

April 10, 2026

The Honorable Doug Burgum  
Secretary of the Interior  
U.S. Department of the Interior  
1849 C Street NW  
Washington DC 20240

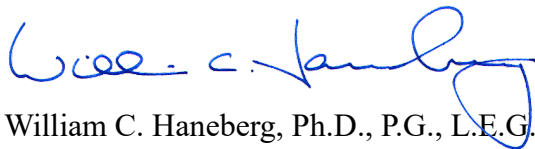
Dear Mr. Secretary:

The Advisory Committee on Landslides (ACL) is pleased to submit the accompanying report titled *Reducing Landslide Risk—Recommendations for Implementation of the National Landslide Hazard Reduction Program: A National Approach to Strengthen Avoidance, Preparedness, and Response*. The content of the report was endorsed unanimously by the Committee during its March 2026 public meeting in Asheville, North Carolina.

The ACL was authorized by the National Landslide Preparedness Act (Public Law 116–323). The law directs the ACL to submit to the Interagency Coordinating Committee on Landslide Hazards (ICCLH), which is led by the Department of the Interior, “...recommendations for the implementation of the [National Landslide Hazards Reduction] 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.”

We trust that the ICCLH will find the report useful as it works to reduce the impacts of landslides, debris flows, and other kinds of slope instability within the United States.

Respectfully,



William C. Haneberg, Ph.D., P.G., L.E.G.

Chair, Advisory Committee on Landslides  
Geological and Geohazards Consultant  
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# Reducing Landslide Risk

*Recommendations for Implementation of the National Landslide Hazard Reduction Program: A National Approach to Strengthen Avoidance, Preparedness, and Response*



Prepared by the Advisory Committee on Landslides

April 2026

**Cover photo:** Oblique aerial view of the 2014 Oso, Washington, landslide that buried the riverside community of Steelhead Haven and killed 43 people. Photo by Mark Reid, U.S. Geological Survey.

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*Components of this document were developed independently by two ACL subcommittees during late 2025 and early 2026 and then used to produce a unified draft report. The unified draft was discussed, revised, and adopted by the ACL during a public meeting March 4-5, 2026, in Asheville, North Carolina.*

## **Advisory Committee on Landslides**

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# INTRODUCTION

*Civilization exists by geological consent, subject to change without notice.*

—Will Durant

Landslides are a pervasive natural hazard across the United States, causing billions of dollars in damage annually and posing risks to life, property, and infrastructure. Passage of the [National Landslide Preparedness Act \(Public Law 116-323\)](#) (hereafter “the Act”) in 2021 was an important step forward in the identification of critical knowledge gaps and actions that can be taken to reduce landslide risks.

Much has been accomplished since the Act was passed. The National Landslide Preparedness Act mandated development of a [National Strategy for Landslide Loss Reduction](#) (hereafter “National Strategy”) and established the Interagency Coordinating Committee on Landslide Hazards (ICCLH). The U.S. Geological Survey Cooperative Landslide Hazard Mapping and Assessment Program, instituted 2024, has awarded approximately \$1 million in grants each year to state, Tribal, territorial, and local governments in support of practical landslide mapping, assessment, and planning. The Advisory Committee on Landslides (ACL) was also established under the Act to provide outside guidance of federal efforts.

This report, the ACL’s first, identifies key challenges and opportunities for nationwide landslide risk reduction within the framework of the National Strategy.

Recognizing that ICCLH agency resources are limited and that much work will have to occur at the local, state, territorial, and Tribal levels, the ACL has prioritized recommendations that may be implemented at a federal level by the Interagency Coordinating Committee on Landslide Hazards (ICCLH) agencies.

The key science and engineering challenges identified by the Advisory Committee on Landslides (ACL) include:

- Incomplete and inconsistent landslide inventories and databases at the state, Tribal, territorial, local, and federal levels.
- Limited understanding of highly variable subsurface conditions, triggering events, and landslide runout behavior.

The 2014 [Oso, Washington, landslide](#) buried the riverside community of Steelhead Haven, killed 43 residents who were unable to escape, destroyed 41 homes, and caused \$120 million in economic losses.

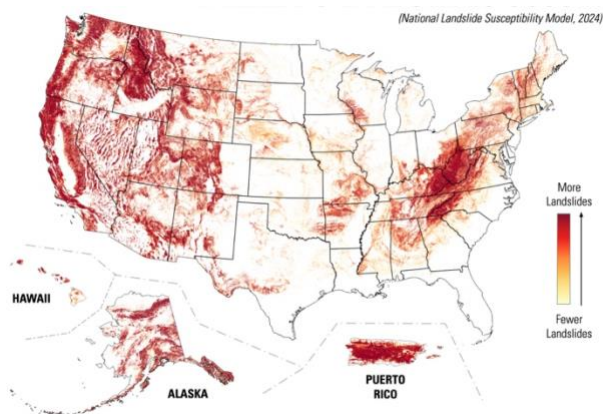
Heavy rainfall as Hurricane Helene moved inland across Appalachia in 2024 [triggered more than 2,000 landslides](#), including ten that merged into a large fast-moving mudflow. That mudflow traveled over a mile, destroyed a neighborhood in Fairview, North Carolina, and killed 13 people.

[Post-wildfire debris flows](#), which received little attention a generation ago, pose increasing risks each year. In 2018, 23 people died when devastating debris flows initiated in the Thomas Fire burn area in Santa Barbara County, California.

- Sparse monitoring and precipitation data, especially in geologically and topographically complicated terrain.
- An absence of standardized national approaches to susceptibility mapping, risk analysis, and loss documentation.

The scientific and engineering gaps are compounded by institutional challenges including inconsistent terminology, weak integration of landslide risk avoidance or mitigation into land-use planning and building codes, imprecisely defined emergency response roles, and limited public awareness of landslide hazards and risks.

By way of this report, the ACL advocates for a continuation of a coordinated national approach built around the four National Strategy goals of **Assess, Coordinate, Plan, and Respond**. ACL



Landslides can occur throughout the country. Source: U.S. Geological Survey (2024).

recommendations include federal leadership and support to establish and maintain standardized, interoperable, nationwide landslide inventories and damage databases; integrate multi-scale monitoring and emerging technologies such as airborne lidar, satellite radar, fiber-optic sensing, and artificial intelligence; develop a national forecast-based landslide warning system; and develop consistent risk analysis, planning, and response protocols. Investments in professional training, public education, and post-event data collection will be important to ensure that scientific advances translate into

reduced losses.

As illustrated below, the broad range of topics addressed in this report touch upon multiple National Strategy goals. For example, improved landslide inventories and databases would support better assessments of hazards and risks; inform science-based planning decisions; and allow for more effective emergency response. Secondly, they would allow for better interagency coordination across all levels from local to federal.

Inventories & Data Infrastructure	Primary	Secondary		
Susceptibility & Modeling				
Risk Assessment				
Monitoring & Detection				
Forecasting & Warning				
Planning & Policy				
Response & Recovery				
Education & Outreach				
	<b>ASSESS</b>	<b>COORDINATE</b>	<b>PLAN</b>	<b>RESPOND</b>

# NATIONAL STRATEGY GOAL 1: ASSESS

*Provide nationwide information on landslide hazards and risks through improved mapping, monitoring, and data collection.*

## Challenges

- Incomplete and inconsistent landslide inventories and databases.
- Limited susceptibility, runout, and risk models and maps.
- Limited understanding of subsurface conditions and triggering events.
- Insufficient monitoring of slope movement and triggering conditions.
- Poor documentation of impacts and losses.

## Opportunities

### National Landslide Inventory and Impact Database

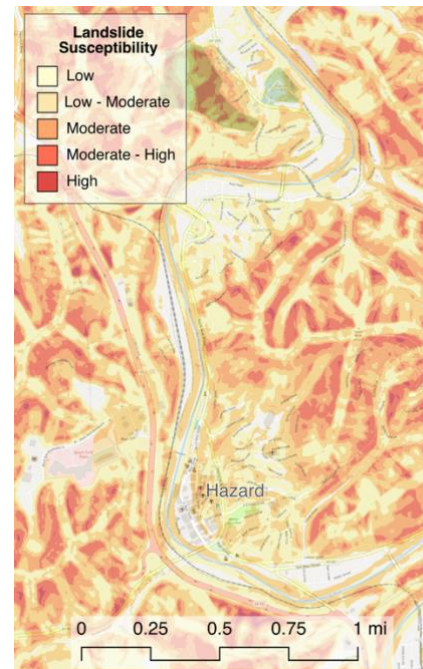
- Development of an interactive, dynamic, and web-accessible national database integrating landslide occurrence with impact and consequence data.
- Focused coverage on high-susceptibility and rapidly developing areas.
- Research on scientifically responsible uses of artificial intelligence (AI) to extract landslide and impact information from public documents such as maintenance records and media reports.

### Standardized Inventory and Susceptibility Protocols

- Definition of common landslide inventory standards, database schemas, and susceptibility modeling protocols in collaboration with local, state, Tribal, territorial, and industry experts.
- Publication of standards, schemas, and protocols.
- Documentation of progress toward national coverage.

### Integrated National Susceptibility Framework

- Integration of locally tailored susceptibility models into a consistent national index analogous to the National Seismic Hazard Model.



Portion of a regional landslide susceptibility map for the area around Hazard, Kentucky, developed using lidar-based landslide inventory maps made by geologists as input for a machine learning model. An interactive version is available through the Kentucky Geological Survey web map portal. Source: Kentucky Geological Survey

## Monitoring and Detection Networks

- Integration of satellite radar (e.g., NASA-ISRO Synthetic Aperture Radar, or NISAR), airborne lidar (e.g., 3D Elevation Program, or 3DEP), ground-based instrument networks, and other emerging technologies such as fiber-optic sensing into a coordinated national monitoring framework.
- Use of automated change detection and AI-enabled analytics to detect precursory movement.
- Prioritization of monitoring investments using standardized susceptibility and risk assessments.

## Risk Analysis and Consequence Assessment

- Development standardized national landslide risk-analysis methods that integrate systematic post-event collection of damage, loss, and fatality data with hazard information.
- Archiving of impact data in accessible national repositories for calibration and validation of risk models.
- Incorporation of the likelihood of increasingly frequent extreme rainfall events and wildfires into hazard and risk assessments.

## ACL Recommendation

**Recommendation:** In support of National Strategy Strategic Action 1.3 (Develop a Publicly Accessible National Landslide Hazard and Risk Database), integrate and further advance a national landslide inventory and impact database using standardized methods. This includes development of modern data and metadata standards for National Landslide Hazard Reduction Program-produced datasets for systems integration and AI-driven workflows for susceptibility mapping, predictive modeling, and risk assessment.

Possibilities could include:

- Incorporation of landslide features (e.g., source, runout, and depositional areas), triggering conditions, anthropogenic modifications, damage, loss, and fatality data.
- Prioritization of areas with limited or incomplete data.
- Prioritization of perishable data and rapid lidar acquisition and sensor deployment.

**Recommendation:** Also in support of National Strategy Strategic Action 1.3, develop a national monitoring and detection framework to integrate multiple data types, such as satellite, airborne, and ground-based sensors, and utilize algorithms and automation to detect and interpret land movement.

# **NATIONAL STRATEGY GOAL 2: COORDINATE**

*Establish interagency coordination, shared standards, and data interoperability*

## **Challenges**

- Fragmented agency roles and responsibilities.
- Inconsistent terminology, protocols, and data practices.
- Limited integration of federal, state, territorial Tribal, academic, and industry knowledge and capabilities.

## **Opportunities**

### **Interagency Working Groups**

- Formation of ICCLH-led working groups to coordinate development of inventory, susceptibility, monitoring, and risk standards across agencies and jurisdictions.
- Active solicitation of state, territorial, Tribal, local, academic, and industry input.

### **Data Standards and Integration**

- Cooperation with the Federal Geographic Data Committee (FGDC) and the National Geospatial Advisory Committee (NGAC) to develop federal standards for publication of findable, accessible, interoperable, and reusable (FAIR) landslide-relevant remote sensing and map products.
- Establishment of an access point for findable, accessible, interoperable, and reusable (FAIR) landslide-related data as part of the national geospatial data infrastructure.

### **Multi-Scale Data Fusion and Sharing**

- Supporting development and use of interoperable formats and real-time data-sharing protocols that link space-based, airborne, and ground-based observations to reduce data friction and computational friction.

### **Consistent Terminology and Communication**

- Standardization of landslide terminology, alert levels, and communication protocols across agencies to reduce confusion during response.

## **ACL Statement**

The committee recognizes that the effective use of remote sensing data including lidar, SAR, InSAR, and spectral imagery, is a critical component of national-scale landslide mapping, modeling, and monitoring. Ensuring these data are discoverable, accessible, and managed consistent with the framework established by the Federal Geographic Data Committee, the Geospatial Data Act of 2018, and the National Spatial Data Infrastructure Strategic Plan 2025–2035 will be an important area of future coordination and the committee anticipates this will be an area of continued focus as it develops future recommendations for the ICCLH.

The committee also considers the adoption of modern, open data formats, FAIR data principles, and standardized metadata across all datasets produced under the National Landslide Hazard Reduction Program—including the national landslide database, susceptibility maps, and risk assessments — to be foundational to the program's long-term success. Data designed from the outset to support machine learning, AI-driven analytical workflows, and integration with complementary federal datasets will significantly strengthen the nation's capacity for predictive modeling, automated detection, and risk reduction. The committee plans to further examine these needs and consider future recommendations to the ICCLH.

## **NATIONAL STRATEGY GOAL 3: PLAN**

*Integrate landslide risk into land-use, infrastructure planning, mitigation, and preparedness*

### **Challenges**

- Weak integration of landslide science into zoning, permitting, and code adoption processes.
- Limited guidance on cost-effective mitigation.
- Low public and professional awareness of landslide risk.
- Increasing frequency of extreme landslide-triggering rainfall events and wildfires.

### **Opportunities**

#### **Risk-Informed Land-Use and Development Guidance**

- Translation of susceptibility and risk information into planning-relevant products for land managers, communities, and property owners.
- Support for development of model guidance and engineering best practices for construction and land-use in landslide-prone areas.

#### **Planning for Future Conditions**

- Collaboration with the National Oceanic and Atmospheric Administration (NOAA)/National Weather Service (NWS) to develop science-based extreme meteorological projections relevant to landslide and debris flow initiation over the next 25 to 50 years.
- Support for development of risk assessment, planning, preparation, and emergency response approaches based on projected extreme rainfall and wildfire scenarios, including development of necessary computational tools.

### **Building Codes and Mitigation Research**

- Research on relationships among landslide processes, building codes, damages, injuries, and fatalities.
- In collaboration with professional standards bodies, incorporation of life-safety-based landslide and/or debris flow provisions into codes and permitting practices.

### **Cost-Effective Mitigation Strategies**

- Support for research and information dissemination to advance understanding of slope stabilization, drainage improvements, and infrastructure retrofitting techniques tailored to different landslide types.

### **Education, Training, and Preparedness**

- Creation of national training programs for emergency managers, planners, and public works officials.
- Development of informational and contemporary media-savvy material and public awareness campaigns explaining landslide risks and protective actions.

### **ACL Recommendation**

**Recommendation:** In support of National Strategy Strategic Action 3.2 (Develop Landslide Outreach Initiatives to Improve Public Knowledge and Preparedness Planning), facilitate the development of research-informed nationally consistent landslide definitions and terminology, including landslide hazards, alerting, evacuations, and protective action messaging to improve coordination, response operations and public communication.

**Recommendation:** Also in support of National Strategy Strategic Action 3.2, develop research-informed and consistent educational materials and public awareness campaigns explaining landslide risks and protective actions.

Possibilities could include:

- Development of national training programs for emergency managers, planners and public works officials.

- Development of executive Summaries and FAQs on USGS current and future efforts, including working groups, committees, etc. to inform local practitioners of resources available now or in development.
- Development of graphics and language that can be utilized in signage and education like “Drop, Cover & Hold on” or “Turn Around, Don’t Drown”
- Incorporation of developed materials on a USGS website for non-scientists.
- Promotion of a Landslide Awareness Week, such as the North Carolina Landslide Awareness week scheduled for August 2026.
- Exploration of partnerships to establish a “Did You Feel It” public engagement portal.

## **NATIONAL STRATEGY GOAL 4: RESPOND**

*Enhance warning systems, emergency response, and recovery operations*

### **Challenges**

- Sparse landslide monitoring and precipitation information
- Limited operational landslide warning system coverage
- Unclear roles and slow data access during emergencies
- Reactive rather than risk-reducing recovery practices

### **Key Opportunities**

#### **National Forecast-Based Landslide Warning System**

- Establishment of a national landslide warning capability leveraging the NOAA/NWS information and communications infrastructure.
- Refinement of rainfall and triggering thresholds using improved precipitation data, landslide inventories, and both data- and physics-driven computer models.
- Investigation of scientifically responsible AI technology to supplement predictive models.
- Development of landslide-specific precipitation observation and forecast products.
- Support for gap-filling weather radar deployment and assessment in complex terrain.

#### **Alerting and Protective Action Protocols**

- Pairing nationally consistent alert levels (advisory/watch/warning) with clearly defined risk-reduction actions.
- Improvement of community understanding through plain-language messaging and education.
- Tailoring information content and delivery using community-based dialogue to engage audiences and incorporate local knowledge.

## **National Landslide Response Framework**

- Definition of clear roles, responsibilities, and coordination mechanisms across federal, state, Tribal, local, and academic partners.
- Establishment of protocols for rapid access to data, remote sensing assets, and technical expertise during events.

## **Post-Event Reconnaissance and Recovery**

- Integration of reconnaissance, monitoring, and standardized damage/loss data collection into response and recovery.
- Promotion of long-term stabilization, monitoring, and science-based land-use planning as part of recovery to reduce repeat losses.

## **ACL Recommendation**

**Recommendation:** In support of National Strategy Strategic Action 4.1 (Support Existing Warning Systems to Include Landslides), define the essential elements of a National Landslide Warning System that provides impact-based decision support.

Possibilities could include:

- Utilization of NOAA/NWS forecast, observation, and communication infrastructure as well as integration of existing and new monitoring networks.
- Application and continuous improvement of precipitation triggering thresholds.
- Development of nationally consistent guidance for landslide hazards and specific actions to take for each alert level and hazard.
- Collaboration with emergency managers and social scientists to develop guidance (e.g., flow charts, decision trees) for actions based on alert levels.
- Collaboration with local, state, territorial, and Tribal entities in development of warning systems.
- Application of state-of-the-art, reproducible, and verified models to support warning programs.

## **FURTHER READING**

The ACL Subcommittee on Science and Technology Gaps and Subcommittee on Advancing Landslide Science Applications for Public Safety reports are available through the ACL web page:

<https://www.usgs.gov/programs/landslide-hazards/advisory-committee-landslides-acl>

An online version of the National Landslide Preparedness Act (Public Law 116-323) is available at:

<https://www.govinfo.gov/content/pkg/PLAW-116publ323/pdf/PLAW-116publ323.pdf>

An online version of the National Strategy for Landslide Loss Reduction is available at:

<https://pubs.usgs.gov/of/2022/1075/ofr20221075.pdf>