Geophysical Research Abstracts
Vol. 17, EGU2015-14124, 2015
EGU General Assembly 2015

Computational approach in estimating the need of ditch network maintenance

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Ditch network maintenance (DNM), implemented annually in 70 000 ha area in Finland, is the most controversial of all forest management practices. Nationwide, it is estimated to increase the forest growth by 1…3 million m3 per year, but simultaneously to cause 65 000 tons export of suspended solids and 71 tons of phosphorus (P) to water courses. A systematic approach that allows simultaneous quantification of the positive and negative effects of DNM is required.

Excess water in the rooting zone slows the gas exchange and decreases biological activity interfering with the forest growth in boreal forested peatlands. DNM is needed when: 1) the excess water in the rooting zone restricts the forest growth before the DNM, and 2) after the DNM the growth restriction ceases or decreases, and 3) the benefits of DNM are greater than the caused adverse effects. Aeration in the rooting zone can be used as a drainage criterion. Aeration is affected by several factors such as meteorological conditions, tree stand properties, hydraulic properties of peat, ditch depth, and ditch spacing. We developed a 2-dimensional DNM simulator that allows the user to adjust these factors and to evaluate their effect on the soil aeration at different distance from the drainage ditch.

DNM simulator computes hydrological processes and soil aeration along a water flowpath between two ditches. Applying daily time step it calculates evapotranspiration, snow accumulation and melt, infiltration, soil water storage, ground water level, soil water content, air-filled porosity and runoff. The model performance in hydrology has been tested against independent high frequency field monitoring data. Soil aeration at different distance from the ditch is computed under steady-state assumption using an empirical oxygen consumption model, simulated air-filled porosity, and diffusion coefficient at different depths in soil. Aeration is adequate and forest growth rate is not limited by poor aeration if the computed oxygen concentration under the rooting zone is > 0. In other case, the forest growth rate is scaled down with a proportion of the realized oxygen flux and the potential oxygen consumption. The growth limitation coefficient is integrated over the area between the ditches and over the simulation time. The growth limitation approach is being validated against field measured data.

Concentration of suspended solids and phosphorus in runoff water are derived from empirical equations. The export load is computed by multiplying the daily concentration with the simulated runoff. The concentration of suspended solids depends on the texture of soil, and the time elapsed from the DNM, and the P concentration depends on the prevailing ground water level. The export loads are integrated over the simulation time.

The computational evaluation of the benefits and the adverse effects of DNM allow us to locate DNM activities to suitable sites and to avoid it on other sites. The simulator allows a systematic optimization of DNM activity.