STRUCTURAL BIODIVERSITY OF THE BEECH TREE STANDS FROM THE NATURAL RESERVATION DRAGOMIRNA (SUCEAVA COUNTY)

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Abstract

The article shows that the biodiversity of the beech stands from Dragomirna reservation consisting of even-aged stands is low. The structural biodiversity in relation with tree diameter, height and volume is presented. The analysis of the opportunity for ecological reconstruction is recommended selecting the adequate treatments with continuous period of regeneration, maybe afforestation works with local seedlings, so that the valuable gene fund of the reservation may last.

Key words: biodiversity, stability, statistical analysis, natural reservation, beech tree.

INTRODUCTION

Of the many definitions of biodiversity we will use the most synthetic one developed by N. Botnariuc (2005):"the totality of the life forms by which the living matter manifests at the individual, populational, biocoenotic and ecologic level".

Aside the fact that biodiversity manifests at the general level, at all level of matter organisation, lately there is increasing talking about other forms of diversity: the structural diversity, the functional diversity, the geographical diversity, the diversity of landscapes and even the aesthetic diversity (Bandiu, 2009, 2011; Institute of Biology, 2001) etc.

Consequence of the biological diversity, the structural diversity appears at all levels of the living matter organisation, but it is more important at the supraindividual levels, playing its role in the composition of the trophic chains and in the occupation of the ecological niches. In the case of the forestry ecosystems, this is expressed by the system of dendrometric variables of the trees and tree clusters (diameter, height, age, composition, manner of grouping, density, etc.) (Giurgiu, 1979), by the floristic composition (trees, shrubs, grasses, moss, etc.), as well as by the fauna, soil, litter and canopy elements (Donita et.al., 1977).

The functional diversity or the diversity of the ecological processes defines the variety and complexity of the processes taking place within a biological system due to the interactions between the composing elements of that particular system.

Other types of diversity (topic, geophysical, of the landscape, cultural) are revealed with specific indicators, either dimensional, or qualitative.

Judging the forest ecosystems from Romania by the Shannon/Weaver synthetic informational index, N. Donita et al., (1977), V. Soran noticed that biodiversity decreases from beech forests to spruce fir forests, from hill altitude to mountain and subalpine altitude, from a moderate humidity to an abundant one.

MATHERIAL AND METHOD

The investigations were conducted within the Forestry Directorate of Suceava County, UPV Dragomirna, u.a. 14 B. For the accomplishment of the proposed objectives, two permanent trial plots of one hectare each were determined. These trail plots had a permanent character (Dragomirna 1 and Dragomirna 2).

The organisation of the data collection activity required a proper documentation which presumed a survey of Patrauti forest administration unit (Suceava County) arrangement and the identification and localization of the beech (*Fagus sylvatica*) forest reservation Dragomirna.

The location of the areas, the delimitation and inventory of the trees from the experimental plots was done in agreement with the established methodology for the study of forestry ecosystems, using phytocoenotic profiles (Popescu-Zeletin, sub red., 1971). The experimental plots have been delimited by stakes at their corners and divided in 10 × 10 quadrates using poles.

Each tree within the experimental plot, having a basal diameter larger of 4 cm was marked with a number in dye and was recorded in the field log: species, diameter at 130 cm, total height (m) on two 10 × 20 bands, Kraft class, quality class, canopy diameter (m), Cartesian coordinates (x, y) for each tree, the health state (growth defects, cracks in the wood, rotten parts, scratches, knots, Chinese tendrils). The data were recorded and processed statistically using the methods used in forestry research.

RESULTS AND CONCLUSIONS

a. Structure of the beech stands in relation with the diameter

We attempted to determine the manner in which the trees are distributed, within the beech stands from the two trial plots, in relation with their diameter, using the distribution functions β (Beta) and γ (Gamma). Following we will present the adjustment of the experimental distribution according to β law (Dragormirna 1) and the adjustment of the experimental distribution according to γ law (Dragormirna 2) (Giurgiu, 1972). (Figs. 1 and 2).

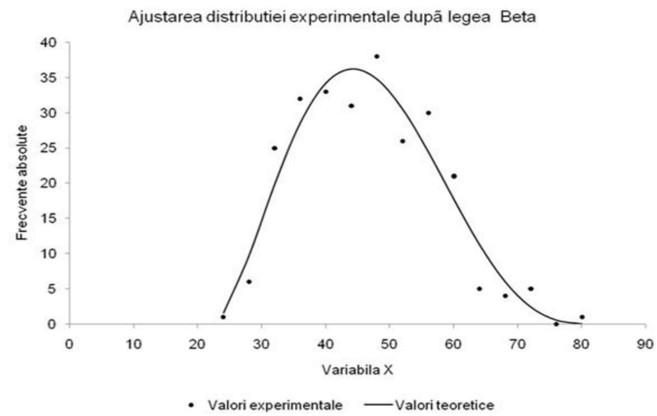

Fig. 1 Comparison of the experimental distribution of the trees by category of diameter, for the trial plot Dragomirna 1 with the theoretical distribution function Beta (χ^2_{exp}=3.9; $\chi^2_{theoretic}$=12.6; it results that $\chi^2_{exp} < \chi^2_{theoretic}$)

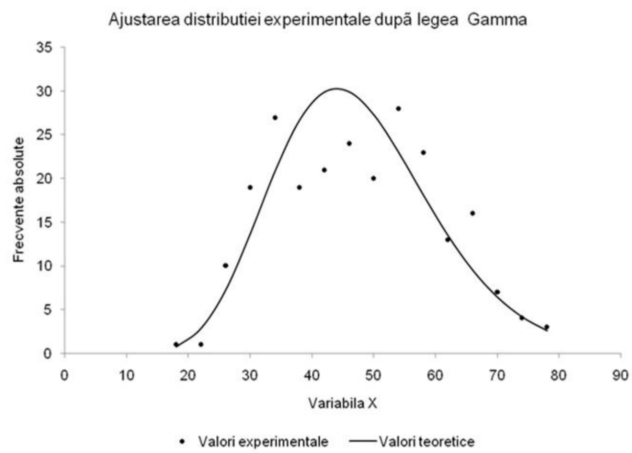

Fig. 2 Comparison of the experimental distribution of the trees by category of diameter, for the trial plot Dragomirna 2 with the theoretical distribution function Gamma (χ^2_{exp}=1.671; $\chi^2_{theoretic}$=22.362; it results that $\chi^2_{exp} < \chi^2_{theoretic}$)

Table 1 shows the main indicators characterising the experimental distribution.

Table 1

Main indicators of the experimental distribution.

Dendrometric trait	Experimental plot	
	Dragomirna 1	Dragomirna 2
Mean (cm)	46.42	47.56
Variance (cm^2)	107.97	170.94
Standard deviation (cm)	10.39	13.07
Coefficient of variation %	22.39	27.49
Standard deviation of the mean (cm)	0.65	0.85
Index of asymmetry	0.36	0.15
Index of excess	-0.32	-0.81

Analysing the obtained values, we may say that:

- The experimental distributions *display a positive left asymmetry*, the index of asymmetry varying between 0.15 and 1.36, which is significant.
- For all the studied cases the *index of excess is negative*, the form of the curve being platikurtic in this case.
- The coefficient of variation ranges between 22.39 and 27.49%. A reduction of the diameter variation from the first trial plot to the second one was noticed; this is explained by the lower number of trees in Dragomirna 2 that were measured (236), compared to Dragomirna 1 (258) (Roibu, 2010).
- In most situations there is a proper similitude of the experimental distributions and the *β distribution*, characterising the beech stands in relation with the tree diameter. This type of distribution *reflects the structure of the beech stands in the horizontal plan and characterizes the relations of competition* (intraspecific in this case) *as effect of the position which the trees have within the stand*. The β distribution shows, however, that some *stands are balanced.*
- For the tree stands from the two trial plots Dragomirna 1 and Dragomirna 2, the *distribution of the trees by diameter category is typical for the even-aged tree stands*. The theoretical distribution type A-Charlier (Fig. 3) shows that the left asymmetry is not exaggerated, close to the Charlier distribution, which shows that *the trees have about the same age* and that the coefficient of variation is rather high.

The site is favourable to the mixture of common oak, beech and oak trees, but the lack of proper management measures caused alterations of the composition, which tends towards a pure beech stand (no maintenance works were performed in good time to favour the common oak and other species; rather, plantation of resinous trees (spruce firs) were performed over the beech trees seedlings, which is inadvisable).

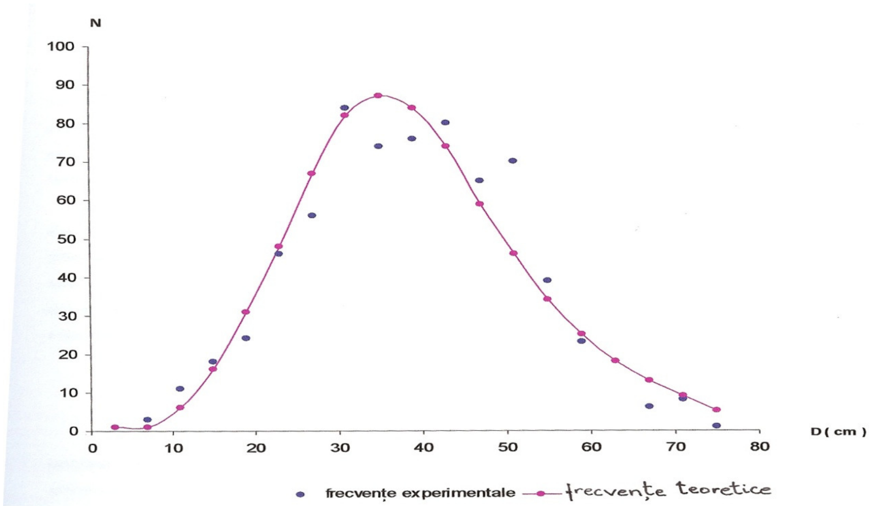

Fig.3 Graphic comparison between the experimental distribution of the trees by diameter and the theoretical Charlier type A distribution

- The Charlier distribution proves statistically that the tree stand is rather even-aged, which resulted from a treatment with a short or medium period of regeneration.
- The attempt to transform this rather even-aged structure into a pluri-aged structure would presume a very long period of transformation (at least 60 to 80 years), but because the forest is protected by a special state of conservation, this problem should not be raised for the time being. This matter could be eventually raised when the forest would be menaced by degradation due to excessive old aging (Seghedin, 1998).

b. Structure of the beech stands in relation with their height

The way in which the trees are distributed within the stand in relation with their height was evaluated using the β function of distribution. The main indicators of the height distribution show: a right negative asymmetry (as shown by the agglomeration of the trees in the upper level because of the competition for light); the coefficient of variation is rather small, which shows a high variation of the heights (χ^2_{exp}=3.9; $\chi^2_{theoretical}$=12.6; it results that $\chi^2_{exp} < \chi^2_{theoretic}$ (Figure 4).

Although the beech tree is a species with shadow temperament, the lower cases of height are poorly populated, which is shown by the classification of the trees in the upper Kraft classes.

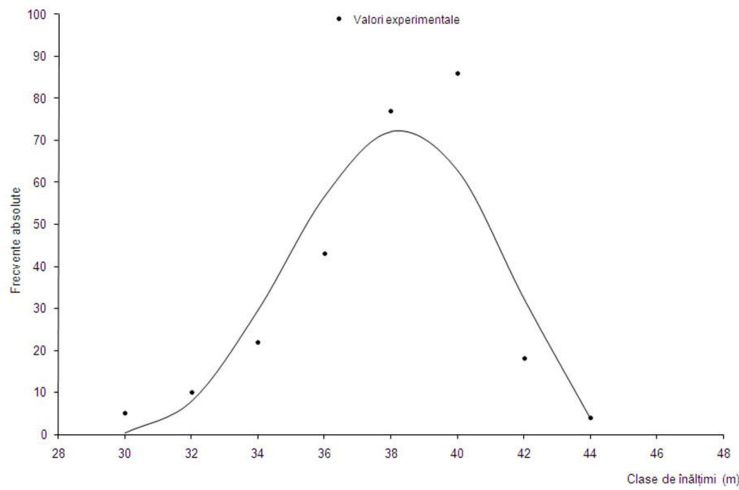

Fig.4. Structure of the beech stands in relation with their height – the beta distribution (χ^2_{exp}=3.9; $\chi^2_{theoretical}$=12.6; it results that $\chi^2_{exp} < \chi^2_{theoretic}$)

The analysis of the bivariate distribution of the number of trees by category of diameter and by category of height allows the proper visualization of the intensity and of the type of correlation between these biometric characteristics of the beech stand (Popa, 2001). The statistical quantification of this correlative relation is done using the curve of heights (Figures 5 and 6).

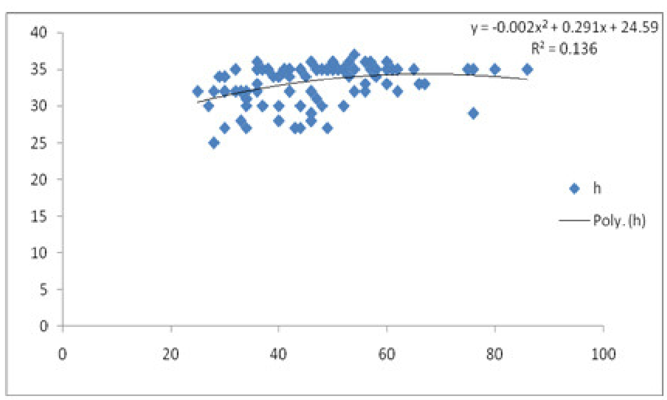

Fig.5 Bivariate distribution of the trees by category of diameter and by category of height in the trial plot Dragomirna 1

- According to these data, the best equation to be recommended is the second degree polynomial equation, which has the highest R^2 coefficient (0.418 for Dragomirna 2 and 0.136 for Dragomirna 1).

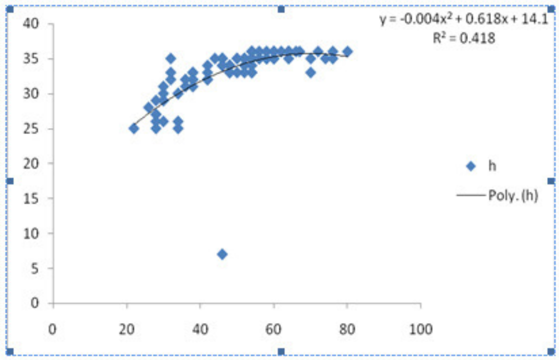

Fig.6 Bivariate distribution of the trees by category of diameter and by category of height in the trial plot Dragomirna 2

These equations observe the ecological law of beech stands structure, because there are no too short heights for the categories of large diameters, nor negative values for the lower categories of diameters.

In the case of the natural beech stands, over longer periods, it is quite feasible to produce the curve of heights, even if fluctuations may be noticed during rather short periods.

c. Structure of the beech stands in relation with their volume

The structure of the beech stands according to the volume of the standing trees (hiving their diameter and height measured) was determined with the bilogarithmic equation of the volume (Giurgiu, 1979):

$$\log v = a_0 + a_1 \log d + a_2 \log^2 d + a_3 \log h + a_4 \log^2 h$$

For the beech trees, the coefficients of regression are: a_0= -4.11122, a_1=1.30216, a_2 = 0.23636, a_3=1.26562 and a_4 = -0.07966. Figure 7 shows the experimental distribution of the trees by volume and their adjustment with the theoretical function of distribution Gamma.

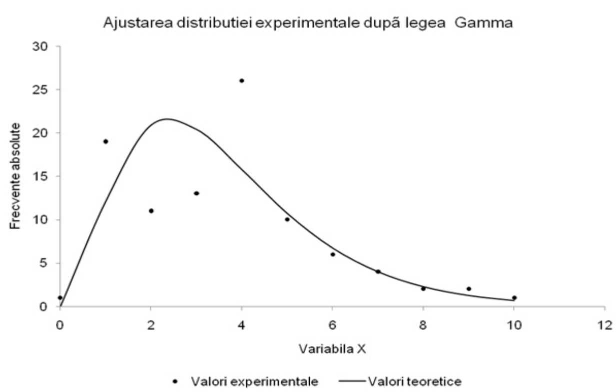

Fig.7 Distribution of the trees by volume and their adjustment with the theoretical function of distribution Gamma.

The following observations resulted:

- χ^2= 3.245; χ^2= 15.507; it results that $\chi^2_{exp} < \chi^2_{theoretic}$
- The theoretical distributions are strongly asymmetrical to the left, as it was noticed for their diameters, but the asymmetry is much stronger this time.
- In most situations there is a good similarity of the experimental distribution with γ distribution which characterises the structure of the beech stands in relation with the tree volume. The γ distribution shows, however, that some of the stands are balanced.
- The structure of the stands in relation with the tree volume has strong auxiologic and ecologic implications. The variability of tree volume in the even-aged beech stands is the consequence of the variability of their three characteristics: *g, h, f.*
- The variation coefficients of the volumes are higher than any coefficient of the mentioned factorial characteristics, $s_{\%}$ varying between 57.94% and 62.92%. The number of trees by class of volumes shows that most trees are included in the lower classes of volume.
- The results of the previous research are supported by our survey: in the even-aged tree stands, the trees are distributed by classes of volume according to distribution laws which show asymmetry and excesses.
- Most trees are included in lower categories of volume, the distribution curve being strongly positively asymmetric to the left. The asymmetry is much stronger than in the case of tree distribution by categories of diameter. There is a very low frequency of the trees in the upper classes of volume.

CONCLUSIONS

- The surveyed beech trees ecosystem consists of rather even-aged beech stands, almost pure, resulting from the regeneration cuts with a short period of regeneration, conducted about 130 years ago. This is seen from the fact that the distribution of the trees by classes of diameter follows the theoretical Charlier distribution A, which is also supported by the χ^2 test. Diameter variability is rather high.
- There is a rather low biodiversity of the species. Only 7 species have been determined on the experimental plots Dragomirna 1 and 2, the beech trees being dominant (90%) in both locations. The accompanying species are the field sycamore maple, linden trees (*Tilia cordata* and *Tilia platyphyllos*) and the hornbeam. Sporadically, common oak (*Quercus petraea*) and spruce firs (planted) can also be noticed. The biodiversity indices are lower than the unit (the Shannon index is 0.134 and the Margalef index is 0.540) which shows a low biodiversity at the species level.

- The surveyed ecosystem has a rather low biodiversity, which, in its current state, cannot provide high stability over the long-term. This conclusion has, otherwise, been demonstrated by the appearance of the abnormal drying phenomenon of the beech trees, during the period of excessive draught.
- The construction of the beech stand in relation with tree diameter has shown that the theoretical β structure which characterises the experimental distribution pointed towards a rather even-aged composition of the beech stands.
- Similarly with the construction of the beech stand in relation with tree diameter, we tried to model the composition of the beech stands in relation with the height of the trees *using the same theoretical function.* The experimental distributions show negative (right) asymmetry, meaning the agglomeration of the trees in the upper level because of the competition for light. Although the beech tree is a species with a shadow temperament, the lower classes of height are poorly populated, also shown by the categorization of the trees in the higher Kraft classes.
- The decrease of the coefficient of variation for height is accountable biologically because the beech stand is quite old.
- We also used γ theoretical function to model the distribution of the trees by volume classes. The results of the previous surveys are supported by the present study which shows that in the even-aged tree stands, the trees are distributed in lower volume classes, the distribution curve displaying a strong left asymmetry. The asymmetry is much stronger than the one displayed by the distribution by category of diameter.
- The high level of ecosystemic homogeneity has also been proved by the distribution of the average diameter, dg, which also followed the theoretical distribution. Even the coefficient of variation of the average diameter is rather low. This observation yields the conclusion that the regeneration cuts performed 130 years ago were conducted on large area and with a rather short period of regeneration.
- The study of the average height variability documented the truth that the surveyed beech stand is rather homogenous in terms of the vertical structure too. This is documented by the similarity of the experimental distribution and the considered theoretical distribution, as well as by the rather low value of the coefficient of variation, $s_{\%} = 9.71$.
- The horizontal distribution of the volumes shows the high ecological stability and homogeneity of the ecosystem, which justifies the classification of the forest in the category of natural reservation.
- In conclusion, we may say that although the beech stand has a stationary high quality and a rather good health (class 0 of the defoliation level), the surveyed ecosystem has a low biodiversity, therefore a low

stability in time, as shown by the high percentage of cracks, by the presence of rot and scars. Although, the overall amount of wood is consistent, it is not of outstanding quality, because of the presence of the mentioned technological defects.

- An analysis of the opportunity for ecological reconstruction is recommended, choosing the most adequate treatments: treatment with long period of regeneration or with continuous period of regeneration (gardening, maybe the treatment of the gardened forest, or just high intensity conservation works), maybe afforestation works with local seedlings, so that the valuable gene fund of the reservation can be inherited unaltered by the future generations for centuries to come.
- Monitoring is also recommended, as well as the establishment of a network for continuous monitoring of the reservation, enabling the evolution of its state of health and structure.

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