ante un deslizamiento de terreno

Según los expertos en Puerto Rico, ocurren cientos a miles de deslizamientos de tierra al año. Conoce cómo se monitorea esta saturación.

Por: **Cuarto Poder** - hace 3 meses


Según los expertos, ocurren cientos a miles de deslizamientos de tierra al año. El sensor de humedad de suelo "Slides PR", es un proyecto de la Universidad de Puerto Rico, recinto de Mayagüez. Precisamente, el sensor instalado y monitoreado por un profesor y en conjunto de líderes de la comunidad Cubuy en Naguabo, salvó la vida de dos vecinos del área.

## Puerto Rico Hydro-meteorological Monitoring Network

Forecasting seems like an achievable goal.

Derrumbe.net




Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

water

MDPI

*Technical Note*

**HydroMet: A New Code for Automated Objective Optimization of Hydrometeorological Thresholds for Landslide Initiation**

Jacob L. Conrad [1,2], Michael D. Morphew [1,2], Rex L. Baum [1] and Benjamin B. Mirus [1,*]

1 U.S. Geological Survey, Geologic Hazards Science Center, Golden, CO 80401, USA; jlconrad@usgs.gov (J.L.C.); mdmorphew@gmail.com (M.D.M.); baum@usgs.gov (R.L.B.)
2 Colorado School of Mines, Golden, CO 80401, USA
* Correspondence: bbmirus@usgs.gov

**Abstract:** Landslide detection and warning systems are important tools for mitigation of potential hazards in landslide prone areas. Traditionally, warning systems for shallow landslides have been informed by rainfall intensity-duration thresholds. More recent advances have introduced the concept of hydrometeorological thresholds that are informed not only by rainfall, but also by subsurface hydrological measurements. Previously, hydrometeorological thresholds have been shown to improve capabilities for forecasting shallow landslides, and they may ultimately be adapted to more generalized landslide forecasting. We present HydroMet, a code developed in Python by the U.S. Geological Survey, which allows users to guide the automated estimation of hydrometeorological thresholds for a site or area of interest, with the flexibility to select preferred threshold variables for the antecedent hydrologic conditions and the triggering meteorological conditions. Users can import hydrologic time-series data, including rainfall, soil-water content, and pore-water pressure, along with the times of known landslide occurrences, and then conduct objective optimization of warning thresholds using receiver operating characteristics. HydroMet presents many additional options, including selecting the threshold formula, the timescale of possible threshold variables, and the skill statistics used for optimization. Users can develop dual-stage thresholds for watch and warning alerts, with a lower, risk-averse threshold to avoid missed alarms and a less conservative threshold to minimize false alarms. Users may also choose to split their inventory data into calibration and evaluation subsets to independently evaluate the performance of optimized thresholds. We present output and applications of HydroMet using monitoring data from landslide-prone areas in the U.S. to demonstrate its utility and ability to produce thresholds with limited missed and false alarms for informing the next generation of reliable landslide warning systems.

**Keywords:** software; landslide early warning systems; hydrometeorological thresholds; automated optimization

check for updates

**Citation:** Conrad, J.L.; Morphew, M.D.; Baum, R.L.; Mirus, B.B. HydroMet: A New Code for Automated Objective Optimization of Hydrometeorological Thresholds for Landslide Initiation. *Water* **2021**, *13*, 1752. https://doi.org/10.3390/w13131752

Academic Editor: Samuele Segoni

Received: 21 May 2021
Accepted: 22 June 2021
Published: 25 June 2021

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

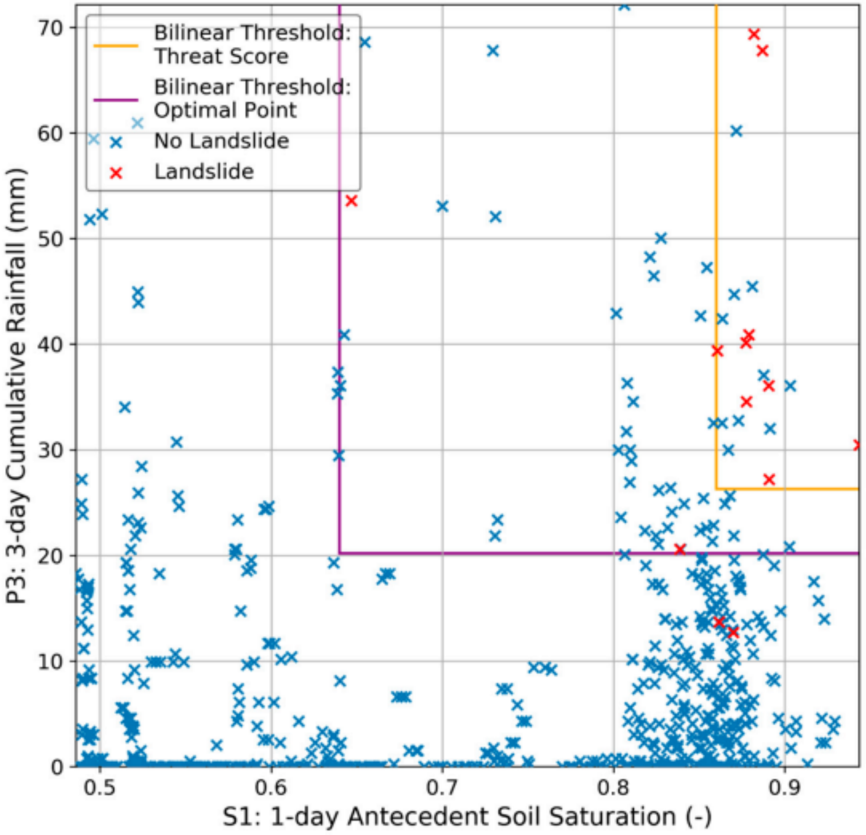


**1. Introduction**

Landslides are a common geologic hazard worldwide that are often destructive and deadly. Landslide early warning systems (LEWS) offer a promising approach for risk reduction in steep, soil-mantled terrain by providing alerts in advance of the potential conditions for landsliding. Typically, LEWS rely on thresholds to distinguish between conditions that are conducive to shallow landsliding from those that are not. The most common and established landslide threshold approach relies on the rainfall intensity-duration (ID) formulation [1–4], such that higher intensity shorter duration storms above the threshold, and lower intensity longer duration storms above the threshold, are both considered equally likely to trigger landsliding events. However, in many settings the antecedent soil wetness conditions influence the variability in rainfall triggering amounts, which has supported an emerging approach that relies on soil hydrology and rainfall to define hydrometeorological thresholds [5–11]. In general, these studies show that explicit



Example dataset from Mulkiteo, Washington




# Puerto Rico Hydro-meteorological Monitoring Network

Establishing antecedent soil moisture and rainfall thresholds for forecast product.

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

LANDSLIDE FORECASTING FOR PUERTO RICO:
ESTABLISHING HYDRO-METEOROLOGICAL THRESHOLDS
FOR RAINFALL-INDUCED
MASS WASTING

by

Tania Figueroa Colón

A thesis submitted in partial fulfillment of the requirements for the degree of

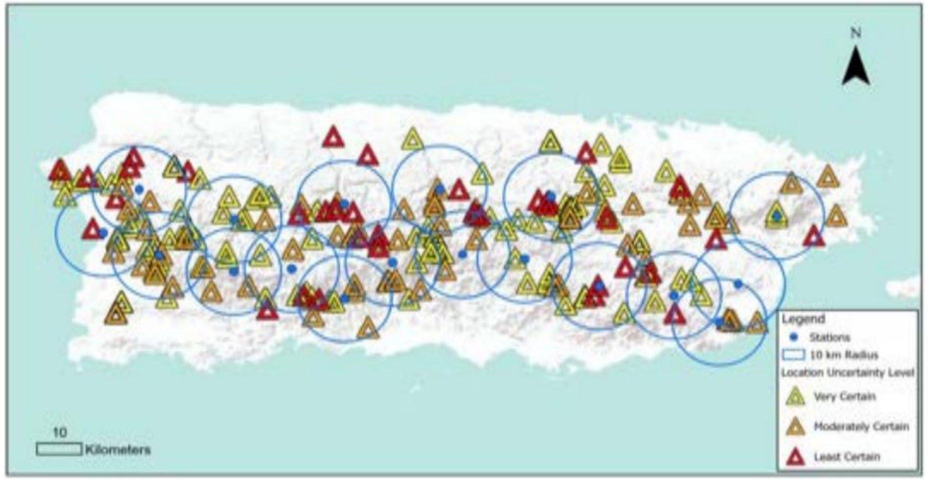
MASTER OF SCIENCE
in
GEOLOGY

UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS
2025

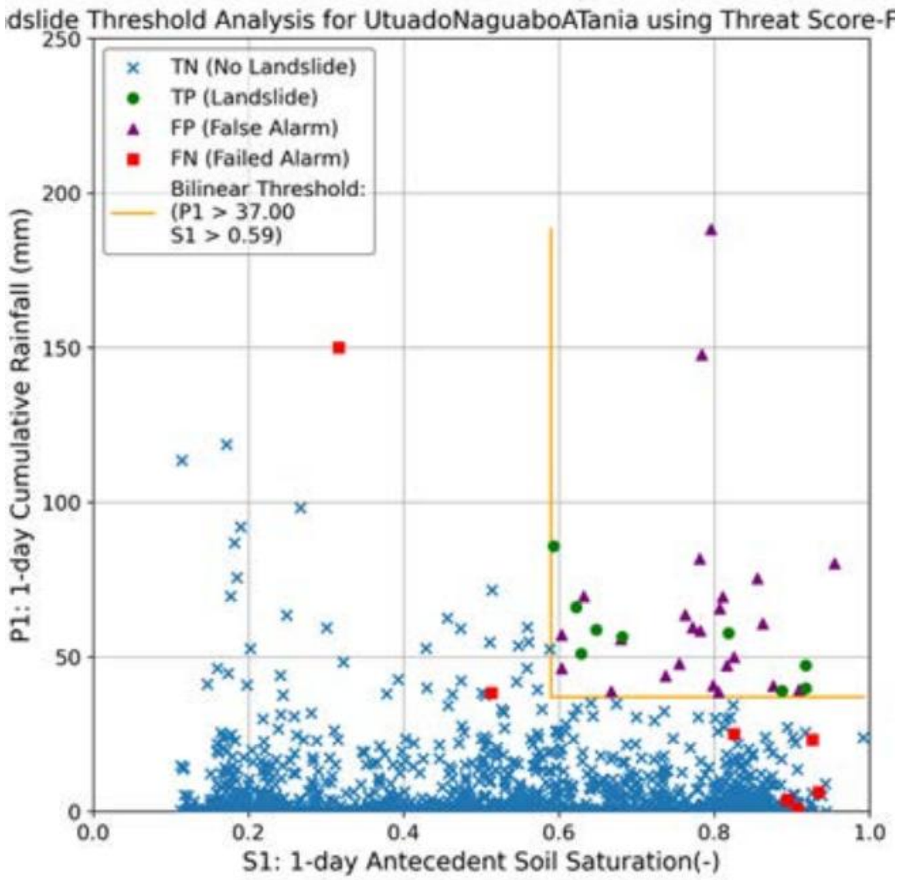
Approved by:

Kenneth S. Hughes, Ph.D.
President, Graduate Committee

Date




← MS Thesis completed by Tania Figueroa in January of 2025




# Puerto Rico Hydro-meteorological Monitoring Network

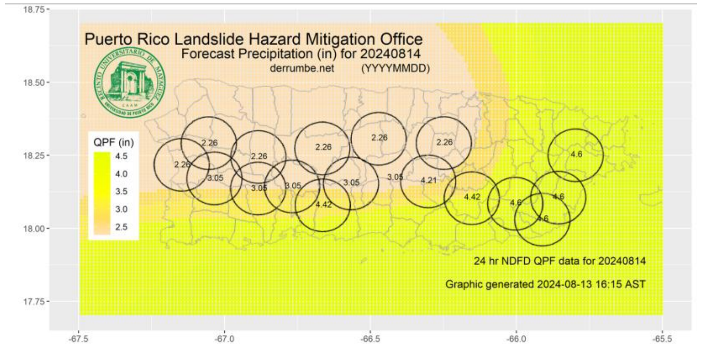
## Establishing antecedent soil moisture and rainfall thresholds for forecast product.

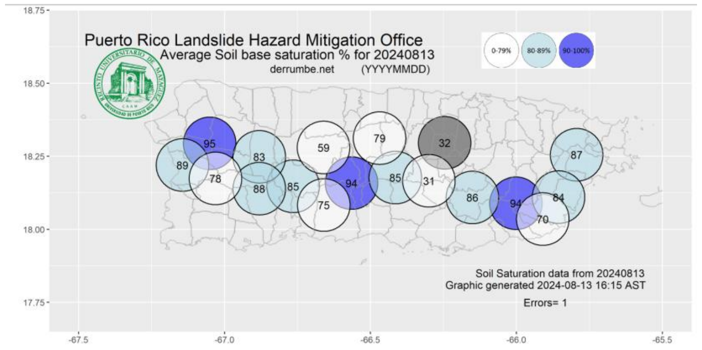
Derrumbe.net

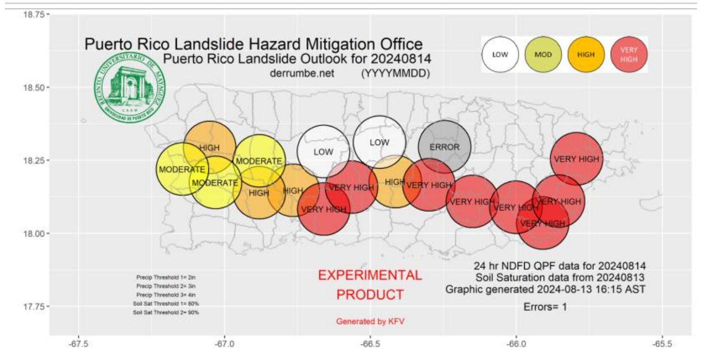



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

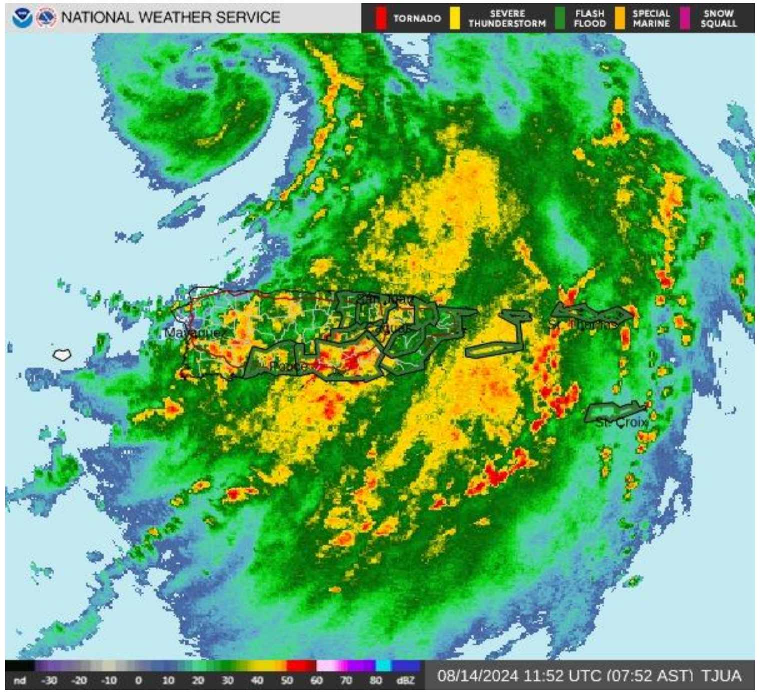
# Puerto Rico Hydro-meteorological Stations




## TS/Hurricane Ernesto (2024)




Puerto Rico Hydro-meteorological Monitoring Network

18 stations

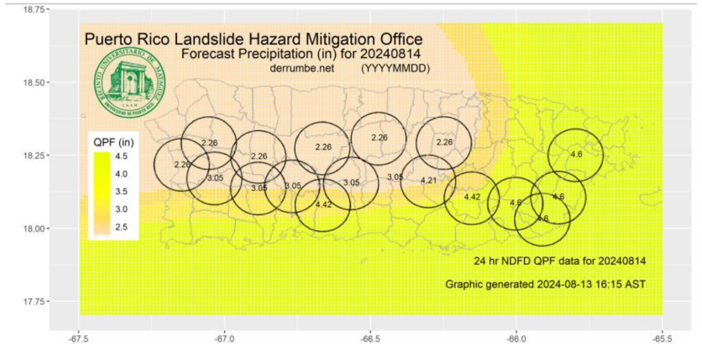
Experimental pilot forecast product running since Jan 2024

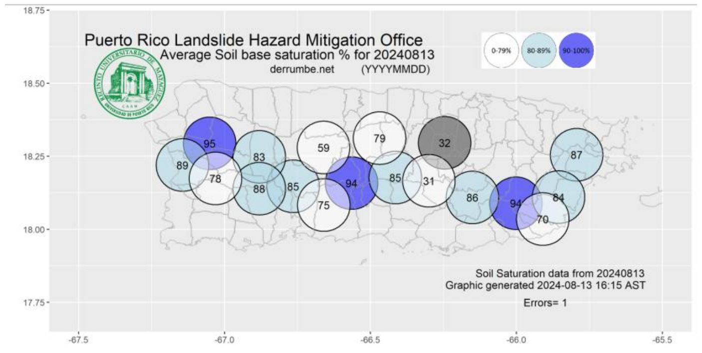
Derrumbe.net

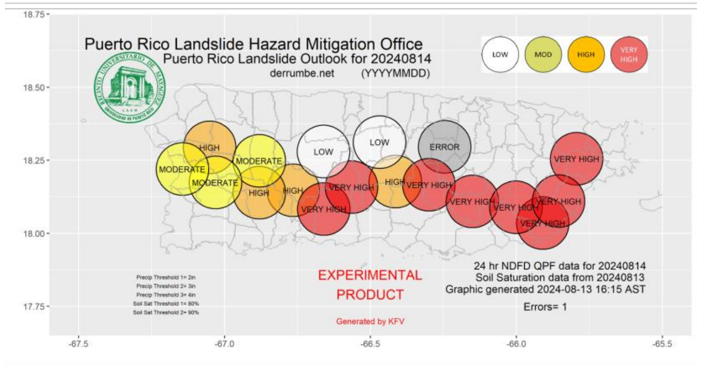
01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Puerto Rico Hydro-meteorological Stations





Puerto Rico Hydro-meteorological Monitoring Network

18 stations

Experimental pilot forecast product running since Jan 2024

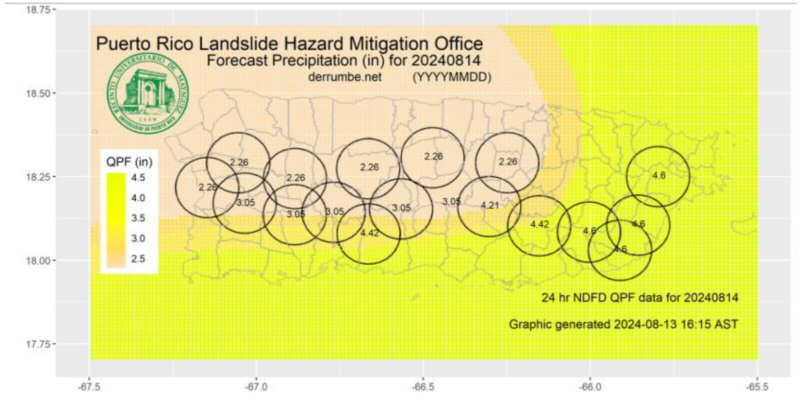
Derrumbe.net

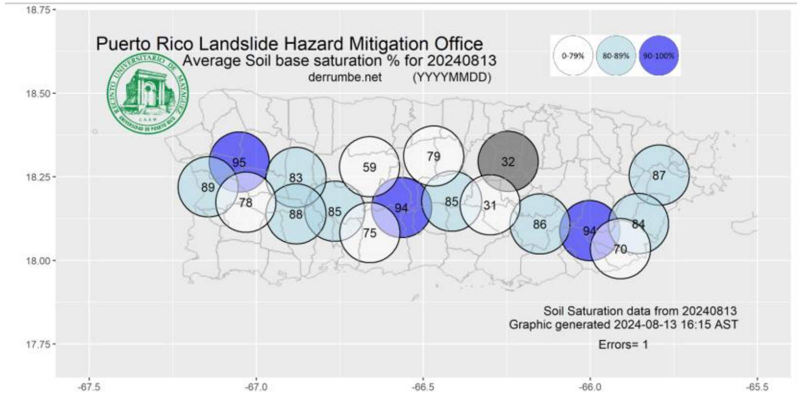
01-Apr-2025
Federal Advisory Committee on Landslides

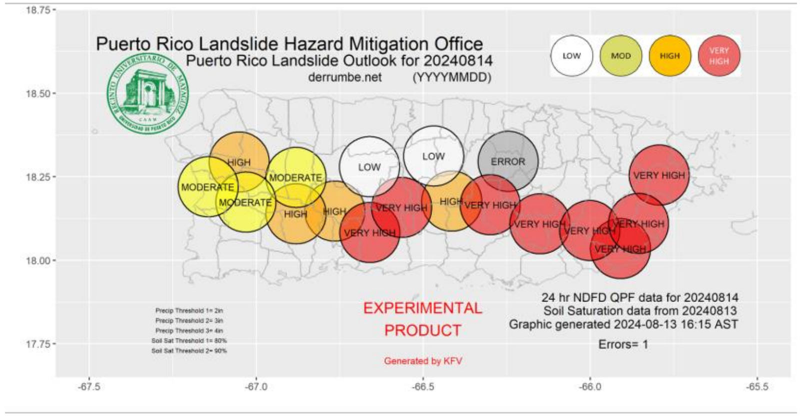

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Challenges:

1) Keeping stations operating
2) Build a system that functions during anticipated power/communications failures
3) Landslide ALERT vs FORECAST
4) Who is the target audience?
5) How many stations is the right number?
6) Maintaining landslide report database
7) Continuity of office operations




## Puerto Rico Hydro-meteorological Monitoring Network

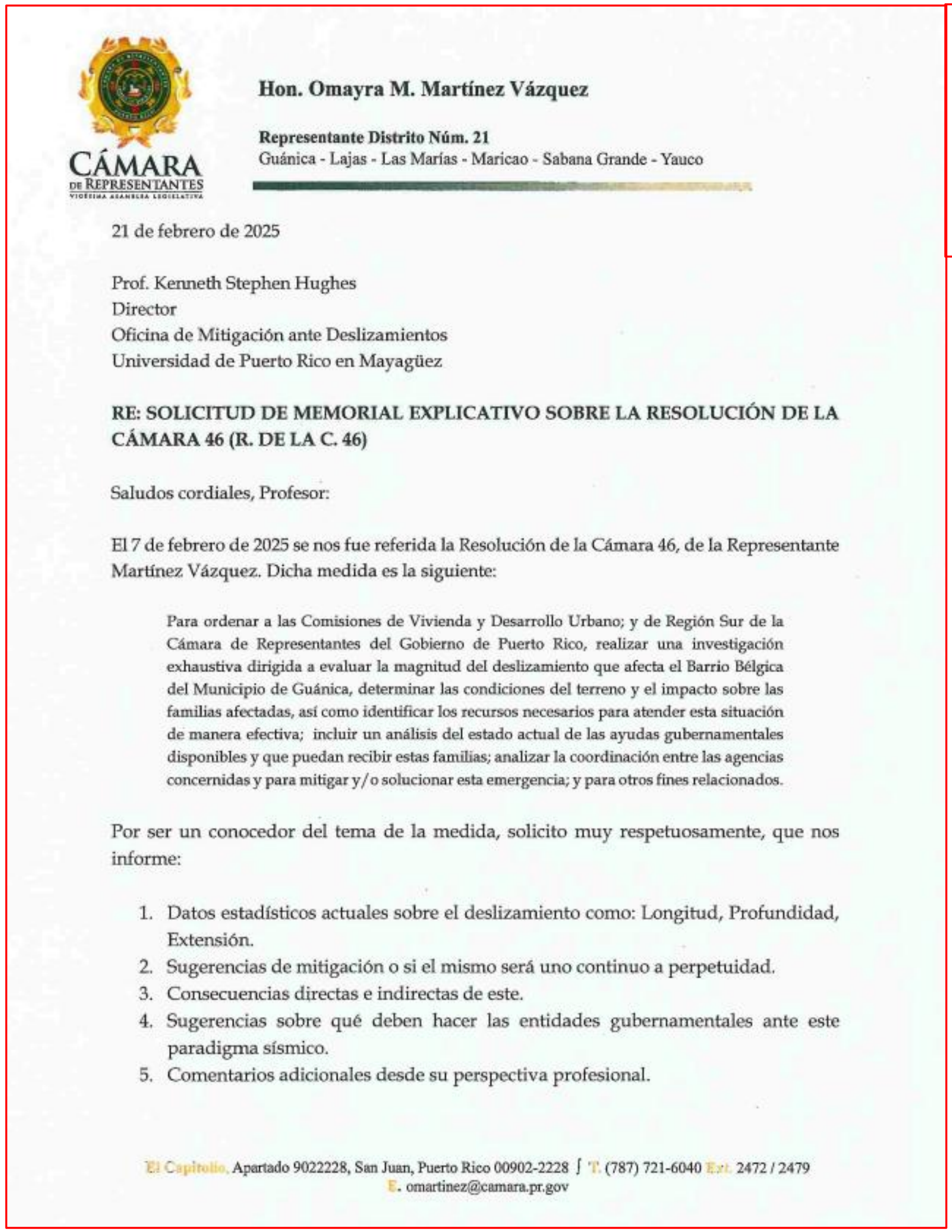
How to operationalize the forecast and build resiliency/redundancy

Derrumbe.net




Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

Monitoring larger and deeper landslides: Alturas de Bélgica in Guánica June to September 2024



Hon. Omayra M. Martínez Vázquez

Representante Distrito Núm. 21
Guánica - Lajas - Las Marías - Maricao - Sabana Grande - Yauco

CÁMARA DE REPRESENTANTES

21 de febrero de 2025

Prof. Kenneth Stephen Hughes
Director
Oficina de Mitigación ante Deslizamientos
Universidad de Puerto Rico en Mayagüez

**RE: SOLICITUD DE MEMORIAL EXPLICATIVO SOBRE LA RESOLUCIÓN DE LA CÁMARA 46 (R. DE LA C. 46)**

Saludos cordiales, Profesor:

El 7 de febrero de 2025 se nos fue referida la Resolución de la Cámara 46, de la Representante Martínez Vázquez. Dicha medida es la siguiente:

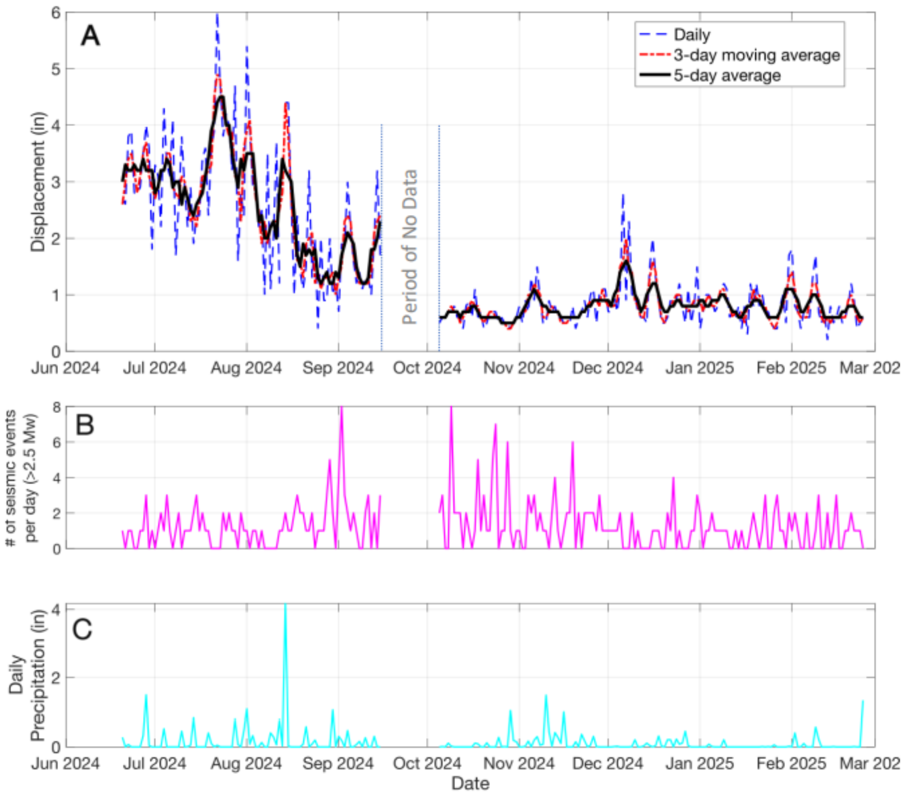
> Para ordenar a las Comisiones de Vivienda y Desarrollo Urbano; y de Región Sur de la Cámara de Representantes del Gobierno de Puerto Rico, realizar una investigación exhaustiva dirigida a evaluar la magnitud del deslizamiento que afecta el Barrio Bélgica del Municipio de Guánica, determinar las condiciones del terreno y el impacto sobre las familias afectadas, así como identificar los recursos necesarios para atender esta situación de manera efectiva; incluir un análisis del estado actual de las ayudas gubernamentales disponibles y que puedan recibir estas familias; analizar la coordinación entre las agencias concernidas y para mitigar y/o solucionar esta emergencia; y para otros fines relacionados.

Por ser un conocedor del tema de la medida, solicito muy respetuosamente, que nos informe:

1. Datos estadísticos actuales sobre el deslizamiento como: Longitud, Profundidad, Extensión.
2. Sugerencias de mitigación o si el mismo será uno continuo a perpetuidad.
3. Consecuencias directas e indirectas de este.
4. Sugerencias sobre qué deben hacer las entidades gubernamentales ante este paradigma sísmico.
5. Comentarios adicionales desde su perspectiva profesional.

El Capitolio, Apartado 9022228, San Juan, Puerto Rico 00902-2228 | T. (787) 721-6040 Ext. 2472 / 2479
E. omartinez@camara.pr.gov

← Request from the Puerto Rico House of Representatives Housing and Urban Development Committee




**Booth No. 18** Booth No. 18: TRACKING A LIMESTONE BEDROCK LANDSLIDE ON AN URBANIZED HILLSLOPE IN GUANICA, PUERTO RICO

*RODRÍGUEZ FELICIANO, César, Department of Geology, University of Puerto Rico Mayagüez, Call Box 9000, Mayaguez, PR 00681, HUGHES, K. Stephen, Department of Geology, University of Puerto Rico Mayagüez, Po Box 9000, Mayaguez, PR 00681-9000, Puerto Rico and VELEZ SANTIAGO, Freddie, Guanica, PR 00647*

Limestone bedrock landslide
Alturas de Bélgica
Guánica, PR

Derrumbe.net



Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

# Partners & Collaborators

USGS
science for a changing world

CCAN
Caribbean Climate Adaptation Network
A NOAA CAP/RISA Team

Puerto Rico
Science, Technology
& Research Trust

National Weather Service

para la Naturaleza

Gobierno de Puerto Rico
DRNA
Departamento de Recursos Naturales y Ambientales


LANDSLIDE READY

Derrumbe.net

01-Apr-2025
Federal Advisory Committee on Landslides

Stephen Hughes
Puerto Rico Landslide Hazard Mitigation Office
Geology Department
University of Puerto Rico at Mayagüez

**Email:**
kenneth.hughes@upr.edu

**Cell:**
787-208-6667

**Office:**
787-832-4040 x6844

**Acknowledgements:**

USGS:
Bill Schulz, Mason Einbund, Kelli Baxtrom, et al.

UPRM:
Tania Figueroa, Pedro Matos, Isabella Cámara, and **many** students

# Thanks

LANDSLIDE READY

Derrumbe.net

# Federal Advisory Committee on Landslides

## April 1st–2nd, 2025—Day 2

# Cooperative Landslide Hazard Mapping and Assessment Grants Priorities

Hall, Slaughter

(e) GRANT PROGRAMS.—

(1) COOPERATIVE LANDSLIDE HAZARD MAPPING AND ASSESSMENT PROGRAM.—

(A) IN GENERAL.—Subject to appropriations, the Secretary may—

(i) provide grants, on a competitive basis, to State, territorial, local, and Tribal governments to research, map, assess, and collect data on landslide hazards within the jurisdictions of those governments; and

(ii) accept and use funds received from other Federal and non-Federal partners to advance the purposes of the program.

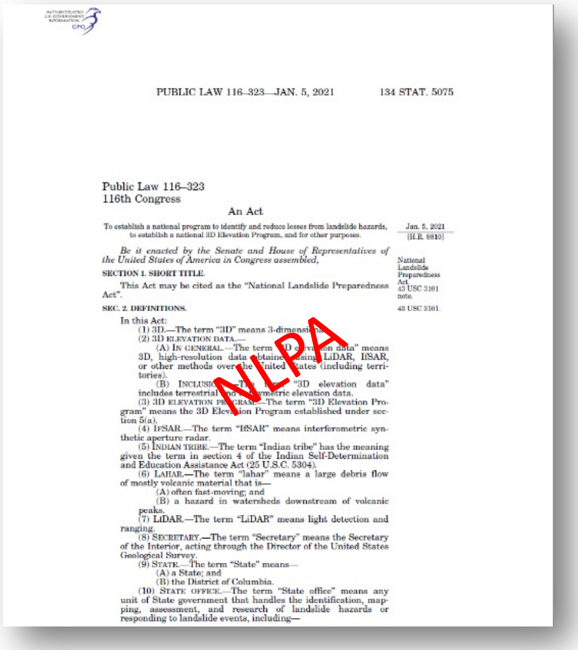
(B) PRIORITY.—

(i) IN GENERAL.—The Secretary shall consult annually with the Committee, States, units of local government, territories, and Indian tribes to establish priorities for the grant program under this paragraph. Consultation.


Cooperative Landslide Hazard Mapping and Assessment Grant Priorities
Guidance Criteria Direction - ACL
April 2025
Stephen Slaughter, Associate Program Coordinator for Landslide Hazards and Grant Project Officer
Sarah Hall, AAAS Science & Technology Policy Fellow
103

# The National Landslide Preparedness Act

*The Secretary shall consult annually with the <u>Committee</u>, States, units of local government, territories, and Indian tribes to <u>establish priorities for the grant program</u> under this paragraph.*



PUBLIC LAW 116–323—JAN. 5, 2021 134 STAT. 5075

Public Law 116–323
116th Congress

An Act

To establish a national program to identify and reduce losses from landslide hazards, to establish a national 3D Elevation Program, and for other purposes.

Jan. 5, 2021
[H.R. 8810]

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

**SECTION 1. SHORT TITLE.**

National Landslide Preparedness Act. 43 USC 3101 note.

This Act may be cited as the "National Landslide Preparedness Act".

**SEC. 2. DEFINITIONS.**

43 USC 3101.

In this Act:

(1) 3D.—The term "3D" means 3-dimensi[illegible]
(2) 3D ELEVATION DATA.—
(A) IN GENERAL.—The term "[illegible]D e[illegible]on data" means 3D, high-resolution data [illegible]btaine[illegible]sing LiDAR, IfSAR, or other methods over the [illegible]nited [illegible]tates (including territories).
(B) INCLUSI[illegible]—The [illegible] "3D elevation data" includes terrestrial [illegible]ymetric elevation data.
(3) 3D ELEVATION PR[illegible]GRAM.—The term "3D Elevation Program" means the 3D Elev[illegible]ion Program established under section 5(a).
(4) IFSAR.—The term "IfSAR" means interferometric synthetic aperture radar.
(5) INDIAN TRIBE.—The term "Indian tribe" has the meaning given the term in section 4 of the Indian Self-Determination and Education Assistance Act (25 U.S.C. 5304).
(6) LAHAR.—The term "lahar" means a large debris flow of mostly volcanic material that is—
(A) often fast-moving; and
(B) a hazard in watersheds downstream of volcanic peaks.
(7) LiDAR.—The term "LiDAR" means light detection and ranging.
(8) SECRETARY.—The term "Secretary" means the Secretary of the Interior, acting through the Director of the United States Geological Survey.
(9) STATE.—The term "State" means—
(A) a State; and
(B) the District of Columbia.
(10) STATE OFFICE.—The term "State office" means any unit of State government that handles the identification, mapping, assessment, and research of landslide hazards or responding to landslide events, including—



USGS

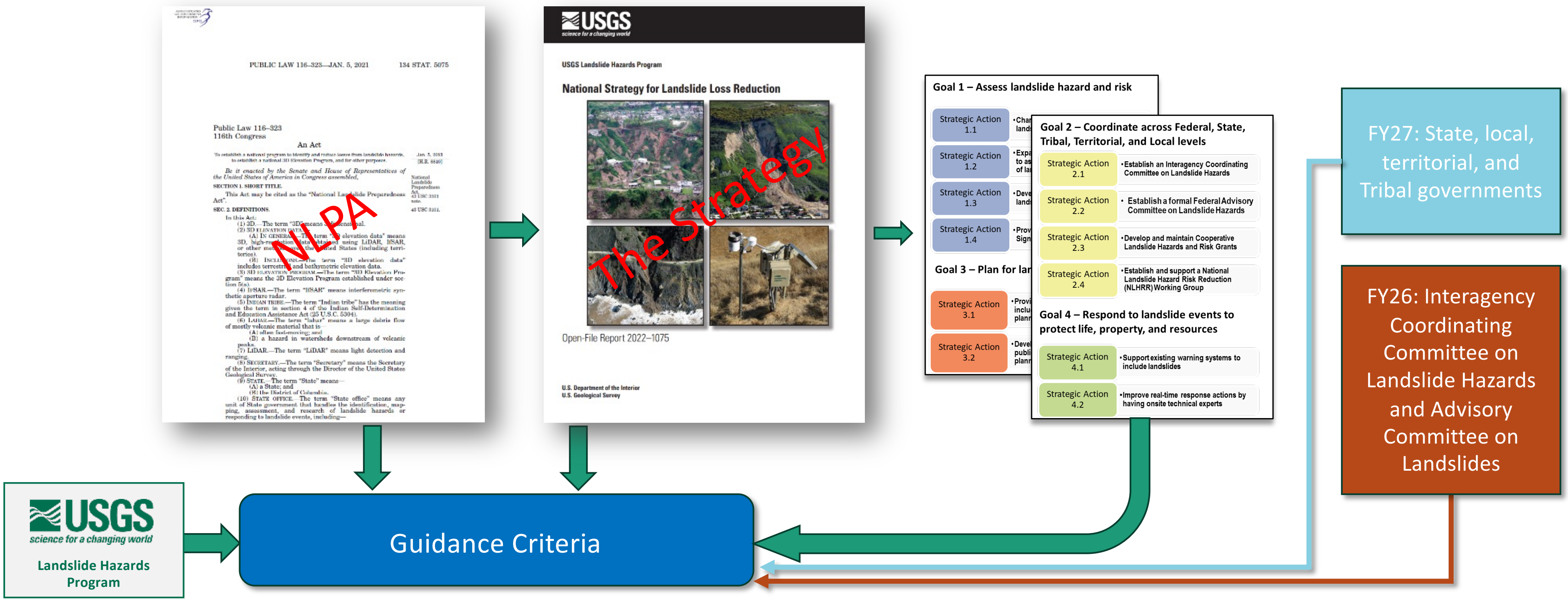
# Grant Background

- Round One closed June 2024 and Round Two closed January 2025
- $1M annual federal assistance as a competitive grant
  - Funding range $10k-250k
- Eligible applicants: local, state, territorial, and Tribal governments

The NLPA states that the USGS Grant Program will *__prioritize__* projects that:

- Achieve the greatest landslide hazard and risk reduction
- **Reflect the goals and priorities of the *National Strategy for Landslide Loss Reduction***
- Provide at least 50% match from non-Federal funds
- Include acquisition [or use] of enhanced elevation data (lidar)

# Current Guidance Criteria



# Landslide Grant Priorities for FY2024/25

- Planning
- Coordination
- Education/Outreach
- Mapping
- Assessments

Guidance Criteria (GC)

GC1: Landslide hazards mapping and assessment

GC2: Planning and coordination

GC3: Education and outreach

USGS

# GC1 - Hazard mapping and assessment

Examples include:

- Inventory using an established protocol and lidar
- Improving a pre-lidar inventory with lidar
- Landslide event database with emphasis in landslide spatial and temporal relationships
- Landslide runout mapping
- Assessment of land use/land management practices to landslide hazards
- Collection and analysis of landslide loss data
- Development of best-practice tools for local landslide/loss mapping, cataloging, etc.
- And others

# GC2 - Planning and coordination

Examples include:

- Development of technical response protocols
  - Roles and responsibilities
  - Products and procedures
- Development of a working group to share:
  - Land use best practice
  - Lessons learned in landslide emergency response
  - Preparedness planning and education
  - Land-use/management practices
- And others

USGS

# GC3 - Education, engagement, and outreach

Examples include:

- Development of educational, outreach and engagement materials (e.g., workshop curricula, grade school or college curricula, landslide guides for homeowners or planners, etc.)
- Host collaborative engagement opportunities (trainings, workshops, etc.)
- Enact new practices for advancing messaging across agencies and sectors
- Develop new tools and products for increasing awareness of hazards and risk
- And others

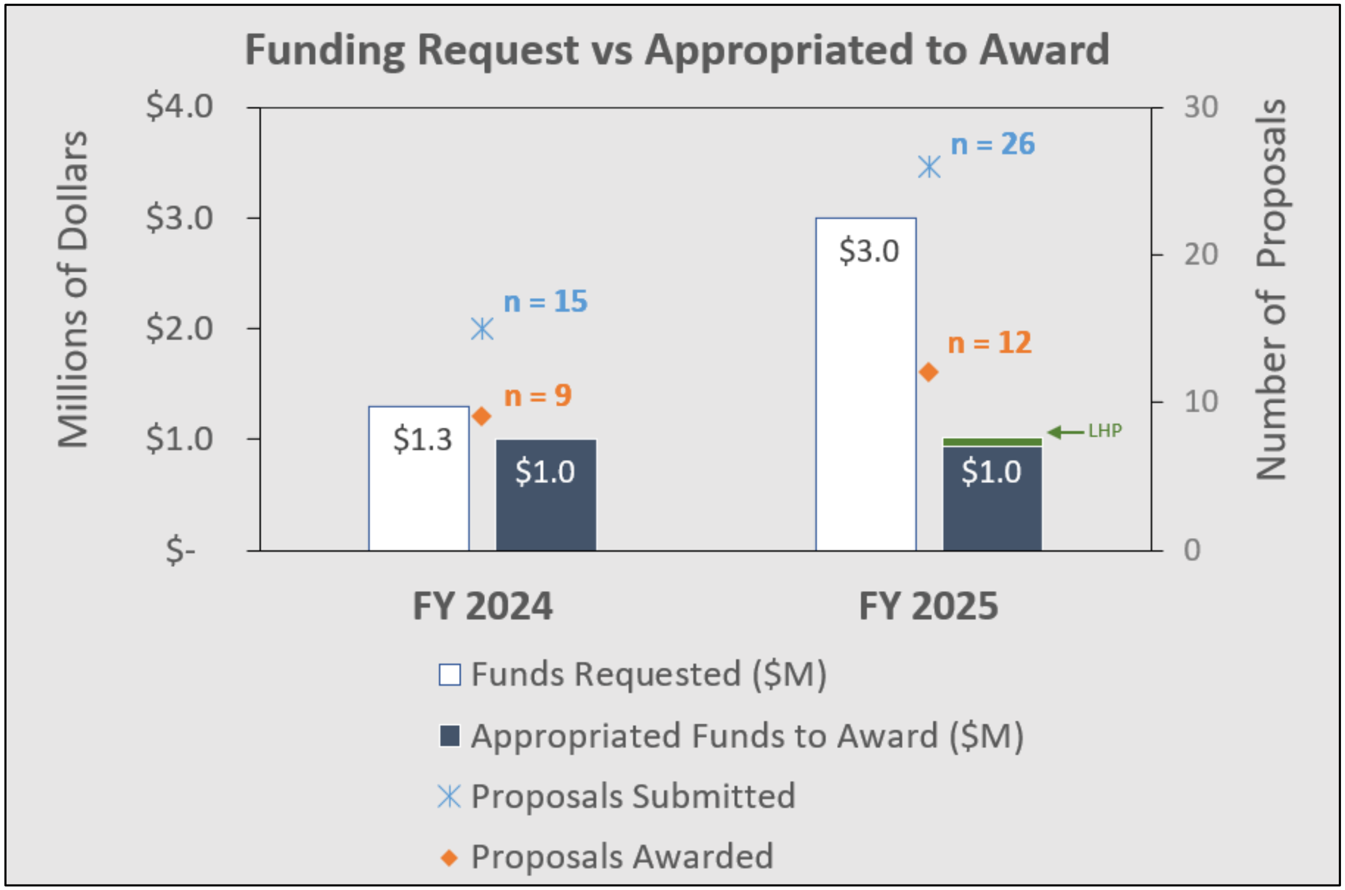
# Landslide Grant Statistics

**Funds available:**

- ➢ **FY24 = $1M**
  - $1M appropriated
- ➢ **FY25 = $1.09M total**
  - $1M appropriated
  - $90k from LHP

**Funding Rate:**

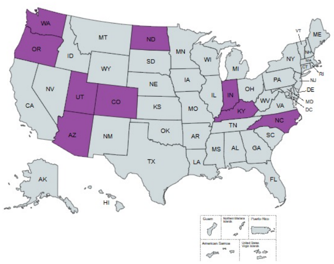
- FY24 = 60%
- FY25 = 46%

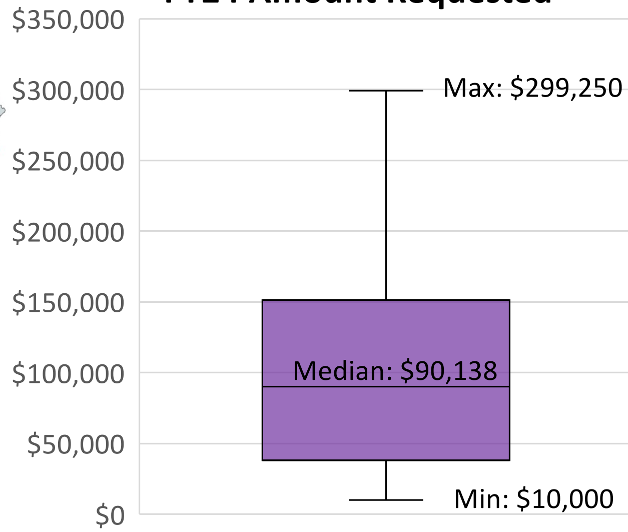



USGS

# Landslide Grant Statistics

## FY 2024






**Total request: $1.3M in 15 proposals submitted from:**

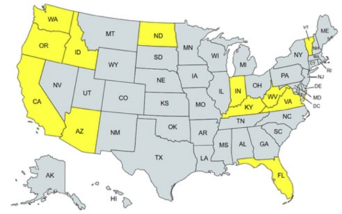
15 State Agencies:

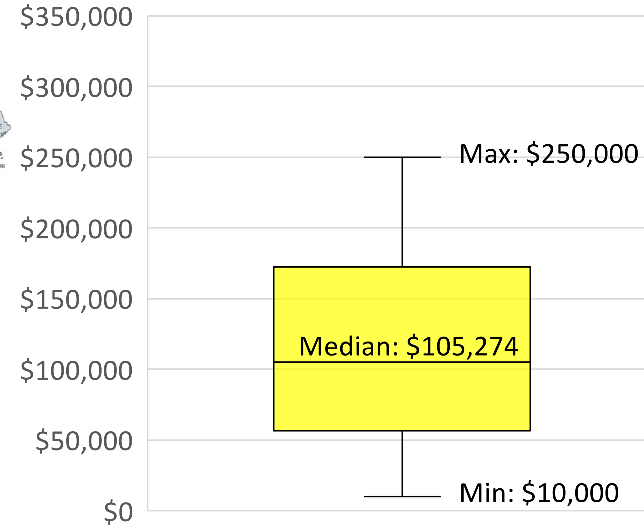
- 13 State Geological Surveys
- 1 State Dept of Transportation
- 1 State Emergency Management Agency

***Awarded $1M to fund 9 projects from State Geological Surveys***

USGS

## FY 2025






**Total request: $3.0M in 26 proposals submitted from:**

19 State Agencies:

- 16 Geological Surveys
- 1 Department of Transportation
- 1 Emergency Management Agency
- 1 Climate Office

7 County or City Agencies:

- Public Works, Emergency Management, Conservation

***Awarded $1.09M to fund 12 projects from state Geological Surveys and a Department of Transportation***

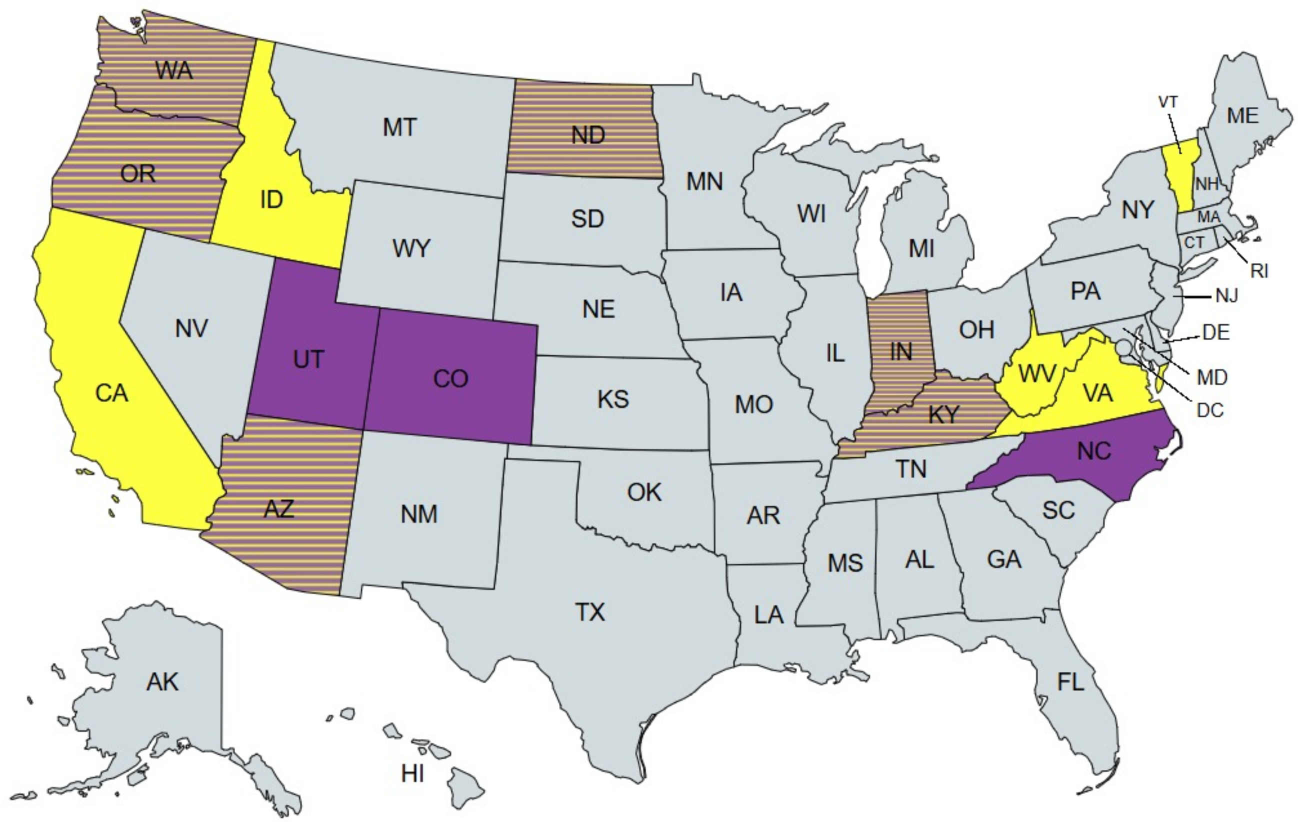
# Landslide Grant Statistics

**Proposal Funded:**

**FY 2024**

**FY 2025**

**Both**

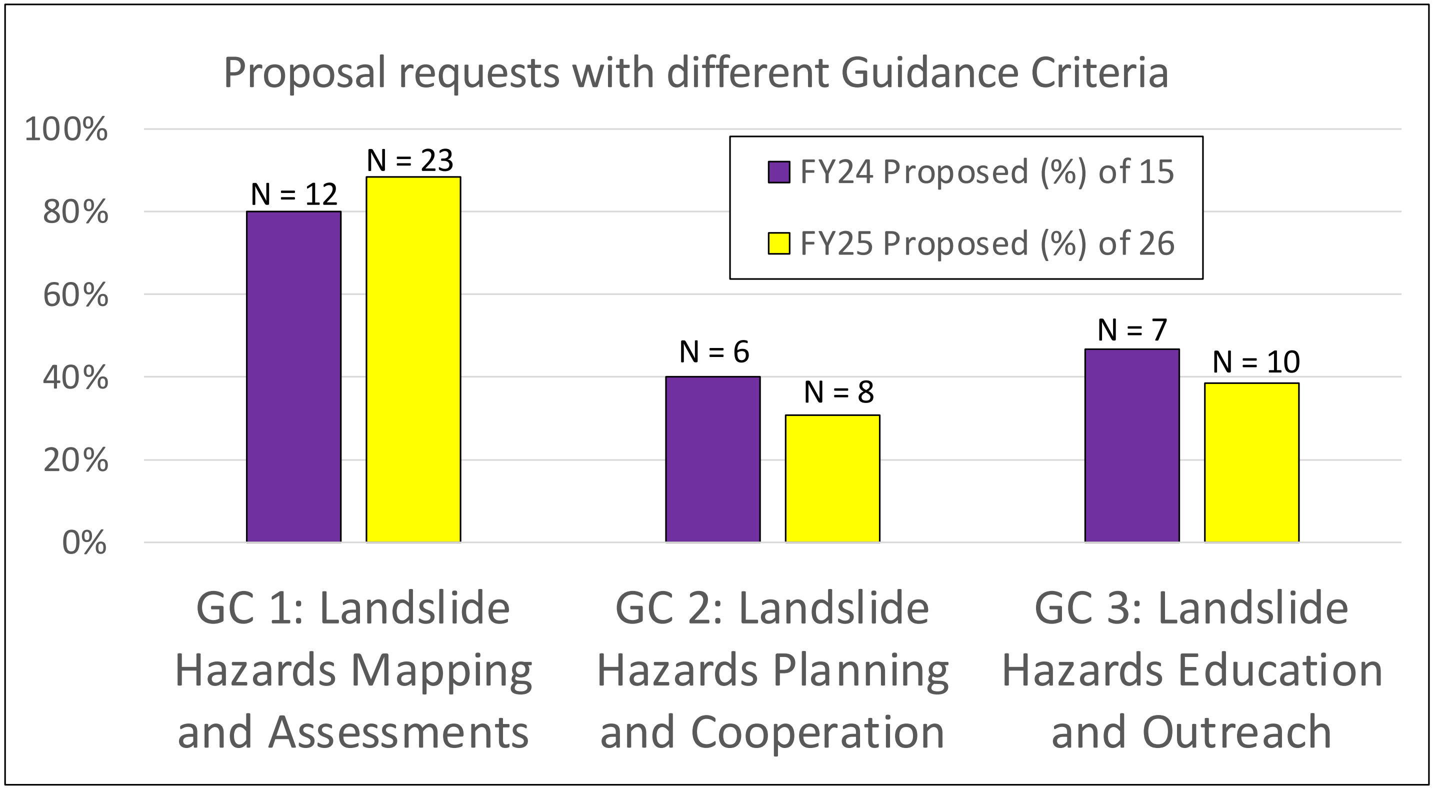



USGS

# Landslide Grant Statistics: Guidance Criteria

## FY24 and FY25: Proposed Projects

- ~80% aim to conduct *Mapping and Assessments*
- ~30-40% address at least 2 guidance criteria
- <20% of projects focus ONLY on *Planning and Cooperation* or *Education and Outreach*




USGS

# Landslide Grant Statistics: Guidance Criteria

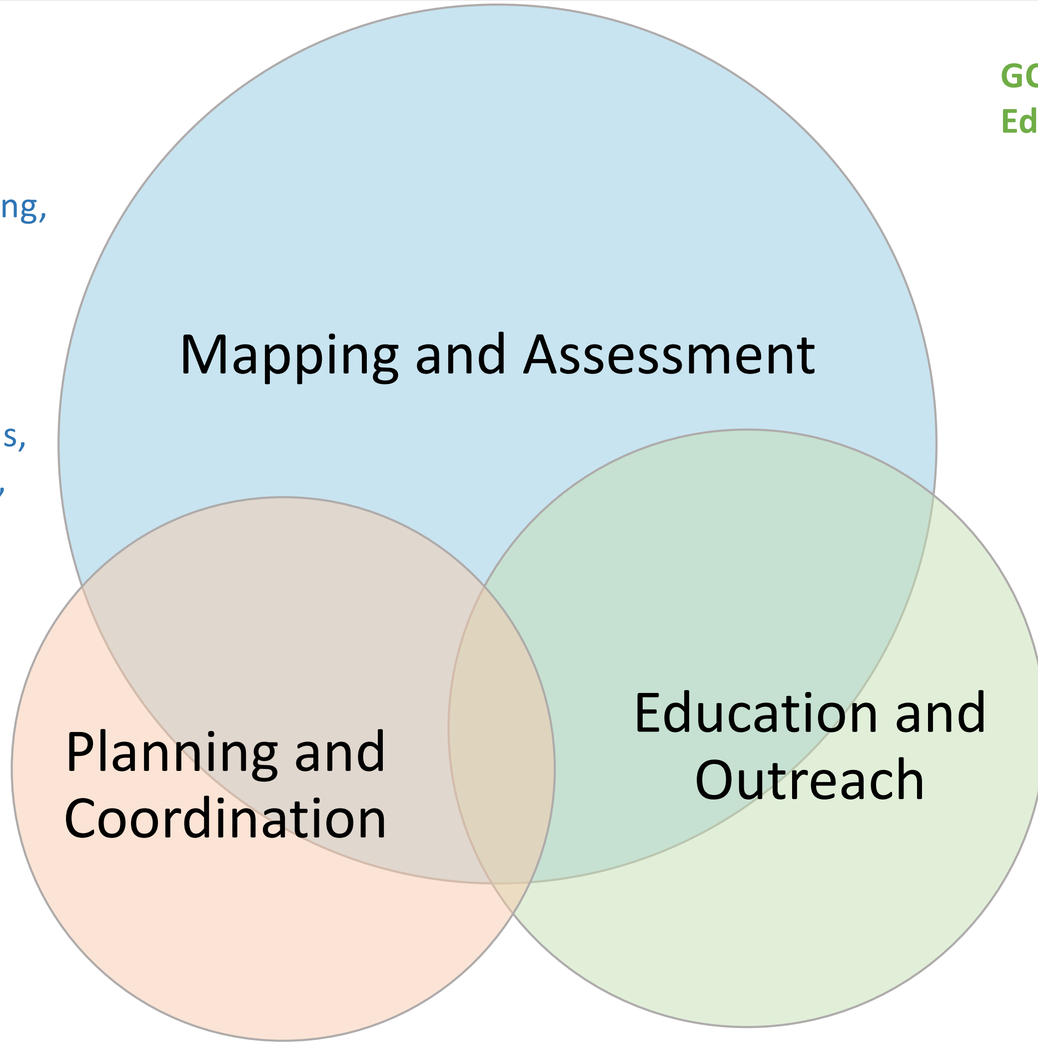
**GC1: Landslide Hazard Mapping and Assessment:**

Foundational:
- Mapping and inventory building, expansion, revision, or improvement

Research or Next Steps:
- Forecasting, rainfall thresholds, debris flow initiation, volume, return rates, triggers

**GC2: Landslide Hazard Planning and Coordination:**

Interagency and Community Collaboration:
- Working groups
- Needs assessment

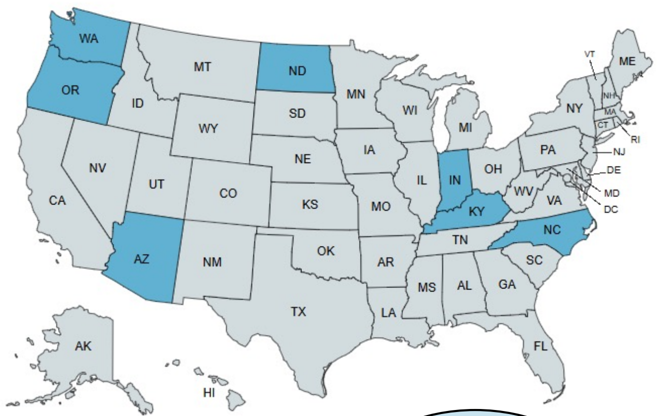


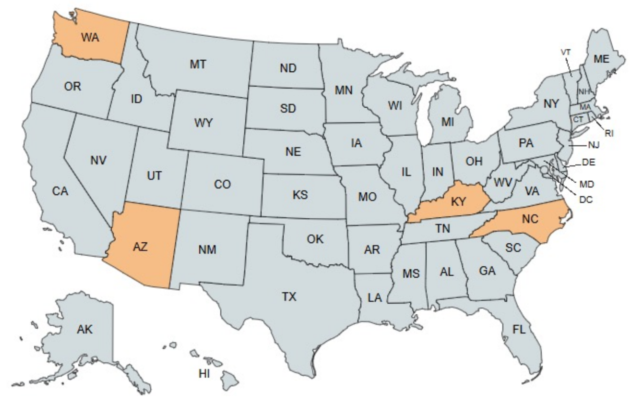

**GC 3: Landslide Hazard Education and Outreach:**

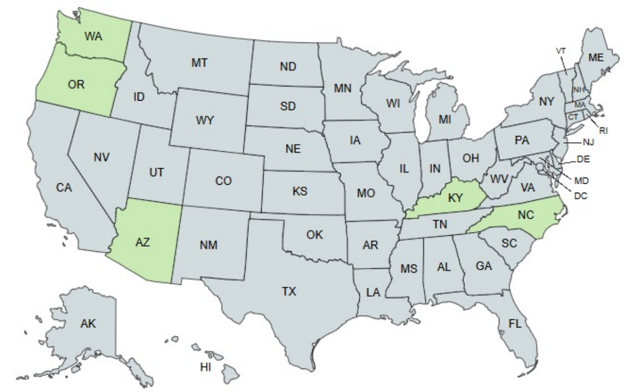
Guidance: for decision makers of all levels
- Factsheets
- Story Maps
- Guidance documents for data products

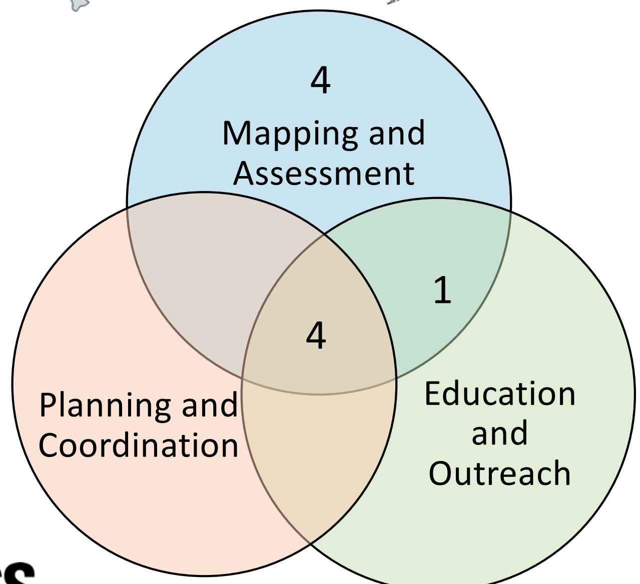
Training: of the public or agency personnel
- Best practice methods
- Technical methods
- Workshops

# Landslide Grant Statistics: Guidance Criteria and FY 2024 Funded Projects

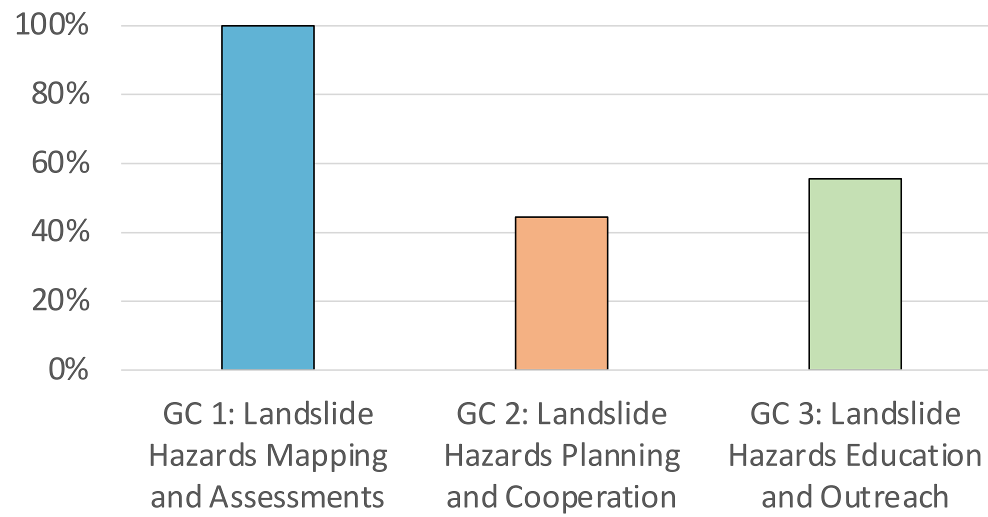


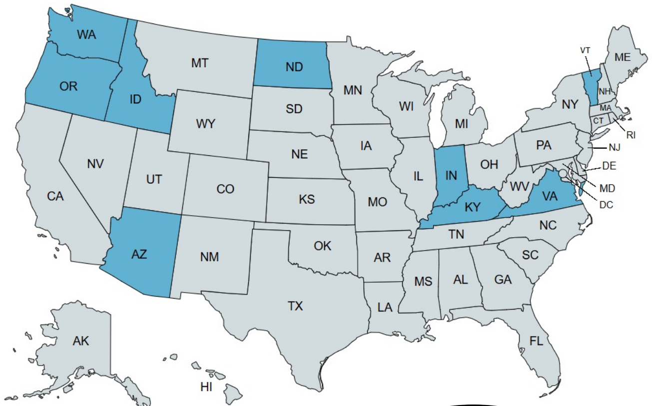



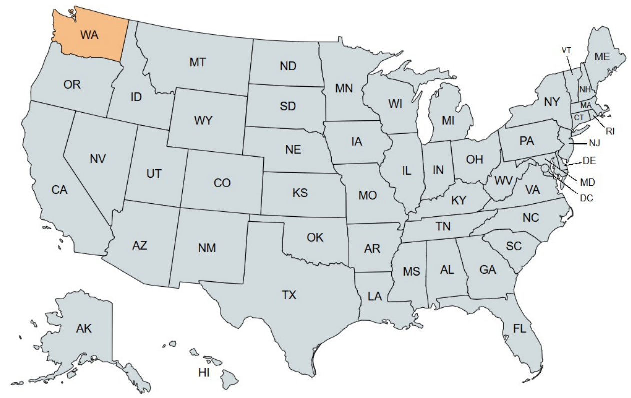

## Guidance Criteria of FY24 Funded Projects

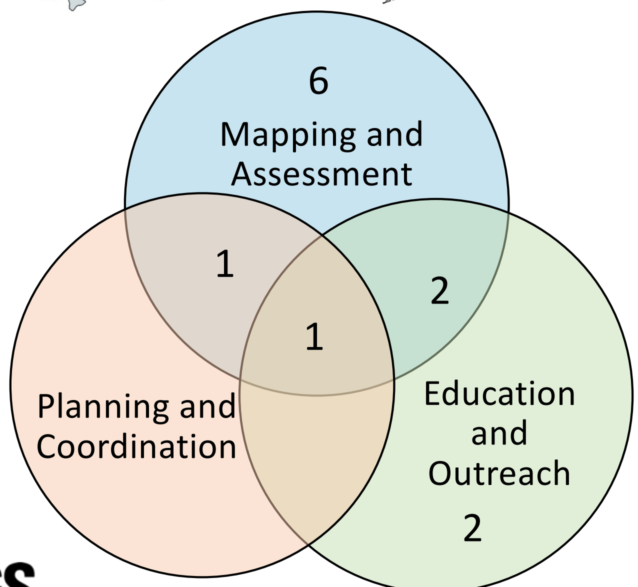


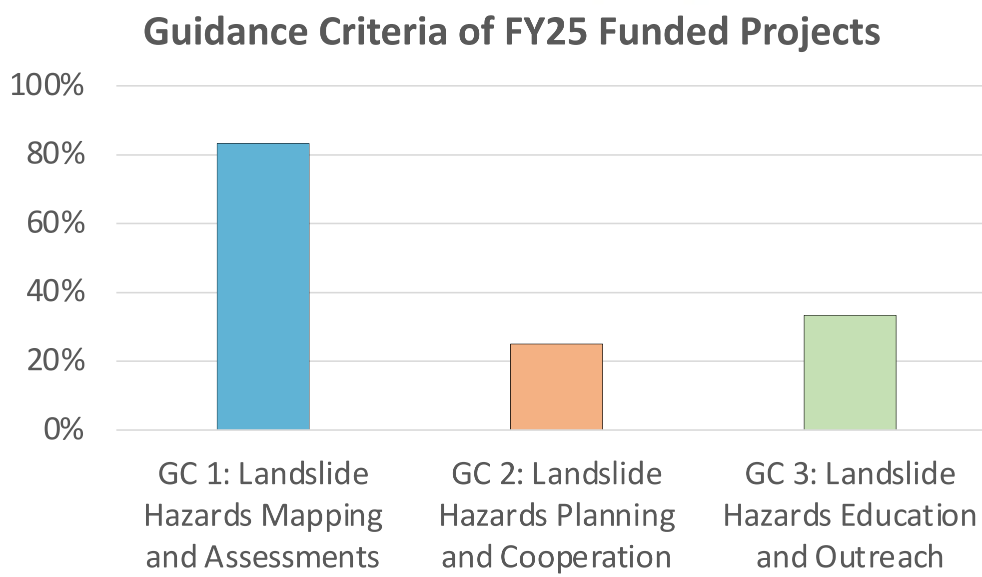

USGS

# Landslide Grant Statistics: Guidance Criteria and FY 2025 Funded Projects



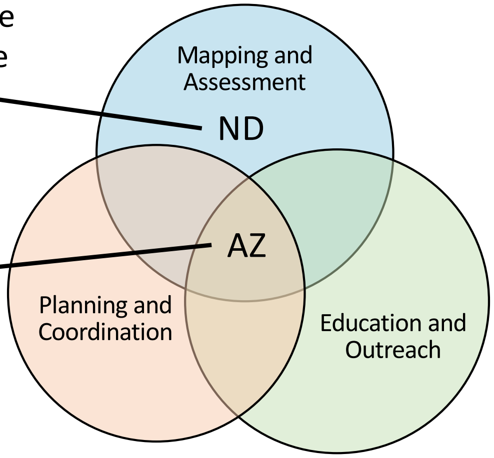



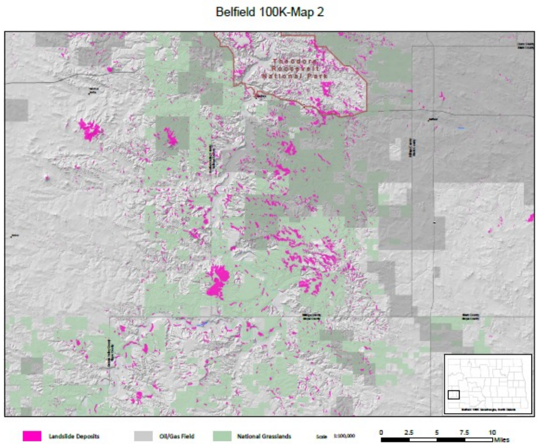
# Examples: Guidance Criteria and FY 2024 Funded Projects

**Example with one focused GC:**

***GC 1: Landslide Hazard Mapping and Assessment***

North Dakota Geological Survey: Mapping active landslides in the Belfield 1:100,000 Quadrangle: Phase 3 of an ongoing state-wide landslide inventory project. *~$10,000*




Belfield Quadrangle, ND

**Example including all three GCs:**

***GC 1: Landslide Hazard Mapping and Assessment,***

***GC 2: Planning and Coordination, and***

***GC 3: Education and Outreach:***

Arizona Geological Survey: Geologic hazards mapping at First Mesa Consolidated Villages (FMCV), Hopi Tribe, Navajo County, AZ:
A collaborative risk reduction project. *~$150,000*

- Coordination and Planning: establish communication pathways and needs assessments
- Mapping, Data Collection, and Analysis: Digital Map product
- Education and Outreach: tool training and feedback from FMCV
- Reporting: GIS data release, Open File Report, Report for FMCV

First Mesa Consolidated Community, AZ

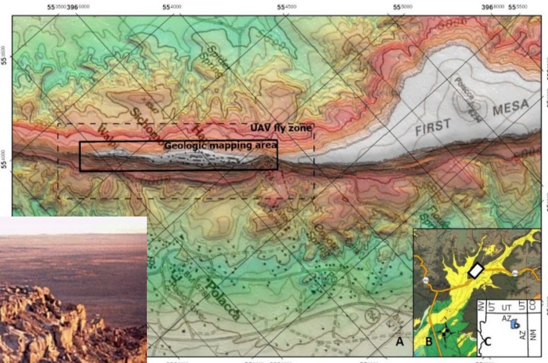


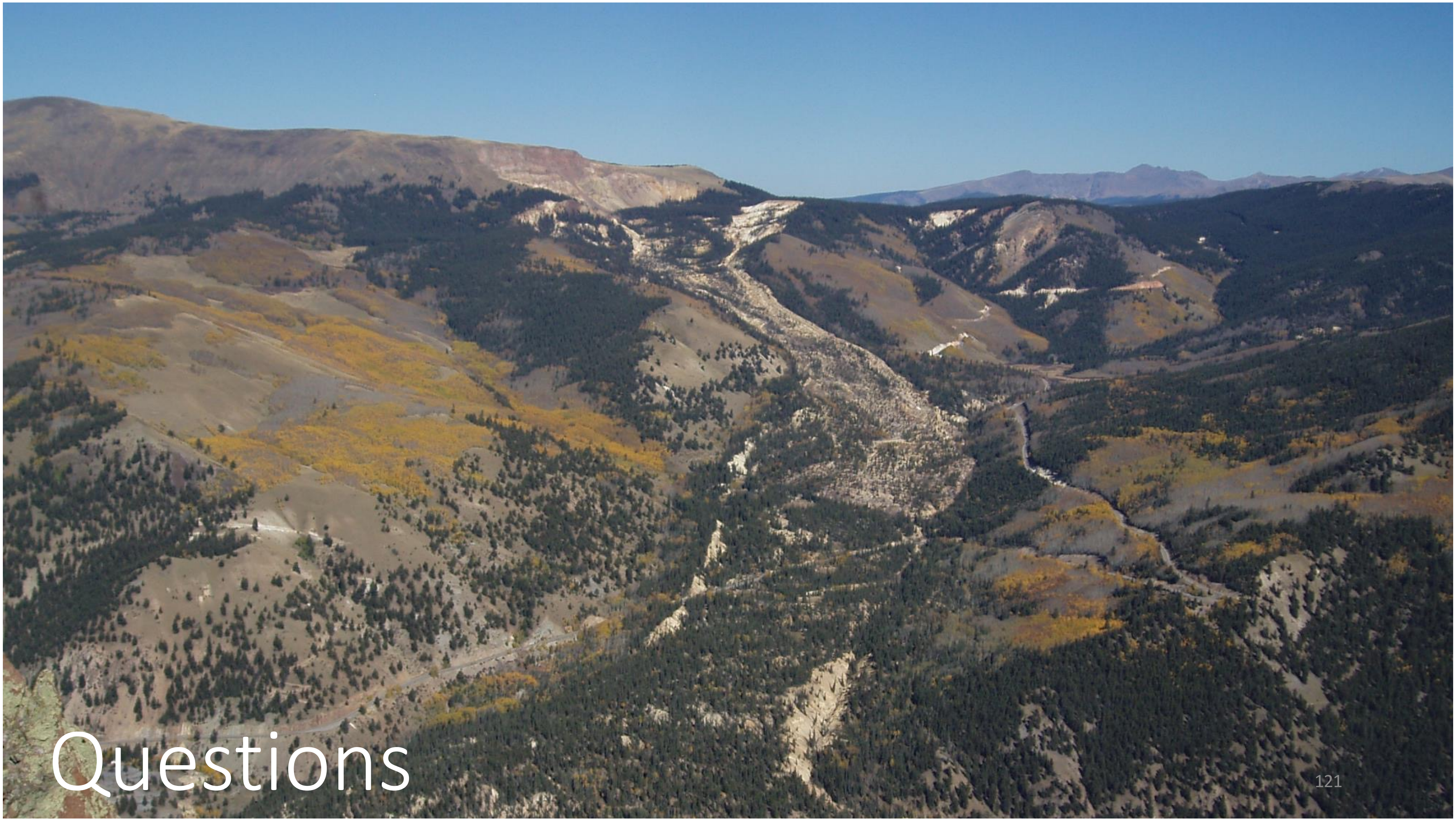

Image: https://firstmesaconsolidatedvillages.com/

USGS

# Considerations

- Modify, streamline, or emphasize portions of the current Guidance Criteria
- Introduce a Rotating Guidance Criteria
  - Prescriptive GC – e.g., runout mapping for urban areas; landslide guides for homeowners
  - Regional emphasis GC – e.g., Appalachia hazard mapping
- GC that aligns with LHP research
  - Post-fire debris flows or other LHP project
  - Landslide inventory compatible with USGS National Schema (in development)
- GC that aligns with other federal partners
  - Federal lands hazard mapping - e.g., BLM, USFS, NPS
- GC for recent, significant landslide events
  - Hurricane Helene landslide mapping

USGS


Questions

# Natural Landslide Hazards Risk Reduction Working Group

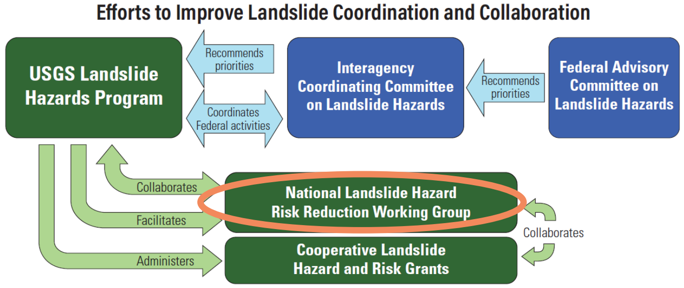
NLHRR Website

**Launched in November 2024 with monthly meetings beginning January 2025**

For professionals working on landslide hazard risk reduction at the regional-local scale:

- Facilitates the sharing of best-practice methods,
- Enables collective and collaborative creation,
- Provides opportunities for training.


Efforts to Improve Landslide Coordination and Collaboration

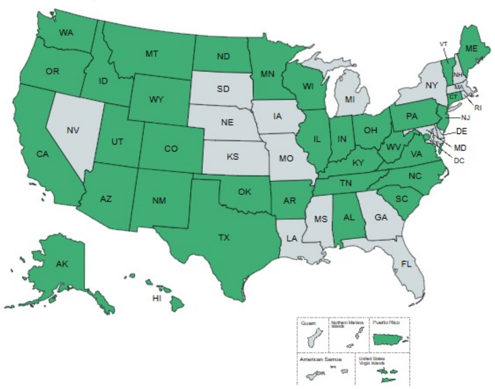



**USGS-supported monthly virtual meetings of landslide hazard risk reduction professionals from across the country.**

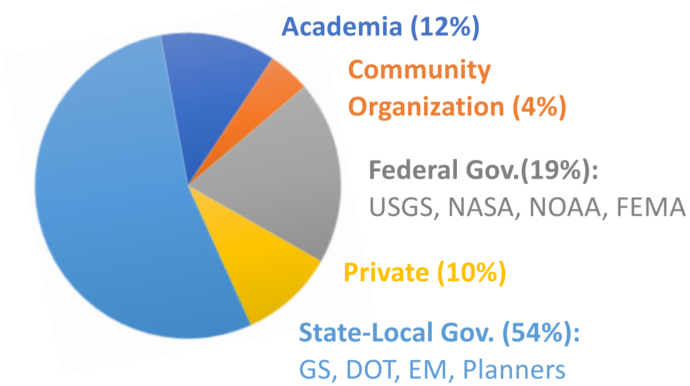
USGS
science for a changing world

# Natural Landslide Hazards Risk Reduction Working Group

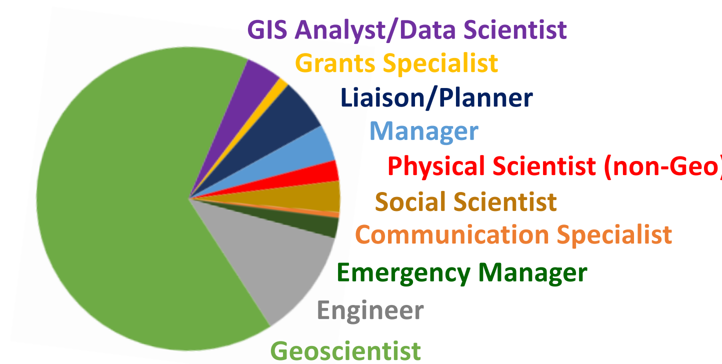
**Geographic distribution:**



**Sectors represented:**




**Expertise represented:**




**2025 Presentation and Discussion Topics:**

**Jan** - *The New National Landslide Susceptibility Map* (Mirus)
**Feb** - *Landslide Mapping, Schema, and Inventory Methods* (Slaughter)
**Mar** - *Landslide Event Response* (Allstadt; Eckhoff)
**Apr** - *Road and population exposure to areas susceptible to landslides* (Wood)
**May** - *Landslide Forecasting and Warning in Puerto Rico* (Hughes and Schulz)

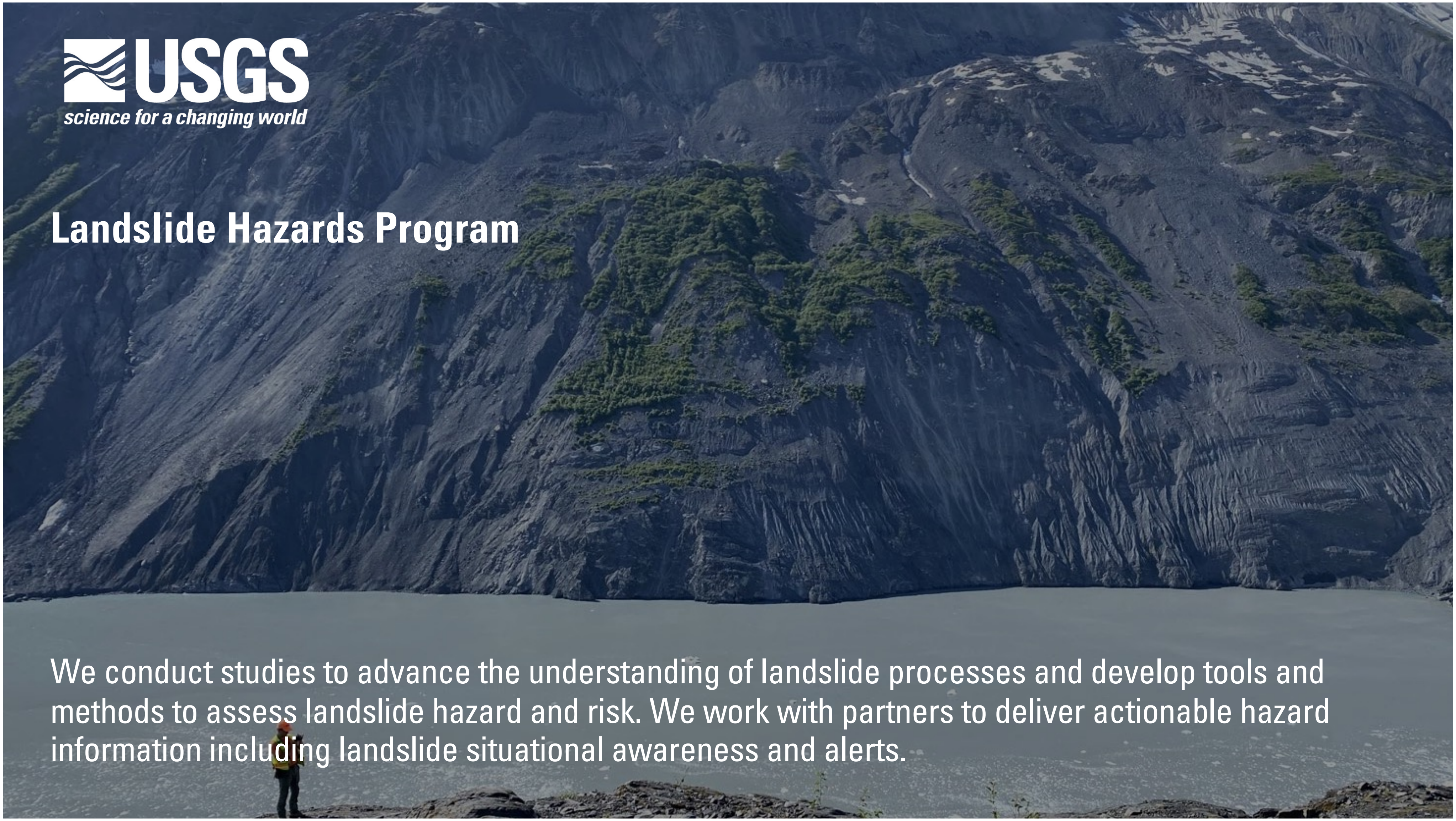
**Interest Groups: Regionally or topically focused sub-groups**

- ✓ Landslide Mapping and Modeling
- ✓ Landslide Event Response and Recovery
- ✓ Landslide Mitigation and Preparedness
- ✓ Landslide Forecasting and Warning
- ✓ Landslide Outreach and Education
- ✓ Eastern U.S. Region
- ✓ Intermountain West U.S. Region
- ✓ Landslide Loss

These groups are:
-- led and populated mainly by external partners
-- focused on applied work aligned with their professional missions

USGS
science for a changing world


National Landslide Hazard Reduction Program
Products Overview
Godt, Riker


USGS
science for a changing world
Landslide Hazards Program
We conduct studies to advance the understanding of landslide processes and develop tools and methods to assess landslide hazard and risk. We work with partners to deliver actionable hazard information including landslide situational awareness and alerts.

**Definitions:**

**Surveys, Investigations, and Research (SIR)** – Funding appropriated by Congress to support USGS activities

**External Assistance** – Funds provided to governmental, academic, and non-profit entities to advance USGS objectives

**Program Office** – Responsible for program governance, including advisory bodies, interaction with Congress, budget oversight, and overall scientific direction

**Science Center** – Responsible for project oversight, management of science staff, scientific integrity, and product management

**Project** – Responsible for data collection, research inquiry, partner interaction, and product delivery

**Fundamental Science Practices (FSP)** – Governance of USGS scientific integrity including peer review and product approval

**Product** – Data, map, model, method, tool, report, or other peer-reviewed scientific information

**Research Grade Evaluation (RGE) position** – Scientific or technical job series (e.g. Geologist, Civil Engineer, other) position evaluated by peers on research contributions and stature

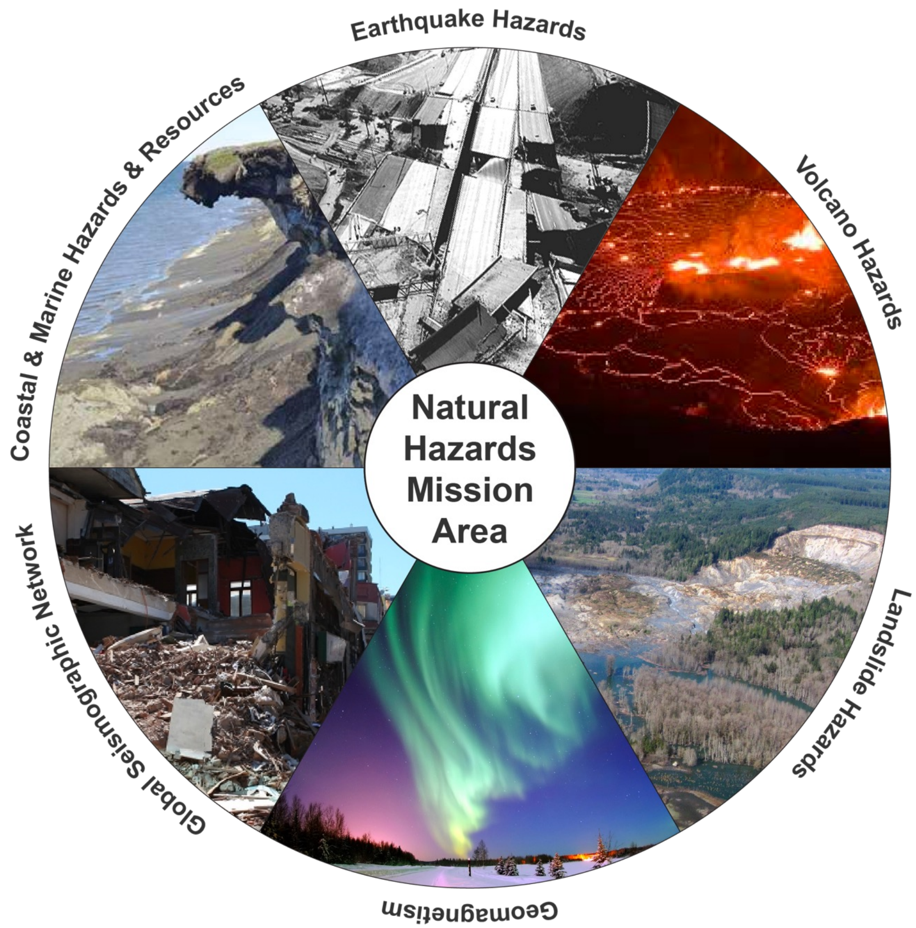
**Operational science position** – Scientific or technical job series evaluated by supervisor

**Student position** – Trainee position at a range of degree levels across job series

USGS

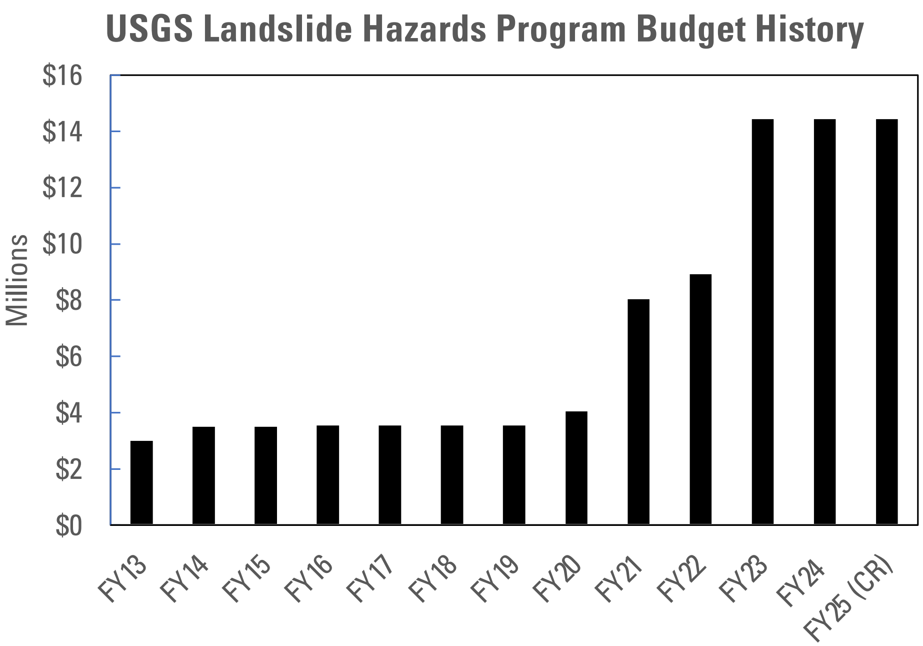
# USGS Natural Hazards Mission Area

- **Six Programs:**
  - Coastal/Marine Hazards & Resources
  - Earthquake Hazards
  - Geomagnetism
  - Global Seismographic Network
  - **Landslide Hazards**
  - Volcano Hazards
- Coordinates the broader hazards mission of the USGS – floods, hurricanes, tsunamis, and wildfires
- Implements integrated science strategies for risk reduction through understanding multi-hazard vulnerability and exposure
- Coordinates USGS science response activities following disasters



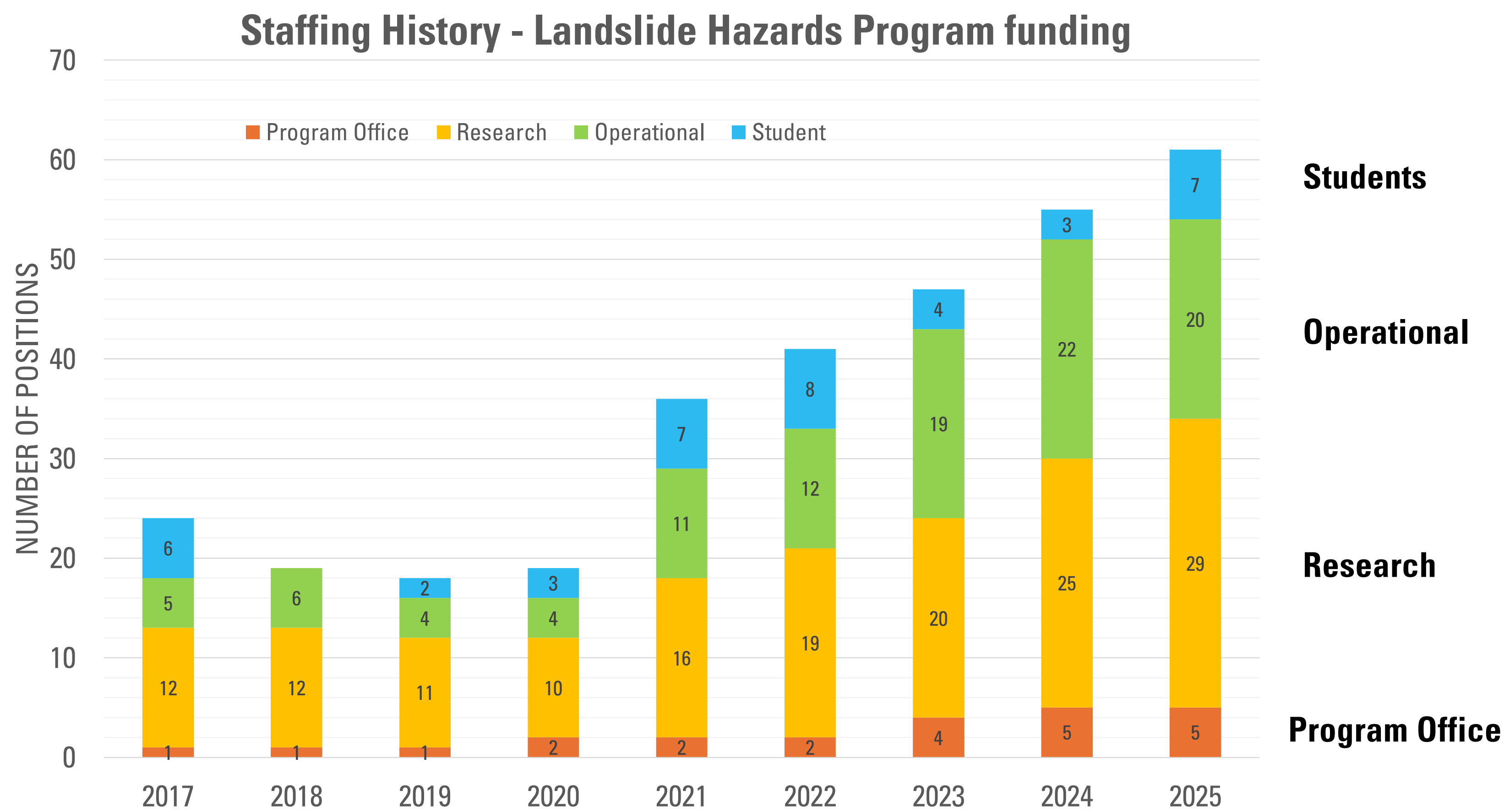

USGS

| USGS Natural Hazards<br>Dollars in Thousands ($000) | 2024 Enacted |
| --- | --- |
| Natural Hazards Total | 198,636 |
| Earthquake Hazards Program | 92,651 |
| Volcano Hazards Program | 37,500 |
| Landslide Hazards Program | 14,432 |
| Global Seismographic Network Program | 7,000 |
| Geomagnetism Program | 5,198 |
| Coastal/Marine Hazards and Resources Program | 41,855 |



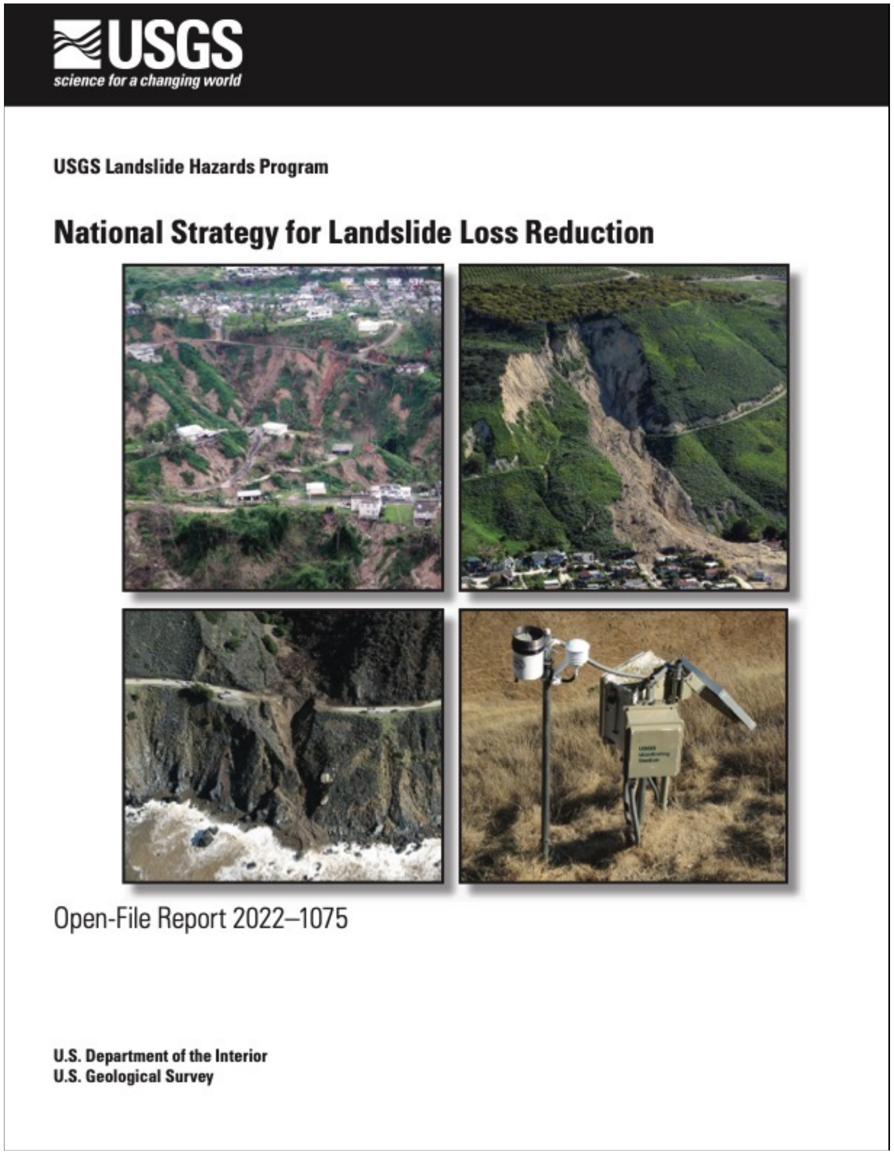

| **Landslide Hazards Program Budget** (thousands $000) | 2024 Enacted |
|---|---|
| Landslide Hazards total | 14,432 |
| Shared costs and LHP operations | 1,984 |
| External assistance including grants | 2,200 |
| Total allocation to Science Centers for projects | 10,240 |
| Alaska Landslide Hazards | 2,771 |
| Postfire Debris-Flow Hazard Assessments | 1,227 |
| Landslide Mechanisms and Forecasts | 1.300 |
| Landslide Geotechnics and Thresholds | 1,193 |
| Landslide Assessments, Situational Awareness, and Response | 1,126 |
| Landslide National Maps | 916 |
| Product development, user experience, and risk communication | 802 |
| Other projects | 913 |

USGS



Staffing History - Landslide Hazards Program funding
Program Office
Research
Operational
Student
NUMBER OF POSITIONS
70
60
50
40
30
20
10
0
2017
2018
2019
2020
2021
2022
2023
2024
2025
Students
Operational
Research
Program Office


USGS


USGS
science for a changing world

USGS Landslide Hazards Program

National Strategy for Landslide Loss Reduction

Open-File Report 2022–1075

U.S. Department of the Interior
U.S. Geological Survey

**Outlines USGS role in leading efforts to reduce landslide risk.**

**Sets out goals, provides a vision, and describes strategic actions to achieve those goals and vision.**

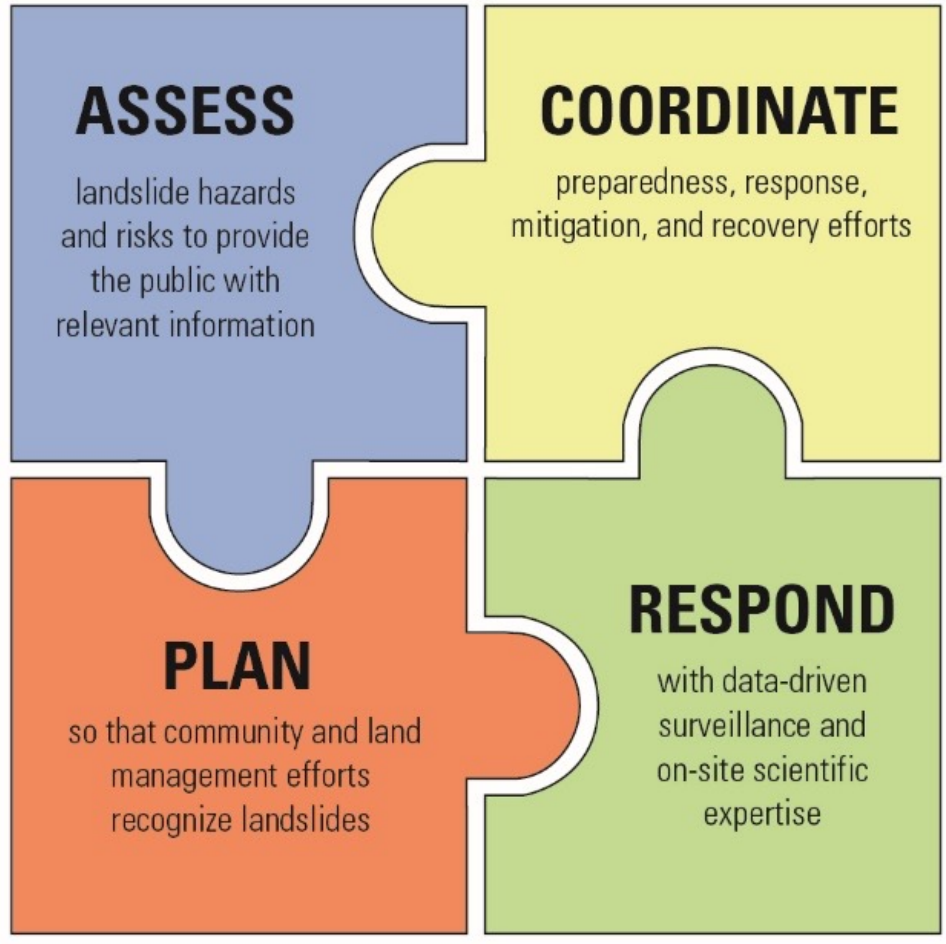
**Identifies involved parties and organizations, describes ongoing efforts, and lists specific actions and initiatives.**

**Goal 1 – ASSESS**: Ensure that decision-makers have access to detailed, nationally consistent, and contextually relevant information on landslide hazard and risk

**Goal 2 – COORDINATE**: Enable efficient and effective coordination of landslide hazard response, mitigation, and recovery efforts across federal, state, tribal, territorial, and local entities

**Goal 3 – PLAN**: Ensure communities at risk, decision makers, and land managers understand and are prepared for landslide hazards

**Goal 4 - RESPOND**: Ensure surveillance and responses to landslide events are effective, efficient, equitable, cooperative, and data-driven to protect life, property, and resources




USGS

# National Landslide Strategy – Goals and Strategic Actions

## Goal 1 – Assess landslide hazard and risk

| | |
|---|---|
| Strategic Action 1.1 | Characterize the societal risks posed by landslide hazards |
| Strategic Action 1.2 | Expand research and development to assess the where, when, and why of landslide hazards |
| Strategic Action 1.3 | Develop a publicly accessible national landslide hazard and risk database |
| Strategic Action 1.4 | Provide publicly available reports of Significant Landslide Events |

## Goal 2 – Coordinate across Federal, State, Tribal, Territorial, and Local levels

| | |
|---|---|
| Strategic Action 2.1 | Establish an Interagency Coordinating Committee on Landslide Hazards |
| Strategic Action 2.2 | Establish a formal Federal Advisory Committee on Landslide Hazards |
| Strategic Action 2.3 | Develop and maintain Cooperative Landslide Hazards and Risk Grants |
| Strategic Action 2.4 | Establish and support a National Landslide Hazard Risk Reduction (NLHRR) Working Group |

## Goal 3 – Plan for landslide hazards

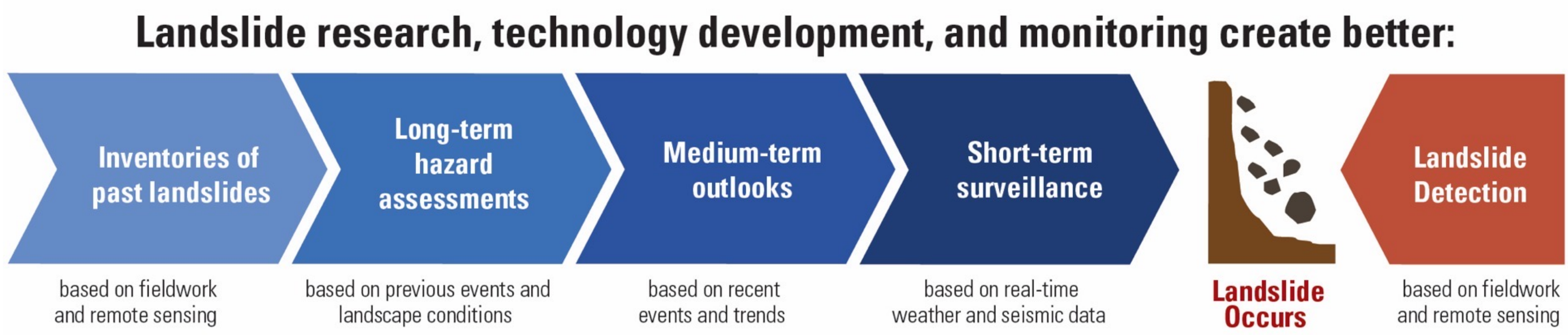
| | |
|---|---|
| Strategic Action 3.1 | Provide guidance, tools, and training to include landslide information in hazard planning |
| Strategic Action 3.2 | Develop landslide outreach to improve public knowledge and preparedness planning |

## Goal 4 – Respond to landslide events to protect life, property, and resources

| | |
|---|---|
| Strategic Action 4.1 | Support existing warning systems to include landslides |
| Strategic Action 4.2 | Improve real-time response actions by having onsite technical experts |

USGS

# U.S. Geological Survey Landslide Hazards Program



# Goal 1 - Characterize the societal risks posed by landslide hazards

**Who and what are vulnerable to landslides?**

- Improve national-scale landslide hazard map

**How do land use, management, and development influence risk?**

- Account for demographic exposure, vulnerability, population trends in risk assessments

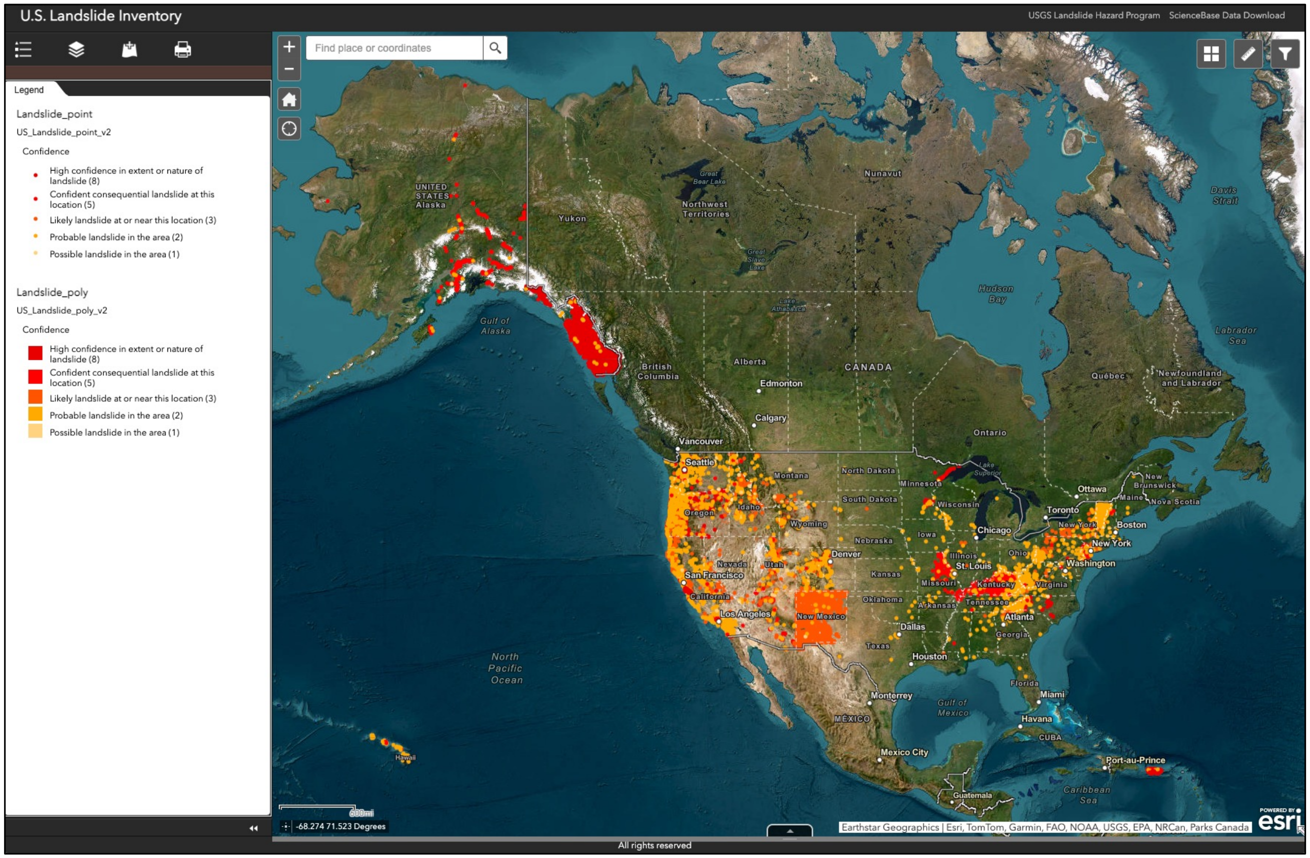
**What can be done to reduce social vulnerability to landslides?**

- Understand the short- and long-term impacts of landslides to local and regional economies, especially for tribal, isolated, and rural communities


*Damage from a post-wildfire debris flow that occurred on 9 January 2018 near Montecito, Santa Barbara County, CA, from heavy rain that fell on steep hillsides that burned in the 2017 Thomas Fire.*

## **Goal 1 –** Develop a publicly accessible national landslide hazard and risk database

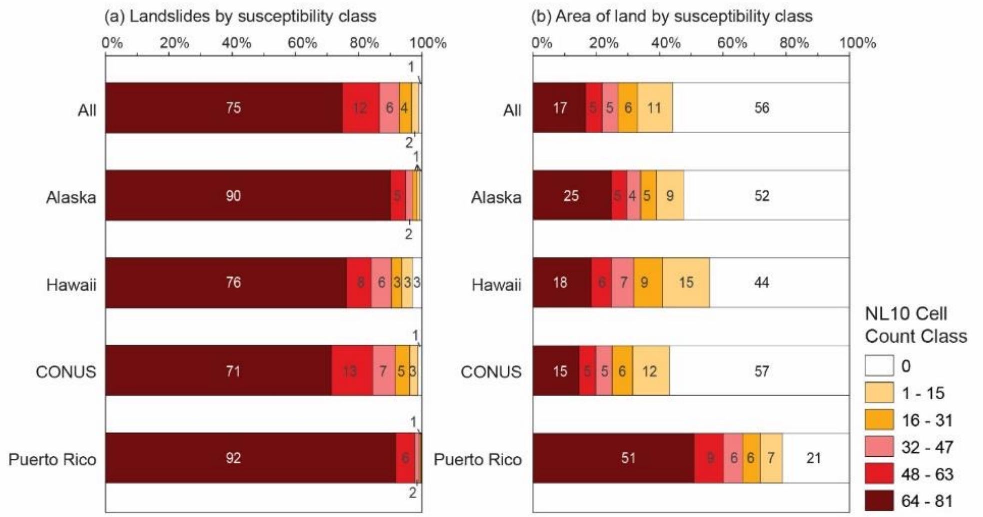
- March 2022 version – almost 1 million landslide locations
- Many mapped by State Geological Surveys
- Vast areas of the US with little or no data
- Enables efforts to begin assessing landslide hazard, exposure, and risk
- Paucity of timing information




*Belair and others, 2022, USGS Science Base*

USGS

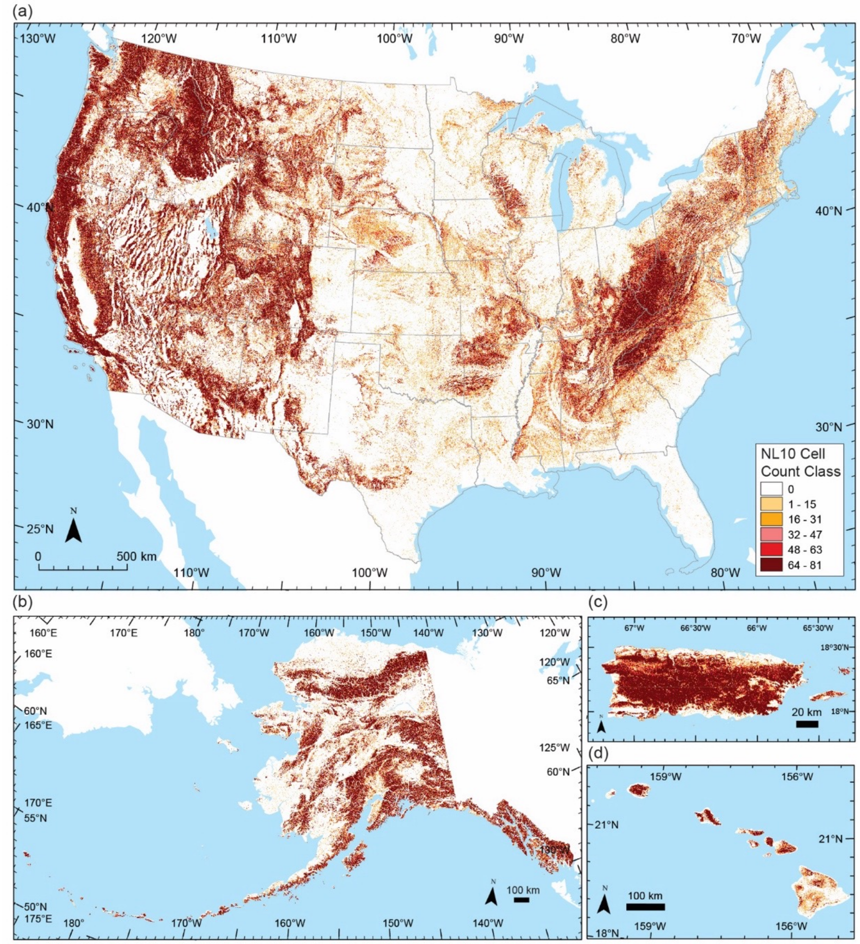
**Goal 1 –** Characterize the landslide risk to public safety, the economy, and critical infrastructure




**For exposure and other applications:**

Negligible (0) Some (1-31) Considerable (32-81)

- 10 m 3DEP elevation
- About 900,000 landslide locations
- Slope-relief analysis using USGS HPC resources
- Output at 90 m grid spacing




Mirus and others, AGU Advances, 2024

# Constraining landslide frequency across the United States to inform county-level risk reduction

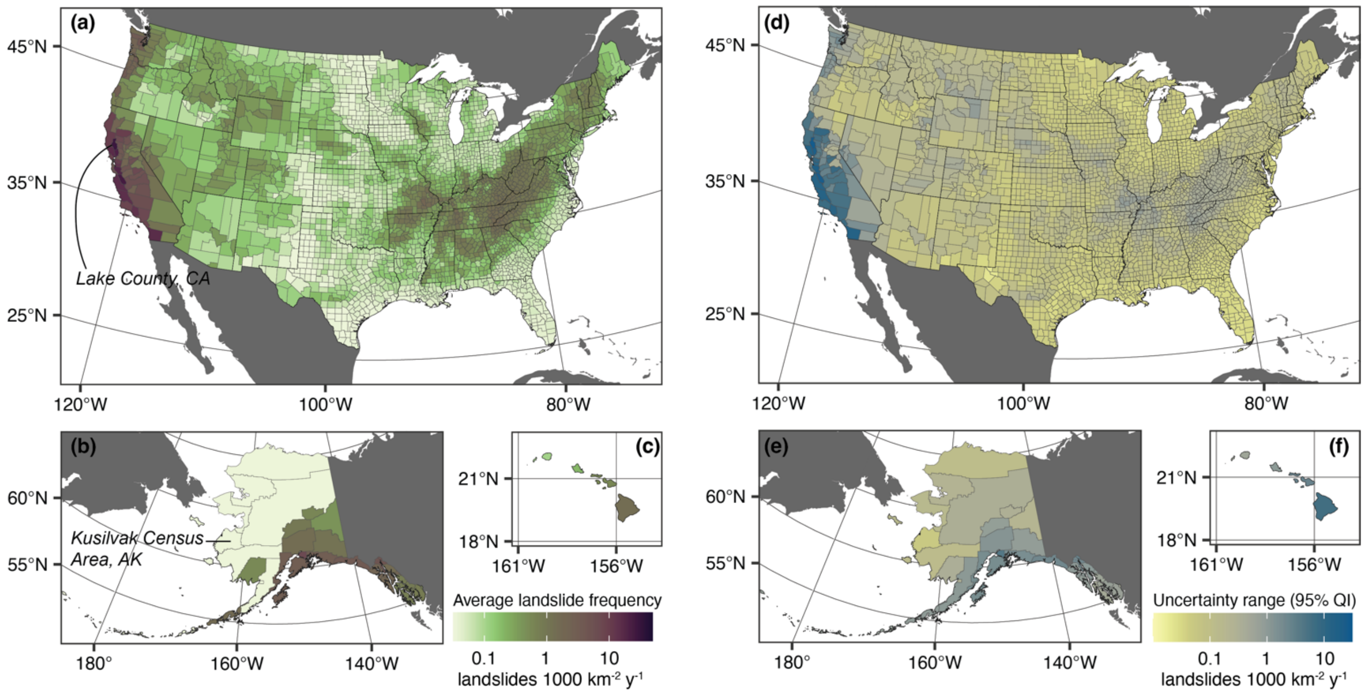



**Figure 3. Average annual landslide frequency by county. (a)–(c)** Posterior median expected (average) annual landslide frequency 1000 $km^{-2}$ $y^{-1}$ for 50-state U.S. counties. Lake County, California (CA) had the highest estimated frequency and Kusilvak Census Area, Alaska (AK) the lowest. **(d)–(f)** Range of posterior 95% quantile interval (QI). Base map data in **(a)–(f)**: U.S. counties from U.S. Census Bureau Cartographic Boundary Files 1:500,000 (U.S. Census Bureau, 2023a), non-U.S. administrative boundaries from Natural Earth (Natural Earth, 2022). Projection and datum: **(a), (d)** continental United States - Albers North American Datum 1983 (EPSG:5070). **(b), (e)** Alaska - Albers North American Datum 1983 (EPSG:3467). **(c), (f)** Hawaii - Old Hawaiian (EPSG:4135).

75K+ landslide locations with known year of occurrence

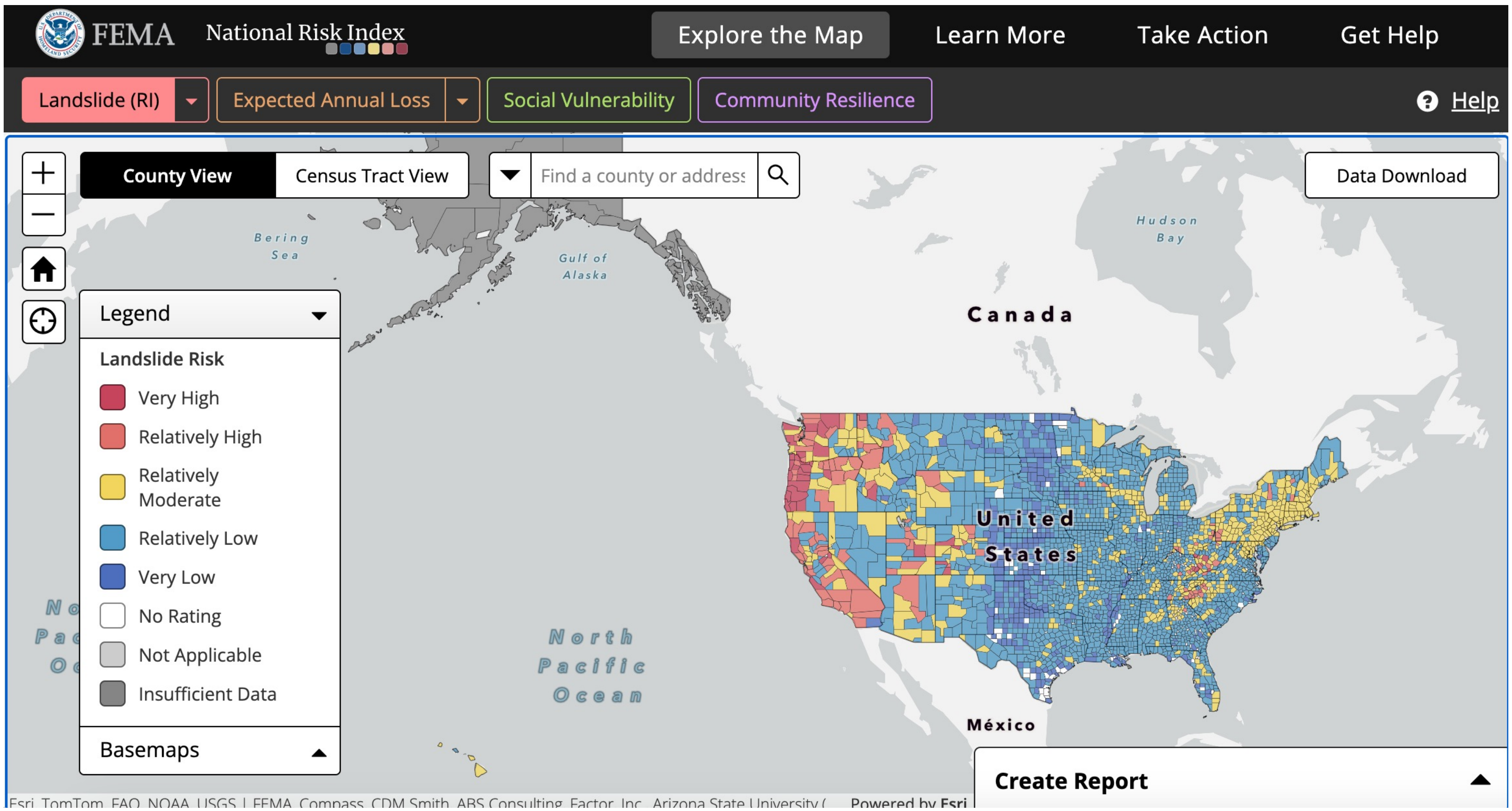
Bayesian binomial regression

Estimates of annual ground shaking and rainfall threshold exceedance

Average annual frequency varies by 5 orders of magnitude

Luna and others, 2025, doi: 10.5194/egusphere-2025-947

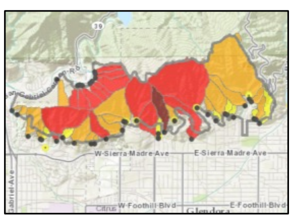
# Goal 3 – Plan for landslide hazards



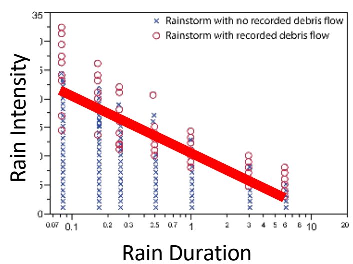
# Goal 1 & 4 – Assessing postfire hazard and supporting early warning

**Postfire debris flow:** **Key questions……**

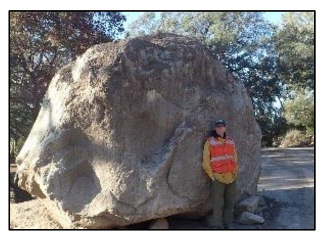
Where?



When?




How big?

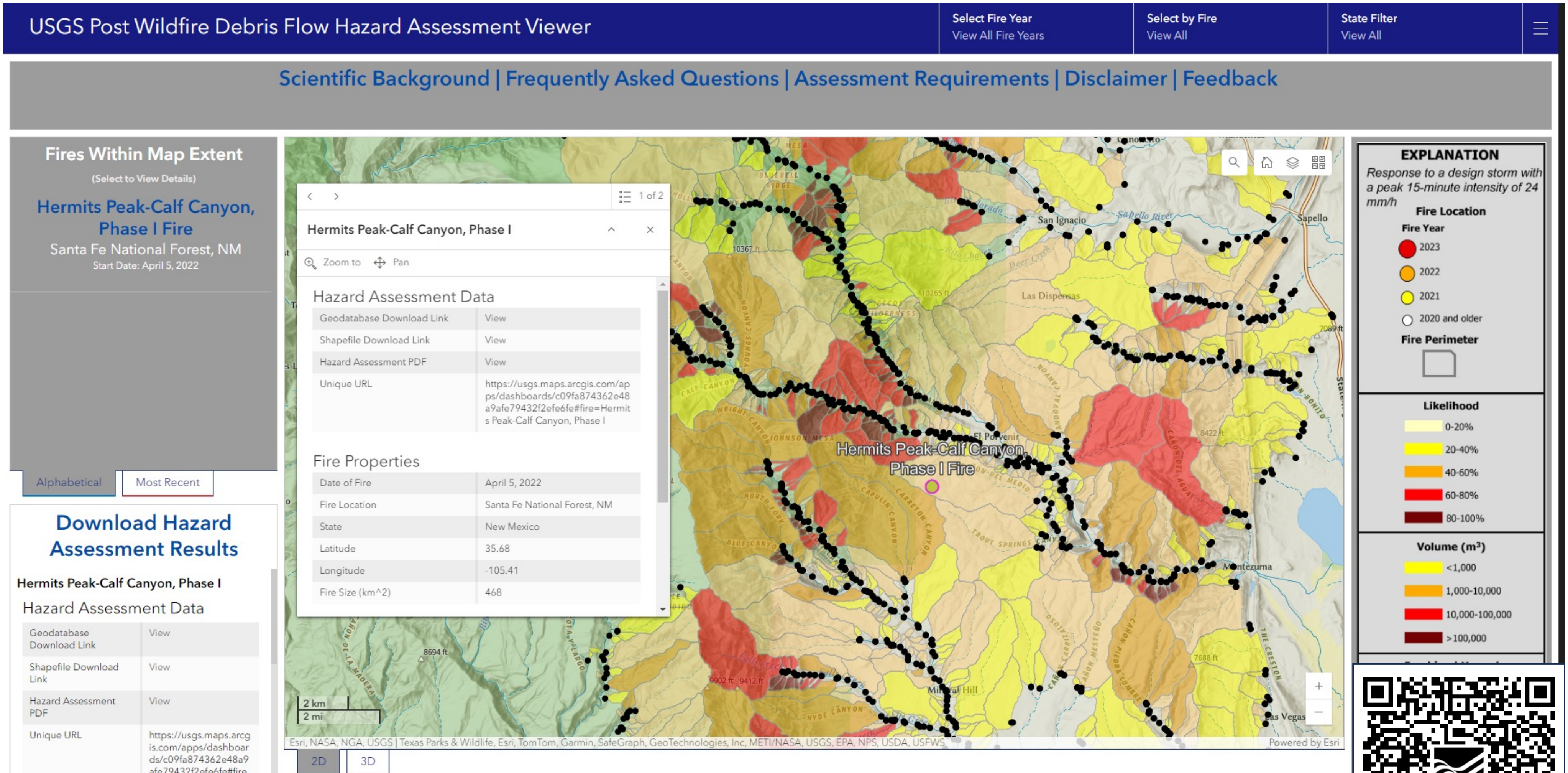


How fast and far?

How long?

Operational products

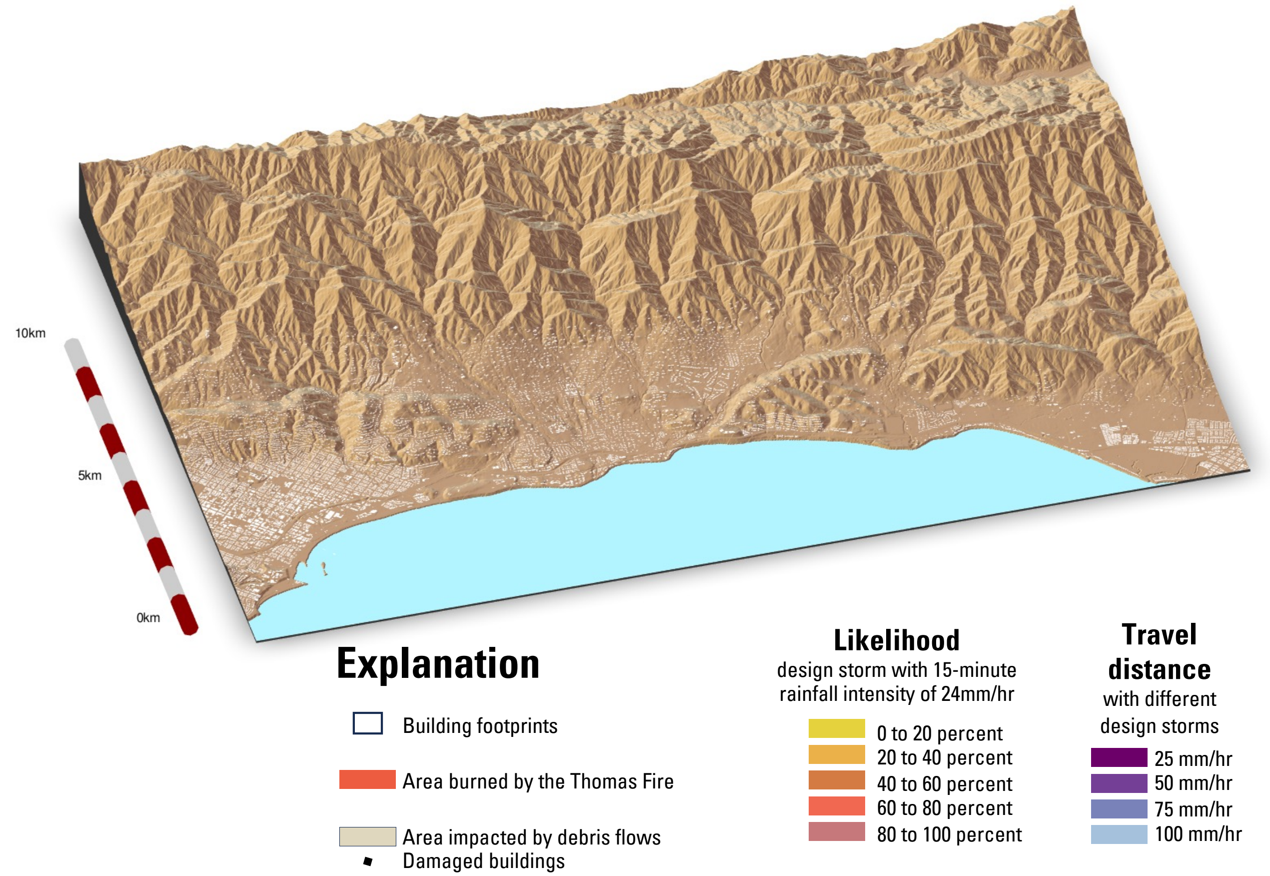
Under development




USGS assesses 20-100 fires each year covering up to 6 million acres/year

## How far will flows travel?

- Several models can predict inundation if properly calibrated, ***BUT***
- **Size matters!** Predicting how far flows travel requires good estimates of size.
- **Good representation of physics** are needed to predict how fast flows move and estimate damage.
- **Stakeholder input** is being incorporated into the design of new debris-flow inundation maps



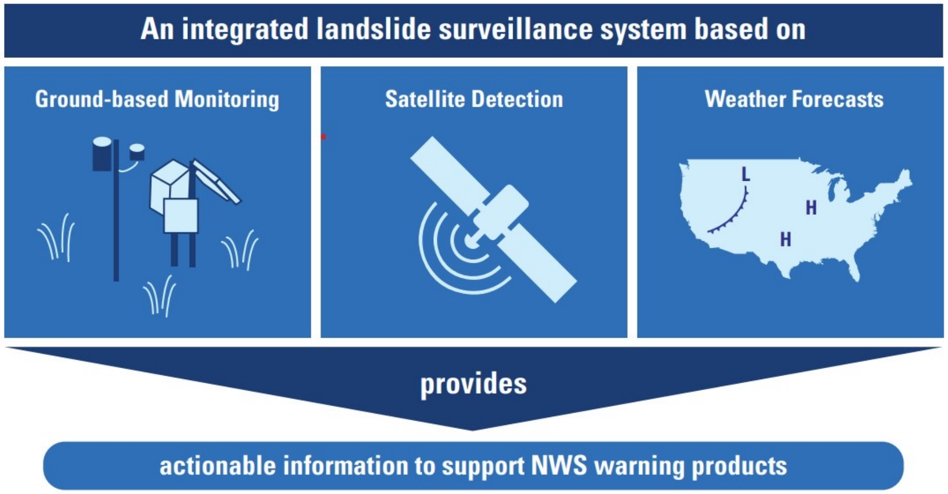

Barnhart et al., 2023, JGR-ES.

Barnhart et al., 2023, USGS-OFR.

Barnhart et al., 2024, NHESS.

## Goal 4 and Strategic Action 4.1 Advance landslide early warning:

1. Develop USGS landslide surveillance systems, including cyberinfrastructure.
2. Improve landslide surveillance products for consistent and accessible messaging.
3. Expand USGS–NWS cooperation on debris flow early warning.




Key partners are the USGS (to monitor and share surveillance information with the NWS), the NWS (to disseminate landslide alerts), and state, tribal, territorial, and local government entities (to reinforce and refine messaging).

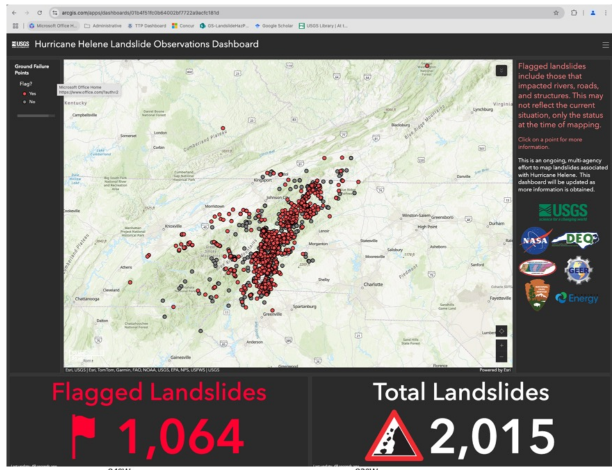
USGS

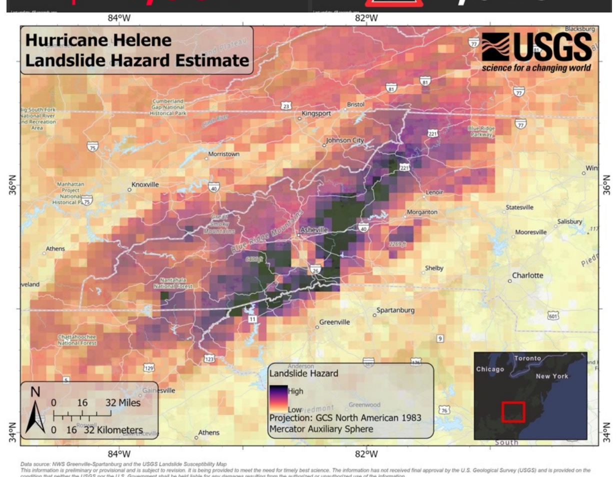
# Landslide early warning to reduce risk

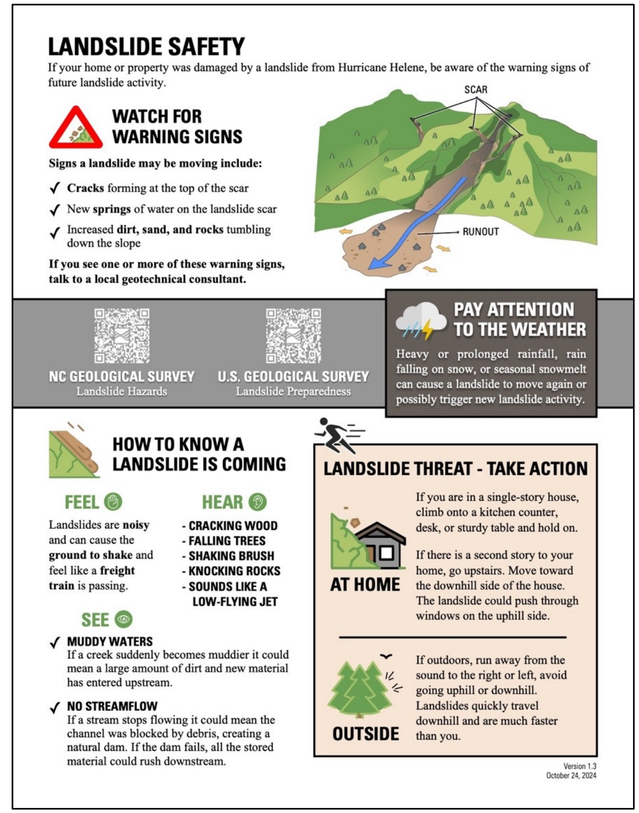
**Technical challenges**

- Landslide triggers vary in type, space, and time
- Once landslides are initiated, there may be just seconds to take action
- Signs may not be present before a landslide becomes hazardous
  - → Landslide forecasts rely on proxies for slope stability
  - → Warnings assess the likelihood of landslides before they occur
  - → Greater warning lead time = more time to take action and greater uncertainty
- Landslides can occur almost anywhere—forecasts and warnings must be site-specific

# Goal 4 – Support response to landslide disasters

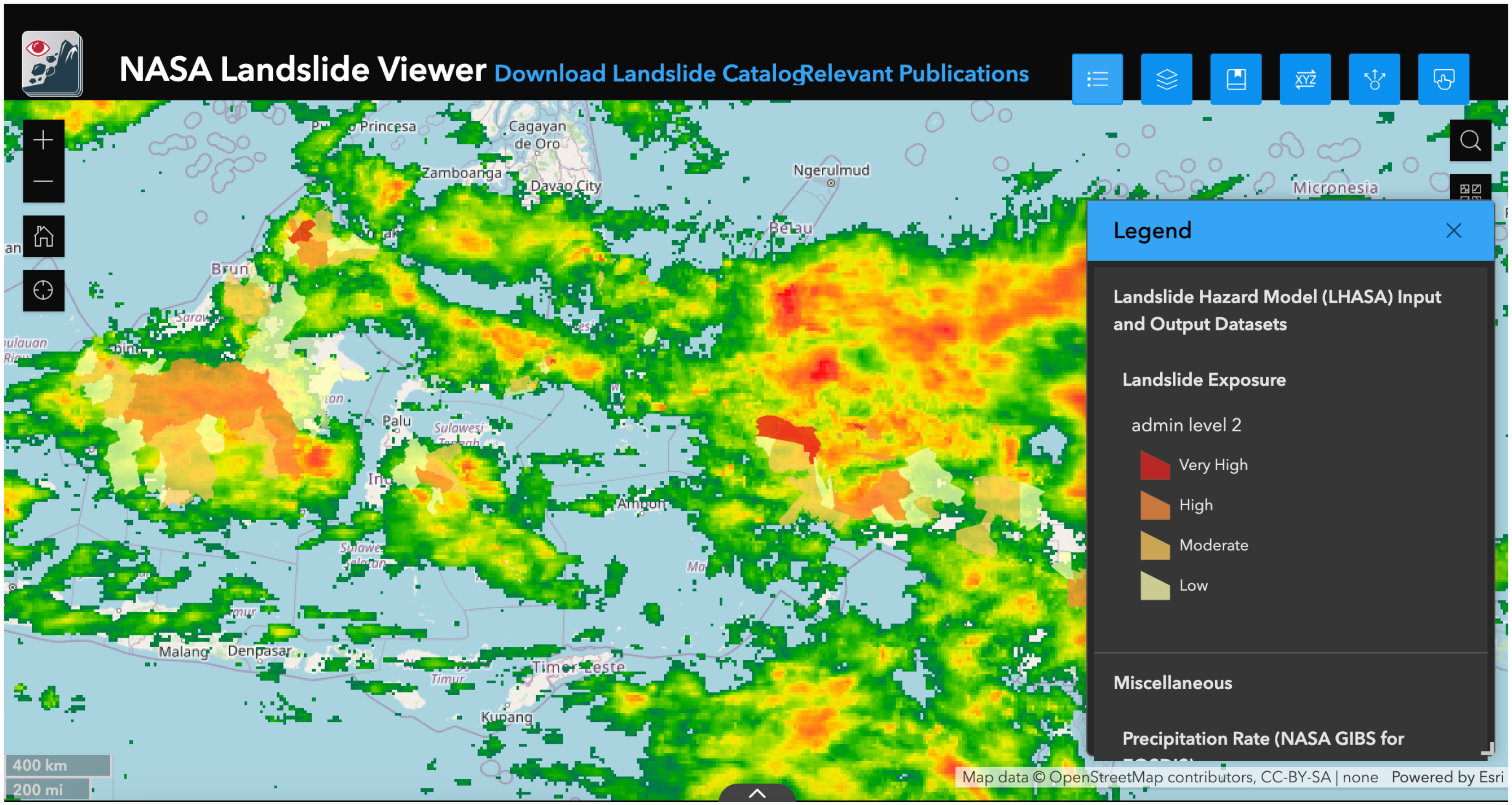


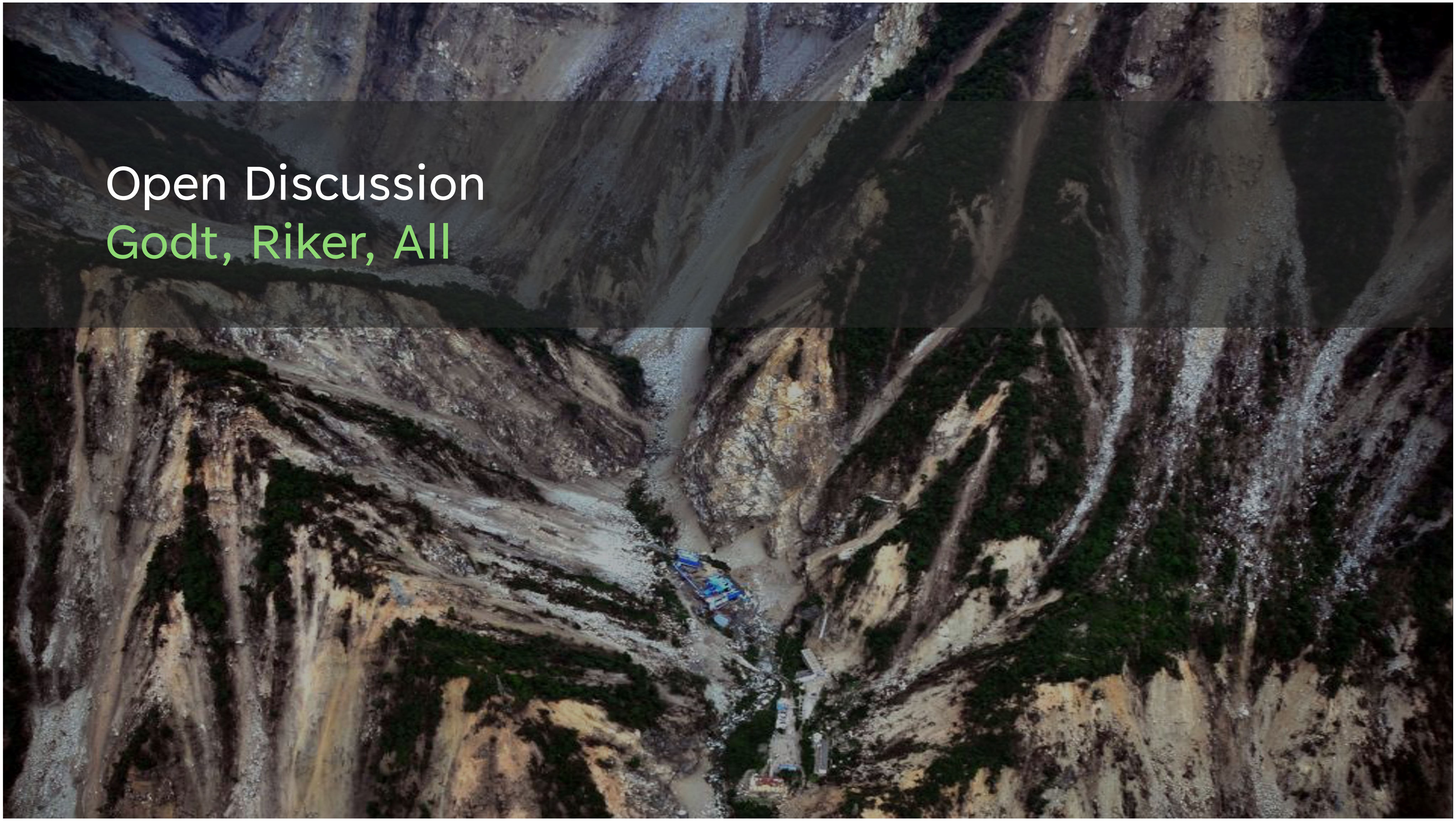

USGS

# Goal 4 – Support response to landslide disasters




USGS

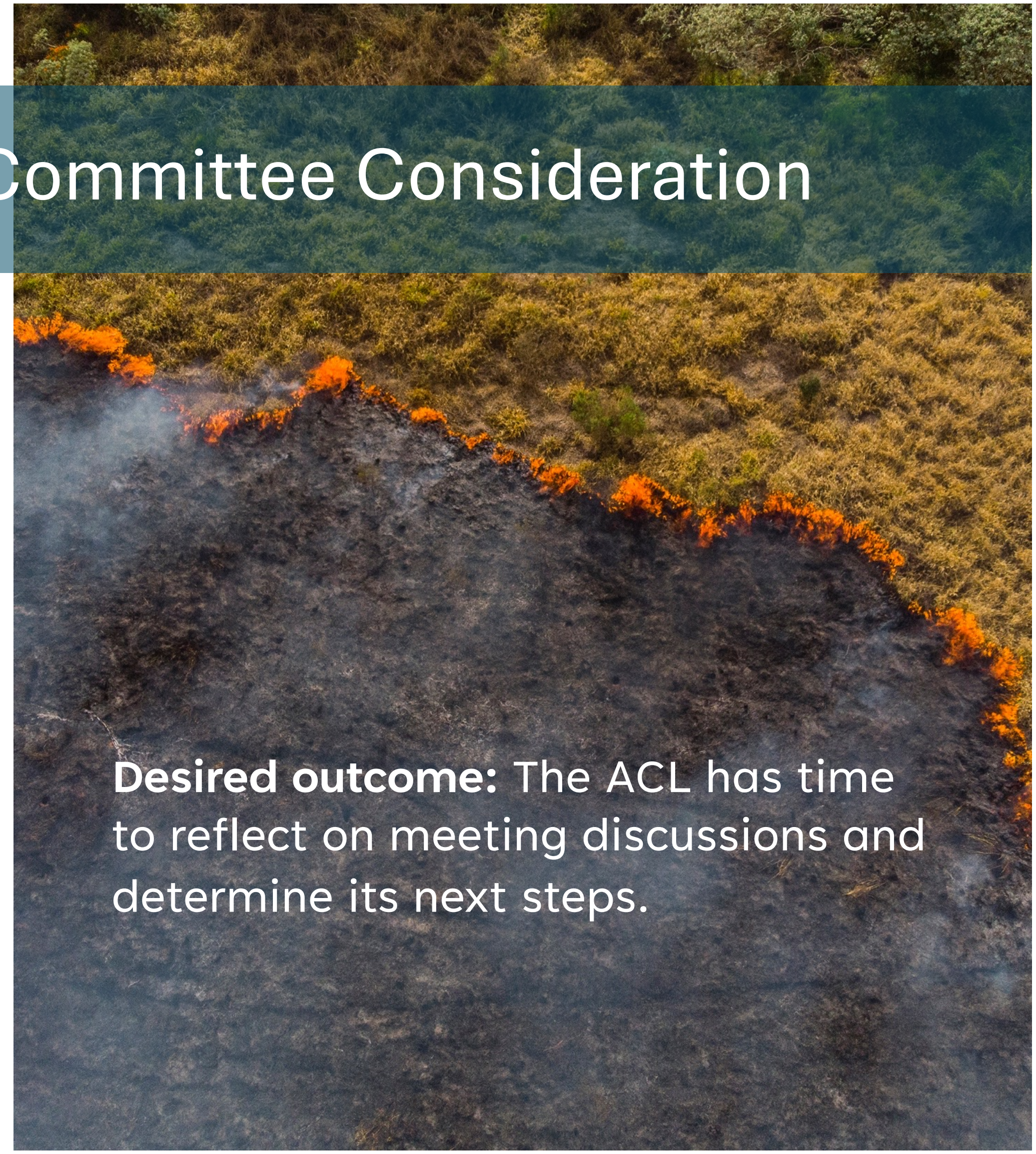
# NLHRP Products Discussion


Open Discussion
Godt, Riker, All

# Day 1 Review, Questions, Reflections

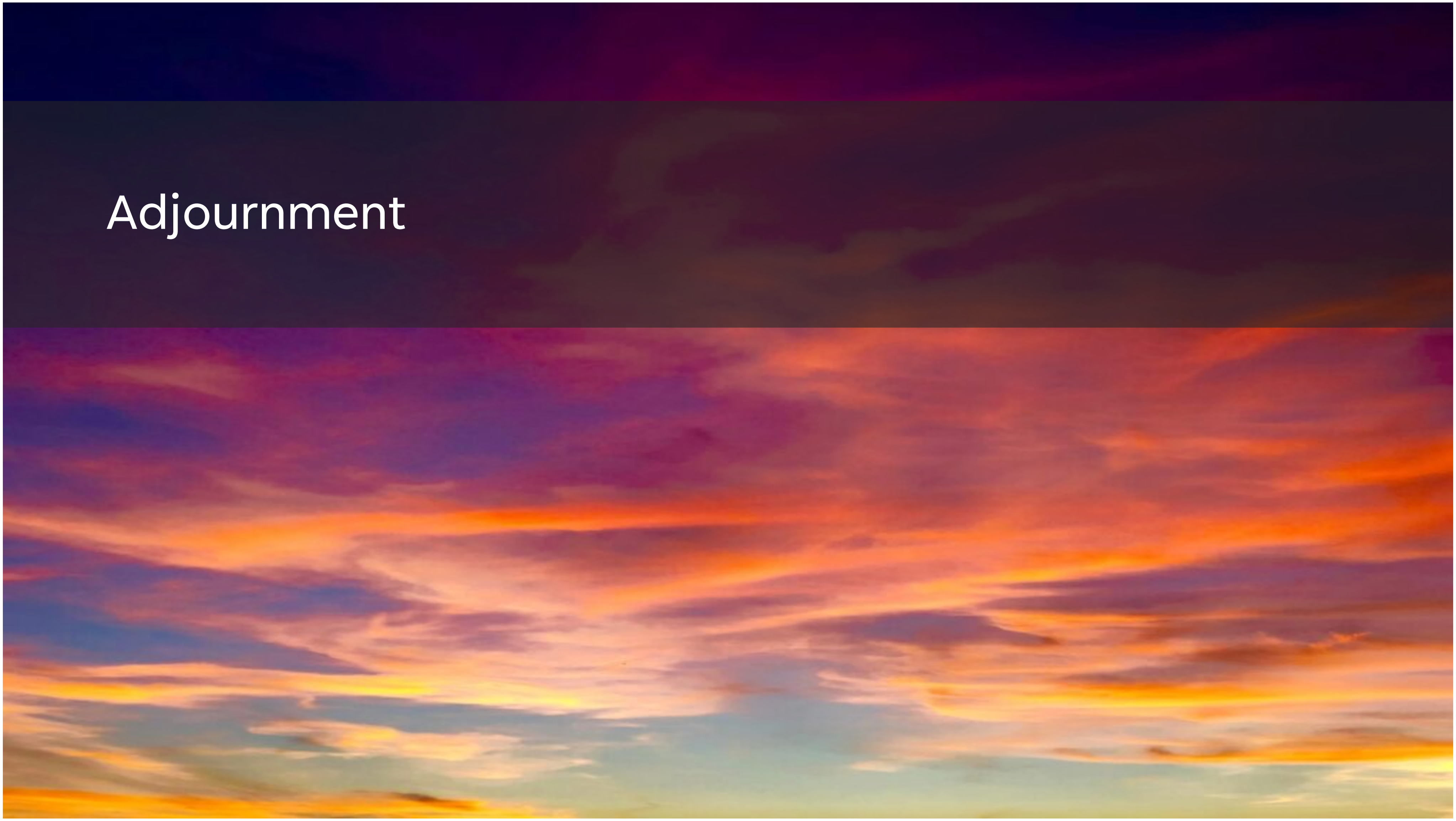
# Questions for Advisory Committee Consideration

- Chair/co-chair updates
- Questions/discussion about ACL role
- Emerging recommendations/ compiling recommendations
- How often should we meet? In what format?
- How should the ACL interact with the ICCLH? The LHP?
- Bylaws and legal updates
- Priority topics for future discussion



**Desired outcome:** The ACL has time to reflect on meeting discussions and determine its next steps.


Public Comment
Riker


Adjournment