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BRITISH COLUMBIA

Coast Forest Region

Timber Harvesting Activities and Geomorphology in Coastal British Columbia

To understand how timber-harvesting activities may affect geomorphology, we need to understand how geomorphic features and processes work

by Thomas Millard, David Campbell and Denis Collins

WHAT IS GEOMORPHOLOGY?

Geomorphology is the study of the earth's surface features – such as mountains, rivers, and beaches; how these features are formed; and how they change over time.

Changes occur as a result of:

- dramatic geomorphic processes such as earthquakes, landslides, and floods, or,
- much smaller, cumulative events such as the movement of soil down the slope due to frost heaves, a raindrop landing on bare soil, or other apparently inconsequential processes.

A watershed – also called a drainage basin or catchment – is the area of land that drains to a particular point on the landscape (Figure 1). It may include one or more rivers, lakes, springs, or any combination of these features. A watershed is a good place to examine geomorphic processes because gravity directs the movement of water, sediment, and woody debris toward the stream channel at the bottom of the watershed.

Landslides and changes to stream channels are the major timber-harvesting related geomorphic

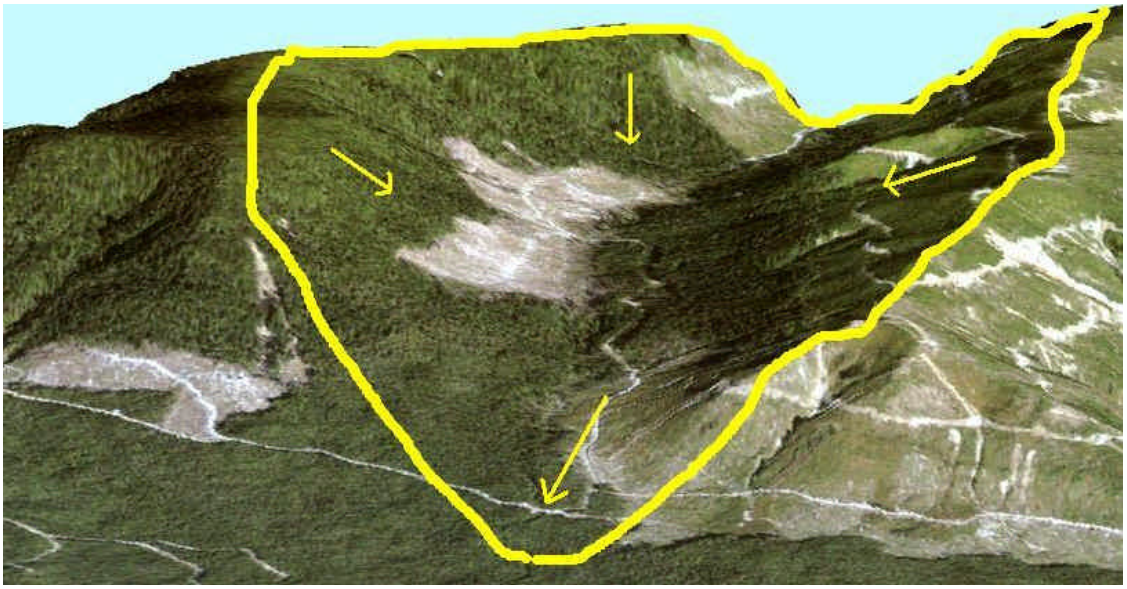

Figure 1. Image of a watershed (drainage basin); ©GeoEye

processes in Coastal British Columbia. Modern forest-management practices include specific measures for minimizing the effects of harvesting activities on geomorphic features.

MAIN TYPES OF GEOMORPHIC FEATURES IN COASTAL BRITISH COLUMBIA

Landslides

Where landslides occur: Landslides are natural events and are common in Coastal British Columbia (Figure 2).

Most landslides in Coastal British Columbia occur within surficial sediment (soil). Bedrock-related landslides are less common and are unlikely to be influenced by harvesting and road-building activities.

How landslides occur: In Coastal British Columbia landslides in soils are typically triggered by a rain storm or a rain-on-snow event in the fall or winter months. Intense rain results in more water entering the soil than the soil is capable of draining. When the soil becomes saturated, it loses strength and the force of gravity may cause the soil to slide.

A steep slope is subject to greater gravitational stress than a gentle slope and is therefore more likely to incur a landslide.

Slope topography often determines which portions of a slope may slide. For instance, a concave area that concentrates slope drainage has greater depths of soil saturation and is more likely to incur a landslide. Trees add strength to the soil because their roots reinforce the soil or anchor the soil mass to the underlying stable bedrock. Other factors that affect landslides include geology and soil type.

Gullies

A gully is a common feature on a slope. A gully is a narrow stream cut into the slope (Figure 3).

The sides of a gully are often steeper than the adjacent slopes, and the soils are often wetter because groundwater concentrates here. As a result, gullies frequently incur landslides.

A landslide in a gully often develops into a debris flow (also called a debris torrent, mudflow, mudslide, or sluice-out). Similar to wet concrete flowing at a high rate of speed, a debris flow may travel down the length of the gully and deposit on gentle slopes at the base of the gully, most typically on an alluvial fan. Floods can also deliver large amounts of sediment and woody debris to the fan.

Alluvial fans

Location and size: An alluvial fan is a fan-shaped deposit of sediment and woody debris that occurs at the base of a steep channel where the channel enters a larger and flatter valley (Figure 4).

Fans range in size from small and steep ones located at the base of gullies and which are almost entirely composed of landslide deposits, to large and gently sloped fans located where a river enters into a much broader and flatter valley, lake, or ocean.

If the fan is located at the base of a steep gully, it is probably subject to receiving debris flows.

Channels and avulsions: Another common feature of a fan is the ability of the channel to suddenly change location – a channel avulsion. A fan has one channel at the top of the fan, but farther down the fan it may have multiple channels or branches, with each split being the site of an avulsion. Avulsions can be caused by debris flows, log jams, or sediment deposits that block the channel and divert flow into a new channel.

Figure 2. A natural landslide in Coastal British Columbia.

Stream channels

Stream content: A stream transports not just water, but also sediment and woody debris.

The size of the channel depends on the volume of water the channel carries. The volume of water partly determines the capability of a stream to erode its banks, and the amount and size of sediment and woody debris it can transport.

Stream location: Some stream channels are located on slopes or in bedrock canyons, and some stream channels are located in valley flats and flow across floodplains that are composed of sediment that the stream itself deposited. In general, the floodplain channels are much more sensitive to disturbance than channels that flow through bedrock or on slopes.

Streamside vegetation: Riparian (streamside) vegetation has important effects on stream channels. The roots of trees help stabilize stream banks. Without trees, larger streams are more likely to incur bank erosion and avulsions. Trees add woody debris to streams as a result of bank erosion, windthrow, or

Figure 3. Gullies in the Queen Charlotte Islands.

landslides. This woody debris has very significant effects on the shape and characteristics of a channel and it is important for fish habitat.

HOW TIMBER-HARVESTING ACTIVITIES MAY AFFECT GEOMORPHIC FEATURES

Post-harvest slope stability and landslides

Incidence of post-harvest landslides: Most steep slopes will not incur landslides after harvesting.

Slopes that incur post-harvest landslides tend to be either naturally unstable or only marginally stable. Just because a slope is steep does not necessarily mean it is susceptible to sliding. Many steep slopes, especially those that are primarily bedrock, are unlikely to incur landslides after harvesting.

Most of the timber-harvesting landslide issues in Coastal British Columbia date from the period after about 1950, i.e., after the full implementation of truck logging. Landslides were recognized as a concern in the mid 1970s, and by 1990 most forest

Figure 4. An alluvial fan, with the boundaries of the fan outlined in yellow.

operations had management practices in place to reduce the incidence of landslides. With the introduction of the Forest Practices Code of British Columbia in 1995, landslide management became a required component of forestry on public land. In 2005 the Forest Practices Board assessed the effects of the Forest Practices Code, and found that the frequency of landslides was much lower after the introduction of the Code.

Harvesting-related causes: Of the landslides associated with timber harvesting in Coastal British Columbia, about half originate from harvested areas, and the other half are related to forest roads.

After a tree is felled, the stump usually remains embedded in the soil. The roots die and rot, which reduces the strength of the soil. Soil strength is also affected by the fact that harvesting increases the rate at which water is delivered to the soil, especially during rain-on-snow events, because the interception of precipitation by foliage is reduced until the trees regenerate (see Extension Note 23, *Timber-Harvesting Activities and Hydrology in Coastal British Columbia*). In addition, tree falling and yarding (dragging trees to the roadside) may damage the structure of the soil and reduce the ability of the soil to drain water. These changes in slope stability factors may lead to landslides in harvested areas.

Forest roads can have major effects on the structure of a slope and on the drainage of water down a slope. Both can affect where and when a landslide starts. If a fill slope on a road is too steep, it can cause a landslide (Figure 5). When a road is built across a slope, it intersects much of the water that is draining down the slope. The water runs along a ditch until it reaches a culvert that delivers the water across the road to below the road, where it once again becomes part of the slope drainage. If too much water is delivered to one location, a landslide might occur.

Avoiding harvesting-related landslides

Today, land and forest managers use several approaches to reduce the incidence of landslides.

Harvesting on slopes

- Terrain stability specialists assess slope stability.
- Harvesting is not conducted in areas highly susceptible to landslides.
- Root rot and the related hydrologic changes in sensitive areas are minimized by using small-patch or single-tree harvesting rather than clearcut harvesting (Figure 6).
- Soil damage is reduced by using helicopter or other sensitive logging methods.
- Harvesting activities are avoided in gullies.

Forest roads

- Alternate routes are constructed to avoid landslide-prone areas.
- Engineering techniques are used to prevent landslides and control drainage.
- Roads may be temporarily deactivated by putting water bars and cross-ditches in to control drainage (Figure 7).
- Old forest roads are deactivated and the original contours of the slope are re-created (Figure 8).
- In some cases, temporary roads are built and then deactivated as soon as possible.

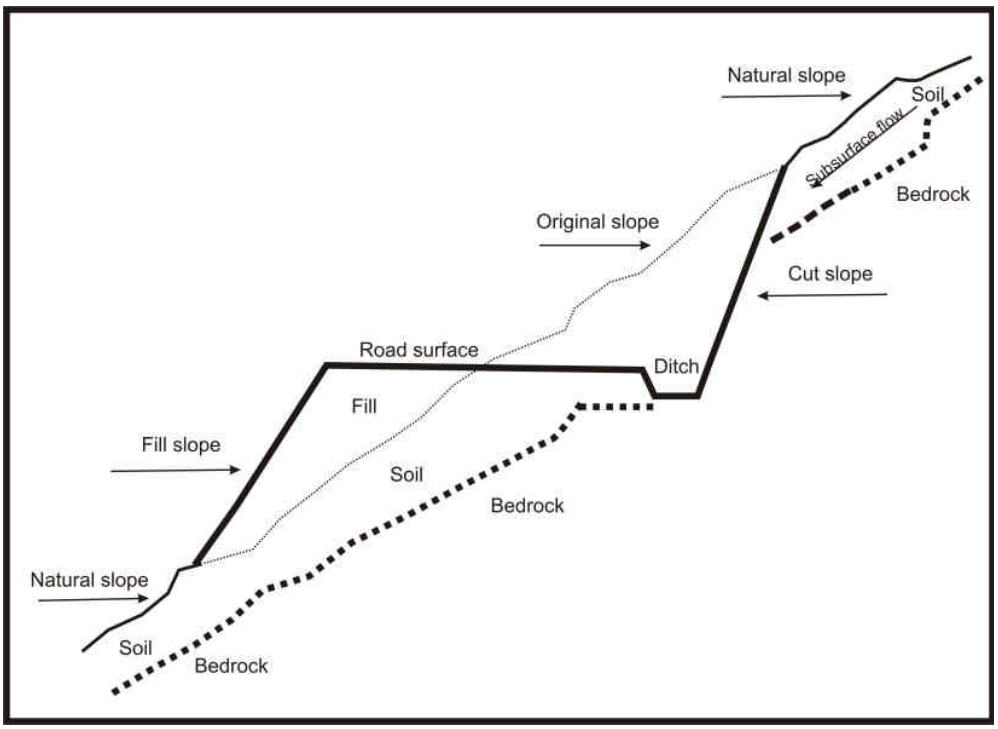

Figure 5. Road construction on a slope.

Figure 6. Small helicopter patch cuts on steep slopes.

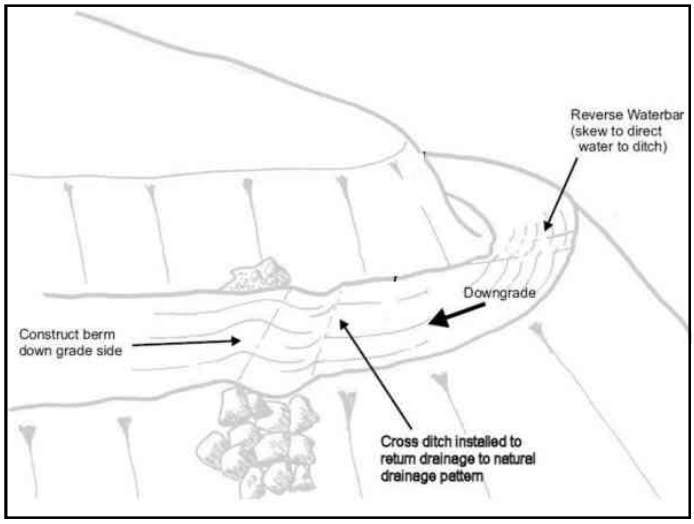

Figure 7. Water bar and cross ditch for temporary road deactivation (modified from *Technical Guidelines and Standards for Forest Road Deactivation/Restoration Activities*. Forest Renewal BC. 1999).

- For gully crossings, roads are designed so as to minimize their influence on slope stability and debris flows.

Harvesting activities on fans

Whenever harvesting activities take place on an alluvial fan, the harvesting plans must take into account how fan processes work.

- Forest harvesting is avoided in the area where channel avulsions are active.
- Specific road designs are developed if a road must cross the active area.
- Roads that climb to a stream crossing are avoided because if an avulsion occurs at the crossing, the water may follow the road and create a new channel.

Harvesting activities around stream channels

Today's land and forest managers recognize that the forest adjacent to a stream is important for providing bank stability, sources of woody debris, microclimate, and riparian habitat.

Under the Forest and Range Practices Act, operational harvesting plans must include the creation of reserved forest and riparian management areas adjacent to streams (Figure 9). The sizes of these areas depend on the width and type of stream. Or, other strategies that protect the stream must be established and followed.

Figure 8. Full deactivation (recontouring) of a forest road.

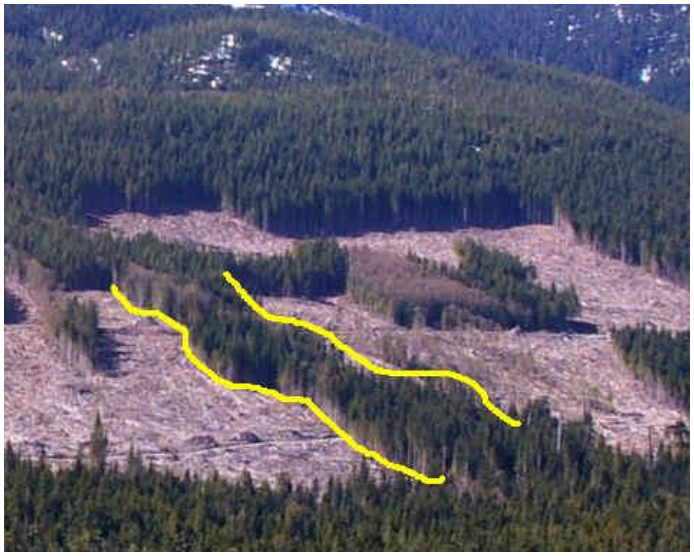

Figure 9. Example of a riparian reserve (outlined in yellow).

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