Can Drainage Facilitate Drought?

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Drainage networks are widely applied to enhance forest productivity in the hemiboreal zone, yet their maintenance can have both positive and negative consequences for tree growth and site hydrology. Radial increment of Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), and silver birch (*Betula pendula*) on drained organic and mineral soils following ditch network maintenance (DNM) was examined. Growth responses were analyzed in relation to species, site type, and stand characteristics. The study aimed to assess whether DNM enhances stem growth, particularly for conifers, while testing the hypothesis that it may also increase the risk of over-drainage under increasing drought effects.

Keywords: *drained forest; ditch network maintenance; increment analysis; anthropogenic disturbance; forest hydrology*

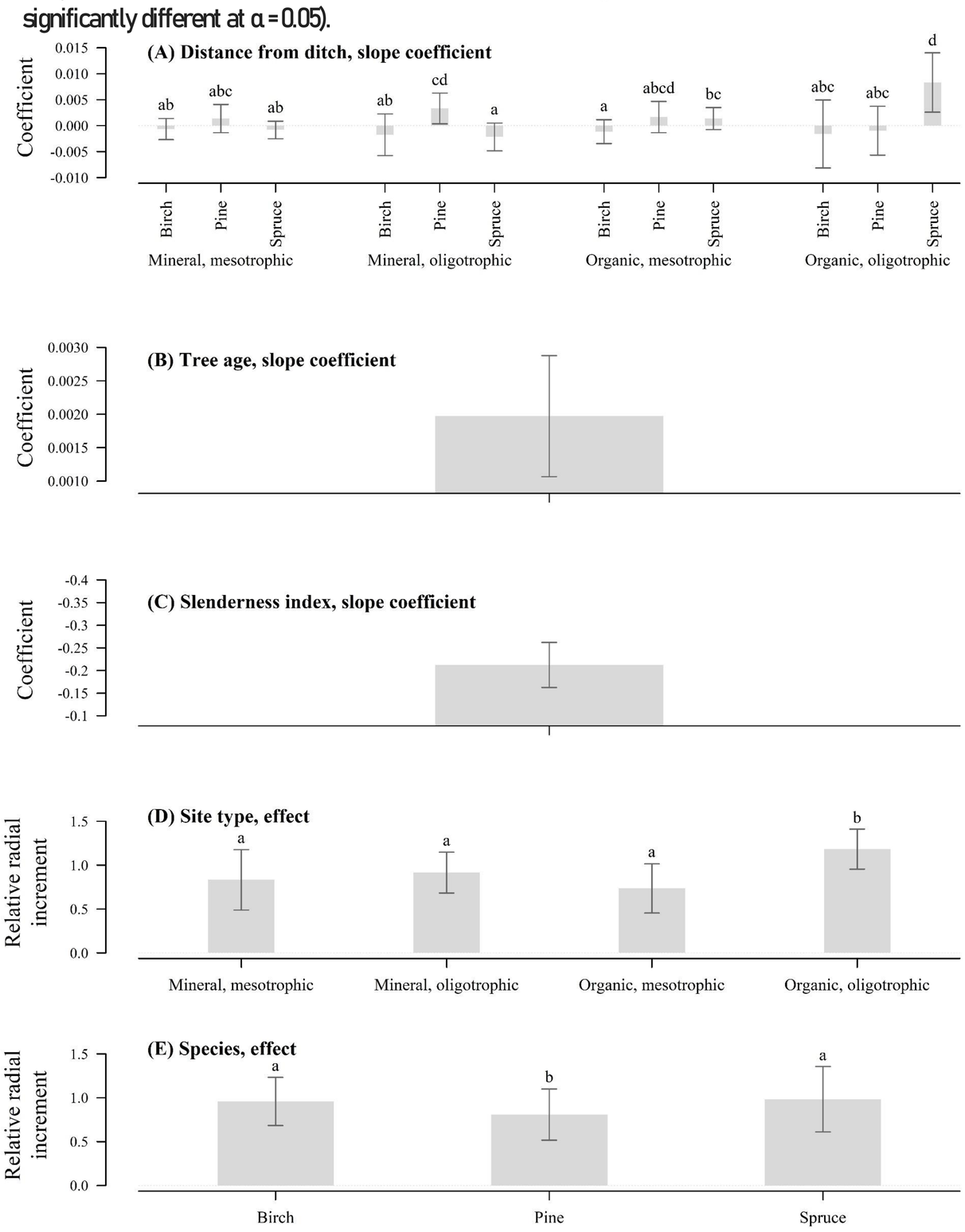
Materials and Methods

- The stands of each species were represented in three age groups: for pine: (1) 21–50 years, (2) 51–80 years, (3) 81–100 years; for spruce and birch: (1) 21–40 years, (2) 41–60 years, (3) 61–100 years.
- Dominant tree species of the stands comprised at least 60% of the canopy layer (by basal area).
- Two soil types (organic and mineral) and two fertility levels (oligotrophic and mesotrophic).
- 1036 increment cores were collected
- TRW was used as the proxy of growth. To evaluate responses of trees to DNM, relative radial increment was calculated as the ratio between the mean TRW 8 years before vs. 8 years after DNM.
- Tree slenderness index, calculated as the ratio of tree height (H) to DBH, was tested as an implicit proxy of stand density.
- A linear mixed-effects model (LMM) was used to analyze the factors influencing relative radial increment. Both tree-level and stand-level variables were tested. The effect of DNM was represented in the model by the distance of each individual tree from the ditch.

Results

- DNM had a significant, yet complex effect on the relative radial increment of tress, as indicated by a significant interaction between species-site type and distance to the drainage ditch.
- Local site-specific conditions have a greater influence on tree response than individual tree characteristics, likely due to soil properties and microrelief.
- In two specific cases—pine on mineral oligotrophic sites and spruce on organic oligotrophic sites—the relative radial increment increased significantly with increasing distance from the ditch (Fig. 1 A). This indicates a growth limitation for trees growing closer to the ditch, likely due to water shortage after DNM.
- Birch response to DNM showed no significant increase or decrease in relation to the interaction between site type and proximity to the drainage ditch, indicating greater plasticity to altered edaphic conditions.
- Age showed a positive influence on relative radial increment (Fig. 1 B). Even though the studied species differed by biological age, the estimated uniformed response suggests similar growth response under drained conditions.
- The effect of stand density on tree responses to DNM was implicitly supported by the significant effect of slenderness index (Fig. 1 C), as greater relative increment was observed in trees with smaller slenderness index values.
- The non-interacted effect of site type indicated that relative radial increment was significant only in organic oligotrophic soils, whereas other site types showed only minor or negligible increases following DNM (Fig. 1 D).
- The independent effect of tree species showed that all species tended to have a positive relative radial increment following DNM (Fig. 1 E), although this may be underestimated due to the increment comparison method, which does not account for the natural decline in growth expected in untreated stands

Figure 1. Tree species and age, site type, distance from the drainage ditch, and slenderness index effects (gray bars) on relative radial increment after DNM (Bars sharing the same lowercase letter are not significantly different at $\alpha = 0.05$).



Conclusions

In most cases, DNM had a generally neutral effect on tree growth, as the drainage network remained functional and maintained optimal soil moisture conditions. Although delayed DNM may lead to growth decline, high stand density (implicitly suggested by the effect of slenderness index) could partially compensate for elevated moisture levels. Although drought risk following DNM was not pronounced, some early warning signs were observed. Overly intensive DNM may reduce soil water availability, increasing the risk of drought stress in both drained peat and mineral sites. Although the applied DNM was largely balanced, to mitigate drought risk more effectively, future DNM planning should be more targeted, considering both tree species, stand density and site type.

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