

Forests, being an important part of the biosphere, help maintain ecological balance and provide the society with various ecosystem services. Up-to-date and reliable information on forest growth and condition is of fundamental importance for determining the capacity of forest ecosystems to mitigate climate change, quantifying carbon stocks in terrestrial ecosystems, and predicting the risk of forest decline. In recent decades, the observed climate changes and changing environmental conditions have had a major impact on forest ecosystems. Numerous observations and studies indicate a significant acceleration in the growth rate of temperate and boreal forests over the last 100 years. Global warming and anthropogenic pressure resulting from nitrogen deposition cause a high risk of imbalance in the natural dynamics of forests. Extreme droughts, unprecedented in the last century, which have been observed in recent years, combined with other factors, threaten the sustainability of forests. Therefore, research on the dynamics of forest growth in connection with health condition is needed. Despite the fact that recent research results indicate that there has been a drastic change in forest growth conditions over the last decades, growth models used in forestry often use historical observations, and therefore do not reflect the current conditions of tree growth.

The main objective of the proposed project is to analyse and understand the impact of various ecological conditions, especially climatic conditions, on the dynamics of tree growth and to develop modern methods for monitoring and forecasting the dynamics of forest growth in changing climatic and environmental conditions. The goal of the project will be achieved through the use of state-of-the-art technologies, including: Internet of Things (IoT) and remote methods of obtaining data about environment, i.e. remote sensing. The project will be carried out in a vast research area covering Poland and the Czech Republic, focusing on the two ecologically and economically most important species of coniferous trees in Central Europe: Scots pine (*Pinus sylvestris*, L.) and Norway spruce (*Picea abies* (L.) H.Karst). The analysis of data collected in Poland and the Czech Republic will cover the entire spectrum of environmental conditions for the growth of these species in Central Europe. As part of our research, we will seek to verify the hypothesis that climatic conditions, mainly rainfall, temperature and soil moisture, determine the growth of forests in Central Europe, but the reaction of stands and trees depends on the productivity of the site as well as the structure of the stand. So far, no such comprehensive research in this field has been undertaken.

The project assumes the use of observations collected at the DendroNetwork monitoring network existing in the Czech Republic and observations from an analogous monitoring network created as part of the project in Poland under the name IoTreesNet. The research plots that make up the discussed monitoring networks are (or will be) equipped with modern sensors operating in the frame of IoT, allowing for the collection in real time with an hourly time resolution of a number of key parameters in tree growth studies, such as: air temperature and humidity, temperature and humidity of soil and tree growth in thickness. Precise measurements of changes in the diameter of the trunk with an accuracy of a micrometre using automatic dendrometers will provide valuable data on the physiological reactions of trees to changing climatic and environmental conditions.

The proposed methodology for assessing the ecological conditions of forest growth by combining the cutting-edge IoT and remote sensing technologies on such a large geographical scale is a pioneering solution on a European scale. Measurements from IoT sensors will be combined with remote sensing data in order to be able to upscale measurements collected at the level of individual trees to the level of stands. As a result, the proposed method will allow for ongoing monitoring of forest growth dynamics on a regional scale, covering the area of Poland and the Czech Republic. The project will analyse various sets of remote sensing data, including multispectral satellite imagery and 3D point clouds acquired using airborne laser scanning (ALS) technology. The data at the disposal of the project consortium and collected as part of the planned research will allow for development of predictive models of forest growth with utilization of artificial intelligence methods.

The results of the project will contribute to the development of new knowledge in the field of ecology of the analysed forest-forming species and modelling of forest growth. Realisation of the project will also allow for expanding knowledge in the field of remote sensing applications in modelling forest ecosystems, with particular emphasis on satellite imagery and ALS data. Developed predictive models based on current observations will allow for reliable simulations of future forest growth dynamics for various climate change scenarios. Knowledge in this field is of key importance in forest research aimed at using forests to mitigate climate change by capturing CO<sub>2</sub> and adaptation of forests to these changes, and in particular the preservation of biodiversity while maintaining wood production and other ecosystem services in changing environmental conditions.