

Federal Advisory Committee on Landslides—Day 1

March 4th, 2026, Asheville, North Carolina

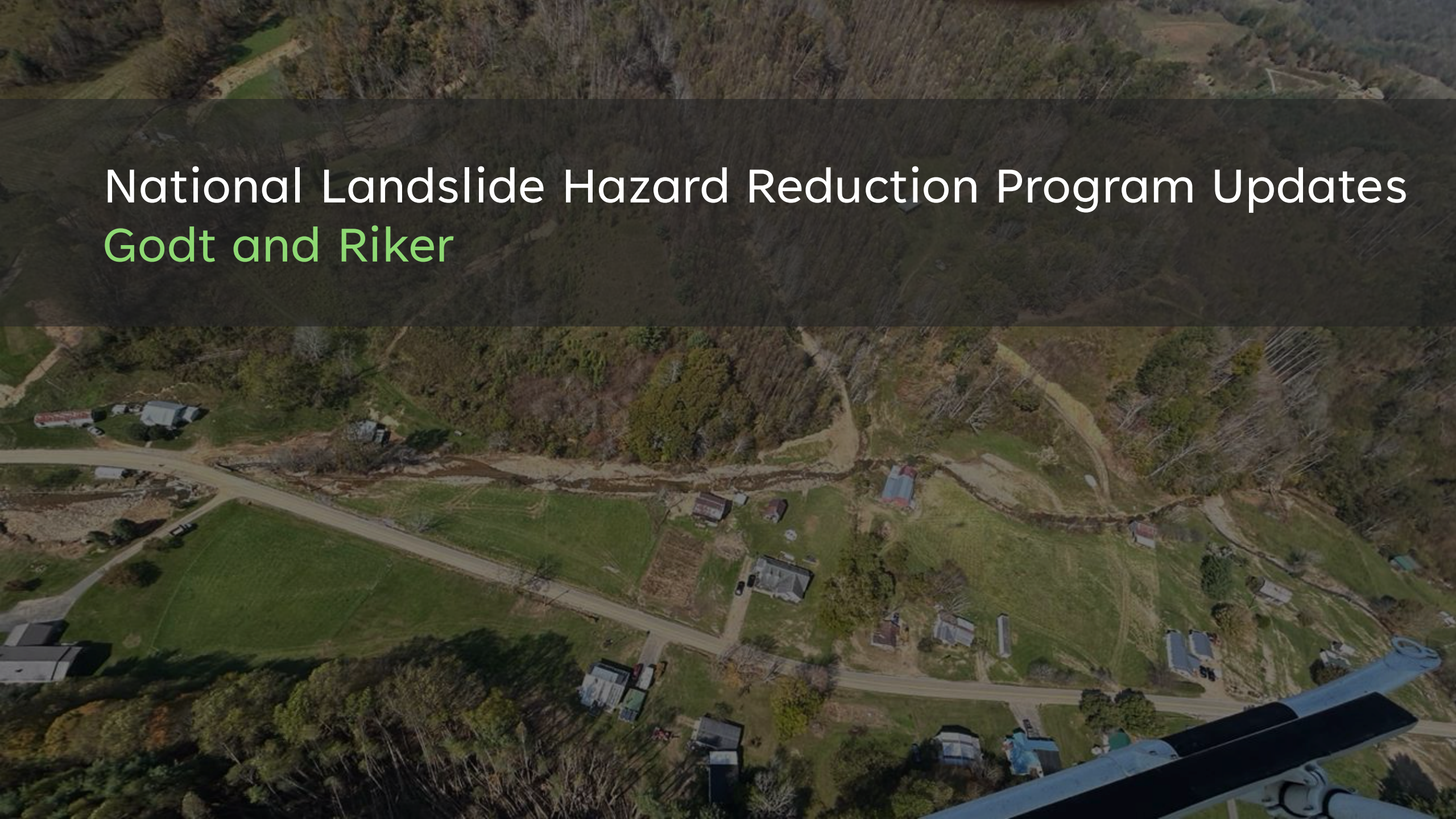


Welcome and Introductions

Haneberg (Chair) and Oakley (Co-Chair)

National Landslide Hazard Reduction Program Updates

Godt and Riker



Engagement Considerations

- ACL members: Raise your name card
- Guests and online: Raise your hand
- State your name and organization before speaking
- Virtual attendees—feel free to keep cameras on
- Meeting notes will be shared publicly

Reauthorization of the National Landslide Preparedness Act

S.1626 - National Landslide Preparedness Act Reauthorization Act of 2025

- Passed Senate on 1/5/2026; HR. 2250 awaits action in the House
- Establishes Regional Partnerships with institutions of higher education
  - Leverage regional expertise
  - Coordinate long-term landslide research
  - Align interagency landslide monitoring efforts
- Expands landslide grant eligibility to Native Hawaiian organizations and institutions of higher education

Interior, Environment, and Related Agencies Appropriations Act, 2026

Landslide Hazards Program - $14,532,000

- $1,500,000 to collaborate with local and regional entities in Alaska
- $1,250,000 for deployment, operation, and maintenance of landslide detection and monitoring systems in high-risk areas
- $1,000,000 for landslide risk-reduction grants

Alaska:

- Work with FEMA to complete landslide data for Risk Index Maps (initial dataset published)
- Continue to collaborate with:
  - Interagency Landslide Working Group in Southeast Alaska
  - Alaska State and local governments to assess landslide potential and hazards
  - Local and Indigenous people and entities to maintain landslide monitoring systems
  - National Oceanic and Atmospheric Administration

Post-wildfire landslides:

- Continue to prioritize efforts to predict and reduce risk

Landslide Observing System

- Provide information within 180 days on creation of cohesive monitoring systems in high-risk areas with participation from Federal, State, Tribal, and municipal entities

Achieving Efficiency Through State and Local Preparedness - Executive Order 14239 of March 18, 2025

Congressional direction:

- Work with State, Indigenous, and local entities in Alaska
- Continue landslide risk reduction grants
- Plan for regional landslide partnerships and observing systems

Example program activities:

- Continue support of National Landslide Risk Reduction Working Group
- Cooperation with National Weather Service to expand landslide alerting
- Meet requests from State and other entities for postfire debris-flow hazard assessments

Elevating and Unifying DOI's Wildland Fire Management Program – Secretarial Order 3443 of Sept. 10, 2025

- Advancing ability to deliver geospatial data on debris-flow inundation potential
- Advancing cooperation with National Weather Service to deliver postfire debris-flow alerts

BREAK

Back at 10:15





Landslide Science and Technology Gaps
Subcommittee Report and Discussion
Wartman (Subcommittee Chair)

ADVANCING THE NATIONAL STRATEGY FOR LANDSLIDE LOSS REDUCTION: SCIENCE AND TECHNOLOGY PRIORITIES

REPORT OF THE ADVISORY COMMITTEE ON LANDSLIDES SUBCOMMITTEE ON SCIENCE AND TECHNOLOGY GAPS

Subcommittee Members: Jennifer Bauer, Casey Hannel, Nina Oakley, Josh Roering, and Joe Wartman (Chair)

Our Charge: "(Prepare) a concise draft document to be presented, deliberated upon, revised as necessary, merged, and (finalized) at our planned ~~November 2025~~ meeting."

Report Focus and Content: Assess major gaps in landslide science and technology needed to advance NLHRP implementation. The Reports should reflect:

1. Summarize the current state of landslide science and risk reduction in the U.S.
2. Identify the most critical knowledge gaps and technological needs.
3. Broadly suggests future actions and priorities to bridge these gaps.

In short: *"**an assessment of major knowledge gaps most relevant to advancing objectives of the National Landslide Hazard Reduction Program and suggestions for moving forward**."*

Process: Multiple subcommittee virtual meetings (with DOF present) during the Fall 2025 and early Winter 2026.

Primary Purpose/Audience: Guidance to Interagency Coordinating Committee on Landslide Hazards, leadership within the Department of the Interior and partner federal agencies, and Congress, while also identifying research priorities for the scientific and academic communities.





ADVANCING THE NATIONAL STRATEGY FOR LANDSLIDE LOSS REDUCTION: SCIENCE AND TECHNOLOGY PRIORITIES

REPORT OF THE ADVISORY COMMITTEE ON LANDSLIDES SUBCOMMITTEE ON SCIENCE AND TECHNOLOGY GAPS, 2026

Subcomittee Members:
Jennifer Bauer, Casey Hannel, Nina Oakley, Josh Roering, and Joe Wartman (Chair)

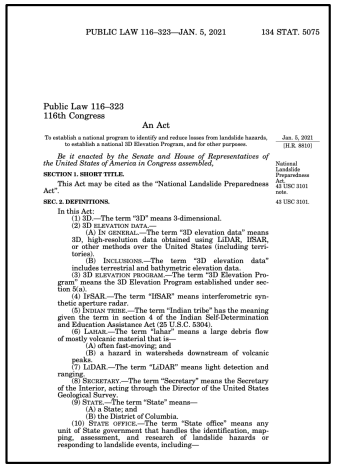
1. Introduction

Landslides occur in all 50 states and most U.S. territories, affecting communities and critical infrastructure nationwide. Although incomplete data limits precise accounting, landslides cause an estimated several billion dollars in damage annually—figures that significantly underestimate true costs because they often exclude indirect impacts such as emergency response expenditures, supply chain disruptions, and housing displacement.

Recent events such as Hurricane Helene in 2024 demonstrate the scale and cascading nature of landslide hazards (Inset 1), underscoring the need for comprehensive national landslide risk reduction capabilities. At the same time, significant opportunities exist to address this challenge. The convergence of advanced remote sensing technologies, the legislative framework established by the National Landslide Preparedness Act (P.L. 116-323), and comprehensive geospatial data infrastructure provides the foundation to advance landslide risk reduction.

The National Landslide Preparedness Act authorized the National Landslide Hazards Reduction Program (NLHRP) to coordinate federal efforts to reduce landslide losses nationwide. To guide this effort, the U.S. Geological Survey developed the National Strategy for Landslide Loss Reduction, which establishes four strategic goals and defines priority actions for federal agencies and their partners. This report, prepared by the Subcommittee on Science and Technology Gaps, identifies the primary scientific and technological barriers that currently limit effective implementation of the National Strategy at the national scale.

This report examines the principal challenges to implementing the National Strategy, reviews current and emerging technologies and data products that can address these challenges, and presents recommendations for priority actions. It provides guidance to the Interagency Coordinating Committee on Landslide Hazards, leadership within the Department of the Interior and partner federal agencies, and Congress, while also identifying research priorities for the scientific and academic communities.



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. 8510]

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

National Landslide Preparedness Act.
42 USC 3101 note.

SECTION 1. SHORT TITLE.

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-dimensional.

(2) 3D ELEVATION DATA.—

(A) IN GENERAL.—The term "3D elevation data" means 3D, high-resolution data obtained using LiDAR, IfSAR, or other methods over the United States (including territories).

(B) INCLUSIONS.—The term "3D elevation data" includes terrestrial and bathymetric elevation data.

(3) 3D ELEVATION PROGRAM.—The term "3D Elevation Program" means the 3D Elevation Program established under section 9(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
science for a changing world

USGS Landslide Hazards Program

National Strategy for Landslide Loss Reduction



Open-File Report 2022–1075

Strategic goals
- Assess
- Coordinate
- Plan
- Respond

Landslide Losses → Landslide Risk Reduction (LRR)

Current Challenges in LRR: "Assess" and "Respond" Goals

- **Mapping and Modeling**
  - Incomplete Inventories
  - Subsurface Uncertainty
  - Runout Prediction
  - Impact and Consequence Tracking
- **Forecasting and Weather Prediction**
  - Limited Precipitation Data
  - Mesoscale Weather Forecast Models
  - Extreme Weather
- **Warning Systems**
  - Limited Operational Coverage
  - Triggering Threshold Uncertainties
  - Monitoring Infrastructure

Current Challenges in LRR: "Coordinate" and "Plan" Goals

- **Institutional Coordination and Training**
- **Policy and Planning**
- **Mitigation Techniques**

Current Data Products and Emerging Technologies

- **High-Resolution Topographic Data**
- **USGS National-Scale Products**
- **Weather Forecasting and Precipitation Monitoring**
- **Next-Generation Satellite Monitoring**
- **Fiber Optic Sensing**
- **Artificial Intelligence**

Recommendation 1: Enhance the National Landslide Data Infrastructure

• Dynamic National Landslide Inventory and Impact Database

- Priority Coverage Expansion
- 3DEP Data Applications
- Rapid Post-Event Airborne Lidar
- Impact and Consequence Documentation
- Landslide Initiation and Runout Mapping
- Artificial Intelligence Applications

• Monitoring and Detection Network

- Satellite-Based Monitoring
- Ground-Based Fiber Optic Sensing
- Multi-Scale Data Integration

Recommendation 2: Develop a National Landslide Forecast-Based Warning System

- Operational Warning System Development
- Refined Triggering Thresholds
- Specialized Precipitation Products
- Pilot System Implementation
- Real-Time Data Processing and Observation Networks
- Gap-Filling Weather Radar

Recommendation 3: Build Community Resilience Through Education and Mitigation

- National Training and Education Program
- Cost-Effective Mitigation and Management Strategies
- Public Awareness Campaigns
- Community Engagement

Questions for Discussion

1. Warning Systems

Rapid events (debris flows, flow slides) and slow-moving landslides (earthflows) pose fundamentally different detection, monitoring, and warning challenges. How should the warning system strategy account for this distinction — and does a single system architecture serve both?

A related but separate question: Given limited resources, how should the national strategy balance investments in improving susceptibility modeling — forecasting where landslides will occur — versus warning system implementation — forecasting when they will occur?

2. Technology Readiness

Remote sensing technologies (e.g., lidar, SAR) and ground-based sensing technologies (e.g., fiber optic sensing) are at different levels of operational maturity. How aggressively should federal agencies embrace these tools, and how do we distinguish what is deployable now from what requires further development?

3. Artificial Intelligence

AI and associated technologies (e.g., computer vision, natural language processing) are advancing faster in the research community than in operational agencies. What is the realistic pathway for transitioning these tools into USGS, federal partner, and state agency workflows — and what validation standards should we expect before they inform decision-making?



Advancing Landslide Science Applications for Public Safety
Subcommittee Report and Discussion
Jones (Subcommittee Chair)

Reducing Landslide Risk

A National Framework for Preparedness, Avoidance & Response

Advisory Committee on Landslides

Subcommittee on Advancing Landslide Science Applications for Public Safety

March 2026

APPROACH

Big Picture

Future work… deep dives

Audience

Federal agencies, ICCLH, DOI leadership, congressional staffers, State and local government, Public safety and response agencies

Framing

Recommendations to ICCLH and federal agencies

Next steps…specific to an agency

Reports should:

- Summarize the current state of the subcommittee topic as it relates to the National Landslide Hazard Reduction Program (NLHRP) implementation
- Highlight important gaps or missing knowledge
- Suggest **broad directions** for future action

Assumption:

- Merged with other sub-committee recommendations
- Prioritization of recommendations would emerge from consolidation or need for further refinement

Report Structure: Five Pillars of Action

1	2	3	4	5
Assessment	**Planning**	**Response & Recovery**	**Technologies, Data & Integration**	**Awareness & Education**
Landslide Inventories	Policy and Planning	Watches, Warnings & Alerts	Supporting Technologies	Public Outreach
Susceptibility & Modeling	Hazard & Emergency	Post-Event Mitigation	Data Standards & Accessibility	Risk Communication
Risk Analysis	Response Planning			Standardized Messaging
Monitoring				

All recommendations directed to the Interagency Coordinating Committee on Landslide Hazards (ICCLH) — USGS, FEMA, NOAA, FHWA, USFS, BLM, NASA and state/tribal/local/university partners

Pillar 1: Assessment — Landslide Inventories & Susceptibility Modeling

THE PROBLEM

- States vary widely in capacity to develop and maintain standardized landslide inventories — significant data gaps
- Inconsistent methods and incompatible formats hinder data sharing and a cohesive national database
- Susceptibility maps use similar categorical labels (none/low/moderate/high) across jurisdictions but with different underlying definitions — leading to confusion and misinterpretation
- Local and regional models cannot be readily combined to support national risk-reduction strategies

RECOMMENDATIONS

✓ ICCLH/USGS jointly establish working group: state surveys, tribes, federal agencies, local gov, universities

✓ Develop standardized inventory protocols, methods, and database schemas for multiple inventory types

✓ Create an updatable national database integrating current and future contributions from all partners

✓ Develop a national susceptibility framework — analogous to the National Seismic Hazard Model

✓ Standardize how susceptibility outputs are expressed so they are comparable across all jurisdictions and scales

Pillar 1: Assessment — Risk Analysis & Monitoring

RISK ANALYSIS — The Critical Gap

Problem: Unlike earthquakes, floods, and hurricanes — which have national frameworks in FEMA Hazus — landslide risk has no standardized national approach. Damage data is rarely collected after an event, so risk models cannot be calibrated or validated.

Recommendation: Establish working group to develop standardized risk analysis protocols; address rapid collection of perishable post-event damage and loss data; characterize runout, velocity, triggering mechanisms, and recurrence intervals; prioritize public safety consistent with other national hazard frameworks.

MONITORING — From Fragmented to Coordinated

Problem: Monitoring is fragmented across agencies and jurisdictions with inconsistent spatial and temporal coverage. Post-event monitoring is not standardized — missed opportunities to assess evolving slope conditions and refine predictive models.

Recommendation: Coordinate existing monitoring networks across federal agencies. Leverage USGS Next Generation 3D Elevation Program and 3D National Topography Model as baseline and Civil Applications Committee satellite contracts. Deploy SAR, AI/ML-enabled automated change detection for precursory deformation and hydrologic triggers. Standardize post-event data collection protocols.

Pillar 2: Planning — Policy & Hazard Response Planning

POLICY AND PLANNING

Problem:

Building codes and permitting practices often fall short in addressing landslide risk — failing to consider where landslides may travel or how risk changes over time. Federal disaster assistance may require rebuilding in the same manner and location, potentially increasing risk.

Recommendations:

- Research impacts of landslides on the built environment: building codes, damages, deaths, mitigation practices
- Collaborate with planning associations to develop life-safety building code standards for landslide-prone areas
- Incorporate landslide considerations into USACE and federal land management land-use practices

HAZARD & EMERGENCY RESPONSE PLANNING

Problem:

No standardized pathways to technical expertise. Critical data is not accessible in a timely, user-friendly way for first responders. Fragmented communication across federal/state/local/tribal/academic partners delays effective response.

Recommendations:

- Develop a National Landslide Response Framework defining roles, responsibilities, and coordination
- Catalog scientific and operational capabilities at all levels for rapid mobilization
- Establish data access standards, satellite tasking protocols, and data-sharing agreements
- National rollout via joint training and exercises at all levels of government

Pillar 3: Response & Recovery

⚠ WATCHES, WARNINGS & ALERTS

Problem: Communities lack timely, understandable, actionable information. Alerts are delayed by inadequate monitoring networks. Protective action guidance is inconsistent. Communities unfamiliar with advisory/watch/warning terminology respond inappropriately — either unnecessary alarm or failure to act.

Recommendation: Establish instrumentation networks for rainfall and ground movement. Develop nationally consistent alert terminology with plain-language protective action guidance. Integrate NWS into monitoring networks. Use two-way communication and citizen science to build community preparedness.

POST-EVENT MITIGATION

Problem: Mitigation is reactive and narrowly focused on immediate threats. Adjacent destabilized slopes go unmonitored. Damage and loss data is not collected systematically. Communities often rebuild without reducing risk.

Recommendation: Integrate reconnaissance and monitoring into recovery operations. Evaluate adjacent intact slopes. Develop long-term stabilization, monitoring systems, and land-use plans. Require standardized post-event damage and loss data collection.

Pillar 4: Technologies, Data, and Integration

THE PROBLEM

- The primary challenge is no longer data collection — it is access and the ability to generate timely, actionable analytics from large data volumes
- Limited access to derived products (change-detection metrics), inconsistent federal acquisition practices, and slow data release constrain effective use of AI and machine learning
- Fragmented access to fixed-wing lidar and imagery; available tools (lidar, SAR, multispectral, optical) are underutilized due to data accessibility and integration barriers

RECOMMENDATIONS

✓ ICCLH, FGDC, and USGS develop federal data standards for timely publication and integration of remotely sensed data

✓ Build on USGS 3D National Topography Model and Next Generation 3D Elevation Program

✓ Align with FGDC National Spatial Data Infrastructure Strategic Plan (2025–2035)

✓ Establish a single, discoverable federal access point for remote sensing data

✓ Advance public-private partnerships to accelerate responsible AI/ML adoption for change detection, susceptibility assessment, and predictive modeling

Pillar 5: Awareness and Education

THE PROBLEM

- Public awareness of landslide hazards remains limited; education and outreach materials vary widely in content, format, and technical complexity
- Inconsistent interpretation of alert terminology (advisory, watch, warning) leads to unnecessary alarm, delayed response, or inadequate protective action
- Duplicative outreach efforts across agencies waste limited resources and slow delivery of clear, authoritative information — undermining public trust
- Without coordinated public education, communities underestimate risk and question the credibility of warnings during emergencies

RECOMMENDATIONS

✓ ICCLH with partners develop coordinated, standardized education and risk communication materials for use across all levels of government

✓ Plain-language explanations of warning terminology with clearly described protective actions at each alert level

✓ Reduce duplication; present a single authoritative voice on landslide hazard communication

✓ Incorporate modern two-way communication approaches and citizen science to build genuine community engagement

✓ Translate technical and scientific information into formats accessible to planners, emergency managers, and the general public

The Common Thread:

Coordination & Consistency

Shared Standards

Data cannot be combined, warnings cannot be trusted, and actions cannot be coordinated without consistent national standards and frameworks for inventories, susceptibility, and risk.

Aligned Capability

Scientific expertise, monitoring data, and response tools exist — but they're siloed. Alignment between science and operational readiness is essential.

Trusted Information

From community warnings to technical models, the public and decision-makers need clear, credible, consistently delivered information to act effectively.

Next Steps: Prioritize Recommendations

Characterize short- and long-term opportunities

Impact and opportunity

Commonalities with other subcommittee paper

Rank recommendations by short-term vs. long-term goals, impact of work, and commonalities with other working group findings.


LUNCH
Back at 1:30

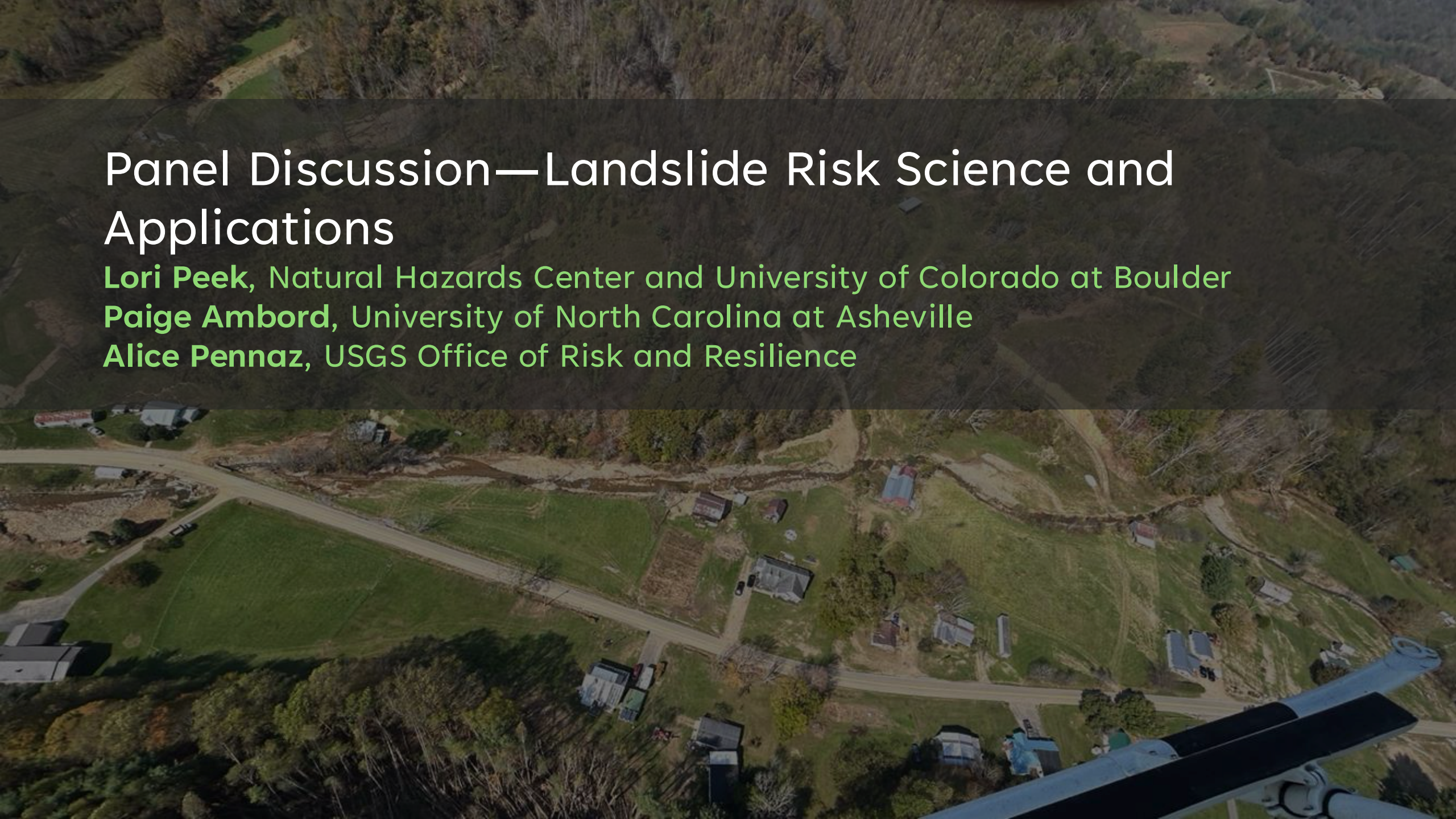


Draft Recommendation Report
Overview and Discussion
Haneberg and Oakley

BREAK

Back at 3:15





Panel Discussion—Landslide Risk Science and Applications

Lori Peek, Natural Hazards Center and University of Colorado at Boulder
Paige Ambord, University of North Carolina at Asheville
Alice Pennaz, USGS Office of Risk and Resilience



University of Colorado **Boulder**

A Call for Participatory Convergence:

Social Science Integration for Landslide Risk Reduction

Lori Peek, Ph.D.
Professor, Department of Sociology
Director, Natural Hazards Center and CONVERGE
Leader, Social Science Extreme Events Research (SSEER) Network
University of Colorado Boulder

NSF Award #1635593, #2536173, and #1841338

NSF

NATURAL HAZARDS CENTER

CONVERGE

Natural Hazards Center

CONVERGE

To **reduce landslide risk,**
we must accelerate the integration of the social and physical sciences, engineering, public health, and other relevant disciplines.

This will require a **convergent approach** that is interdisciplinary, participatory, problem-focused, and solutions-based.



Photo by: Jonathan Godt, USGS, 2017



Landslide Risk Reduction is a *scientific endeavor* and inherently *social process* that involves people, organizations, institutions, and policy making bodies.

This process necessitates the deep integration of social science knowledge and approaches.

Photo by: Jonathan Godt, USGS, 2017



3 Key Points regarding the importance of **social science integration** and **convergence**

Photo: Jason Marineau, DOI, 2017

1. Social Science / Interdisciplinary Questions are at the Heart of Landslide Risk Reduction

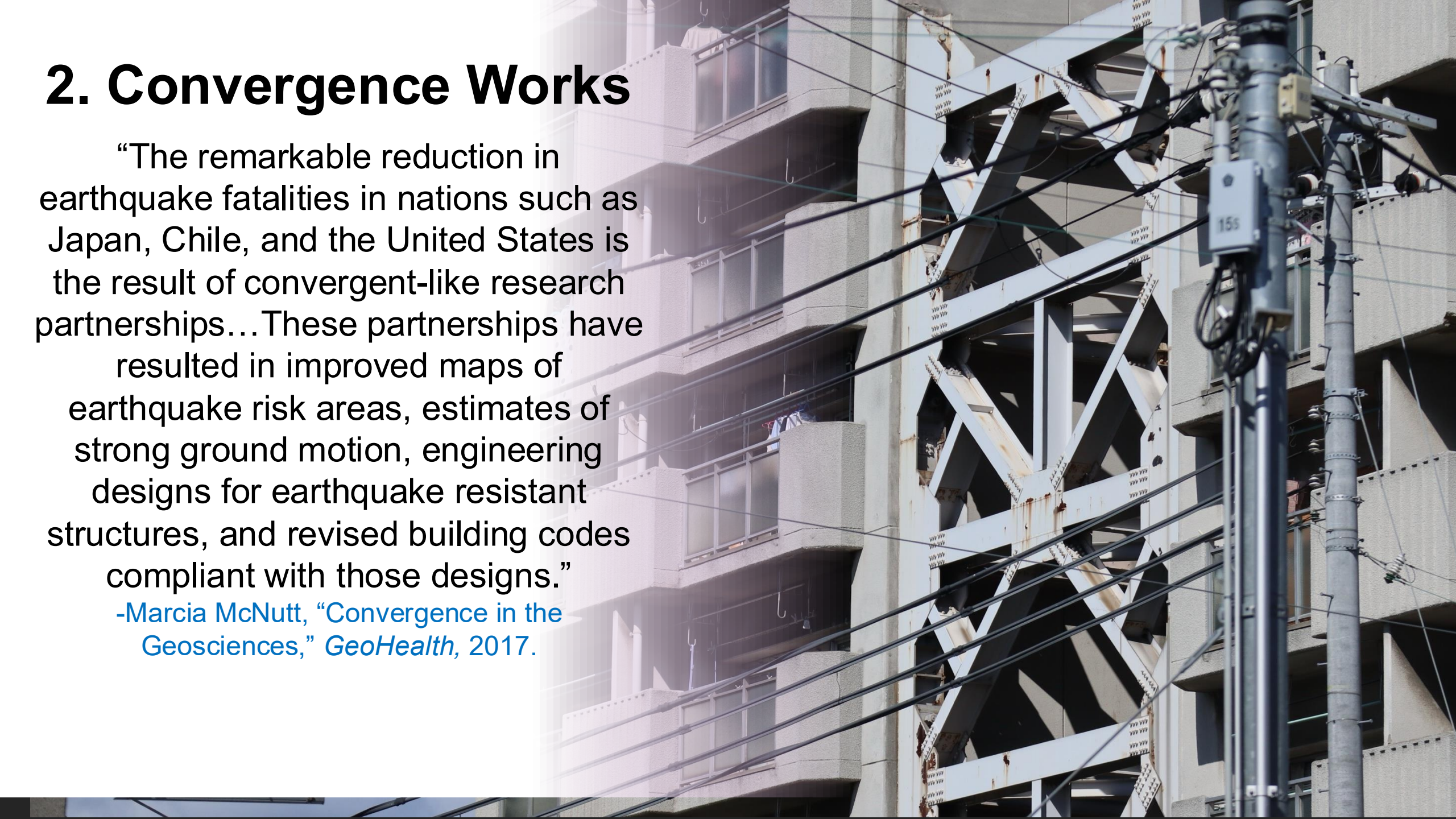
- *Risk:* Who is most at risk to landslides and why? *(hazard exposure x physical and social vulnerability / capacity)*
- *Risk Perception and Action:* How do diverse people perceive and act in response to the risks that they face?
- *Impacts:* When landslides occur, what are the environmental, health, economic, political, and social impacts on communities and people?
- *Policy Evaluation:* What landslide risk reduction policies and programs are in effect at the local, state, tribal, and territorial levels? How effective are these programs at reducing risk?


Photo by: Jonathan Godt, USGS, 2017

2. Convergence Works

"The remarkable reduction in earthquake fatalities in nations such as Japan, Chile, and the United States is the result of convergent-like research partnerships…These partnerships have resulted in improved maps of earthquake risk areas, estimates of strong ground motion, engineering designs for earthquake resistant structures, and revised building codes compliant with those designs."

-Marcia McNutt, "Convergence in the Geosciences," *GeoHealth,* 2017.



3. *Participatory* Convergence Works Even Better

- Despite initial scientific breakthroughs, early applications of convergent research provided little guidance for going beyond basic science and engineering to **reach impacted communities**.
- Yet, societal transformation requires that scientific innovations are **received, understood, and implemented** by practitioners, policy makers, and, most importantly, the communities and populations impacted by the serious problems to be addressed.
- **Participatory convergence** is an approach that emphasizes the values and commitments of *participatory action research* and *convergence research*: listening to multiple voices to learn and comprehensively understand the scope of a *problem* while also working together across disciplinary and organizational boundaries and in partnership with communities to develop equitable, multi-faceted *solutions*.



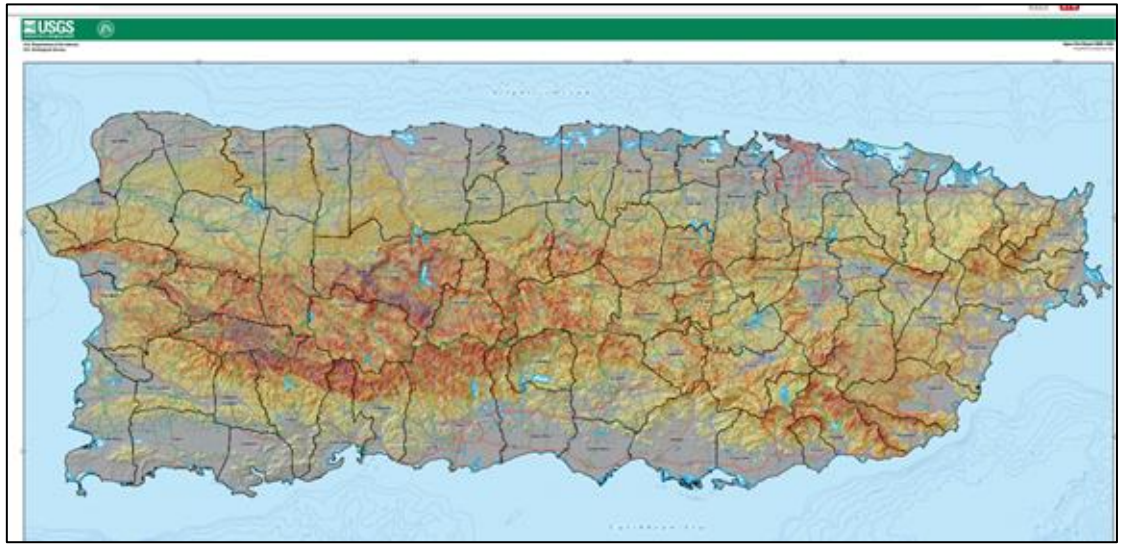


Participatory Convergence In Action

- Hurricane Maria triggered more than **70,000 landslides** in Puerto Rico
- The USGS Landslide Hazard Program responded to Puerto Rico in the wake of Hurricane Maria and, **based on stakeholder requests,** identified the need to assist with the development of scientific products and education and outreach materials.

USGS + UPRM Partnership: Scientific Products

- Landslide inventory
- Landslide susceptibility map
- Products for hardest hit municipalities

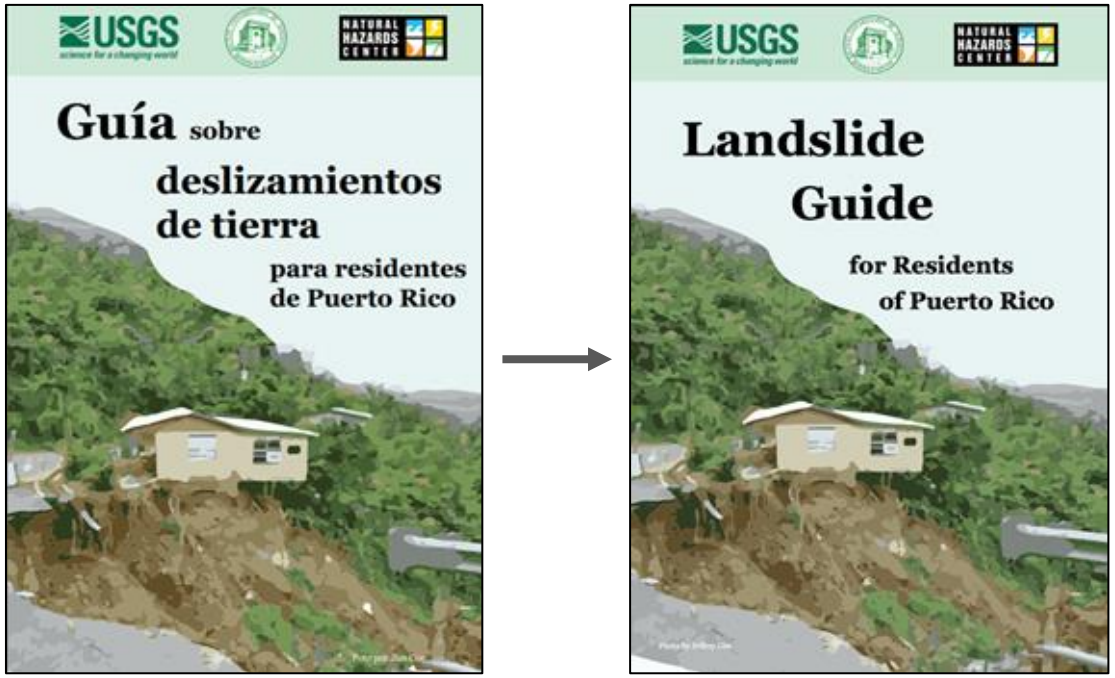


pubs.er.usgs.gov/publication/ofr20201022

Hughes and Schulz, 2020

USGS + NHC + UPRM Partnership: Education and Outreach Products

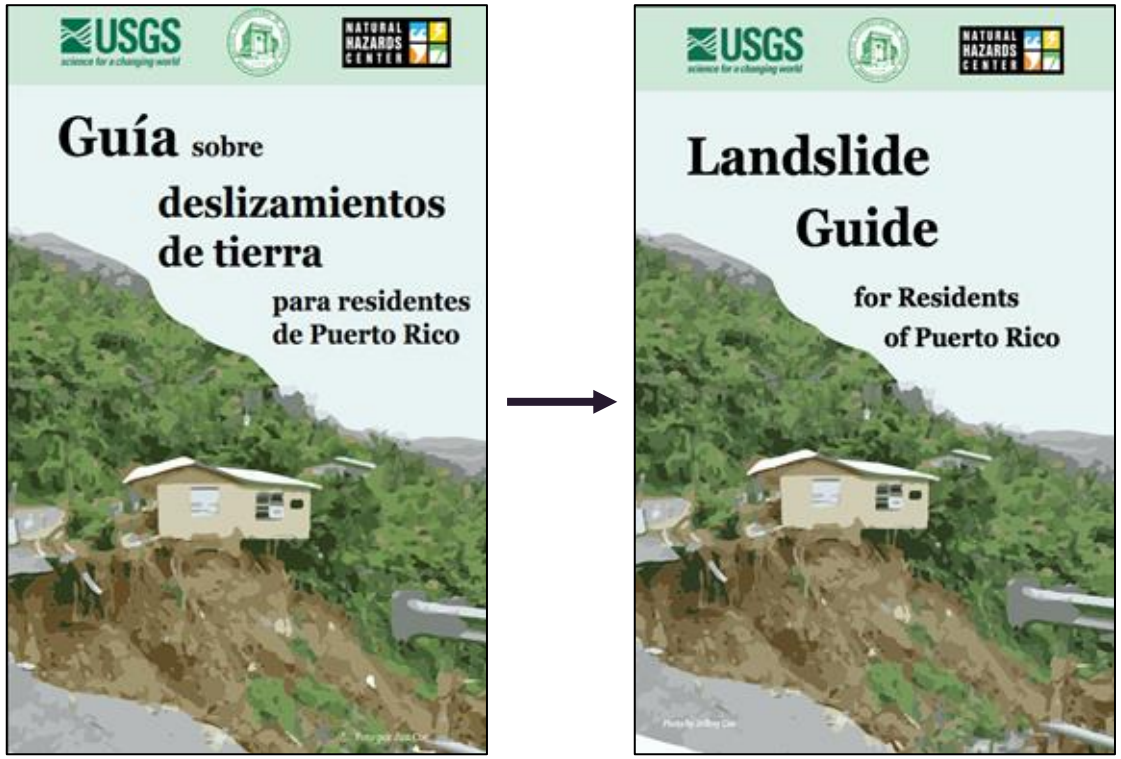
- Landslide guide (Spanish/English)
- Complementary products:
  - Trainings, radio scripts, infographics, & more



Download the Guides: hazards.colorado.edu/puertorico

Core Project Team: Lindsay Davis, Jocelyn West, (co-leads) Godt, Hughes, Lugo Bendezú, Álvarez, Peek

Why was the Landslide Guide created?

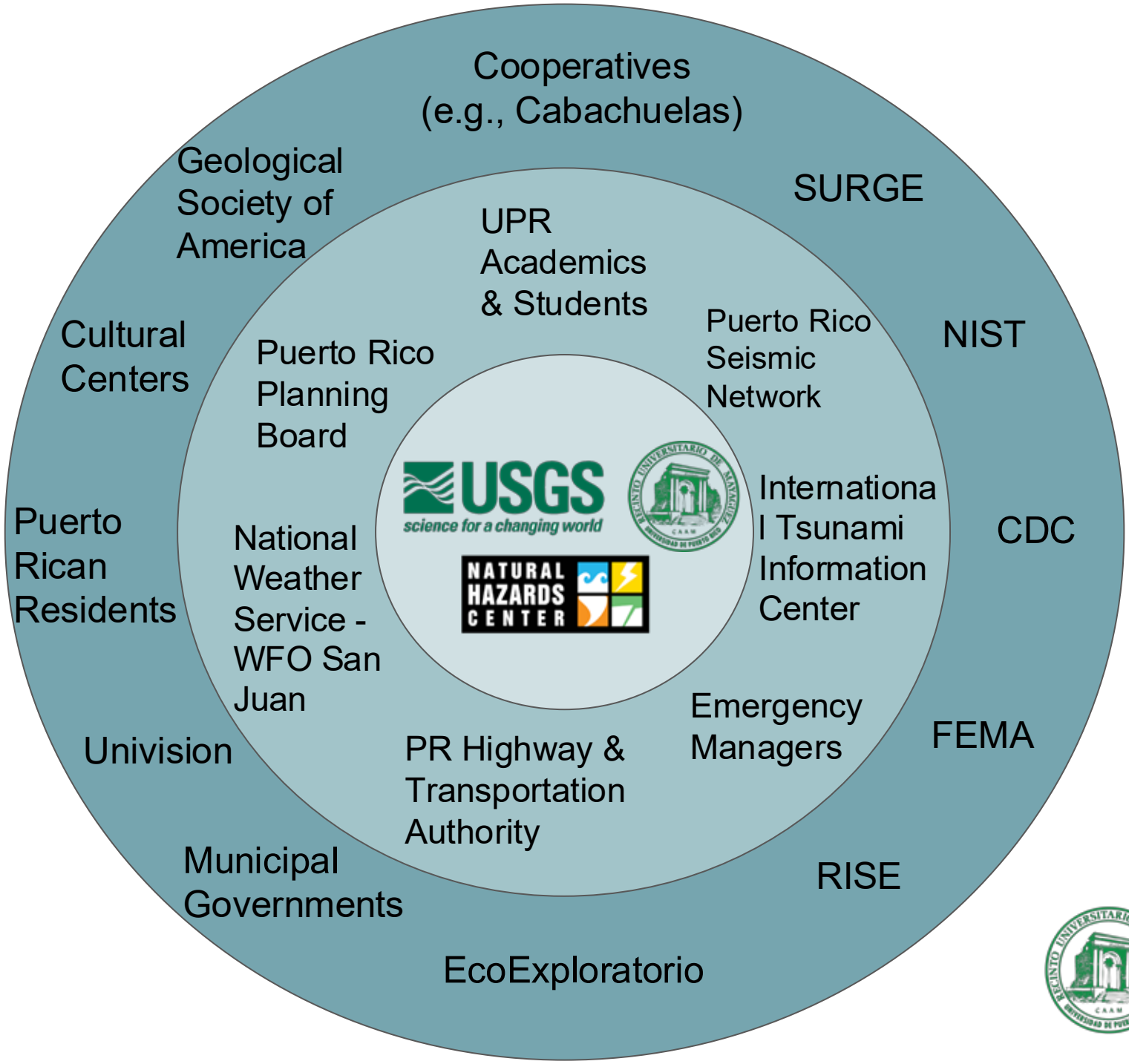


A: To **support the risk reduction objectives** of residents and professionals in Puerto Rico.

B: To **engage, inform, and raise awareness** about landslide risks in communities in Puerto Rico.

C: To **serve as a foundation for various additional modes of risk communication** including multimedia, workshops, and presentations.

Participatory convergence requires trusting relationships and long-term collaboration



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science for a changing world



Photo: Stephen Hughes, Puerto Rico, 2020

What is holding us back?

1. There is **no cohort of landslide social science researchers** akin to the generations of social scientists who've studied earthquakes, hurricanes, tornados, and wildfires.
   - Only 2.65% of 1,800+ Social Science Extreme Events Research (SSEER) members have studied a landslide event.
   - There has been less federal/academic investment in building the capabilities of landslide social science researchers when compared to other hazards.

2. Landslides are one of the **least studied natural hazards** among social scientists.
   - Landslides often hit rural or geographically isolated populations. There is a tendency in the social sciences toward studying large-scale events that impact large numbers of people.
   - This bias shows up in the landslides that social scientists *have* studied, with the Oso Landslide (2014) and Southern California Mudflows (2018) among the most investigated events in the U.S. by social scientists (still, less than 10 social scientists report having focused on those disasters.)

3. Save for a few remarkable examples of interdisciplinary, deeply integrated social-physical-engineering-health research, we have **few examples of truly participatory convergent research** in the landslide hazard space.

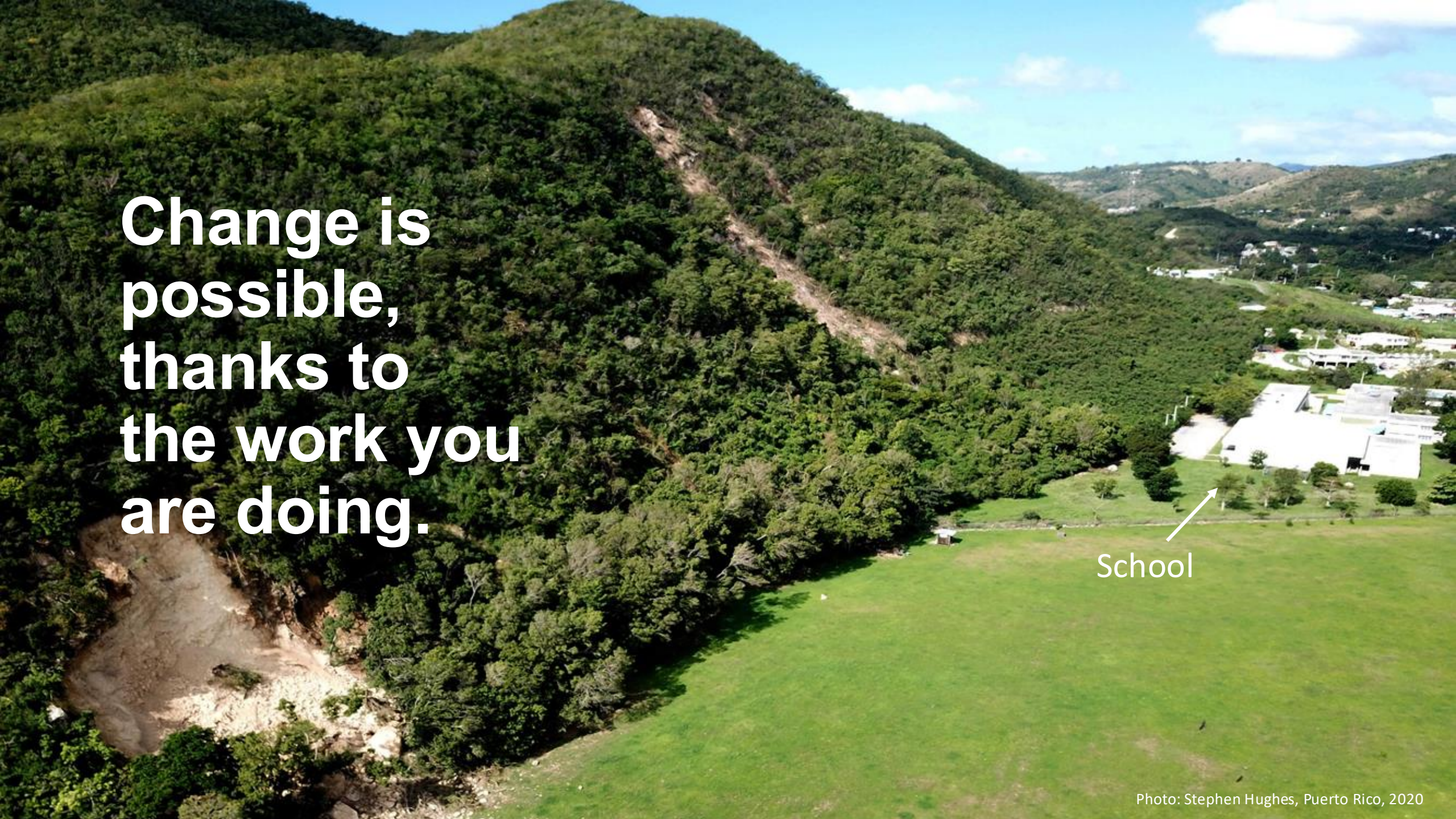


Photo: Stephen Hughes, Puerto Rico, 2020

University of Colorado **Boulder**

THANK YOU

Special Acknowledgements:

- Jocelyn West, Lindsay Davis
- Jonathan Godt and Jenny Riker

Questions? Contact:
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Lori.Peek@Colorado.edu

hazards.colorado.edu
converge.colorado.edu

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Natural Hazards Center

CONVERGE

NSF Award #1635593 and #1841338

Landslide Risk Perceptions: The Case of Tropical Storm Helene

Paige Ambord, Ph.D.

Assistant Professor of Sociology

University of North Carolina, Asheville

UNIVERSITY of NORTH CAROLINA ASHEVILLE

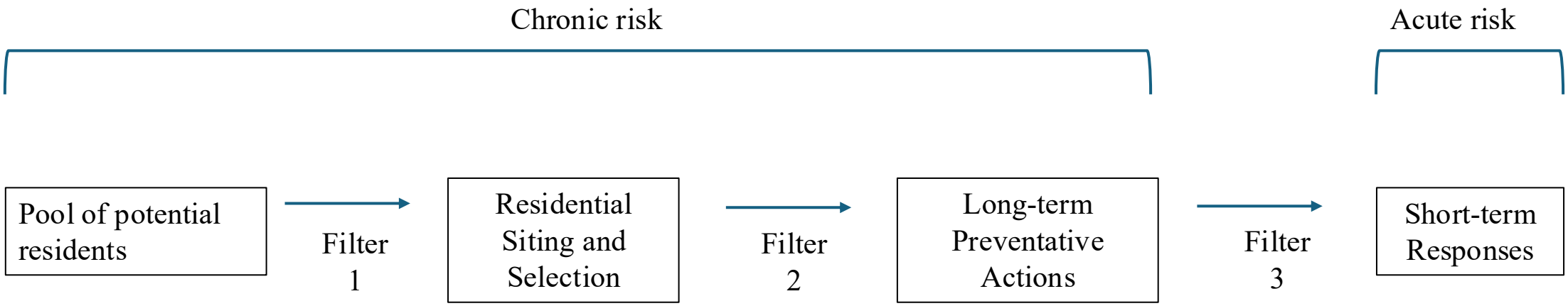


Figure 2. Filter model for landslide risk communication

1 2 3 4

KEY FINDINGS

Three Critical Gaps in Landslide Risk Communication

Low Baseline Awareness

Landslide risk is not as well known or understood as other risks.

Susceptibility maps are shown to be effective in raising risk perceptions

- Inventories and susceptibility maps do not exist for all places
- Education paired with maps is best (maps themselves are most effective if one knows of a risk already)

Landslide disclosure and geological inspection is uncommon in NC

For Example:

5 of 30

Were aware of living in a landslide-prone area

1 resident unknowingly lived in a home that had previously been hit by a landslide

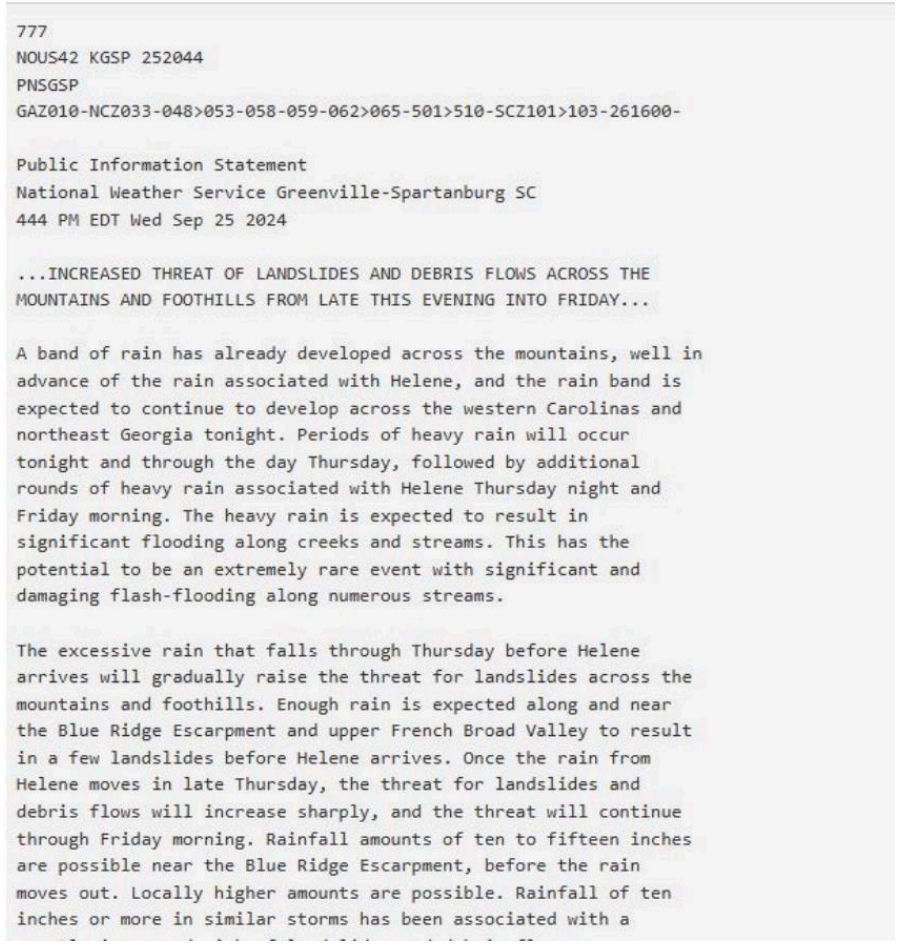
The Compound Hazard Problem

Many residents did not connect landslide risk to flash flood or hurricane risk.

Landslide risk was included in official notices (sometimes in addition to other risks).

For residents this backfired, they received flash flood alerts and reasoned the warnings simply didn't apply to them.

- As one participant couple put it: "We were getting flash flood warnings… But, you know, it was like, well, oh, that's flooding — that doesn't really apply to us here."



```
777
NOUS42 KGSP 252044
PNSGSP
GAZ010-NCZ033-048>053-058-059-062>065-501>510-SCZ101>103-261600-

Public Information Statement
National Weather Service Greenville-Spartanburg SC
444 PM EDT Wed Sep 25 2024

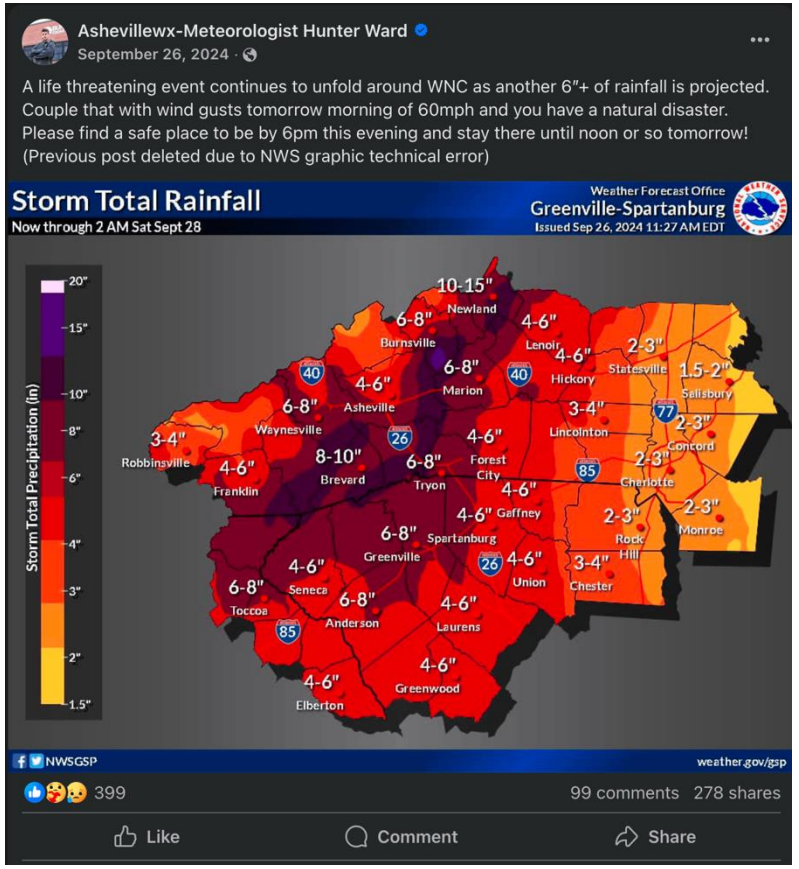
...INCREASED THREAT OF LANDSLIDES AND DEBRIS FLOWS ACROSS THE
MOUNTAINS AND FOOTHILLS FROM LATE THIS EVENING INTO FRIDAY...

A band of rain has already developed across the mountains, well in
advance of the rain associated with Helene, and the rain band is
expected to continue to develop across the western Carolinas and
northeast Georgia tonight. Periods of heavy rain will occur
tonight and through the day Thursday, followed by additional
rounds of heavy rain associated with Helene Thursday night and
Friday morning. The heavy rain is expected to result in
significant flooding along creeks and streams. This has the
potential to be an extremely rare event with significant and
damaging flash-flooding along numerous streams.

The excessive rain that falls through Thursday before Helene
arrives will gradually raise the threat for landslides across the
mountains and foothills. Enough rain is expected along and near
the Blue Ridge Escarpment and upper French Broad Valley to result
in a few landslides before Helene arrives. Once the rain from
Helene moves in late Thursday, the threat for landslides and
debris flows will increase sharply, and the threat will continue
through Friday morning. Rainfall amounts of ten to fifteen inches
are possible near the Blue Ridge Escarpment, before the rain
moves out. Locally higher amounts are possible. Rainfall of ten
inches or more in similar storms has been associated with a
```

Communication Disconnect

- Information was most effective if it was from a trusted family member, friend, or community member (local meteorologist, pastor, etc.)
  - Many get there information from social media or apps, not the National Weather Service or network news
- Failure of cellular infrastructure meant many did not receive warnings in a timely manner
  - Interest in other warning mechanisms



Public Comment Period





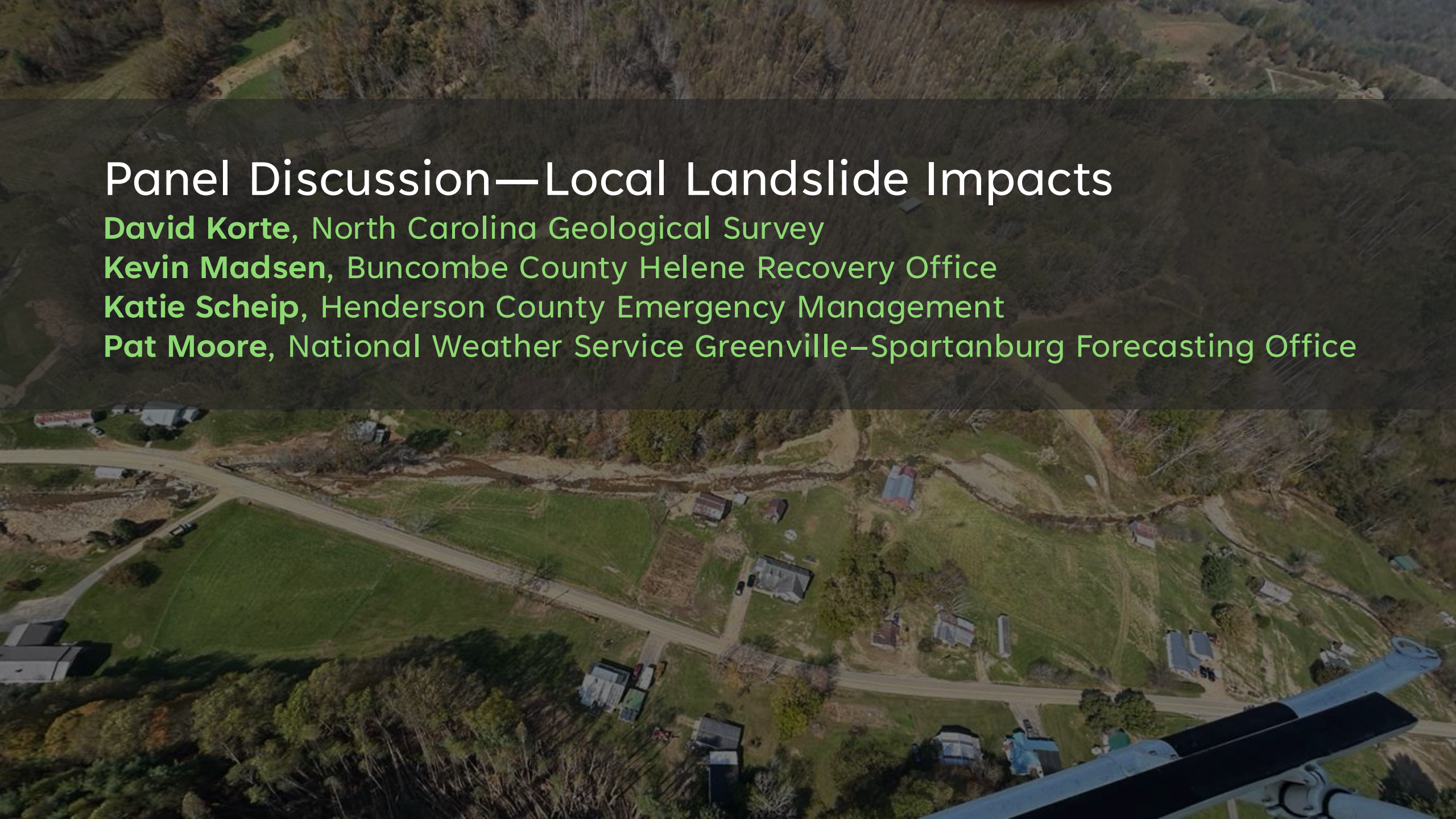
Federal Advisory Committee on Landslides—Day 2

March 5th, 2026, Asheville, North Carolina



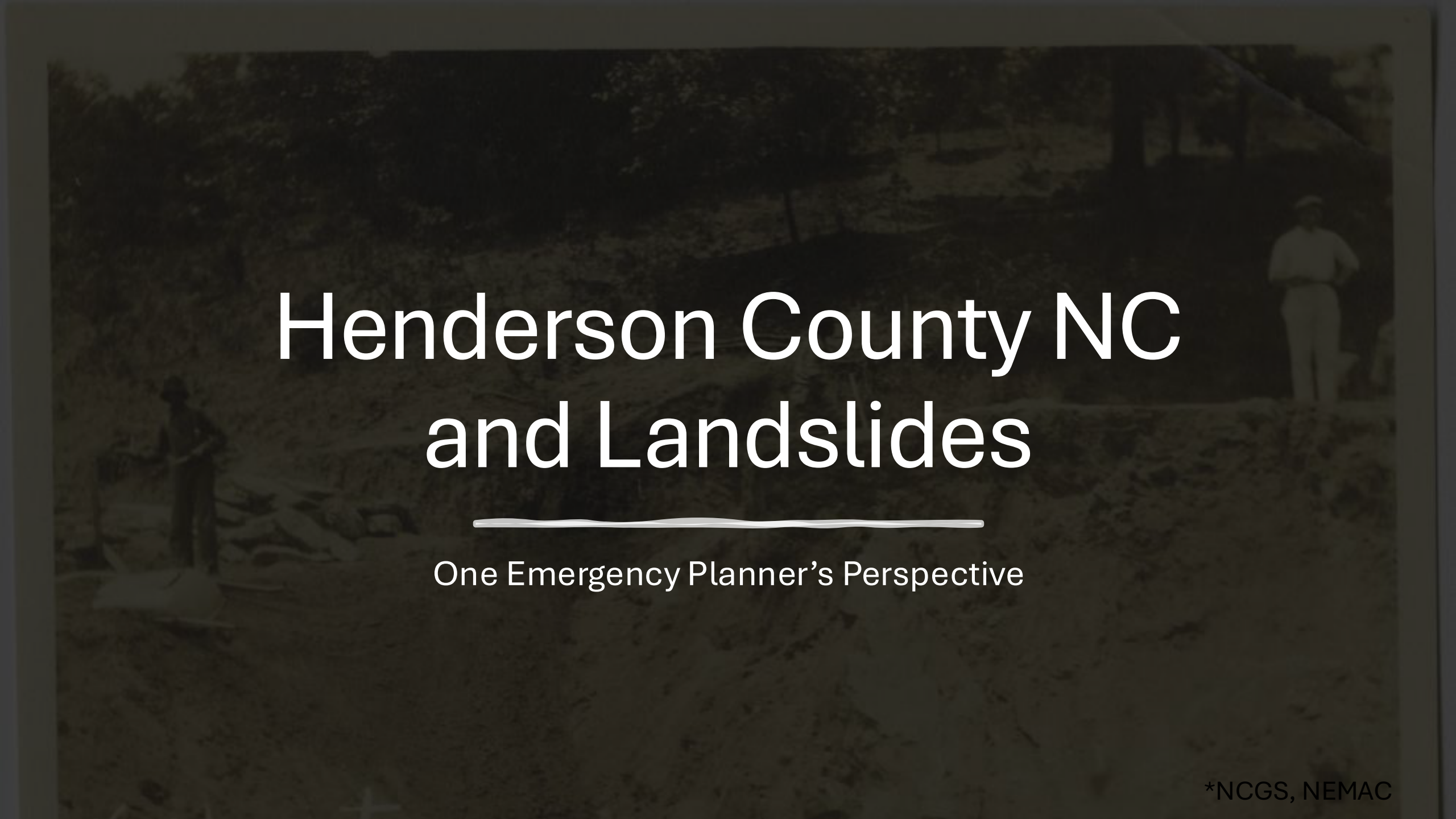
Welcome back, Questions, Reflections

Haneberg and Oakley



Panel Discussion—Local Landslide Impacts

David Korte, North Carolina Geological Survey
Kevin Madsen, Buncombe County Helene Recovery Office
Katie Scheip, Henderson County Emergency Management
Pat Moore, National Weather Service Greenville–Spartanburg Forecasting Office



Henderson County NC and Landslides

One Emergency Planner’s Perspective

*NCGS, NEMAC


PARK
CLOSED
PARK CLOSED TODAY
due to
road repairs.
We're sorry for this
inconvenience.
STOP





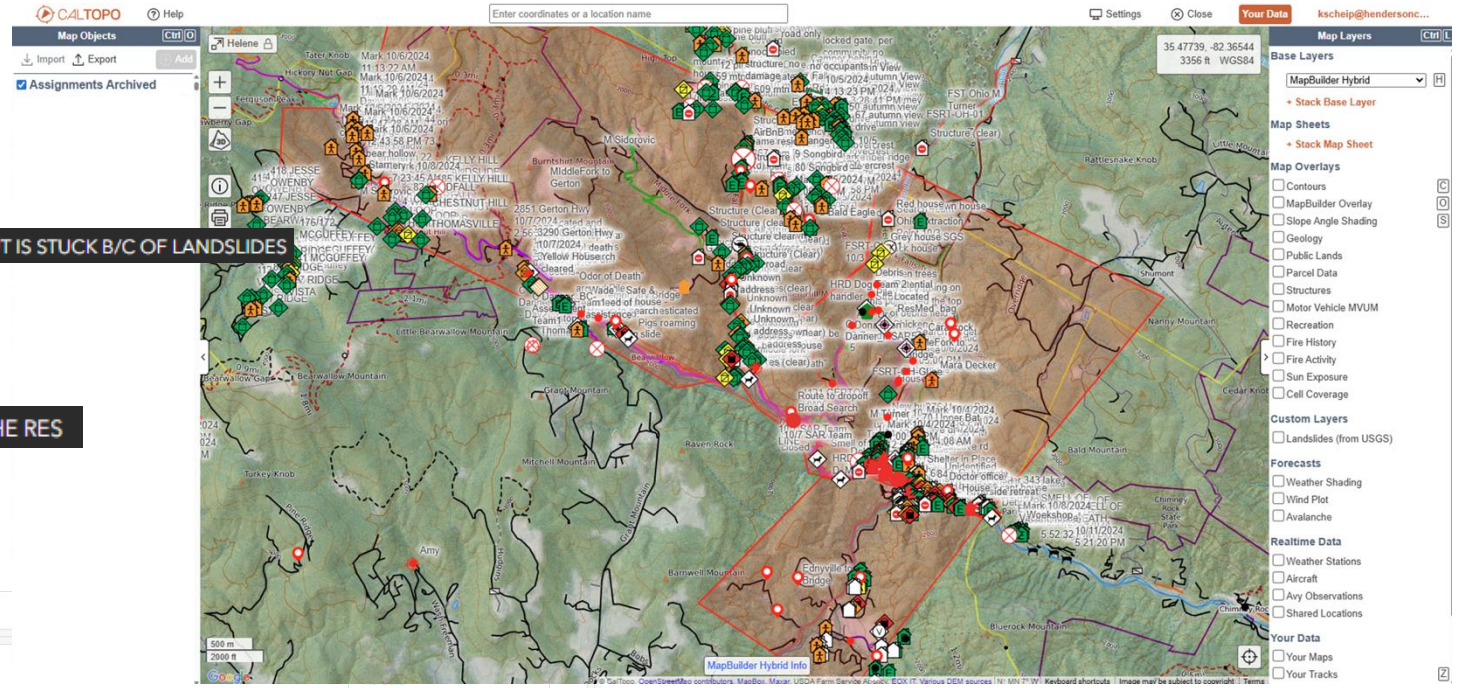


LANDSLIDE BESIDE HOUSE AND NOW UNABLE TO MAKE CONTACT WITH NEIGHBOR

SHE IS STUCK WANTS TO BE PUT ON THE LIST FOR RESCUE// SHE IS NOT HURT OR IN IMMEDIATE DANGER BUT IS STUCK B/C OF LANDSLIDES

LANDSLIDE/4 ADULTS IN RESIDENCE/NO CONTACT

MUD SLIDE THAT JUST OCCURRED AND TOOK OUT A HOUSE WITH TWO SUBJ INSIDE THE RES



Hurricane Helene Henderson County NC

Henderson County Damage Assessment Data is still undergoing quality control checks, numbers may fluctuate.

Unaffected
54k
Last update: 3 minutes ago

Affected
1.3k
Last update: 3 minutes ago

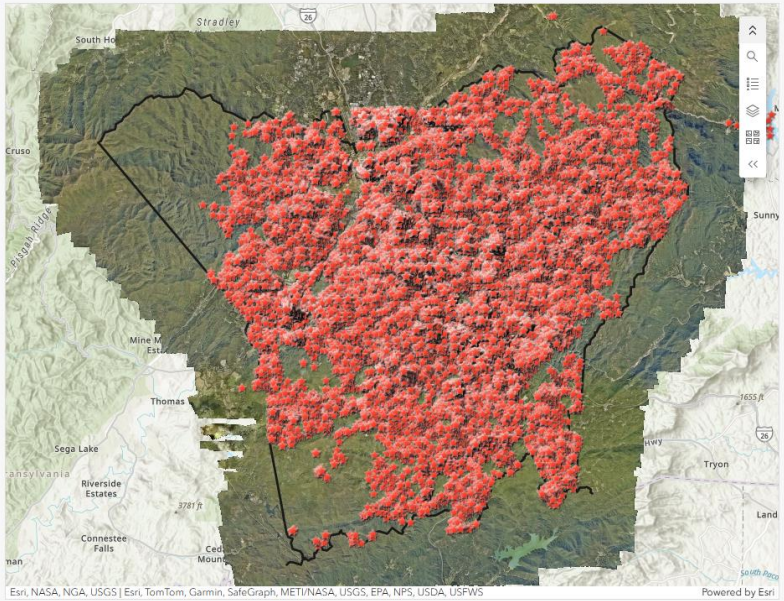
Minor
1.7k
Last update: 3 minutes ago

Major
1.4k
Last update: 3 minutes ago

Destroyed
288
Last update: 3 minutes ago

Unknown
811
Last update: 3 minutes ago

Total Assessments Performed
59.5k
Last update: 3 minutes ago



Henderson Damage Assessment - SAR Data Collector NCEM

Henderson County Border

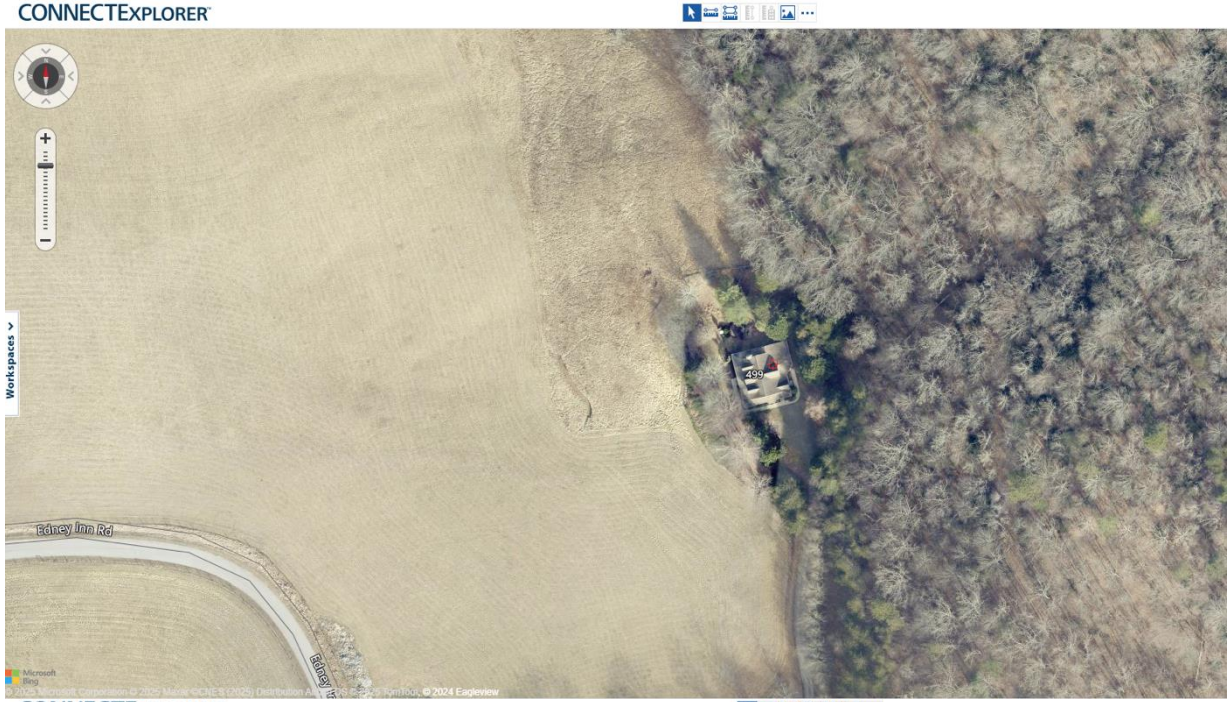
Damage Assessment | NC Damage Assessment | Debris | Dam Damage | Non-DOT Maintained Road Damage | Lanslides | DOT Damage | Henderson Co Welfare Checks | 211 | Isolated Communities

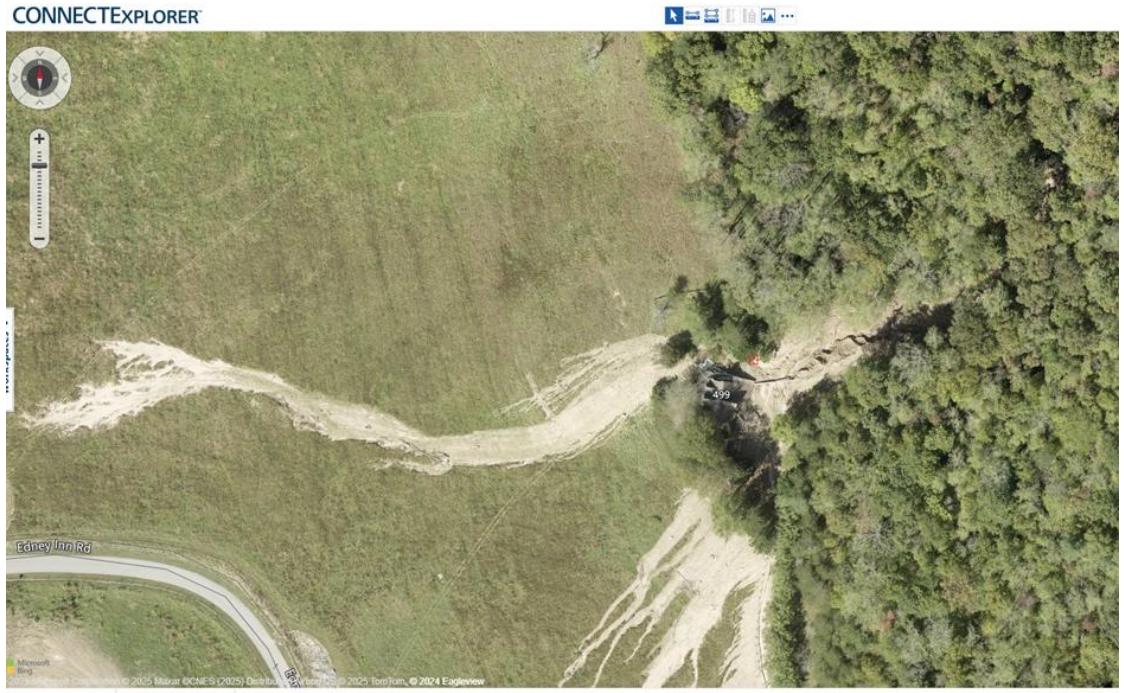
"HOUSE COLLAPSED ON HILLSIDE" UNKN FURTHER- NO RESPONSE ON TEXT

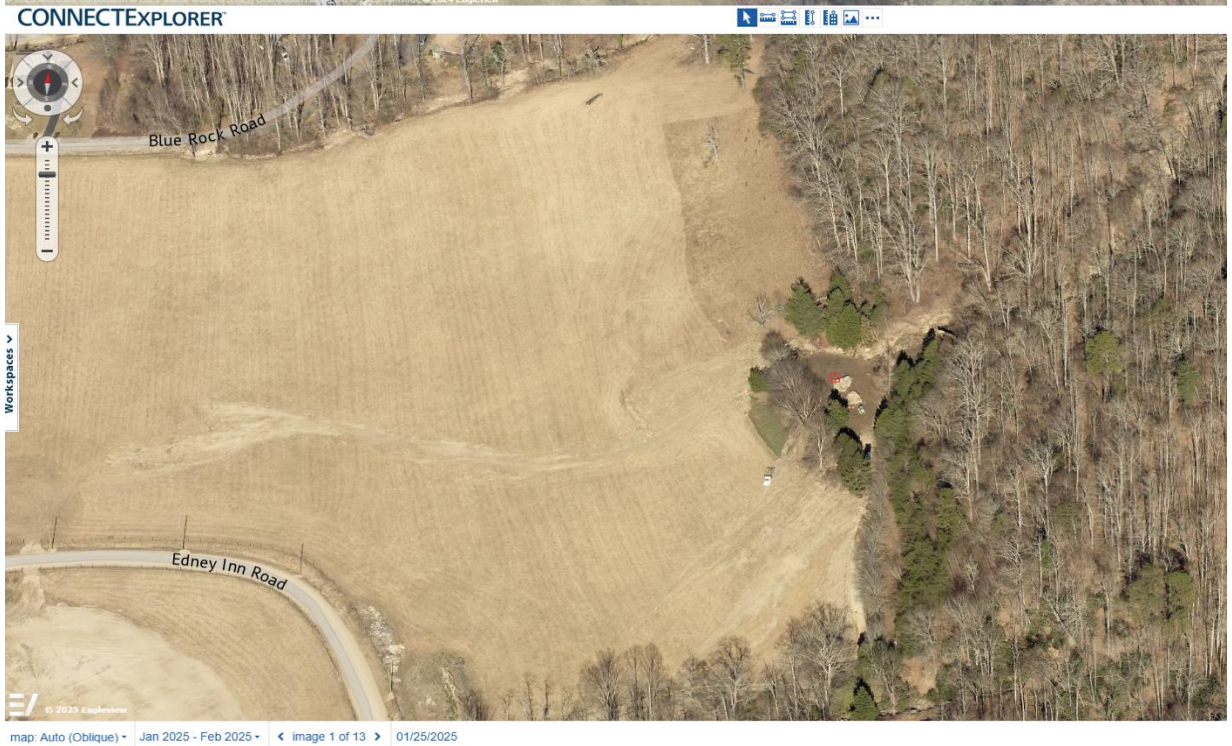
MUDSLIDE WITH PEOPLE TRAPPED ON TOP OF A TRAILER

LAND SLIDE TOOK NEIGHBORS HOME//UNK OCCUPANTS OR PI

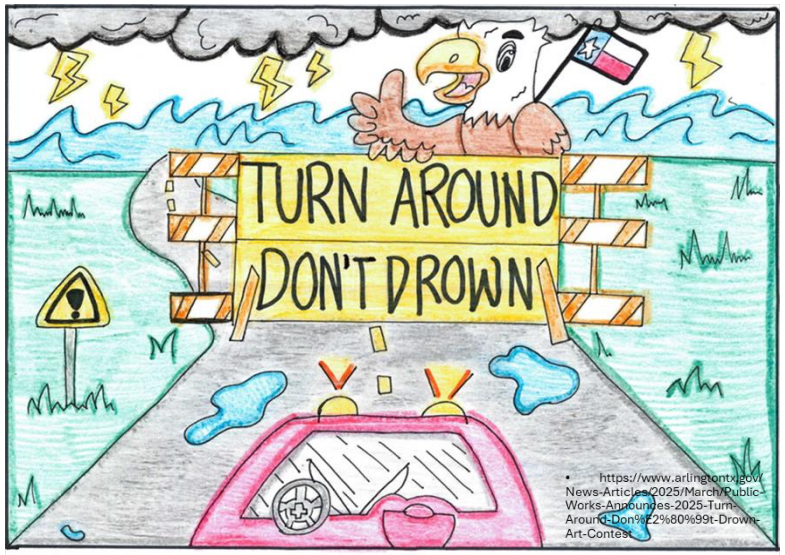
HOUSE CAVED IN AND IS TRAPPED BACK OF HOUSE//NO INJURIES


CONNECTEXPLORER
Workspaces
499
Edney Inn Rd


CONNECTEXPLORER
499
Edney Inn Rd
map: Auto (Mosaic)
Oct 2024 - Oct 2024
10/07/2024 - 10/18/2024


CONNECTEXPLORER
Workspaces
Blue Rock Road
Edney Inn Road
map: Auto (Oblique)
Jan 2025 - Feb 2025
image 1 of 13
01/25/2025



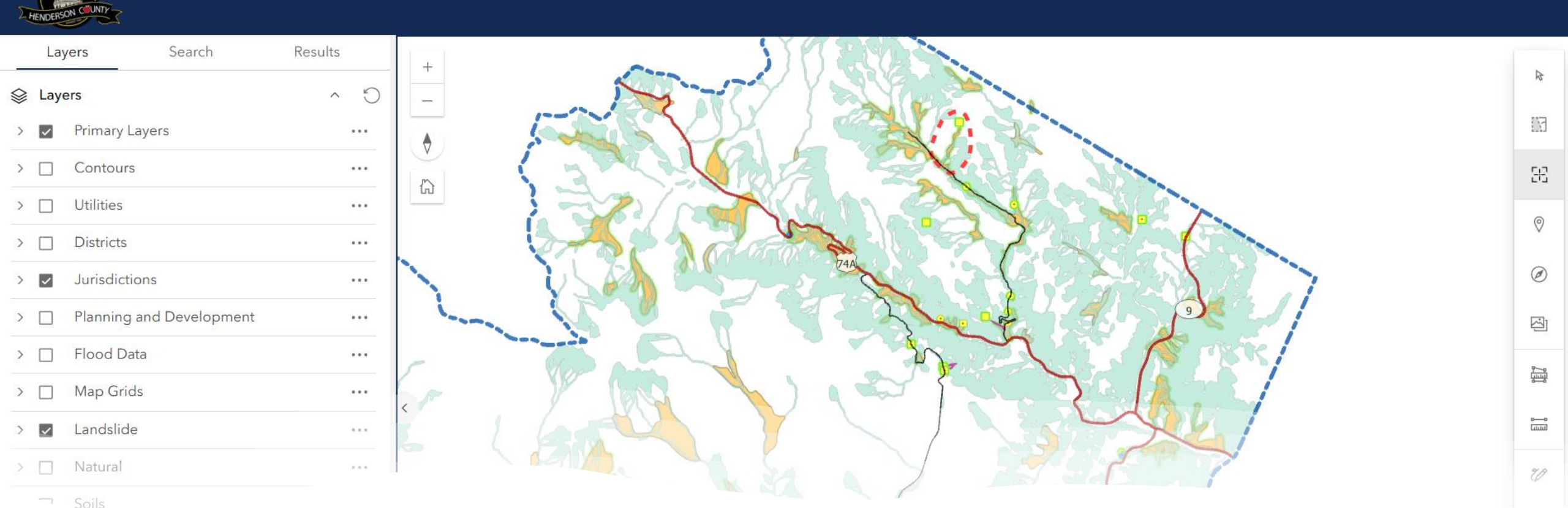


- https://www.arlingtontxgov/News-Articles/2025/March/Public-Works-Announces-2025-Turn-Around-Don%E2%80%99t-Drown-Art-Contest



? ? ? ?

Escape a landslide, watch your sides?



- Improved online parcel map including landslide information



Completed form, signed by each owner listed on the tax card, is required for Hazard Mitigation Grant Program application.
Omitted or incorrect information may delay processing application or deem application ineligible for consideration.

Section 1: Property Site Inventory (Part A and B)

Part A. Property Owner and Property Information:

1. ***Address of structure being considered for mitigation ("mitigated structure"):***

Street (number and name): _____

City: _____ State: NC Zip code: _____ _____ County

2. ***Type of mitigation assistance being requested for the above property:***

☐ (1) Acquisition (land parcel and structures will be bought and turned to green space)

☐ (2) Elevation (house will be raised)

If your preferred type of mitigation is not available, would you consider an alternative type of mitigation?

Yes ☐ No ☐

If yes, please select alternate mitigation type:

☐ (1) Acquisition ☐ (2) Elevation

3. ***Structure owner(s)*** all persons listed on tax record, required. Use additional forms to include additional owners, if necessary.

Name(s): (1) _____ (2) _____

Phone: (1) _____ (2) _____

Email: _____ Preferred Contact Method: ☐ Phone ☐ Email

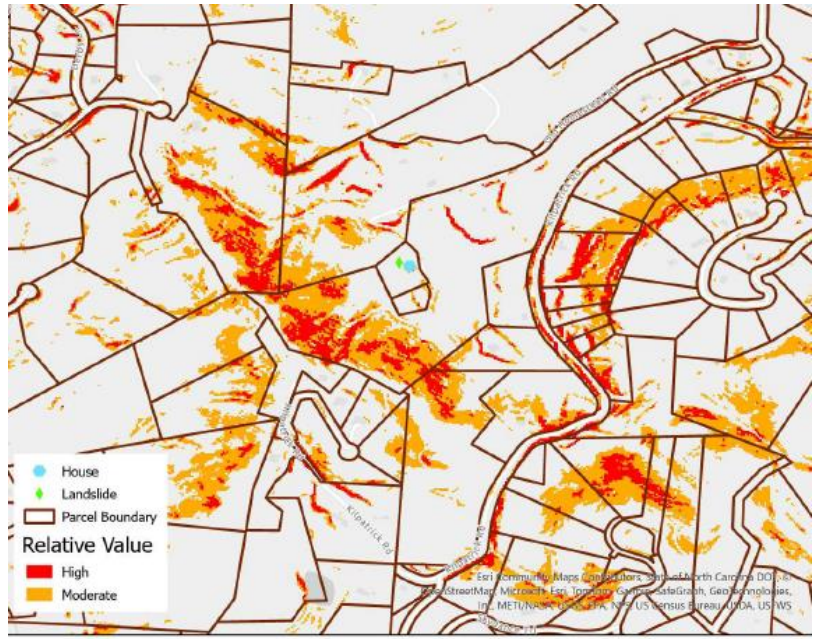
Are land owners different from structure owners? ☐ Yes ☑ No



roperty: Hendersonville, NC 28739

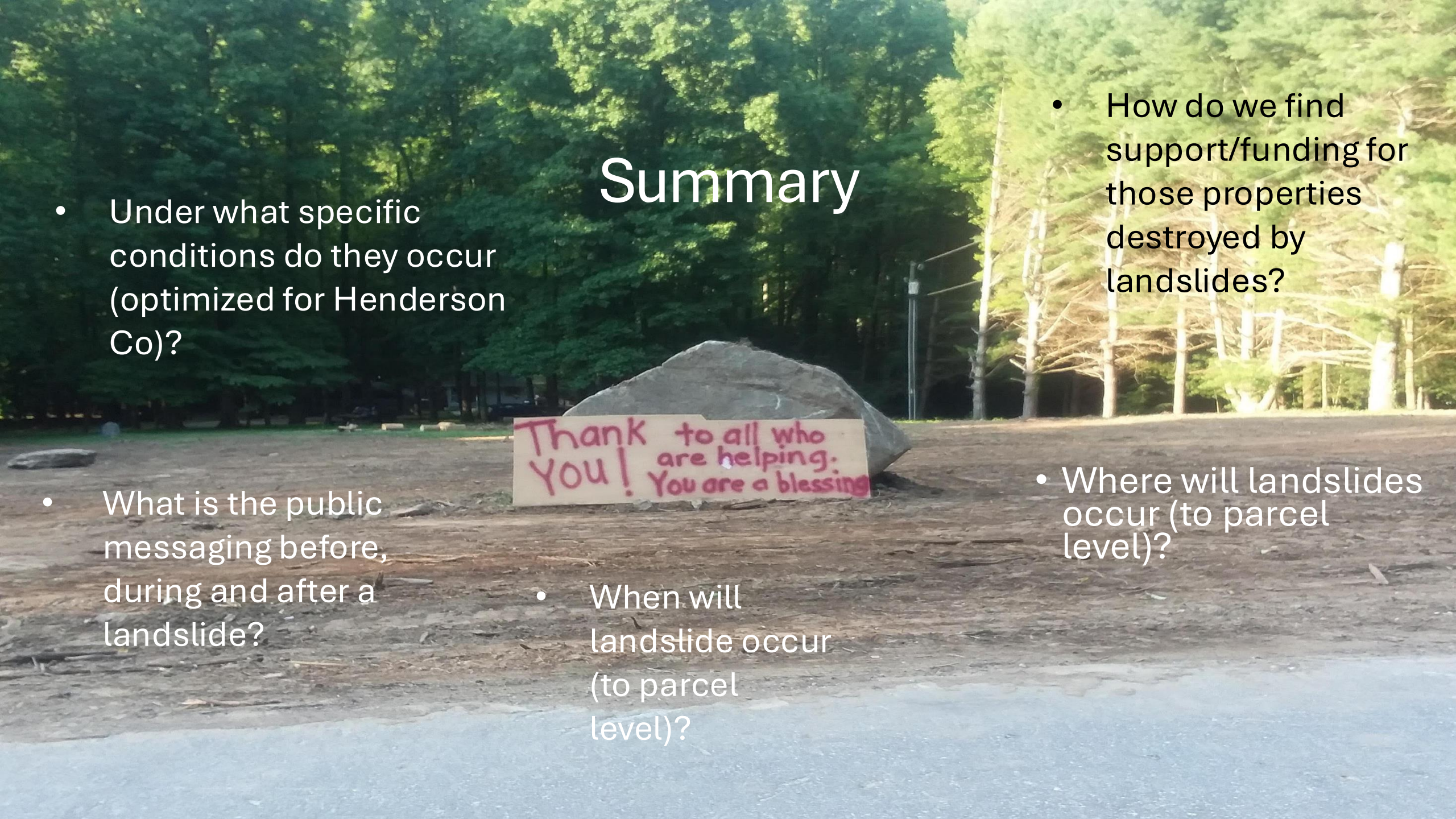
- Continue to lose significant amount of soil and constantly battle new grade that leads to water falling towards house AND the constant erosion of my driveway every time it rains. Temporary check dams or catch basins are already full and inaccessible. Temporary bend in driveway over a new stream is too sharp a radius to allow longer vehicles to approach residence, ie: fire trucks and ambulance response cannot reach house presently. I constantly am battling erosion and runoff, unsuccessfully, and trying to maintain access to my home. A site visit is preferred to see the new grade and catchment area and how water slices towards my house and crawlspace and then carves out the sides of a recently (temporarily) created road to my house.

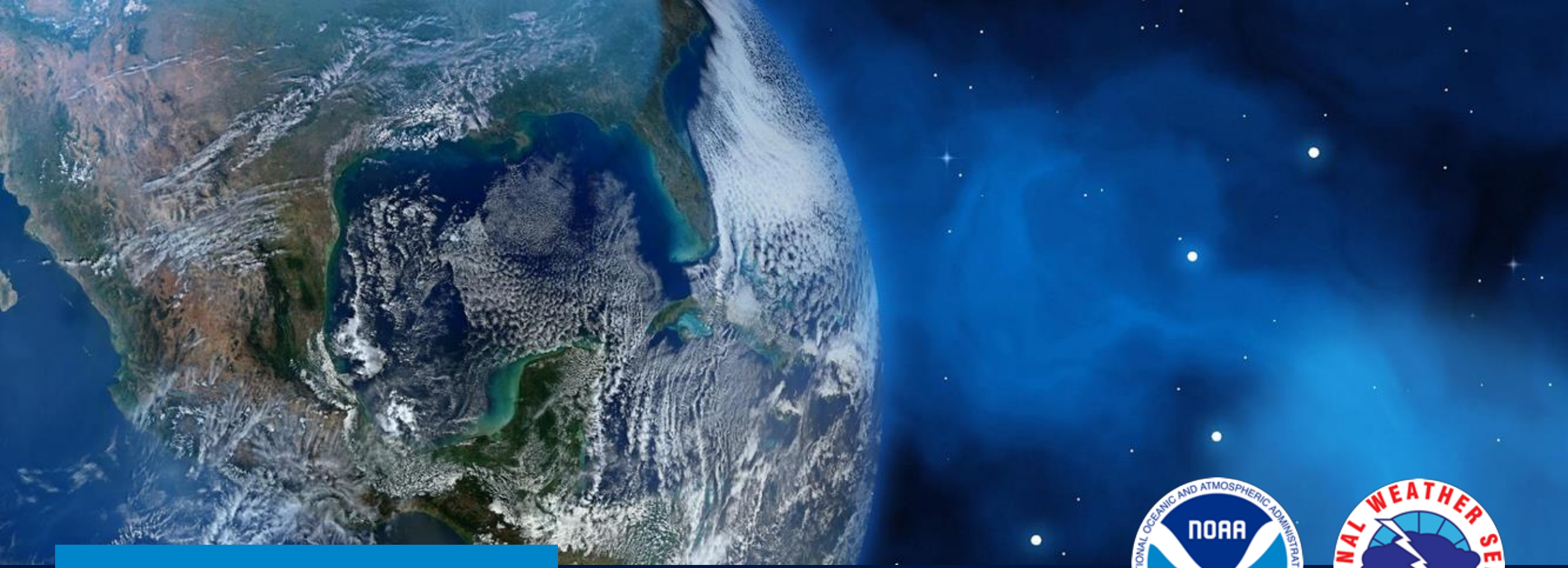
10/09/2024



Summary

- Under what specific conditions do they occur (optimized for Henderson Co)?
- What is the public messaging before, during and after a landslide?
- When will landslide occur (to parcel level)?
- Where will landslides occur (to parcel level)?
- How do we find support/funding for those properties destroyed by landslides?

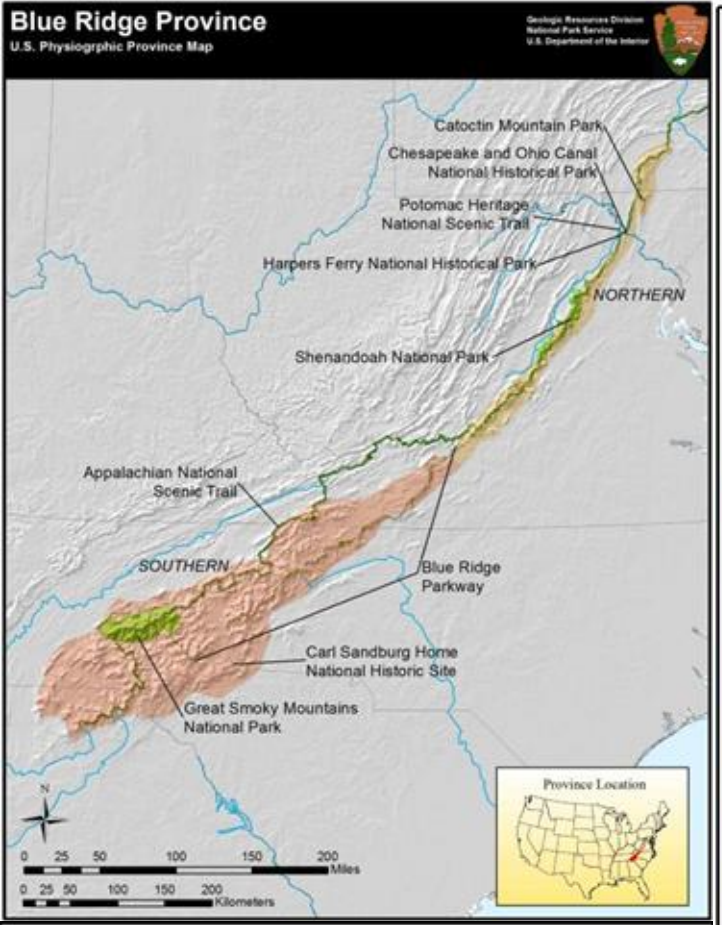


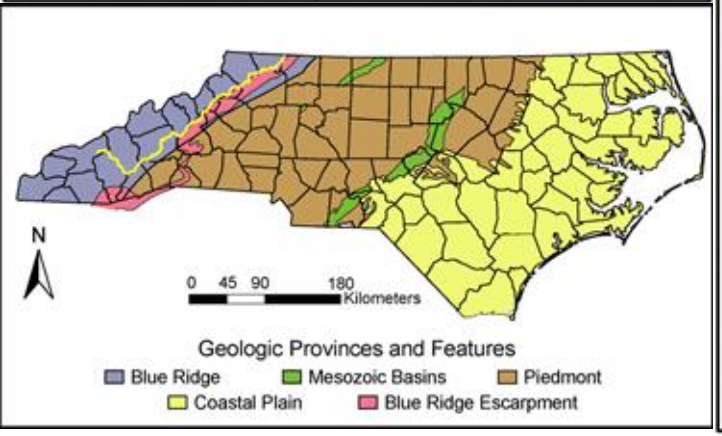


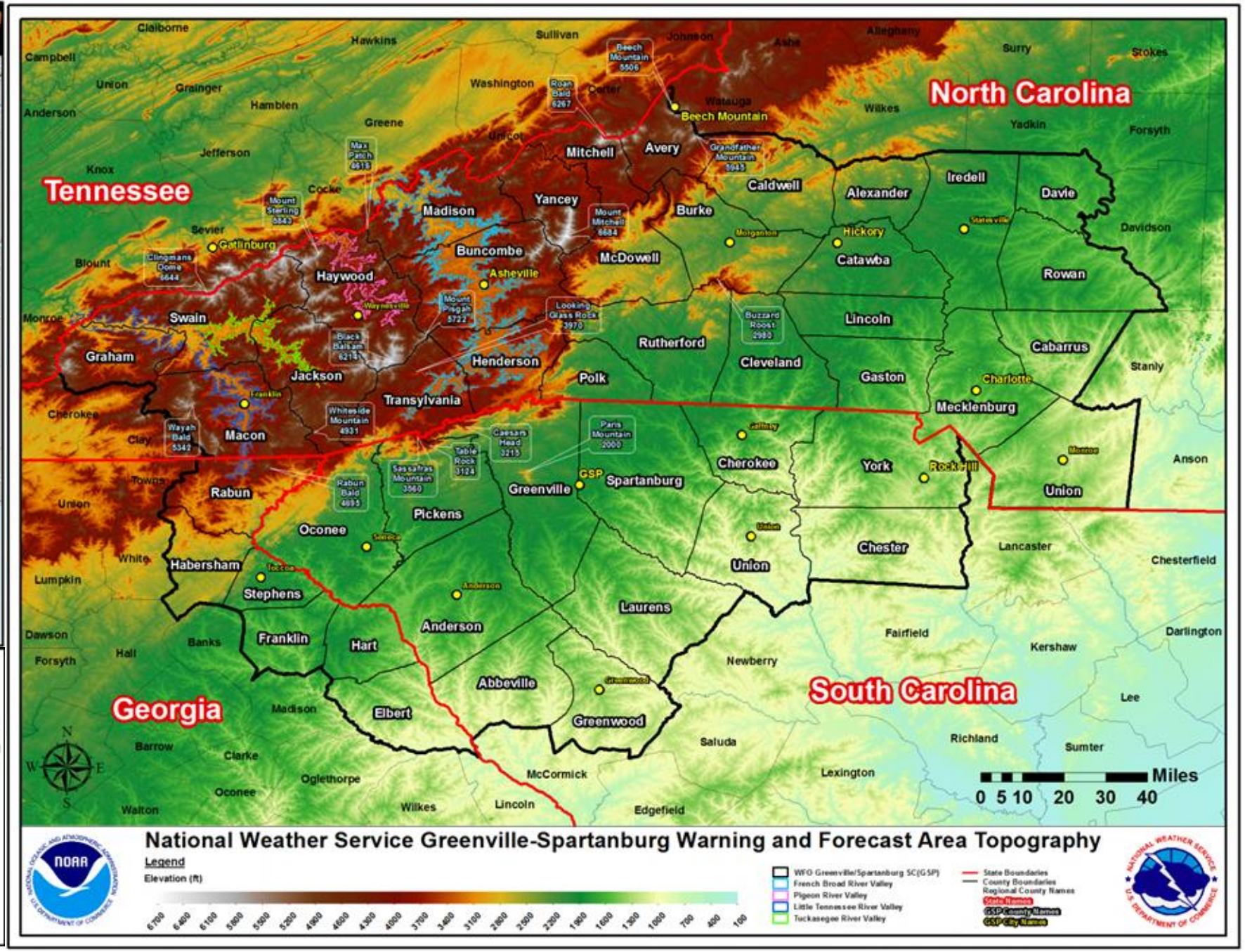
NWS Role and Response During Helene

Patrick Moore/Lead Meteorologist

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service/WFO Greenville-Spartanburg SC


Blue Ridge Province
U.S. Physiogrphic Province Map
Catoctin Mountain Park
Chesapeake and Ohio Canal National Historical Park
Potomac Heritage National Scenic Trail
Harpers Ferry National Historical Park
NORTHERN
Shenandoah National Park
Appalachian National Scenic Trail
SOUTHERN
Blue Ridge Parkway
Carl Sandburg Home National Historic Site
Great Smoky Mountains National Park
Province Location
0 25 50 100 150 200 Miles
0 25 50 100 150 200 Kilometers


0 45 90 180 Kilometers
Geologic Provinces and Features
Blue Ridge
Mesozoic Basins
Piedmont
Coastal Plain
Blue Ridge Escarpment


North Carolina
Tennessee
Georgia
South Carolina
Beech Mountain
Grandfather Mountain
Mount Mitchell
Asheville
Hickory
Statesville
Morganton
Gatlinburg
Waynesville
Franklin
Greenville
Spartanburg
GSP
Rock Hill
Anderson
Greenwood
Clemson
Union
Monroe
Charlotte
Mecklenburg
Cleveland
Gaston
Lincoln
Rutherford
Polk
Henderson
Transylvania
Jackson
Haywood
Buncombe
McDowell
Yancey
Mitchell
Avery
Watauga
Caldwell
Burke
Alexander
Iredell
Davie
Rowan
Cabarrus
Stanly
Anson
Union
Chester
Lancaster
Chesterfield
Darlington
Kershaw
Lee
Sumter
Richland
Fairfield
Newberry
Laurens
Abbeville
Greenwood
Saluda
Lexington
Edgefield
McCormick
Elbert
Hart
Franklin
Banks
Habersham
Stephens
Rabun
Macon
Swain
Graham
Cherokee
Clay
Towns
Union
White
Lumpkin
Dawson
Forsyth
Hall
Oconee
Pickens
Barrow
Clarke
Madison
Oglethorpe
Wilkes
Lincoln
Walton
Miles
0 5 10 20 30 40
National Weather Service Greenville-Spartanburg Warning and Forecast Area Topography
Legend
Elevation (ft)
WFO Greenville/Spartanburg SC(GSP)
French Broad River Valley
Pigeon River Valley
Little Tennessee River Valley
Tuckasegee River Valley
State Boundaries
County Boundaries
Regional County Names
State Names
GSP County Names
GSP City Names

Landslide Plan of Action

*The NWS has no stand-alone product for landslide alerts**

Outlook…*(Ready)* **Watch…***(Set)* **Warning…***(Go!)*

1. **Highlight in Partner Briefings when *storm total* rainfall forecast is greater than 5 in.**
2. **Issue Public Information Statement when *storm total* rainfall forecast exceeds 10 in.**
3. **Include landslide call-to-action in Flood Watch when *storm total* rainfall exceeds 5 in.**
4. **Include landslide call-to-action in Flash Flood Warnings when observed rainfall exceeds 5 inches in 24 hours and rainfall rates are high.**

* NWS offices over southern Appalachians (GSP, RNK) use Flood Watch/Warning products to convey landslide threat information because any weather system that produces enough rain to trigger landslides will almost certainly result in flooding.

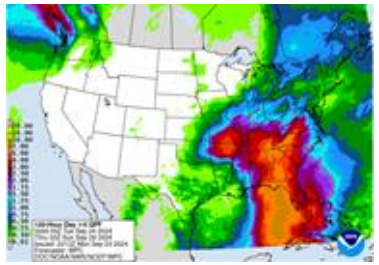
Hurricane Helene Event Timeline

Landslide Threat Recognition, Coordination, and Communication

Sept 23, 11 AM
PTC9 Adv.1



Sept 23, 613 PM
WPC QPF



Sept 24, 410 PM
WPC ERO Moderate Risk
"Mudslides and landslides will become increasingly common in the southern Appalachians as rainfall amounts approaching 12 inches are expected."

Sept 24, 500 PM
NHC Advisory 6 Key Messages
"…risk of landslides across the southern Appalachians."

Sept 24, 600 PM
4th Partner Briefing
Landslides…Moderate confidence of extreme impacts.

Sept 25, 503 AM
WPC ERO High Risk
"Landslides are possible in areas of steep terrain in the southern Appalachians given these rainfall amounts."

Sept 25, ~ 530 AM
PRE Begins

90 **Indication of Event** 72 **Connect with Key Partners** 48

Sept 23, 528 PM
2nd Partner Briefing
"one-pager"

Sept 24, 351 AM
AFD
"PRE"

Sept 24, 617 AM
3rd Partner Briefing
"Amount of forecast rainfall would likely result in isolated landslides in areas of steep terrain."

Sept 24, 330 PM
Webinar
"Several landslides may occur across the mountains."

Sept 24, 939 PM
Internal e-mail
"If forecast doesn't change, a significant landslide/debris flow problem…"

Sept 25, 600 AM
5th Partner Briefing
"Numerous landslides may occur across the mountains, with a couple of large, damaging debris flows/slope failures possible."

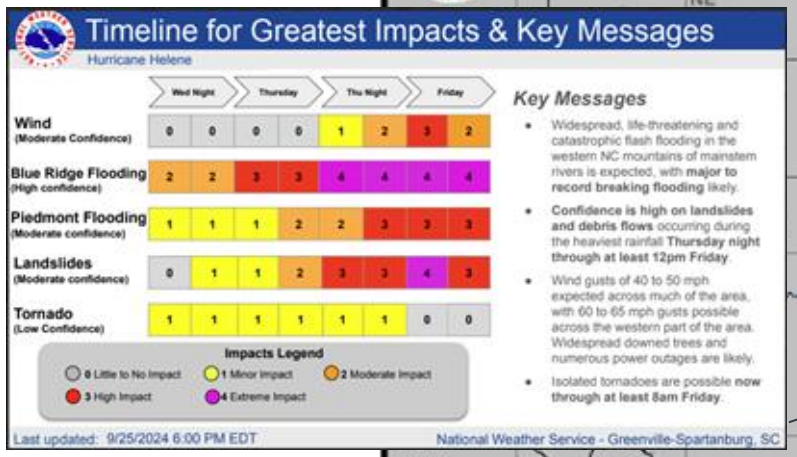
Sept 23, 1159 AM
1st Partner Briefing
"one-pager"



Sept 24, 100 PM
NCGS Contacted

Sept 24, 322 PM
Flood Watch Issued
Rainfall of more than five inches…
…increased risk of landslides…

One NWS…



Public Information Statement
National Weather Service Greenville-Spartanburg SC
444 PM EDT Wed Sep 25 2024

...INCREASED THREAT OF LANDSLIDES AND DEBRIS FLOWS ACROSS THE MOUNTAINS AND FOOTHILLS FROM LATE THIS EVENING INTO FRIDAY...

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

"Extreme rainfall rates (i.e., torrential downpour) across the mountainous terrain of the southern Appalachians will likely inundate communities in its path with flash floods, landslides, and cause extensive river and stream flooding."

"Several landslides due to the prolific rainfall are very likely with a history of these types of events producing catastrophic damage…"

Key Messages for Hurricane Helene
Advisory 10: 4:00 PM CDT Wed Sep 25, 2024

3. Catastrophic and life-threatening flash and urban flooding, including landslides, is expected across portions of the southern Appalachians through Friday. Considerable to locally catastrophic flash and urban flooding is likely for northwestern and northern Florida and the Southeast through Friday. Widespread minor to moderate river flooding is likely, and isolated major river flooding is possible.

One Forecast…

Helene Review…

- What we think we did well…
  - Threat recognition… Identified potential for significant threat
  - NWS coordination… All parts of NWS mentioning landslide threat
  - Lead time… At least 60 hrs for landslide threat
- What we think we did okay…
  - Threat communication… Did the landslide threat get lost in the shuffle?
  - Collaboration with NCGS… Did they get needed information from us?
- What we need to work on…
  - Response… How do communities evacuate for landslide threat?
  - Outreach… Landslide Awareness Week?
  - Targeting threats…
    - Can we model where threats are elevated?
    - Might we coordinate watch messages with input from USGS/NCGS like we do with USFS/NCFS in our Fire Weather program?



Jonathan Godt, USGS

BREAK

Back at 11:15





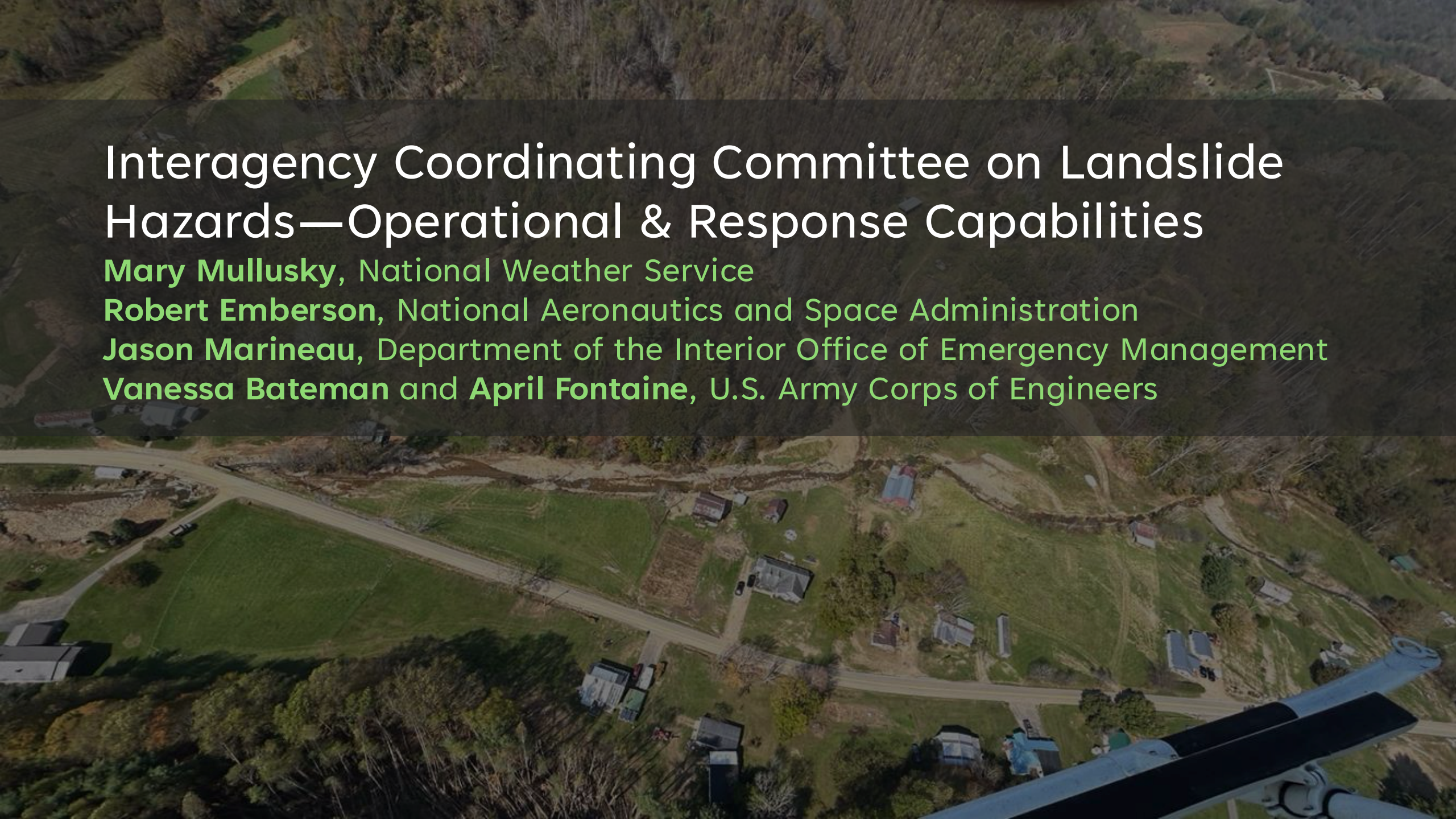
Discussion—Recommendation Report Finalization

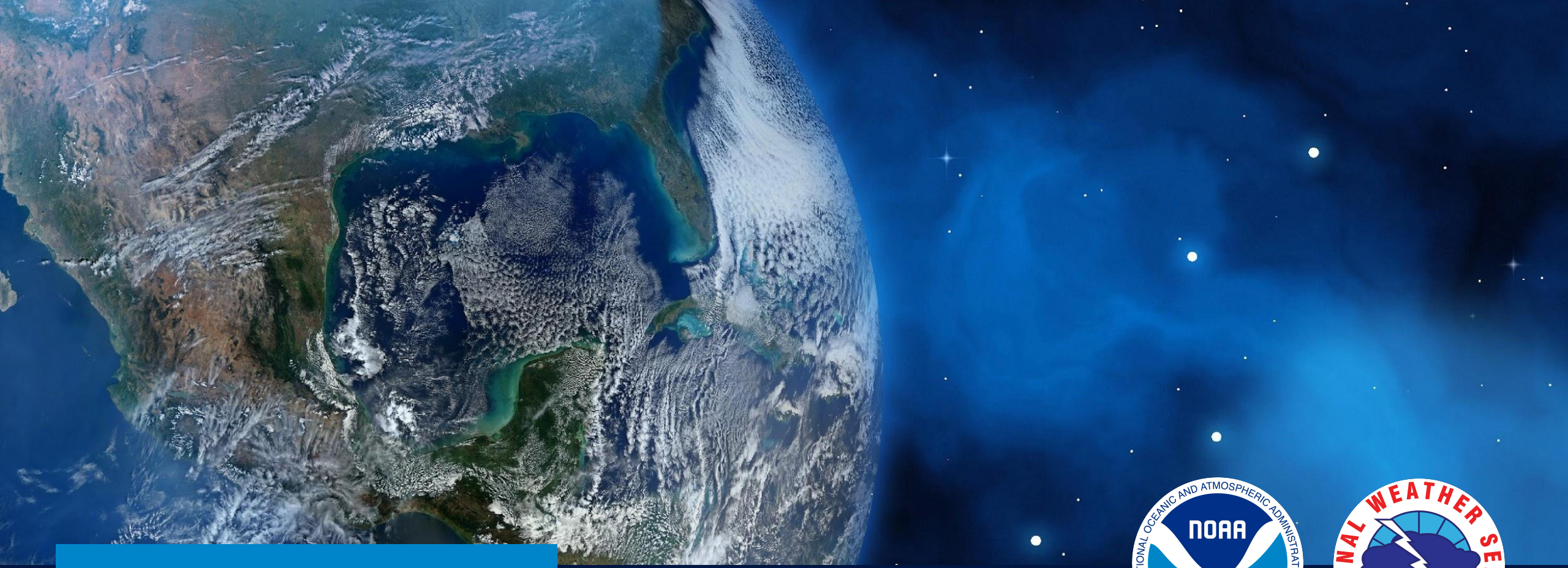
Haneberg and Oakley


LUNCH
Back at 1:30

Interagency Coordinating Committee on Landslide Hazards—Operational & Response Capabilities

Mary Mullusky, National Weather Service
Robert Emberson, National Aeronautics and Space Administration
Jason Marineau, Department of the Interior Office of Emergency Management
Vanessa Bateman and **April Fontaine**, U.S. Army Corps of Engineers





National Weather Service Presentation to the Advisory Committee on Landslides

Mary Mullusky, Chief, Operational Services Division

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service

National Weather Service Mission

Provide weather, water and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy.

National Weather Service Vision

A Weather-Ready Nation: Society is prepared for and responds to weather, water, and climate-dependent events.



Where We Are

122
Weather Forecast Offices

21
Center Weather Service Units

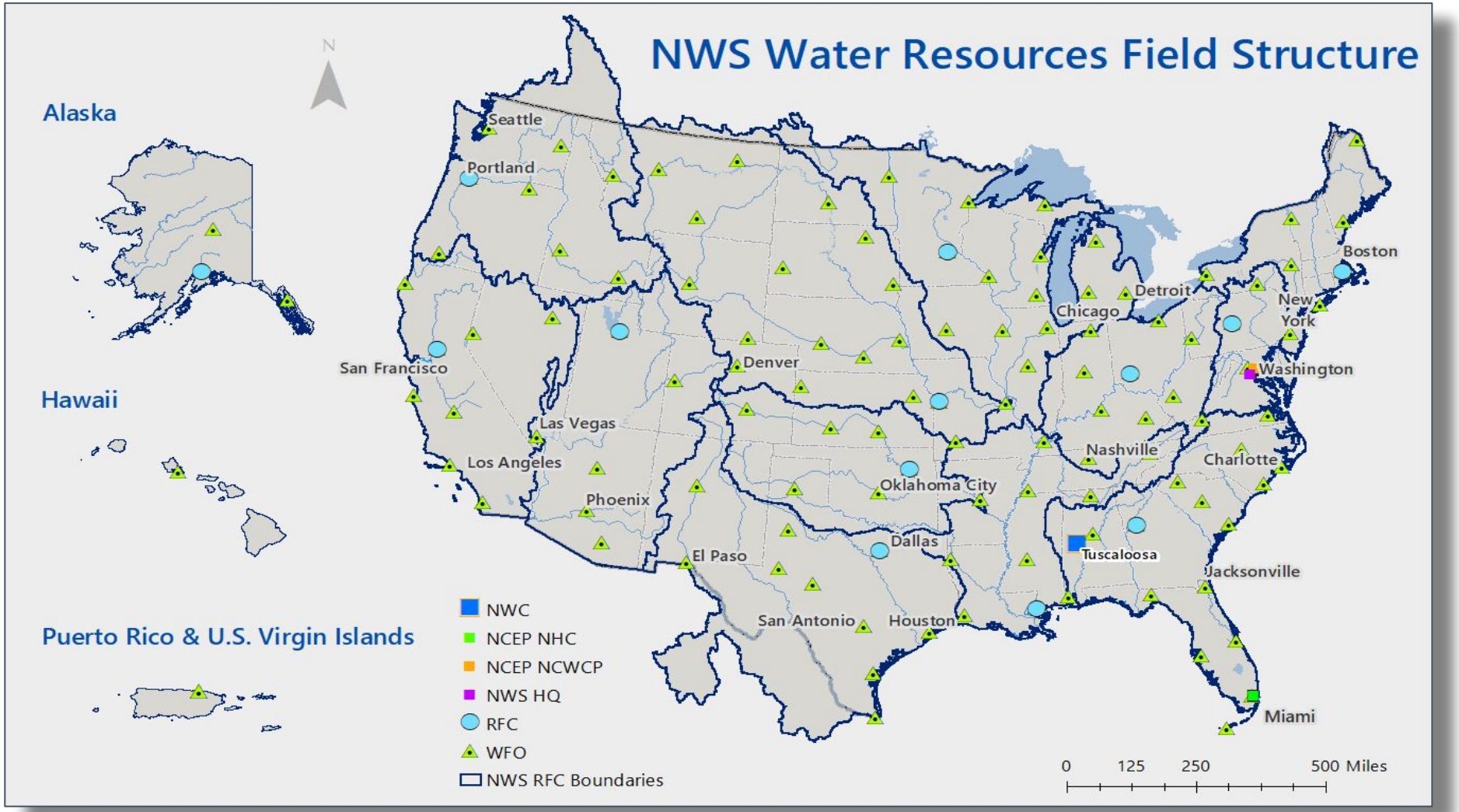
13
River Forecast Centers

9
National Centers for Environmental Prediction

7
National/Regional Headquarters

2
Tsunami Warning Centers

1
National Water Center

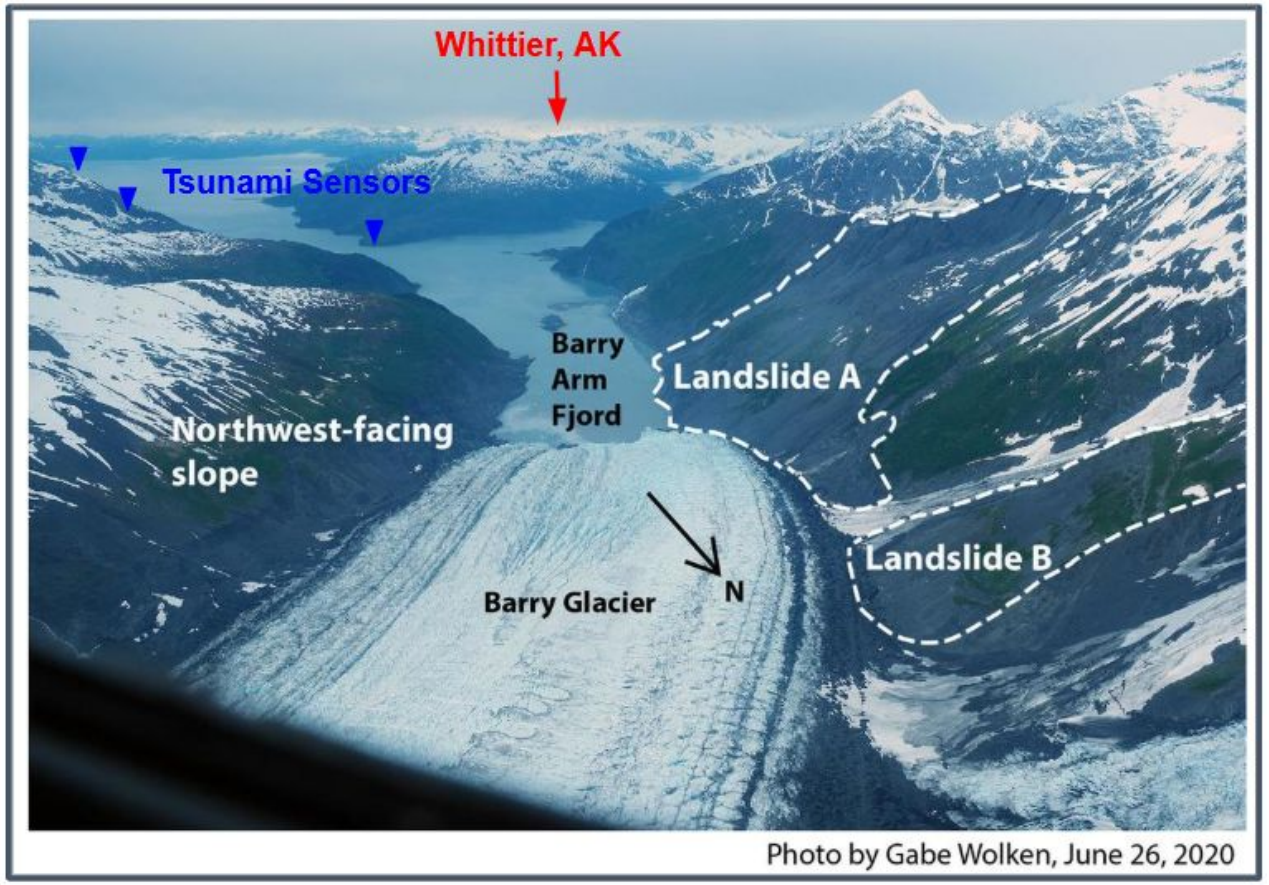


Title

- NWS leverages post-fire debris-flow hazard assessments for our situational awareness of the post-fire debris flow threat and to inform our watches and warnings for threats of flash floods and debris flows generated from the burn area.
- Prolonged precipitation can also create conditions conducive to landslide initiation. As USGS continues to advance their predictive landslide science, NWS is undertaking an effort to more accurately capture observations of these impactful events.
- The NWS works with agencies in the landslide hazard community to share public safety messages throughout the hazard lifecycle from pre-event preparedness to alerting and support of public response before and after landslides and debris flows.

- NWS is regularly engaged with USGS, USCG, USFS, and state of Alaska agencies in an interagency working group focused on internal coordination and external messaging for the Barry Arm landslide tsunami hazard.

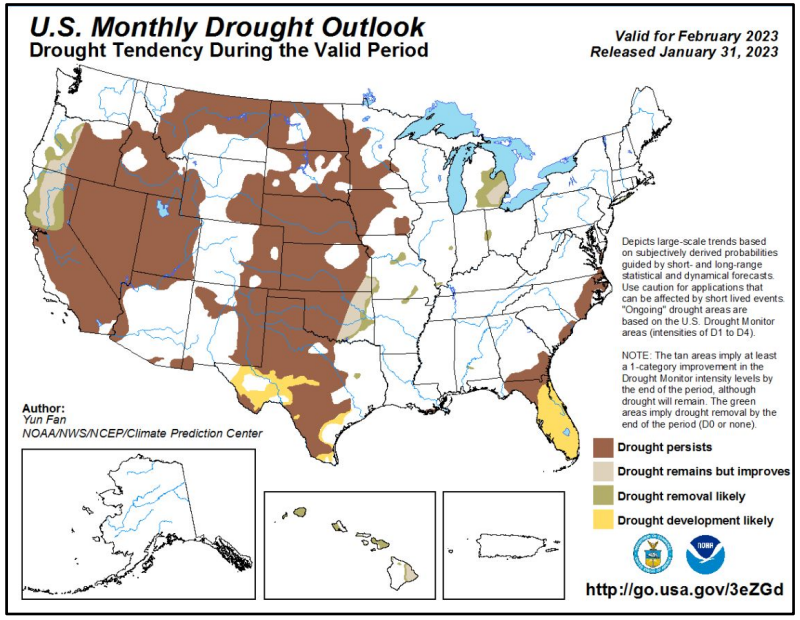
- USGS science and monitoring provides hazard assessment and situational awareness informing improved operational response at the National Tsunami Warning Center.
- NWS is also collaborating with these groups on public messaging in the form of regularly released published updates and education and outreach to regional communities.



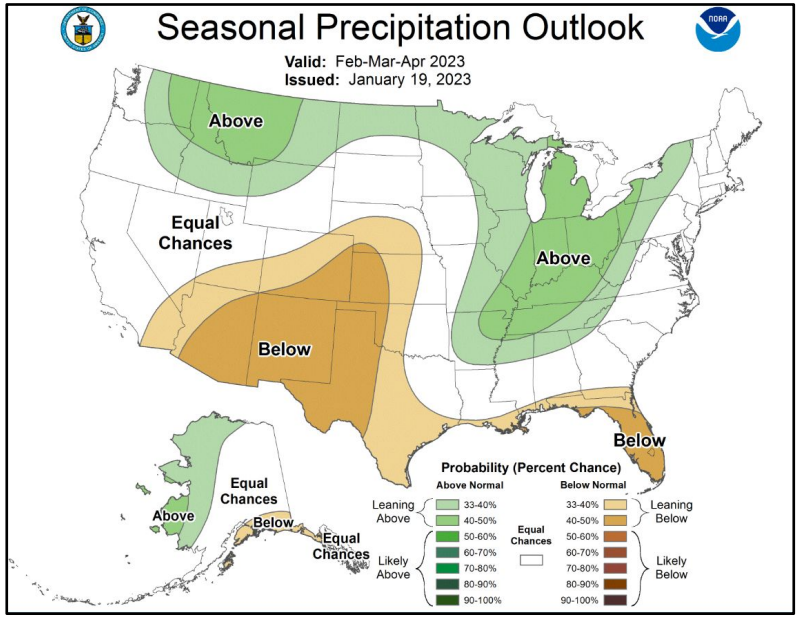
Landslide Prepar

Landslides are often driven by changes in ground moisture content. NWS provides resources for monitoring and predictions leading to these conditions:

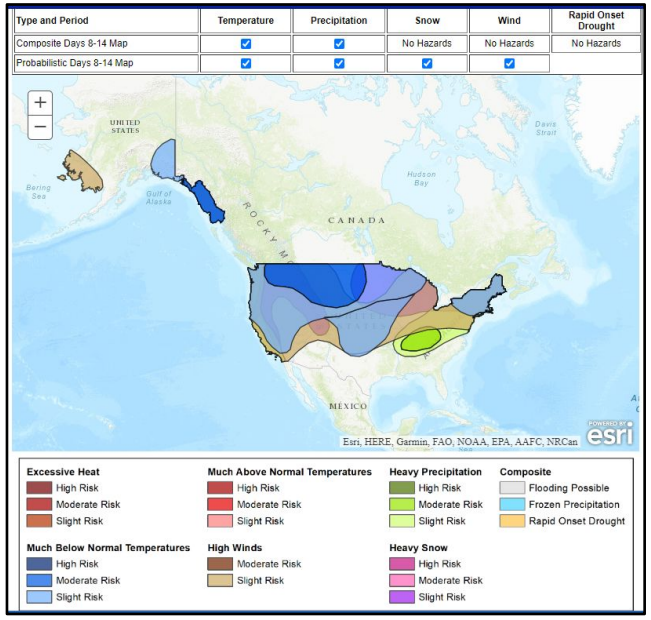
Drought Monitoring and Seasonal and Monthly Outlooks



Three-Month Precipitation Outlooks for upcoming year



Days 8-14 Hazard Outlooks for Temp, Prec, Snow, Wind, and Rapid Onset Drought



NWS opportunities from the National Strategy for Landslide Loss Reduction

NWS is called out specifically in the following Goals and Strategic Actions:

- Strategic Action 1.2: coordinate with the USGS to enhance the scope, accuracy, and effectiveness of post-fire debris-flow and landslide-generated tsunami alerts.
- Strategic Action 3.1: include landslide hazards information in guidance and doctrine pertaining to the four phases of emergency management
- Strategic Action 4.1: produce and disseminate landslide-related warning products for shallow, rainfall-induced landslides based on data provided by the USGS landslide surveillance network


Oso, Washington
Mudslide; October 2014



Questions?

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BREAK

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Discussion—Recommendation Report Finalization

Haneberg and Oakley



Open Advisory Committee Discussion

Godt, Riker, Haneberg, and Oakley

Adjournment

