The *Grand Challenges for Disaster Reduction* outlines a ten-year strategy crafted by the National Science and Technology Council's Subcommittee on Disaster Reduction (SDR). It sets forth six Grand Challenges that, when addressed, will enhance community resilience to disasters and thus create a more disaster-resilient Nation. These Grand Challenges require sustained Federal investment as well as collaborations with state and local governments, professional societies and trade associations, the private sector, academia, and the international community to successfully transfer disaster reduction science and technology into common use.

To meet these Challenges, the SDR has identified priority science and technology interagency implementation actions by hazard that build upon ongoing efforts. Addressing these implementation actions will improve America's capacity to prevent and recover from disasters, thus fulfilling our Nation's commitment to reducing the impacts of all hazards and enhancing the safety and economic well-being of every individual and community. This is the landslide and debris flow-specific implementation plan. See also **sdr.gov** for other hazard-specific implementation plans.

What is at Stake?

DEFINITION AND BACKGROUND. Landslides are triggered by a number of mechanisms, including intense rainstorms and earthquakes, wildland fire, coastal erosion, and the loss of permafrost in arctic regions. The most dangerous landslides are debris flows where slope material becomes saturated with water resulting in a slurry of rock and mud picking up trees, houses, and cars, thus, at times, blocking bridges and tributaries, causing flooding along its path.

IMPACTS. Landslides, debris flows, and other forms of ground failure affect communities in every state of the Nation. Despite advances in science and technology, these events continue to result in human suffering, billions of dollars in property losses, and environmental degradation every year.[1] Approximately two-thirds of the United States population lives in counties where landslide susceptibility is moderate to high.[2]

Landslides routinely disrupt lifelines, such as transportation routes and public utilities, causing billions of dollars in direct property loss annually. Equally as important, but much harder to measure, are the indirect costs encountered when community business and social activities are disrupted. The United States has experienced several catastrophic debris-flow events in recent years. In 1985, a massive debris flow in southern Puerto Rico killed 129 people, inflicting the greatest loss of life by a single landslide in United States history. More recently, in December 2003, 14 people died in Waterman's Canyon in southern California following summer wildfires. The 1982-83 and 1983-84 El Niño season triggered landslide events that affected the entire western United States, including California, Washington, Utah, Nevada, and Idaho. A more recent event, the 1997-98 El Niño rainstorms in the San Francisco Bay area, produced thousands of landslides and caused over $150 million in direct public and private losses.[3]

LANDSLIDE AND DEBRIS FLOW

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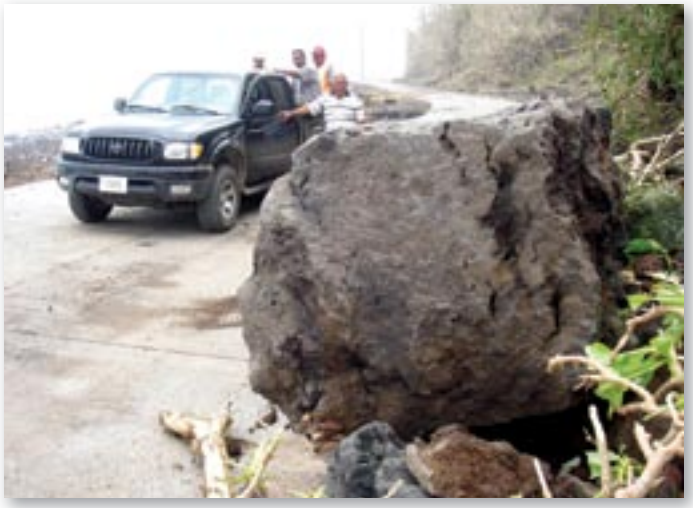
Grand Challenges for Disaster Reduction: Priority Interagency Landslide and Debris Flow Implementation Actions

GRAND CHALLENGE #1: Provide hazard and disaster information where and when it is needed.

- Increase the use of Interferometric Synthetic Aperture Radar as well as airborne and ground-based side-looking LiDAR for more accurate landslide hazard assessments, susceptibility mapping, and to determine the volumes of susceptible material and possible runout distances;
- Inventory sensors needed to predict and monitor landslides. Determine and fill critical gaps.



GRAND CHALLENGE #2: Understand the natural processes that produce hazards.

- Research landslide initiation processes to better understand the interaction between soil type, texture, terrain grade, weather, fire, and other hazards;
- Develop better rainfall threshold models for landslides in areas routinely threatened by hurricanes and winter rainy seasons;
- Better integrate models that evaluate post-wildfire debris flow and landslide potential with near real-time rainfall estimates that blend *in situ*, radar, and satellite observations.

Key: ■ Short Term Action (1-2 years) ➤ Medium Term Action (2-5 years) ◆ Long Term Effort (5+ years)

GRAND CHALLENGE #3: Develop hazard mitigation strategies and technologies.

- ➤ Develop improved structural mitigation techniques for landslide hazards;
- ➤ Evaluate effectiveness of alternative treatments for post-fire rehabilitation and restoration of severely burned slopes on reducing landslides and debris flows hazards.

GRAND CHALLENGE #4: Reduce the vulnerability of infrastructure.

- ◆ Inventory and assess the vulnerability of the Nation's most critical infrastructure to landslide hazards;
- ◆ Utilize research and data from past events to provide the technical basis for codes and standards and local zoning decisions that will locate hospitals, schools, power plants, and other essential facilities away from the risk area, or retrofit to provide adequate protection from the assessed landslide risk.

GRAND CHALLENGE #5: Assess disaster resilience.

- ■ Incorporate the use of risk analysis techniques to guide loss reduction efforts at the state and local levels;
- ➤ Update the national landslide susceptibility map and state landslide susceptibility maps;
- ➤ Produce landslide hazard maps for communities at risk throughout the U.S.;
- ➤ Complete risk assessments for at-risk communities;
- ➤ Provide information necessary to develop effective land use plans and policies for at-risk communities;
- ➤ Develop comprehensive pre-event recovery plans.

GRAND CHALLENGE #6: Promote risk-wise behavior.

- ■ Develop a guidebook with best practices for mitigating landslide hazards and train local decision makers to use it efficiently and effectively;
- ■ Test a pilot warning system for debris flows following fires in Southern California and expand the system to other parts of California;
- ■ Develop a warning system that utilizes an emergency communication network, forecasting ability, and geologic expertise;
- ■ Continue to build better links between the fire fighting community, landslide researchers, forest managers, and communities most at risk near forested areas;
- ➤ Identify and develop effective methods to educate individuals and decision makers about landslide threats so they can make more informed decisions when purchasing land and structures;
- ◆ Test and expand the warning system for debris flows to other susceptible regions.

Key: ■ Short Term Action (1-2 years) ➤ Medium Term Action (2-5 years) ◆ Long Term Effort (5+ years)

Expected Benefits: Creating a More Disaster-Resilient America

Fulfilling this landslide and debris flow-specific implementation plan will create a more disaster-resilient America. Specifically:

Relevant hazards are recognized and understood. More communities across the Nation will have landslide susceptibility and hazard maps by combining more robust rainfall threshold models with more accurate and detailed weather forecasting and high-frequency, spatially continuous precipitation monitoring. Agencies will be better able to incorporate landslide and debris flow risk reduction into long-term planning and event response.

Communities at risk know when a hazard event is imminent. Communities will incorporate landslide susceptibility and hazard maps into their land use and emergency response plans. More accurate and effective warning systems will be the result of high frequency, spatially continuous precipitation monitoring and accurate weather forecasting at the local level through expanded existing radar networks and next-generation radar development.

Individuals at risk are safe from hazards. The integration of earthquake, volcano, landslide, flood, and other hazards data will improve the effectiveness of modeling, warnings, response, and recovery efforts for communities at risk. Individuals and communities will know how to protect themselves from dangerous and costly landslides through professional training and community outreach.

Disaster-resilient communities experience minimum disruption to life and economy after a hazard event has passed. Fewer people will be in the path of landslides due to improved zoning and land use decisions. Communities will be more aware of potential landslide and debris flow hazards and can respond quickly.

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