Estimating development of aboveground biomass and its response to climate of Scots pine forests in Estonia

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1. Introduction

Global warming has become a major problem on a global scale. Increased occurrence of extreme climatic events in local environment has affected greatly natural and anthropogenic systems. In Estonia, resent increase in air temperature and occurrence of strong storms have been reported, but their impacts on the coastal forests are still not well understood. Boreal forests including Estonian forests contain 32% of carbon stored in the world forests. Boreal forests may be affected easily by an increase in air temperature, because they are adapted to cold conditions. Additionally, drought and storms accompanied by the warming can affect the forests. Therefore, Scots pine forests which are the dominant species in Estonia were chosen for this study. The main objective of this study was to identify the impact of storms on the forests and their response to climate variables.

2. Materials and Method

I established three research plots in Juminda peninsula, two in north and two in southwest of Hiiumaa island in Estonia. The dominant species was Scots Pine in each forest. I measured tree height and diameter at breast height. I also selected 6 to 8 Scots Pine trees in each plot and collected stem core samples at several heights. For the purpose of detecting the effects of storms, I measured aspect of leaning trees and collected stem core samples at about 15cm above and below the deformed or forked part of the trees. I applied the stand reconstruction method that utilizes stem analysis of selected individual trees and tree census at present, since historical census data of these forests were not available. Then, the aboveground biomass in the past was calculated through the stand reconstruction algorithm. We fitted several growth curves to the reconstructed aboveground biomass. The shift of the growth curve is considered to occur when inhibitory effects such as shortage in light intensity are removed. In this research, the s-w growth curve which involves several growth curves and can fits biomass growth flexibly was used. The index of estimated aboveground biomass was calculated with the growth curves and relationships between the estimated aboveground biomass and climate parameters were analysed through the response function analysis.

3. Results and Discussion

Wind is considered to have affected the trees because aspect of the leaning trees followed wind direction. Most of stem deformation and breakage of the trees occurred in 1870-1930 and the present stands started to grow from that time. Therefore, it is likely that the impacts of storms were huge around 1900 and they destroyed the trees and then new Scots pine forests started to grow. According to the growth analysis, many growth shifts of aboveground biomass occurred when the stands were younger than 60 years old. However, there were no growth shifts in stands (which are over 100 years old now) except one stand (which is about 200 years old now) after the stand age of 60 years. The results of response function analysis showed that one of the stands showed a positive response to February air temperature of the current year, but there are no significant responses to any climate parameters in the other stand($p<0.05$). Therefore, the problematic increase in air temperature may not affect the coastal forests directly. Storms are likely to cause disturbances when the forests are younger than 60 years old and affect less to those older than 60 years. However, storms may destroy the stands and create new stands when their frequency and strength are high.