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CONTINUOUS FOREST INVENTORY
WITH
PUNCHED CARD MACHINES
FOR
A SMALL PROPERTY

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Acknowledgement

The authors wish to express their appreciation to all the companies actively participating in C. F. I. projects, who obligingly provided copies of the plans for their operations. These plans have been freely drawn upon for ideas, methods and modes of procedure, and equipment most commonly used in C. F. I. in the South. Cal Stott and his associates in the U. S. Forest Service deserve special thanks from any C. F. I. user for their outstanding contributions to this inventory system in the United States. The use of these materials so freely provided facilitated the completion of the project. Charles Mathis, Malcolm Rodrigues and John Utley, then undergraduate students in the Department of Forestry, gave valuable assistance in the field work.

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CONTINUOUS FOREST INVENTORY WITH PUNCHED CARD MACHINES FOR A SMALL PROPERTY

ROBERT D. BAKER and ELLIS V. HUNT, JR.

1960

Continuous forest inventory has been employed in Europe for decades. In use there, it is essentially a system of periodic remeasurements of all trees in the forest using the same procedure each time. The purpose of C. F. I.[1] is to collect comparative data which can be used to assess the status of current forest management and silvicultural practices. Because of large forested areas and other conditions peculiar to American forestry, forest inventory here developed into a system wherein only samples are measured instead of all trees, and the condition of the forest is deduced from the condition of the samples. Different sampling schemes are employed in a number of combinations, depending on circumstances, and data are analyzed by various kinds of punched card machines or computers to produce statistical analyses sometimes not theoretically suitable to the sampling scheme but of sufficient usefulness to justify.

Thus, breaking with the past to some extent, C. F. I. in the United States has by now emerged as a characteristic flexible concept having the following structure:

1. Permanent numbered forest plots constituting a very small sample of the forest, very often less than one tenth of one percent.

2. Nonstratified sampling so that values from one measurement can be compared directly to those from remeasurements.

3. Individual records of numbered trees in the plots.

4. Precise measurement and remeasurement of trees and other items according to rigid written standards.

5. Punched card machine analysis of tree and plot data.

6. Statistical control to insure the collection of adequate and usable data.

7. Compilation of reports useful to executives, accountants and production men as well as foresters.

In this general form the C. F. I. system seems to fill the historic void between the forest and the office. Although one user may stress one value of C. F. I. more than others, it is probable that each will recognize most of the advantages inherent in the system over a period of years.

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[1]In conventional use continuous forest inventory is abbreviated C. F. I. and is referred to as such in this report.

THE PROBLEM

C. F. I., with punched card machine analysis, has proven to be acceptable to large ownerships but has not been applied extensively on small properties of 5,000 acres or less. Two primary reasons are advanced to justify this, and they both evolve around the fact that a relatively larger sample is required to obtain accurate data on small ownerships as compared to larger holdings. These reasons are:

1. The cost of sample establishment, measurement, and subsequent remeasurement would be exorbitant.

2. The cost of data analysis by punched card machines would be too high to justify.

These reasons do not appear to be as formidable as they would seem, and it is quite possible that C. F. I. can be used advantageously on small ownerships.

This study was initiated to investigate the following specific questions:

1. Will a sample of about 25 acres out of 2,500 prove to be significantly accurate?

2. Will the cost of employing punched card machines be exorbitant for this volume of data?

3. Will total cost justify the position that American style C. F. I. is not feasible for small forest ownerships?

Although the study was limited to these objectives, all measurements and computations were made as accurately as possible and considerable effort was expended to search out errors of a detectable nature short of remeasuring each tree.

Literature Review

Numerous references to permanent sample plots can be found in American forestry literature since the first such plots were installed in 1904 (Sterrett, 1907), but the earliest record obtained showed an operational C. F. I. project in 1946 in the Lake States. Prior to that time a number of projects involving permanent sample plots with individual tree records had been initiated, but none had the major characteristics of C. F. I., a typical study being 140 plots established on one area in 1938 and remeasured in 1958 (Stott, 1959). In 1952 the Brunswick Pulp and Paper Company initiated the first C. F. I. project in the South (Oliphant, March 18, 1958). Today, however, the system is finding wide application. In his monthly news letter Stott said by February 1959 his records included at least 17,000 C. F. I. plots containing a half million trees on 6 million acres in the North Central Region alone, and nationwide he said (Stott, June 1959) there were over 49,000 C. F. I. plots on at least 20 million acres involving about 62 ownerships.

Owners of small holdings, except for research organizations, have been slow to accept C. F. I. Douglas Craig (1956) urged owners of forest lands of 30,000 acres or larger planning such projects to use the punched card machine approach and pointed out that southern forestry companies had turned to these methods with increasing frequency. Craig added that with costs then applicable he did not think that the system would be practical for forests smaller than 30,000 acres. In reference to the same situation, W. J. Bridges (1956) stated that C. F. I. with business machine methods was being used on smaller tracts at reasonable cost, but he questioned the accuracy of results since so few plots were established in such instances. Subsequent correspondence between the authors and new satisfied users[2] of the system on large tracts of land has elicited many uniformly pessimistic opinions concerning its use on a small area such as 2,500 acres.

Preliminary Analysis

In view of the unfailingly discouraging opinions, a small scale investigation of the probable cost of a C. F. I. program using punched card machines was initiated for the Special Use Area of the Stephen F. Austin State College Department of Forestry in the Sabine National Forest[3] in 1956.

Preliminary analysis gave the following information:

Estimated size of the area, acres	2500[4]
Number of sample plots	150
Number of trees per plot	30
Pre-planning time of the forester	$220
Special equipment for first inventory	$300
Labor for plot establishment	$1500
Machine cost for processing cards	$430
Forester and machine wiring labor	$620
Total cost of project	$3070
Cost per acre for establishment	$1.23

As Baker (1957) pointed out, $1.23 per acre seems high when compared with four cents an acre for contemporary C. F. I. punched card machine projects, but at current sawtimber prices, it is the equivalent of only 41 board feet per acre. It was further estimated that subsequent costs at 5-year intervals would be $.72 or 24 board feet per acre. This meant that C. F. I. costs would be equal to only eight board feet an acre per year to begin with and five board feet an acre per year after that. Baker expressed the opinion that if C. F. I. did not give facts enabling a forest manager to grow more extra wood than this, it was of little use anyway. This analysis led to the initiation of the

[2]Correspondence is on file at the Department of Forestry, Stephen F. Austin State College.
[3]Hereafter this will be called The Use Area.
[4]Actual area of the Use Area is 2358 acres, but 2500 acres was used in cost estimates.

plan reported herein. Preliminary analysis consumed about 38 man-hours of a forester's time and 12 hours of non-technical and clearical time.

PROCEDURE

Planning

The plan is the heart of any C. F. I. project where standardized methods and clear thinking are of utmost importance. If the work is to progress in a systematic and workmanlike manner, planning must be completed in detail before field work is initiated. The use of punched card machines for data analysis makes this phase of the work even more important because the machines must be wired with exact and detailed instructions. Accordingly, the following schedules were prepared:

1. The schedule for plots, designating size, the method of location, establishment and numbering as well as the categories used in plot classification.

2. Schedule for trees in the plots, detailing the methods of numbering and marking, a minimum diameter, and the tree classifications to be used.

3. Check sheet listing all equipment to be used by the crew.

4. Schedule describing completely all forest types likely to be encountered.

5. Schedule showing the tree grading system to be employed.

6. Tree cull guide, attempting to describe accurately all defects to be considered.

7. Schedule listing all of the tree card code numbers for ready reference in the field.

8. Schedule listing all of the plot card code numbers.

9. A plot location sheet for referencing the location of each plot and its witness trees.

10. Volume tables and species factors to be used in the computation of tree volumes and a flow plan for data.

11. Schedules for recording cost and time spent on the project.

The most costly items in the plan were the volume tables and species factors computed from local tree measurements obtained from The Use Area, and the flow plan for data analysis which was tailored to the peculiar needs of the project. These two items consumed approximately three-fourths of the time required for developing the plan.

Field Work

The field work consisted of establishing plots and collecting

and entering plot and tree data on marked sense cards for later transfer to punched cards. This was initiated in the summer of 1957 and completed in 1958. The Use Area C. F. I. system consists of 110 circular one-fifth acre plots, located ten chains apart on parallel lines 20 chains apart (Figure 1). Due to the irregular shape of the area this resulted in a sample of 0.93 percent. Remeasurements are planned for five-year intervals, the first scheduled for 1962.

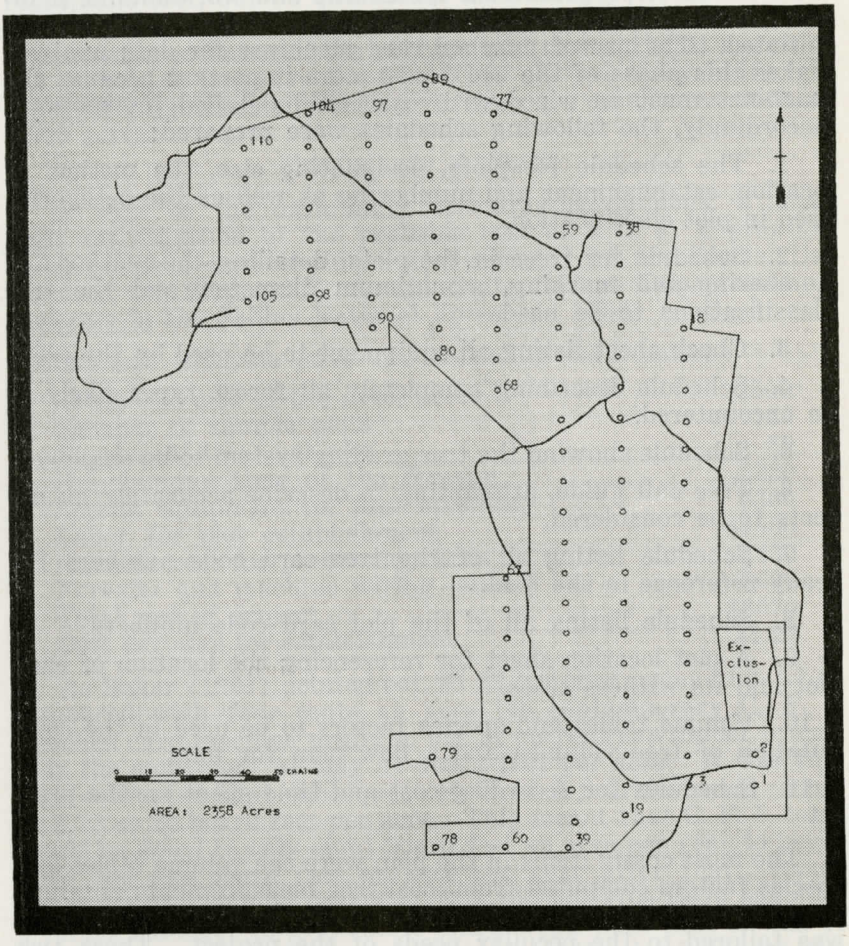

Figure 1. Plot Location, Special Use Area

Students worked in the field crews under supervision of the authors, and written field instructions were carried at all times

so that any unusual situation could be properly analyzed. The 110 plots used 930 man hours, or 8.45 man hours per plot. Professional foresters accounted for only 190.5 man hours of the total, leaving 739.5 sub-professional man hours. Two-, three-, and four-man crews were used in this work at various times. The three-man crew was found to be the most economical under existing conditions (Table 1).

TABLE 1

TIME CONSUMED IN PLOT ESTABLISHMENT

Crew Size	Plots	Total Man Hours	Man Hours Per Plot
2	69.5	607.5	8.74
3	35.0	262.5	7.50
4	5.5	60.0	10.91
Total	110.0	930.0	8.45

The work in each plot progressed in an orderly manner as follows:

In the three-man crew one man had the sole assignment of mark sensing cards and taking records. The other two men made all measurements. Plot measurements were completed before tree measurements began. The two "measurements men" worked together on witness tree establishment, site index determination and reproduction count. The other plot chores were done individually. The "measurements men" worked together on tree measuring and tagging. One of them measured d.b.h., helped measure distances and estimated soundness and use classes, and the other carried the tape for base distance measurements, measured height, estimated crown class and checked the work of his partner. By contrast, in the two-man crew the "mark senser" measured tree height, estimated crown class and helped on plot measurements. This arrangement made the "mark senser" a critical man as far as crew speed was concerned. The four-man crew was employed only a short time, but no logical division of labor was found.

The work in each plot progressed in an orderly manner as follows:

1. The center was located, and the stake was driven.
2. Reproduction was counted and recorded.
3. Soil samples were collected and depth-to-mottling was measured and recorded.
4. Witness trees were tagged and plot location sheets were completed.
5. Plot location was marked on aerial photos.

6. Site index was determined and recorded.

7. Cover type was noted and recorded.

8. Stand size class was noted and recorded.

9. Stand density was determined with a prism and recorded.

10. Topographic position was noted and recorded.

11. With reference to fresh stumps and a timber sale area map, the year last cut-over was determined and recorded.

12. Hardwood problem was noted and recorded.

13. Damage to the forest was noted and recorded.

14. Individual trees were tagged, measured, evaluated, and the records of these trees were entered on individual mark sense cards.

15. The plot was checked for missed trees.

16. The tree cards were checked for missed measurements or impossible combinations of data.

17. The equipment check list was run through; the equipment was packed, and the crew proceeded to the next plot.

Once the sequence of work was mastered, little time was wasted. At the end of work, the records for the day were checked again and filed for later use. The crew also repaired any broken or damaged equipment and made ready for the next work day by completing four sets of tree tags covering up to 40 trees per plot.

The result of this work was 3070[5] tree detail cards and 110 plot master cards marked sensed with field information. These cards had been sight checked at each plot, but they were subsequently re-checked in several different ways, including the use of cut-out overlays. Many mistakes could be corrected in the office, but several corrections were necessarily made in the field, involving twenty-three man-hours. In addition, about a hundred torn, extremely soiled, or crimped mark sensed cards were replaced. The cards were then filed ready for machine processing.

Preliminary Card Processing

Because a forester could not be with the machines, all punched cards were made from mark sensed cards, making a total of six decks of mark sensed cards as follows:

Deck I	Tree detail cards
Deck II	Plot master cards
Deck III	Board foot volume factors
Deck IV	Cubic foot volume factors

[5]Four more trees were found subsequent to initial field work.

Deck V	Species volume factors
Deck VI	Tree volume soundness factors

These decks were sent to the I. B. M. center for processing into punched cards before data analysis began. Basically, the work done at this time was to:

1. Offset mark sense punch 3554 cards.
2. Hand pull the last 374 cards (Decks III, IV, V, and VI).
3. Offset intersperse gang punch 3070 tree detail cards from the 110 plot master cards.
4. Interpret at the top all 3554 cards and make a duplicate interpretation at the top of 3554 blank cards.

The punched and interpreted cards were carefully checked several times by the authors before subsequent analysis. About 500 cards were punched improperly due to omission of a single punch on the first twenty plot master cards. The cards were returned to the processing center for correction. This experience ililustrates the necessity for professional checking of all machine work. After comprehensive checking the punched cards were ready to be machine processed for individual tree volume computations and subsequent punching, sorting, and data analysis.

Final Card Processing

Stott and others stress that satisfactory completion of the C. F. I. project using punched card machines involves close cooperation between the forester supervising the project and the laboratory processing the information, especially in the computational procedures. No matter how well the forester may plan the card processing, problems arise which need immediate attention. For this reason it was decided to use the I. B. M. facilities of the Agricultural Experiment Station at Texas A & M College. The field cards, punched cards, and office computation decks, were personally delivered to the Statistical Laboratory at the College, and the authors worked closely with the laboratory supervisor through the complete card processing operation.

The forester in charge of a small property can use plot master cards, properly interpreted, as source documents for many of his management decisions without resort to certain prepared tables required when the number of plots runs into several hundred. With this consideration in mind the plan for the project was limited to the following tabulations:

1. Species stock and stand table for entire property.
2. Species volume and tree count by forest type.
3. Species sawtimber volume and tree count by tree quality.
4. Species volume and tree count by size class.

5. Volume and tree count by plot.
6. Individual tree detail listing.[6]

The original flow plan for the project called for 30 steps in card processing, the first eight of which were associated with preliminary processing. However, due to limitations of machines available at the time and location of final card processing, the plan was enlarged to include 38 steps. The principal changes from plan to practice involved:

1. The preparation of a compilation deck for stock and stand tables (Deck VII).
2. The addition of individual tree listing.
3. The production of a new plot master deck.
4. Interpretation of new cards replacing error cards.

Report and Table Preparation

Due to the limited quantity of plot cards, it was considered desirable for the forester, using a desk calculator, to prepare many reports based on plot totals sorted by various plot measurement characteristics when or if they are needed. For instance, if necessary, the forester can compute quickly the volume and tree count by sawtimber size class by sorting the plot cards by this characteristic and totalling the desired information. Also, a number of statistical measures of accuracy and reliability was thought to be calculated more economically by the forester than by the punched card machines. This combination of punched card machine for lists and tabulations and desk calculator for final reports permits error correction immediately upon detection, so that information on the C. F. I. project can be maintained correctly. On The Use Area project approximately ten errors were detected subsequent to final card processing and the correct information was posted and tabulated by hand before final reports were prepared. The final report included these items (Appendix III):

1. Stock and stand table.
2. Stand illustration showing pine and hardwoods.
3. Sawtimber volume by tree quality.
4. Volume and stand by timber size class.
5. Volume per acre by type.
6. Acreage by sawtimber volume class.

In addition to these tabulations the initial report handed to the owner of the small property would include a cost statement, a map of the plots, perhaps a photo-mosaic of the property, and a schedule of future C. F. I. operations. Therefore, the operational phase of the project was considered finished at this point.

[6]Samples of these are in the appendixes.

RESULTS AND DISCUSSION

Reliability of Volume Estimates

The first part of the problem, "Will a sample of about 25 acres out of 2,500 prove to be significantly accurate?", is answered in the affirmative by the results of statistical analysis of plot volumes (Table II). Accuracy limits of ±9.9 percent for pulpwood and ± 11.5 percent for sawtimber at two standard errors of the mean are within accuracy restrictions usually imposed on even the largest C. F. I. projects. In addition, bias was checked for through the use of aerial photographs and nothing significant was detected.

TABLE II

ACCURACY OF TIMBER VOLUMES

Measure	Cubic Feet of Pulpwood			Board Feet of Sawtimber		
	Pine	Hardwood	Total	Pine	Hardwood	Total
Mean volume per acre	200.42	128.22	328.64	3892.0	980.7	4872.7
Standard deviation of volume per acre	162.92	121.56	170.63	2850.3	1244.3	2912.5
Coefficient of variation[1]	81.3	94.8	51.9	73.2	126.9	59.8
Standard error of volume per acre	15.53	11.59	16.27	271.8	118.6	277.9
Proportional limit of error[1] [2]	15.5	18.1	9.9	14.0	24.2	11.5

The project was not planned with a precise accuracy limit in mind, but some projections can properly be made after the fact. Pine sawtimber is the most important and valuable product on the area. If accuracy limits for pine sawtimber had been set at ±20 percent of the mean volume at the 95 percent confidence level, only 55 plots should have been taken, whereas a limit of ±10 percent of the mean would have called for 200 plots. The latter accuracy goal would no doubt have proven to incur exorbitant cost.

Project Cost

The total cost of the project was $3310.13, which was $1.40 an acre (Table III). Hourly charges have been assigned at the rate of $2.50 an hour for forester's time, and $1.50 an hour for clerical and non-professional time. Actual costs have been used for supplies, equipment and card processing.

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[1]Expressed as a percentage.

[2]As used by Hall (1959) this value is the ratio: $\frac{2 \text{ standard errors}}{\text{mean}}$ expressed as a percentage.

Cost of Employing Punched Card Machines

Another question planned for investigation in this study was "Will the cost of employing business machines be exorbitant for this volume of data?" It is probable that this question cannot be answered completely, but the cost will include the laboratory fee as well as the charge for making cards available for processing and the value of assistance offered at the time of processing. The cost for The Use Area project was $780.10, or $0.33 an acre or $0.25 a tree. Whether this cost is exorbitant or not might be illustratively answered by comparing it to the cost of hand methods for obtaining similar information.

Rather than duplicate the punched card machine computations, a hand calculated C. F. I. project would no doubt employ standard volume tables. Preparation cost for one species group and the cost of computing and listing for the first five plots was expanded to pertain to the entire Use Area project sample. The cost was $663.38, which is $0.28 an acre or $0.22 a tree, at hourly rates previously mentioned. This did not include the cost of a typewritten tree detail listing nor any checking for errors. Therefore, compared to the most logical alternative method the cost of employing punched card machines is not exorbitant in spite of the fact that $0.33 an acre is high compared to the cost of this phase for a large project.

TABLE III

PROJECT TIME AND COST RECORD

Item	Man-Hours Forester	Man-Hours Non-Prof. Clerical	Labor	Cost Supplies or Process	Total
Preliminary investigation	38	12	$ 113.00	$ 0	$113.00
Planning field work	59	0	147.50	114.46	261.96
Plot establishment	190	740	1585.25	54.72	1639.97
Error detection	39	22	130.09	0	130.09
Error correction	59	52	224.75	51.04	275.79
Preparation for IBM analysis	106	59	353.13	1.07	354.20
Preliminary card processing	1	1	4.00	110.40	114.40
Final card processing	56	0	141.00	170.50	311.50
Final report preparation	32	19	109.22	0	109.22
Project total	580	905	$2807.94	$502.19	$3310.13
Per acre					$1.40

Cost Evaluation[7]

The last question, rephrased, was "Is American style C. F. I. feasible for small ownerships?" Just because one sees that C. F. I. is successful on the large area, he cannot infer that the owner of small acreages should install it regardless of the cost for reasonable accuracy. The cost of C. F. I. should be considered as one of a number of management costs, each of which must be recovered through future profits. Since the C. F. I. cost on an acre basis is high on a small property, it is only proper to compare this cost with the tied-up investment value of land and timber. The cost of installing a reasonably accurate C. F. I. system on a small property may be $1.25 an acre or more. With remeasurements every five years this would mean $.25 an acre a year for installing and maintaining it. If the investment in land and timber is $125.00 an acre, the C. F. I. charge is only two-tenths of one percent of the investment value.

The C. F. I. cost-investment ratio is not, however, the entire story. A timber owner recovering ten percent return (before taxes) on his growing stock investment then would be paying only two percent of this before-tax income for his C. F. I. control. If C. F. I. does not remunerate this small reduction in income through better future control of growing stock, then it is not advisable. The timber owner, on the other hand, who earns only two percent of his growing stock investment would have to re-invest ten percent of his income for C. F. I., which under any conditions would be a heavy burden.

In order for C. F. I. to be a practical venture on the small area, it must recover the "borrowed" two percent of earnings rather than the less-than-one-percent "borrowed" in the case of the large area. Establishment and remeasurement cost must be exchanged somehow for the added control which C. F. I. yields the small area over the control it offers the large area.

One payback to the small project is through the record of measurements on individual trees. A single tree card, with punched holes interpreted to numbers at the top, stands as a recognizable unit out of 2000 or 3000, whereas it is lost in the crowd of 10,000 to 100,000 on the large project. Instead of going back to the I. B. M. machines when new management situations arise, the forester can readily classify interpreted tree and plot cards into required combinations long after the initial project has been completed and long before the second remeasurement is planned.

The smallest management unit in the small area is the stand. A handful of plot cards comprises the C. F. I. inventory infor-

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[7]This discussion is substantially the same as a portion of the following: Baker, Robert D. Measuring small areas by use of continuous inventory plots. Proceedings of Short Course in Continuous Inventory Control in Forest Management, University of Georgia, May 4-8, 1959, p. 140-146.

mation for each stand. The forester can spread the cards out on a table and have a printed, yet separate, record of the survey units comprising each stand, thus achieving swifter, more accurate impressions of management techniques necessary to reach optimum regulation. The adaptability to office analysis offers more control at less cost for the small project than it would offer for the large project.

Success of the Project

This report encompasses only the initial measurements of trees on the sample plots and a projection of these measurements to the property. The results show that total cost is not exorbitant, and that volumes are sufficiently accurate. Although it has been demonstrated that C. F. I. using punched cards machines may be an economically feasible operation; this does not infer that it is the most efficient method of determining the volumetric condition of The Use Area. The authors estimate that to determine the volume of timber within reasonable limits of accuracy would have taken a three-man crew, using aerial photographs, less than a week of field work and a week of office work to accomplish. Surely, then, the "old fashioned" method would have cost much less than $1.40 an acre, and could have been just as accurate as the more expensive method.

The purely volumetric condition of a forest at any particular time is not, however, the principal contribution of C. F. I., which is rather, to demonstrate changes in volume and quality which have occurred in the forest between measurements. These changes will be available upon remeasurement, and when they are projected by standard statistical methods from the sample area to pertain to the entire 2358 acres, they will be the principal parameters that C. F. I. is designed to estimate.

The final success or failure of The Use Area C. F. I. project as a tool of intensive forest management is yet to be determined. Actually, then, the principal contribution of C. F. I. to the small property cannot be assessed validly until after at least one remeasurement.

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APPENDIX A

COMMENT

Design of Mark Sense Cards

To facilitate field sensing of cards, and to reduce time and the chance for error in mark sensing, proper arrangement of card columns is important. For plot master cards and tree detail cards, the arrangement used in this program closely followed that for most C. F. I. projects (Figure 1a).

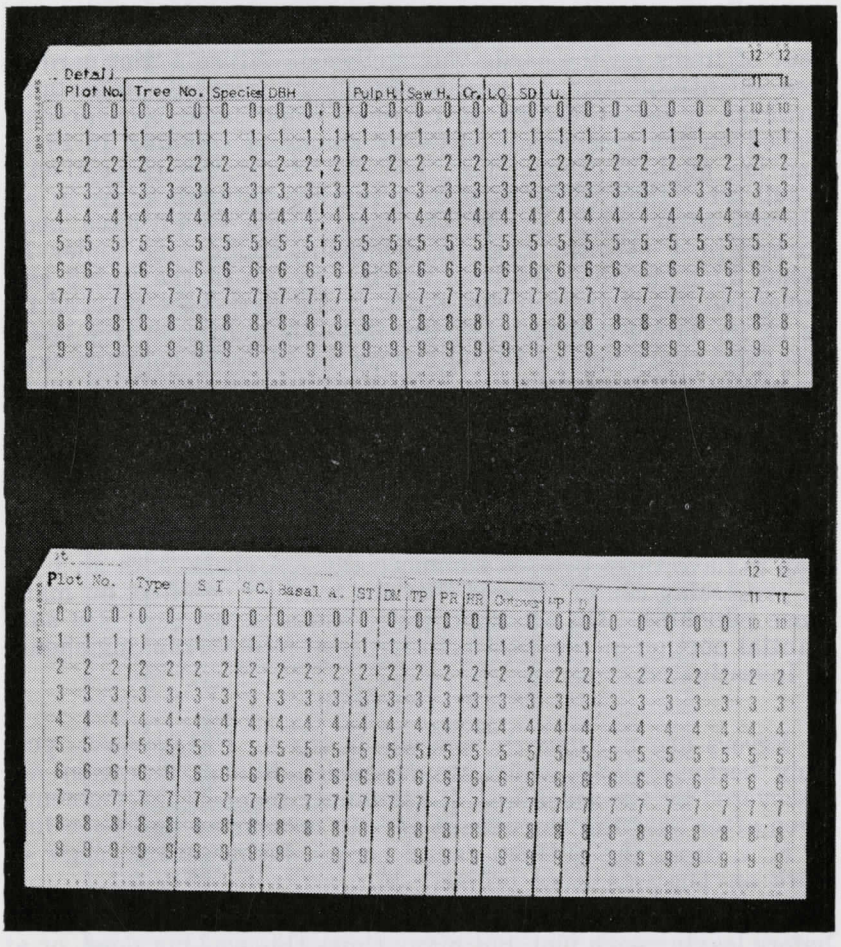

Figure 1a. Card design used in C. F. I. project on Special Use Area

The most common species were coded with the same number in each column, i.e., shortleaf pine was coded 11, loblolly pine was coded 22, etc., through a code of 99 for hickory. This was designed to speed mark sensing and to reduce the chance for error.

The authors discovered that it was most convenient to have mark sensed information in the exact sequence as this information is to appear on the punched card. If data must be moved from one sequence in the mark sensed card to another in the punched card, extra machine wiring is necessary. An example of this in The Use Area project was the movement of a *deck number* to column 1 of all punched cards from column 27 of the mark sensed cards.

After several plots had been measured, the columnar arrangement of items on the cards was analyzed. Since a plot card is used so infrequently, column arrangement is not so important. However, a better design of columns could have been accomplished on the tree detail cards by changing columns 16-19 to read log quality, crown class, use and soundness respectively. A cull tree then could have been marked through zeros in all columns after d.b.h. except the last, which could have been marked in 4 (Figure 2a). A dominant, sound tree under 18 inches d.b.h. would have been marked by 1's in the last 3 columns, and one over 18 inches d.b.h. would have been marked by 1's in the last 4 columns (Figure 3a). A pulpwood tree could have been mark sensed through zeros in adjacent columns sawlog height and log quality, and frequently could have been mark sensed through 3's in the adjacent columns of crown class and use (Figure 4a). This would have increased speed of mark sensing, a frequent cause of work slowdown.

After investigation, the authors found that it was much more economical to mimeograph the card headings and rulings, rather than to have them printed commercially. A check with an I. B. M. processing center showed that the ink had no effect on mark sense punching. On small projects, where setup cost is a substantial portion of the total printing cost, mimeographing should be investigated.

Error Detection

Errors are particularly onerous in the C. F. I. project, possibly because many which would escape human detection are discovered by the machines, at seemingly inopportune moments. Even after exerting the utmost care in measuring and recording C. F. I. data, the authors found errors during every phase of work on The Use Area project.

Printed instructions directed the field crews to check all cards before leaving each plot, but many times this was not done, or at best was hurriedly done. The most common detectable error during the plot check was omission of data which was checked

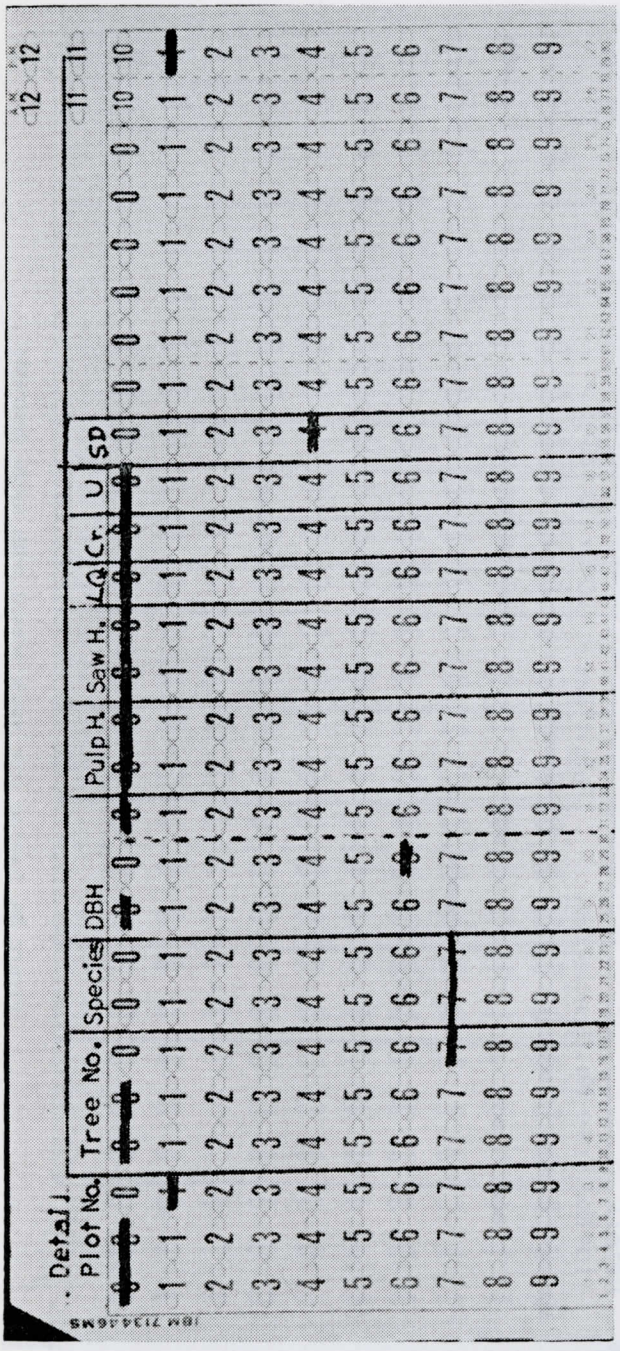

Figure 2a. Cull tree mark sensed with more desirable column arrangement

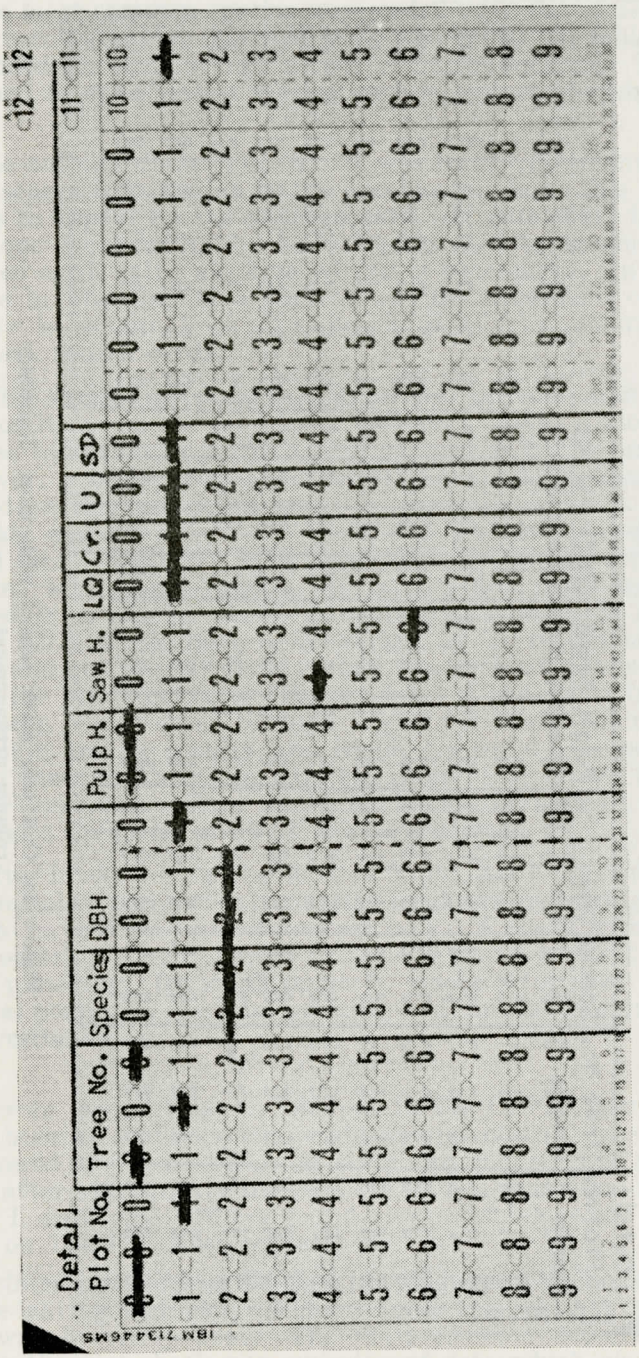

Figure 3a. Sawlog tree mark sensed with more desirable column arrangement

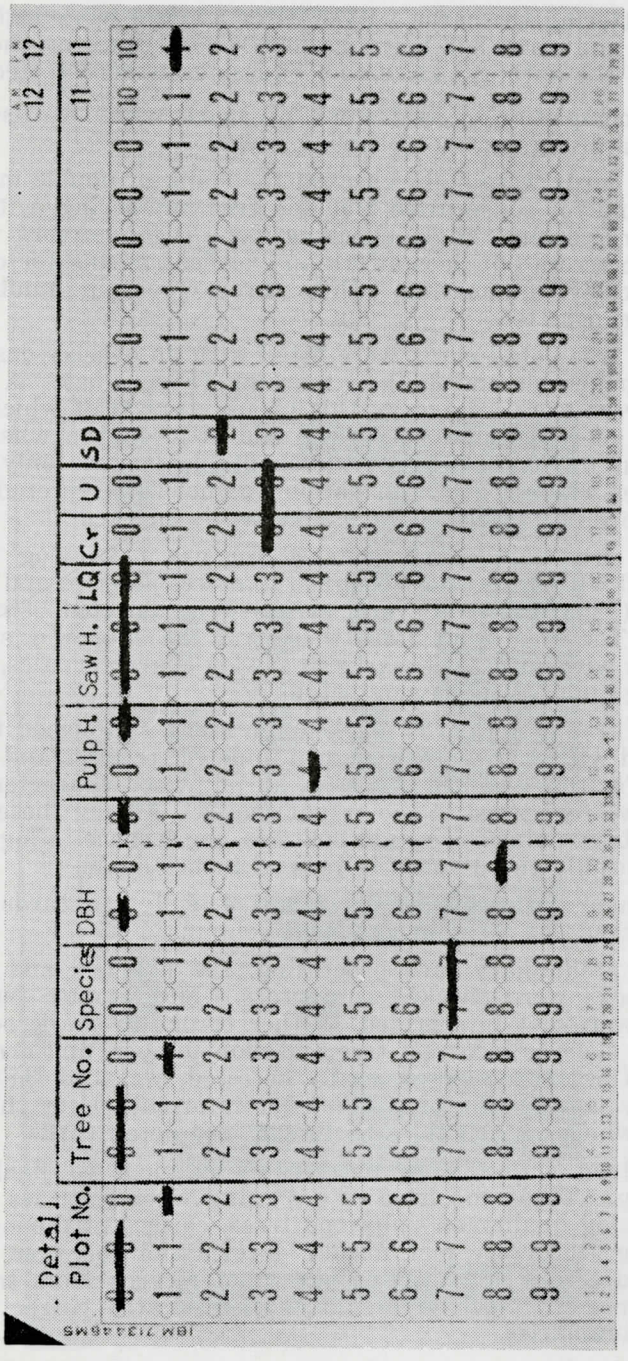

Figure 4a. Pulpwood tree mark sensed with more desirable column arrangement

for by fluttering the cards. Even after all field work had been completed and cards had been checked several times by the field crews and the authors, 42 column omissions were detected.

Upon completion of field work, all mark sensed cards were checked carefully by the following steps:

1. All cards were sight checked for blank or double marked columns and for consecutive plot and tree numbering, with unsatisfactory results. Sight checking alone is too cursory to detect subtle errors but does afford an excellent means for checking consecutive numbering. Only three errors in numbering were later detected.

2. All tree detail cards were fitted with an overlay designed to show impossible and unlikely marking (Figure 5a). A number of errors were located by this means, typical of which was recording merchantable height by odd foot-lengths when the plan called for even two-foot merchantable lengths only. All card spaces where coded information was not to be entered were cut out to detect their being inadvertently marked.

3. All tree detail cards marked for use 1 (sawlog trees) were fitted with an overlay designed to detect *possible* and likely marking (Figure 6a). Several errors were detected using the overlay. The most obvious of these was the case of a sawlog coded tree without sensed marks in sawlog characteristics, principally log quality and sawlog height.

4. All tree detail cards marked for use 3 (pulpwood trees) were fitted with an overlay designed to detect *possible* and likely marking for this use. In this case, all pulpwood characteristics should have registered in the cutout spaces. Among these were marks in both pulpwood height columns, the 0 space in log quality, and usually the 0 space in tens of inches d.b.h.

5. Concurrently with steps 3 and 4, cull tree cards were sight checked for zeros in pertinent columns.

After preliminary card processing, the punched and interpreted decks were checked for errors. Most double punched columns were not interpreted. Other errors in mark sensing appeared, such as incorrect tree and plot number, and errors in coding. One serious error, easily detected, was the failure to punch the last column of plot master information for the first 20 plots which carried through to 499 tree detail cards.

Seventeen errors were detected subsequent to final card processing. These consisted of assigning wrong species codes, assessing log quality on pulpwood trees, cards lost during final processing, incorrect plot master information on tree detail cards, and errors in preparing plot master cards from tree detail summaries. Such errors often necessitated correction of printed summaries.

Undoubtedly a number of errors remain and will be non-de-

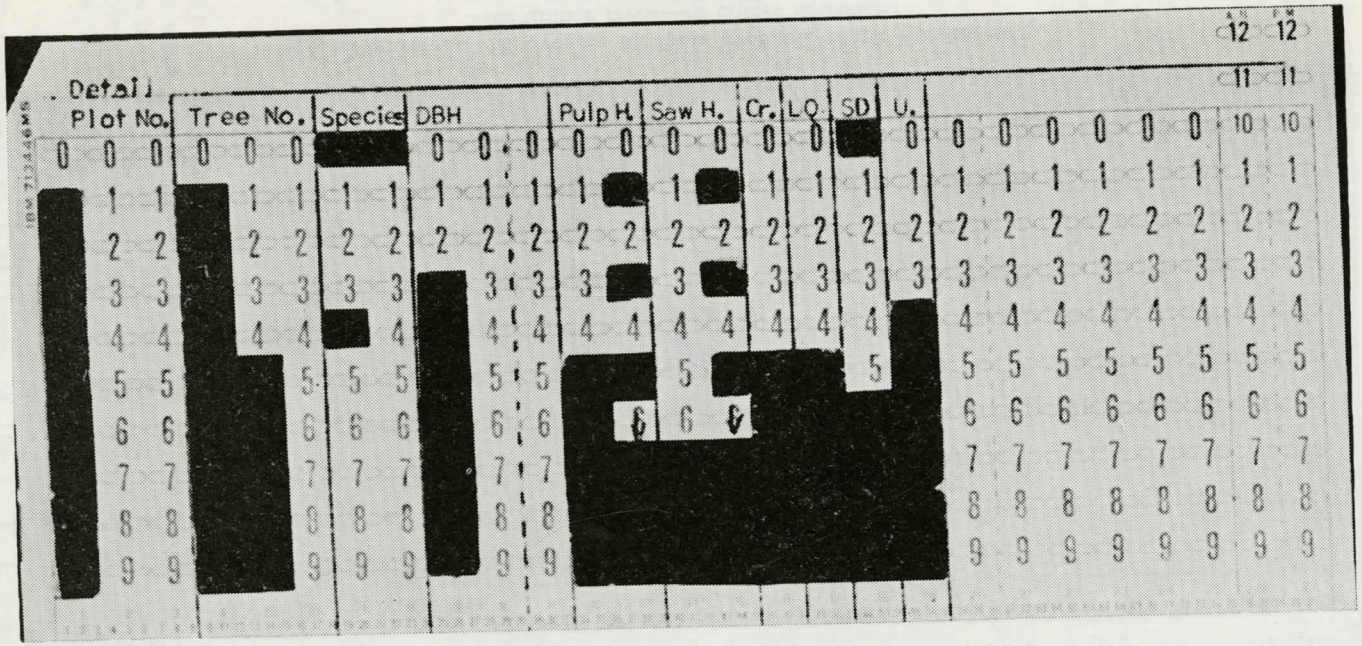

Figure 5a. An overlay to detect impossible or improbable mark sensing

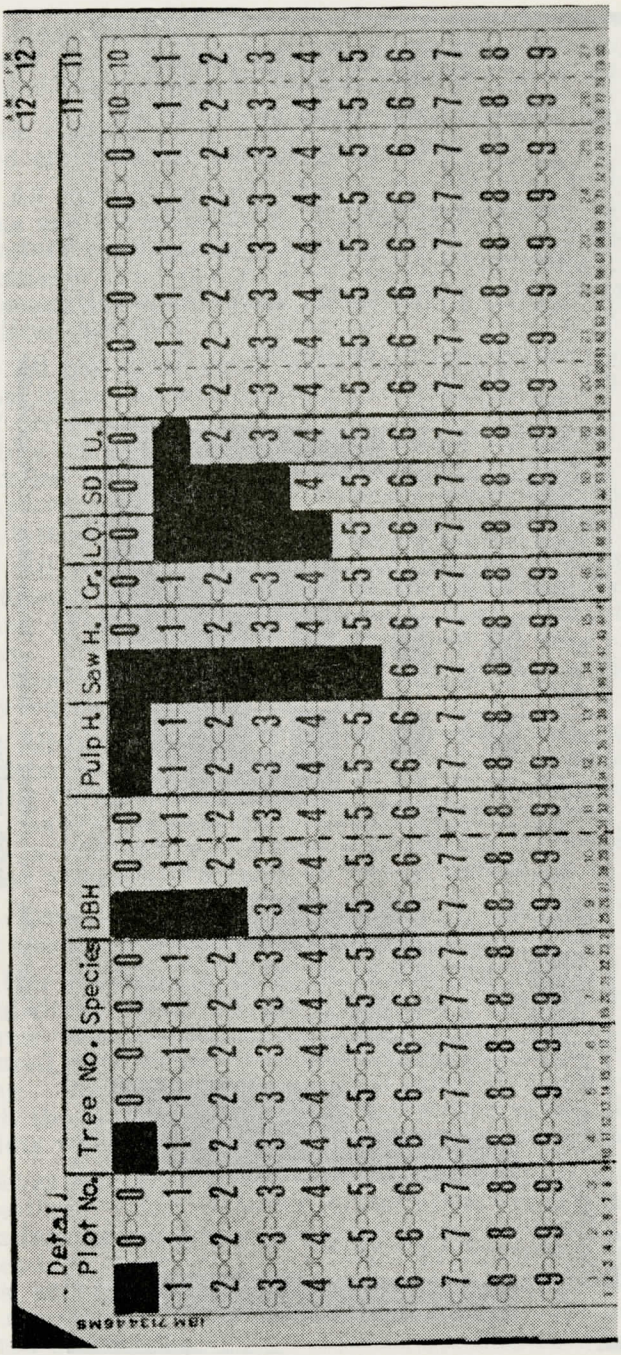

Figure 6a. An overlay to show probable mark sensing of sawtimber trees—to detect omissions

tectable until the first remeasurement. The consequences are not too important as long as proper changes are made; old measurements are corrected, and all computed answers reflect the relationship of real differences.

Height Measurement

Merchantable tree height was measured using a tape and Haga Altimeter on all trees where merchantable height exceeded 14 feet. At least for the first few remeasurements, new heights will not be recorded except for those trees having a change in product use. There are three reasons for such a decision.

1. Merchantable height will not be measured to the same diameter outside bark, top of merchantable stem, by any two men or even by the same man at five year intervals. Such errors would be masked by calculated growth.

2. Of the two commonly measured variables in standing timber volume determination, diameter is much more accurately determined, since judgment is reduced to a minimum by careful field practice.

3. A tree which is taller than average in its diameter class will probably remain in this relative position as it grows into larger classes as long as the basic characteristics of the forest do not change. A small number of broken or badly deformed trees will not conform.

Tree Volume

Due at least in part to the views expressed above, tree volumes were computed by the "average tree method." For each d. b. h. class, average volume, average height, and the percentage deviation of volume per unit change of height from average were computed (Appendix B). In the field, diameter and actual merchantable height were measured and the individual tree volume was computed with the formula:

$$GV = [1.0 + (AL - BL)\ (V/F)]\ (BV)\,(SpF)$$

where GV = gross volume
AL = actual length
BL = base length
V/F = variance percent per foot
BV = base volume
SpF = species factor

Nails

At the time field work was inisiated, 6 d double galvanized nails were available locally. Investigation of these nails in the plots installed for two years shows no deterioration. The cost of double galvanized wire nails was much less than for aluminum nails; in this case $3.75 compared to $12.69.

Tag Puncher and Tags

Communications with users of the C. F. I. system in the

South indicated that metal tags were preferred to painted numbers. The authors investigated the use of manufactured metal tags, numbered serially, but these appeared to be undesirable because of high cost. One contact reported using a metal tag embosser producing tags at $6 a thousand. This tag puncher, the Roovers Midgie Labeler[1] with monel tape at $1.60 per 23-foot roll, was used in The Use Area project. Twenty-six rolls of tape were consumed in labeling measured trees, witness trees and plot stakes, at a total cost of $41.50. This is $13.51 per thousand trees, or $.38 a plot. A liberal amount of tape was used on each tree. There were no complaints from the field crew on the use of the label embosser, and only one part needed replacement during the project.

Center Stakes

The decision to employ metal tags which were visible but not prominent, enabled the use of somewhat more conspicuous center stakes than certain operational projects require. The best locally available material was scrap pipe. In practice the stakes were 2.5 to 3 feet long and when in place, about one foot of stake remained above ground.

Haga Altimeter

Of all available height measuring devices, the Haga altimeter seemed to be the most promising because of its adjustable scales and ease of manipulation. The authors were familiar enough with the altimeter to have faith in its accuracy, although a short literature search showed no results of height tests.[2] One communication received mentioned that it needs more checking than others, with which the authors heartily agree.

Card Holder

Upon investigation of costs of commercially available card holders, the authors decided that a homemade holder would suffice and constructed one (Figure 7a). Both blank plot cards and blank tree cards were held in the same compartment, the plot cards at the bottom. As a blank card was used, it was removed from the compartment, fastened to the outside of the case, mark sensed, and returned to the compartment for completed cards.

Maps

A mimeographed map of The Use Area was carried and each plot was located on it as the plot was encountered. This allowed ready referencing of plots to planimetric details and allowed adding map detail as the survey work progressed. A separate

[1]Roovers-Lotsch Corporation, 3611 14th Avenue, Brooklyn 18, New York.
[2]Subsequent tests by Hunt (1959) and Warren (1958) show that the Haga altimeter is as accurate as any of the other hand-held height measuring instruments, and speedier than most.

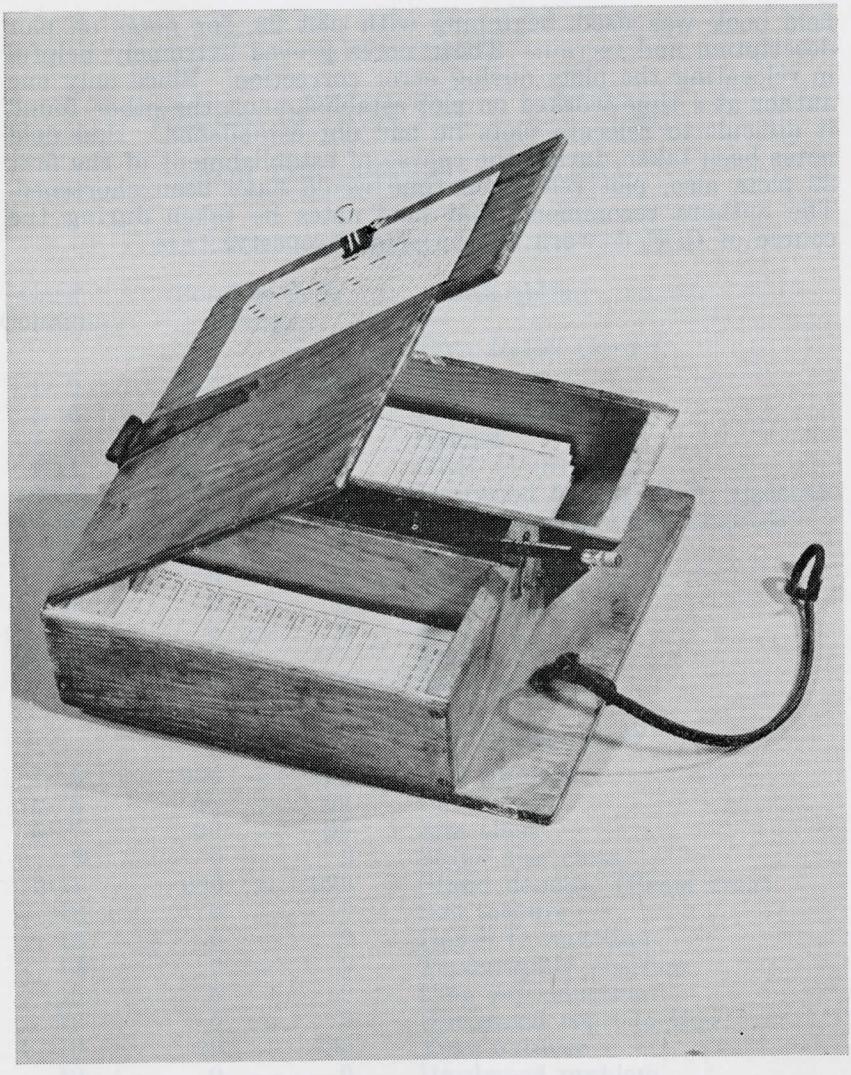

Figure 7a. A homemade C. F. I. card case

copy of the progress map was placed in the equipment room for posting at the end of each day's work. If the area in which a plot was located had been cut during the last five years, this information was to be marked on the plot card. In order to facilitate this observation, a sketch map of previous cuts from The Use Area was made and carried with the crews.

Surveyor's Field Book

Although not a part of the preliminary plan, a surveyor's

field book was used, beginning with plot 23, for notes on plot description and terrain. These notes proved extremely helpful in relocating the plots during error correction. Since only one author at a time worked on plot establishment, the other found it difficult to relocate plots he had not established. Had field notes been taken during the course of establishment of the first 22 plots also, plot relocation time would have been shortened. The authors recommend that field notes be taken during the course of C. F. I. work on the small property.

APPENDIX B

EXCERPTS FROM THE C. F. I. PLAN

FOR THE SPECIAL USE AREA

MARK SENSE CARD DESCRIPTIONS

Card Columns	Possible Code Range	Description
		Tree Detail Card
1- 3	000 — 999	Plot number
4- 6	000 — 999	Tree number
7- 8	00 — 99	Species
9-11	00.0 — 99.9	DBH (1 decimal)
12-13	00 — 99	Pulpwood height (2 ft. classes)
14-15	00 — 99	Sawlog height (2 ft. classes)
16	0 — 9	Crown class
17	0 — 9	Log quality
18	0 — 9	Soundness
19	0 — 9	Use
20-26		Blank
27	0 — 9	Deck number
		Plot Master Card
1- 3	000 — 999	Plot number
4- 5	00 — 99	Cover type
6- 7	00 — 99	Site class
8	0 — 9	Stand size class
9-11	000 — 999	Stand density (Basal area)
12	0 — 9	Soil texture
13	0 — 9	Depth to mottling
14	0 — 9	Topographic position
15	0 — 9	Pine reproduction
16	0 — 9	Hardwood reproduction
17-18	00 — 99	Year cutover
19	0 — 9	Hardwood problem
20	0 — 9	Damage
21-26		Blank
27	0 — 9	Deck number

PUNCHED CARD DESCRIPTION

Card Columns	Code Range	Description
	Tree Detail Card	
1	1	Deck number
2- 4	001 — 110	Plot number
5- 7	001 — 053	Tree number
8- 9	11 — 99	Species
10-12	04.6 — 31.3	DBH (1 decimal)
13-14	00,08 — 58	Pulpwood height (2 ft. classes)
15-16	00,08 — 76	Sawlog height (2 ft. classes)
17	1 — 4	Crown class
18	0 — 4	Log quality
19	1 — 5	Soundness
20	1 — 3	Use
21-22	52 — 92	Cover type
23-24	06 — 11	Site class
25	3 — 6	Stand size class
26-28	000 — 130	Stand density (Basal area)
29	1 — 4	Soil texture
30	1 — 7	Depth to mottling
31	1 — 7	Topographic position
32	1 — 5	Pine reproduction
33	1 — 5	Hardwood reproduction
34-35	00,54 — 56	Year cutover
36	1 — 4	Hardwood problem
37	0 — 3	Damage
38	1 — 2	Pine or hardwood
39-40	12 — 54	Base length (0 decimals)
41-43	1.71 — 6.28	Volume variance factor (4 decimals)
44-48	0046.0 — 0908.0	Base volume, bd. ft. (1 decimal)
49-52	01.08 — 23.28	Base volume, cu. ft. (2 decimals)
53-57	0.8000 — 1.0200	Species factor (4 decimals)
58-62	0000.0 — 0622.6	Gross volume, bd. ft. (1 decimal)
63-66	00.00 — 37.62	Gross volume, cu. ft. (2 decimals)
67-71	0000.0 — 0622.6	Net volume, bd. ft. (1 decimal)
72-75	00.00 — 37.62	Net volume, cu. ft. (2 decimals)
76-80		Blank
	Preliminary Plot Master Card	
1	2	Deck number
2- 4	001 — 110	Plot number
5- 6	52 — 92	Cover type
7- 8	06 — 11	Site class
9	3 — 6	Stand size class
10-12	000 — 130	Stand density (Basal area)
13	1 — 4	Soil texture
14	1 — 7	Depth to mottling

Card Columns	Code Range		Description
15	1 —	7	Topographic position
16	1 —	5	Pine reproduction
17	1 —	5	Hardwood reproduction
18-19	00,54 —	56	Year cutover
20	1 —	4	Hardwood problem
21	0 —	3	Damage
22-80			Blank

Sawlog Base Factor Master Card

1		3	Deck number
2- 9			Blank
10-12	09.6 —	29.8	DBH (1 decimal)
13-14	27 —	54	Base length
15-17	1.98 —	1.71	Volume variance factor (4 decimals)
18-22	0046.0 —	0908.0	Base volume, bd. ft. (1 decimal)
23-26		00.00	Base volume, cu. ft. (2 decimals)
27-80			Blank

Pulpwood Base Factor Master Card

1		4	Deck number
2- 9			Blank
10-12	04.6 —	14.4	DBH (1 decimal)
13-14	12 —	36	Base length
15-17	6.28 —	2.80	Volume variance factor (4 decimals)
18-22		0000.0	Base volume, bd. ft. (1 decimal)
23-26	01.08 —	23.28	Base volume, cu. ft. (2 decimals)
27-80			Blank

Species Factor Master Card

1		5	Deck number
2- 7			Blank
8- 9	11 —	99	Species
10-14	0.8000 —	1.0200	Species factor (4 decimals)
15	1 —	2	Pine or hardwood
16-80			Blank

Soundness Factor Master Card

1		6	Deck number
2-18			Blank
19	1 —	5	Soundness
20-22	0.00 —	1.00	Soundness factor (2 decimals)
23-80			Blank

Stock and Stand Compilation Master Card

1		7	Deck number
2- 7			Blank

Card Columns	Code Range	Description
8- 9	11— 99	Species
10-12	04.6— 26.9	DBH
13-19	000000.0—001986.6	Total volume, bd. ft. (1 decimal)
20-22	000— 010	Total sawtimber trees
23-29	000000.0—00109.58	Total volume, cu. ft. (2 decimals)
30-32	000— 025	Total pulpwood-poles trees
33-34		Blank
35-41	000000.0—000090.3	Volume per acre, bd. ft. (1 decimal)
42-46	000.00— 000.45	Sawtimber trees per acre (2 decimals)
47-53	000000.0—00004.98	Volume per acre, cu. ft. (2 decimals)
54-58	000.00— 001.14	Pulpwood-poles trees per acre (1 decimal)
59-80		Blank

Final Plot Master Card

1		8	Deck number
2- 4	001—	110	Plot number
5- 6	52—	92	Cover type
7- 8	06—	11	Site class
9	3—	6	Stand size class
10-12	000—	130	Stand density (Basal area)
13	1—	4	Soil texture
14	1—	7	Depth to mottling
15	1—	7	Topographic position
16	1—	5	Pine reproduction
17	1—	5	Hardwood reproduction
18-19	00,54—	56	Year cutover
20	1—	4	Hardwood problem
21	0—	4	Damage
22-23	0—	53	Total trees measured
24-25	0—	45	Total pines measured
26-27	0—	27	Total hardwoods measured
28-29	0—	48	Total pulpwood trees measured
30-31	0—	16	Total sawlog trees measured
32-33	0—	15	Total culls measured
34-39	00000.0—	02318.8	Gross volume, bd. ft. (1 decimal)
40-45	0000.00—	0158.96	Gross volume, cu. ft. (2 decimals)
46-51	00000.0—	02294.8	Net volume, bd. ft. (1 decimal)
52-57	0000.00—	0158.96	Net volume, cu. ft. (2 decimals)
58-80			Blank

FLOW PLAN

Step Number	IBM Machine	Procedure
1	Field and Office	The tree detail cards (Deck 1) and plot master cards (Deck 2) come from the field sensed in tree number sequence by plot, preceded by the plot card, with the plots in numerical order. Master cards for sawlog base factors (Deck 3), pulpwood-poles base factors (Deck 4), species factors (Deck 5), and soundness factors (Deck 6) have been mark sensed in the office by the forester.
2	514, 519	Detail, plot and factor master cards remain together in the deck while being mark sense offset punched. Order is Deck 2 and 1 interspersed, followed by Decks 3, 4, 5 and 6. Mark sense columns 1-26 punched into columns 2-27 and column 27 punched into column 1. Do not punch unmarked columns. (All decks referred to from this time on are punched decks).
3	Clerical	Hand pull Decks 3, 4, 5 and 6 and file.
4	514	Intersperse offset gang punch from the plot masters (Deck 2) into tree details (Deck 1). Gang punch master plot card columns 5-21 into tree detail columns 21-37. Deck 2 card precedes Deck 1 cards for each plot.
5	Clerical	Replace Decks 3, 4, 5 and 6 at rear of interspersed Decks 1 and 2.
6	522	Interpret all cards and make duplicate set of interpreted cards on blank stock.
7	Clerical	Send field cards and punched cards to originating office for checking by forester.
8	Clerical	Forester separates plot masters (Deck 2) and factor masters (Decks 3, 4, 5 and 6) before sending back to IBM center for processing.
9	082	Sort tree detail cards first by tenth-inch diameter classes (columns 10-12); then by sawlogs or pulpwood-poles (1 in column 20 indicates sawlog, 2 or 3 in column 20 indicates pulpwood-pole, 0 in column 20 indicates cull).
9	082	Sort out and file cull tree cards (0 in column 20) for gang punching zeros in them. Keep sorted

Step Number	IBM Machine	Procedure
		cards in plot order within above sorting breakdown.
10	514	Gang punch culls with zeros in columns 39-52, 58-75.
11	077	After volume master decks for sawlogs or pulpwood-poles (Decks 3 and 4) have been checked for DBH sequence, merge volume factor decks separately into the two groups of details on DBH with the master preceding the details. DBH is in columns 10-12 on all sets of cards.
12	604	Offset gang punch base length, volume variance factor and base volume into each tree detail card. Punch columns 13-26 of master cards into columns 39-52 of tree detail cards.
13	082	Place culls behind sound tree details. Sort tree detail cards by species. Sort out volume factor decks (Decks 3 and 4) and file. First pass—sort on column 9 Decks 3 and 4 not punched in this column and fall out on the no-punch stack. Second pass—sort on column 8.
14	077	After tree detail cards have been sorted for species on DBH and plot sequence, merge species factor deck (Deck 5) into species-sorted tree detail deck with masters preceding the details. (Species codes in column 8-9 on all sets of cards.)
15	517	Offset gang punch species factor and hardwood or pine designation into each detail card. Columns 10-14 into tree detail columns 53-57, column 15 into tree detail column 38.
16	082	Sort out species factor deck and file. Sort out cull tree cards and file. Sort out use 1 trees and use 2-3 trees together. Sort on column 20, respectively unpunched, 0, 1, 2-3.
17	604	Calculate gross cubic foot volume of each pulpwood-pole tree and punch zeros in gross and net board foot volume fields. Use 2-3 cards—2 or 3 punched in column 20. Pick up AL in columns 13-14 (0 decimals) Pick up BL in columns 39-40 (0 decimals) Pick up V/F in columns 41-43 (4 decimals, 3 digits) Pick up BV in columns 49-52 (2 decimals)

Step Number	IBM Machine	Procedure
		Pick up SpF in columns 53-57 (4 decimals, 5 digits) Calculate and punch in columns 63-66 (2 decimals) Also punch zeros in columns 58-62, 67-71. Read Deck 1—16 columns Punch Deck 1—14 columns
18	604	Calculate gross board foot volume of each sawtimber tree and punch zeros in gross and net cubic foot volume fields. Use 1 card—1 punched in column 20. Pick up AL in columns 15-16 (0 decimals) Pick up BL in columns 39-40 (0 decimals) Pick up V/F in columns 41-43 (4 decimals, 3 digits) Pick up BV in columns 44-48 (1 decimal) Pick up SpF in columns 53-57 (4 decimals, 5 digits) Calculate and punch in columns 58-62 (1 decimal). Also punch zeros in columns 63-66, 72-75. Read Deck 1—17 columns Punch Deck 1—13 columns
19	082	Sort sawlog deck and pulpwood-poles deck for soundness, keeping the two decks separate. Hand merge soundness factor masters in front of each soundness group, first for sawlog deck before step 20 and then for pulpwood deck before step 21.
20	604	Calculate net sawlog volume and punch into sawlog deck (Columns 67-71). Pick up gross volume in columns 58-62 of sawlog deck. Pick up soundness factor in columns 20-22 of Deck 6 (2 decimals). Calculate and punch in columns 67-71 (1 decimal). Read Deck 1—5 columns Read Deck 6—3 columns Punch Deck 1—5 columns
21	604	Calculate net pulpwood volume and punch into pulpwood-poles deck (Columns 72-75). Pick up gross volume in columns 63-66 (2 decimals). Pick up soundness factor in columns 20-22 of Deck 6 (2 decimals).

Step Number	IBM Machine	Procedure
		Calculate and punch in columns 72-75 (2 decimals). Read Deck 1—4 columns Read Deck 6—3 columns Punch Deck 1—4 columns
22	082	For each tenth-inch diameter class sort by species. Sort on columns 12, 11, 10, 9, 8 respectively.
23	407 514	Summary punch net board foot volume and tree count and net cubic foot volume and tree count by tenth-inch diameter class and species. Prepare printed report of totals simultaneously. Summary punch blank deck. Board foot volume—Columns 67-71 total. Tree count—count 1's in column 20. Cubic foot volume—Columns 72-75 total. Tree count—count 2's and 3's in column 20. Punch DBH and species code (Columns 8-12). Punch board foot subtotal (Columns 13-19). Punch sawtimber tree count (Columns 20-22). Punch cubic foot subtotal (Columns 23-29). Punch pulpwood-poles tree count (Columns 30-32).
24	604	Calculate stock and stand table for sawlog trees and punch into summary deck (Deck 7).
25	604	Calculate stock and stand table for pulpwood-poles trees and punch into summary deck (Deck 7).
26	407	Prepare stock and stand tables for sawlogs and pulpwood-poles. Print deck number, species code, DBH, board foot volume and tree count, cubic foot volume and tree count. Subtotal for each inch class .0 through .9 and grand total for each species.
27	082	Sort sound tree cards by type within species. Sort on columns 22, 21, 9, 8 respectively.
28	407	For each species list total net pulpwood-poles and sawlog volume and tree count for each type.
29	082 Clerical	Sort cards by log quality within species. Sort each species separately by placing dividing cards between species.

Step Number	IBM Machine	Procedure
30	407	For each species tabulate total net sawlog volume (tree detail columns 67-71), tree count (card count of cards tallied) by log quality. Do not count log quality 0 trees.
31	082 Clerical	Sort cards by stand size class within species. Sort each species separately by placing dividing cards between species.
32	407	For each species tabulate total net pulpwood-poles (tree detail columns 72-75) and sawlog volume (tree detail columns 67-71) and tree count (card count of each description) by stand size class.
33	082 Clerical	Place culls back into deck. Sort all cards in plot and tree sequence. Sort columns 7, 6, 4, 3, 2 respectively.
34	407 517	Tabulate and summary punch into blank deck (Deck 8, Plot Master Deck) all information for which plot totals are meaningful.
a		From leading card in each plot, punch into blank deck all original plot information. Print an 8 in column 1. Punch tree detail columns 2-4 and 21-37 into plot master card columns 2-4 and 5-21.
b		Make a tree detail card count and punch total into columns 22-23 of plot master. (*The total tree count*).
c		For every entry of "1" in column 38 tree detail card, tabulate and punch total into columns 24-25 of plot master. (*The total pine count*).
d		For every entry of "2" in column 38 tree detail card, tabulate and punch total into columns 26-29 of plot master. (*The total hardwood count*).
e		For every entry of "2" or "3" in column 20 of tree detail card, tabulate and punch into columns 28-29 of plot master. (*The pulp tree count*).
f		For every entry of "1" in column 20 of the tree detail card, tabulate and punch total into columns 30-31 of plot master. (*The sawlog tree count*).
g		For every entry of "0" in column 20 of tree detail card, tabulate and punch total into col-

Step Number	IBM Machine	Procedure
		umns 32-33 of plot master. (*The cull tree count*).
h		Total columns 58-62, 63-66, 67-71, 72-75 in tree detail cards and punch respectively into columns 34-39, 40-45, 46-51, 52-57 of plot master cards. Punch all columns, using zeros where necessary.
35	552	Interpret all tree detail cards, columns 38-75 on second line at top of card, single spacing between entries.
36	552 024	Interpret all plot master cards (Deck 8). Two lines needed. Since there are no trees in plot 34, reproduce columns 1-21, punch zeros in columns 22-57, prior to interpretation.
37	Clerical	Hand sort or flutter all tree detail cards to find those replaced subsequent to preliminary card processing. Two separate sorts desirable.
38	552	Interpret top line of cards located in step 37.

Excerpt from

Board Foot Volume Factors

Diameter Class (inches)	Base Volume (bd. ft.)	Base Height (feet)	Percent Volume Variance per foot
9.6	46.0	27	1.98
9.7	47.0	27	1.98
9.8	48.0	28	1.98
9.9	49.0	28	1.98
10.0	50.0	28	1.97
10.1	51.0	29	1.97
. . .			
29.2	868.0	54	1.71
29.3	874.5	54	1.71
29.4	881.0	54	1.71
29.5	887.5	54	1.71
29.6	894.0	54	1.71
29.7	901.0	54	1.71
29.8	908.0	54	1.71

Excerpt from

Cubic Foot Volume Factors

Diameter Class (inches)	Base Volume (cu. ft.)	Base Height (feet)	Percent Volume Variance per foot
4.6	1.08	12	6.28
4.7	1.18	12	6.21
4.8	1.28	13	6.13
4.9	1.38	13	6.06
5.0	1.48	14	5.98
5.1	1.58	14	5.91
. . .			
13.9	22.41	36	2.80
14.0	22.70	36	2.80
14.1	22.99	36	2.80
14.2	23.28	36	2.80
14.3	23.57	36	2.80
14.4	23.86	37	2.80

EQUIPMENT LIST FOR TWO-MAN CREW

1. Hammer and nails
2. Tag puncher and tags
3. Center stakes

Figure 1b. Equipment carried by two-man crew

4. Two chain trailer tape
5. Haga altimeter

6. Staff compass and staff
7. Abney hand level
8. Diameter tape

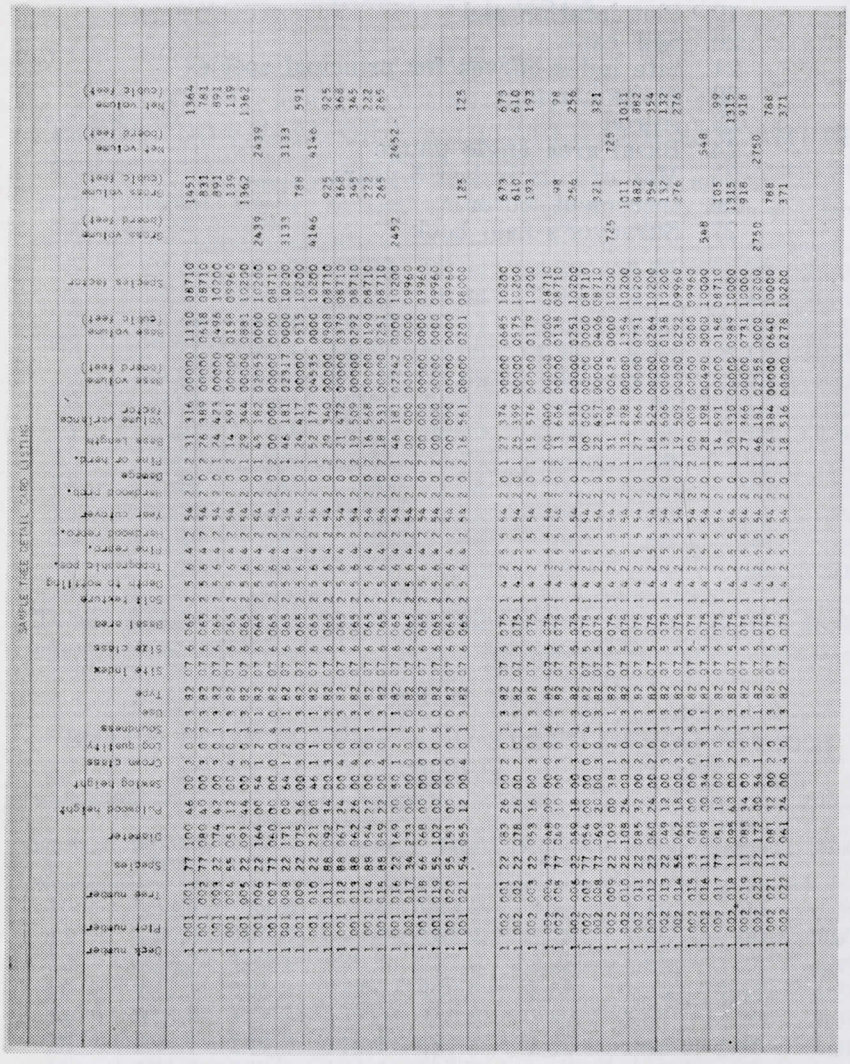

Figure 2b. Example of IBM tabulation

9. Tree cards and holder
10. Plot cards and holder
11. Aerial photos, prick, pen, and stereoscope
12. Copy of instructions
13. Plot tape

14. Mark sense pencils
15. Progress map
16. Pack sack
17. Soil auger
18. Trowel and cloth square
19. Plot location pad
20. Soil cans
21. Site index curves for principal species
22. Stake hammer
23. Apron
24. Basal area angle gauge
25. Map of cuts in last 5 years
26. Increment borer
27. Surveyor's field book

APPENDIX C

TIMBER CHARACTERISTICS OF THE SPECIAL USE AREA FROM C. F. I. DATA

TABLE Ic

CUBIC FOOT VOLUME AND STAND OF TREES TOO SMALL OR UNSUITABLE FOR SAWTIMBER

D.B.H.	Volume Per Acre				Trees Per Acre			
	Shortleaf Pine	Loblolly Pine	Hardwood	Total	Shortleaf Pine	Loblolly Pine	Hardwood	Total
5	12.41	8.07	13.36	33.84	8.59	5.63	11.79	26.01
6	18.13	15.04	15.27	48.44	7.05	5.72	7.87	20.64
7	26.48	14.47	16.16	57.11	6.18	3.32	5.04	14.54
8	27.71	16.38	14.87	58.96	4.55	2.64	3.72	10.91
9	29.28	21.04	21.37	71.69	3.45	2.42	3.03	8.90
10	2.95	.39	27.57	30.91	.29	.05	3.10	3.44
11	2.02	.84	17.67	20.53	.10	.10	1.68	1.88
12	1.08	.00	.23	1.31	.05	.00	.05	.10
13	1.46	.00	.00	1.46	.05	.00	.00	.05
14	1.71	.00	1.21	2.92	.05	.00	.05	.10
15	.00	.00	.00	.00	.00	.00	.00	.00
16	.00	.00	.45	.45	.00	.00	.05	.05
Total	123.23	76.23	128.16	327.62	30.36	19.88	36.38	86.62

TABLE IIc

BOARD FOOT VOLUME AND STAND OF SAWTIMBER TREES

D.B.H.	Volume Per Acre				Trees Per Acre			
	Shortleaf Pine	Loblolly Pine	Hardwood	Total	Shortleaf Pine	Loblolly Pine	Hardwood	Total
10	134.5	88.8	.0	223.3	2.72	1.80	.00	4.52
11	146.5	105.6	.0	252.1	2.28	1.69	.00	3.97
12	192.7	109.1	79.7	381.5	2.28	1.33	1.36	4.97
13	181.1	135.9	113.0	430.0	1.59	1.34	1.41	4.34
14	213.9	139.9	132.0	485.8	1.52	1.07	1.38	3.97
15	234.1	247.0	150.7	631.8	1.33	1.46	1.30	4.09
16	170.6	299.0	139.6	609.2	.84	1.47	.98	3.29
17	138.3	290.8	78.7	507.8	.56	1.09	.48	2.13
18	109.8	257.7	69.3	436.8	.39	.92	.39	1.70
19	28.1	262.7	42.3	333.1	.10	.75	.20	1.05
20	19.0	180.9	80.5	280.4	.05	.47	.30	.82
21	0.0	74.5	15.3	89.8	.00	.19	.10	.24

22	19.3	69.1	20.8	109.2	.05	.14	.05	.29
23	0.0	20.6	0.0	20.6	.00	.05	.00	.05
24	0.0	22.1	13.9	36.0	.00	.05	.00	.05
25	0.0	0.0	20.5	20.5	.00	.00	.05	.05
26	0.0	0.0	0.0	0.0	.00	.00	.00	.00
27	0.0	0.0	24.4	24.4	.00	.00	.05	.05
Total	1587.9	2303.7	980.7	4872.3	13.71	13.82	8.05	35.58

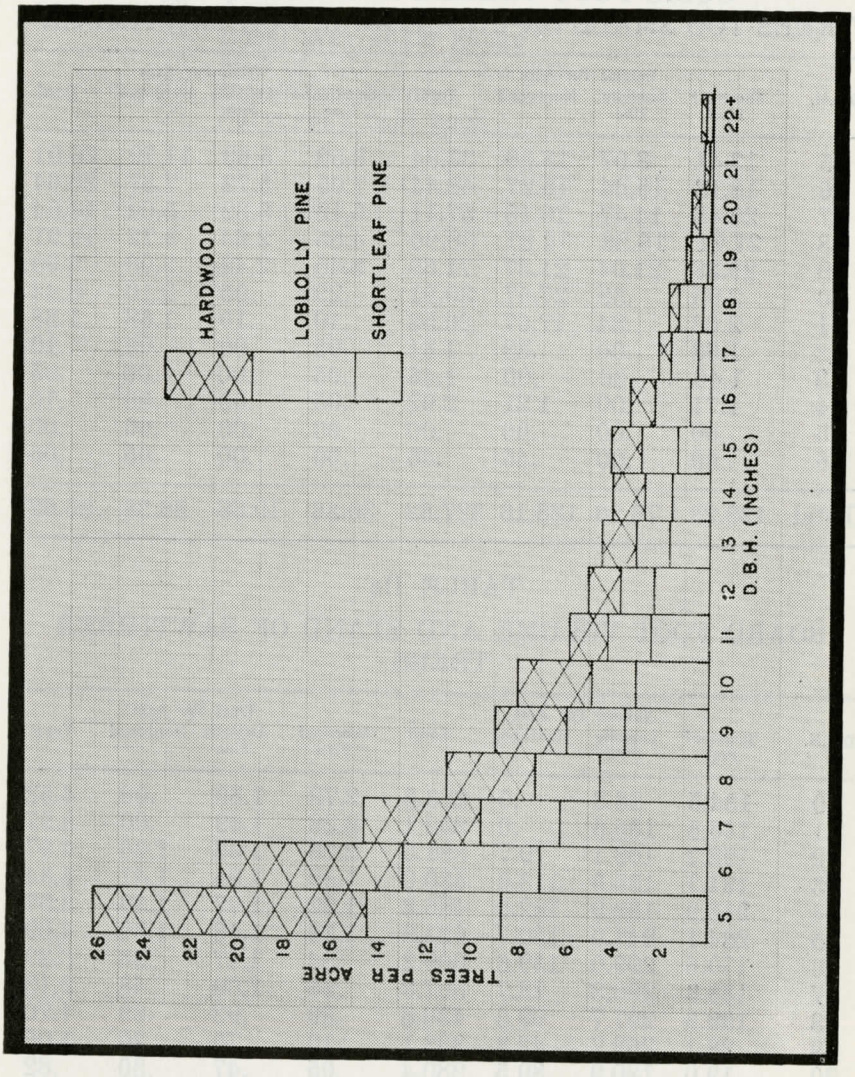

Figure 1c. Timber stand all trees

TABLE IIIc

SAWTIMBER VOLUME BY TREE QUALITY

Tree Quality Class[1]	Shortleaf Pine		Loblolly Pine		Hardwood	
	Board Feet per Acre	Percent	Board Feet per Acre	Percent	Board Feet per Acre	Percent
1	38.2	2.5	344.3	14.9	73.9	7.5
2	675.1	42.5	1158.3	50.3	265.2	27.0
3	812.6	51.1	754.6	32.8	537.0	54.8
4	62.0	3.9	46.7	2.0	104.7	10.7
Total	1587.9	100.0	2303.9	100.0	980.8	100.0

[1]Tree Quality Class based on quality of butt log.

TABLE IVc

VOLUME AND STAND PER ACRE BY TIMBER SIZE CLASS

Species Group	Large Sapling			Small Pole			Large Pole			Small Sawtimber		
	Bd. Ft.	Cu. Ft.	Stand	Bd. Ft.	Cu. Ft.	Stand	Bd. Ft.	Cu. Ft.	Stand	Bd. Ft.	Cu. Ft.	Stand
Shortleaf pine	551.5	22.58	17.50	419.9	109.93	45.00	1360.6	267.28	78.34	1703.6	150.03	39.84
Loblolly pine	0.0	8.40	5.00	1850.2	167.12	48.00	587.1	79.59	25.84	2606.2	72.82	34.29
Hardwood	0.0	5.73	2.50	76.6	83.03	36.00	366.2	99.15	42.09	1139.7	137.25	44.45
Total	551.5	36.71	25.00	2346.7	360.08	129.00	2313.9	446.02	146.27	5449.5	360.10	118.58

TABLE Vc

VOLUME PER ACRE BY TIMBER TYPE

Timber Type	Portion of Sample (percent)	(board feet) Sawtimber Volume	Pulpwood Volume (cubic feet)
Shortleaf pine	11.82	4895.1	348.71
Shortleaf pine—oak	23.63	3817.3	362.83
Shortleaf pine—loblolly pine	19.09	5233.6	320.93
Loblolly pine	7.27	5576.3	329.81
Loblolly pine—hardwood	34.55	5301.8	321.27
Hardwood types	3.64	4282.9	140.23

TABLE VIc

ACREAGE BY SAWTIMBER VOLUME CLASS

Board Feet per Acre	Number of Plots	Percent of Area	Representative Acres
0	2	1.82	43
1— 2500	26	23.63	557
2501— 5000	38	34.54	815
5001— 7500	24	21.82	515
7501—10000	14	12.73	300
10001—12500	5	4.55	107
12501—15000	1	0.91	21

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Savannah Cross Lockey (Mrs. E. D.)	1965	Troup
Mr. Frank White	1965	Cleveland

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