METHOD FOR DRAWING FOREST MAPS BY MEANS OF AN OFFICE COMPUTER

by

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1. Introduction   O.D.C. 582

Since in forest inventory an increasing number of operations and calculations may be performed automatically, we will attempt in this contribution to map out certain quantities (such as number of trees, basal area, volume, etc.) by means of a modest computer unit.

We used an Olivetti P 203, consisting of a modified calculator Programma 101 and a joined typewriter Tekne 3. The program elaborated to draw forest maps is recorded on a magnetic card and may be entered continuously into the memory of the computer by means of the same card. A broad description of the construction and functioning of the P 203 has been given previously (Goossens [1]). At the same time it was shown how the calculations of the quantities mentioned above could be performed automatically by means of such an office computer. In the contribution below we therefore suppose these quantities already available.

2. Principle

In forest inventory as well as in mapping a network is used, which once applied to the forest map, serves as a basis for the sampling points in the field .The distance between these points or the number of samplings per ha, depends on a certain number of factors, among which the necessary precesion as to this choise plays without doubt an important part (Pardé [3]).

Each point being a centre, a circular plot is marked out in the field (optical method), the area of which is also determined by the precision strived at and the nature and constitution of the forest or stand under discussion. Within this area all diameters are mea-

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sured as usual and recorded according the tree species and diameter class. The work in the field finishes with an eventual measuring of the tree heights and the taking of cores (according to the method used). With these data and by means of a computer and a appropiate program (Goossens, [1]) several quantities per ha are calculated such as : number of trees, basal area, increment of the basal area, volume, volume increment, money value of the standing trees and eventually different average trees.

For a given characteristic (e.g. growing stock) each point of the network on the map has a certain value (in our example the amount m^3 of timber per ha) resulting from samplings in the corresponding points in the field. The drawing of the map amounts only to grouping the points belonging the same class into specific coloured zones or with other means (lines, points,...)

For practical reasons (see below) wathever characteristic that has to be mapped out is assigned 10 classes (K_u) with $K_u =$ 0, 1, ..., 9 and u respectively equalling 1, 2, ..., 10. The class interval k depends of course on the highest values wich are found, or are to be expected normally, for the characteristic under discussion.

class K_u	interval
0	$0 \leqslant P_0 < k$
1	$k \leqslant P_0 < 2k$
2	$2k \leqslant P_0 < 3k$
3	$3k \leqslant P_0 < 4k$
4	$4k \leqslant P_0 < 5k$
5	$5k \leqslant P_0 < 6k$
6	$6k \leqslant P_0 < 7k$
7	$7k \leqslant P_0 < 8k$
9	$8k \leqslant P_0 < 9k$
8	$9k \leqslant P_0 < 10k$

The table above gives a survey of the classes K_u wich will be used in further calculations, P_0 being the value in a point with x_i and y_i as coordinates, situated in our elementary square of the basic network on the map (see fig. 1). As a map is composed of a whole series of similar squares, the problem may for the moment be reduced to one of them. Such a square always consists of a series of four sampling points A_1, A_2, A_3 and A_4, wich represent in the calculations below the values of the measured or calculated (cfr. average trees) quantities. If we consider A_1 as starting point and equal the distance between A_1 and A_2 (or A_3 and A_4) to x_m and the distance between A_1 and A_3 (or A_2 and A_4) to y_m, then these symbols should in principle suffise to elaborate the formulas required
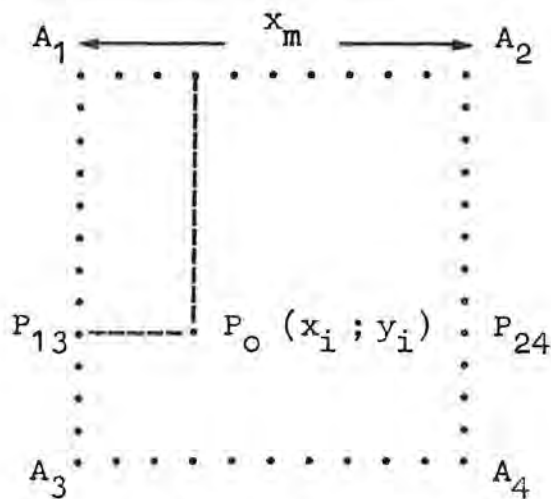
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Fig. 1. Elementary square of the network on the forest map (A_1, A_2, A_3 and A_4 sampling points and corresponding values measured in the plots).

to calculate the value in a given point P_0 (x_i; y_i) situated upon or in the elementary square of the network.

Since the drawing of the forest map is left to the typewriter of the office computer, the sides of the square have to be split up into an certain number of steps, as well in the x-as in the y-direction; so that the computer may calculate a series of even-spaced points and so that the typewriter may print them on the right spot by means of the code K_u.

We proceed for instance to divide the distance x_m into «a» equal parts (= distance between two succeeding characteristics or a multiple of it) and the distance y_m into «b» equal parts (= interline or a multiple of it). The value of P_0 with the coordinates (x_i; y_i) may now be calculated as follows (see fig. 1) :

1. First we calculate the value in an auxiliary point P_{13} (o; y_i) situated on the line segment $A_1 A_3$, y_i being the distance from A_1. This results in :

$$P_{13} = A_1 + (A_3 - A_1) \frac{y_i}{b} \qquad (1)$$

the values for y_i varying succeedingly from 0, 1, 2, ... to b

2. Then the value in an auxiliary point P_{24} (x_m; y_i) on the line segment $A_2 A_4$ is calculated, y_i being also the distance from A_3, so that :

$$P_{24} = A_2 + (A_4 - A_2) \frac{y_i}{b} \qquad (2)$$

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y_i having the same values.

3. Since P_{13} and P_{24} are now known, the value of P_o on the line sigment $P_{13}P_{24}$, may be calculated according to the same principle as follows :

$$P_o = P_{13} + (P_{24} - P_{13}) \frac{x_1}{a} \qquad (3)$$

x_1 having succeedingly the values 1, 2, 3, ... a

Once P_o is calculated, the computer program examines to wich class interval the value belongs, which results in a code K_u as shown above. This number (going from 0 till 9) is printed by the typewirter on the place wich precisely corresponds to the coordinates used in the calculations.

Fig. 2 (A) presents a practical example of a similar elementary square of the network, having a = 10 and b = 12. The specific construction of the typewriter accounts for the fact that the horizontal definition (12 lines) differs from the vertical one (10 lines). Taking in account this kind of differences, it is possible to arrive at the square wanted. Equally possible is the combination a = 5 and b = 6 (see fig. 2B). In both cases an open space is horizontally left between each K_u-value, whereas the vertical moves of the carriage (line space) are performed in position 1.
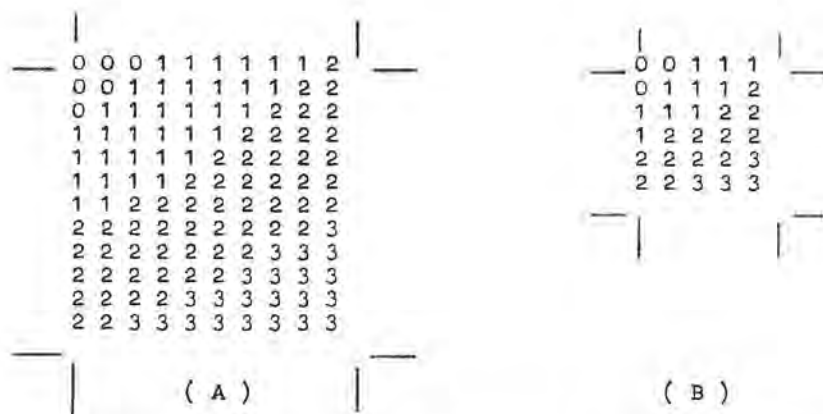

Fig. 2. Elementary squares printed by the typewriter of the Olivetti P203.
(A) — 2" × 2"
(B) — 1" × 1"

According to the precision required, thing may be adapted to the circumstances.

Fig. 2 clearly demonstrates why it is necessary to number the classes from 0 till 9, because otherwise a code of two digits would result in blending and an unclear representation.
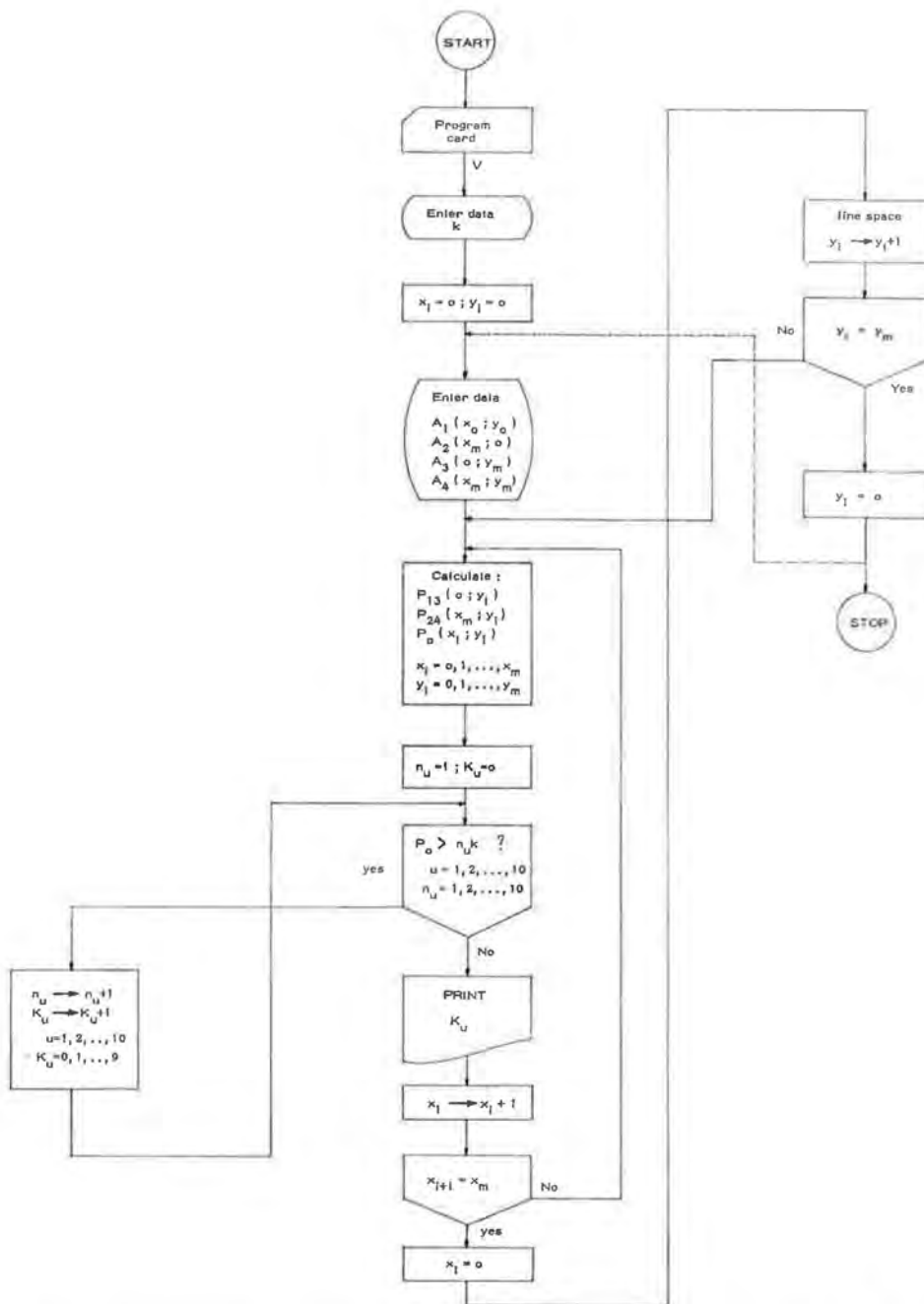
3. Procedure

The general procedure is summarized by the flowchart (appendix 1). The program card being inserted, the class interval k is entered into the memory by means of the keyboard of the calculator. This has to be done only once for each forest map that has to be drawn. As soon as the carriage of the typewriter is arranged in the right position, the data A_1, A_2, A_3 and A_4 can be entered into the memory also by means of the keyboard, so that the calculations and the printing of an elementary square of the network on the forest map are performed automatically.

In the beginning of the program x_i equals y_i which equals 0. After P_{13}, P_{24} and P_0 are succeedingly calculated the last value is compared with $n_u.k$. This test starts with $n_u = 1$ and $K_u = 0$. If P_0 surpasses $n_u.k$, n_u and K_u are raised, with one unit, whereafter the same test is carried out as many times as required for P_0 to become equal to or smaller than $n_u.k$, so that the carriage moves one position forwards and prints the value K_u. Then x_i is increased with one unit and tested against the value of x_m. Is the latter still higher, the calculations start again for the following point on the same line etc.... If on the other hand $x_i = x_m$, x_i is reset to zero and one unit is added to y_i. Then the carriage of the typewriter returns to the margin and the computer calculates again all the P_0-values on that following line. Similar calculations only take place when y_n surpasses y_i. In case y_n is equal to y_i, y_i is again fixed to zero and the calculations finished. In this way a complete elementary square of the network is calculated and printed. Appendix 2 surveys the complete program.

Four new points A_1, A_2, A_3 and A_4, being introduced, the whole program is carried out again. It is important first to finish all the elementary squares situated one under another so as not to be obliged to adjust continually the margin of the carriage.

Fig. 2 show that in the elaboration of an elementary square the last column as well as the bottom line are not printed. This was provided for in the program, since the elementary squares below as well as the one next to it have respectively this line and this column in common.

Appendix 3 gives an example. The bottom page comes out of the typewriter and represents the distribution of the different

START

Program
card

V

Enter data
k

$x_i = 0 ; y_i = 0$

line space
$y_i \longrightarrow y_i + 1$

Enter data

$A_1 (x_0 ; y_0)$
$A_2 (x_m ; 0)$
$A_3 (0 ; y_m)$
$A_4 (x_m ; y_m)$

$y_i = y_m$

No

Yes

$y_i = 0$

Calculate :

$P_{13} (0 ; y_i)$
$P_{24} (x_m ; y_i)$
$P_0 (x_i ; y_i)$

$x_i = 0, 1, \ldots, x_m$
$y_i = 0, 1, \ldots, y_m$

STOP

$n_u = 1 ; K_u = 0$

$n_u \longrightarrow n_u + 1$
$K_u \longrightarrow K_u + 1$

$u = 1, 2, \ldots, 10$
$K_u = 0, 1, \ldots, 9$

$P_0 > n_u k$?

$u = 1, 2, \ldots, 10$
$n_u = 1, 2, \ldots, 10$

yes

No

PRINT
K_u

$x_i \longrightarrow x_i + 1$

$x_{i+1} = x_m$

No

yes

$x_i = 0$

Appendix 1.

Flowchart. — Program for printing the elementary squares of the network on the map.

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P 203

program: Mapping (1" x 1")

code: K 1 , dec. indic.: 0 + (4)

card: 1   Nb. cards: 1

INSTRUCTIONS

regist. 1		regist. 2		regist. F		regist. E		regist. D	
1	A V	33	F/X	65	S	97	S	129	
2	S	34	A/↑	66	S	98	S	130	
3	E/↑	35	R S	67	S	99	S	131	
4	/◊	36	D/-	68	A Z	100	S	132	
5	B W	37	:	69	+	101	S	133	
6	S	38	D/+	70	F/↕	102	A Y	134	
7	B/↑	39	D/↕	71	F/↓	103	↕	135	
8	S	40	A/↑	72	A/↑	104	-	136	
9	B ↑	41	D/S	73	R S	105	/Y	137	
10	S	42	E ↑	74	D/-	106	F *	138	
11	C/↑	43	E/↓	75	↕	107	/◊	139	
12	S	44	D ↕	76	-	108	C W	140	
13	C ↑	45	C Z	77	/W	109	A/W	141	
14	B Y	46	A/V	78	E/S	110	A/Y	142	
15	C/↓	47	D ↓	79	W	111	C Y	143	
16	B/-	48	E/+	80	S	112	S	144	
17	F X	49	D ↕	81	S	113	S	145	
18	A/↑	50	E ↓	82	S	114	S	146	
19	R S	51	A/↑	83	S	115	S	147	
20	D/X	52	D/↓	84	A W	116	S	148	
21	:	53	+	85	F/*	117	S	149	
22	B/+	54	E ↕	86	F ↓	118	S	150	
23	D/↕	55	B Z	87	A/↑	119	S	151	
24	C ↓	56	D/↓	88	D/↓	120	S	152	
25	B -	57	D -	89	+	121	S	153	
26	F X	58	/V	90	F ↕	122	S	154	
27	A/↑	59	E <	91	F ↓	123	S	155	
28	R S	60	↑	92	A/↑	124	S	156	
29	D/X	61	F/↓	93	R S	125	S	157	
30	:	62	A/↑	94	D/X	126	S	158	
31	B +	63	D/↓	95	Y	127	S	159	
32	D/-	64	Z	96	S	128	S	160	

content of register	
M	operational
A	operational
R	operational
b	A_1
B	A_2
c	A_3
C	A_4
d	subtotals
D	k_u
e	k
E	n_u ;instruct.
f	x ;instruct.
F	y ;instruct.

input data	digits
k	4
A_1	15
A_2	15
A_3	15
A_4	15

constants on card		constants on card	
	↑		↑
	↑		↑
	↑		↑

REMARKS:

1. Start program ——► V
2. Input k
3. Input A_1, A_2, A_3 and A_4
4. Stop ——►3

Appendix 2.

growing stock classes (m³/ha) over a part of a fictitious woodcomplex. The distance between the sampling points ammounts to 70.7 m, which corresponds to two plots a ha. As to the reproduction and the drawing-speed, the combination a = 5 and b = 6 was used, so that an elementary square of 1 " × 1 " appears on the bottom page. On top of it cames the proper forest map, (a blanco basical map for all possible mapping work) reproduced on transparent material, the scale being 1 " to 70.7 m. This rather unusual scale doesn't present the least difficulty since the map is not a final one and it may be reduced easily to an usual scale in final reproductions.

As shown in appendix 2, it is now rather simple to draw and represent on the forest map the situation of the different growing stock classes or other characteristics of the forest.

4. Conclusions

The contribution above shows that something may be achieved in the field of the automation of forest mapping with limited means too.

Although the calculations and drawing for an elementary square of 1 " × 1 " scarcely take less time than in case the calculations would be performed by an ordinary calculation machine and the drawing manually, this method has nevertheless some important advantages. In the first place this time is spared entirely for other activities, except for the entering of the data A_1, A_2, A_1 and A_2. Secondly the precision of the method is much greater, since the space within the elementary square is thoroughly searched; on the contrary, when using the manual method, only the position of the class-limits on the sides of the squares are calculated and drawn and in some cases also the position of these limits before one diagonal. According to the choice of one of both diagonals the results therefor do differ.

Finally this method almost excludes errors, which is certainly not be said of the classical method. Add to that, that in some cases it is not always clear how the borderlines between the classes eventually have to be drawn.

A similar difficulty is avoided by our method because the complete surface is covered by figures from 0 till 9 (see appendix 3) and the borders are always situated at the transition from one figure to another. Besides the speed of calculating and drawing which is still to slow, the fact that a group of four data has always to be entered is in our opinion a far from smart procedure. The former drawback will be dispersed within the future as office computers
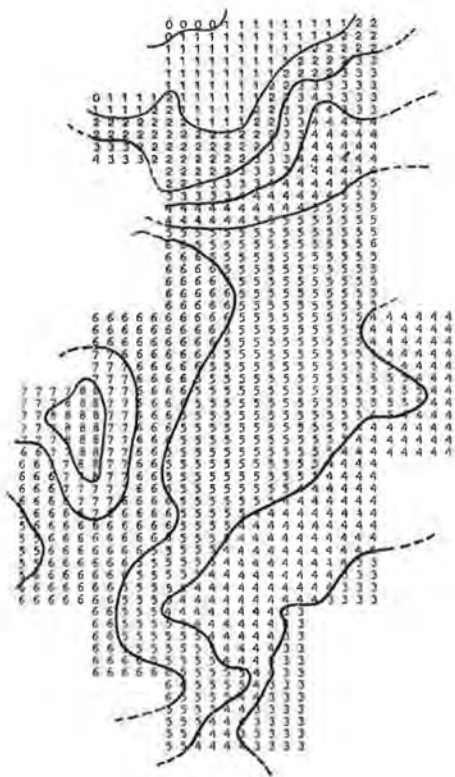
8
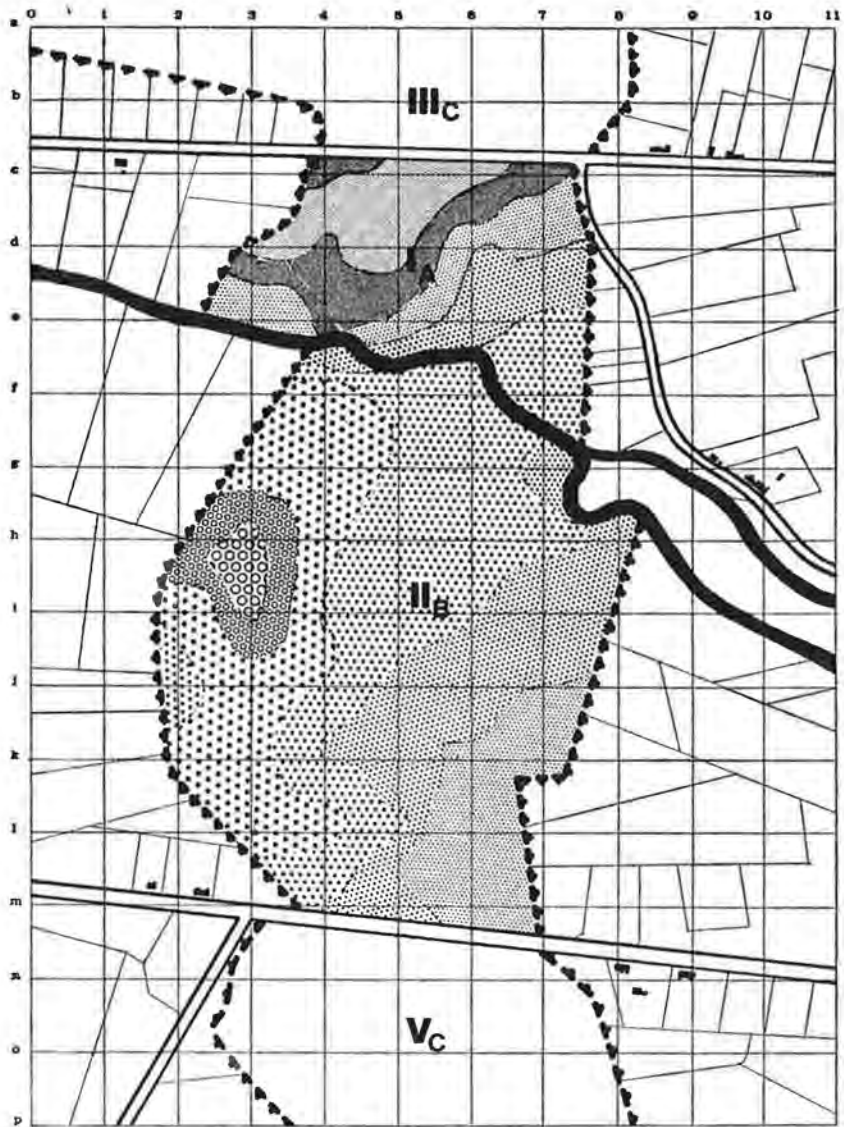
STOCKING (m³/ha)

	0 - 50		250 - 300
	50 - 100		300 - 350
	100 - 150		350 - 400
	150 - 200		400 - 450
	200 - 250		450 - 500

Appendix 3.

OLIVETTI P 203

will became quicker and more polyvalent. The latter difficulty could be overcome by entering the data automatically by means of a « punch read-unit ». In the near future it probably will become possible to join such a unit to the Olivetti P. 203.

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SUMMARY

Method for Drawing Forest Maps by means of an Officer Computer

In this article we tried to perform the drawing of forest maps, together with the calculations involved, automatically by means of relatively simple aids.

The computer unit used is an office computer Olivetti P203. As an example the growing stock (in m^3/ha) was mapped out. The proper inventory in the field is done according to the classical method by means of a previously fixed network of squares (70,7 m × 70,7 m), which corresponds to two plots a ha.

The quantity which is measured and mapped out (in this case the growing stock) is in a similar form not very useful in mapping. Therefore a division in classes (K_u) numbered from 0 to 9, is set up. An appropriate program calculates for a certain number of points within this elementary square, to which class they have to be assigned, whereas the typewriter prints the corresponding code number on the right place.

Fig. 1 and the formulas (1), (2) and (3) represent the principle of the calculations while fig. 2A and B reproduce the results printed by the typewriter for a elementary square of respective 1" × 1" and 2" × 2". The whole of similar network of squares eventually results in a basical document, on which the existing forest map with an adapted scale is laid (see appendix 3) and the class limits are drawn.

If desirable, the scale may be adapted when the forest map under discussion is definitely reproduced.

SAMENVATTING

Methode voor het tekenen van boskaarten met behulp van een bureel-computer.

Met dit artikel werd een poging gedaan om ook het tekenen van boskaarten, samen met de berekeningen die hiermee gepaard gaan, met behulp van relatief eenvoudige hulpmiddelen te automatiseren. De hierbij gebruikte computer-eenheid bestaat uit een bureelcomputer Olivetti P203. Als voorbeeld wordt de voorraad (in m^3 per ha) in kaart gebracht. De eigenlijke inventarisatie op het terrein geschiedt volgens de klassieke manier met behulp van een vooraf gefixeerd kwadraatnet van 70,7 m × 70,7 m, wat overeenstemt met twee opnamepunten per ha. De gemeten en in kaart te brengen grootheid (in dit geval de voorraad) kan moeilijk onder dergelijke vorm verder worden gebruikt bij de kartering. Daarom dient een indeling in klassen (K_u) doorgevoerd, genummerd van 0 tot en met 9. Een aangepast programma berekend voor een zeker aantal punten

binnen dit kwadraatnet gelegen, in welke klasse ze dienen ondergebracht, terwijl de schrijfmachine het desbetreffende codenummer op de juiste plaats uitdrukt.

Fig. 1 en de formules (1), (2) en (3) geven het princiepe van de berekeningen aan, terwijl fig. 2 A en B het resultaat van de schrijfmachine reproduceert bij een kwadraatnet van respektievelijk $1'' \times 1''$ en $2'' \times 2''$.

Het geheel van dergelijke netten vormt uiteindelijk een basisdokument waarop dan de bestaande boskaart met aangepaste schaal wordt gelegd (zie bijlage 3) en de klasse begrenzing overgetekend. Indien wenselijk, kan bij de definitieve reproduktie van de boskaart in kwestie, de nodige schaalaanpassing worden doorgevoerd.