Lesnícky časopis - Forestry Journal

Správy – *Reports*

Scope and tasks of the research project "Effect of intra- and inter-specific competition on production ecology in beech and spruce stands"

Project objectives and scientific hypothesis

The scheme "*Effect of intra- and inter-specific competition on production ecology in beech and spruce stands",* TREECOMP, is a scientific project supported by the Slovak Research and Development Agency (Bratislava) in 2011. The participating organisation is the National Forest Centre in Zvolen and the operating period of this project is 42 months. The project began in July 2012 and is expected to close by December 2015.

The principal objective of the project is to investigate the effect of inter- and intra-specific competition in European beech and Norway spruce stands. The impact of competition on biomass structure and other morphological properties of tree species will also be examined. The project includes an investigation of the relationships between ground vegetation and tree species with emphasis on the regeneration growth stage of forest stands. Moreover, the competitions' effect of ground vegetation on tree species at their juvenile stages will also be investigated. In the synthesis of the results, the most significant competition indices will be identified. The effect of competition on the production pattern of beech and spruce stands and their static stability will be reported.

In fact, although significant attention has been paid to the issue of competition in forest stands for some time, there are many unresolved and unexplored issues. There exists a general lack of research focused on the youngest growth stages of forest stands (advanced regeneration and thicket). In Slovakia, a noticeable lack of studies focusing on inter-specific competition and competition between tree species and other non-wooded vegetation (shrubs, herbs, grasses, etc.) is present, especially in the belowground part of forest ecosystems. The task at hand is to study growth strategies (i.e. biomass turn-over) of beech and spruce in terms of carbon fluxes. Hence, the forest community is regarded here as a tool for affecting the carbon fluxes rather than only being a passive entity subjected to climate change.

Competition relationships of older trees and stands will be evaluated by employing up-to-date scientific methods based on a clear quantification (competition indices), into which the measured empirical values of the competitors will be entered, including the environment. Advanced geospatial information will be used which, as an improvement on conventional surveys, will also contain clear localisation (position of the trees) at the local level (within a particular research plot) and regional level (within the study region).

The project will test the following scientific hypotheses or issues:

(A) Different sociological position of spruce and beech trees in a stand affects tree biomass distribution.

(B) Different sociological position of spruce and beech trees in a stand affects their growth efficiency.

(C) What is the ratio of below ground and above ground biomass, size and density of leaves (needles), the vertical distribution of leaves of beech and spruce at varying competition degrees?

(D) How are the length, crown width, height-to-diameter ratio, and stem shape of spruce and beech trees changing?

(E) How abiotic factors and environmental conditions affect the competition in spruce and beech stands?

(F) How do the competition relationships differ between trees and other types of ground vegetation in mature stands at the time of regeneration and on clear-cut areas?

(G) What is the development of vegetation on clear-cut areas and its competition effect on the initial growth stages of beech and spruce stands?

(H) How do the different bio-sociological status of spruce and beech trees affect the growth dynamics (dendrochronological analysis)?

(I) What is the vertical, horizontal distribution and morphological characteristics of coarse and fine roots of beech and spruce trees at different growth stages and different sociological positions?

Structure and tasks of the project

The project will be divided into four main sub-tasks. The first three sub-tasks will be handled during the initial 36 months. These will comprise of the collection of empirical material and its on-going analysis plus initial interpretations. The remaining sub-tasks will be continuously performed in a responsive mode to information generated by the previous sub-tasks, but mainly in the latter 12 months on the project. This sub-task will be a mostly analytical and synthetic one, where the data from previous sub-tasks will be integrated into existing knowledge taken from other research teams.

Subtasks of the project are as follows:

1) Intra- and inter-specific competition relationships of beech and spruce in their initial growth stages.

Research will focus on initial growth stages of natural regeneration such as seeding, advanced regeneration, and thicket. Stands in these growth stages are often dense and inter- and intra-specific competition dynamics are the most intense. There are significant inter-annual dynamic changes in the number of competing individuals and relationships that significantly modify the size of trees, the proportion of total biomass components, as well as their morphological (e.g. size and density of assimilation organs) and physiological (e.g. the growth efficiency) properties.

2) Intra- and inter-specific competition relationships in older beech and spruce stands.

This phase will be focused on the investigation of older growth stages such as small pole stage, pole stage, and large-diameter stands. The competition at these stages is thought to be less dynamic. Contrary to the young stages, due to smaller stand density, these stands facilitate investigations of mutual relationships between neighbouring trees employing various competition indices. In this phase, we will perform dendrochronological analyses to study competition patterns.

3) The competition effect of ground vegetation on beech and spruce growth at their juvenile growth stage

The investigation will be focused on growth stages, which are most important in terms of tree species regeneration. The removal of a mature stand is at the moment when the ground vegetation wields the greatest competition power. The competition relationships between ground vegetation and tree species will be evaluated in both mature stands before harvest, as well as on clear-cut areas. The competition in the below ground part (rhizosphere), will also be analyzed.

4) Synergistic relationships between inter- and intra-specific competition in beech and spruce stands and its environment in relation to the growth and production of the species.

This sub-task will be performed as a synthesis of previous stages. It will mainly evaluate the production aspects of beech and spruce stands with regard to the competition relationships in the stands and its ecological conditions. Methods of geostatistics and mathematical modelling will be employed here. The investigation of the static stability of the beech and spruce stands regarding to competition relationships and ecological factors will be a part of this phase.

Project materials and methods

Part of the research activities will be focused on young forest stands, in particular the following growth stages: advanced regeneration (mean height of stand ranges from 50 to 150 cm) and thicket (mean height over 150 cm and mean thickness lower than 5 cm). In the case of stands from natural regeneration, the competition is very high, especially in young growth phases due to the very high stand density. The study area comprises 20 research plots established within research project APVT-27-023504 "The quantification of 1st age stage forest stands biomass", 10 of them are located in young (thicket growth stage) pure spruce stands and 10 in pure beech stands. 5 circlular subplots containing at least 30 tree individuals were established in each stand. Each tree is labelled by an identification number. The tree height, diameter, crown base height and crown projections will be measured within these subplots once a year. Furthermore, the assessment of bio-sociological positions of tree individuals will be carried out. Assimilation organs will be sampled in order to derive the leaf area and its specific weight. Whole trees, including belowground parts, will be taken and analyzed. Tree samples will be divided into the following components: assimilation organs, branches, stems and roots. All component samples will be dried and weighed. Afterwards, the weight of components in standing individuals will be derived using allometric relations with tree height and thickness as independent variables. The differences in allometric relations between tree data sets of different bio-sociological positions will be compared, as well as differences in morphological properties of leaves, such as leaf area, weight and specific weight. Allometric relations of total leaf area and growth efficiency (production of each woody part per unit of leaf area) will be derived for trees of different bio sociological positions.

An essential part of the study system of competitive relations in young forest stands will be the research site "Vrchslatina", where 5 plots in beech and 5 in spruce stands were established prior to this project. In these plots, the same procedures as described above will be followed, plus additional measurements of production ecology and physiology will be carried out. We will also consider 5 plots colonized by non-woody communities dominated by *Calamagrostis epigejos* at this site. Such communities have developed after forest harvest on sites where regeneration of trees was not successful. The competitive relationships will be investigated between these communities and young tree stands.

The proposed research will also focus on competition in the rhizosphere. The following methods will be applied: ingrowth bags, soil cores and a system for scanning of roots (CI-600 Root Scanner). The combination of these methods provides a dependable evaluation of biomass, its distribution, production and morphological and physiological properties of fine roots. We will also have an opportunity to investigate the competition among roots of plant species. One of the possible approaches, called "gradient approach", is defined as an assessment of root properties within the ecoton of two ecosystems.

For the investigation of competitive relations at older growth stages, we will firstly search for available and suitable data within existing databases of research plots. The plots have to meet certain conditions for the study of competition: the species composition has to be composed of beech and/or spruce, the plot has to contain information about the position of trees, dendrometric measures and site conditions. Within selected plots the various parameters of bio-sociological positions will be evaluated, such as distances between neighbouring trees, and indicators of competitive pressure. In order to investigate the influence of competition on growth changes, dendrometric parameters must have been measured repeatedly (with at least 10 years' time lapse). Several characteristics of individual tree growth with focus on mortality, diameter, height and biomass increment, will be evaluated. A tree core sample will be taken for dendrochronological analyses to investigate the long-term influence of competition on growth and development of individual trees in regard for changes in climate. The tree height, tree crown length and width, height-to-diameter ratio and further parameters will be analyzed.

The competitve relations between trees and ground vegetation will be investigated at two levels: i) regeneration and development of tree juveniles under the mature stand and ii) within forest cutting areas. Research methods in belowground environments have already been mentioned (ingrowth bags, soil cores and root scanning system). The assessment of plants' competition above ground level will be based on data from species composition and biomass sampling. Data acquisition will be carried out on small square plots (approx. 1 m^2), located in the sufficient number and design within the same plots used for the research at tree level. Use of such an overlaying approaches of sampling, guarantees the compatibility of all research data. In the case of stands at older growth stages, due to the existing knowledge of adult tree positions and dimensions, it will be possible to analyze the influence of forest stand structures on ground vegetation and tree regeneration. In the case of young growth stages, the plots will be located parallel to tree plots. This ensures the possibility of investigating the development of different communities within the same site conditions. On each plot, species' presence and abundance will be assessed, as well as its biomass. The succession of vegetation after the forest harvest or after the creation of new canopy gaps is usually a very fast process. In order to assess this process and changes in competitive relations, plots will be established in different developmental stages and repeatedly sampled at higher frequency. In addition to small plots, we will also apply research at larger scales. Within squares 30×30 m in size established at selected locations, details of occurrence of species will be recorded each year. By comparing such vegetation maps, the interactions among species in space and time will be evaluated.

In the synthesis phase, productivity patterns of beech and spruce stands in regards to growth conditions (competition) and characteristics of the abiotic environment (soil and climatic conditions) will be interpreted. Here, methods used in geostatistics and mathematical modelling will be employed. The investigation of the static stability of beech and spruce stands as affected by competition relationships and ecological factors will be analyzed.

The competition relationships between trees and its competitors will also be derived by using the simulator Sibyla. The model not only evaluates the competition relationships between individual trees but also between tree species. Moreover, it also takes into account the competition in the crown part of trees. The model is based on the CCL index calculation, having first defined a $Beta_{ij}$ competition angle for each tree and its potential competitors. $Beta_{ij}$ angle is based on the competition light cone, depending on tree species.

Indices that are independent of distance and position of trees and their neighbors will be used only when a stand is consisting of trees with uniform spatial distribution and homogeneous in height and diameter. When a stand has a high variability of height and diameter with asymmetric spacing of trees, distance dependent indices will be mainly used. Some indexes take into account the different weight of the competition effects of competitors' diameter and its distance so that the parameters are placed in the exponent. These parameters should be derived in the first step through the analysis. The height of competitors will also be tested as an additional parameter indicating the size of competitors.

The empirical material will come from various sources that meet the requirements for the analysis of competition relationships at tree level (dendrometric measurements of trees with their positions). The largest database is a database obtained from the National Forest Inventory and Monitoring (NFIM) of SR, which was carried out in 2005 and 2006. It consists of 1 419 plots. Of this number 600 plots will be used for the analysis. We also have data from 120 research plots with a predominance of spruce and beech in the Low Tatra Mountains, which were established during the project "Research of management methods for high mountains on the principle of sustainable development" (1999 – 2002). Moreover, the plots of the level II in the programme of Monitoring of health conditions of Slovak forests will also be used here.

Acknowledgement

The study is supported through the project "Effect of intra- and inter-specific competition on production ecology in beech and spruce stands" APVV-0273-11 awarded by the Slovak Research and Development Agency.

Vladimír Šebeň[1], Bohdan Konôpka[1,2]

[1]National Forest Centre - Forest Research Institute Zvolen, T. G. Masaryka 2175/22, SK – 960 92 Zvolen, e-mail: seben@nlcsk.org, bkonopka@nlcsk.org

[2]Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Kamýcká 129, CZ – 165 21 Praha 6 – Suchdol