

Regularities of Scots pine tree growth under recent environmental changes in Lithuania

Algirdas Augustaitis¹, Ingrida Augustaitiene¹, Gintautas Mozgeris¹, Romualdas Juknys², Adomas Vitas²

¹Aleksandras Stulginskis University, Kaunas dstr. Lithuania, LT-53362, ²Vytautas Magnus University, Kaunas, Lithuania, LT-46324,

Problem:

Climate is among key factors comprising the global change threat to forest sustainability. Through the direct effect on tree physiological processes, its impact on the distribution and deposition of air pollutants can alter air quality. Vice versa, pollutants can modify tree responses to the impact of specific climatic changes. However, implementation of the international legislation has led to significant reduction of the emission in Europe what could have stimulated forest condition recovery. Climate change, which in most cases is pronounced through the warming dormant period and re-distribution of precipitation amount could also have had additional effect on forest condition and growth. Therefore it is of paramount importance to develop reliable scenarios of climate change and air pollution effects on forest sustainability as well as their adaptation and mitigation ability.

Method:

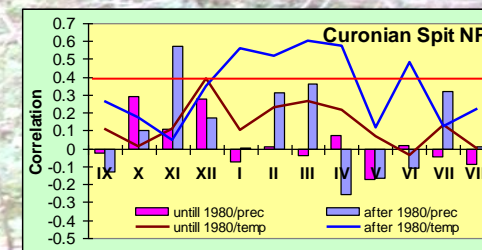
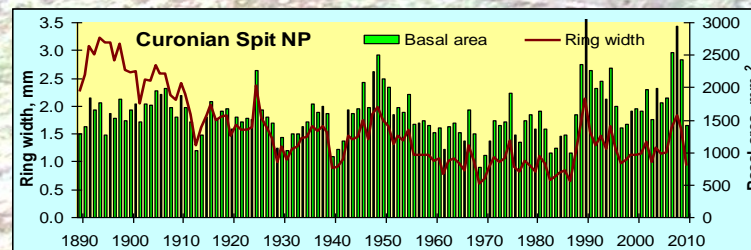
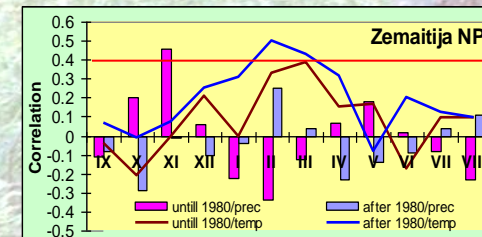
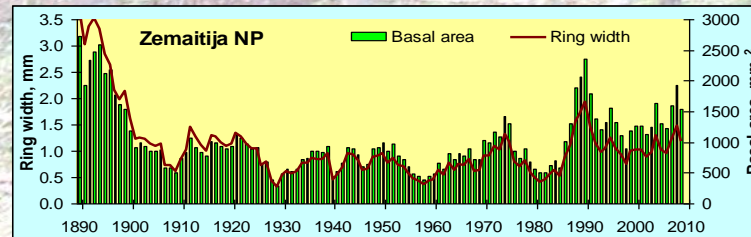
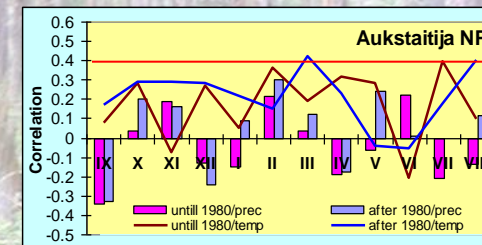
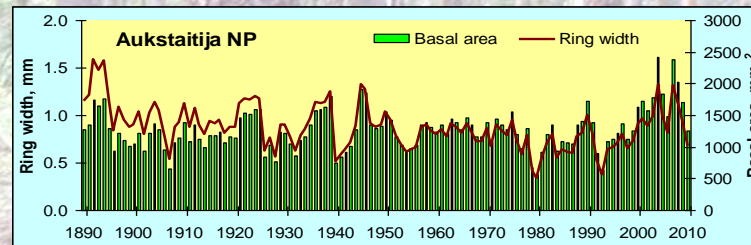
Data on meteorological parameters, air pollutants, and acid wet deposition were obtained from Aukstaitija and Zemaitija Integrated monitoring stations as well as from Preila EMEP station. About 100 monitored pre-dominant pine trees with upper crown standing above the general level of the canopy, and diameter of which at breast height exceeded 50 cm and age 120 years were selected at experimental sites to check the hypothesis of the study. A comparative study of the relationships between meteorological parameters and parameters of pine growth over two equal 30 year long periods (from 1950 to 1980 growth width showed a decreasing tendency while from 1980 to 2010 - an increasing tendency) enable to detect key meteorological parameters resulting in "V" form growth of pine trees in Lithuania. To assess the integrated effect of key meteorological parameters and air pollutants on pine stem annual basal area increment a method of multiple climatic response models was employed.

Results:

Time data series of the basal area increment of the monitored pine trees revealed stable or decreasing tendency until 1980 ($p < 0.05$), when after a significant increase was registered by almost 33 mm² per year ($p < 0.05$) in Aukstaitija NP; 24 mm² per year ($p < 0.05$) in Zemaitija NP and 25 mm² per year ($p < 0.05$) in Curonian Spit NP. An increased significance of the positive effect of mean temperature of the dormant period and negative effect of precipitation of September of two years period are mainly responsible for the intensive growth of pine trees over the last 30 year long period in Aukstaitija NP. Increased significance of the positive effect mainly of mean temperature of dormant period (from December through April) and June-July as well as positive effect of precipitation of November are mainly responsible for the intensive growth of pine trees in Zemaitija NP. The same parameters and increased positive effect of precipitation in July are mainly responsible for the intensive growth of pine trees in Curonian Spit NP. Precipitation amount was not key factor resulting recent intensive pine growth.

Conclusion. Key factors attributed to pre-dominant healthy trees which demonstrated intensive growth since the beginning of 1980 are mainly meteorological parameters and first of all air temperature of the middle dormant period (December - March, April) and the middle of vegetation (May-July-August). Effect of precipitation is less significant; meanwhile more abundant precipitation over July-August resulted in higher pine stem increment. No negative effect of higher air temperature over the vegetation period months was established. Decrease in sulphur air concentration and its deposition together with fertilization of growth condition by N species should reinforce the growth of predominant pine trees in Lithuania.

Hypothesis: Mean temperature and amount of the precipitation of different periods through the interaction with air concentrations of acidifying compounds and their deposition have additional effect on growth of the prevailing tree species in Lithuania - Scots pine.



Mean temperature of April, May through September of previous year and December through March of the current year together with precipitation amount of July through August of the current and previous seasons explained 52% variation in pre-dominant and over-matured pine basal area increment in Curonian Spit NP:

$$Zq = -97.1 + 1.7 \times Pr_{(VII-VIII)}^{-1} + 58.6 \times Tm_{(IV)}^{-1} + 82.8 \times Tm_{(V-IX)}^{-1} + 108.6 \times Tm_{(XII-III)}; R^2 = 0.522, p < 0.000;$$

Mean temperature from December through April and May through August of two seasons explained 41% variation in annual basal area increment variation in Zemaitija NP:

$$Zq = -848.1 + 47.5 \times Tm_{(XII-IV)}^{-1} + 87.9 \times Tm_{(XII-IV)} + 64.1 \times Tm_{(V-VIII)}^{-1} + 73.3 \times Tm_{(V-VIII)}; R^2 = 0.415, p < 0.000;$$

Mean temperature from July through August of the previous year, and temperature over December through March, and July through August of the current season together with precipitation amount over July - August of the current year and September of two seasons explained 42% variation of annual basal area in Aukstaitija NP:

$$Zq = -639.6 - 2.91 \times Pr_{(IX)}^{-1} - 2.58 \times Pr_{(IX)} + 1.23 \times Pr_{(VII-VIII)} + 67.9 \times Tm_{(VII-VIII)}^{-1} + 22.2 \times Tm_{(XII-III)} + 62.1 \times Tm_{(VII-VIII)}; R^2 = 0.416, p < 0.000;$$

Ammonium and sulphur deposition (Dep) with SO₂ air concentration explained about 40% variation of residuals of stem basal area increment when effect of meteorology was accounted for:

$$Zq_{resid} = -112.4 + 1.54 \times Dep(NH_4^+) - 0.609 \times Dep(SO_4^{2-}) - 57.6 \times SO_2; R^2 = 0.390; p < 0.004.$$

Meteorological parameters and acidifying species over their integrated effect on pine growth statistical significant explained up to 80% variation in recent intensive growth of pre-dominant healthy pine trees which age exceed 130 year.