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POSSIBILITIES OF APPLYING SAMPLING MEASUREMENT IN THE INVENTORY OF STRUCTURALLY HETEROGENEOUS STANDS

SUMMARY

In structurally heterogeneous forests of Serbia, the information needed for management is collected by total measurement. Although the most accurate, the total measurement has some weaknesses as well, which are demonstrated by distinctly low cost-effectiveness and inability to define error which exists, like with any other measurement. Having in mind these observations and substantial areal representation of heterogeneous stand forms in the growing stock of Serbia, substituting total measurement with sampling measurement is an imperative of forest inventory in small areas. Consequently, researches of the most favorable shape of sample plots were conducted (circle with constant radius, concentric circles or angle-count sampling), their sizes, distribution and measurement intensity. The obtained results were evaluated through a prism of accuracy and cost-effectiveness of information in specific conditions. The scope of statistical and empirical errors relating to the number of trees and volume, at the measurement intensity of 10-15%, as well as clearly higher cost-effectiveness of sampling measurement, is such that it indicates a possibility to substitute total measurement in conditions of structurally heterogeneous stands. However, high deviations in distribution of the number of trees and volumes, particularly in the highest diameter degrees, and all the problems in planning, silviculture and exploitation of forests resulting from such deviations, eliminate this possibility. In this respect, basic hypotheses of these researches have not been confirmed, except the one relating to higher cost-effectiveness of sampling measurement compared to total measurement.

Key words: total measurement, sampling measurement, number of trees, volume, empirical error, statistical error

INTRODUCTION

Forest inventory implies collection, processing, evaluation and presentation of data about growing stock, its spatial distribution, structure, time

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(dynamic) development, level of exploitation, etc. The task of forest inventory is to ensure a reliable data base for forest ecosystems in the most cost-effective manner. The established databases create a starting point for activities in a number of other forestry disciplines, primarily forest management planning, forest exploitation and silviculture (Bankovic and Pantic, 1999; Bankovic et al., 2002). Control role of forest inventory (monitoring of forest ecosystems) is important as well. Periodical measurement (dynamic inventory) can show all positive and negative trends in the development of the growing stock and, in that respect, it emphasizes a corrective role of inventory in forest management. Transition from mono-functional to multifunctional management and evolution of the society's awareness of importance of forest ecosystems has lead to more complex quantitative and qualitative requirements for data to be provided by the forest inventory (Andjelic et al., 2012). Consequently, a number of techniques and methods of collection of relevant data on forests have been developed, and stand conditions have been defined in which these techniques and methods provide the best results. Total measurement is used in structurally heterogeneous stands (uneven-aged forests in the broadest sense), in highly valuable stands and in all cases when sampling measurement, based on sampling technique, would not provide good results. Sampling measurement collects data in homogeneous conditions, such as young to maturing even-aged forests.

Starting from large areal representation of structurally heterogeneous forests in the growing stock of Serbia, beech forests in particular (Medarevic et al., 2003; Medarevic, 2006; Bankovic et al., 2009), and related substantial financial expenses incurred by total measurement, these researches have been conducted with primary goal of reviewing, given the aforementioned conditions, a possibility for substituting total measurement with sampling measurement, whereby the reliability of data would not be questioned. Having in mind the primary task of these researches, the following hypotheses have been defined:

- sampling measurement can substitute total measurement in structurally heterogeneous beech stands,
- measurement intensity which ensures results within limits of permitted error (max ± 8%) will not exceed 30%,
- the best results will be provided by angle-count sampling plots,
- sampling measurement is substantially more cost-effective than total measurement.

MATERIAL AND METHODS

The data for these researches were obtained by measurements in 73 compartments of the Management Unit "Kukavica I" managed by PE "Srbijasume" – part of the enterprise Forest Estate "Suma" Leskovac. The size of the compartment is 29.42 ha, and forests belong to the management class 26.352.421-high uneven-aged beech forests-*Fagetum moesiacae montanum* on various brown soils, intended to provide protection of land from erosion (Bankovic and Medarevic, 2003/a). These beech forests are found at 610 – 1000 m.a.s.l., on a very steep terrain of 25-30° slope, preserved, complete canopy and moderately tended (POGS-Kukavica I, 2006).

The methodology that was applied for measurements, primarily in the design phase, diverted from standard procedures defined by the “Code book of Forest Management Plans and Programmes, Annual Operational Plan and Temporary Annual Management Plan for Private Forests” (2003). The diversions are conditioned by a need to conduct both total and sampling measurements in the same inventory unit on three shapes of sample plots (circles with constant diameter, concentric circles and angle-count sampling) and with different measurement intensities: full grid (distance between sample plots 50 x 50 m), then a grid from which every other direction is eliminated (distance between sample plots 50 x 100 m), and a grid from which every other sample plot in directions is eliminated (distance 100 x 100 m).

Sampling measurement was conducted after total measurement, whereby sample plots were distributed in a square grid with 50 x 50 m distance between centres, leading to 110 sample plots in total (Figure 1). Once every other direction was eliminated (50 x 100 m grid), the number of sample plots was 55 (Figure 2), and by eliminating every other sample plot in the direction (100 x 100 m grid) this number was brought down to 29 (Figure 3).

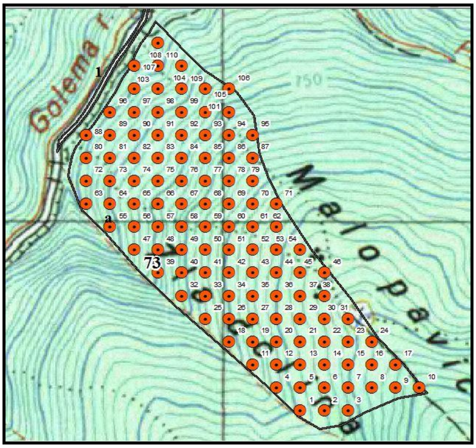


Figure 1: Full grid of sample plots, 50 x 50 m grid, n =110

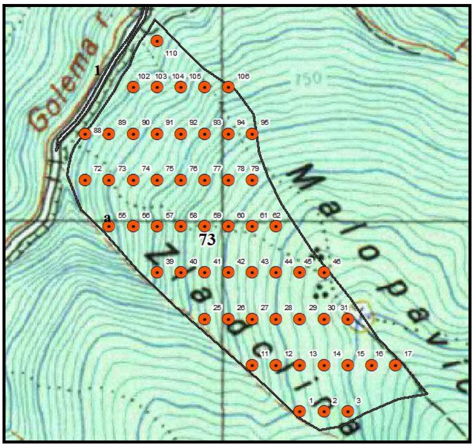


Figure 2: Grid of sample plots with every other direction eliminated, 50 x 100 m grid, n = 55

Sampling measurement was performed on 10 acres sample plots (circles with constant diameter), 1, 2, 5 and 10 acres (concentric circles), with counting factor 1 (angle-count sampling) (Bankovic and Medarevic, 2003/b; Bankovic and Pantic, 2006). Given the number and size of some sample plots, sampling measurement was performed with different intensities (Table 1).

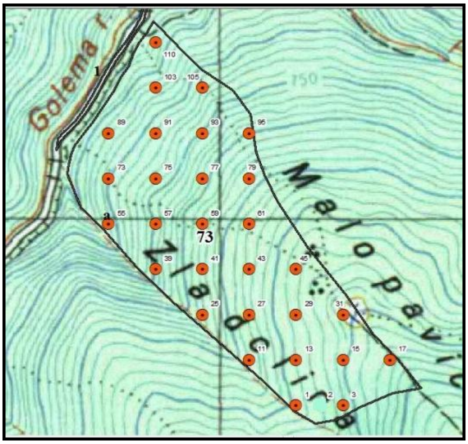


Figure 3: Grid with every other sample plot eliminated, 100 x 100 m grid, n =29

Table 1: Implemented intensities of sampling measurement depending on the shape of sample plots and grid density

Circles with constant radius		Concentric circles		Angle counting (WZP)	
Measurement intensity (%)	Number of sample plots	Measurement intensity (%)	Number of sample plots	Measurement intensity (%)	Number of sample plots
Full grid 50x50 m					
37,39	110	37,39	110	52,38	110
Every other direction eliminated 100x50 m					
18,35	55	18,35	55	26,54	55
Every other sample plot eliminated 100x100 m					
10,20	29	10,20	29	14, 86	29

Note: In order to have circles with constant radius include a sufficient number of trees in a specific inventory unit (15-25 trees/circle), 10 acres circles were used, hence the identical measurement intensities for this shape and for concentric circles.

The collected data were processed in OSNOVA software. There are numerous outputs of data processing, with the following being important for these researches: number of trees and volume, scope of statistical and empirical error, which was used to define these numerical elements.

RESULTS AND DISCUSSION

The number of trees and volume resulting from tested measurement methods (total and sampling, where sampling measurement was performed on various shapes of sample plots, with different intensity) are presented in chapters below. The scope of empirical and statistical errors, which were used to assess the said elements within dynamic measurement, is presented as well. Empirical error here represents a difference between arithmetic mean of a sample and arithmetic mean of the basic set, while statistical error does not give real error, but only ranges of the real error with a certain probability.

Number of trees in inventory unit

The statistical error of assessment of the number of trees for all three shapes of sample plots and all three measurement intensities is lower than the permitted measurement error of ±8%. In the full grid of sample plots these range between ±2.73% and ±4.58%, in a grid consisting of every other direction, these range between ±2.54% and ±6.36%, and in a grid consisting of every other sample plot, these range between ±4.89% and ±7.35%, which is a logical trend of this error when measurement intensity is dropping.

Statistical error in assessing the number of trees in circles with constant radius ranges between ±2.54% and ±4.89%. In concentric circles, this interval ranges between ±4.58% and ±7.35%, and in angle counting it ranges between ±3.89% and ±7.25% (Table 2).

Table 2: Number of trees, empirical and statistical error for different methods and measurement intensities

	N	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9
$\sum$	176,6	166,2	188,8	175,8	167,1	179,6	183,5	165,9	163,9	203,4
PmN (%)		-6,0	+6,8	-0,5	+5,4	+1,6	+3,8	-6,1	-7,2	+15,1
Pm$\bar{N}$ (%)		2,73	4,58	3,89	2,54	6,36	4,46	4,89	7,35	7,25

Designations in Table 2 have the following meaning:

N – number of trees obtained by total measurement,
N_1 – number of trees obtained by sampling measurement, circles with constant radius, full grid of sample plots (s-50 x 50 m, n=110 circles, Pp=37.39%),
N_2 – number of trees obtained by sampling measurement, concentric circles, full grid of sample plots (s-50 x 50 m, n=110 circles, Pp=37.39%),
N_3 – number of trees obtained by sampling measurement, angle-count sampling, full grid of sample plots (s- 50 x 50 m, n=110 circles, Pp=52. 38%),
N_4 – number of trees obtained by sampling measurement, circles with constant radius, every other direction eliminated from the grid (s-50 x 100 m, n=55 circles, Pp=18.35%),
N_5 – number of trees obtained by sampling measurement, concentric circles, every other direction eliminated from the grid (s-50 x 100 m, n=55 circles, Pp=18.35%),
N_6 – number of trees obtained by sampling measurement, angle-count sampling, every other direction eliminated from the grid (s-50 x 100 m, n=55 circles, Pp=26.54%),
N_7 – number of trees obtained by sampling measurement, circles with constant radius, every other direction and every other sample plot eliminated from the grid (s-100 x 100 m, n=29 circles, Pp=10.20%),

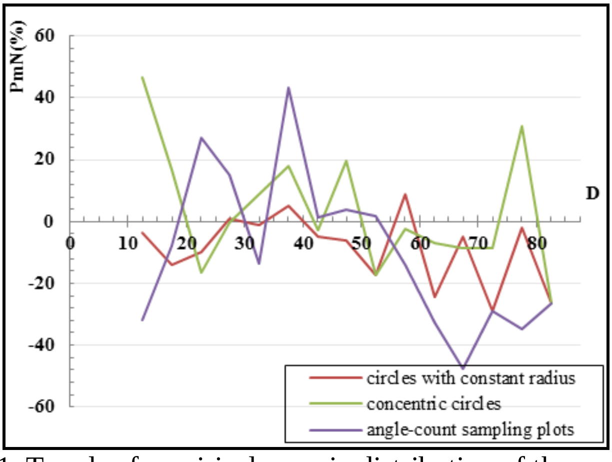
N_8 – number of trees obtained by sampling measurement, concentric circles, every other direction and every other sample plot eliminated from the grid (s-100 x 100 m, n=29 circles, Pp=10.20%),
N_9 – number of trees obtained by sampling measurement, angle-count sampling, every other direction and every other sample eliminated from the grid (s-100 x 100 m, n=29 circles, Pp=14.86%),
PmN (%) – percentage of deviation of the number of trees obtained by sampling measurement in comparison with total measurement (empirical error),
Pm$\bar{N}$ (%) – relative error in the assessment of the number of trees (statistical error).

It can be stated that the highest statistical error occurs in sampling measurement on sample plots in the shape of concentric circles, while the lowest statistical error occurs in circles with constant radius. Concerning the size of this error, angle-count sampling is in the middle, between aforementioned shapes of sample plots. To a certain extent, such results are surprising given the structural heterogeneity of the inventory unit and expectations that angle-count sampling, which is based on principles of uneven selection, would give the best results.

Empirical error ranges between -0.5% and 15.1%. In a full grid, the error ranges between -6.0% and 6.8%, in a grid with every other direction it ranges between 1.6% and 5.4%, and in a grid consisting of every other sample plot it ranges between -7.2% and 15.1%. The trend of empirical error is logical with dropping of the size of the sample, i.e. measurement intensity.

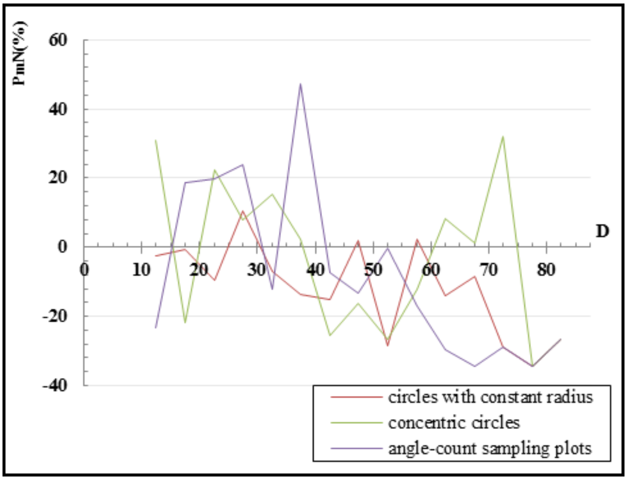
Empirical error on sample plots in the shape of circles with constant radius ranges between -6.1% and 5.4%. This interval in concentric circles ranges between -7.2% and 6.8%, and between -0.5% and 15.1% in angle counting.

Consequently, the highest empirical error occurs in angle counting, in a grid consisting of every other sample plot, whereas the lowest empirical error occurs in concentric circles.



Graph 1: Trends of empirical error in distribution of the number of trees by diameter degrees (full grid of sample plots)

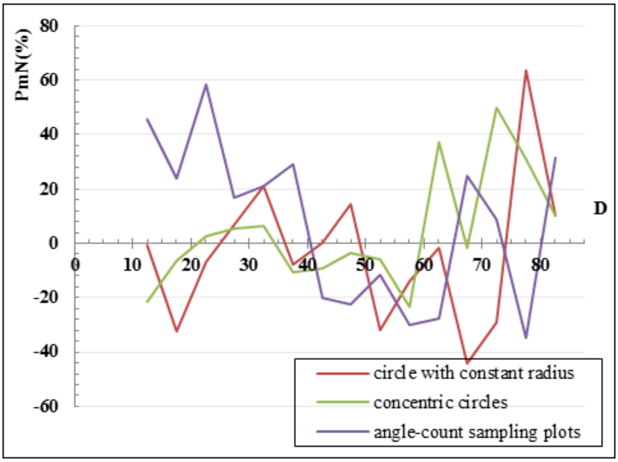
Diversion of diameter structure obtained by sampling measurement with full grid of sample plots, in comparison with diameter structure of total measurement, is presented in Graph 1. Generally, the lowest diversion in the diameter structure occurs on sample plots in the shape of circles with constant radius, whereas the most pronounced diversion occurs in angle-count sampling. Differences in the number of trees by diameter degrees on all three shapes of sample plots, in comparison with total measurement, exceed the permitted error of ±8% and with pronounced extremes reaching even ±40%.



Graph 2**:** Trends of empirical error in distribution of the number of trees by diameter degrees (every other direction eliminated from the grid)

At reduced intensity of sampling measurement (every other direction eliminated from the grid), the lowest diversion of diameter structure occurs on sample plots in the shape of circles with constant radius (Graph 2). Angle-count sampling plots give approximately the same values as the previous method, but include some extremes, particularly in the diameter degree of 37.5 cm, with a value of 47.4%. As with the previous measurement intensity, in comparison with total measurement, all three shapes of sample plots show significant diversion in diameter structure (well above the permitted error of ±8%).

As a consequence of low measurement intensity, the highest differences in tested distribution of trees by diameter degrees (Graph 3) were observed in a grid from which, unlike the previous grid, every other sample plot was eliminated. Sample plots in the shape of circles with constant radius show more pronounced diversions, particularly with trees whose diameter is above 60 cm. A characteristic of this shape of sample plots is that there is an extreme minimum of -44.4% in the diameter degree of 67.5 cm, and extreme maximum of +63.5% already in diameter degree of 77,5 cm, which implies a two-way and extremely variable nature of empirical error in distribution of trees by diameter degrees. Significant diversions in almost all diameter degrees were observed in angle counting, while the size of this error in concentric circles was observed to be between the values of this error on aforementioned shapes of sample plots. In comparison with total measurement, all three shapes of sample plots, generally, show significant diversion in diameter structures at this intensity as well, which are well above the permitted error of ±8%.



Graph 3: Trends of empirical error in distribution of the number of trees by diameter degrees (every other sample plot eliminated from the grid)

Volume of inventory unit

Statistical error in assessing volume for all three shapes of sample plots and all three measurement intensities is below the permitted error of ±8%. In the full grid of sample plots, this error ranges between ±2.52% and ±3.44%, and in a grid from which every other direction is eliminated, this error ranges between ±3.42% and ±4.68%, and in case when every other sample plot is eliminated from a grid, this error ranges between ±3.50% and ±6.60% (Table 3).

Table 3: Volume, empirical and statistical error with various methods and measurement intensities

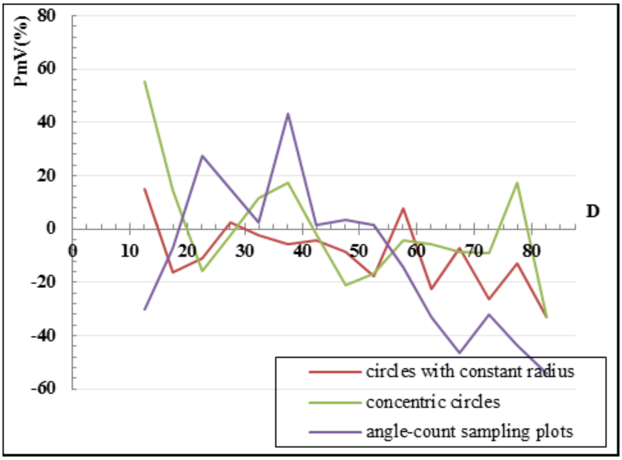
	V	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9
∑	227,2	209,2	216,8	216,6	202,3	212,8	211,7	210,9	213,4	209,3
PmV (%)		-7,9	-4,6	+4,7	-11,0	-6,3	-6,8	+7,2	-6,1	-7,9
Pm$\overline{V}$ (%)		3,10	3,44	2,52	3,93	4,68	3,42	3,50	6,60	4,83

Note: the meaning of elements in Table 3 is the same as in Table 2, but instead of the number of trees, here we have volume of inventory unit per hectare and its errors.

As far as the difference between tested shapes of sample plots is concerned, statistical error in assessing volume in circles with constant radius ranges between ±3.10% and ±3.93%. In concentric circles, it ranges between ±3.44% and ±6.60%, and in angle counting it ranges between ±2.52% and ±4.83%. It is noticeable that the highest statistical error occurs in sampling measurement on sample plots in the shape of concentric circles, whereas the lowest statistical error occurs in angle-count sampling. However, the scope of errors on all three shapes of sample plots, regardless of the grid density, is such that it can be stated that all tested shapes provide good volume assessment results. This observation applies particularly to angle counting, where the error is the lowest, which is a consequence of unequal probability of selection of trees. Namely, larger diameter trees (volume carriers) are subject to higher probability of being measured, which would result in the best assessment of this element.

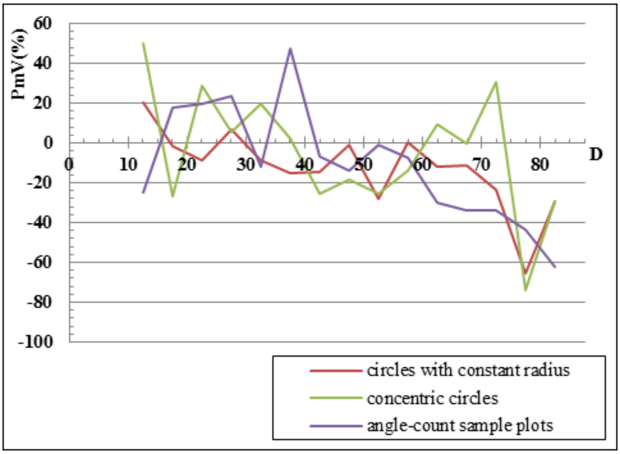
Empirical error (diversion in volume which is obtained by sampling measurement, as compared to total measurement) ranges between -11.0% and 7.2%. In full grid, this error ranges between -7.9% and 4.7%, and in a grid with every other direction eliminated it ranges between -11.0% and -6.3%, and in a grid from which every other sample plot was eliminated, it ranges between -7.9% and 7.2%.

Empirical error on sample plots in the shape of circles with constant radius ranges between -11.0% and 7.2%. In concentric circles, it ranges between -6.3% and -4.6%, and in angle counting it ranges between -7.9% and 4.7%. Such results coincide, to a certain point, with empirical error in the number of trees in an inventory unit, where concentric circles provided the best results as well.



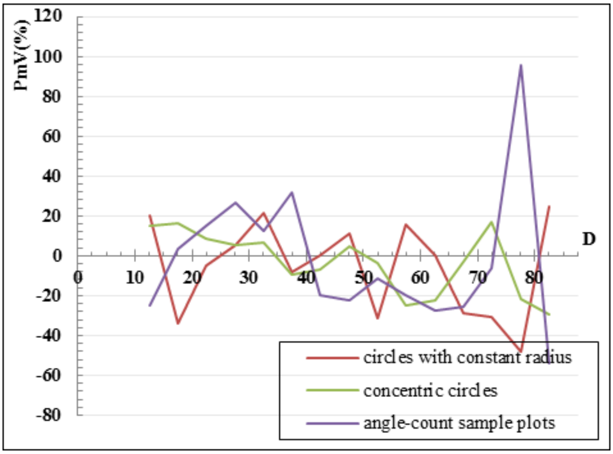
Graph 4: Trends of empirical error in distribution of volume by diameter degrees (full grid of sample plots)

In a full grid of sample plots (Graph 4), the lowest diversion in distribution of volume by diameter degrees, in comparison with total measurement, occurs in circles with constant radius. It is somewhat more pronounced in concentric circles, while it is the most pronounced in angle-count sampling. Regardless of the shape of sample plots, the error shows high variability by diameter degrees, two-way nature, pronounced extremes and values well above permitted.



Graph 5: Trends of empirical error in distribution of volume
by diameter degrees (every other direction eliminated from the grid)

Higher diversions in volume structure on all three shapes of sample plots were observed in the measurement intensity which implied elimination of every other direction (Graph 5), almost in all diameter degrees, in comparison with total measurement. Circles with constant radius show the lowest diversions in this case as well, followed by concentric circles and round plots of angle counting. Variability of error by diameter degrees, its two-way nature, values by diameter degrees above ±8% with pronounced extremes of even up to 75%, are also characteristic of this measurement intensity.



Graph 6: Trends of empirical error in distribution of volume
by diameter degrees (every other sample plot eliminated from the grid)

Larger diversions in volume structure on all three shapes of sample plots were observed with the lowest measurement intensity (every other sample plot was eliminated, Graph 6), compared to the previous two grid densities. This is a logical trend (increase) of error with dropping of measurement intensity. Other than larger values, other characteristics of empirical error are the same as in previously discussed grid density of sample plots.

Measurement cost-effectiveness

In addition to reliability of data, cost-effectiveness of tested methods also has an important role in considering a possibility for substituting total measurement with sampling measurement. In that respect, Table 4 shows basic elements for calculating costs of implementation of certain inventory methods in specific conditions.

Table 4: Elements for calculating costs of inventory

Operation	Measurement unit	Number of workers	Performance in 8 hours	Unit price
Preparatory works				
Preparation of work maps	ha			12.00
Collection of enumeration data				
High forests – total measurement	ha	2	3	696.00
High forests – constant and concentric circles	circle 0.10 ha	2	15	
High forests – angle counting	circle	2	20	
Computer data processing				
Data entry, processing and printing	circle	1	125	

Notes:

- Table 4 is a part of the Table downloaded from the official website of the Public Enterprise “Srbijasume”-www. srbijasume.rs,
- Average daily fee is calculated based on daily performance, unit price and number of workers, and amounts to 1044 RSD,
- Costs of preparatory works and data processing are minor and equal for all measurement methods. Other costs (renting necessary instruments and tools, use of Osnova and Arc Gis) are also the same for discussed inventory methods. Therefore, the differences in costs relate only to the activity of collecting field data.

Costs of total and sampling measurement are calculated based on the presented data, the size of the inventory unit and the number of sample plots:

Total measurement - 20.483,00 RSD

Sampling measurement (full grid of sample plots, n = 110)

- circles with constant radius - 15.305,04 RSD
- concentric circles - 15.305,04 RSD
- angle counting - 11.484,00 RSD

Sampling measurement (every other direction eliminated from the grid, n = 55)

- circles with constant radius - 7.565,00 RSD
- concentric circles - 7.565,00 RSD
- angle counting - 5.742 ,00 RSD

Sampling measurement
(every other sample plot eliminated from the grid, n = 29)

- circles with constant radius - 4.038,00 RSD
- concentric circles - 4.038,00 RSD
- angle counting - 3.028,00 RSD

It is obvious that cost-effectiveness of sampling measurement is higher than cost-effectiveness of total measurement. Even with a full grid of sample plots (Pp=37.39%, i.e. 52.38%), costs of sampling measurement are by 25% (on constant and concentric circles), or by 44% (angle counting) lower than the costs of total measurement. At the lowest intensity (Pp=10.20%, or 14.86%), the costs of sampling measurement are lower by 80% in circles with constant radius and concentric circles, and by 85% in angle counting. As far as the shape of sample plot is concerned, implementation costs are the lowest for round plots of angle counting, which is also logical given the technique used for this measurement.

CONCLUSIONS

Comparative analysis of accuracy and cost-effectiveness of sampling measurement on various shapes of sample plots and with various implementation intensity compared with complete (total) measurement leads to the following conclusions:

1. Statistical error in the assessment of the number of trees for all three shapes of sample plots, and for all three measurement intensities, is lower than the permitted measurement error of ±8%. Logically, this error increases and comes closer to aforementioned limit with reduction of a sample. Circles with constant radius show the lowest error in the assessment of the number of trees, followed by angle counting, and the highest error occurs in concentric circles. Such results are surprising to a certain extent given the structural heterogeneity of the inventory unit and the expectations that angle-count sampling, which is based on principles of unequal probability of selection of trees, would give the best results.

2. Empirical error in the number of trees ranges between -0.5% and 15.1% and shows a growing trend with dropping of the density of sample plots in an inventory unit. The empirical error is the lowest in circles with constant radius, followed by concentric circles, while it reaches even 15% in angle counting.

3. Distribution of the number of trees by diameter degrees in all three shapes of sample plots shows significant inconsistency with the distribution obtained based on the total measurement data, which is particularly pronounced in cases of the lowest measurement intensity. These diversions (errors) are characterized by occurrence of significant extremes, particularly in the lowest and the highest diameter degrees, by two-way nature and the size which is substantially above the permitted level.

4. Statistical error in the assessment of volume for all three shapes of sample plots, and at all three measurement intensities, is below the permitted

measurement error of ±8%. As with the number of trees, this error comes closer to the permitted limit with dropping of a sample in an inventory unit. Although within permitted limits, the highest statistical error in the assessment of volume occurs in sampling measurement on sample plots in the shape of concentric circles, while the lowest error occurs in angle counting. This sequence of sample plots is a consequence of the fact that angle-count sampling is based on the principles of unequal probability of selection of trees. This means that trees of large diameter (volume carriers) are subject to a higher probability of being measured, which resulted in the best assessment of this element by this shape of sample plot.

5. Empirical error in volume ranges between -11.0% and 7.2%, and the highest empirical error occurs in circles with constant radius, followed by angle-count sampling, while the lowest diversion, compared to the volume obtained by total measurement, is observed in concentric circles.

6. The diversion in volume structure obtained by sampling measurement, compared to the one obtained by total measurement, coincides with diversions identified in distribution of the number of trees. The diversion is substantial, particularly in the lowest and the highest diameter degrees, with numerous extremes; they are of two-way nature and well above the permitted value of ±8%.

7. Sampling measurement, even with very high measurement intensity (above 50%) is substantially more cost-effective compared to total measurement, which applies particularly to angle-count sampling.

To summarize the above conclusions, an overall observation can be made that the levels of statistical and empirical errors in the number of trees and in volume, at the measurement intensity of 10-15%, as well as clearly higher cost-effectiveness of sampling measurement, are such that they indicate a possibility to substitute total measurement in the conditions of structurally heterogeneous stands. However, high diversions in distribution of the number of trees and volume, particularly in the highest diameter degrees, and all the resulting problems in planning, silviculture and exploitation of forests, eliminate such possibility. Therefore, starting hypotheses have not been confirmed, other than the one relating to higher cost-effectiveness of sampling measurement compared to total measurement. This does not mean that these attempts should be abandoned, but that similar researches should be intensified on a much larger sample, which would allow drawing more precise conclusions.

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MOGUĆNOST PRIMENE DELIMIČNOG PREMERA U INVENTURI STRUKTURNO HETEROGENIH SASTOJINA

SAŽETAK

U strukturno heterogenim šumama Srbije informacije neophodne za gazdovanje prikupljaju se potpunim premerom. Iako najtačniji, potpuni premer ima i određene nedostatke, koji se ogledaju u izrazitoj neekonomičnosti i nemogućnosti određivanja greške koja, kao i kod svakog merenja, postoji. U skladu sa ovim konstatacijama i značajnom površinskom zastupljenošću heterogenih sastojinskih oblika u šumskom fondu Srbije, supstituisanje potpunog premera delimičnim premerom jedan od imperativa malopovršinske inventure šuma. Stoga su sprovedena istraživanja najpovoljnijeg oblik primernih površina (krug sa konstantnim poluprečnikom, koncentrični krugovi ili ugaono primerno izbrajanje), njihove veličine, rasporeda i intenzitet premera. Dobijeni rezultati su vrednovani kroz prizmu tačnosti i ekonomičnosti informacija u konkretnim uslovima. Veličine statističkih i empirijskih grešaka broja stabala i zapremine, pri intenzitetu premera 10-15%, kao i neosporno veća ekonomičnost delimičnog premera, takvi da ukazuju na mogućnost supstituisanja potpunog premera u uslovima strukturno heterogenih sastojina. Međutim, velika odstupanja u distribucijama broja stabala i zapremine, posebno u najjačim debljinskim stepenima i svi problemi koji s aspekta planiranja, gajenja i korišćenja šuma iz toga proizilaze, eliminišu ovakvu mogućnost. U tom smislu, nisu potvrđene polazne hipoteze ovih istraživanja, osim one koja se odnosi na veću ekonomičnost delimičnog u odnosu na potpuni premer.

Ključne reči: potpuni premer, delimični premer, broj stabala, zapremina, empirijska greška, statistička greška