LANDSLIDES AND CLEARCUTS:

What Does The Science Really Say?

Doug Heiken, dh@oregonwild.org

The table below summarizes 26 separate data sets from 22 scientific studies which inventoried the relative number and volume of landslides in forested areas compared to harvested areas and roadways in the Pacific northwest. The table shows that clearcuts and forest roads are associated with dramatic increases in both the number of slides and the volume of slides relative to natural forest conditions.

Slide Risk for Clearcuts vs. Forested Areas

In terms of the number of slides per unit area, several of the studies indicate that clearcuts exhibit landslide rates up to 20 times higher than the background landslide rate observed in forested areas. (The average among all the data sets was 13x)

In terms of total slide volume per unit area, several of the studies showed that clearcuts exhibit soil transfer rates up to 8 times higher than forested areas. (The average among all the data sets was 7x) Slide Risk for Roadways vs. Forested Areas

In terms of the number of slides per unit area, several of the studies indicate that road rights-of-way exhibit landslide rates as much as 300 times higher than forested areas. (The average among all the data sets was 210x).

In terms of total slide volume per unit area, several of the studies showed that road rights-of-way exhibit soil transfer rates up to 200 times higher than forested areas. (The average among all the data sets was 103x)

Causal Mechanisms: How Clearcutting and Roadbuilding Increase Landslide Risk

The mechanisms whereby logging causes an increase in landslide risk include:

Large living trees have strong roots that often penetrate fractured bedrock (providing vertical soil cohesion) and make lateral connections with the roots of nearby trees and shrubs (providing horizontal soil cohesion). When the trees are harvested, the roots of the stumps decay and begin to lose their strength so the soil loses its vertical and horizontal cohesion. (Root strength is directly proportional to root size, so full recovery of soil cohesion is not realized for decades after harvest);

Unlike living trees, each of which might have a full acre of leaf surface area available to draw water out of the ground and transpire it to the air, stumps lack living leaves and are unable to transpire water out of the soil. This leads to increases in soil saturation, subsurface flow and surface run-off. (The natural hydrologic function of a forest does not recover for 100 years or more);

The removal of the forest canopy eliminates a partial "umbrella" that intercepts some rain and disperses the effects of intense storm events;

Dragging logs across steep slopes and using heavy machinery damages the soil surface and the roots that help hold the soil. Log yarding can also disrupt natural pathways for water drainage and can create new pathways as well. Logging, yarding and heavy equipment also damages "toe slopes" that act as retaining walls and help hold the soil on steep slopes;

Logging "slash" (debris left over after timber harvest) can accumulate in small stream gullies forming water blockages that can trigger slides;

Logging removes trees and damages root columns that buttress soil masses on the hill above them. The soil above and between two tree root columns can also form a structural "arch" that helps hold the soil on the slope above the arch;

Harvest sites are often burned after logging to prepare the site for replanting. Intense burning adversely affects soil cohesiveness so that the top layers of soil just dissolve and disappear with the first big rain. Fire can also kill residual vegetation initiate the decay of residual roots in shrubs, ferns, and grasses that may have survived the logging operation; and

Herbicide spraying is often done to reduce competition between unwanted plants and the small tree seedlings in a plantation. Such chemical spraying kills residual vegetation and initiates the decay and loss of strength in the roots of plants that survived the logging operation.
In addition to removing all trees, stumps, and other vegetation, road building has a few of its own causal mechanisms:
Roadbuilding completely disrupts the natural soil profile.

Heavy equipment creates large amounts of unconsolidated soil that is often "sidecast" along miles and miles of roadway. This sidecast material can overload and "oversteepen" already steep slopes.

Road building disrupts subsurface drainage, turning subsurface flow into surface flow, and often creates dangerous areas of water concentration;

Road culverts often dump large amounts of water on unconsolidated fill material;

Are the Current Forest Practice Rules Good Enough?

Some people say that the slides are caused by past practices, especially old road-building techniques that (according to some) are no longer practiced. Unfortunately, the backbone of Oregon's forest transportation system is the older roads built with the old practices. Private landowners are also much slower to adopt modern techniques than the federal forest managers. These old high risk roads should be modified or their impacts mitigated.

While it's true that roadways experience a period of relatively higher risk of sliding within a few years after they are built, these old roads remain at high risk relative to forested areas for decades after construction. Also, many of our older roads follow streams for miles often being within flood plains where rivers and streams continually shift and can erode their fill slopes which tends to increase slide risk.

Furthermore, there's not much that can be done to mitigate for a clearcut. All things being equal, most slides are initiated where clearcutting is still practiced the old-fashioned way-- either along intermittent stream courses or on midslope areas-- where current forest practice rules provide very little protection. Experts also often point out that while roads have a higher relative risk of sliding than clearcuts, they occupy a much smaller portion of the land base. In many of our private land areas, clearcutting rates are so high that up to 50 percent of the land area is in age classes less than 20 years which puts them at higher risk of landslides.

Potential Mitigation: What Can We Do To Minimize The Risks?

It might be possible to mitigate the increase in landslide risk caused by timber harvest, but that will require significant modifications to our forest practices rules:

1) Leaving some large areas uncut because they are simply too risky in terms of human life, potential property damage or critical water quality impacts (e.g., community water supply and salmon habitat);

2) Leaving uncut "leave areas" in high risk areas (with significant buffers, so that wind storms don't play havoc with small leave areas and actually increase the slide risk as has been observed in some studies);

3) Leaving significantly wider stream buffers, and adding protection for intermittent streams and incipient channels where there is virtually no protection in the state forest practice rules today; and

4) Leaving large firmly-rooted trees well-distributed across every acre of potentially unstable ground. (No one has shown that such thinning actually works. The influence of wind on the remaining trees in the thinned stand might actually cause more slides than if more or less trees were left, but it's worthy of some research.)

Explanation and Discussion of the Table (see below)

The column entitled "Study Period" shows the length of time during which slides occurred and were inventoried. This ranges from many decades to one winter or even one storm. In general, longer study periods would have larger sample sizes and statistically more reliable results, but longer study periods sometimes introduce difficulties of inventorying slides that occurred in the past that are now partially grown over with vegetation.

Another problem with study periods is that some of the investigators used different time periods for different land uses. That is, they inventoried slides in forested areas that occurred over many decades, while they inventoried slides in harvested areas over a more recent and shorter time period during which the area was affected by timber harvest. Some investigators used the "cumulative area total" method to account for this difference others did not. In general, use of longer study periods for forested areas than for harvested areas and failure to account for the cumulative time that the area was forested or harvested or roaded would tend to bias the results toward under-estimating the risk of slides in clearcuts and roadways.

The column titled "Study Area" shows the area of land inventoried in square kilometers. In general, larger study areas would have larger sample sizes and more reliable statistics but larger study areas also increase the difficulty of completing comprehensive surveys. Most of the largest studies were done using aerial survey techniques which probably increases the likelihood that the inventory missed some slides. Aerial techniques probably miss slides in all three land use categories-- forested areas, clearcuts, and roadways-- but there will likely be a slight bias towards under-estimating the risk of slides in forested area. Any of the studies that have results in the column titled "Relative Soil Transfer Rates" presumably involved ground-based measurement of slide volumes. This ground-based activity may have led to the identification of additional slides that were not found during aerial surveys which might partially correct the bias.

The column titled "Relative Rate of Slide Initiation for Forest/Clearcut/Road" represents the relative number of slides per unit area. The number of slides per unit area of clearcut and road right-of-way were represented as multiples of the background rate of slides in forested areas.

The column titled "Relative Soil Transfer Rate for Forest/Clearcut/Road" represents the relative volume of slide material per unit area. The soil transfer rate for clearcut areas and road rights-of-way were represented as multiples of the background soil transfer rate in forested areas.

The bottom of this page set forth the full citations of the studies presented in the table.

Table of Pacific Northwest Landslide Surveys

Author(s) and date(s) of publication	Study Location	Study Period	Study Area (km2)	Relative Rate of Slide Initiation for Forest/Clearcut/Road	Relative Soil Transfer Rate for Forest/Clearcut/Road	Survey Method: Aerial or Ground
Bishop et al 1964	Southeast Alaska Maybeso Creek Neets Bay	1948-1962 ~14 years.	na	1x | 93x | na1	na	Both
Dyrness 1967	Oregon Cascades H.J.Andrews Forest	1964-1965 1 winter	61	1x | 10x | 309x	1x | 8x | 60x	Ground
O'Laughlin 1972, Swanston et al 1976	Southwest British Columbia Coastal Mountains	1939-1972 ~33 years	640	1x | 5x | 20x	1x | 2x | 25x	Aerial
Fiksdal 1974	Washington Stequaleho Creek	1887-1971 ~84 years	24.5	1x | na | 1600x	1x | na | 224x	Both
Swanson et al 1975	Oregon Cascades HJ Andrews Forest	1946-1972 ~26 years	64	1x | 3x | 33x	1x | 3x | 30x	Both
Morrison 1975	Oregon Cascades Alder Creek	1946-1975 ~29 years	174	1x | 12x | 366x	1x | 2.6x | 343x	Both
Gresswell et al 1976	Oregon Coast Range Mapleton RD	1975 1 winter	760	1x | 24x | 73x	na	Aerial
Swanson et al 1977	Oregon Coast Range Mapleton RD	1957-1977 ~20 years	64	1x | 1x | 7x	1x | 2x | 45x	Both
Swanson et al 1977	Cedar Creek Oregon	?	?	1x | 5x | 40x	na	?

	Mapleton RD					
Ketcheson 1977, Ketcheson et al 1978	Oregon Coast Range Mapleton RD	1963-1978 ~15 years	7.28	1x | 2x | na	1x | 3.4x | na	Ground
Hughes 1978	Umpqua NF Granite Ck, Oregon	1971-1978 ~7 years	0.8	na	1x | 10x | 27x	Ground
Marion 1981	Oregon Cascades Blue River	1946-1981 ~34 years	61.66	1x | 10x | 106x	1x | 9x | 44x	Both
Lyons 1981	Oregon Cascades Middle Fork Willamette River	1959-1967 ~8 years	668	1x | 23x | 29x	na	Aerial
Lyons 1981	Oregon Cascades Middle Fork Willamette River	1967-1972 5 years	657.7	1x | 7x | 10x	na	Aerial
Hicks 1982	Oregon Cascades Middle Santiam R.	1955-1981 ~26 years	60	1x | 3x | 74x	1x | 3.4x | 95x	Aerial
Chesney 1982	Oregon Cascades Willamette NF	1949-1959 ~11 years	5262	1x | 4x | 33x	na	Aerial
"	Oregon Cascades Willamette NF	1959-1967 ~9 years	5240	1x | 13x | 208x	na	Aerial
"	Oregon Cascades Willamette NF	1967-1972 ~6 years	5240	1x | 22x | 705x	na	Aerial

"	Oregon Cascades Willamette NF	1972-1979 ~8 years	5240	1x | 5x | 254x	na	Aerial
Swanson et al 1982	Willamette NF (moderately stable areas)	~30 years	6700?	1x | 3x | 47x	1x | 2.5x | 37x	Both
"	Willamette NF (unstable areas)	~30 years	6700?	1x | 7x | 336x	1x | 5.5x | 250x	Both
Schwab 1983	British Columbia Rennel Sound	1978 1 winter	160	1x | 17x | 28x	1x | 41x | 46x	Both
McCashion et al 1983, Amaranthus et al 1985	Northwest California	na	na	1x | na | 9x	na	Both
Schroeder 1984	Oregon Coast Range Palouse Creek	1981-1982 1 winter	11.35	1x | 10x | na	na	Aerial
"	Oregon Coast Range Larson Creek	1981-1982 1 winter	9.72	1x | 6x | na	na	Aerial
Amaranthus et al 1985	Siskiyou NF Klamath Mountains, Oregon	1956-1976 ~20 years	556	1x | 19x | 138x	1x | 7x | 112x	Aerial

1. In Bishop et al 1964 the 93x slide risk factor probably represents the combined effect of clearcutting and roads.

Pacific Northwest Landslide Surveys Listed in Table

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