A Terrain Attribute Study of Helicopter Logging Related Landslides in the Southwest Coast Mountains of British Columbia

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A helicopter logging terrain attribute study (HTAS) was carried out in the Eldred and Khartoum Lake watersheds in the SW Coast Mountains. Fifteen (9.3%) of 162 clear-cut terrain polygons contain landslides – six (3.7%) ≥ 0.05 ha. Landslide frequencies are 0.055 total landslides/ha and 0.019 landslides ≥ 0.05 ha/ha in terrain polygons logged on average 8 years prior to sampling. Eighty percent of polygons with landslides are gullied, the remaining 20% are open slopes. Polygons with gullies ≥ 3 m deep account for 67% of all polygons experiencing post-logging landslides. Landslide frequencies in all gullied polygons are 0.139/ha in total and 0.057 landslides ≥ 0.05 ha/ha. In open slopes landslide frequencies are 0.0124/ha - none of these landslides are ≥0.05 ha. Approximately 73% of all HTAS polygons with landslides occupy slopes > 35° (70%).

Data from 142 conventional cable logged polygons in the Eldred and Lois River watersheds from Rollerson et al.’s (1998; 1999) conventional cable logging terrain attribute study (CTAS) were also examined. Seventeen (12.0%) contain landslides and 9 (6.3%) contain landslides ≥ 0.05 ha amounting to a landslide frequency of 0.028 landslides ≥ ha amounting to a landslide frequency of 0.028 landslides ≥ 0.05 ha/ha over an average 8 year period flowing logging. Landslide counts for landslides < 0.05 ha were not available. Forty-seven percent of all polygons with landslide contain gullies, all ≥ 3m deep. Open slopes account for 53% of unstable polygons. Landslide frequencies are 0.055 landslides ≥ 0.05 ha/ha in gullied polygons and 0.019 landslides ≥ 0.05 ha/ha in open slopes. Slopes > 30° (58%) contain 82% of all unstable CTAS polygons.

The percentage of CTAS polygons containing landslides is 1.3 times (29%) higher than in the HTAS. In landslides ≥ 0.05 ha/ha, the CTAS landslide frequency is 1.5 times (47%) higher than in the HTAS. Statistically, this difference is not significant but when samples are split into gullied and open slope categories a dichotomy is observed. The percentage of polygons containing any landslides is 3.5 times (250%) higher in CTAS open slopes and conversely 1.4 times (38%) higher in HTAS gullied polygons. Landslide frequencies are 0.019 landslides ≥ 0.05 ha/ha in CTAS open slopes versus zero in the same HTAS polygons and 1.04 times (3.6%) higher in HTAS gullied polygons. These differences are only statistically significant in open slopes. Therefore, landslides following conventional logging are significantly higher in open slope terrain and within a normal range of variability in gullied polygons.

CHAID and logistic regression analyses produced two different post-logging landslide probability models. Logistic regression produced a more successful and widely applicable model using two predicting variables: average slope gradient and the presence/absence of gullies <3 m or ≥ 3m deep. Ninety-six percent of post-logging instability was successfully predicted by the HTAS logistic regression model in gullies ≥ 3m deep with average slope gradients > 30°.

HTAS probabilistic landslide hazard classifications and other results are most applicable in similar terrain in the watersheds sampled. To a lesser extent these results may also provide guidance throughout representative terrain experiencing similar climate conditions throughout the a representative regions termed the Southwest Coast Mountain Zone (SWCMZ). Beyond the SWCMZ applicability becomes increasingly limited. In this respect, watersheds and large climate regions may be thought of as different scales of polygons within which post-logging landslide influences may vary less than outside. Overall, the HTAS landslide hazard classifications are best suited to preliminary identification of potentially unstable areas and can not be used in the field in place of site-specific terrain stability assessments by qualified professionals.

Forestry personnel should exercise particular caution in gullies approximately ≥ 3 m deep and with average slope gradients > 30°. Above the critical slope break 73% of these gullies experienced post-logging landslides resulting in a landslide frequency of 0.45 landslides/ha. Sixty percent of all unstable HTAS polygons studied meet this terrain criteria accounting for only 6.8% of all HTAS polygons and < 8% of the total study area. Predicted post-logging landslide probabilities for this terrain range from 65-84%. These steep gullies are efficient conduits for debris transport and pose the greatest risk to downslope elements at risk. Landslide hazard assessments should focus here before logging commences.