

Possibilities for Realizing the Calculations in the GIS Databases

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Abstract: *The paper sets out to enhance which are the possibilities the user disposes of in view of realizing the calculations in the GIS database. To this purpose there was used a GIS project specific to the Bran basic unit, for whose accomplishment there were identified a number of 40 basic plans, scale 1 :5.000, which comprised elements of forestry interest (limits of compartments and sub-compartments, boundary marks, forestry roads etc.). Their processing through digitization was accomplished through the software AutoCAD Map, the layers created this way being subsequently imported in ArcGIS. Here, the implicit database was completed with the existing data within the compartment description. In order to exemplify the manner of realizing the calculation (simple or complex) in the GIS database, there was used the method of the indicating growth for determining the allowable cut as regards the forests in UB Bran.*

Keywords: *GIS, basic plans, digitization, database, elements of forestry interest.*

1. Introduction

Although they have made their way and although they are used on quite a wide scale in different spheres of activity, however, the systems of geographical information are not exploited on the level of their potential. Unfortunately, these systems are very much used only on the level of the map drawing up, however this capacity is being held by any product in the CAD family. In the framework of this paper, we set out to deal with a very important aspect, which constitutes a great advantage that GIS holds, that is the possibility to carry out different calculations (simple or even very complex) in the database. In order to exemplify these possibilities, we will take into consideration the calculation algorithm for determining the allowable cut through the method of the indicating growth.

2. Creation of the database

The creation of the GIS project specific to the basic unit¹ Bran involved the identification of the basic plans that comprised information with respect to the unit under study. The digitization of these elements was carried out through the AutoCAD Map software, upon individualized layers, according to the type of the data within (point, line, polygon). The layers created this way were exported as files *.shp. The error editing and the topology creation were accomplished in ArcInfo. Subsequently, the files *.shp were imported in ArcGIS, this way there ensuing the implicit database (that comprises a different number of fields, according to the type of data within). The database created this way was afterwards completed with all the other elements (concerning the stational conditions and those of the stand) taken over from the compartment description, at the present moment there being held all necessary information in order to pass to the stage of calculus realization in view of substantiating the forest-organizing decisions.

¹ The basic unit stands for an administrative unit that designates forests pertaining to the particular structures

3. Defining a mathematical model for determining the allowable cut

With the purpose of determining a mathematical model that should allow the automation of the determinations specific to the method of indicating growth, there was used an adapted variant of the SIMBIOF (Seceleanu, 1998). The adaptation of this software referred to the conditions imposed to every stand with the purpose of its being fit within one of the 6 groups presented above.

Determining the measure of the allowable cut of main products through the intermediary of this model implies compulsorily going through two stages:

- a) Repartition of the stands included within the production fund, through the intermediary of a condition of separation in six groups (C1...C6). In the framework of every group, for every stand there will be calculated the growth of the principal production in different moments specified in the relations described within the algorithm. There imposes itself the condition for every stand to be placed in a single group;
- b) Calculation of the indicators XV1...XV6 and application of the procedure for determining the possibility.

3.1. Repartition of the stands and calculation of the principal production growths

There are taken into consideration the stands which become exploitable in the following 60 years.

C1 – there are included information with respect to the stands that meet the requirement:

$TA > TE - 10$, where: TA – actual age of the stand; TE – maturity age.

The stands included in this group will be further differentiated into 3 categories in relation to the length of the remaining regeneration period (PRM): $PRM \leq 10 \Rightarrow C11$; $11 \leq PRM \leq 20 \Rightarrow C12$; $PRM \geq 21 \Rightarrow C13$.

There will be calculated and added up the volume of the stands and of the growths on the period (for the stands entered within C1):

$$V_1 = \sum V_1^1 + \frac{1}{2} \sum V_1^2 + \frac{1}{3} \sum V_1^3 \quad (1)$$

where: V_1^1 - the volume of the stands included within C11; V_1^2 - the volume of the stands included within C12; V_1^3 - the volume of the stands included within C13.

V_1^1, V_1^2, V_1^3 there will be calculated with the relations:

$$V_1^1 = V_{TA}^R + \frac{V_{TA+10}^C - V_{TA}^C}{2} \quad (2)$$

$$V_1^2 = V_{TA}^R + \frac{V_{TA+20}^C - V_{TA}^C}{2} \quad (3)$$

$$V_1^3 = V_{TA}^R + \frac{V_{TA+30}^C - V_{TA}^C}{2} \quad (4)$$

where: V_{TA}^R - the real total volume of the stand at the age TA (existing in the database); V_{TA}^C - the calculated total volume of the stand at the age TA; $V_{TA+10}^C, V_{TA+20}^C, V_{TA+30}^C, \dots, V_{TA+80}^C$ - the calculated total volume of the stands at the age TA+10, TA+20, TA+30, ..., TA+80.

C2 – there are included information with respect to the stands that fulfill the condition:

$TA > TE - 20$

The stands included in this group will be differentiated in 3 categories in relation to the duration of the remaining period of regeneration (PRM): $PRM \leq 10 \Rightarrow C21$; $11 \leq PRM \leq 20 \Rightarrow C22$; $PRM \geq 21 \Rightarrow C23$

There is calculated and added up the volume of the stands and of the growths on the period (for the stands entered within C2):

$$V_2 = \sum V_2^1 + \frac{1}{2} \sum V_2^2 + \frac{1}{3} \sum V_2^3 \quad (5)$$

where: V_2^1 - the volume of the stands included within C21; V_2^2 - the volume of the stands included within C22; V_2^3 - the volume of the stands included within C23.

V_2^1, V_2^2, V_2^3 - there will be calculated with the relations:

$$V_2^1 = V_{TA}^R + (V_{TA+10}^C - V_{TA}^C) + \left(\frac{V_{TA+20}^C - V_{TA+10}^C}{2} \right) \quad (6)$$

$$V_2^2 = V_{TA}^R + (V_{TA+10}^C - V_{TA}^C) + \left(\frac{V_{TA+30}^C - V_{TA+10}^C}{2} \right) \quad (7)$$

$$V_2^3 = V_{TA}^R + (V_{TA+10}^C - V_{TA}^C) + \left(\frac{V_{TA+40}^C - V_{TA+10}^C}{2} \right) \quad (8)$$

C3 – there are included information with respect to the stands that fulfill the condition: $TA > TE-30$

The stands included within this group will be likewise differentiated in 3 categories, in relation to the duration of the remaining period of regeneration (PRM): $PRM \leq 10 \Rightarrow C31$; $11 \leq PRM \leq 20 \Rightarrow C32$; $PRM \geq 21 \Rightarrow C33$.

There will be calculated and added up the volume of the stands and of the growths upon the period (for the stands entered within C3):

$$V_3 = \sum V_3^1 + \frac{1}{2} \sum V_3^2 + \frac{1}{3} \sum V_3^3 \quad (9)$$

where: V_3^1 - the volume of the stands included within C31; V_3^2 - the volume of the stands included within C32; V_3^3 - the volume of the stands included within C33.

V_3^1, V_3^2, V_3^3 - will be calculated with the relations:

$$V_3^1 = V_{TA}^R + (V_{TA+20}^C - V_{TA}^C) + \left(\frac{V_{TA+30}^C - V_{TA+20}^C}{2} \right) \quad (10)$$

$$V_3^2 = V_{TA}^R + (V_{TA+20}^C - V_{TA}^C) + \left(\frac{V_{TA+40}^C - V_{TA+20}^C}{2} \right) \quad (11)$$

$$V_3^3 = V_{TA}^R + (V_{TA+20}^C - V_{TA}^C) + \left(\frac{V_{TA+50}^C - V_{TA+20}^C}{2} \right) \quad (12)$$

C4 – there are included information with respect to the stands that fulfill the condition: $TA > TE-40$

The stands included within this group will be likewise differentiated in 3 categories in relation to the duration of the remaining period of regeneration (PRM): $PRM \leq 10 \Rightarrow C41$; $11 \leq PRM \leq 20 \Rightarrow C42$; $PRM \geq 21 \Rightarrow C43$.

There will be calculated and added up the volume of the stands and of the growths upon the period (for the stands entered within C4):

$$V_4 = \sum V_4^1 + \frac{1}{2} \sum V_4^2 + \frac{1}{3} \sum V_4^3 \quad (13)$$

where: V_4^1 - the volume of the stands included within C41; V_4^2 - the volume of the stands included within C42; V_4^3 - the volume of the stands included within C43.

V_4^1, V_4^2, V_4^3 - will be calculated with the relations:

$$V_4^1 = V_{TA}^R + (V_{TA+30}^C - V_{TA}^C) + \left(\frac{V_{TA+40}^C - V_{TA+30}^C}{2} \right) \quad (14)$$

$$V_4^2 = V_{TA}^R + (V_{TA+30}^C - V_{TA}^C) + \left(\frac{V_{TA+50}^C - V_{TA+30}^C}{2} \right) \quad (15)$$

$$V_4^3 = V_{TA}^R + (V_{TA+30}^C - V_{TA}^C) + \left(\frac{V_{TA+60}^C - V_{TA+30}^C}{2} \right) \quad (16)$$

C5 – there are included information with respect to the stands that fulfill the condition: TA>TE-50

The stands included within this group will be likewise differentiated in 3 categories in relation to the duration of the remaining period of regeneration (PRM): PRM ≤ 10 ⇒C51; 11 ≤ PRM ≤ 20 ⇒C52; PRM ≥ 21 ⇒C53.

There will be calculated and added up the volume of the stands and of the growths upon the period (for the stands entered within C4):

$$V_5 = \sum V_5^1 + \frac{1}{2} \sum V_5^2 + \frac{1}{3} \sum V_5^3 \quad (17)$$

where: V_5^1 - the volume of the stands included within C51; V_5^2 - the volume of the stands included within C52; V_5^3 - the volume of the stands included within C53.

V_5^1, V_5^2, V_5^3 - will be calculated with the relations:

$$V_5^1 = V_{TA}^R + (V_{TA+40}^C - V_{TA}^C) + \left(\frac{V_{TA+50}^C - V_{TA+40}^C}{2} \right) \quad (18)$$

$$V_5^2 = V_{TA}^R + (V_{TA+40}^C - V_{TA}^C) + \left(\frac{V_{TA+60}^C - V_{TA+40}^C}{2} \right) \quad (19)$$

$$V_5^3 = V_{TA}^R + (V_{TA+40}^C - V_{TA}^C) + \left(\frac{V_{TA+70}^C - V_{TA+40}^C}{2} \right) \quad (20)$$

C6 –there are included information with respect to the stands that fulfill the condition: TA>TE-60

The stands included within this group will be likewise differentiated in 3 categories in relation to the duration of the remaining period of regeneration (PRM): PRM ≤ 10 ⇒C61; 11 ≤ PRM ≤ 20 ⇒C62; PRM ≥ 21 ⇒C63.

There will be calculated and added up the volume of the stands and of the growths upon the period (for the stands entered within C4):

$$V_6 = \sum V_6^1 + \frac{1}{2} \sum V_6^2 + \frac{1}{3} \sum V_6^3 \quad (21)$$

where: V_6^1 - the volume of the stands included within C61; V_6^2 - the volume of the stands included within C62; V_6^3 the volume of the stands included within C63.

V_6^1, V_6^2, V_6^3 - will be calculated with the relations:

$$V_6^1 = V_{TA}^R + (V_{TA+50}^C - V_{TA}^C) + \left(\frac{V_{TA+60}^C - V_{TA+50}^C}{2} \right) \quad (22)$$

$$V_6^2 = V_{TA}^R + (V_{TA+50}^C - V_{TA}^C) + \left(\frac{V_{TA+70}^C - V_{TA+50}^C}{2} \right) \quad (23)$$

$$V_6^3 = V_{TA}^R + (V_{TA+50}^C - V_{TA}^C) + \left(\frac{V_{TA+80}^C - V_{TA+50}^C}{2} \right) \quad (24)$$

3.2. Calculation of the indicators for determining the measure of the allowable cut

Determining the measure of the possibility implies the calculation of the following indicators:

XVD – the volume of wood that may be harvested in the first decade;

XVE – the volume of wood that may be harvested in the first 20 years;

XV3 – the volume of wood that may be harvested in the first 30 years;

XVF – the volume of wood that may be harvested in the first 40 years;

XV5 – the volume of wood that may be harvested in the first 50 years;

XVG – the volume of wood that may be harvested in the first 60 years;

The calculation of these indicators is carried out through the relations:

$$\left. \begin{aligned} XVD &= V_1 \\ XVE &= V_1 + V_2 \\ XV3 &= V_1 + V_2 + V_3 \\ XVF &= V_1 + V_2 + V_3 + V_4 \\ XV5 &= V_1 + V_2 + V_3 + V_4 + V_5 \\ XVG &= V_1 + V_2 + V_3 + V_4 + V_5 + V_6 \end{aligned} \right\} \quad (25)$$

The final algorithm for determining the possibility is constructed on the following steps:

a. calculation of the indicators **XDD1, ..., XDD6**, with the relations:

$$\left. \begin{aligned} XDD1 &= 2 \cdot XVD - 20 \cdot CI \\ XDD2 &= XVE - 20 \cdot CI \\ XDD3 &= XV3 - 30 \cdot CI \\ XDD4 &= XVF - 40 \cdot CI \\ XDD5 &= XV5 - 50 \cdot CI \\ XDD6 &= XVG - 60 \cdot CI \end{aligned} \right\} \quad (26)$$

b. calculation of the indicator for excess through the relation:

$$XQ = (20 \cdot CI + XDM) / (20 \cdot CI) \quad (27)$$

where:

$$XDM = \min(XDD1, XDD2, XDD3, XDD4, XDD5, XDD6)$$

c. calculation of the allowable cut through the relation:

$$XPCI = \begin{cases} \min \left\{ \begin{array}{l} XVD/10, XVE/20, XV3/30, XVF/40, \\ XV5/50, XVG/60 \end{array} \right\} & \text{if } XQ < 1 \\ [a + (1-a) \cdot XQ] \cdot CI & \text{if } XQ \geq 1 \end{cases} \quad (28)$$

where:

CI – indicating growth of the production fund;

a,b – coefficients of an equation of regression, differentiated in relation to the size of the adopted cycle.

4. Utilization of the ArcGIS software for determining the allowable cut on the basis of the created model

Determining the allowable cut may be carried out with the help of the software ArcGIS. Unfortunately, the facilities offered by this software as regards the use of the data are less used, within our country there being practically no preoccupation in this respect.

The ArcGIS medium offers this possibility if there are known software developing notions in Visual Basic. In order to solve this issue, we have gone through the following stages (Tereşneu, 2007):

- Determining the stands which are to be fit in the sub-unit A. This is carried out through the addition of a new field of data in the database, called "SUPRAF_SUP_A", for which there will be built a software sequence VBA (fig. 1), which should adequately complete this field.

Consequently, the field will be completed and through appealing to the function *Statistics...* associated to the former, there will be displayed all calculated information (fig. 2).

- There are calculated the volumes V_{TA}^C (calculated total volumes) through processing the corresponding data from the adequate dendrometric tables (Giurgiu &, 1972) and they are inscribed in a distinct column of the database.

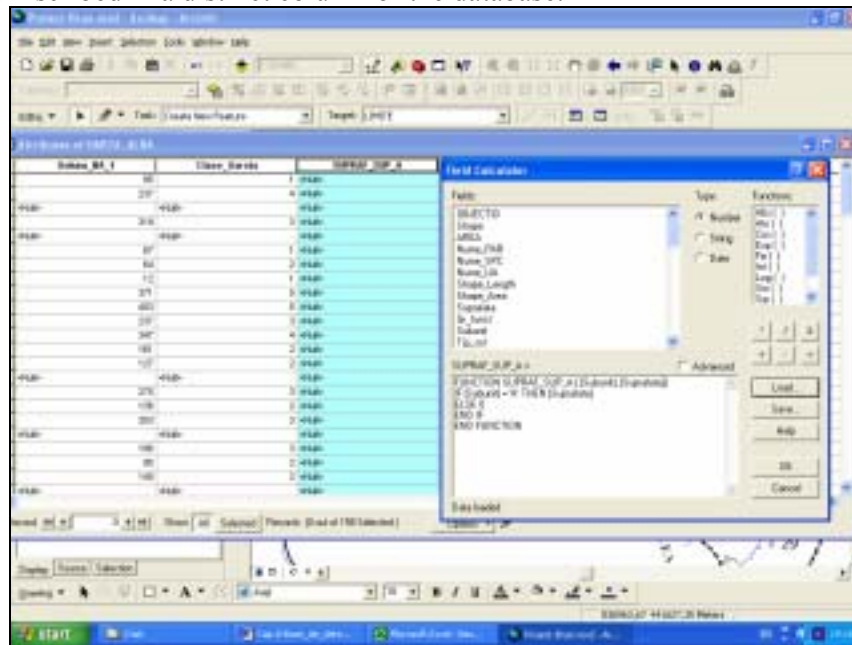


Fig. 1. Building the VBA program sequence in order to determine the stands included in SUP A

- Determining the volume V_1 on the basis of the formula (1). In this respect there was created a function called *Calcul_Volum_V1* that digitizes this calculation (fig. 3). Being saved in a separate file, this function may be appealed to at any time for other determinations. Likewise, through the application of the function *Statistics...* upon the new created field, there is obtained a series of information with respect to the values comprised here (fig. 4)

- d. Calculation of the volmes V2, ..., V6 in a similar manner.
- e. Through adding up the values previously calculated, there were determined the volumes XVD, XVE, XV3, XVF, XV5, XVG, according to the relations (25). As it is about simple relations, there is longer the need to build software sequences VBA, there was only introduced the mathematical relation afferent to each case.

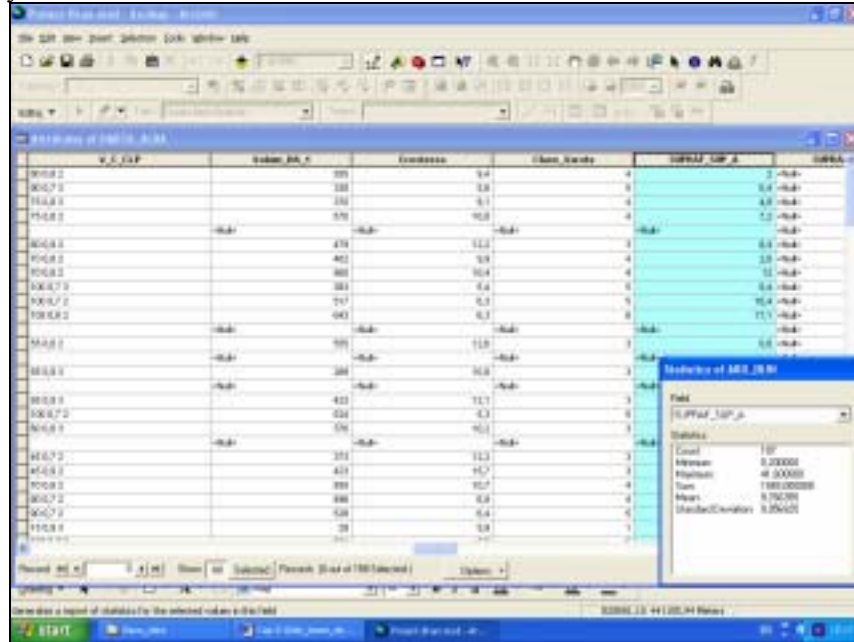


Fig. 2. Applying the “Statistics...” function to the SUPRAF_SUP_A field

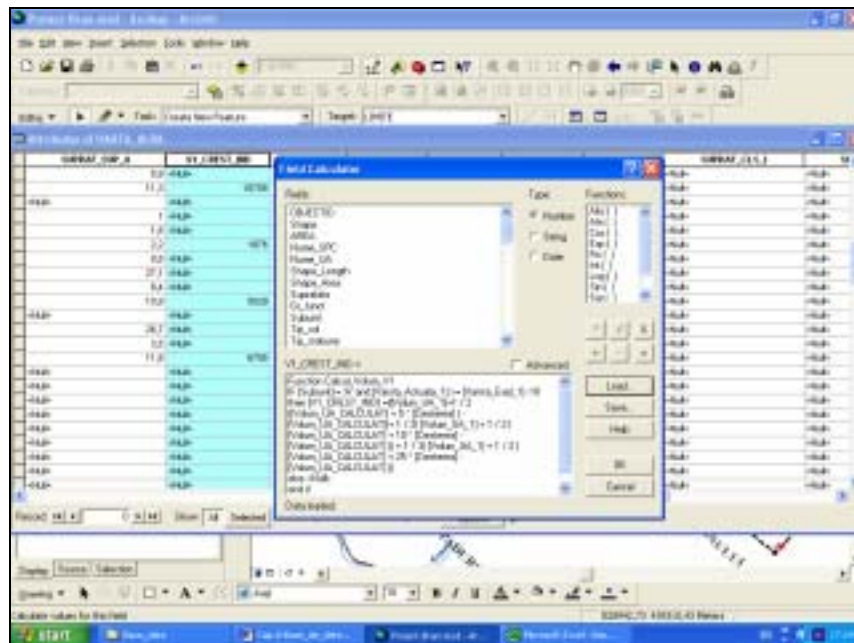


Fig. 3. Determining the V1 volume in ArcGIS

- f. There is introduced the indicating growth, which was calculated with the software AS, in a separate column.
- g. There are calculated the indicators XDD1, ..., XDD6 resorting to the relations (26). Neither in this case there is need to build software sequences VBA. There will be

introduced the mathematical relations through appealing to the fields that make the object of these processings. In order to exemplify, there is presented in figure 5 the manner of obtaining the indicator XDD1.

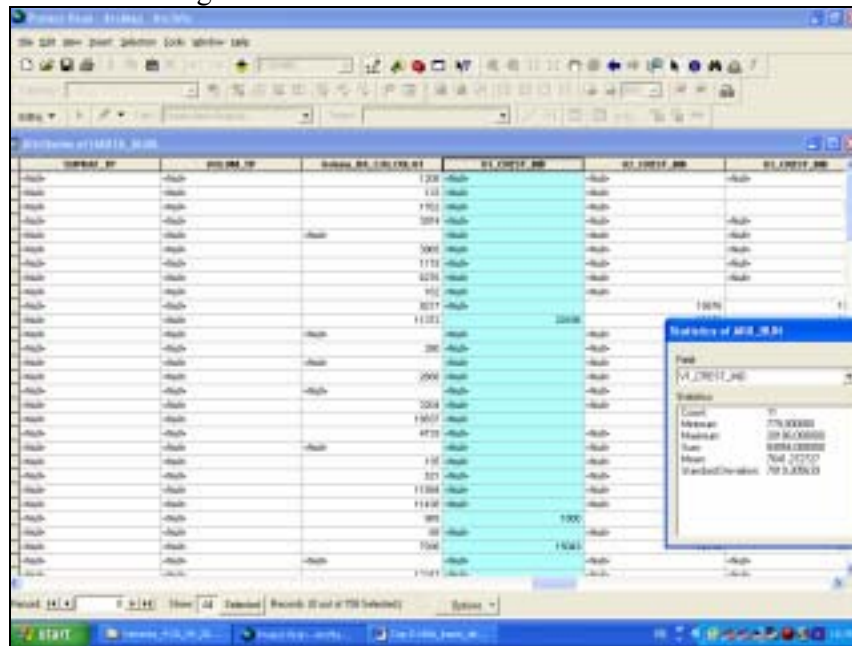


Fig. 4. Statistical information concerning the V1_CREST_IND field

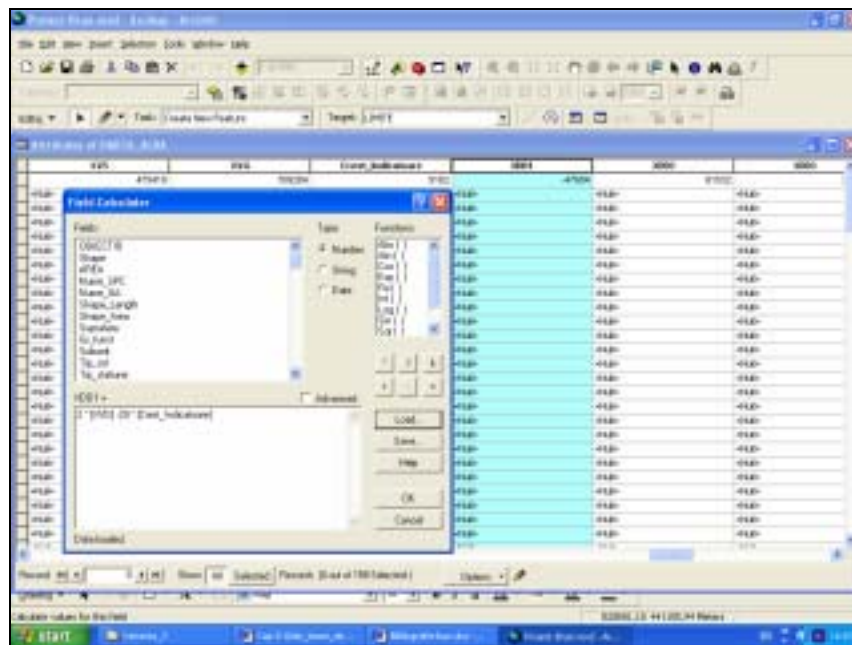


Fig. 5. Determining the indicator XDD1

- h. Determining the value XDM in view of obtaining the excess indicator, through taking over the minimal value out of the interval (XDD1; XDD6).
- i. Calculation of the excess indicator XQ through the relation (27). This formula is transposed with the help of the mathematical operators in the space of the window Field Calculator (fig. 6).

- j. Realizing the corresponding divisions in order to carry out the reports XVD/10, ..., XVG/60 and their inscription in distinct columns.
- k. Determining the possibility through the intermediary of the relation (28). Practically, in this case, there is about settling and taking over the minimal values out of the interval XVD/10, ..., XVG/60.

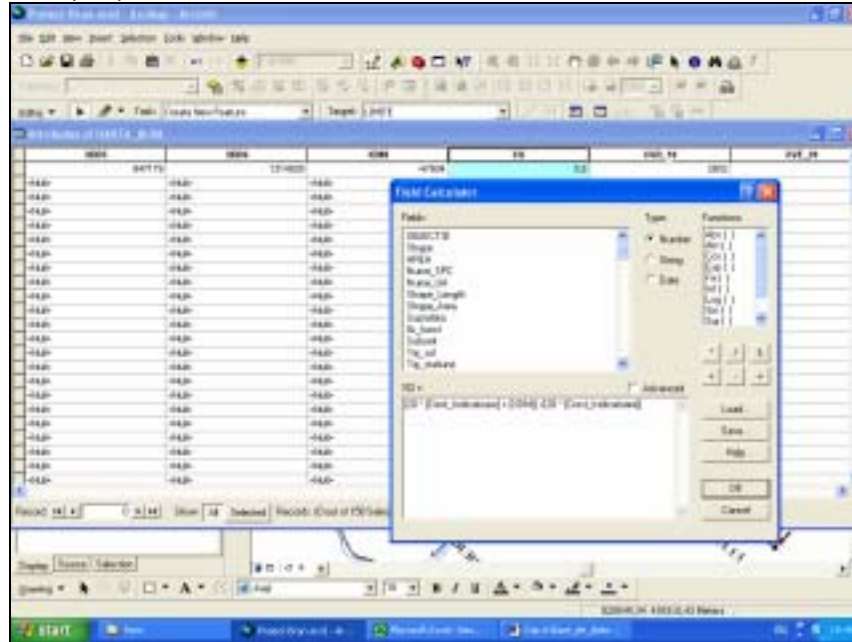


Fig. 6. Calculating the surplus indicator XQ

The obtained result for the allowable cut indicator through the method of the indicating growth is 2802 m^3 . In order to verify, this indicator was determined with the help of two other types of software: the software AS which is still being used on the national level in view of determining the possibility and the software Microsoft Excel. The obtained results were identical.

5. Conclusions

The particular facilities that the software ArcGIS contains make of this one an instrument of great help for the experts who work with any type of geographical data. The rich possibilities for processing the database, inclusively through the intermediary of the software sequences VBA (integrant part of ArcGIS), confer to this product software a particular flexibility and recommend it as one of the most adequate, easy to be applied and perfectly adapted to the realities in the forestry sector.

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