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Sidebar from Landslide Sites and Areas of Landslide Susceptibility Map

Introduction

Landslides are a common geologic hazard in Maine. Although they usually occur on a small scale and cause minimal damage, recent increased damage from landslide activity in the state (**Photo 1**) has raised awareness of this hazard and has demonstrated the need to examine the landslide threat on a regional basis. Landslide is a general term used to describe both the downslope movement of soil, rock, and organic material under the effects of gravity, and also the landform that results from such movement.

This map shows (1) sites of past landslides, and (2) areas susceptible to future landslide activity. This information is intended to describe the landslide risk, and to encourage mitigation strategies by individuals or local governments.

Sites of past landslides

Sites of past landslides, slope failures, and earth movements including slumps, debris slides, soil flows, and erosional debris flows are shown on the map in deep purple. They were identified based on aerial photo interpretation and field investigations in 2008, which documented evidence of past ground motion.

Evidence of ground motion and instability. Careful observation of the land surface and vegetation can reveal evidence of ground motion and slope instability. An irregular or arcuate edge along slopes adjacent to rivers, streams, and lakes can indicate past landslides or areas of increased erosion. When a weak point on a slope fails, the slide moves inward into the slope face, forming a curve around the original point of failure. Tension cracks may form near a weak zone where the soil surface is moving downslope (**Photo 2**). These cracks appear as splits in the ground where soil, a road surface, or vegetation have moved apart. Cracks may be visible along the top edge of the slope. On slopes of high relief, a hummocky land surface or terraces indicate past slumping or landslides. Unvegetated slump scars or slopes are obvious evidence of recent rapid soil movement. A bowl-shaped slope often shows the location of a former landslide, with the center of the bowl as the area of failure and greatest land displacement. Distorted vegetation provides evidence of soil creep or former episodic landslides. Tree trunks curved near their base are evidence of downslope movement (**Photo 3**). Trees tilted at different angles are evidence of former slides. Trees tilted upslope indicate past downward slope movement and are good indicators of future slope failure (**Photo 4**). At the base of bluffs along streams, rivers, ponds, and lakes, toppled trees and bare roots are evidence of past landslides (**Photo 5**). Undercutting and steepening of the slope in areas of high relief may destabilize the slope and lead to increased erosion and possible landslides. Terraces of sediments at the base of such high relief areas are often remnants of old landslides (**Photo 6**).

Landslide types. Each landslide site shown on the map is accompanied by a letter symbol which indicates the landslide type. The landslide classification scheme is based on the primary mechanism by which the earth movement occurred (see diagram entitled *Common Types of Landslides in Maine*). Each of these landslide types produces characteristic evidence of ground motion that allows the landslide type to be assigned. In some cases, more than one mechanism may have been important, or successive landslides in one place may have occurred by different mechanisms. In either case, multiple letter symbols are shown on the map.

Areas susceptible to future landslides

Local clues to future slope failure. Although the evidence of ground movement listed above cannot predict a landslide, it can be used to recognize unstable areas that are susceptible to landslides and slope failure. Areas that have experienced past landslides are good candidates for future landslides. Generalizing from known occurrences and an understanding of landslide mechanisms, the pattern of documented landslides can be related to geologic risk factors, and to terrain-related risk factors. These risk factors have been used to construct the landslide susceptibility map presented here.

Geologic risk factors. The primary geologic factor influencing landslide susceptibility is sediment grain size. Correlation with geologic mapping shows that a majority of earth movements occur in fine-grained sediments such as clay, silt, and mud, which are prone to move by slumping (landslide type A), sliding (type B), or creep (type I) when saturated with water. The material properties of these sediments, especially their low shear strength, makes them more susceptible to landslides than other sediment types. Existing maps of the surficial geology (see ***Sources*** below) were used to divide the town crudely into areas with fine-grained sediment and areas with other sediment (or rock) mapped at the land surface. Areas of fine-grained sediment include glacial-marine deposits and alluvial deposits. Most of these areas are underlain by the Presumpscot Formation, a marine silt and clay deposit of variable thickness in which Maine's most notable landslides have occurred. Areas assigned to the "other sediment" category include glacial till, stratified drift, and bedrock outcrop.

Terrain-related risk factors. The most important terrain-related risk factor influencing slope stability is the steepness of the slope. Additional geomorphic or terrain-related risk factors that increase landslide susceptibility include slope aspect, slope curvature, and local relief. For more details, see the table entitled "Terrain-related risk factors."

Landslide susceptibility mapping. This map takes into account the geologic risk factors by using one set of colors for fine-grained sediments, and a second set of colors for other sediments. For each sediment type, colors indicate relative landslide risk due to the presence of one or more terrain-related risk factors.

For areas underlain by fine-grained sediments, areas with slope less than 5 percent (a 5-foot rise in 100 feet) are shown in green; areas with a steep slope (equal to or greater than 5 percent) are shown in bright yellow. Within the areas of steep slope, areas containing one additional terrain-related landslide risk factor are shown in orange, and areas with two or more additional terrain-related risk factors are shown in red. The brighter colors indicate relatively higher landslide risk, although this risk has not been quantified. The most important distinction is between areas of low slope (in green), and areas of steep slope (bright colors).

For areas underlain by other sediments, areas with low slope (< 5%) are shown in gray; areas with steep slope (≥ 5%) are shown in pale yellow. Additional risk factors are not shown for these areas, because their importance in these other sediments has not been assessed.

Mitigation strategies

This map can be used to identify areas with historical landslide activity and to identify areas that are susceptible to future landslide activity. In these areas, additional steps should be undertaken before construction or other development is started that could be at risk due to a future landslide. Most insurance policies do not cover damage from landslides.

It is important to realize that the land surface of Maine is continually being eroded. Areas susceptible to landslides should be monitored frequently for evidence of ground motion and instability (see above). If you are concerned about ground movement in your area, you may want to investigate other related geologic information. Maps available from the Maine Geological Survey show topography, sediment composition, ground-water characteristics, and bedrock geology. Some specific map titles are listed under ***Sources***. MGS geologists are available to explain these maps.

If you find indications of ground movement, you may want a professional geologist or engineer to investigate your property. If high landslide risk is confirmed, it may be prudent to avoid building new roads or structures. For existing structures or planned new construction, site utilization should take the hazard into account. To reduce the risk of a landslide, these professionals may recommend changing the slope of the land surface, diverting water flow, armoring the toe of an eroding slope, planting erosion-resistant vegetation, or taking other measures to control surface erosion. In some cases, relocation of roads or structures may be recommended. Different landslide types may requre different mitigation strategies.

Any such measures must be done in an environmentally acceptable way. Building or engineering on Maine's slopes and bluffs, especially along waterways or in coastal areas, may be subject to regulation under the Natural Resources Protection Act and the Mandatory Shoreland Zoning Act. Permits from the Maine Department of Environmental Protection may be required for site modifications. Local Town Code Enforcement Officers will give advice on local requirements.

Contacts for more information

Maine Geological Survey
Information available: maps of landslide hazards, coastal bluffs, surficial geology, surficial materials, ground-water, bedrock, USGS topographic maps
Contact: Maine Geological Survey at address shown in title block

Geological Consultants
Information available: studies of specific property: slope stability, ground-water, soil mechanics, subsurface coring, site mapping, risk analysis, advice on hazard reduction and slope remediation
Contact: consult local yellow pages -- geologists, geotechnical or environmental services

Engineers
Information available: plans to reduce hazard, ground-water diversion, shoreline engineering, slope alteration, soil mechanics, risk analysis
Contact: consult local yellow pages under engineers - environmental or environmental services

Maine Department of Environmental Protection
Information available: information on state laws including the Natural Resources Protection Act, Shoreland Zoning, and the permit process
Contact: on the internet: http://www.maine.gov/dep/blwq/

Town Code Enforcement Officers
Information available: provide advice on Shoreland Zoning and other municipal requirements
Contact: local town office or http://www.maine.gov/local/

Evidence of ground motion

Photo 1. In 2005 a landslide occurred in Wells, Maine along the banks of the Merriland River. The slide destroyed a portion of a walking trail in the Rachel Carson National Wildlife Refuge and removed the backyard of a nearby house. Parts of the house's foundation were left exposed and the house was declared unsafe to inhabit.

Photo 2. Tension cracks forming and movement along a roadway prior to full slope failure. Downslope forces cause surface layers to stretch. When the tension becomes great enough, a crack forms and some pressure is released. Tension cracks indicate instability and motion along the slope, and are precursors to complete slope failure.

Photo 3. Soil "creep," the downslope movement of soil on a slope, will cause tree trunks to tilt toward the base of the slope. As a moving tree continues to grow, the trunk will curve as the tree tries to right itself and grow toward the sun. These trees are known as "pistol butt" trees, due to their curved shape.

Photo 4. Trees tilted upslope are indicators of downward slope movement and indicate areas of possible future slope failure.

Photo 5. Trees tilted at different angles and trees with exposed roots show areas of past landslides.

Photo 6. Lobes or terraces of sediments at the base of steep slopes indicate past landslide activity. Shown here is the lobe or "toe" of a landslide that occurred in Brunswick, Maine in 2007.

Related information for mitigation and planning

National Research Council, 2004, Partnerships for reducing landslide risk: The National Academies Press, Washington, D.C., 144 p.

Novak, Irwin D., 1987, Inventory and Bibliography of Maine Landslides; Maine Geological Survey, Open-File Report 87-2, 27 p. report and map.

Schwab, J. C., Gori, P. L., and Jeer, S. (editors), 2005, Landslide hazards and planning: American Planning Association, Planning Advisory Service Report no. 533/534.

Sidle, R. C., and Ochiai, H., 2006, Landslides: processes, prediction, and land use: American Geophysical Union, 312 p.

Spiker, E. C., and Gori, P. L., 2003, National landslide hazards mitigation strategy: a framework for loss reduction: U.S. Geological Survey, Circular 1244, 56 p.

Varnes, D. J., 1978, Slope movement types and processes, p. 11-33, *in* Schuster, R. L., and Krizek, R. J. (editors), Landslide analysis and control: Transportation Research Board, National Academy of Sciences, National Research Council, Special Report 176, Washington, D.C.