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Forest harvesting influence on slope erosion in Baikal Basin Mountains

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Post-logging recovery of forest water protection and erosion prevention functions can occur different ways on slopes and in big river catchments. While erosion decreases several times during only three to five years after logging on slopes, as compared to its immediate post-logging rate, water silt load in big rivers can remain high for decades after forest logging in their catchments. Among other factors, this can be attributable to erosion of timber transportation roads and skidding trails, which become extremely eroded 10-15 years following forest logging. One should not underestimate a probable sediment load increase resulting from post-logging channel runoff changes. Disregarding this increase leads to contradictory conclusions about post-logging recovery of forest water protecting capability. Investigating this issue requires to clearly determine the type of the forest site of interest (a certain slope, an elementary or a complex catchments) and to consider the experience gained so far in estimating erosion rate changes depending on changing forest areas of continents. Therefore, hierarchical river catchments ranking should be recognized effective and useful for forest hydrology. This approach will allow systematizing the existing information and facilitating the development of fruitful analysis of water protection and erosion prevention functions of forest in areas of different ranks.

This study used an approach that enabled a single-model description of the rate of soil erosion previously estimated by different models for areas of various ranks, from a micro slope to elementary catchments. An elementary catchments is defined as the smallest drainage area characterized by uniform surface, ground, and vegetation structures and having a single well-pronounced channel, with hydro network being practically absent. Using runoff slope length as the argument and introducing a dummy variable that describes specific investigation methodologies ensured high generality of this model.

The model describing soil erosion rates on separate slopes and in elementary catchments is:

ln M=-9,3+0,95lnX-0,064NlnL+0,069lnXlnm/lnL+5,03K+1,49lnI+
+0,0162ln((X-W)/In)i-0,00026ln((X-W)/In)i2

R2 =0,86; [U+F073]=1,04; F=221;

where M is sediment load module, t/km2; N is time since the last disturbance (fire or logging), years; X is precipitation amount, mm; I is precipitation rate, mm/min; m is soil mineralization level, %; L is length of slope where surface runoff occurs, m; W is forest floor moisture capacity, mm; In is soil water permeability, mm/min; i is slope, degrees; K is investigation methodology indicator (it is assumed to equal 1 in the case of area sprinkling and 2 in erosion observations on permanent runoff sample sites and in catchments); R^2 is multiple determination coefficient; [U+F020] [U+F073] is standard deviation, ton per km2; and F is Fisher criterion. All coefficients are 95% confident.

This model shows a monotonous increase in sediment load module with increasing total moisture in an area and soil mineralization on burned or harvested sites. This module decreases with increasing forest floor moisture capacity and soil water permeability. These trends, as well as slope-caused soil erosion changes, were reported by earlier studies. Our experimental data obtained by other methods did not impact the earlier identified relationships. Therefore, estimating slope length precipitation rate influences on sediment load and predicting soil erosion slowdown on disturbed sites present a great interest.

Numerical experiments with this model showed the sediment load module to increase with increasing precipitation rate and to decrease with increasing slope length. This decrease might be attributable to soil particle re-deposition in the lower parts of a slope. Re-deposited erosion products do not get into streams and become involved again in soil development.