## 3.9 RISK ASSESSMENT: LANDSLIDE

### DESCRIPTION

Landslides may be classified by both type of movement and material. An understanding of the types of landslides that occur is fundamental to assessing the landslide hazard and evaluating potential mitigation measures. The following list is a simplified differentiation based on the type of movement.

**Falls:** Free falls of soil and rock with local rolling, bouncing, or sliding.

**Slides:** Lateral and downslope movement of partially intact masses.

**Flows:** Viscous flows of completely fragmented material, saturated with water.

Landslides can also be differentiated based the type of material involved.

**Rock:** Bedrock

**Debris**: Predominantly coarse material.

**Earth:** Predominantly fine material.

**U.S. Highway 95 Bonners Ferry Landslide, 1998 / Source: www.landslidetechnology.com/landslides/bonnersferry.htm**

Together, movement and material produce a composite classification scheme. For example, a free fall of bedrock is referred to as a "rock fall," while a viscous flow of predominantly fine material is referred to as an "earth flow." The wettest flows are referred to as "mud flows." These events may be very difficult to distinguish from heavily debris-laden flash floods and functionally are essentially the same.

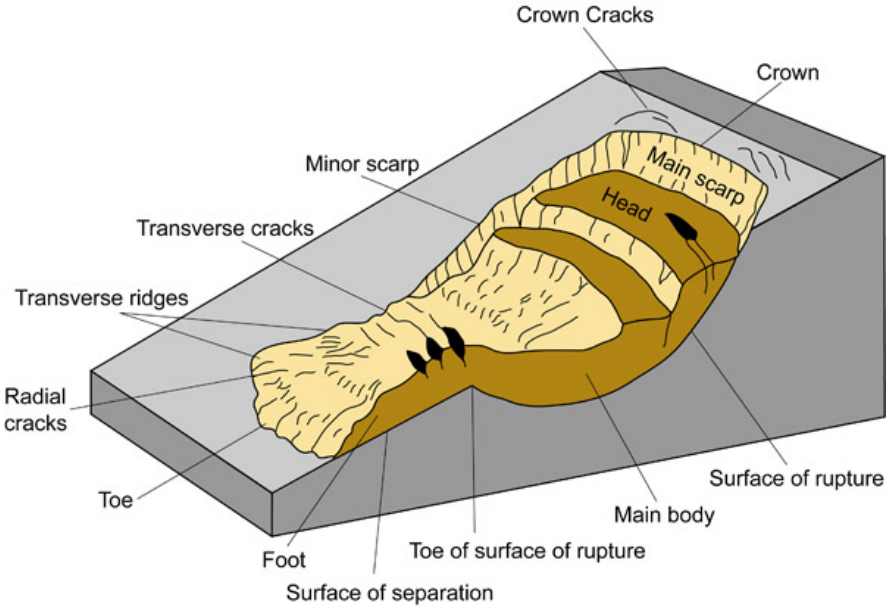
#### Factors Contributing to Landslides

**Natural Factors:** Natural factors contributing to landslides include slope morphology (shape), slope material (soil), bedrock geology, vegetation, and climate. Generally, the steeper a slope is, the more prone it is to landslides (except when the slope is so steep that loose material does not accumulate). A study of landslides in central Idaho has shown that most slides occurred on slopes of about 30 degrees and that landslides were rare on slopes steeper than 41 degrees. The general shape of a slope also influences the likelihood of a landslide. On a concave slope (e.g., hollow, swale, gully), water and debris tend to concentrate, making landslides more likely. Conversely, on a convex slope (e.g., ridge, nose), water and debris are less likely to accumulate.

The slope surface materials and their underlying geology also determine landslide risk. A landslide event is generally dependent on a material weakness. For example, if an impermeable layer exists, subsurface water will accumulate there, leading to reduced slope strength and a potential failure plane. The underlying and adjacent geology often influence the risk of landslides by controlling the movement of groundwater.

Vegetation contributes to slope stability in two ways. First, roots increase the shear strength of the slope material. Second, vegetation removes water from the hill slope by evapotranspiration. Therefore, burned watersheds are particularly vulnerable to landslides.

The climate of a region determines the frequency and magnitude of precipitation events. The amount of precipitation in Northern Idaho is higher than the statewide average. This, along with the topography of the region, increases the likelihood of landslides in this part of the State. The size and timing of precipitation events also has a great impact on landslide risk. They influence the processes of rock weathering (important in influencing soil depth and strength), the type of vegetation that occupies the hill slopes, and the fire regime of the region. Most wildfires occur in mid- to late summer, the same season that severe thunderstorms are most likely to contribute to landslides. Further, the transition into fall often sees higher precipitation amounts that can impact recently burned areas. This was a major concern in the Sun Valley area following the 2007 fire season.




**Landslide Terminology / Source: www.idahogeology.com**

**Human Activities:** Some human activities and land uses can increase the potential for landslides. These include road construction, timber harvesting, grazing, mining, and long-term fire suppression. Such activities can contribute to slope instability by changing infiltration rates and groundwater movement, removing vegetation, and/or over-steepening slopes. In a study of 700 landslides in the Payette River drainage, less than 3 percent of observed recent landslides occurred on undisturbed sites; the rest were associated with forest disturbances including wildfire, timber harvesting, and roads.

Irrigation and others ways that additional water is introduced (e.g., sprinklers, injection wells, and even septic systems) may also contribute to local slope instability. This may be critical along the Snake River

canyon in Bonneville, Jerome, and Twin Falls Counties and near urban centers. In July 2006, a landslide in Washington County, Idaho, is thought to have been caused, at least partially, by the presence of irrigation water. This landslide damaged one home and blocked the irrigation canal, depriving a large area of irrigation water. A State Disaster Proclamation was issued for this landslide. Placing roads on steep slopes has been widely identified as the single human activity most likely to increase the landslide hazard on a site. Roads increase the amount of bare soil and, if constructed across steep slopes, result in a portion of the road fill being steeper in gradient than the natural slope. Road construction on slopes also diverts groundwater to the surface, where it is concentrated and can obtain a higher flow velocity. Mining activities can have similar impacts.

### Landslide Triggers

An unstable slope will remain in place and intact until a landslide is triggered. Typical triggering events include (alone or in combination): water, seismic activity, volcanic eruptions, and the rapid erosion of the slope toe material (e.g., by stream down-cutting or road excavation). The most frequent landslide-triggering mechanism is water from intense rainfall, rapid snowmelt, or human-introduced sources.

A common cause of failure is the infiltration of water into the slope, which usually leads to an increase in ground stresses and a reduction of the soil's strength. Late spring and early summer comprise “slide season”, particularly after days and weeks of greater than normal precipitation. When water accumulates on the surface as runoff, a flow may be triggered. Flows in mountainous terrain are a year-round threat and may be triggered by a heavy, brief rainfall during summer thunderstorms.

Seismic activity and volcanic eruptions, due to their infrequent natures, play a relative minor role in triggering landslides in Idaho. However, these events can affect a large area and may trigger numerous unstable slopes. Floods are often accompanied by numerous landslides due to toe cutting and the introduction of large amounts of water.

### Landslide-related Damages

Landslides threaten residences, businesses, transportation corridors, fuel and energy lines, and communication facilities. Landslides range from very small to massive, and they may affect only a single property or slope or an entire drainage area. A landslide event may be composed of a single discrete landslide or numerous landslides over an entire region. Landslide hazards may be classified

**Earth flow damage to Highway 95 near Bonners Ferry**
**Source: www.idahogeology.com**

as "onsite" and "offsite." Onsite hazards correspond to landslides that originate on or near the development site. These are typically the slower moving and spatially limited falls and slides. Offsite hazards begin on slopes away from the development and travel great distances or cover large extents. These are typically flows or, in some cases, massive slides. Both onsite and offsite landslides may impact lives, property, and the environment.

A possible secondary hazard in Idaho is a "seiche," a damaging wave triggered by landslide into lakes. Seiches, similar in effect to tsunamis, can damage or destroy shorefront property, docks, and boats. Seiches are uncommon but do occur. They damaged docks and some boats around Lake Pend Oreille (at Bayview and Sand Point) in 1946 and 1963. A seiche triggered by the 1959 Hebgen Lake earthquake caused water to slosh over the top of the dam, resulting in cracks and erosion. Another secondary hazard is when landslides and debris flows block culverts and other flow routes, creating drainage and flooding hazards.

While landslide events are undoubtedly costly, losses in Idaho are difficult to estimate because of landslide frequency and the fact that many smaller events are handled locally or privately, without State involvement. For example, ongoing landslide problems magnify the challenges of maintaining U.S. 95, the primary north-south link in the Panhandle region. It is often impossible to redirect traffic on this heavily traveled road, as alternate routes do not exist, and detours in steep terrain are difficult or impossible to construct. Landslides here disrupt emergency functions and commerce, as well as personal lives. Some of these impacts can be quantitatively measured (e.g., lost business) while others, such as the disruption of families, is impossible to quantify.

## LOCATION, EXTENT, AND MAGNITUDE

Landslide activity is considered to be localized in the State. The USGS is currently updating its research on hazardous landslide processes, including their mechanisms, recurrence, distribution, and probability (http://landslides.usgs.gov/research/).

The United States' landslide hazard was mapped in the past by the USGS. This mapping is referenced below and shown on Map 3.9.D, at the end of this section.

> In compiling the original map, the authors considered landslides to be any downward and outward movement of earth materials on a slope. Not included in the compilation were talus deposits, deposits resulting from ancient landslides not related to present slopes, large gravitational thrust sheets, solifluction deposits, snow avalanches, and debris deposited by flows that contribute to alluvial fans in arid regions. Individual landslides could not be shown at this scale. The map was prepared by evaluating formations or groups of formations shown on the geologic map of the United States (King and Beikman, 1974) as being of high, medium, or low susceptibility to landsliding and classified the formations as having high, medium, or low landslide incidence (number of landslides). Susceptibility to landsliding was defined as the probable degree

of response of the areal rocks and soils to natural or artificial cutting or loading of slopes or to anomalously high precipitation. High, medium, and low susceptibility are delimited by the percentages given below for classifying the incidence of landsliding. Susceptibility is not indicated where lower than incidence. The effect on slope stability caused by earthquakes was not evaluated, although many catastrophic landslides have been generated by ground shaking during earthquakes. Areas susceptible to ground failure under static conditions would probably also be susceptible to failure during earthquakes.

In areas of continental glaciation, additional data were used to identify surficial deposits that are susceptible to slope movement. The map units were classified into three incidence categories according to the percentage of the area involved in landslide processes. Area involved in landsliding incidence >15% High; 1.5-15% Medium; <1.5% Low. Published data were used whenever possible for the original map. In many places, the percentage of a formation involved in landsliding, as shown on large-scale published maps, was determined by counting squares of a superimposed grid. Formations shown on the large-scale maps were then correlated with geologic units on the geologic map of the United States. Aerial photography, newspaper accounts, fieldwork, and other published data were used in other areas. For many parts of the country, however, particularly for parts of the Western United States, information on landslides and their relation to geologic conditions is sparse. Data from the relatively small number of geologic maps and reports that give detailed information on slope stability in scattered places were therefore extrapolated as accurately as possible into adjacent areas. Although both slope angle and precipitation influence slope stability, full weight was not given to these factors in preparing the original map. At that time no slope map or detailed precipitation map existed at a suitable scale for the entire United States.

The susceptibility categories are largely subjective because insufficient data were available for precise determinations. Where source maps show slope movement for one part of a geologic unit but not for others, it is generally unknown whether the absence of recorded landslides indicates a difference in natural conditions or simply a scarcity of information on landslides for those parts of the unit. Generally, the authors assumed that anomalous precipitation or changes in existing conditions can initiate landslide movement in rocks and soils that have numerous landslides in parts of their outcrop areas. Because the map is highly generalized, owing to the small scale and the scarcity of precise landslide information for much of the country, it is unsuitable for local planning or actual site selection.
(Source: http://landslides.usgs.gov/learning/nationalmap/)

At this time there is no magnitude scale for landslides.

## PAST OCCURRENCE

Idaho's geology, landscape, climate, soils, and other factors are locally conducive to landslide activity, and numerous landslides occur each year in Idaho. Many of these, though, are small events without well-documented impacts. The Idaho Geological Survey has identified and plotted over 3,000 major landslides in the State. Landslides are also included on local and regional geologic maps and other geologic sources.

Significant landslide events (those resulting in disasters) are rarer, but several have been recorded in the State (see Table 3.9.A below). Prior to 1976, major events that had a significant impact on transportation, communities, and natural resources occurred in 1919, 1934, 1948, 1964, 1968, and 1974. At the end of this section, Map 3.9.C shows counties that have experienced major landslide events.

**TABLE 3.9.A: LANDSLIDE STATE AND FEDERAL DISASTER DECLARATIONS**

| Year | Month | Federal | Counties Affected |
|---|---|---|---|
| **1982** | July | | Boise |
| **1986** | February | | Boise |
| **1986** | March | | Boise, Elmore, Lewis, Nez Perce, Owyhee |
| **1991** | April | | Bonner |
| **1996** | November | X | Adams, Benewah, Boise, Bonner, Boundary |
| **1997** | January | | Clearwater, Elmore, Gem, Idaho, Kootenai, Latah, Nez Perce, Owyhee, Payette, Shoshone, Washington |
| **1997** | March | X | Benewah, Bonner, Boundary, Kootenai |
| **1997** | June* | | Shoshone |
| **1998** | May | | Lemhi, Nez Perce, Washington |
| **1998** | October | | Boundary |
| **2000** | June** | | Kootenai |
| **2011** | March | X | Bonner, Clearwater, Idaho, Nez Perce, Nez Perce Tribe, Shoshone |

*** Additional counties in the southeastern portion of the State were added to the declaration at a later date but damage there was related to flooding only. ** This event occurred in January but was not declared until June.**
**Source: Spatial Hazards Events and Losses Database of the United States**

### Federally Declared Disasters

**Northern and Central Idaho, 1996-1997:** During late December 1996, above-normal snowfall in Northern and Central Idaho was quickly followed by significant amounts of warm rain. The melting

snow and heavy rains overwhelmed rivers and their tributaries, leading to widespread landslides and severe flooding, mainly in the West-Central region of the State. Large sections of the highway system were damaged or destroyed, isolating several communities for days. Six deaths and three serious injuries were attributed to this disaster.

Massive landslides and floods occurred in the Payette, Weiser, and Little Salmon river basins, causing extensive damage to structures, roads, and bridges. Boise County in particular experienced substantial landslide damage. Numerous soil failures on saturated faces of hillsides resulted in major landslides and mud flows. Numerous small landslides obstructed culverts, flowed over roads, and caused undercutting on the downhill side. Numerous debris flows throughout Western Idaho caused extensive damage. Deposits left by these flows were several feet deep and up to 300 feet wide, and they overwhelmed the 1- to 3-foot culverts designed to pass rainfall runoff. Several gulches had significant slides that overwhelmed structures built on the alluvial fans of debris flow. A massive debris flow that hit the community of Lower Banks flowed down from an area burned over in 1992. The slide deposited mud, rocks, and debris at the base of the slope and expanded to cover the whole community. Most buildings (residential and business) appeared to be damaged or destroyed. Buildings were moved from their foundations and submerged in mud up to two-thirds of the buildings' height. Many public facilities were damaged or destroyed.

**Source: ThinkStock.com**

From Horseshoe Bend to Banks, access to U.S. Highway 55 was restricted for one week. Several slides occurred in a half-mile section near Banks, with the largest estimated at 100,000 cubic yards.

Highways 17 and 21 were closed by landslides, isolating the communities of Lowman and Garden Valley. On Old Idaho 17 there were miles of highway with landslides every 200-500 feet. U.S. 95 experienced 11 washouts that isolated residents for days, and McCall was isolated and suffered economic hardship due to the disruption of its winter recreation activities. Local roads and forest access were likewise affected. Mudslides destroyed much of the 6,000-mile road system in the Boise National Forest, threatening fisheries and access to popular recreation areas in the spring.

On January 4, 1997, the President declared a major disaster (designated as DR-1154) in the State of Idaho; 18 counties were declared eligible for Federal assistance. As of February 1, 2001, this funding included $19,404,105 in public assistance, $39,988 in individual assistance, $125,937 from the NRCS, $576,314 from the U.S. Army Corps of Engineers, and $5,593,892 in hazard mitigation grants. Much of

the impact of these landslides occurred on virtually unpopulated public and private lands managed by the Forest Service, Bureau of Land Management, Idaho Department of Lands, and Boise Cascade Corporation.

In addition to infrastructure damage (e.g., forest roads), the impact included a large input of sediment and woody debris into stream channels. The increased sediment in the stream channels affected fish habitat. Based on past studies, it is suspected that road construction played a large role in the origin of these slides. Recent wildfires may also have played a role in the extent and severity of the landslide by reducing root strength, reducing transpiration by plants, and increasing runoff due to reduced infiltration.

**Northern Idaho, 1997:** In early March 1997, northern Idaho received 12 to 18 inches of snow on top of an existing snow pack that exceeded 150 to 170 percent of the average. A subsequent rainstorm caused a rapid snow melt. The resulting mudslides and flooding lasted for an extended period and damaged many public facilities, including county road systems. The President issued a Federal Disaster declaration (DR-1177) on June 13, 1997, for Boundary, Bonner, Benewah, Kootenai, and Shoshone Counties.

**Northern Idaho, 2011:** DR-1987 - On May 6, 2011, Governor C.L. "Butch" Otter requested a major disaster declaration due to flooding, landslides, and mudslides during the period of March 31 to April 11, 2011. The Governor requested a declaration for Public Assistance for six counties and one Tribe and Hazard Mitigation statewide. During the period of April 26 to May 2, 2011, joint Federal, State, Tribal, and local Preliminary Damage Assessments (PDAs) were conducted in the requested areas and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

On May 20, 2011, President Obama declared that a major disaster exists in the State of Idaho.

This declaration made Public Assistance requested by the Governor available to State, Tribal, and eligible local governments and certain private nonprofit organizations on a cost-sharing basis for emergency work and the repair or replacement of facilities damaged by the flooding, landslides, and mudslides in Bonner, Clearwater, Idaho, Nez Perce, and Shoshone Counties and the Nez Perce Tribe. This declaration made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

### State Disasters

**Bonner County, 1991:** The damaging event that occurred near Sandpoint in April 1991 illustrates the somewhat confusing continuum between flash floods and debris flows. Although classified in the State declaration as a flash flood, the high debris load makes it somewhat indistinguishable from a debris flow. The torrents blew out large sections of the road leading to Schweitzer Basin ski area, stranding

dozens of people; contaminated the city's primary water supply; and heavily damaged the water treatment facility. The cost to clean out and repair the water treatment facility was several hundred thousand dollars.

**Boundary County, 1998:** On October 19, 1998, a mudslide covered Highway 95, 1 mile north of Bonner's Ferry. Additional sliding the next day caused extensive damage to the State highway, a county road, and 1,000 feet of Union Pacific Railroad tracks. The blockage kept emergency medical and fire services from half the county. Truck traffic was rerouted 112 miles around the slide, and up to five trains were stranded each day. The Governor declared a disaster (due to economic impact).

**Nez Perce County, 1998:** A landslide that began on May 4, 1998, blocked Snake River Avenue in Lewiston, restricting access to some businesses. A second slide on May 13 destroyed a mobile home and caused an additional road closure. The Lewiston Elks Temple was also threatened by ongoing slide activity in the vicinity. Total public costs for this event are estimated at just under $4.5 million; approximately $4 million for Idaho Transportation Department and $485,000 for Nez Perce County.

**Kootenai County, 2000:** A major landslide on January 30, 2000, blocked the only access road to Ravens Point (near Bayview). A second rockslide two days later exacerbated the problem. Access to 75 homes was cut off. Kootenai and Bonner counties, Timber Lakes Fire District, and Lakes Highway District provided essential services. Residents shared personal resources and maintained communication through a specially designed Web page. A 65-passenger ferry was leased for travel to and from Bayview. Governor Kempthorne and the Legislature authorized up to $725,400 for BHS to reimburse local agencies. The NRCS provided much-needed Federal assistance in stabilizing the banks above the lake and removing road blockage. The State paid the non-Federal match required by NRCS. The request for a Presidential disaster declaration was not approved.

### Other Landslide Events

**Gem County, 2013:** A sandstone ledge under a rather large canal is falling apart and landing on State Highway 52. The State of Idaho Transportation Department (ITD) maintenance crews have been cleaning up the debris for a long time, but since Friday, May 31, 2013, the quantity of material is escalating and requires non-stop attention. On June 2, the debris quantity was such that ITD closed the road. The uncontrolled debris is threatening public safety, canal stability, communications lines, transportation, economy, and infrastructure. Gem County declared a disaster on June 6, 2013, and ITD set up barriers and restricted traffic to one lane on Hwy 52. Testing revealed water seepage from canal

but has not been conclusively determined to have caused the landslide. The canal was drained and will be relined. Consultants are working with officials to determine a course of action.

**Kootenai County, 2006:** On January 15, 2006, a landslide was caused by construction on U.S. Highway 95, north of Worley. It resulted in approximately $7,500 in damages to the project.

**Twin Falls County, 1999+:** The Bluegill Landslide (near Buhl on Salmon Falls Creek, 5 to 10 miles from its confluence with the Snake River) was identified during the summer of 1999, when local rock climbers noted changes in the bedrock cliffs, an unusual amount of rock fall, and fractures opening up on the trail.

Subsequently, a 12-acre block of canyon rim composed of basalt and sediments began sliding into Salmon Falls Creek. This ongoing slide activity may threaten irrigation pumping stations and generate flood risks to upstream and downstream development. The slide is still active and moving.

**Gooding County, 1993:** On July 24, 1993, approximately 100 acres of ground failed and slid into the Snake River just south of Bliss. The river was temporarily dammed, and a new set of rapids was created. The access road on the south side of the river was destroyed. The initial slide and subsequent erosion of the toe introduced a large amount of sediment into the river. The landslide site shows extensive evidence of earlier activity.

**Hagerman Fossil Beds National Monument, 1979+:** A series of major landslides has struck the plateau along the Snake River located in Hagerman Fossil Beds National Monument since 1979. These large slope failures have occurred approximately every two years, and typically affect areas ranging from 300 to 800 feet wide and up to 1,000 feet long. The 1987 event destroyed a $1 million irrigation pumping facility and nearly killed two workers.

## FUTURE OCCURRENCE

The geophysical processes that contribute to landslides during a particular year are statistically independent of past events. Unfortunately, the short period of recorded and observed landslides and associated conditions that contribute to the risk make it difficult to develop return periods for landslide-prone areas in Idaho. Landslide occurrence is not directly attributed to a specific major meteorological event, such as the 1-percent-annual-chance or 100-year snowfall; though rainfall events are one known cause of events.

## RELATIONSHIPS TO OTHER HAZARDS

Landslides can influence or impact the initiation of some natural hazards. Landslides do have the ability to block stream channels and waterways, which could result in localized flooding. The eventual release of these blockages would also mirror the effects of a dam, levee, or canal breach. Landslides are also known to trigger seiches, which can cause waves in larger bodies of water. This has the ability to negatively affect dams, levees, and canals. A seiche triggered by the 1959 Hebgen Lake earthquake caused water to slosh over the top of the dam, resulting in cracks and erosion. Locations of past

landslides do have the ability to increase the immediate area's susceptibility to future landslides and flooding, due to the removal and transport of tree, vegetation, and other ground materials.

From a human-caused perspective, landslides do have the ability to affect energy transmission and communication lines, possibly resulting in energy shortages or cyber disruptions.

## ENVIRONMENTAL IMPACTS

Landslides have minor environmental impacts compared to several other hazards discussed in this document, but more than avalanches, which have the buffering effects of snow cover. Impacts to the natural environment due to landslides are generally localized in nature. The impacts do not tend to travel beyond the confines of the event, as compared to the potential effects from hazardous material leaks or volcanic ashfall. An exception to this would be seiche effects in a lake due to landslide, where bank vegetation and other resources could be impacted relatively far from the initial event.

Landslides can cover vegetative communities, destroying habitat; however, it is unlikely that the continued existence of rare species or vegetative communities would be jeopardized by landslide, because of the localized nature of the hazard. There is potential for unique historic and archeological resources to be damaged or lost. With respect to geology and soils, landslides can change topography and remove topsoil, but farmland soils are not usually located in the steeper areas where landslides are more common. Landslides have the potential to alter floodplains and drainage patterns. Also, debris can form dams, causing flooding upstream and disrupting the aquatic habitat.

**Source: ThinkStock.com**

## DEVELOPMENT TREND IMPACTS

Analysis of historical data indicates relatively little damage to structures and does not indicate that development causes more structures to be destroyed by landslides. Past events have impacted transportation corridors, often limiting access to communities for a short time. This needs to be taken into account as development occurs, and possible mitigation measures should be considered. Overall, any development within known or suspected landslide areas will increase the hazard somewhat.

## CRITICAL INFRASTRUCTURE AND STATE FACILITY IMPACTS

Major highways, railways, and power/communication transmission lines would be the State assets most impacted by a landslide event. Generally, State facilities are not located in known landslide paths;

although a wildfire event could expose new areas to this hazard. Such potential damage, while significant, cannot be forecasted.

As part of the 2010 Plan update, one action that the State identified was the need to collect improved and up-to-date State-owned facility and infrastructure data in a geospatial format. As of the writing of the 2013 Plan update, this action is still considered in progress, although great strides have been made. The State Chief Information Officer (CIO) is currently working towards the realization of a State-owned facilities and infrastructure geodatabase. This on-going process has been slowed by recent budget shortfalls in addition to inconsistent data holdings across many of the State's Agencies. Once available, this database will enable for a more in-depth review of State-owned facilities and infrastructure, as it relates to both vulnerabilities to hazards and the associated loss estimations.

## VULNERABILITY ASSESSMENT

Landslides are essentially localized events. Establishing the likelihood and potential magnitude of events at specific sites requires detailed site analysis and can be a time-consuming and expensive process. It is therefore extremely difficult to generate a statewide projection of future landslide activity and disasters. Some generalizations may be made, however, and geologists and planners can identify zones of potential landslide hazard based on geology, topography, and climate through broad-brush analyses. The geology of the central, western, and Panhandle regions of the State lends itself to landslide-prone terrain. Large and damaging landslides may be expected to continue to occur. Most landslide-prone areas have steep slopes of significant length. Although these characteristics are often associated with the mountainous areas of the State, occurrences may be found throughout the State. Even in the relatively flat Snake River Plain and Owyhee County regions, numerous landslides occur along the near-vertical walls of deeply incised river canyons.

Any landslides are associated with precipitation events and/or saturated soils. Throughout the State, these conditions may be expected to occur in the winter (heavy rain storms), spring (during snow melt), or summer (significant thunderstorms). In the evaluation of local sites, the conditions that lead to landslides are generally understood and predictable. The factors contributing to landslides described above (natural factors, human activities, and landslide triggers) should all be considered when evaluating hazards.

Additionally, significant damage often occurs in areas that show evidence of past landslides. An evaluation of past activity can be a powerful projection tool. Landslides may be expected to occur throughout the State, where local conditions are favorable. However, these events generally only have disastrous consequences when they occur in populated areas or intersect infrastructure such as highways. Consequently, the mountainous areas of the State are most at risk from future landslide activity. In these areas, a considerable number of communities, transportation systems, and supporting infrastructure are located in steep canyons and alluvial fans close to rivers. Development of forest and mineral resources has also resulted in the construction of roads in steep and potentially unstable terrain.

Recent population growth has caused development to occur more frequently in hazardous areas. This trend is expected to continue in the near future.

The United States Geological Survey (USGS) has produced a GIS dataset that defines those areas that are the most susceptibility to possible landslides. Using this data layer, vulnerability analysis was performed on the ICRMP locally-owned facilities data. Table 3.9.B below presents the results of that analysis, showing those facilities that were exposed to landslide zones defined by USGS as being 'High Incidence' or 'Moderate Incidence/High Susceptibility'. This table, summarized at the BHS Regional level, includes counts of structures considered to be vulnerable to the threat of landslides, in addition to the associated building values and building content values. Map 3.9.D at the end of this chapter presents this same information, although it is difficult to visually present structure-related information on a State-wide map. Additional details regarding the ICRMP data can be found in the introductory section of this chapter, Section 3.0.

| TABLE 3.9.B | In High Risk Area | | | Statewide | | |
|---|---|---|---|---|---|---|
| | Number of Facilities | Building Value ($) | Building & Contents Value ($) | Number of Facilities | Building Value ($M) | Building & Contents Value ($M) |
| **Central** | 1 | $25,000 | $27,600 | 1,570 | $815 | $972 |
| **North Central** | 0 | $0 | $0 | 756 | $248 | $289 |
| **Northeast** | 19 | $4,506,033 | $5,317,633 | 994 | $474 | $580 |
| **Northern** | 0 | $0 | $0 | 1,334 | $669 | $850 |
| **Southeast** | 0 | $0 | $0 | 1,270 | $381 | $488 |
| **Southwest** | 0 | $0 | $0 | 2,513 | $1,090 | $1,310 |
| **TOTALS** | **20** | **$4,531,033** | **$5,345,233** | **8,437** | **$3,677** | **$4,489** |

### Local Hazard Mitigation Plan Vulnerability Assessments

Forty-seven local mitigation plans were analyzed to determine the major hazards in each jurisdiction. Six counties ranked landslides as such: Boise, Bonner, Boundary, Clearwater, Latah, and Nez Perce (see Map 3.9.E). Since the 2010 State Plan update, Latah was the only jurisdiction that has increased their ranking of landslide to now be considered major. Since 2010, Ada was the only jurisdiction to have removed landslide from its list of major hazards.

These local vulnerability assessment changes seem to better align with the historical data presented in Map 3.9.C. Presidential Disaster DR-1987, which occurred in 2011, seems to have helped increase the visibility to this hazard, especially for those jurisdictions in the northern panhandle of the State.

## LOSS ESTIMATION

No specific, statewide loss estimation exists for the hazard of landslide. Historical losses tend to be related to infrastructure damages more than to loss of life and injuries.

From a general perspective, landslides damage and destroy public, commercial, and private property. The resulting costs are for debris removal, stabilizations, restoration, maintenance, response, and post de facto litigation. Road and railroad closures are not uncommon. The economic costs of these disruptions can be significant, especially in areas with limited access options.

Direct costs can be defined as the cost of debris removal, stabilization, and response for a specific landslide event. All other costs are indirect and include (1) loss of industrial and commercial productivity as a result of damage to infrastructure, facilities, or interruption of services, (2) loss of access to communities and facilities, , and (3) the cost of litigation as a consequence of the release. Some of these indirect costs are difficult to measure and tend to be ignored. As a result, most estimates of loss are far too conservative.

The vulnerability assessment documented above was able to also provide initial estimates as they relate to possible losses for the hazard of landslides. See Table 3.9.B above for the loss estimates that were produced as part of that assessment.

### Local Hazard Mitigation Plan Loss Estimations

Out of the six localities that ranked landslides as a major hazard, only Bonner County provided loss estimates which equated to $3,375,622,000.

## MITIGATION RATIONALE

"Landslide" is the general term for the movement of a soil and/or rock mass down a slope. It covers a variety of processes and landforms derived from those processes. In general, the term "landslide" is employed in this document for situations involving any of these processes. Although all landslides may pose serious hazards, one type is of particular interest. This type is a "flow," including debris flows, which is often difficult to distinguish from a flash flood and possesses similar destructive potential and rapid onset. Debris flows generally occur during periods of intense rainfall or rapid snowmelt. They usually start on steep hillsides as shallow slides that liquefy and accelerate. The consistency of debris flows ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars. Material can be accumulated as a slide grows, and flows from converging drainage may join together. When the flows reach canyon mouths or flatter ground, debris can spread over a broad area, sometimes accumulating in thick deposits.

## GENERAL MITIGATION APPROACHES

Landslides are site-specific hazards that may be influenced by offsite conditions (e.g., inappropriately channeled runoff) and may have large-scale consequences (e.g., the disruption of transportation routes or contamination of water sources). Mitigation must balance the need for localized action with the potential of regional benefits. The State may need to take a role in what is otherwise perceived as a local issue.

As with all hazards, the preferred method of mitigation is to separate human development and population from hazard-prone areas. When this is not possible or practical, a variety of measures may be employed to reduce the potential impact of events on property and lives. Some landslide hazards cannot be mitigated or are too costly to mitigate and, therefore, are best avoided. Other landslide-prone areas are easily mitigated and need not influence land use significantly as long as the hazard is identified. Because of this, general landslide hazard information should be utilized in developing local master plans and zoning ordinances, so that land use can take landslide hazards into account.

### Hazard Management

There are two basic approaches of hazard management: diversion of debris and landslide/slope stabilization. The choice of mitigation approach should be based on a thorough investigation of the site in order to evaluate all pertinent characteristics of a potential landslide site.

Diversion of Debris: This mitigation activity involves redirecting the debris from its run-out path to avoid damage to existing development.

Landslide/Slope Stabilization: This mitigation to stabilize a landslide or an unstable slope area may involve any one or more of three strategies:

Drainage control: conveyance of surface and shallow groundwater away from the site.
Re-grading of the hazard area: removing soil from the slope in order to reduce the weight of the slide mass and lower slope gradient, both of which will increase slope stability.
Mechanically restraining slope movement: vegetation or armoring of slope surfaces or construction of retaining walls.

**Source: ThinkStock.com**

### Information/Outreach and Public Education

Many property owners and residents are unfamiliar with the landslide hazard associated with their property and homes. Relatively small steps in home construction and landscaping can play a large role in hazard reduction. As with all natural hazards, public information and education is the first line of defense, not only increasing people's knowledge of the problem but also gaining higher compliance with regulatory and voluntary mitigation measures.

### Infrastructure

Infrastructure should be constructed so as to avoid landslide hazard areas. Where infrastructure elements (e.g., roads) and public facilities are at direct risk from landslides, steps should be taken to mitigate the hazard (through debris diversion of slope stabilization) or provide for functional backups.

### Regulatory

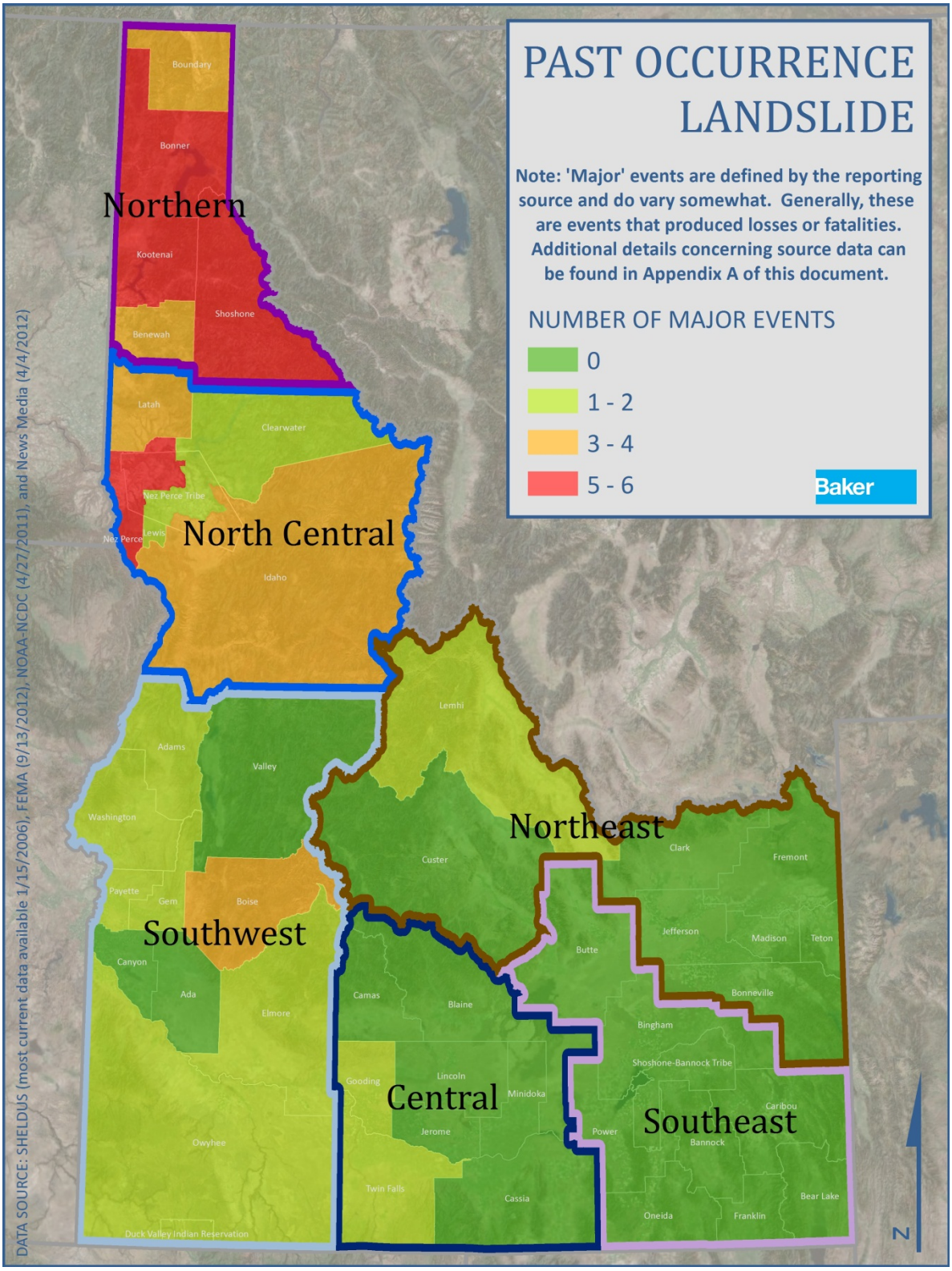
The generally preferred method of landslide mitigation is avoidance of hazard areas. Mitigation by avoidance involves a designation of landslide hazard area buffers and building setbacks or, in more extreme cases, may involve the total restriction of use or occupation within the hazard area. In addition to restricting new development from hazardous areas, regulations can require that landscaping and construction activities do not contribute to slope instability. This step can help minimize the impact on existing development and avoid increasing the extent of hazard areas. When landslide regulations are developed, the first step is to identify potentially hazardous areas. Geotechnical investigations performed by qualified engineering geologists and engineers are required to address hazards and recommend appropriate action prior to development in "potentially hazardous areas."

### Mapping / Analysis / Planning

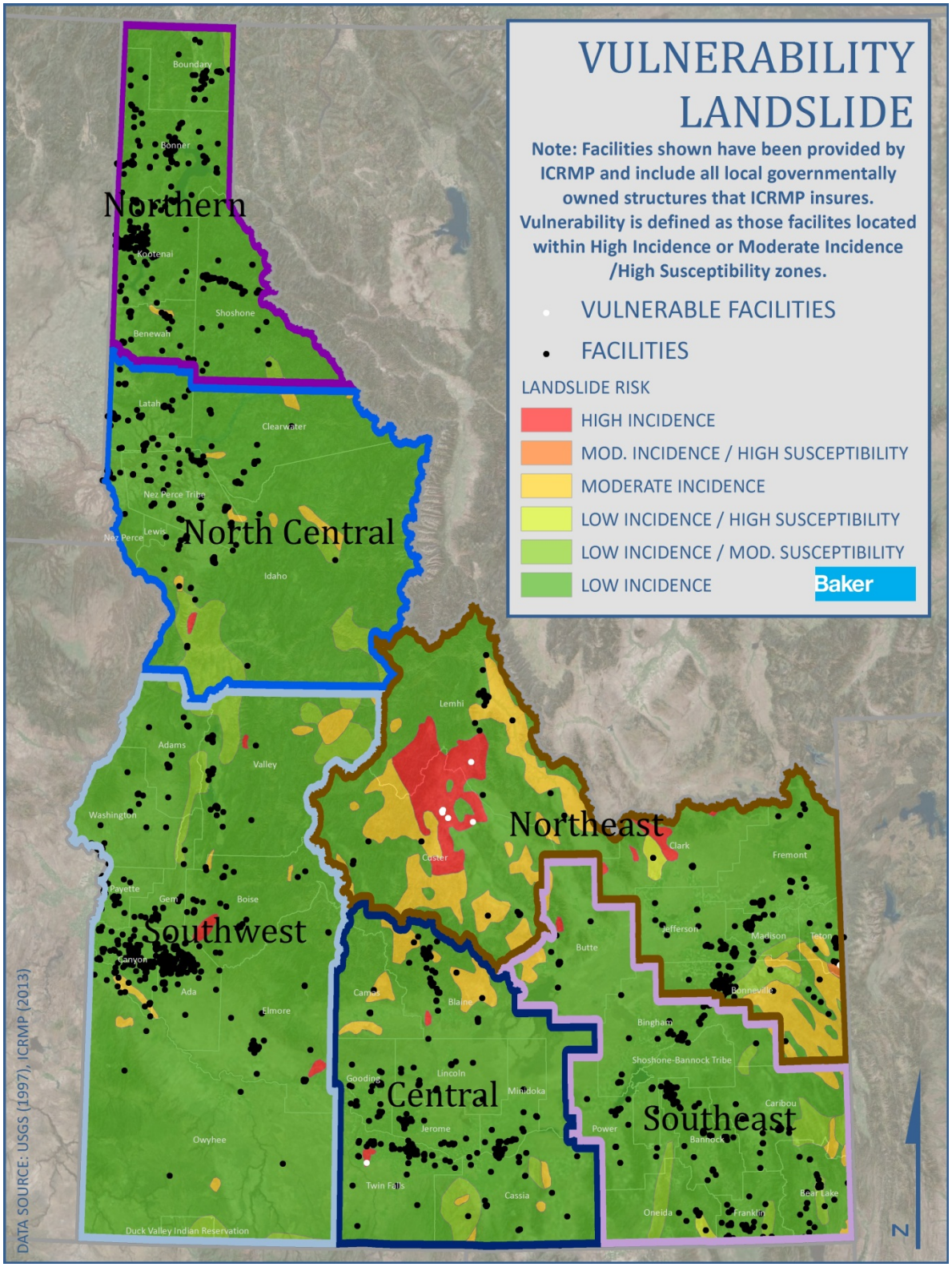
An accurate understanding of a hazard is the first step towards successful mitigation. To fully understand a hazard and the risk that it poses, the ability to accurately assess vulnerability is vital. After vulnerability is determined, it is then possible to assess potential losses if a state inventory of facilities and infrastructure is available.

At the time of the 2013 Plan update, major advances in the availability of various data inputs allowed for an improved vulnerability and loss assessment to be performed. Continued refinement of both vulnerability and inventory data will enable for continued refinements in the risk assessment process.

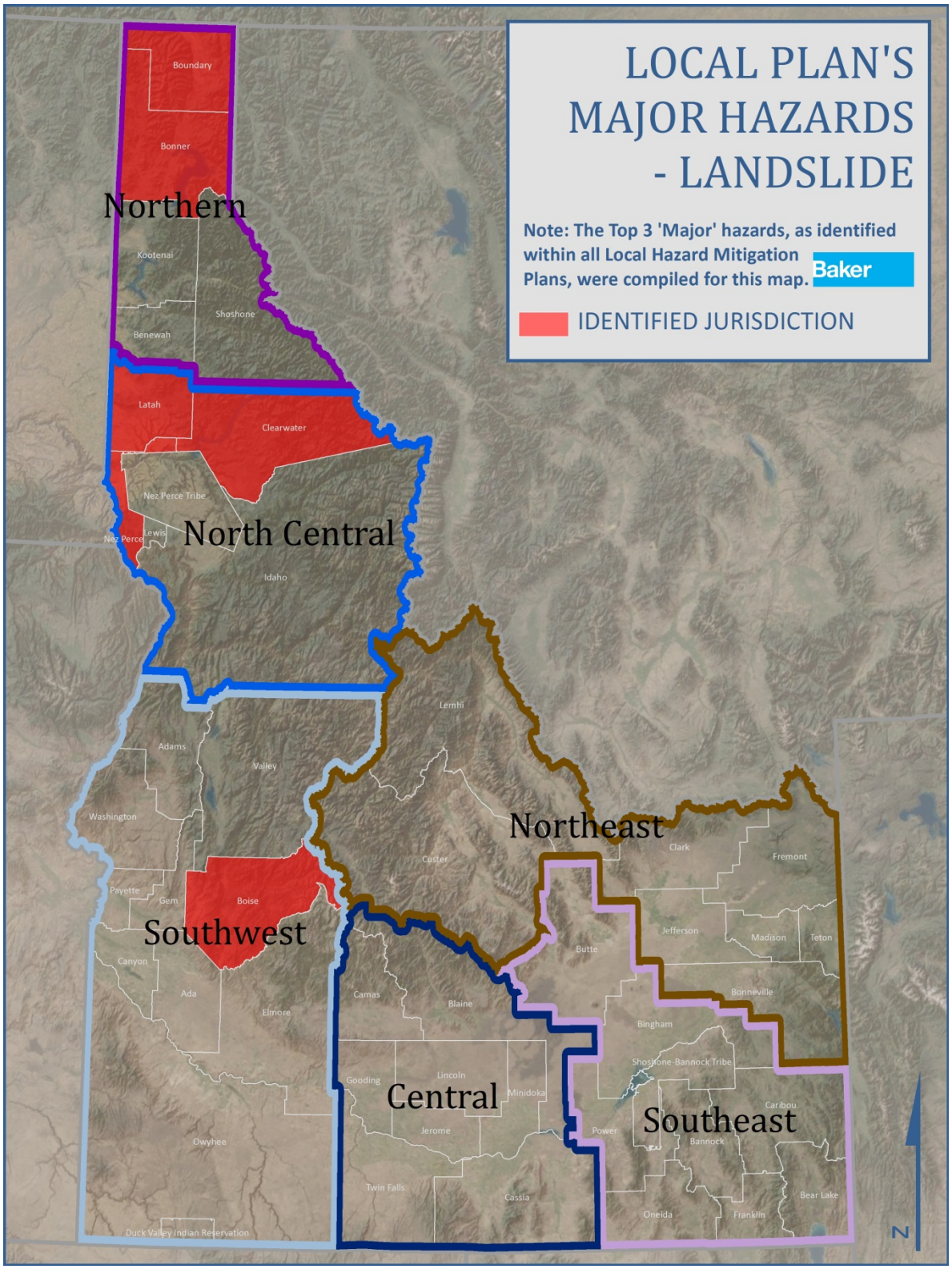
**Source: ThinkStock.com**




**Map 3.9.C: Past Landslide Occurrence**




**Map 3.9.D: Landslide Vulnerability**




**Map 3.9.E: Landslide Identified as Local Plan Major Hazard**

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