Skogssällskapet

Slutrapport

Projektrubrik: When do we ditch the ditch? A field test of the "DitchFlowTracker" to prioritize forest drainage ditch maintenance for sustainable forest management

Huvudsökande: Eliza Hasselquist, Sveriges lantbruksuniversitet

Projektets löptid: 2017-04-01 – 2018-03-31

Populärvetenskaplig sammanfattning

Almost 25% of the forests in Fennoscandia have been artificially drained by ditches over the past century to increase timber production, with a recent estimate of 1 million km of ditches occurring in all of Sweden, twice the length of all natural streams. Ditching can improve forest production but is often ineffective and may cause nutrient losses as well as increased transport of mercury and sediment. As ditches age, ditch maintenance (DM) may be required and the Swedish Forest Agency and County Administrative Boards from around Sweden are in urgent need of guidance on how to prioritize DM. We set up permanent infrastructure to test a new model, the DitchFlowTracker (DFT), as support tool for prioritizing DM in an effort to balance the positive effects on tree productivity against negative environmental impacts. The DFT uses new digital elevation models generated from recent aerial laser scans of Sweden combined with soil maps and flow accumulation models in GIS to estimate how much water drains in particular ditches. We measured flow and ditch properties in over 100 ditches during high and low flow as well as measured forest stand properties at increasing distances from ditches. We found that the DFT was accurate at predicting flow in ditches, but the results are less clear when trying to use the DFT to predict forest productivity. Forest stand volume was higher on glacial till soils than peat and the effect of the ditch on stand volume was only found in till soils, lasting up to 40 m away. But, it was not the flow accumulation, or catchment area, that predicted tree growth near ditches, but measurements of discharge (Q, measured in liters per second) that best explained the stand volume near ditches. We are still investigating the missing link between why the DFT cannot predict tree growth, when it can predict discharge and discharge predicts tree growth. Our research will continue with these sites and which are an invaluable research infrastructure to continue working with this complex topic to investigate the effect of soil nutrients and slope around ditches. Furthermore, we will focus on how we can find a combination of simple field measurements along with data from an app, like that developed by the WAMBAF group, that can determine if a ditch needs maintenance, e.g. depth and width of the ditch combined with CA, so that one does not need to measure flow in ditches. Additionally, this project was the basis of a successful Formas application that will start a collaboration between Finnish and Swedish researchers that will combine the DFT with a forest stand growth model. The new Formas project will fully enable the cost-benefit analysis of DM and create a more holistic – and- accurate tool for ensuring DM is done where it will actually affect tree growth, thereby ensuring better water quality originating from forests.

Resultat

WP1. Evaluating ditch hydrology

We hypothesized that catchment area (CA), soil type, and forest age would affect the flow of water in ditches. To test this, we measured flow, ditch depth and width, and water depth in ~100 ditches during Spring flood high flow (May) and Summer low flows (August) in 2017 (Fig. 1). The ditches were categorized by three different CA's based on Hasselquist et al. (2018)(<0.4, 0.4-1, and 1-4 ha), the two dominant soil types affected by ditches in Sweden (glacial till and peat), and three ages of forest (recently harvested, <3m tall; young forest, <10m tall; and old forest, >10m tall). At least five replicates of each category of ditch were measured. Discharge (Q) was calculated using the field data collected and compared with the DFT model. Here are our main findings:

1) We found that drainage function increases with CA. More than 80% of ditches with CAs <1 ha had flows high enough to drain forests of excess water.

2) We found that ditches on till soils have higher flow than those on peat soils, regardless of forest age. Thus, ditches that occur on till soils are significantly less likely to need cleaning to increase their flow.

3) We found that forest age did not influence drainage function in ditches. This is contrary to our expected findings as we hypothesized that flow in ditches would be greater in clear-cut sites than in old forest sites due to less water being in ditches due to the higher evapotranspiration of older trees. Further work needs to be done to confirm this finding because there was a trend that younger forests had higher flow, but it was not statistically significant.

WP2. Tree growth near ditches

Although we found that ditches with CAs >1 ha had higher flow, we wanted to do field tests to ensure ditches are not changing hydrological conditions in other ways that affects tree growth and are not accounted for in the DFT. Thus, we evaluated the effectiveness of old forest ditches using tree growth as measured by tree height, volume, tree stem density, and finally, tree ring analysis.

We selected our sites from the ~100 sites used in the hydrology study, but just picked mature stands so that we could take tree cores and identify growth responses of when ditches were first dug or cleaned. Three replicates of each of the six possible combinations were used (two soil types; three CA's), for a total of 18 sites. At each site, 12 plots were set up at different distances from the ditch (Fig. 2). The plot located 75 m from the ditch was used as a control since the ditch should not have any influence from this distance. In total, we established 216 circular plots.

We collected the following data in each plot: site type, soil type, humus layer thickness and volumetric water content of the soil (VWC). In the first sample plot on each transect several measurements of the ditch, including width, depth, water depth and water flow velocity (if water was present) using a few drops of non-toxic colored dye (Fluorescein sodium salt).
All trees within each sample plot were calipered at breast height (DBH), their heights measured and an increment core sample collected from the tree with largest DBH. Thus, 12 increment cores were collected per site for a total of 216 cores total. Tree stand characteristics have been analyzed, but the only a basic analysis of the growth responses to ditching based on the tree cores. Thus far, our main findings are as follows:

1) Although water flow was significantly related to CA (hydrology section, above), we found that stand volume could not be explained by CA.

2) Instead, tree growth, specifically stand volume, was more related to soil type (Fig. 3); stand volume was higher in till soils than peat. Furthermore, the effect of the ditch on stand volume was found in till soils only, lasting until 17 m away from the ditch, although the effect was still somewhat evident up to 40 m away (Fig. 3). This was primarily due to sites in peat soils having a higher density of small diameter trees closest to the ditch evening out the stand volume across the distances. This is likely the effect of some combination of forest management (thinning) and wetland protection (not thinning near wetlands), not really the drainage effect of the ditch. Further exploration of this result is needed.

3) We later tested if ditch function, i.e. flow, itself could better explain tree growth than CA. In sites with high flow (>1 l/s) stand volume was higher than low flow (0.01 -1 l/s) and both were greater than sites no water or no flow (Fig. 4). Thus, flow could be a better predictor of the effect of the ditch of tree growth than CA.

Målbeskrivning

Our goals were to test the DitchFlowTracker (DFT) with field data to ensure we are developing an accurate tool for prioritizing DM across a range of forest ages and soil types. Our goals were to do this by performing tasks within two different work packages (WP): (WP 1) measuring existing ditch function (i.e. water flow) during times of high and low flow and (WP 2) evaluating if existing ditches are enhancing tree growth using analyses tree cores. We achieved our goal of measuring hydrology of ditches (WP1) and most of our goal of evaluating effect of ditches on tree growth (WP2). We ended up just using tree stand properties as our measurement of the effect of ditches on tree growth because the tree cores ended up being difficult to analyze for many reasons. First, not all of our trees were old enough to have been alive when the ditches were dug. This was really needed to be able to determine the growth response of the trees to the initial ditch digging and for how long the growth response lasted. Second, we did not collect enough tree cores. Only 12 trees per site were collected, and it would have been better to have more samples to have a better chance of detecting the effect of the ditch. But, with the help of a Forestry Masters Student, we were able to also collect tree stand characteristics that helped us evaluate the effect of the ditch on tree growth and therefore the DFT's ability to predict tree growth.

A number of other issues came up during this project that will require further study to make better recommendations to forest managers. One is that we chose our sites based on the Swedish Geological Survey (SGU) soil maps. SGU maps peatlands based on aerial photos and thus, peatlands are obvious from the air only if they are open with few trees and have low productivity. Regardless of the maintenance needs for ditches in these peat sites, it is unlikely that the ditches are allowed to be cleaned due to them being in wetlands. Also, forest thinning operations have made buffers around the peatlands that have changed the forest stand properties, making it difficult to evaluate these sites. Additionally, we do not have information on the nutrient status of the soil. We would like to go back to the sites and take soil samples to exclude the effect of soil nutrients. Furthermore, we would like to measure slope in more detail. Even though the slope from the ditch to the plot 75 m away was less than 5%, small deviations from this could still influence the growth patterns slightly.

Our time schedule was followed except for receiving a five month extension due to the PI (Eliza Maher Hasselquist) being on parental leave.

Kommunikation och nyttiggörande av resultat

The results of this study were presented at the 29th European Dendroecological Fieldweek in Lonjsko Polje, Croatia, organized by the Swiss Federal Institute for Forest, Snow, and Landscape Research (WSL) in September of 2018. Researchers form 18 countries where represented at the workshop that covered the full spectrum of dendrochronolgocial issues – all things related to determining how tree growth is affected by environment and climate. Thus, my research has been spread to all corners of the world. My work in this project was also highlighted in the "Vi måste prata om skogen" film series by Future Forests (https://www.youtube.com/watch?v=-WN38WwKzYs&feature=youtu.be), that focused on forestry effects on water quality. Furthermore, Hanna Glöd, a Forestry (Jägmästere) Masters student based her thesis on testing the DFT and she presented the results of her thesis work in February 2018. I participated in a VIMLA workshop entitled “Water balance and leaching in ditch cleaning measures in forestry” in November 2017 organized by the Swedish Forest Agency (Skogsstyrelsen), that also involved the Västerbotten County Administrative Board (Länstyrelsen), Skogforsk, Skogscentralen (Finnish), and various entrepreneurs. As well as will participate in the WAMBAF conference “Forestry and Water in the Baltic Sea Region” on 29 January at World Trade Center in Stockholm.

More formal project outcomes are the following publications:

- Kuglerová, L.*, E.M. Hasselquist*, J.S. Richardson, R. Sponseller, D. Kreutzweiser, & H. Laudon. 2017. Management perspectives on Aqua incognita: connectivity and cumulative effects of small natural and artificial streams in boreal forests. Invited Commentary in Hydrological Processes. 1-7. *shared first-authorship
- Hasselquist, E.M., W. Lidberg, R.A. Sponseller, A. Ågren, & H. Laudon. 2018. Identifying and assessing the potential hydrological function of past artificial forest drainage. Ambio. 47: 546
- Glöd, Hanna. 2018. Forest drainage effect on tree growth in northern Sweden: developing guidelines for ditch network maintenance. Masters Thesis (Second cycle), Forest Faculty, Department of Forest Ecology and Management, Umeå, Sweden
- Hasselquist, E.M., H. Glöd, M. Peichl, T. Mörling, & H. Laudon. In prep. Drainage effect of forest ditches depends on ditch function and soil type, not forest stand age. In preparation for Forests