Development of Fir Trees in Mixed Forests of Spruce, Fir and Beech (Piceeto-Abieti-Fagetum) on Mt. Ljubišnja

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Abstract

In order to analyse the developmental characteristics of individual fir trees (*Abies alba*) in tri-dominant forests of beech, fir and spruce (Piceeto-Abieti-Fagetum s. lat.) on Mt. Ljubišnja, eight dominant fir trees were felled.

Felling four trees from the experimental field that has been set near the village of Vrba (Vukodol site), which is on a limestone base, and four trees from experimental field in the vicinity of the mining village of Sula, situated on basic eruptives, together with further stem analysis of such trees, gave us important conclusions about the basic characteristics of fir growth in these forest communities. This provided insight into the relations and impact of habitat characteristics to the development of fir trees in mixed stands of beech, fir and spruce on Mt. Ljubišnja.

By studying the pattern of development of those trees, it was determined that the slow growth (so-called vegetative time) period lasted longer in trees from the Vukodol site, on the limestone soils.

The results confirmed that fir trees at a very advanced age could have a good height and volume increment. The average increment of fir culminated very late. These facts may be applicable in designing management goals for these and similar stands.

Key words:Dominant species, Fir growth, mixed forest

1. INTRODUCTION

Tri-dominant forests of beech, fir and spruce (*Piceeto-Abieti-Fagetum* s. lat.) are of great significance for science, as well as the practice. Taking into account the importance of mixed forests of beech, fir and spruce, they should be protected from further deterioration in future. The forest eco-systems of Mt. Ljubišnja in Montenegro (fig. 1.) are typical representatives of massifs rich in high mountainous, mixed deciduous-coniferous forests. For that reason, these forests were selected for the groundwork of this research. These are high quality forests with highly valued timber volume in which all three edificators achieve large stem dimensions, both in height and width, and most of them live to an old age. In pilot plots at Vukodol site the quantity of standing volume in average is 404 m^3/ha with the biggest standing stock in diameter level of 47.5 cm. At Sula site it was recorded higher values for volumes of trees per unit of area, which in average is 584 m^3/ha with the biggest standing stock in diameter level of 67.5 cm (Čurović et al. 2011).

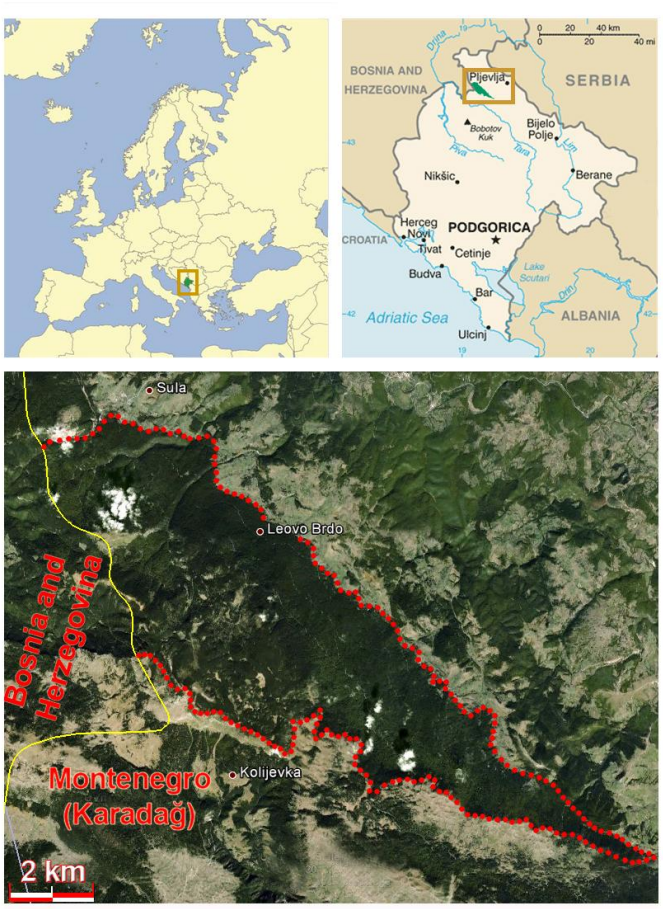


Image 1. Position of the studied area

The stability of these stands, according to Hartman (1999), is reflected in the ability of beech to act like alabaster and fill in the gaps that result from the death of certain trees, and in the extraordinary ability of fir to persist in shade, interposing itself among the shoots of the beech. Fir trees can stay in a latent state for up to 300 years (Banković et al. 1994). On the basis of 230 trees felled in selection stands in Serbia, Pantić et al. (2011) stated that the duration of the vegetative time for fir trees on Mt. Goč was up to 330 years, while the stagnation stage on Mt. Tara was up to 185 years. It is clear from the structure found through irregular selection that it is supported by fir and beech, while presence of spruce makes possible more rational utilization of the habitat's production (spatial) potential.

The fastest growth in early stage was recorded with beech and the slowest with fir. Even as sapling, the beech shows in average higher horizontal projection and crown volume in comparison to fir and spruce. Higher density therefore contributes to the fir abundance and maintenance, whilst lower density is more favorable for beech, which is more heliophilic

Studying of the pattern of stem development, as well as observing the stands in general, reveals, primarily, the biological features of certain tree species and their productive capacity. Such studies, in addition to their theoretical importance, also have significant practical importance: they are an important component in determining the most favorable management practices (Banković and Pantić 2006).

2. Materials and work method

Stem analysis is a procedure used to establish the stem growth in the past by directly measuring accumulated increments height and thickness.

Eight permanent experimental plots (0.2 - 0.5 ha) were set up, of which four are on sites with limestone and four are on sites with silicate soils (Fustic and Djuretic 2000.). Four experimental plots (1-4) were set up in the south-east part of Ljubisnja (Vukodol site), which is on limestone soil, and the other four (5-8) were set up in the vicinity of the miners' settlement, Šula, where basic eruptives occur as parent substrate on the north-west part of Ljubisnja. In these sites (Vukodol and Šula) a pedological profile was opened, in order to obtain more exact data on soils.

The main criteria for selection of stands where the permanent experimental plots were set up was that they had to be among the best stands for a specific environmental unit (homogeneous, and with optimal inventory size and structure) and that all of them, under all separate environmental units, were at approximately the same developmental stage (Jović et al. 1991). In the process of selecting the experimental plots, care was taken to ensure that the conditions of homogeneity of habitat and stand circumstances were met.

For the purpose of analyzing the developmental features of individual stems, one medium dominant tree of each of the species represented was felled from each of the permanent experimental plots. These were stems of extraordinary age and dimensions. The fir trees were up to 300 years of age, while the spruce trees were over 250 years old.

Image 2. Samples for analysis of a stems

Round cross cuttings (tree cookies) were analyzed, taken at heights of 0.30 m, 1.30m, and 5.30m, and then at every 2 meters to the top of the stem. The data obtained were processed with support from specialized data processing programs adjusted to "Apple Macintosh" personal computers at the Department for Increment, Technical University Munich.

The analysis establishes the dimension and the volume of the stem at the end of certain life stages. The recommendation of Husch (1963) was accepted, according to which forming and marking of ten-year periods in cross sections are done from the periphery towards the centre. In that way, the oldest (central) period at the cross section remains largely incomplete.

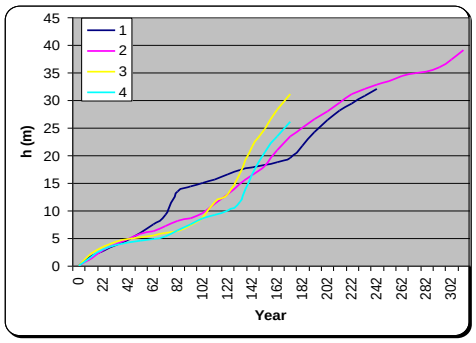
Although applicability of this method was disputed in the United States because, according to Meyer (1953), analysis of one or several stems is not enough to establish with adequate confidence the patterns of increment of a stand, and hence it is not possible to make development forecasts; this has been the most frequently used method, and the one still applied in European forestry science and practice, where it is considered the most accurate method for determining the

development and increment of volume and its elements during the whole lifetime of a tree.

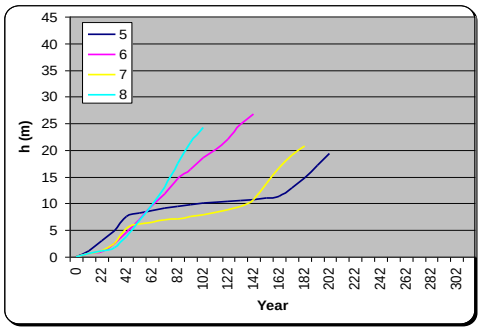
The significance in difference regarding the development trends of breast diameters, heights and volumes in the first 100 years of analyzed fir stems from different sites was calculated in an objective manner, by application of t-test. Statistical significance threshold was α = 0,05 (level of error is equal to or less than 5 %).

3. Results and discussion

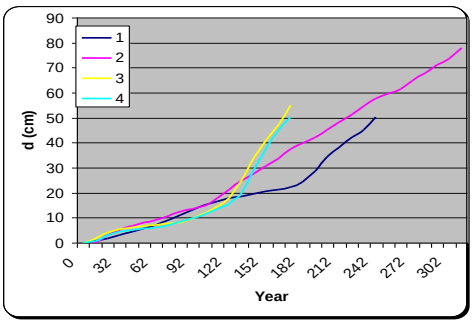
Lines of fir height development basically have shapes of slightly or strongly broken polygons. At the Vukodol sight (graph no 1), the period of slow growth (70 years) was followed by a continuous growth with clearly pronounced upward trend in experimental plots 1 and 3. All experimental plots showed pronounced height increment in the "waking up phase" of analyzed stems, i.e. after vegetation stage. It takes 160-220 years to reach dominant height values (>30m). At the Šula site (graph. no 2), the period of vegetation was shorter (up to 30 years) in experimental plots where the upper canopy has no spruce (6 and 8). Lines of height increment of the stems analyzed at these experimental plots had almost continuous, clear growing flow. The stems from the experimental plots 5 and 7 showed clear growth stagnation in the period from 40th to 140/160th year, most likely due to the unfavorable spatial positions of stems. After this period, these stems also showed visible and intensive height growth.



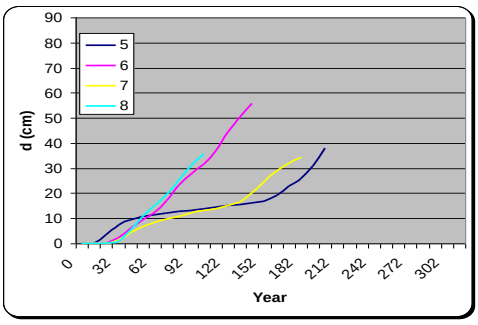
Graph 1. Height development – Vukodol



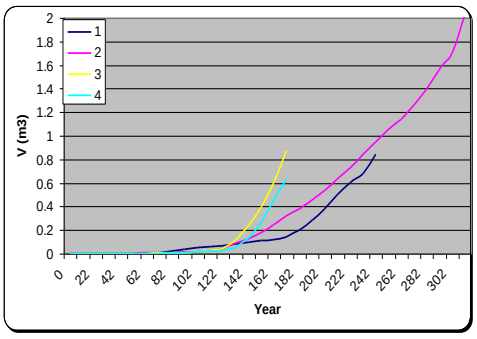
Graph 2. Height development – Sula



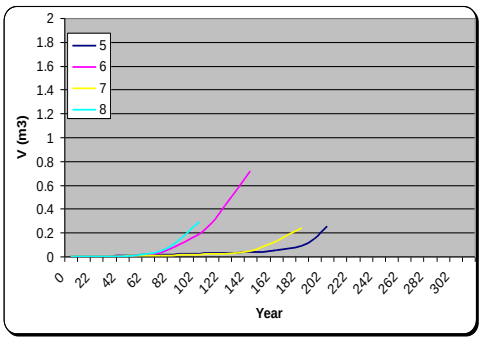
Graph 3. Breast diameters development – Vukodol



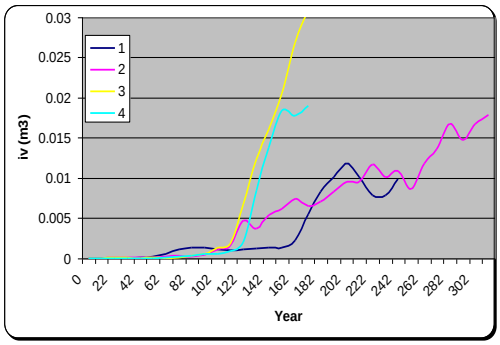
Graph 4. Breast diameters development – Sula



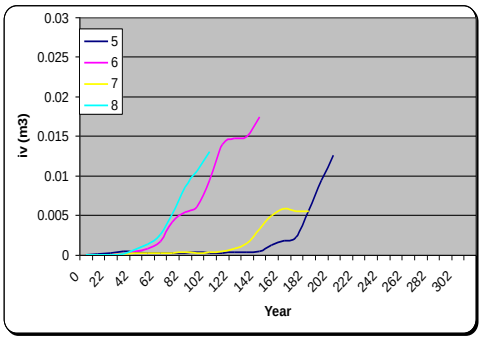
Graph 5. Volume development – Vukodol



Graph 6. Volume development – Sula



Graph 7. Volume increment – Vukodol



Graph 8. Volume increment – Vukodol

Lines of breast diameter development of firs at the Vukodol site (graph 3) have almost identical trend until the age of 120 years, with slight growth. This period was continued by a pronounced upward trend of the same lines of fir stems from experimental plots 3 and 4. The stage of slower growth of fir 1 diameters lasted up to 180 years, followed by a phase of more intensive thickness development. The analyzed fir stem from experimental plot 2 was characterized by quite balanced upward flow of the breast diameter development line after the 120th year. It took between 150 and 240 years for analyzed fir stems from the Vukodol site to reach a breast diameter (without bark) of 50 cm.

At the Šula site (graph no 4), breast diameter development lines of fir from experimental plots 6 and 8 had almost continuous, clearly pronounced growing trend. The analyzed fir stems from experimental plots 5 and 7 showed from the 30th, respectively 40th, until 130th, respectively 150th year, a significant stagnation in thickness development. This period was followed by more intensive growth of breast diameters of these stems.

Among all dominant dendoflora elements, the period of slower growth, so-called vegetation stadium, can be most clearly noticed on volume development lines of fir. At the Vukodol site, all stems were characterized by low volumes (graph no 5). This period was followed by a clearly noticeable upward trend as regards the volume development lines of fir 3 and 4, whilst the increase of volume of fir 2 was less intensive. A pronounced upward trend of fir 1 volume increase can be noticed only after 180 years.

At the Šula site, vegetation period lasted shorter for fir stems from experimental plots 6 and 8 and upward trend of volume development was noticed immediately after 70-80 years. “Waking up" of stems from experimental plots 5 and 7 was noticeable only after 160-180 years (graph no 6).

Joint characteristic of analyzed fir stems from Vukodol site in the first 120 years is the exceptionally low value of current volume increment (graph no 7). This period was followed by a pronounced increase of increment value, particularly with firs from experimental plots 3 and 4. The line of current increment of fir 2 after the 120th year has unequal, wavy, upward trend, while the increase of the stated curve is pronounced with fir from experimental plot 1, but only after the 160th year.

Firs from experimental plots 5 and 7 on the Šula site (graph no 8) clearly show upward trend of current volume increment even after the 50th year. Firs 6 and 8 had exceptionally low values of current volume increment befor the 140th, respectively 160th year.

The researches of development trends of breast diameters, heights and volumes of analyzed fir stems (as the most dominant specie) from different sites showed that there are statistically significant differences.

Significant differences in height of firs from the Šula site and Vukodol site were determined at the age of 12, 22, 52 and 62. Due to the slower growth of stems at the Šula site in the first 30 years, where only one analyzed stem reached the breast height (1,30m), the significant difference in breast diameters was determined only after this period. The determined differences proved, by the t-test, to be significant at the age of 52, 62 and 72. The researches of differences in volume development trends of firs from these two sites showed that volume values at the 52nd and 62nd year of life of the analyzed stems were statistically significant.

4. Conclusions

Some of the characteristics of analyzed stems are as follows:

- The lines of height and breast diameter development of fir from the Vukodol site show a high level of correspondence with the duration of vegetation stadium from 120-170 years.
- At the Šula site, the fir development curves significantly differed depending on the presence of spruce at the upper canopy. It was noticed that at experimental plots where there is no spruce, the firs grow faster and vegetation stage lasts around 80 years. The vegetation stage on experimental plots 5 and 7 lasted even over 170 years.
- The results confirmed that fir is a species that has a good height and volume increment at an advanced age.
- The wavy flow of curves in the current volume increment can explained by occasional deterioration of the canopy, releasing the trees in shade and re-establishing of the full plant density by extension of the crowns of overstory trees.
- The researches of development trends of breast diameters, heights and volumes of analyzed fir stems (as the most dominant specie) from different sites showed that there are statistically significant differences. After the 52nd year of age, the differences in intra-group and intergroup variations proved to be statistically significant in respect to the structural elements.
- The analysis of fir stem developments at the subject sites showed exceptional tolerance of fir to the upper canopy. Such characteristic is very useful for the forest management in practice when determining the intensity of selected felling in respect to certain levels and classes.

The research of the flow of growth and attainable dimensions of concrete dendroflora elements, in this case of fir, in forests with preserved stands as in Mt. Ljubišnja in Montenegro, doubtlessly contributes to setting the objectives of forest management in this and similar forest communities.

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