

4.0 LANDSLIDES

4.1 Landslide Overview and Definitions

The term “landslide” refers to a variety of slope instabilities that result in the downward and outward movement of slope-forming materials, including rocks, soils and artificial fill. Four types of landslides are distinguished based on the types of materials involved and on the mode of movement. These types of landslides are illustrated in Figures 4.1 to 4.4 and described below.

Rockfalls are abrupt movements of masses of geologic materials (rocks and soils) that become detached from steep slopes or cliffs. Movement occurs by free-fall, bouncing and rolling. Falls are strongly influenced by gravity, weathering, undercutting or erosion.

Rotational Slides are those in which the rupture surface is curved concavely upwards and the slide movement is rotational about an axis parallel to the slope. Rotational slides usually have a steep scarp at the upslope end and a bulging “toe” of the slid material at the bottom of the slide. . Rotational slides may creep slowly or move large distances suddenly.

Translational Slides are those in which the moving material slides along a more or less planar surface. Translational slides occur on surfaces of weaknesses, such as faults and bedding planes or at the contact between firm rock and overlying loose soils. Translational slides may creep slowly or move large distances rather suddenly.

Debris Flows (also called debris torrents) are movements in which loose soils, rocks and organic matter combine with entrained water to form slurries that flow rapidly downslope or within a stream channel. They may travel 100’s to 1000’s of feet. With respect to public safety concerns this is the predominant landslide type in the Oregon Coast Range and Cascade Range in Lane County.

All of these types of landslides may cause road blockages by dumping debris on road surfaces or road damages if the road surface itself slides downhill. Utility lines and pipes are prone to breakage in slide areas. Buildings impacted by slides may suffer minor damage from small settlements or be completely destroyed by large ground displacements or by burial in slide debris. Also, as evidenced by 1996 winter storms in Oregon, landslides may also result in injuries or fatalities.

There are three main factors that determine susceptibility (potential) for landslides:

- 1) slope steepness,
- 2) soil/rock characteristics or landform shape, and
- 3) subsurface water.

Loose, weak rock or soil is more prone to landslides than is more competent rock or dense, firm soils. For landslides, the term competent rock means solid, coherent rock with good bearing strength that is less prone to landslides. Finally, water saturated

soils or rock with a high water table are much more prone to landslides because the water pore pressure decreases the shear strength of the soil and thus increases the probability of sliding.

**Figures 4.1 to 4.4
Major Types of Landslides**

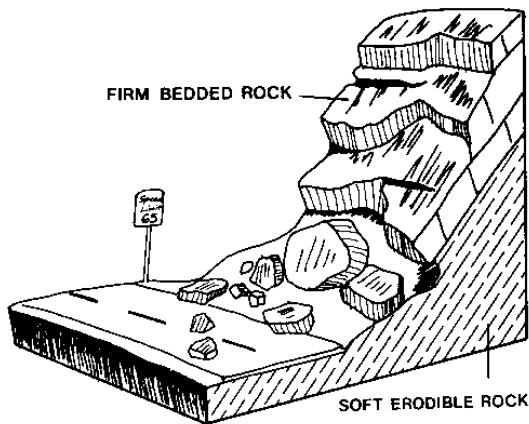


Fig. 8-1. Rockfall

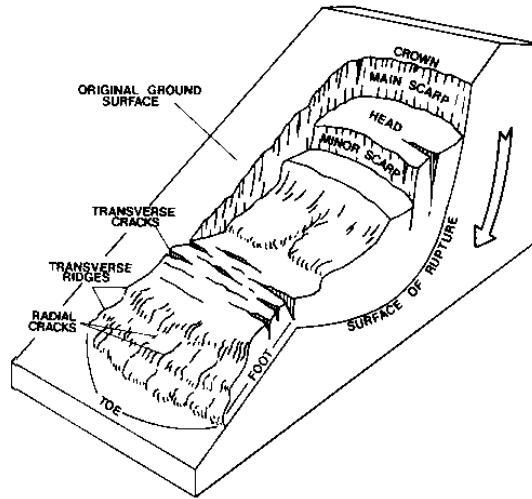


Fig. 8-2. Rotational Landslide

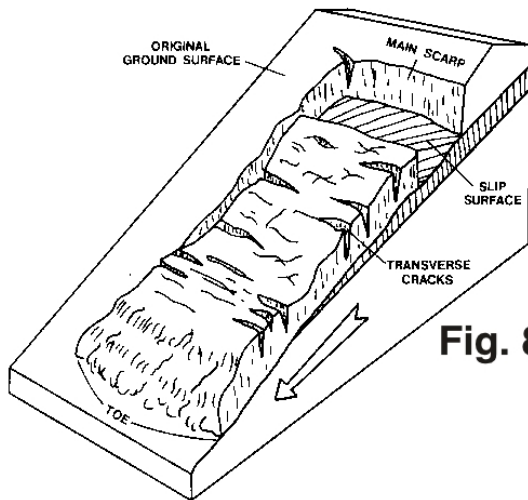


Fig. 8-3. Translational Landslide

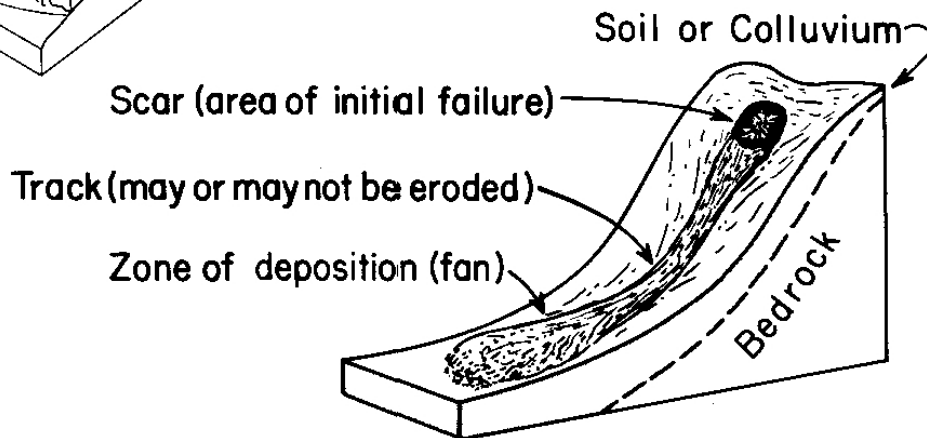


Fig. 8-4. Debris Flow

The water content of soils/rock is a major factor in determining the likelihood of sliding for any given slide-prone location. Thus, the vast majority of landslides happen during rainy months, when soils are saturated with water.

Landslides may happen at any time of the year. In addition to landslides triggered by a combination of slope stability and water content, landslides may also be triggered by earthquakes. Areas prone to seismically triggered landslides are generally the same as those prone to ordinary (i.e., non-seismic) landslides. As with ordinary landslides, seismically triggered landslides are more likely for earthquakes that occur when soils are saturated with water.

Debris flows and landslides are a very common occurrence in hilly areas of Oregon, including Lane County. Many landslides occur in undeveloped areas and thus may go unnoticed or unreported. For example, DOGAMI conducted a statewide survey of landslides from four winter storms in 1996 and 1997 and found 9,582 documented landslides, with the actual number of landslides estimated to be many times the documented number. For the most part, landslides become a problem only when they impact developed areas and have the potential to damage buildings, roads, or utilities.

4.2 Landslide Hazard Assessment for Lane County

There were two storms in 1996 that contributed to landslides throughout Northwest Oregon. The February storm was an intense, long duration rainfall event that was preceded by long periods of winter rainfall and a heavy snowfall in the mountains. A tropical jet stream flow brought intense warm rain that melted the snow, which contributed to the timing and runoff from the already wet soil. This resulted in slopes that were already slide-prone to fail. The November storm was a shorter, less intense rainfall event but still resulted in record setting levels for one-day rainfall amounts (inches). The Oregon Department of Forestry conducted a 3-year study of the impacts and landslides of the two 1996 storms and, within the study area, observed 76 landslides in the Mapleton area and 51 landslides in the Vida area.

In December of 1998 a landslide in the Deadwood area blocked Deadwood Creek Road cutting off transportation to and from 30 homes for two days until the road could be cleared.

In December of 2000 another landslide in the Deadwood area closed West Fork Road for several months because crews were unable to make repairs due to unstable soil conditions. Area residents were forced to use a Forest Service Road to travel to and from their homes.

The highest hazard for shallow rapid landslides in western Oregon occurs on slopes of over 70% to 80% steepness (depending on landform and geology). There is a moderate risk of these landslides on slopes of between 50% to 70%. Landslides that entered stream channels during the storms of 1996 typically occurred in very steep landscapes, or adjacent to stream channels. Even landslides that initiate as relatively small debris slides can mobilize into debris flows that mobilize large volumes of material and move long distances. Landslide characteristics vary greatly according to local landscape and geologic factors. Debris flows that were not initiated by up-slope

landslides were uncommon. A debris flow occurs when landslides move downslope, scouring or partially scouring soils from the slope along its path.¹

Areas with high landslide potential within Lane County were shown on the 40 community maps in Chapter 6. The high landslide potential areas on these maps represent primarily surficial debris flow hazard areas, but also are generally representative of landslide hazards for other types of landslides as well.

DOGAMI has also mapped several developed areas with high potential for landslides in Lane County. These DOGAMI landslide maps are available for the following communities within Lane County: Eugene/Springfield Metropolitan Area, Cottage Grove, and Florence – Dunes City. These maps are available from DOGAMI and may also be included in the mitigation plans for these individual communities. These DOGAMI maps are also generally representative of areas with high potential for rockfalls, rotational slides, and translational slides from non-earthquake events (such as heavy rainfalls).

It is important to note that while an earthquake may trigger numerous landslides, the return interval of major earthquake-induced landslides may be several hundred years, while the return interval for major storm-induced landslides may be only about 10 years. Therefore, for Lane County the probability of occurrence for major storm-induced landslides greatly exceeds that for earthquake-induced landslides.

A county-wide landslide hazard map for Lane County could be developed, using slope data, rainfall data, and soil/rock data. However, such a county-wide map does not currently exist.

More detailed landslide hazard assessment requires a site-specific analysis of the slope, soil/rock and groundwater characteristics at a specific site. Such assessments are often conducted prior to major development projects in areas with moderate to high landslide potential, to evaluate the specific hazard at the development site.

For Lane County any occupied structures located below steep slopes or at the mouth of drainage basins (some of which may be relatively small) are at risk of debris flows or debris torrents, especially in the Coast Range and Cascade Range.

4.3 Landslide Risk Assessment for Lane County

In this section, we review a methodology for estimating landslide losses due to winter storm induced landslides. Winter storms with intense rainfalls are the most common trigger for landslides in Oregon, including within Lane County. Major storms with intense rainfall can result in numerous landslides in slide-prone areas.

Of course, at any given slide-prone location, landslides can occur with or without winter storms, but such occurrences are isolated and not likely to result in the type of fairly widespread landslide impacts that are possible during winter storms. Widespread landslides can also be triggered by earthquakes, especially if the

¹ Oregon Department of Forestry, Storm Impacts and Landslides of 1996: Final Report

earthquake occurs during the rainy season when soils are saturated. However, since the probability of storm-induced landslides is greater than that for earthquake-induced landslides, it makes sense to focus mitigation efforts on storm related landslide hazards. (See Chapter 10 (Earthquakes) for further commentary on earthquake-triggered landslides.)

As with any risk assessment, we must overlay the hazard assessment (frequency and severity of landslides) with the inventory exposed to the hazard (value and vulnerability) by considering:

- 1) Extent of landslide susceptible areas,
- 2) Inventory of buildings and infrastructure in landslide susceptible areas,
- 3) Severity of winter storm event (inches of rainfall in 24 hours),
- 4) Percentage of landslide susceptible areas that will move and the range of movements (displacements) likely, and
- 5) Vulnerability (amount of damage for various ranges of movement).

For Lane County, the threat posed by landslides is significant in the pockets of high hazard potential which overlap with developed areas (cf. the 40 community maps in Chapter 6 and the DOGAMI maps referenced above). Significant landslides in these areas could damage or destroy one or more homes, damage utilities and roads in the area, and pose some level of life safety risk for residents.

In addition to direct landslide damages within Lane County, communities are also subject to the economic impacts of road closures due to landslides, which may disrupt access/egress to/from communities. The February 1996 winter storms provided numerous examples of landslide damages, especially to the road system, with landslides closing many roads in Lane County and other nearby counties.

The potential impact of debris flows and landslides on Lane County are summarized below in Table 4.5.

**Table 4.5
Potential Impacts of Debris Flows and Landslides on Lane County**

Inventory	Probable Impacts
Portion of Lane County affected	Landslides are most likely to occur in the Coast Range and Cascades. Areas prone to debris flows and landslides are shown on the community maps in the Appendix.
Buildings	Buildings at high risk include those situated below steep slopes or at the mouth of drainage basins. Most buildings in landslide potential areas are residential,; the inventory of landslide prone buildings in Lane County is not yet determined.
Streets within communities	Minor road closures possible from landslides; limited impact because of short detour routes within communities.
Roads within and to/from Lane County	Potential closures of major highways due to landslides, especially roads into the Cascades and through the Coast Range.
Electric power	Potential for localized loss of electric power due to landslides affecting power lines in or near Lane County
Other Utilities	Potential outages of water, wastewater and natural gas from pipe breaks from landslides. Probable impacts are very localized.
Casualties	Landslides that impact buildings or roads could result in a small number of casualties (deaths and injuries)

4.4 Mitigation of Landslide Risk

In terms of public safety there are two broad types of landslides to be concerned about: 1) those that can be solved by engineering methods (such as road fill failures and slow moving landslides, and 2) those that can typically only be solved through prudent building siting (debris flows, debris torrents). It is important to make this distinction to understand that some landslide problems do not lend themselves to engineering solutions.

Mitigation of landslide risks is often quite expensive. In some cases, slope stability can be improved by addition of subsurface drainage to reduce pore water pressure, by construction of appropriate debris dams, retaining walls or by other types of geotechnical remediation. In some cases, buildings can be hardened to reduce damages. An alternative mitigation strategy for already built buildings or infrastructure with high potential for landslide losses is to relocate the facilities outside of known slide areas.

Mitigation of landslide risk can also be accomplished by effective land use planning to minimize development in slide-prone areas. Generally, such land use planning requires rather detailed geotechnical mapping of slide potential so that high hazard areas can be demarcated without unnecessarily including other areas of low slide potential.

The impacts of slide damage on road systems can also be partially addressed by identifying areas of high slide potential or of repetitive past slide damages so that alternative routes for emergency response can be pre-determined.

An example of a landslide mitigation project in Mapleton is given below. This location has been subjected to road closures due to rockfalls from a steep slope. Construction for this project took place in August 2004.

Triangle Lake Rockfall Project

Project location

- The project is located on the Mapleton – Junction City Hwy, (Hwy 36 MP 25)

Project purpose and need

- The purpose of the project is to excavate the rock slope to prevent rock falls. This is the only route serving this area. A 1997 event at this location resulted in highway closure.

Construction overview

- Approximately 1000 cu meters of material will be removed from the rock face.
- Trim blasting techniques will be used to dislodge the material
- Any damaged caused to the highway or guardrail by falling rock will be repaired.
- The road will be closed during construction.
- Construction will take approximately 3 weeks.
- Traffic will be detoured to the Florence-Eugene Hwy (Hwy 126)
- Slope matting material will be placed on the slope face to help prevent future dislodged rocks from entering the roadway.

Cost estimate

- Estimated construction cost—\$200,000

Key project milestones

- An environmental assessment is in process and should be completed by the end of October.
- A public information meeting, open house format, is scheduled for September 24th at 7 PM. It will be held at the Triangle Lake Conference Center, 19291 Hwy 36.
- The contract is scheduled to let April, 2004.
- Construction will begin in August and will be completed prior to the beginning of the 2004-2005 school year.
- BLM is a cooperating agency in the project.

For more information contact:

- Ann Sanders, Project Leader, (541) 744-8080. E-mail: ann.i.sanders@odot.state.or.us.
- Don McLane, Assistant Project Manager (541) 744-8080 E-mail: donald.g.mclane@odot.state.or.us.
- Ed Schoaps, Community Relations Coordinator, (503) 986-2880. E-mail: edward.f.schoaps@odot.state.or.us.

The following table contains landslide mitigation action items from the master Action Items table in Chapter 4.

**Table 4.6
Landslide Mitigation Action Items**

Hazard	Action Item	Coordinating Organizations	Timeline	Ideas	Plan Goals Addressed					
					Public Awareness	Life Safety	Protect Property Minimize Losses	Partnerships & Implementation	Emergency Services	Protect Environment
Landslide Mitigation Action Items										
Short-Term #1	Complete the inventory of locations where buildings or infrastructure are subject to landslides	All Hazard Mitigation Planning Committee, Public Works Dept.	1-2 Years	pg. 4-3 pg. 8-8	X					
Long-Term #1	Consider landslide mitigation actions for slides seriously threatening buildings or infrastructure	All Hazard Mitigation Planning Committee, Public Works Dept.	5 Years	pg. 4-3 pg. 8-8		X	X		X	
Long-Term #2	Limit future development in high landslide potential areas		Ongoing	pg. 4-3 pg. 8-8	X	X	X		X	