FOREST MANAGEMENT AS A REGULATOR WATER BUDGET IN BASSIN BAIKAL LAKE

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Sins long lake Baikal has been renowned for the quality and impressive size of its water reservoir. The lake watershed covers 57.1 million ha, half of which is situated in Mongolia. Selenga River is the biggest tributary of Baikal, but it is characterized high water pollution. Thus transboundary water resources management in Baikal basin is very actual problem.

The Russian part of the Baikal basin consists of densely forested mountains. The mountain forests of Russian part of the Baikal basin maintain ecological processes in the watershed through soil and water regulation, thus being of great importance to the lake. Forest ecosystems are a major factor controlling moisture circulation on watersheds. Forest vegetation, along with climate, soil, topography, and lithosphere characteristics, has a considerable influence on moisture budget structure and surface and ground water quality.

The forested watersheds of mountain rives of Russian part of the Baikal basin are responsible for quality and quantity of Baikal water. In this case hydrological base of basin management is connected with forest management in watershed. Extensive commercial forest logging usually results in increasing forest fire hazard, reduction of the major woody species area, and promotion of young and secondary deciduous forests. These forest cover changes force hydrological regime to transform. The present paper is devoted to one aspect of forest management impact on water resources.

Forests are important in terms of snow distribution and accumulation, as hydrological regimes of most Siberian Rivers are determined mainly by watershed snow moisture budget. Forest is known to influence snow accumulation in two ways. On the one hand, conifer forest canopy intercepts a part of precipitated snow, which then evaporates more rapidly as compared to open sites. As a result the forest canopy reduces snow loading. On the other hand, forest enhances snow accumulation on the ground through reducing under-canopy snow evaporation, blowing away, and melting during thaw spells. Notwithstanding contradictions existing in estimating forest influence on snow pack, there are general trends of snow pack (load) variability with forest stand age, density, species composition, above-ground biomass, canopy closure, and other inventory and biometric parameters.

Based on these trends, forested watershed surface runoff can be increased by creating a desirable spatial forest patterns using appropriate forest treatments. Surface runoff can be enhanced, for example, by alternating forest and non-forest (open) sites, because such a “cellular” forest pattern would increase snow accumulation.

Mathematical modeling of hydrological processes, particularly numerical experiments with models describing snow-accumulating capabilities of patchwork forest landscapes, is very helpful for achieving an optimal forest area in a given watershed. The results of our numerical experiments indicate that snow loading (pack) is grater on sites subjected to different ways of forest thinning as compared to cleat cuts. Two forest logging options were analyzed: (1) a clear cut, when 20% of forest was left on a watershed and (2) two-stage gradual felling on another watershed. In the latter case, the felling was conducted twice during 40 years, with wood extraction being 40% of the watershed forest area at each felling stage, totaling, as a result, the same forest harvesting percentage (80%) as in the clear cut case. Snow accumulation analysis indicated forest logging to be generally favorable for snow accumulation on leeward slopes. However, an average snow pack increment was calculated to be 60-70mm in the case of gradual felling vs. 30mm for the clear cut watershed. Modeling for upwind slopes showed an about 40mm and zero snow pack increments, respectively.

It is noteworthy that snow storms have an important role in the process of snow accumulation, as snow surface moisture evaporation increases and snow is redistributed across a given area during these storms. The deepest snow pack was found to occur relatively small downwind conifer forest clearings and glades. Up to 95% of the total snow accumulated on such sites was recorded to remain until snowmelt onset, while the value was calculated to be as low as 20-60% for big open sites on windward slopes.

Several models describing open-site snow pack dependence on site size and the snow amount precipitated were obtained as a result of a study of snow cover formation on open sites conducted in different landscapes found in Khamar-Daban mountain range, southeastern fore-Baikal region.

Our numerical experimenting with models showed that a snow pack increment depends on the amount of watershed forest area. We compared the increment obtained for watersheds characterized by optimal forest patterns with that obtained for post-clear cut forest patterns. This dependence can be written as:

$$\Delta X = X\,(0{,}11 \ln L - 0{,}0055L + 0{,}00003X)$$

where ΔX is snow pack increment, mm; X is precipitated snow, mm; L is forested area of a watershed, %.

Our study results allowed us to make an important conclusion that forest ecosystem capability to accumulate snow can be controlled by wood extraction methodologies. The study also showed that snow accumulation on forested watersheds is vegetation-, climate-, and weather-specific. However, the general trend of snow accumulation changes with changing percent forest areas and logging site patterns on watersheds remains.

Our studies revealed that snow water budget is structurally dependent on forest vegetation characteristics and sizes of non-forest sites. The greatest snow moisture loss through evaporation (60-240mm) was found to occur on vast open sites, particularly on upwind slopes. This loss appeared to be minimal on 0.05-05-ha open sites and in poorly-stocked young stands situated downwind (15-35 and 20-40mm, respectively). Our modeling experiments showed that the greatest snow accumulation is characteristic of watersheds having alternating open and forested sites, with forest area accounting for 30-60% of the entire watershed. The lowest snow accumulation was recorded for treeless, mostly upwind watersheds. Along with estimating snow pack in forest stands and open sites, the models we developed allow to assess the capability of a patchwork forest landscape shaped by fire, logging, and other human-caused disturbances to accumulate snow.

Snow pack increments determined by watershed forest patterns can thus be considered as a forest hydrological effect increasing the incoming part of watershed moisture budget. This effect was found to be most pronounced were forest area is 20-40%. Decreasing wind activity and increasing relative humidity and winter air temperatures were determined to reduce this effect, because snow moisture evaporation differences between relatively small and big open sites become smoothed out due to decreasing snowstorm frequency. This snow accumulation effect is probably the only clear example that forest can act as a moisture regulator in the atmosphere-land cover system.

In the context of the total moisture circulation and water budget changes on watersheds, snow accumulation by forest depends on geographical conditions and ranks of particular areas. While snow pack increment depending on spatial forest distribution can range 80 to 100mm on elementary mountain taiga watersheds of 1-5 km^2, that receive 350-500m of snow annually, the absolute snow increment does not exceed 20-30mm in forest-steppe areas characterized by much less annual snow precipitation.