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forestry & natural resources

WOODLAND MANAGEMENT

APPRAZ—A Timber Volume Estimation Program for the HP-41C*

by Thomas W. Beers, Department of Forestry and Natural Resources

The availability of convenient and powerful hand-held programmable calculators, such as the Hewlett-Packard 41-C, promises to have a significant impact on most of the scientific community. In fact, the applicability of such calculators to the field of forestry, in general, and to forest inventory, in particular, is enormous.

This bulletin presents and describes APPRAZ—a program for the HP-41C—to show how routine forest inventories can be readily processed on this relatively inexpensive calculator instead of through laborious handwork. Although other programmable calculators are capable of forest inventory programming, the HP-41C is chosen for the sake of example and convenience.

APPRAZ is a program to calculate log volumes and to obtain, primarily, summaries by species and log grades as might be typical of a small-scale timber appraisal where *individual* log diameter, length, and grade are recorded in the field.

For those not familiar with the features of the HP-41C, it should be noted that its continuous memory feature and very long battery life suggest the feasibility of direct tally of tree data into the calculator therefore eliminating the pencil-paper recording operation. The system is not foolproof yet, and users are urged to apply APPRAZ to the situation where field data have been recorded on paper and an on-the-spot, or at least very timely, summary is needed. Obviously, for large forest inventories, the use of computer processing is desirable and frequently justified.

Following are five aspects involved in the use of APPRAZ—a general description; the program procedure; typical data and example; storage register assignments; and a program listing.

* This publication is the first in a series of two on the use of programmable calculators in forest management. The second is entitled, FNR-108 "CRUZ—A Timber Volume Estimation Program for the HP-41C."

General Description

1. Program title: APPRAZ
2. Calculator: HP-41C with 3 memory modules; can be used with or without the HP-82143A printer attached.
3. Purpose: to calculate timber volumes and summarize same by species and log grade; additionally, numbers of trees by species and DBH class are summarized as are number of logs by species. Grand total volume, number of logs, and number of trees are also provided.
4. Application: to be used in timber harvest inventories, on site, or from tally sheets where data are recorded by logs in the form

dd - LL - G

where dd = scaling diameter of log in inches

LL = log length in feet

G = log grade (5 grades possible)

5. Justification: the primary advantage of calculator processing is that the very time-consuming operation of sorting by grade within species is eliminated; secondarily, all calculations and sums are automated, thus avoiding table look-up or calculation errors and minimizing transcribing errors.

Program Procedure

The following instructions are rather detailed, assuming that the user is "feeling his way." It is recommended that the procedure be read in its entirety at least once before actual implementation. If a printer is attached to the calculator, displayed output will be printed.

Step

- 1 XEQ SIZE 141 and load program APPRAZ.
- 2 To initialize (set flags and clear stack and registers; assign species names) XEQ APPRAZ. Assigning APPRAZ to a key (say X$\leq Y$) is only advisable for demonstration purposes, and, in general, USER mode should not be used until all data have been processed (step 6).
- 3 In response to "SPECIES?"
 - a. Key in species code for first tree; example: WALNUT = 1, WH.OAK = 2, etc. (9 species possible)
 - b. If tree count is not desired by DBH class, depress CHS (change sign). The presence or absence of negative on this first tree only dictates absence or presence of the DBH count summary for entire cruise.
4. Depress R/S
 - a. In the absence of a negative species code, the prompt will be "DBH CLASS?"; go to step 5.
 - b. If first species code was negative, the prompt will be "dd.LLG?"
 - (1) whereupon, for the first log, one "keys-in" the integer scaling diameter (dd), decimal point, the integer length (LL) and log grade (zero through 4; i.e., five grades)
 - (2) depress R/S and the log will be processed; an audible tone will sound and the prompt will be "NEW TREE? Ø"
 - (a) for a new log in the same tree, press R/S and prompt will be "dd.LLG?" as for first log (as in 4b)
 - (b) for a new tree, press zero, then R/S and prompt will be "SPECIES?" as in 3
- 5 In response to "DBH CLASS? " key-in an integer diameter class (10 to 40) and press R/S.

- a. Tree count by DBH class will be processed, and the prompt for the first log will be "dd.LLG?"
 - b. Proceed as in 4b, eventually depressing 0, R/S for a new tree.
 - c. For each new tree, the "DBH CLASS?" prompt will automatically appear, unless species code is negative, in which case the DBH prompt and summary will be aborted. To re-activate this option, flag 1 must be set manually, i.e., f SF 01* (or start over by XEQ APPRAZ).
- 6 When all trees have been processed, summaries are available as follows:

- a. In USER mode, depress keys A through E and fA through fD for species 1 through 5 and 6 through 9, respectively. Example:

depress C (i.e., species 3) and output will be:

```

SPECIES 3      (pause)
RE.OAK        (pause)
GR.0 = x x x x (pause)
GR.1 = x x x x (pause)
GR.2 = x x x x (pause)
GR.3 = x x x x (pause)
GR.4 = x x x x (pause)
Σ VOL. = x x x x (pause)
Σ TREES = x x   (pause)
Σ LOGS = x x   (pause)

```

- b. Similarly, in USER mode, depress fE to read grand totals of volume by grade (i.e., across species); output will be:

```

GRAND TOTALS (pause)
GR.0 = x x x x (pause)
GR.1 = x x x x (pause)
GR.2 = x x x x (pause)
GR.3 = x x x x (pause)
GR.4 = x x x x (pause)
Σ VOL. = x x x x (pause)
Σ TREES = x x   (pause)
Σ LOGS = x x   (pause)

```

- c. Total number of trees by DBH class (DD) can be displayed using any of three options: semiautomatic (DBH); automatic display, one inch classes (AD1); or automatic display, two inch classes (AD2).

* Throughout this program, the letter "f" is used to indicate depression of the shift (gold) key.

- (1) XEQ DBH (semiautomatic display)
 - (a) at the prompt "DBH CLASS?", key-in desired DD (10 to 40), depress R/S; "NO. TREES = xx." will be displayed for approx. 2 seconds then the "DBH CLASS?" prompt will reappear.
 - (b) repeat (a) for another DBH class.
- (2) XEQ AD1 (automatic display, one-inch classes; assuming data were recorded by one-inch classes in the cruise)
 - (a) at the prompt "1ST CLASS:1:?", key-in the class where you want the consecutive automatic display to start, say DD (10 to 40), depress R/S.
 - (b) starting with this initial class, and then by increments of one-inch, the class will be identified rapidly by "DBH CLASS:DD". Then "NO. TREES = xx". will remain for two seconds.
 - (c) display will stop after 40-inch class has been displayed (to stop manually, depress R/S)
- (3) XEQ AD2 (automatic display, two-inch classes; assuming data were recorded by two-inch classes in the cruise)

Procedure is the same as for AD1, except that the prompt will be "1ST CLASS:2:?", whereupon an initial even DD (10 to 40) class should be keyed-in. Display will then proceed by two-inch increments through the 40-inch class.

- 7 **SPECIAL NOTE:** The contents of any two-digit storage register (00 through 99) can be displayed at any time by depressing f VIEW nn. Calculations are not affected since the stack is not disturbed. A depression of ← will restore the x register contents to display. For example, the accumulated volume in species 1 grade 2 can be viewed by f VIEW 12; volume in species 6, grade 0 by f VIEW 60; grand total volume by f VIEW 05; etc. (Refer to storage assignments list for other data locations)

- 8 **ERROR CORRECTIONS.** If one observes faulty species code, DBH, or log data in the display prior to processing that tree or log, the correction key (←) can be used to rectify the information.

If one senses that faulty information has just been processed, certain "erasure" routines are possible:

- a. To erase the effect of an erroneous species code or DBH class at the time of the first dd.LIG prompt in a tree (i.e., before the audible tone)
 - (1) XEQ TGOOF (for tree goof)
 - (2) prompt will then become "SPECIES?"
 - (3) proceed with correct species code and DBH as in step 3.
- b. To erase the effect of erroneous log data at the time of the "NEW TREE? Ø" prompt (i.e., just after the audible tone)
 - (1) XEQ LGOOF (for log goof)
 - (2) erroneous volumes and counts will be deducted and prompt will again be "NEW TREE? Ø" after tone sounds.
 - (3) depress R/S (as for any new log); key-in correct log data, and depress R/S to process the correct data.

9 Program as written assumes bd. ft. volumes, Doyle scale:

$$V_i = (d_i - 4)^2 \frac{L_i}{16}$$

where V_i = log volume in board feet

d_i = log diameter in inches, inside bark at the small end

L_i = log length in feet

If other log rules or cubic foot volume formulas are desired, one can substitute a subroutine with the label LBL 13; for location convenience, it is located last in the APPRAZ program.

Examples:

a. Scribner bd. ft. volume:

$$V_i = (.79d_i^2 - 2d_i - 4) \frac{L_i}{16}$$

Subroutine:

```
LBL 13, RCL08, x2, .79, x, RCL08, 2, x, -, 4, -,
RCL09, x, 16, ÷, FIX0, XEQ RND, STO98,
FIX3, RTN
```

10 The species codes and names used in the program are as follows:

- 1 = WALNUT
- 2 = WH.OAK
- 3 = RE.OAK
- 4 = ASH
- 5 = TULIP
- 6 = HICKRY (yes, it's misspelled, but for convenient storage one is limited to six characters!)
- 7 = H.MAPL
- 8 = S.MAPL
- 9 = MISC.

To alter this list or use entirely different names or assignments, one can make appropriate changes in subroutine 15, near the end of the program, as follows:

- a. To get to this part of the program, make sure that the calculator is not in PRGM mode; depress f GTO 15.
- b. Put the calculator in PRGM mode, and use the delete key (←) to delete the unwanted names; then key-in the desired names from top (1) to bottom (9); they will be separated by XEQ 14 instructions.
- c. Take calculator out of PRGM mode.

11 If calculator is turned off before a summary is finished, it is most logical (though not necessary) to do this after a given tree has been processed and \emptyset , R/S have been depressed. To see the prompt for the next tree when the calculator is turned on, depress ALPHA key. Depress ALPHA again (i.e., out of ALPHA mode) before keying-in the next log data.

Typical Data and Example

The hypothetical data given here are meant to be used as a test after APPRAZ has been appropriately loaded in the HP-41C. A four-tree sample (2 black walnut, 1 white oak, and 1 red oak) is shown. Typical summary tables are then presented. In practice these tables should be prepared in skeleton form, then filled-in from observing the calculator display or the paper tape (see example in part C) if a printer has been used. Note that volumes shown are board feet, Doyle Scale. Other volume units can be obtained by program alteration as described in Step 9 of the "Procedure."

A. Data:

Tree No.	Spec.	DBH	LOG #1		LOG #2		LOG #3	
			dd.LIG	vol.	dd.LIG	vol.	dd.LIG	vol.
1	BLW(1)	22	21.060	108	18.082	98		
2	WHO(2)	18	16.100	90	15.101	76		
3	BLW(1)	18	15.121	91	14.081	50	12.083	32
4	REO(3)	24	21.122	217				

B. Results:

ITEM	SPECIES									GRAND TOTALS
	1 WALNUT	2 WH.OAK	3 RE.OAK	4	5	6	7	8	9	
Grade 0	108	90	0							198
Grade 1	141	76	0							217
Grade 2	98	0	217							315
Grade 3	32	0	0							32
Grade 4	0	0	0							0
Total volume	379	166	217							762
Tree count	2	1	1							4
Log count	5	2	1							8

DBH CLASS	NUMBER OF TREES
.	.
.	.
18	2
20	0
22	1
24	1
.	.
.	.
40	-

C. Sample printout obtained by pressing A, B, C, and f E and by executing (XEQ) AD2.

XEQ A
SPECIES: 1
WALNUT
GR. 0=109
GR. 1=141
GR. 2=98
GR. 3=32
GR. 4=0
Σ VOL.=379
Σ TREES=2
Σ LOGS=5

XEQ B
SPECIES: 2
WH.OAK
GR. 0=90
GR. 1=76
GR. 2=0
GR. 3=0
GR. 4=0
Σ VOL.=166
Σ TREES=1
Σ LOGS=2

XEQ C
SPECIES: 3
RE.OAK
GR. 0=0
GR. 1=0
GR. 2=217
GR. 3=0
GR. 4=0
Σ VOL.=217
Σ TREES=1
Σ LOGS=1

XEQ E
GRAND TOTALS
GR. 0=199
GR. 1=217
GR. 2=315
GR. 3=32
GR. 4=0
Σ VOL.=762
Σ TREES=4
Σ LOGS=8

XEQ "AD2"
1ST CLASS:2: 7
16 RUN
DBH CLASS:16
NO. TREES=0
DBH CLASS:18
NO. TREES=2
DBH CLASS:20
NO. TREES=0
DBH CLASS:22
NO. TREES=1
DBH CLASS:24
NO. TREES=1
DBH CLASS:26
NO. TREES=0
DBH CLASS:28
NO. TREES=0

STOP

Storage Register Assignments

The location of various intermediate and final calculations can be found in the following table. One can determine the contents of register nn by using f VIEW nn or RCL nn, but this is not recommended until the entire data set has been completed. Otherwise, program processing might be adversely disturbed.

<u>Register</u>	<u>Contents</u>	<u>UNUSED:</u>
00	Volume in Grade 0 logs	19
01	Volume in Grade 1 logs	29
02	Volume in Grade 2 logs	38,39
03	Volume in Grade 3 logs	48,49
04	Volume in Grade 4 logs	58,59
05	Grand total volume	68,69
06	Grand total no. trees	78,79
07	Grand total no. logs	100
08	Current value of dd	111
09	Current value of LL	113
10	Volume in species 1, Grade 0	.
11	Volume in species 1, Grade 1	.
12	Volume in species 1, Grade 2	137
13	Volume in species 1, Grade 3	139
14	Volume in species 1, Grade 4	
15	Total volume for species 1	
16	Total no. trees for species 1	
17	Total no. logs for species 1	
18	Current value of G	
20-27	Same as 10-17 for species 2	
28	Current species code or alteration	
30-37	Same as 10-17 for species 3	
.	.	
.	.	
.	.	
80-87	Same as 10-17 for species 8	
88	DBH class start for automatic display	
89	Control number for automatic DBH display	
90-97	Same as 10-17 for species 9	
98	Current log volume	
99	Pointer for DBH summary register	
101-109	Species names	
110	No. trees in 10" class	
111	No. trees in 11" class	
.	.	
.	.	
.	.	
140	No. trees in 40" class	

} If 2-inch DBH classes are used.

APPRAZ

01*LBL "APPRAZ"	51 ST+ 07	101 STOP
02 CLST	52 ST+ IND 28	102 GTO 01
03 CLRG	53 7	103*LBL E
04 SF 01	54 ST- 28	104 5
05 XEQ 15	55 RCL 18	105 STO 28
06*LBL 01	56 ST+ 28	106 XEQ 12
07 "SPECIES ?"	57 RCL 98	107 STOP
08 PROMPT	58 ST+ IND 28	108*LBL a
09 X<0?	59 ST+ IND 18	109 6
10 CF 01	60 RCL 18	110 STO 28
11 ABS	61 ST- 28	111 XEQ 12
12 1 E01	62 RCL 98	112 STOP
13 *	63 TONE 9	113*LBL b
14 STO 28	64 "NEW TREE? 0"	114 7
15 FS? 01	65 PROMPT	115 STO 28
16 XEQ 10	66 X=0?	116 XEQ 12
17 1	67 GTO 01	117 STOP
18 ST+ 06	68 GTO 11	118*LBL c
19 6	69*LBL 10	119 8
20 ST+ 28	70 "DBH CLASS?"	120 STO 28
21 1	71 PROMPT	121 XEQ 12
22 ST+ IND 28	72 ENTER↑	122 STOP
23 6	73 100	123*LBL d
24 ST- 28	74 +	124 9
25*LBL 11	75 STO 99	125 STO 28
26 " dd.LLG ?"	76 1	126 XEQ 12
27 PROMPT	77 ST+ IND 99	127 STOP
28 INT	78 RTN	128*LBL e
29 STO 08	79*LBL A	129 "GRAND TOTALS"
30 LASTX	80 1	130 AVIEW
31 FRC	81 STO 28	131 PSE
32 1 E02	82 XEQ 12	132 0
33 *	83 STOP	133 XEQ 03
34 INT	84 GTO 01	134 STOP
35 STO 09	85*LBL B	135 GTO 01
36 LASTX	86 2	136*LBL 12
37 FRC	87 STO 28	137 FIX 0
38 1 E01	88 XEQ 12	138 RCL 28
39 *	89 STOP	139 "SPECIES: "
40 STO 18	90 GTO 01	140 ARCL X
41 XEQ 13	91*LBL C	141 AVIEW
42*LBL 04	92 3	142 PSE
43 ST+ 05	93 STO 28	143 CLA
44 5	94 XEQ 12	144 100
45 ST+ 28	95 STOP	145 +
46 RCL 98	96 GTO 01	146 ARCL IND X
47 ST+ IND 28	97*LBL D	147 AVIEW
48 2	98 4	148 PSE
49 ST+ 28	99 STO 28	149 RCL 28
50 1	100 XEQ 12	150 1 E01

151 *	201+LBL 17	251 1
152+LBL 03	202 FIX 0	252 ST- 06
153 FIX 0	203 +	253 ST- IND 28
154 STO 28	204 STO 89	254 ST- IND 99
155 RCL IND 28	205+LBL 16	255 GTO 01
156 *GR. 0="	206 *DBH CLASS:"	256+LBL 15
157 XEQ 02	207 ARCL 88	257 101.109
158 *GR. 1="	208 AVIEW	258 STO 00
159 XEQ 02	209 CLA	259 *WALNUT"
160 *GR. 2="	210 *NO. TREES="	260 XEQ 14
161 XEQ 02	211 ARCL IND 89	261 *WH.OAK"
162 *GR. 3="	212 AVIEW	262 XEQ 14
163 XEQ 02	213 PSE	263 *RE.OAK"
164 *GR. 4="	214 ISG 89	264 XEQ 14
165 XEQ 02	215 GTO 18	265 *ASH"
166 *Σ VOL.="	216 STOP	266 XEQ 14
167 XEQ 02	217 FS?C 02	267 *TULIP"
168 *Σ TREES="	218 GTO "AD2"	268 XEQ 14
169 XEQ 02	219 GTO "AD1"	269 *HICKRY"
170 *Σ LOGS="	220+LBL 18	270 XEQ 14
171+LBL 02	221 FS? 02	271 *H.MAPL"
172 ARCL X	222 2	272 XEQ 14
173 AVIEW	223 FC? 02	273 *S.MAPL"
174 PSE	224 1	274 XEQ 14
175 1	225 ST+ 88	275 *MISC."
176 ST+ 28	226 GTO 16	276+LBL 14
177 RCL IND 28	227+LBL "AD2"	277 ASTO IND 00
178 RTN	228 *1ST CLASS:2: ?"	278 ISG 00
179+LBL "DBH"	229 PROMPT	279 RTN
180 *DBH CLASS?"	230 STO 88	280 0
181 PROMPT	231 1 E02	281 STO 00
182 FIX 0	232 +	282 GTO 01
183 100	233 .14002	283+LBL 13
184 +	234 SF 02	284 RCL 08
185 STO 99	235 GTO 17	285 4
186 RCL IND 99	236+LBL "LGOOF"	286 -
187 *NO. TREES="	237 7	287 X+2
188 ARCL X	238 ST+ 28	288 RCL 09
189 AVIEW	239 2	289 *
190 PSE	240 ST- IND 28	290 16
191 PSE	241 ST- 07	291 /
192 GTO "DBH"	242 7	292 FIX 0
193+LBL "AD1"	243 ST- 28	293 RND
194 CF 02	244 -1	294 STO 98
195 *1ST CLASS:1: ?"	245 ST+ 98	295 FIX 3
196 PROMPT	246 RCL 98	296 RTN
197 STO 88	247 GTO 04	297 .END.
198 1 E02	248+LBL "TGOOF"	
199 +	249 6	
200 .140	250 ST+ 28	

.END. 791 BYTES

Related Publications

The following Extension publication completes the series on using programmable calculators for timber volume estimation:

FNR-108 CRUZ—A Timber Volume Estimation Program for the HP-41C

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