

Landslide Hazards in the National Park System

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Landslides include a wide range of phenomena involving downslope ground movement, such as rockfalls, deep slope failure, shallow debris flows, and avalanches. Gravity acting on a slope is the primary cause of landslides, but there are other important and dynamic factors that serve as triggers. Saturation of slopes by precipitation (rain or snowmelt) weakens soil and rock by reducing cohesion and increasing the pressure in pore spaces, pushing grains away from each other. Erosion and undercutting of slopes by streams, rivers, glaciers, or waves increase slope angles and decrease slope stability. Earthquakes create stresses that weaken slopes and physically cause slope movement. Perhaps most significant from a management perspective, the over weighting, and/or under cutting of slopes for facilities, roads, trails, mines, and other man-made structures change the natural slope equilibrium and cause slopes to fail.

The NPS has been aware of landslide hazard issues since parks were first created. In the past landslides were often viewed as extreme or unusual events that had to be cleaned up and/or stabilized. More recently, it has been recognized that landslides, like other geologic processes, are natural and play a fundamental role in shaping ecosystems.

Nevertheless, human activities may accelerate landsliding processes by altering the land surface for agriculture, grazing, development, or other uses. Structures and facilities may be located in the path of natural landslide zones increasing the potential for damage or destruction. Safety hazards to staff and visitors are a prime concern at parks with virtually any topographic relief. Recent and well-known events that have affected park lands include the 1995 Madison County Event (Shenandoah NP), the 1996 Happy Isles Event (Yosemite NP), the 1997 New Year's Day Event (Redwood NP, Whiskeytown NRA, Oregon Caves NM, Lassen Volcanic NP, and Yosemite NP), the 2001 New River Event (New River Gorge NR), and the 2002 Rockfall Event (Zion NP).

Slope failure and associated flooding events may cost parks hundreds of millions of dollars. This cost is even greater when considering all of the smaller, more routine landslides that parks deal with on a regular basis, such as cut-bank failures along road corridors or rockfall along roads, trails and overlooks.

Response to slope failure events has typically been reactive, on a case by case basis. That is, when a landslide event occurred, the NPS dealt with the consequences of that event (i.e., cleanup, stabilization, repairing damage, etc.). More recently, however, incident responses have been significantly more proactive, including large-scale inventories and assessments of the changes to natural and, in many cases, cultural resources. Assessment teams, similar to the Burned Area Rehabilitation Teams used for areas affected by forest fires, are being used for landslide areas as well. These teams are comprised of geomorphologists, hydrologists, botanists, fisheries biologists, archeologists, and many others to evaluate what kind of event occurred, when and why it occurred, and what the impacts were, and what response is needed for resource protection.

The NPS lacks an adequate and comprehensive approach to planning, assessment, monitoring, information management and dissemination, mitigation, and emergency preparedness and response to catastrophic slope failure. In a few cases, Mount Rainier NP, Yosemite NP, and Shenandoah NP, for example, parks have developed planning documents addressing landslide and rockfall prone areas based on available information. Nevertheless, at most parks subject to significant slope failure, comprehensive landslide hazards assessment and planning are not available.

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A large boulder demolishes a portion of park housing at Zion National Park. Fortunately, no one was injured. NPS photo.



However, the NPS has the basic framework in place to implement such an effort. This framework is contained primarily in the NPS Management Policies (2001). The principle approach to natural processes, including landslides, is to allow them to operate unimpeded (§4.1, §4.8.1.5) and to treat the effects of natural processes only when necessary (§4.1.5). Such necessary exceptions may include provisions for visitor safety (§8.2.5.1), which allow parks to provide safe experiences, and for facility siting (§9.1.1.6) which encourages the avoidance of natural hazards. Combining these policies with the NPS planning framework (e.g., Director's Order 2), will enable parks to be prepared for future events. Given the potential effects of global climate change (e.g., increased frequency of intense storms), such preparedness is warranted.

The NPS is not alone in the need for comprehensive landslide hazard assessment, monitoring, and planning. Federal land management agencies such as the Bureau of Land Management and the Forest Service, many municipalities, and most states must address landslide hazards. The U.S. Geological Survey has taken a lead role in developing a nationwide Landslide Hazards Mitigation Strategy to reduce losses from landslides. The Strategy provides a framework for responding to rising costs from landslide hazards nationwide by developing and facilitating partnerships among governments at all levels, academia, and the private sector. These partnerships would focus resources on landslide research, mapping, assessment, real-time monitoring, forecasting, information management and dissemination, development of mitigation tools, and emergency preparedness and response.

Further information on the USGS Landslide Hazards Mitigation Strategy can be found online at: <http://geology.cr.usgs.gov/pub/open-file-reports/ofr-00-045/>.



This large scale debris flow changed many miles of stream habitat at Shenandoah National Park. Note park staff in left center of photo for scale. Photo by Dave Steensen.