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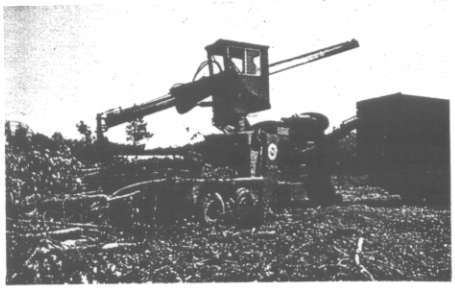
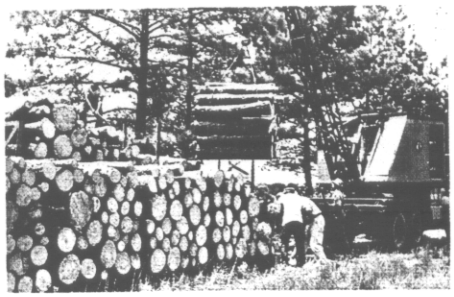
TBCP--A COMPUTER PROGRAM THAT ESTIMATES:



TOTAL TREE CHIPS

SAW LOGS



PULPWOOD

FIREWOOD

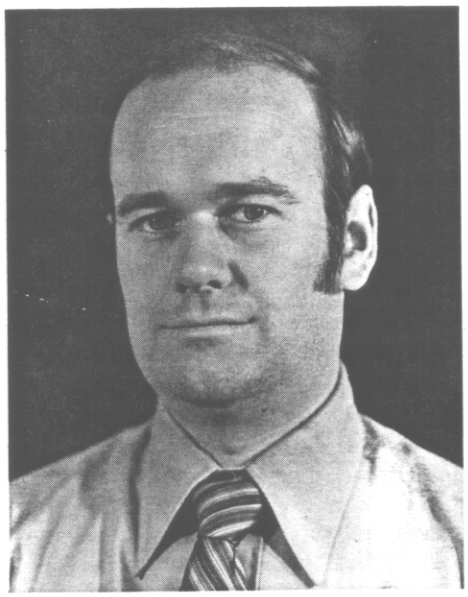
BY

ALEXANDER CLARK III AND RICHARD C. FIELD

RESEARCH DIVISION

GEORGIA FORESTRY COMMISSION

AUTHORS



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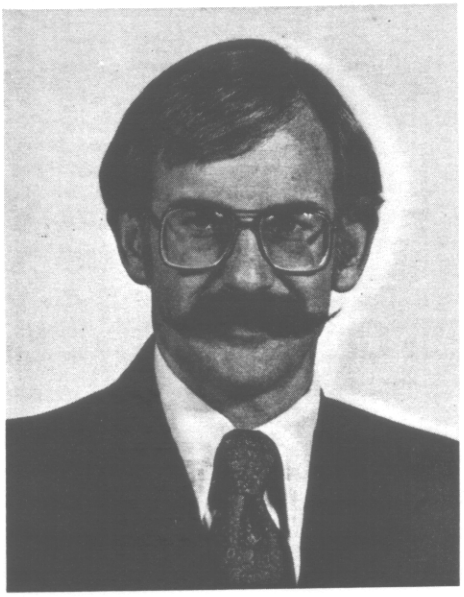

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TBCP--A COMPUTER PROGRAM THAT ESTIMATES TOTAL TREE CHIPS, SAW LOGS, PULPWOOD, AND FIREWOOD FROM CRUISE SUMMARY DATA.

BY

ALEXANDER CLARK, III AND RICHARD C. FIELD

INTRODUCTION

It is no longer sufficient for foresters to tell a landowner only the board foot volume or number of cords in a tract of timber that is considered for sale. Southern pines are now marketed for veneer, saw logs, and pulpwood by weight rather than stick scaled to determine board foot and cord volume. Total trees can now be marketed for fuel chips and poor quality hardwoods sold for firewood. To assist landowners in making forest management decisions and to improve utilization practices, foresters need an easy-to-use procedure for simultaneously estimating the weight and volume of total trees and their forest products. The Total Biomass Cruise Program (TBCP) meets this need[1/].

TBCP is an efficient, easy to use computer program that determines the weights and volumes of total trees, saw logs, pulpwood, and firewood given standard tree cruise data. The program provides per acre and per tract estimates of total tree and tree component biomass yields for forest-grown trees 1-inch d.b.h. and larger. These estimates may be reported in tons, cords, or cunits (100 cubic feet of wood excluding bark) and saw log volumes in board feet using either the Doyle, Scribner, or International ¼-inch board foot rules.

The program is designed for use by foresters with little or no previous computer experience. To access TBCP, the user needs a computer terminal and a telephone to connect the terminal with the computer on which TBCP is stored (Figure 1). The TBCP program will instruct the user on how to answer various questions about the cruise and to input the tree data in an interactive mode. A general users manual is currently available in draft form (1).

[1/]TBCP was developed by the Utilization of Southern Timber and the Mensurational Concepts for Forest Management Decisions Research Work Units, USDA Forest Service, Southeastern Forest Experiment Station, in cooperation with the Georgia Forestry Commission.

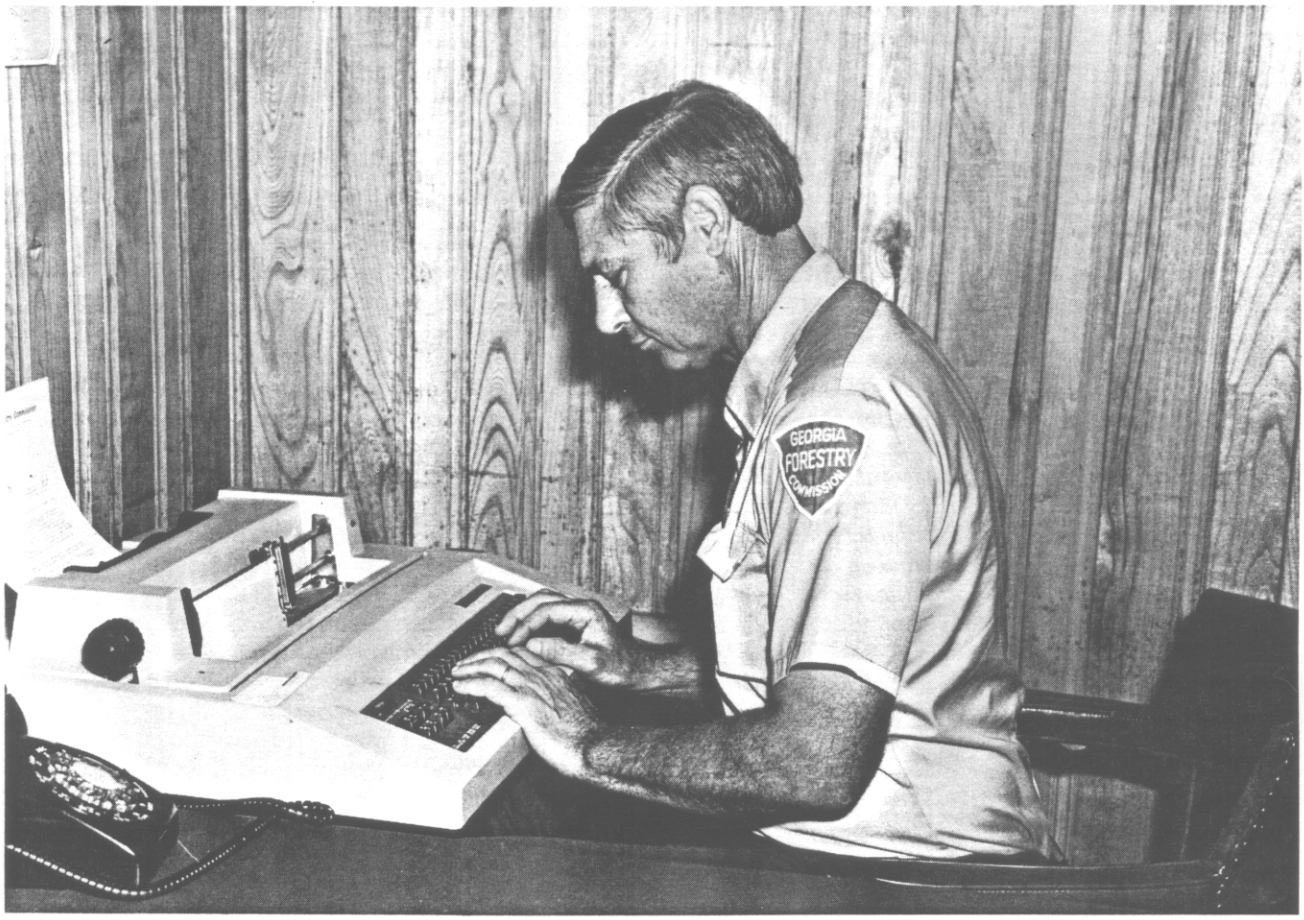

Figure 1--Georgia Forestry Commission service forester entering cruise summary data into TBCP using a computer terminal.

PROGRAM DESIGN

TBCP is a versatile program permitting foresters to collect tree cruise data using their normal cruise procedures and estimate stand biomass and forest product yields. The following standard cruise methods are accepted by the program: (1) fixed area plots--for any specified plot size, (2) point sample--using a prism with any specified prism factor, (3) strip cruise--given the width and total length of the strip or percent of tract cruised and size of tract, and (4) 100 percent mark tally. The cruise data are entered by three species groups: pine (natural or plantation southern pine or white pine), hard hardwoods and soft hardwoods. The program will also accept data by commercially important individual species and will provide reports accordingly.

The user enters the cruise data by one or two inch d.b.h. classes and by 5- or 10-foot height intervals or by half-logs. The program will handle cruise data for forest-grown trees 1 to 40 inches d.b.h. and 5 to 140 feet in height or containing up to six 16-foot saw logs. Trees are separated into three tree size classifications for input, analysis, and output:

Sapling trees--between 1.0 and 5.0 inches d.b.h.
Pulpwood trees--between 5.0 and 9.0 inches for pine and between 5.0 and 11.0 inches d.b.h. for hardwoods.
Sawtimber trees--above 9.0 inches d.b.h. for pine and above 11.0 inches d.b.h. for hardwoods.

This permits the forester to choose from a variety of tree d.b.h. and height combinations to measure while making a cruise. Any of the following tree dimension combinations may be used.

In a single analysis the same dimensions must be used for soft hardwood and hard hardwood but different dimensions may be specified for the pine.

Tree classification	Tree dimensions measured in cruise
Sapling	d.b.h. (inches) d.b.h. and total height (feet)
Pulpwood	d.b.h. (inches) d.b.h. and total height (feet) d.b.h. and height to 4-inch top (feet)
Sawtimber	d.b.h. (inches) d.b.h. and total height (feet) d.b.h. and height to 4-inch top (feet) d.b.h. and saw log merchantable height (logs)

TBCP selects biomass prediction equations based on data from the general geographic area of the user to expand the cruise data to forest stand biomass. For example, Georgia has been divided into three geographic regions, Coastal Plain, Piedmont, and Appalachian Mountains. Biomass weight and volume equations are stored in TBCP for each species or species group by geographic region. The equations used in TBCP were developed by the Utilization of Southern Timber Research Work Unit of the Southeastern Forest Experiment Station in cooperation with the Georgia Forestry Commission, Region 8 of the USDA Forest Service, and forest industries and are published elsewhere (2-7, 9-11). The equations predict the green weights of wood and bark and volume of wood in the total tree above stump and its components (stem, saw log, pulpwood, crown, and crown firewood).

Biomass expressed in cords is calculated from the estimated weight of wood and bark. Weight of wood and bark per cord equivalents are stored in the program by geographic region and species group. These values may be changed by the user when running the program.

Equations for predicting saw log board-foot volume were developed from Mesavage and Girard (8) volume tables and are stored in the program. Mesavage and Girard's tables overestimate the volumes of 10- and 12-inch trees which are generally of a lower form class anyway. Therefore, estimates of 10- and 12-inch trees are made using form class 77 while all other saw log board foot volumes are made using form class 78. The user specifies the desired board foot rule for sawtimber reports. A form class other than 78 may also be requested and the predicted board foot volumes of all d.b.h. classes will be adjusted up or down by 3 percent for each unit change in form class.

The forester or data entry specialist using TBCP answers prompted questions about the tract and the cruiser and certain characteristics of the cruise. The cruise summary tree frequency count data by d.b.h. and height classes for each species or species group are then entered. Stand biomass estimates are based on this information and the stored equations and the results are reported as described below.

OUTPUT FROM TBCP

Output from TBCP is designed to provide the landowner and forester with information needed to evaluate the forest utilization options available for marketing the timber on a tract and making forest management plans. The output from the program tells the landowner the total biomass above stump on the tract by species or species group. It breaks down that biomass by saw logs, pulpwood, and crown firewood by d.b.h. classes and gives these estimates in tons, cords, cunits and board feet. This information is provided in three basic output tables: A summary table, a table showing biomass by d.b.h. classes, and a table showing saw log board foot volume by d.b.h. class. Output consists of predicted totals only. No statistical sampling inference is calculated since only cruise summary data are entered into the program. Statistics based on plot data is a feature currently under development.

Figure 2 is an example of the output table which shows the predicted gross saw log board foot volume by d.b.h. class, the totals for each species group, and the grand total. Also displayed are the average saw log heights and the number of trees by species and d.b.h. class for each species group. The volumes in this table will be presented in either the Doyle, Scribner, or International ¼-inch log rules as indicated by the user.

The second output table shows the predicted biomass for the total tree and its components (stem to 4-inch top, saw log, stem pulpwood, and crown firewood larger than 4 inches d.o.b. and larger than 2 inches d.o.b.) by d.b.h. classes for each species group (Figure 3). This table also shows the average height and estimated total number of trees per d.b.h. class. At the user's option, this table may appear one or more times each using a different measure (tons, cords, cunits).

TOTAL BIOMASS CRUISE PROGRAM

LANDOWNER – JOHN DOE
ADDRESS – WAYCROSS GA.
LOCATION – CHARLTON CO GA.
FORESTER – SMITH
ADDRESS – WAYCROSS GA.

CASE NO.–4
DISTRICT NO.–12
TRACT SIZE (AC) – 40.0
PHONE – 912-283-5464
DATE – 81/07/09.

DBH	AVERAGE HEIGHT			TREES			SAWLOG VOLUME SCRIBNER,FC-78.			
	PINE	HHWD	SHWD	PINE	HHWD	SHWD	PINE	HHWD	SHWD	ALL
IN	---- LOGS ----			---- NUMBER ----			---- THOUSAND BOARD FEET ----			
				YIELD PER ACRE						
10	2.1	.0	.0	11.5	.0	.0	.5	.0	.0	.5
12	2.7	1.6	1.7	10.1	1.1	1.1	.9	.1	.1	1.0
14	3.2	1.6	1.8	7.4	.4	1.9	1.1	.0	.2	1.3
16	3.4	2.0	2.2	3.5	.2	.7	.8	.0	.1	.9
18	3.7	1.8	2.2	1.0	.2	.7	.3	.0	.1	.5
20	4.0	2.0	2.0	.3	.2	.3	.1	.1	.1	.3
22	3.6	.0	2.4	.1	.1	.2	.1	.0	.1	.2
24	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
26	.0	.0	.0	.0	.1	.0	.0	.1	.0	.1
28	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
30	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ALL CLASSES				33.8	2.3	5.0	3.7	.4	.8	4.9

Figure 2.––An example of output showing estimated gross saw-log board-foot volume by d.b.h. classes.

TOTAL BIOMASS CRUISE PROGRAM

LANDOWNER – JOHN DOE
ADDRESS – WAYCROSS GA.
LOCATION – CHARLTON CO GA.
FORESTER – SMITH
ADDRESS – WAYCROSS GA.

CASE NO.–4
DISTRICT NO.–12
TRACT SIZE(AC)–40.0
PHONE–912-283-5464
DATE–81/07/09

DBH	AVERAGE HEIGHT	TREES	TOTAL TREE	SAWLOGS	STEM PULPWOOD	CROWN FIREWOOD 2 IN.	CROWN FIREWOOD 4 IN.
IN	FT.&LOGS	NO.	TONS				
			YIELD PER ACRE				
			PINE				
2	20.0	148.6	1.0				
4	32.5	66.4	2.5				
6	48.8	36.5	5.5		3.7	.1	
8	61.1	16.4	5.4		4.5	.1	
10	2.1	11.5	7.3	4.7	1.2	.2	
12	2.7	10.1	9.5	7.0	.9	.3	
14	3.2	7.4	9.8	7.8	.4	.4	
16	3.4	3.5	7.1	5.3	1.4	.1	
18	3.7	1.0	2.7	2.1	.5	.0	
20	4.0	.3	1.0	.8	.2	.0	
22	3.6	.1	.4	.3	.1	.0	
24	.0	.0	.0	.0	.0	.0	
26	.0	.0	.0	.0	.0	.0	
28	.0	.0	.0	.0	.0	.0	
30	.0	.0	.0	.0	.0	.0	
			HARD HARDWOOD				
2	15.0	25.3	.2				
4	22.0	4.0	.1				
6	44.2	4.2	.6		.4	.1	
8	47.0	2.0	.6		.4	.1	
10	56.0	.6	.3		.2	.1	
12	1.6	1.1	1.1	.6	.2	.1	.0
14	1.6	.4	.6	.3	.1	.1	.0
16	2.0	.2	.4	.2	.1	.1	.0
18	1.8	.2	.7	.3	.2	.1	.1
20	2.0	.2	.8	.4	.2	.2	.1
22	2.5	.1	.4	.2	.1	.1	.1
24	2.5	.0	.3	.1	.0	.1	.0
26	2.5	.0	.3	.1	.1	.1	.1
28	3.0	.0	.4	.2	.1	.1	.1
30	3.0	.0	.3	.1	.1	.1	.1
			SOFT HARDWOOD				
2	23.1	41.1	.5				
4	37.7	23.7	1.4				
6	51.1	9.8	1.3		.9	.2	
8	59.6	4.7	1.3		1.0	.2	
10	59.0	2.7	1.2		.9	.2	
12	1.7	1.1	1.0	.6	.3	.1	.0
14	1.8	1.9	2.5	1.3	.7	.3	.1
16	2.2	.7	1.3	.7	.3	.2	.1
18	2.2	.7	1.6	.9	.4	.3	.2
20	2.0	.3	1.0	.5	.2	.2	.1
22	2.4	.2	.7	.4	.2	.1	.1
24	2.0	.0	.1	.0	.0	.0	.0
26	2.2	.1	.3	.1	.1	.1	.1
28	.0	.0	.0	.0	.0	.0	.0
30	2.8	.0	.2	.1	.0	.1	.0

Figure 3—An example of output showing estimated total tree and tree component biomass by d.b.h. classes.

TOTAL BIOMASS CRUISE PROGRAM

LANDOWNER – JOHN DOE
ADDRESS – WAYCROSS GA.
LOCATION – CHARLTON CO GA.
FORESTER – SMITH
ADDRESS – WAYCROSS GA.

CASE NO. – 4
DISTRICT NO. – 12
TRACT SIZE (AC) – 40.0
PHONE – 912-283-5464
DATE – 81/07/09

COMPONENT	PINE	H–HARDWOOD	S–HARDWOOD	ALL TREES
		GREEN TONS OF WOOD AND BARK		
TOTAL TREE (ALL)	52.4	7.1	14.4	73.9
SAPLINGS (BELOW 5 IN)	3.6	.4	1.8	5.8
TOTAL TREE (ABOVE 5 IN)	48.8	6.7	12.6	68.1
TOTAL STEM TO 4 IN TOP	40.9	4.6	9.6	55.1
SAWLOGS 1/	28.0	2.6	4.6	35.2
PULPWOOD (ALL)	12.9	2.0	5.0	20.0
PULPWOOD TREES	8.2	1.0	2.9	12.1
SAWTIMBER TOPS	4.7	1.0	2.2	7.9
TOTAL CROWN	7.9	2.2	3.0	13.0
CROWN FIREWOOD – 2 IN	1.3	1.4	1.8	4.5
CROWN FIREWOOD – 4 IN	.0	.6	.8	1.4
		CORDS OF WOOD AND BARK 2/		
TOTAL TREE (ALL)	18.7	2.5	5.1	26.3
SAPLING (BELOW 5 IN)	1.3	.1	.6	2.1
TOTAL TREE (ABOVE 5 IN)	17.4	2.4	4.4	24.2
TOTAL STEM TO 4 IN TOP	14.6	1.6	3.4	19.6
SAWLOGS 1/	10.0	.9	1.6	12.5
PULPWOOD (ALL)	4.6	.7	1.8	7.1
PULPWOOD TREES	2.9	.3	1.0	4.3
SAWTIMBER TOPS	1.7	.4	.8	2.8
TOTAL CROWN	2.8	.8	1.0	4.6
CROWN FIREWOOD – 2 IN	.5	.5	.6	1.6
CROWN FIREWOOD – 4 IN	.0	.2	.3	.5
		VOLUME OF WOOD (CUNITS)		
TOTAL TREE (5 IN AND ABOVE)	12.6	1.7	3.6	17.9
TOTAL STEM TO 4 IN TOP	10.9	1.2	2.8	14.9
SAWLOGS 1/	7.9	.7	1.3	9.9
PULPWOOD (ALL)	3.0	.5	1.5	5.0
PULPWOOD TREES	2.2	.2	.9	3.4
SAWTIMBER TOPS	.8	.3	.6	3.4
TOTAL CROWN	1.8	.5	.8	3.0
CROWN FIREWOOD – 2 IN	.4	.3	.5	1.2
CROWN FIREWOOD – 4 IN	.0	.1	.2	.3
		SAWLOG BOARD-FOOT VOLUME -- (MBF)		
SAWLOGS (DOYLE)	2.3	.3	.5	3.2
SAWLOGS (SCRIBNER)	3.7	.4	.8	4.9
SAWLOGS (INT. ¼)	4.5	.4	.9	5.8
		(BASAL AREA PER ACRE (SQ.FT.))		
SAPLING TREES	9	0	2	11
PULPWOOD TREES	12	1	5	18
SAWTIMBER TREES	29	3	6	38
ALL TREES	50	4	13	67

1-SAWLOG MERCHANTABLE TOP; 7-INCH DOB FOR PINE, 9-INCH FOR HARDWOODS OR THRU LOG GRADE NUMBER 3 MERCHANTABILITY
2-POUNDS PER CORD: PINE=5600., SOFT HARDWOOD=5700., HARD HARDWOOD=5700.

Figure 4.—An example of output summarizing the predicted total tree and tree component weight and volume per acre.

The summary table (Figure 4) shows the total biomass of all trees on the tract or per acre in tons, cords, and cunits for each species group and all species combined. The total biomass is also broken down by saplings, trees 5.0 inches d.b.h. and larger, stem to 4-inch top, and crown. The biomass in the stem to 4-inch top is divided into saw logs and pulpwood. The pulpwood is further subdivided to show that which comes from pulpwood size trees as opposed to that from the tops of sawtimber size trees. The amount of crown firewood that is greater than or equal to 2-inch d.o.b. small end and greater than or equal to 4 inches d.o.b. small end is also shown. Also displayed are the total saw log board foot volumes for each species group by desired board foot rule. Finally, the estimated average basal area per acre in square feet is given by tree size classes and species group.

USE AND INTERPRETATION OF OUTPUT

The output produced by TBCP is designed to provide gross total tree and tree component stand biomass estimates. Thus, foresters and landowners should interpret and use these biomass estimates carefully. Estimates are made assuming the most efficient utilization during timber harvesting. If the loggers fail to cut saw logs to the upper stem limit cruised, cut stem pulpwood to only a 6-inch rather than a 4-inch small end diameter, or fail to utilize all branches greater than 4 inches for firewood, TBCP will overestimate product yields. Therefore, users should adjust saw log, pulpwood, and firewood estimates to coincide with local harvesting practices.

The output tables showing biomass by d.b.h. classes (Figure 3) and the summary table (Figure 4) contain weight and volume estimates for the basic components of the tree. These basic values allow users to combine component estimates to stimulate harvesting practices in their area. For example, in some areas only hardwood saw logs can be sold commercially and no market for hardwood pulpwood exists. Stem pulpwood estimates could therefore be combined with crown firewood and marketed as such.

TBCP assumes that the cruise was a random sample and will therefore lead to unbiased estimates. However, these estimates may contain errors due not only to harvesting differences but also associated with the biomass prediction equations and timber cruise procedures. When timber is 100% cruised, the error associated with the cruise is minimized since all trees are tallied. Preliminary tests of TBCP using this cruise procedure indicate that predicted total tree, total stem to a 4-inch top, and saw log weights and volumes will generally be within 10% of the actual weights and volumes, if d.b.h. and some estimate of height are provided the program. Biomass of upper stem pulpwood and crown firewood varies considerably more. Estimates of these components were found to vary by as much as 40% from the observed values. TBCP users should use these component estimates carefully until they gain field experience as to their reliability. Biomass estimates based on fixed area plots, point sampling or strip cruising can contain more error than those based on 100% cruise. To minimize sampling error, plots and strips must be located without bias, border trees must be measured carefully to determine if they are in or out of the cruise and a sufficient number of plots and strips must be taken.

CURRENT APPLICATIONS

TBCP is written in Fortran IV and currently operates on the CDC CYBER 170/730 computer at the University of Georgia Office of Computing Activities in Athens. The Total Biomass Cruise Program is accessible through the Forestry Weather Interpretation System (FWIS) communication network monitored by the Southeastern Forest Experiment Station Southern Forest Fire Laboratory for use by the Georgia Forestry Commission. The Georgia Forestry Commission has a computer terminal at each District office in the State on which service foresters can access TBCP to input cruise data and receive estimates of total tree and forest product yields for a landowner. A batch version (card input and line printer output) is also available.

The program in part or in total has been requested for use by other states, other units of the Forest Service, other federal agencies and several private forestry organizations. Studies to further test the program results are also underway or are being planned.

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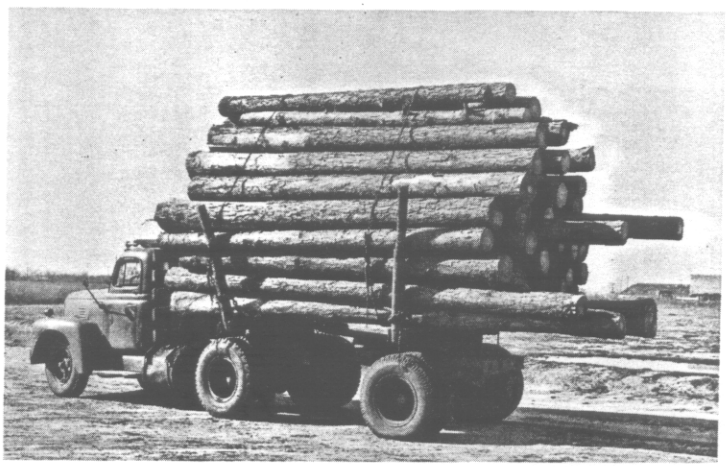
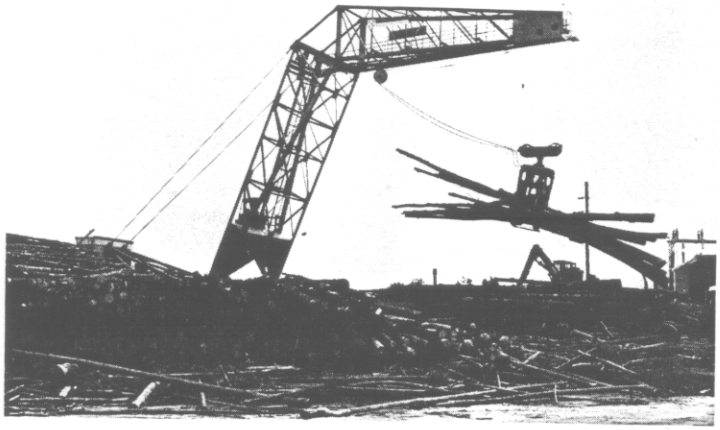
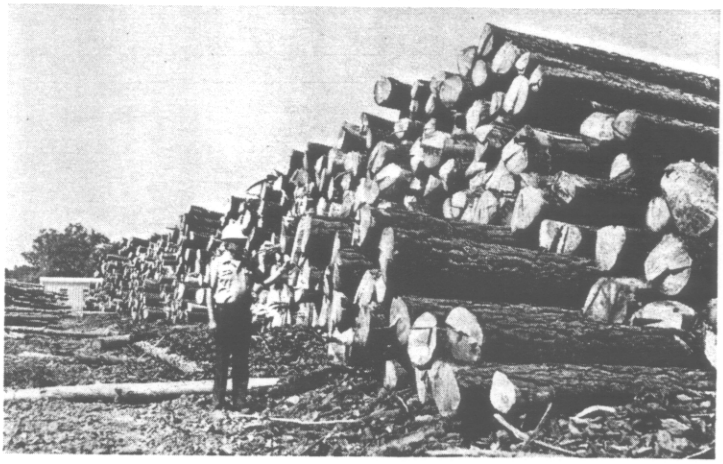
In this total tree harvesting operation, the best logs are reserved as saw timber, while the remainder will go for wood energy purposes.



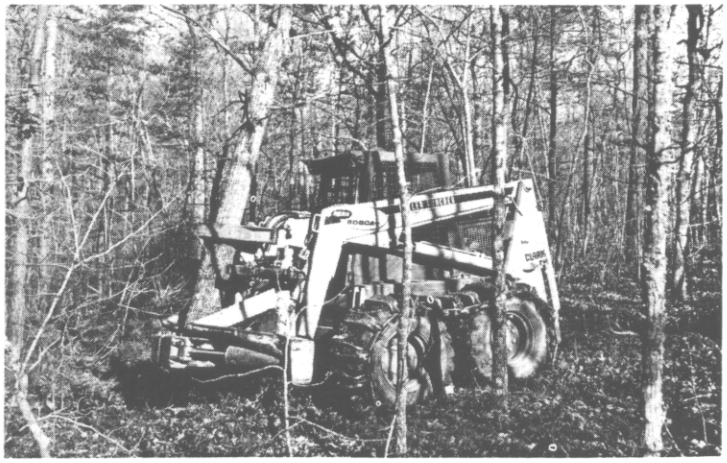
A load of quality sawlogs on the way to a lumber mill.



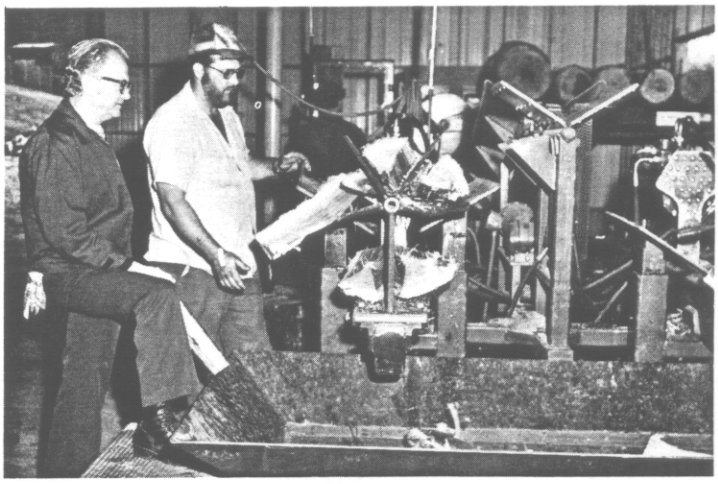
Tree length logs are unloaded at a concentration yard.



These tree length logs will be used to the best advantage. Some will be utilized as saw timber, while others will be processed as energy wood.



A feller buncher clips a tree into at ground level in a harvesting operation of low quality hardwoods destined for energy wood utilization.



Low quality timber is automatically split in this firewood processing operation.

A conveyor carries firewood to a loading ramp at one of Georgia's largest firewood processing plants.

In this low quality hardwood harvesting operation, the timber will be used for energy purposes.

GEORGIA FORESTRY COMMISSION

A. Ray Shirley, Director
John W. Mixon, Chief of Forest Research

Cost $2,995
Quantity 5,000