

A SURVEY OF CONTINUOUS FOREST INVENTORY
IN THE UNITED STATES AND CANADA

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ABSTRACT

A survey was made by means of a mailed questionnaire to determine the extent of Continuous Forest Inventory usage on forest ownerships of 50,000 acres or larger in the United States and Canada. Response was obtained from over 95 percent of the 376 organizations contacted, and revealed 105 CFI systems in current operation. Sixty-seven replies reported that CFI systems were either being installed or planned for installation in the future.

An average forest ownership with CFI consists of over one-half million acres and contains over 1,300 permanent plots, each of which represents almost 450 acres of forest land.

Approximately 85 million acres of timber lands are being managed with the help of data gathered from permanent sample plots. This includes over 57 million acres managed by federal agencies, about 26 million acres managed by private organizations, and about 6 million acres managed by state agencies. Most of the forest area with CFI is managed by the U. S. Forest Service, or by pulp and paper corporations, and is located primarily in the South and Lake States. Ninety-four of the 105 CFI systems have been installed since 1951.

The field design of most CFI systems includes systematically located, well-marked, one-fifth-acre plots, one at each sample location. However, point-samples, as well as hidden plots, have become much more common since 1957. There is general agreement that the cost of CFI is less than costs of previously used inventory methods.

Other distinguishing characteristics of American CFI include an average remeasurement interval of about 5 years, with the initial interval being slightly shorter than the subsequent ones. Field tally sheets are generally used to record field data, but mark sense and port-a-punch cards are also popular. IBM equipment is generally used in processing the field data, but some small ownerships still use desk calculators.

CFI is sometimes the sole forest inventory procedure used on an ownership, and is frequently used to supplement a well established forest management program. Its general use, however, is to provide a basic foundation of factual data upon which to base forest management and administration.

In general, the most important use of CFI data is for inventory or growth determinations. These two uses were generally considered important enough to justify solely the cost of installing CFI. Other important uses of CFI data are to supply information for top administrative and woodland management, and to provide data on ingrowth, mortality, and the cutting budget.

The satisfaction with CFI usage and with individual plot and tree data was usually high. Widespread recording or usage of an item, however, did not necessarily indicate that this item or its use proved to be satisfactory. The greatest degree of satisfaction was generally expressed with items that were obtained for specific, effective use in the forest management program.

Limitations of CFI as expressed by CFI users, in decreasing order of importance, are as follows:

- (1) The data are applicable only to the entire forest or to very large subdivisions of the forest.
- (2) The cost of CFI is too high.
- (3) The rigid procedures in CFI often hamper the forest manager when changes and modifications are needed.
- (4) Intensive training, demonstration, and supervision of personnel is required so that observers will measure, observe, and record plot and tree data uniformly.
- (5) Biased silvicultural treatment of easily identified sample plots concerns many forest managers.
- (6) In some cases, CFI has been oversold to top administrative management as a solution to all forestry problems.
- (7) Growth information does not become available until one measurement interval has elapsed.
- (8) Several respondents suggested that too many measurements were taken on CFI sample areas, and were not utilized in the forest management or administrative program.

Most foresters would not consider these limitations as disadvantages of CFI. However, each alleged limitation should be considered carefully by the forest manager before a system of permanent plots is installed.

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IN THE UNITED STATES AND CANADA

by

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TABLE OF CONTENTS

	Page
I. <u>INTRODUCTION</u>	1
II. <u>HISTORY AND LITERATURE REVIEW</u>	5
A. Development of the Control Method	6
1. First Phase	6
2. Second Phase	7
3. Third Phase	17
III. <u>PROCEDURE</u>	24
IV. <u>RESULTS AND DISCUSSION</u>	26
A. Questionnaire Returns	26
B. Current CFI Installations	27
1. Chronological Development of CFI in the United States	27
2. Ownership Classes	30
3. Size of Ownerships	32
4. Scope of CFI in the United States	36
5. Inventory Methods Used Prior to CFI	39
6. Inventory Methods Used to Supplement CFI	41
7. Costs of CFI	42
8. Field Procedures Used in CFI	45
a. Plot Location and Characteristics	45
(1) Plots and Point-Samples	46
(2) Systematic and Random Locations	50

	Page
(3) Stratification Prior to Sample Locations	51
(4) Use of Aerial Photographs	56
(5) Marked and Hidden Plots	58
(6) Acres per Sample	61
(7) Clustered Sampling	65
(8) Tally Methods	66
b. Plot Data Recorded	72
(1) Stand Age or Size	73
(2) Reproduction	74
(3) Site Class	75
(4) Density	75
(5) Condition Class	76
(6) Silvicultural Treatment	77
(7) Operability	78
(8) Soil Type	79
(9) Other Plot Data	80
c. Tree Data Recorded	81
(1) Diameter Breast Height	81
(2) Species	81
(3) Cull Class	82
(4) Merchantable Height	82
(5) Tree Vigor	83
(6) Tree Quality	84

	Page
(7) Total Height	85
(8) Form Class	87
(9) Tree Value	88
(10) Crown Diameter	88
(11) Other Tree Data	89
d. Remeasurement Interval and Number of Remeasurements	90
(1) First Remeasurement Interval	92
(2) Subsequent Remeasurement Intervals	95
(3) Number of Remeasurements	96
9. Office Procedures	99
a. Data Processing Methods	99
b. Accuracy Determinations	103
(1) Area or Volume	105
c. Ownership of Computers and Tabulating Machines	106
10. Purposes for Which CFI Data Have Been Used	108
a. Inventory	114
b. Growth	114
c. Top Administrative Management	119
d. Ingrowth	120
e. Mortality	121
f. Woodland Management	123
g. Cutting Budget	125
h. Tax Information	126

	Page
i. Stand and Stock Tables	129
j. Type or Stand Size Class Areas	130
k. Stand Classification	131
l. TSI and Planting	132
m. D.B.H. - Height - Volume Curves	133
n. Timber Operating Schedules in Specific Areas	133
o. Local Volume Tables	134
p. Instruction, Research, and/or Training	135
q. Wildlife	136
r. Other Uses	137
C. Non-Users of CFI	138
D. Limitations of CFI	142
1. Suggested Changes and Improvements Needed in CFI	145
2. How Satisfactory is CFI?	149
a. Satisfaction with Plot and Tree Data	152
3. Abandoned CFI Installations	158
E. The Average CFI System	159
F. The Future of CFI	162
V. <u>CONCLUSIONS</u>	166
VI. <u>SUMMARY</u>	172
VII. <u>LITERATURE CITED</u>	178
VIII. <u>APPENDIX</u>	187

LIST OF FIGURES AND TABLES

	Page
Figure 1. Regional division of the United States for survey purposes, and the number of CFI users in each region	28
Table 1. Returns of CFI questionnaires by major forest land-owners in the United States and Canada, 1960	29
Figure 2. Annual and cumulative number of CFI installations	31
Table 2. Regional distribution of CFI systems, by ownership classes, 1960	33
Figure 3. Number of CFI users by size of forest ownership, 1960	34
Table 3. The scope of CFI in The United States by ownership classes, 1960	37
Table 4. Representation of CFI plots in the United States and Canada, 1960	38
Table 5. Comparison of costs between CFI and inventory methods used prior to CFI	44
Table 6. Size of plot and point-samples used by CFI systems in the United States and Canada, 1960	49
Table 7. Average number of acres per CFI sample, by ownership class, 1960	63
Figure 4. Number of CFI systems with similar areas represented by each sample location, 1960	64
Table 8. Use of clustered sampling in CFI systems, by regions, 1960	67
Table 9. Use of clustered sampling in CFI systems, by ownership class, 1960	68
Table 10. Remeasurement intervals of CFI systems by regions of the United States and Canada, 1960	94
Table 11. Regional distribution of CFI systems with remeasurement data, 1960	97

Table 12.	CFI systems with remeasurement data, by ownership class, 1960	Page 98
Table 13.	Important uses to which CFI has been placed, 1960	109
Table 14.	Average rating of uses of CFI, 1960	111
Table 15.	Paired comparisons of major CFI uses, 1960	113
Table 16.	Attitudes of the non-CFI users in the United States and Canada that own or manage over 50,000 acres of forest land, by ownership class, 1960	140
Table 17.	Satisfaction rating of CFI purposes and uses, 1960	151
Table 18.	Plot data recorded, and satisfaction expressed by CFI users, by ownership class, 1960	154
Table 19.	Tree data recorded, and satisfaction expressed by CFI users, by ownership class, 1960	155
Table 20.	Satisfaction ratings for CFI plot and tree data, 1960	156
Table 21.	Average CFI systems in the United States and portions of Canada, by ownership types and selected years, 1960	160
Table 22.	Average CFI systems in the United States and portions of Canada, by regions, 1960	161
Table 23.	Calculations for rank correlation, CFI users on private ownerships	195
Table 24.	Calculations for rank correlation, CFI users on federal and state ownerships	196

INTRODUCTION

Much of the timbered area in the United States is managed on a short-term basis, with little or no investment to provide for future yield. Forest management of these areas generally includes only the established systems of fire protection, combined with practices such as high grading, overcutting, and unwise clearing. Such practices prove wholly satisfactory where capital for forest development is lacking, where production of the forest is of secondary nature, or where management is on a temporary basis. For these practices, little or no inventory information is necessary. Even when the forest is in the early stages of development and management, a temporary, relatively low-intensity, inexpensive survey will often suffice to initiate forest operations on a sound basis. But when practices aimed at achieving sustained yield are to be applied, and when the intensity of forest management is to be increased to meet today's economic requirements, a longer-lasting, more thorough inventory method becomes necessary.

The more important features of forest management planning include the acquisition of accurate information on land area, timber volume, and reasonable predictions of future growth and mortality. Since timber growth, stand development, and cutting are continuous processes in a managed forest, it appears that continuous forest records of these processes should be kept. The term continuous forest inventory has become widely applied to management techniques that utilize basic data from the periodic remeasurement of permanent sample plots. These

techniques enable the forester to measure changing forest conditions so that the effectiveness of past policies can be evaluated, and improved policies formulated for the future. The abbreviation, "CFI" is now in general use by foresters to designate collectively the techniques involved in continuous forest inventory^{1/}.

Most definitions of CFI are general sketches of the characteristics, components, and uses of existing systems. Such definitions usually state that all plots must be systematically located and permanently established, that individual trees must be specifically marked, and that the information must be processed by electronic tabulating machines. While these items are commonly found in most CFI installations, they are not a prerequisite to the method itself and thus these descriptions are not really definitions at all.

Stott (1960) presented a general definition of CFI when he stated that:

"Continuous forest inventory or CFI is a precise, frequently repeated, and directly comparable measurement of all commercial trees in systematically placed sample plots. These plots have fixed radii and are permanently located in the forest. Their treatment and the treatment of the surrounding forest must be analagous."

This definition adequately describes the CFI techniques developed and advocated by the U. S. Forest Service, but it does not recognize the wide variation in current CFI methodology or the fact that CFI has

^{1/} C. B. Stott of the U. S. Forest Service is generally given credit for coining the term Continuous Forest Inventory, and its abbreviation, CFI.

become a concept and not a specific system to be rigidly applied.

Later, Stott (1960) condensed his definition to read:

"CFI is merely a system of frequently repeated inventories designed to keep an ever current record of the ever changing forest."

For the purpose of this investigation, CFI will be interpreted as:

"a system by which field data, obtained from permanent samples, are analyzed, reduced, and used as a basis for forest management."

The idea that CFI is a concept, rather than a rigid system, appears in a definition by K. P. Davis quoted by Stott (1957a).

"Americanized CFI is the process of obtaining information needed for continuous forest production."

Past studies of CFI have been limited to broad generalizations about the field of CFI, and to studies of CFI as a management tool used by individual companies. This study surveys the entire field of American CFI for the purpose of summarizing the uses to which it has been placed, comparing systems in the various sections of the country, in the various ownership types, and in determining the chronological trends and developments of its component parts. Specific objectives were as follows:

1. To determine the interest in CFI among the large forest land owners of the United States and Canada.
2. To evaluate the uses of CFI in present-day forest management.
3. To determine the limitations of CFI and possible ways of overcoming them.

- 4 -

4. To determine trends in methodology of collecting and analyzing CFI data.

HISTORY AND LITERATURE REVIEW

Continuous forest inventory is a system of forest management based on data obtained from permanent sample plots of various sizes and spacings throughout the forest. Its origin dates from the European method of management called "la methode du controle."

Adolph Gurnaud (1825 to 1898) was the first forester to initiate and use what came to be known as the "la methode du controle." He developed this method while in charge of the communal forests in the Swiss Jura from 1863 to 1875 (Knuchel, 1953). In connection with the World Exhibition in Paris in 1878, Gurnaud published a paper concerning the forests of Eperons in France in which this new method of management was being applied (Gurnaud, 1878, 1884, 1890).

Since this new method was mentioned only in fragmentary fashion in his publications, and was not described in a separate publication, it is quite conceivable that even its originator was not completely convinced of its virtues. Gurnaud reported that the recurring inventory system was designed to bring all parts of the forest to a state of highest productivity. Based on careful selective harvesting, the production of the residual stand was improved, because every silvicultural harvest was simultaneously a cultural operation..

The "la methode du controle" was tried in the French Alps with only mediocre success (Hough, 1954). This, along with the fact that Gurnaud's method had never been published as a special monograph, explains the poor reception given it by the French foresters; to date,

they have not officially adopted the system.

From management practices based on rigid theoretical considerations, Gurnaud's work was expanded and modified by later workers, and came to be known as the control method.

Development of the Control Method

Development of the control method has passed through three general phases. The first extends from its introduction by Gurnaud circa 1878 until 1914 when Biolley reported his results for the first time. The second phase, again primarily European, extends from 1914 until the 1940's, when the possibilities of the control method were first emphasized by C. B. Stott of the United States Forest Service. The third phase extends from the 1940's to the present time, and finds American CFI gaining momentum in the United States until it promises to become the dominant scheme of forest inventory and management used by major progressive forest land owners.

First Phase

Tichy, a forerunner to those advocating the control method, promoted a system of management that is quite similar in some respects to present-day CFI with point-sampling (Knuchel, 1953). He divided the forest into "felling series" of 250 to 500 acres, and each of these into five equal sections, corresponding to the years in a five-year cutting cycle. Each section was then divided into five stands. A plot equal to one-tenth the area of the stand was taken every five

years, measuring basal area only, using a special set of basal area calipers. The cut $\underline{E}$ was equal to the growing stock $\underline{G}$ times the percent $\underline{P}$ from yield tables, or: $E = G \times 0.0P$. This rigid framework had little practicality for management, but it proposed a management system based on a sample of basal area measurements.

Foresters who sought to follow Gurnaud had to construct their own systems based on brief guidelines from his writings and much initiative. Once methods were developed, considerable time was required for results to show the benefits or shortcomings of management practices. Flury (1901) and Biolley (1901) published critical observations on their methods after two 6-year management periods had elapsed. However, foresters of that time believed that 12 years were insufficient for a scientific test of this nature. (Popescu-Zeletin, 1936).

Discussion during the first phase generally compared the control method with the ordinary "high forest method" as to timber production, both qualitatively and quantitatively. Wernick (1910) stated that, in his opinion, forests under the control method appeared to produce as much, and in many cases more, than forests managed under other systems.

Second Phase

Henri Biolley (1858 to 1939) continued work on the control method, and is recognized as its first strong advocate (Popescu-Zeletin, 1936). He became manager of the Neuchatel Forest Charge in the Val-de Travers in 1880, at a time when clear-cutting was common in

Switzerland. He introduced the control method in the Canton of Neuchatel in 1889. This conversion to selection management took place quietly, first in the form of a small experiment, then on a larger scale, and finally by 1917, when Biolley was made chief forester for the Canton, it was the only management method used in all its forests. Biolley spent his whole life working for the adoption of improved forest management based on accurate studies of actual stand conditions and changes. With the publication of Biolley's book in 1920 (Biolley, 1920), its German translation in 1922, and the English translation in 1954, the control method became widely known.

Through the results of Biolley's work, Swiss foresters generally accepted the control method, and they believed that with the species composition and the geography of Switzerland, there was no better means of obtaining a permanent maximum yield of timber. Modifications and simplifications, however, were common. In fact, a slightly different procedure was used in almost every Canton. Some of these differences included slight modifications in diameter classes, methods of obtaining measurements, and various means of obtaining the optimum number of stems per diameter class.

Biolley believed that in European countries, the establishment of pure, uniform stands, with species often unsuited to the site, greatly increased the risk of increment loss. Thus, the more-difficult-to-manage, uneven-aged stands fitted in perfectly with the control method, which subjected the forest to a perpetual system of research. It based

the management of the forest on the progressive development of the stand. The best measure of this development was current increment as determined by successive 100-percent inventories. In this manner, yields comprised the basis of management procedures. But, even with an accurate measure of increment, a clear idea of the effects of management could not be ascertained from one management period alone. For instance, increased rainfall in one remeasurement interval might help increase yield regardless of management practices.

Even with the fine proof that Biolley offered as to the suitability of the control method, many of the older foresters were skeptical, and hesitated to introduce a system which threatened to depart from their placid ideas of normality and order (Huber, 1952). This same reluctance was evident in some of the more backward areas. Pipan (1953) stated that the control method had found little application in the management of Yugoslav selection forests. This attitude did not result from backward management and administration, but from the influence of eminent specialists like Hufnagl, who were opposed to its application in selection forests.

Gurnaud applied the control method to certain forests on a small scale only. The method was then continued by his pupils and adherents. One of these, F. de Liocourt (1898), derived a mathematical "law" concerning the ratio of stem numbers to diameter in a selection forest. This law was later expanded and further developed by H. A. Meyer, who plotted a curve on semi-log paper of stem numbers over diameter class to

to represent the stand (Meyer, 1934). In selection forests, this relationship indicates that the distribution of trees by diameter class is a decreasing geometric series defined by the ratio between two adjacent diameter classes.

The graphical representation of normal stocking in a selection forest provided a standard or goal toward which management was to proceed. Forest managers attempted to duplicate de Liocourt's computed diameter distribution in their stands. The state of equilibrium in a stand, as defined by de Liocourt's "law," has not been attained in an actual forest, not even in the forests managed by Biolley in the Canton of Neuchatel.

Biolley opposed attempts at mathematically expressing the stocking in selection forests. He severely condemned such "new attempts at systematizing silviculture," even though some of his close friends were following de Liocourt's lead. He feared that if emphasis were placed on the stand's diameter distribution rather than increment, the meaning and objectives of the control method would be lost.

Since 1922, the outstanding work of Professor H. Knuchel in the Forestry College in Zurich, Switzerland, helped to continue the momentum of the control method until it became widely accepted wherever selection cutting practices were used in Europe. From the beginning of his teaching career, he supported the control method by his lectures, writings, and especially through his research activities which include mathematically testing the foundations of the system.

Eberbach (1922) pointed out that the control method of Gurnaud and Biolley was first introduced into Germany under the name of "Dauerwald" as advocated by Möller (1922). Möller considered that the control method of Biolley differed from "Dauerwald" only in the words used to describe the system.

Professor J. G. Böhmer of Norway (1929) worked with the idea that the selection forest form is determined by the distribution of stem totals. These in turn are functions of the "unreduced crown projection," an European concept similar to that of crown closure in America. In 1930, a Roumanian forest was first managed under the control method (Popescu-Zeletin, 1936). There are some experimental areas in the Carpathian Mountains of Poland on which the control method is being used (Popescu-Zeletin, 1936). Bourne (1951) reported that the Parkmoor Beechwoods of England were also being managed under this system.

The control method, as developed in Europe during the first and second phases, seeks to provide the forest manager with a reliable survey of forest conditions. By accurately measuring stocking at regular intervals, this system includes a combination of silvicultural and increment control which the forest manager can use to achieve the productive potential of his forest.

The control method has become widely applied in European selection forests, but has had little application in even-aged stands. It deviates

from the inflexible area allotment and formula types of yield regulation, and the rigidity of even-aged management practices. Although it provides the basis for adequately determining increment and yield, the major emphasis is placed on silvicultural techniques.

Variations in the control method may be found throughout the selection forests of Europe; however, once a system is installed, it is retained intact so that comparable results are obtained from successive inventories. A general procedure often found in European application of the control method includes the following: (1) administrative and woodland management is placed in the hands of one person with complete authority; (2) the forest is divided into permanent compartments, each approximately equal in size with fixed boundaries; (3) reinventories are made at intervals of not more than 10 years; (4) volume computations are based on volume tables called "tarifs"; (5) measurements are taken on all felled trees; (6) increment by size class is computed by the Gurnaud-Biolley method.

If intensive forestry is to be practiced on a given area, a system of management must be set up which insures both the development and continuity of the forest, and which provides for the forest production requirements of the owner. Administrative and operational management may not be completely compatible in all cases, but since they both work toward attaining the highest forest production possible, they are most frequently combined under the same authority.

One of the first requirements of the control method is a detailed

areal subdivision of the forest. By placing fixed permanent boundaries around each compartment, subsequent remeasurement data are tied to ground control. Fixed boundaries also help facilitate the 100 percent tallies that are used.

Diameter measurements are generally obtained on all trees above a specified diameter (or circumference) breast high with calipers or diameter tapes. Tallied trees are lightly scribed on the bark at breast height to insure that future measurement occurs at the same point.

In the early stages of the control method, it was believed that greater accuracy was associated with smaller diameter class intervals. H. A. Meyer (Popescu-Zeletin, 1936) showed that the precision of the survey did not depend on the width of the diameter class interval.

When presented in tabular form, diameters are grouped as small, average, or large timber. Groupings of this nature permit better estimation of stand composition, better interpretation of the increment, and better marking rules (Biolley, 1920).

Remeasurements are the fundamental task of the control method, and are repeated at the end of each given period. According to Knuchel (1953), the remeasurement interval should range from 6 to 10 years. Anderson (1953) advocates an interval which equals the period between thinnings. H. A. Meyer (1934) found that the greater the accuracy of the field work, the greater may be the size of the compartment and the longer the remeasurement interval. To lessen the effects of errors in field work, and to allow slow growing timber to produce a maximum of

measurable increment, a longer interval is generally used. In his later years, Gurnaud himself favored longer periods for the sake of the larger differences between inventories (Wahlenberg, 1941). A short management period insures that each felling is light, and is often used on better sites with their correspondingly higher increment rates.

Once the number of stems per unit area has been determined, an estimate of the standing volume is obtained by using a local volume table, called a "tarif." This tarif gives a fixed silve value for each d.b.h. class without regard to the actual contents of each tree. The silve is a special administrative unit which normally applies only to standing timber. It is approximately equal to one cubic meter and serves as an estimate of cubic volume based on conditions as they are when the tarif is set up and not necessarily as they will be at future times. Where felled timber is sold, the more reliable cubic meter is the standard unit used. Proper conversion factors can be used to express each silve in cubic meters for a given stand.

The tarif is established only after the first inventory, and is then used without further alterations for each successive remeasurement. Experience has shown that a tarif can be used for a rather large area without interfering with the effectiveness of the control method (Huber, 1952). Absolute volume figures are not as important as the relative change between inventories. The use of tarifs is advantageous because of its ease of application. Its use allows volumes of both inventories and felled trees to be based on the same measurements.

Both Gurnaud and Biolley first made multiple tariffs which presented volumes based on height classes and species as well as diameter. They later changed to one consolidated table for all trees in a general area. This placed even more weight upon the periodic change in growing stock.

Comparison of volume differences between two consecutive inventories alone does not give reliable data on increment. From the initial survey, that amount of timber removed through fellings is subtracted. Measurements on trees cut and harvested from the forest normally are recorded by both diameter tally and by their actual yield in merchantable products. The ratio of volume and silves of the felled timber to merchantable volumes of the same trees is used to correct the volume inventory. This correction factor accounts for any change in utilization standards or in average form and height of trees. Meyer (1935) regarded the need for accurate measurements of all timber removed from the forest as a major disadvantage of the control method. If the volume removed from the stand is measured when the stand is marked, complications may arise because some trees marked for harvest are missed in the logging process.

The formula:

$$Z = V_2 + N - V_1 - P, \text{ in which:}$$

Z is the increment,

V_1 is the volume at the first survey,

V_2 is the volume at the second survey,

N is the volume of the timber felled, and

P is the combined recruitment 1/ and ingrowth 2/.

was used by both Gurnaud and Biolley to determine the growth of the forest (Knuchel, 1952).

The size and number of felled trees are recorded, and the volume found from appropriate tariffs to give the volume for N. Increment is computed from stand and stock tables by finding the volume of the trees that move upward into each of the three general size groups. This method assumes that during the remeasurement interval, trees move up a maximum of one diameter group. With long remeasurement intervals or with narrow diameter groupings, some fast-growing trees move up more than one diameter category. In these cases, the portion of the recruitment can be computed by using volumes from the second and third lowest size classes in the tarif.

Another method that is used to calculate ingrowth directly is to tally separately, at the time of a remeasurement, the trees not scribed in the previous survey. The reliability of this method may be quite low due to errors or indistinct old scribe marks.

Rates of volume increase obtained for recruitment and ingrowth are then used as a basis for allocating the cut. According to Gurnaud,

1/ Recruitment is the volume of timber moving into the medium and large group divisions.

2/ Ingrowth is the volume of timber moving into the lowest merchantable size group.

if the recruitment and ingrowth come to more than two silves per hectare, the recruitment and ingrowth should be exploited (Knuchel, 1953). On the other hand, if the recruitment and ingrowth are insufficient, that is, less than 1.5 silves per hectare, the stand should be opened up, and more than the increment felled. Of course, in the latter case, the stand is not cut heavily if it is vigorous, young timber. The reason for this procedure is based on the conclusion that volume growth rates increase with larger diameters in selection forests managed by the control method, in contrast to those found in even-aged stands.

Third Phase

The third phase is not strictly chronological, but includes the stages through which the control method has evolved from European practices to the present stage of CFI in the United States.

Permanent sample plots in the United States were first used for experimental work. According to Sterrett (1907), "the sample plot idea was originated by Professor Graves and work commenced in the summer of 1904." This initial permanent plot establishment was strictly experimental; however, Sterrett remarked that there was no reason why a large tract of forest harvested in a prescribed manner should not be made to serve the same purpose. Other data on this subject were presented by Woolsey (1912) when he listed the objectives of permanent sample plots for experimental use.

Recknagel (1949) reported on permanent sample plots that had been measured since 1925 by a private company in New England. This company established one-acre growth plots as early as 1911, but it was not until 1933 that quarter-acre plots were established in a system that closely resembles some present CFI systems. Their plot locations were selected in a systematic fashion, with large variable-sized plot clusters in areas that resembled as nearly as possible, the timber types of the surrounding township.

Many foresters believe that Kirkland (1934) was the first American forester to advocate use of the control method. He believed that for each major subdivision of the forest, the forest manager should have precise knowledge of the inventory, the losses, and the gains of all kinds during the cutting cycle. This information had to be based on field measurements of samples, and provided a live, continuous inventory for every forest division.

Kirkland stated that the control method clarified more than any other the application of the selection system where the emphasis is on the management of older trees with their correspondingly high volume and value. He considered the regeneration and growth capacity of seedlings and saplings to be of lesser importance, because many will disappear naturally and not contribute to utilizable volume.

Modern CFI systems, as advocated by the U. S. Forest Service, particularly C. B. Stott, had their beginning in 1937 and 1938 with a few hundred sample plots on industrial forest land in the Lake States

(Stott, 1960b). Installations spread into the farm woodlots of Ohio and Wisconsin, and by 1952, several large forest land-holdings in the Central and Lake States were using CFI data in their forest management operations. Since 1952, CFI systems have spread rapidly to all sections of the United States.

In 1940, Stevenson and Meyer reported that a continuous inventory system was installed on a 332-acre forest in Pennsylvania. They stated that it was more important to obtain comparable results by applying the same local volume table than it was to get possibly higher absolute accuracy by readjusting the volume tables after each remeasurement. Their system used a 100-percent inventory (Stevenson and Meyer, 1940).

A system of CFI using the mark sense method of tally on International Business Machines cards was presented in 1952 by Stott. He compared a going forestry concern to a going business concern, and stated that each technique of sound forestry was similar to an accepted principle of sound business management (Stott, 1952).

Meteer (1953) found that the continuous processes of timber growth, cutting, and development of the stand could be adequately measured by the use of permanent sample plots. He believed a knowledge of individual tree attributes of growth, value, and quality can be expected to precede more thorough timber management considerations of the future. He recommended McBee Keysort cards as a good means of recording data at a reasonable cost, especially for the small forest landowner with a minimum number of sample plots.

In April, 1954, the first in a continuing series of U. S. Forest Service monthly leaflets "Forest Control by Continuous Inventory" was published by the regional office at Milwaukee, Wisconsin. Its objectives are to explain CFI procedures and to help further the intensification of current forest management. Stott, the current author of these leaflets, has used this medium to publicize the expanding interest in CFI, and to provide information to prospective CFI users. This monthly publication provides a rapid means of disseminating the latest advancements in CFI, and in them, an up-to-date, economical aid to better forest management has been established. Through these monthly leaflets, and his strong personal salesmanship of CFI, Stott has made a significant contribution to the intensity of American forestry.

Cutler established a permanent plot system of survey in the ponderosa pine stands of the southwest to obtain information on growth and mortality (1955). He found that this method procured accurate growth data for use in making long range management plans.

Hall (1959b) stated that CFI gives an estimate of growth rate that is probably more accurate than that available with equal sampling intensity through other methods of growth measurement. He also stated that higher correlations of growth and volume are obtainable through the use of shorter remeasurement intervals.

A concise summary of the component parts of CFI has been prepared by Barton (1960b). His brief summary provides a good general view of the items which should be included in a modern CFI system.

Baker and Hunt completed a study of CFI using punched card machines on a 2,500-acre forest in Texas (1960). They concluded that even though success or failure of their study could not be determined until the first remeasurement had been completed, their cost of \$1.40 per acre was probably not too high provided that intensive forestry practices are justified.

Examples of uses to which information from industrial CFI systems has been placed are included in papers presented at the proceedings of the Society of American Foresters 1954, 1956, and 1957 annual meetings (Abel, 1956; Belcher, 1957; Wright, 1954). Short courses covering CFI procedures and discussing various problems and uses of CFI have been held in several sections of the United States. Two of the more significant sessions were held at the University of Georgia in 1959, and at Purdue University in 1960.

Advocates of the European control method and most American foresters have believed that the stand should be the basic unit of the forest. More recently, Meteer (1953) has suggested that with the advent of the high speed computer, a study of the individual tree can provide a better silvicultural understanding of forest changes.

The stand and the site, considered together as a single production unit, provide a criterion for measuring the contents and growth potential of a forested area that will provide information on a broad scale. In the same manner that a regression produces the most accurate curve that will fit a series of individual points, average information

for the stand as a whole will reveal general shortcomings of the stand.

Results of a study by Wahlenberg (1941) indicated that there would be less clerical work without apparent loss in accuracy if a general stand method were used instead of more complicated measurements on individual trees. Several industrial and public forest organizations are currently using a method of management termed "unit area control" (LeBarron, 1958). This approach utilizes the stand description, and from the standpoint of the practicing forester, it is said to produce satisfactory results.

Pearson (1946) has stated that individual tree records furnish better information on growth, mortality, and competition than customary practices of mass averaging. Meteer (1953) believed that mass averaging of sample data was not enough, but that a knowledge of the reaction of individual classes of trees must be fully realized before a stand and its environment could be managed at their optimum output. It must be realized, however, that the intensity of forest management in the United States at the present time, has not progressed in many cases to the point where information on individual trees can be fully utilized.

PROCEDURE

A comprehensive study covering the status and use of CFI in the United States and adjacent portions of Canada must, for obvious reasons, be conducted via a mailed questionnaire. Such a questionnaire was prepared and reviewed by several foresters in private, public, and educational forestry organizations who are well acquainted with CFI procedures. Their composite suggested changes were incorporated as far as possible in the final version of the questionnaire (see Appendix).

Most items in the questionnaire could be answered by checking an appropriate choice, or by a single word. However, because of the variation in CFI systems, interpretations in the analyses were sometimes necessary where short explanatory statements were given in answers to questions. Some items were not answered on all questionnaires, thus reducing the number of returns available for complete analysis.

General information available about CFI in the United States indicated primary usage on the larger forest ownerships. Therefore, major attention was focused in this study upon the larger forest land owners, specifically those owning 50,000 acres or more. The 1958 "Timber Resources for America's Future" reported a total of 283 private forest ownerships of 50,000 acres or more in the United States. Addresses of practically all of these were obtained from state and federal forestry organizations; forestry schools; and pulp, paper, and lumber associations. In all, 376 questionnaires were distributed and 358 were returned.

National forests were contacted only if information from regional administrative offices indicated that CFI was being used. As many as 4 reminders were sent to some of the addressees in an attempt to stimulate response, but few returns were received after the second reminder.

CFI users were classified into private, state, and federal ownership types. This procedure made it possible to make comparisons between CFI methods and uses by regions, ownerships, and chronological establishment, and eliminated overstressing information in returns from very recent installations. Where a system had been installed piecemeal over several years, the initial start was taken as the date of establishment.

Information on the components of CFI systems was compiled to show what the average functioning current CFI system is like. The uses of CFI were analyzed to determine which items appear to provide information valuable enough to justify the entire cost of installing CFI.

Returned questionnaires from private and industrial non-users of CFI among the 50,000-acre-plus ownerships were analyzed to determine reasons for non-use. Instances where a CFI system had been installed and discontinued were considered separately.

Distribution of information about CFI, and active assistance and cooperation with all classes of forest owners in installing CFI systems, has been primarily the responsibility of the Division of State and Private Forestry in each regional office of the U. S. Forest Service.

For this reason, the returns from the United States were grouped into 8 geographical regions for a portion of the analysis.

RESULTS AND DISCUSSION

QUESTIONNAIRE RETURNS

To determine the degree to which continuous forest inventory is being used in American forest management, a survey was conducted through a mailed questionnaire. Response was unusually high, for replies were received from over 95 percent of the correspondents (Table 1). While several reminders sent to some landowners may have influenced them to send in the returns, it is believed that the strong interest among forest landowners in this relatively new concept in forest management was primarily responsible for the exceptionally high percentage of returned questionnaires. Even the 2 questions requiring written answers and the remarks sections on the questionnaires were completed in most cases. Several respondents included answers on separate sheets so that certain items might be outlined more fully. As a result of the high response to this survey and the completeness of the returned questionnaires, data compiled and analyzed in this study present a comprehensive picture of CFI in current American forest management.

To facilitate regional comparison of CFI systems, the United States was divided into 8 regions, similar in some respects to the administrative regions of the U. S. Forest Service. In the western half of the country, however, only 2 regions were recognized. California comprised one region, and all other states formed the other region. Canada was considered as a separate region (Fig. 1).

CFI systems are found in all parts of the United States. Users of CFI were concentrated, however, in the southeastern Coastal Plain, California, and the Lake States. From these data, it could be inferred that these concentrations occur where forest management is most intensive. Certainly it is obvious that in these areas are many forestry organizations which are willing to try new forest management techniques.

CURRENT CFI INSTALLATIONS

The use of permanent sample plots in American forestry has changed from the time when a few plots were established to provide information usually unrelated to forest management needs, to the present stage, where highly-developed sampling designs are being used to obtain information needed by the forest manager. Because of the complexity of current CFI installations, it is impractical to discuss CFI as a single, generalized forest management procedure. Instead, each component must be considered separately, and conclusions drawn on the utility and adequacy of that part.

Chronological Development of CFI in the United States

After a slow start in the 1940's, the recurring inventory of permanent sample plots for management purposes increased steadily. In this study, only 6 organizations were found which had established permanent sample plots prior to 1950 for purposes other than experimental work. Three of these were on widely separated private ownerships, one

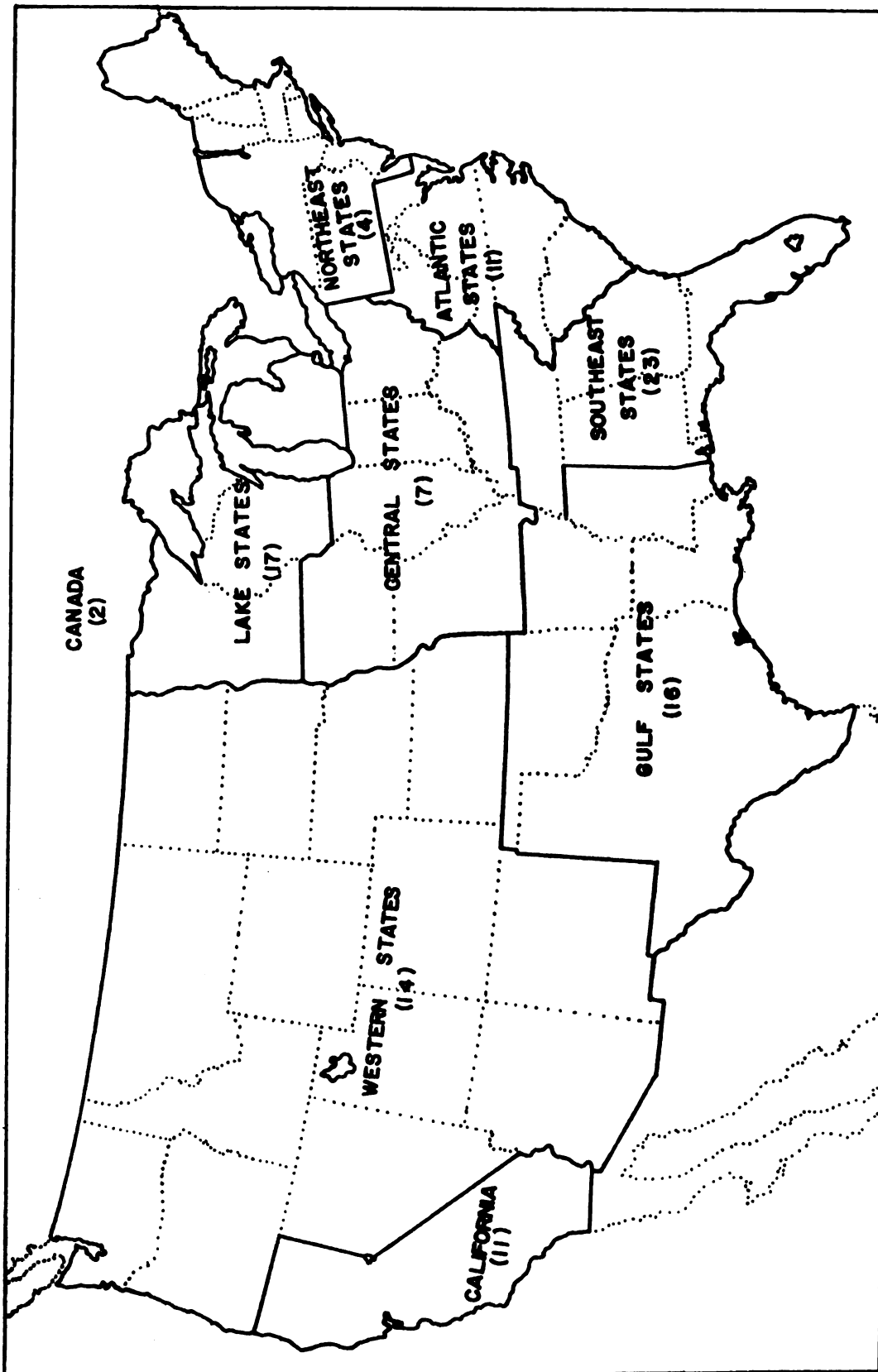


FIG.1: REGIONAL DIVISION OF THE U.S. FOR SURVEY PURPOSES, AND THE NUMBER OF CFI USERS IN EACH REGION.

Table 1. Returns of CFI questionnaires by major forest landowners in the United States and Canada, 1960.

Type of Ownership	Questionnaires Sent	Questionnaires Returned	Number of Ownerships over 50,000 acres	Number of CFI Installations
<u>United States</u>				
Private:				
Pulp and Paper Corporations	87	83	73	32
Lumber Companies	116	106	84	22
Misc. Wood Producers	89	85	64	14
All Private	292	274	221	68
State:				
State Forests	60	60	52	18
Institutions	4	4	0	4
All State	64	64	52	22
Federal:				
Forest Service Regions	10	10	10	8
Other Federal	6	6	6	5
All Federal	16	16	16	13
<u>Canada</u>				
Private:	4	4	4	2
All Ownerships	376	358	293	105

on state lands, and two on federal forest ownerships. The earliest significant acceleration in CFI installations occurred in 1952 (Fig. 2). Six systems were established that year as compared to a total of only 11 installed before 1952. The number of CFI systems established annually increased steadily to a high of 19 in 1958 and 1960 (Fig. 2). This increase portrays the tremendous interest in CFI that continued to build up in the 1950's.

The cumulative number of CFI systems is also shown in Fig. 2. It appears reasonable to assume that increases in CFI installations will continue. If the number of CFI systems does increase in the next decade as it has in the past ten years, every major forest landowner in the United States will be using CFI by 1970. Continued increase in CFI usage will depend on successful operation of present systems.

Ownership Classes

A discussion of mensurational or sampling techniques for obtaining forest data must be made against a background of dissimilar management objectives and budget limitations of differing ownerships. Three major forest land-ownership classes -- private, state, and federal -- were used to facilitate the compilation and analysis of information.

The survey showed that CFI is being used in forest management in 8 of the 10 U. S. Forest Service regions, in 16 of the states, and in 7 out of 77 Indian reservations. In addition, CFI is used by 70 of the 218 private organizations in North America that own or control over

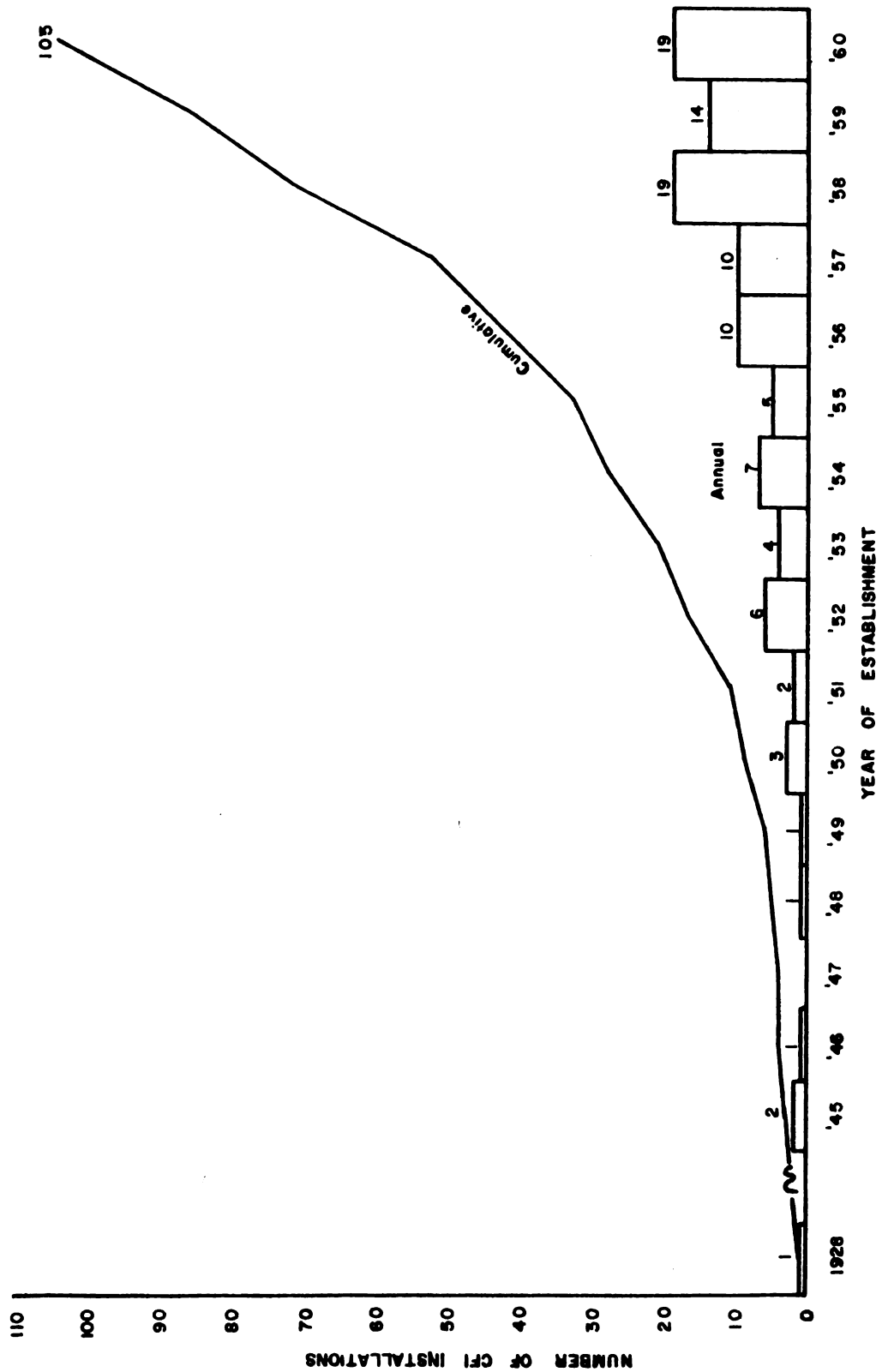


FIGURE 2: ANNUAL AND CUMULATIVE NUMBER OF CFI INSTALLATIONS

50,000 acres of forest area. CFI appears to be firmly established as a forest management procedure on public land. The spread of CFI to additional state and federal forest ownerships will depend to a great extent upon the satisfaction and usage which current systems provide.

Private ownerships with CFI include 34 pulp and paper companies, 22 lumber companies, and 14 ownerships distributed among railroads, private individuals, and miscellaneous wood-using industries. Table 2 shows the regional distribution of CFI systems, by ownership classes.

Size of Ownerships

CFI is generally considered to be a practical forest management procedure only for large forest properties. The results of this study substantiate the fact that continuous forest inventories are most common on areas larger than 50,000 acres. However, there has been increasing use of CFI on smaller forest properties since 1957 ^{1/}. Seventy-five of the 105 CFI systems currently in use are on ownerships of over 100,000 acres, and 93 are on areas of more than 50,000 acres (Fig. 3).

In general, private holdings with CFI are somewhat smaller than those in public ownership. Fifty-one of the 70 private ownerships with CFI are larger than 100,000 acres, and 67 are at least 50,000 acres in size. Ownerships of less than 50,000 acres include one company that was dissatisfied with its system, one with valuable bottomland hardwood land,

^{1/} Small ownerships refer to areas of less than 50,000 acres.

Table 2. Regional distribution of CFI systems, by ownership classes, 1960.

Regions <u>1/</u>	Private			State		Federal		Total
	Pulp & Paper	Lumber	Misc.	State Forests	Educational Inst.	Forest Service Regions	Other	
	- - - - - <u>Number of CFI Systems</u> - - - - -							
Atlantic	5	3	1	1	--	--	1	11
California	--	8	--	2	--	1	--	11
Canada	2	--	--	--	--	--	--	2
Central	--	--	2	4	1	--	--	7
Gulf	6	5	2	1	2	--	--	16
Lake	7	--	2	3	1	1	3	17
Northeast	1	--	1	1	--	1	--	4
Southeast	12	3	5	2	--	1	--	23
West	1	3	1	4	--	4	1	14
All Regions	34	22	14	18	4	8	5	105

^{1/} See map, Figure 1, p. 28.

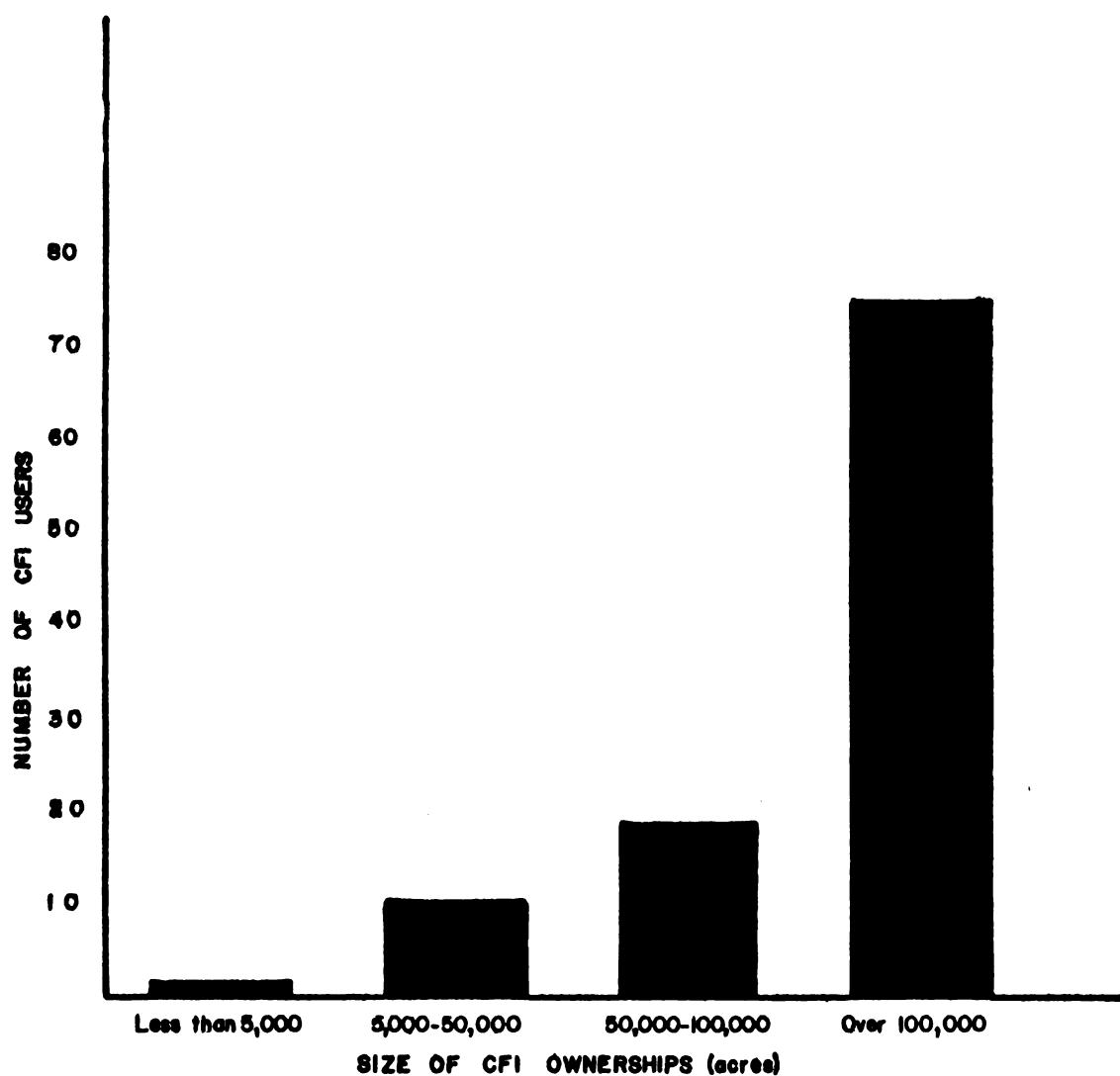


FIGURE 3: NUMBER OF CFI USERS BY SIZE OF FOREST OWNERSHIP, 1960

and one that regarded its one-year-old program as too new for evaluation. One other company in this lower acreage class, and one of the smaller state forests, has already abandoned its CFI system. While this record of CFI use on areas smaller than 50,000 acres is not an impressive one, the trend is a foundation for more intensive management on small forest acreages.

On public forest land, CFI is generally used only on the larger areas. All federal forest lands with CFI are those of more than 100,000 acres. Among state-owned forest lands with CFI, 13 of the 22 systems are on areas over 50,000 acres. Four colleges and universities, whose major application of CFI is in research and teaching and whose holdings are small, are included in the group of state agencies with CFI. Two systems on smaller state holdings were initiated in 1960, while 2 others have been in operation for 5 years or longer.

By regions, recurring inventory systems on larger areas are generally found in the West and Canada, while systems on smaller areas are more common to the Central States and the South. In this study, no CFI system was found on areas less than 50,000 acres in the western part of the United States. Three of the public ownerships using CFI are in the Central States, 1 in the Lake States, and the remaining 4 are in the South. All 3 small private ownerships using CFI are located in the Southeast region. From 1959 to 1960, the number of CFI systems on areas less than 50,000 acres increased from 6 to 12; 5 of the 6 additional systems established in 1960 are in the South. The widespread use of CFI in the

southern regions, especially those on the smaller properties, is an indication that intensive forestry is being stressed in this area where private forest ownership predominates.

Scope of CFI in the United States

The scope of CFI in American forest management in 1960 for various ownership classes is indicated in Tables 3 and 4. These data show that the 100 CFI systems embrace 136,000 established permanent sample plots on approximately 85,000,000 acres of forest land in the United States. This represents over 17 percent of the 485,000,000 acres of commercial timber land in the United States, reported in "Timber Resources for America's Future" (U. S. Forest Service, 1958). As recurring inventory systems become more numerous, the percentage of total commercial forest land being managed by use of CFI data will continue to increase.

It is also significant that the 105 CFI users represent but a fraction of 1 percent of the total forest owners in this country. Obviously, some forest owners have too little land to utilize CFI procedures at the present time.

These data show the importance of CFI in present-day forest management. In view of its brief history, CFI has spread rapidly in American forest management, especially in contrast with the slow acceptance of certain other forest management techniques.

Table 3. The scope of CFI in the United States by ownership classes, 1960.

Ownership Class	Number of CFI Systems	Total Number of Permanent Samples	Total Forest Area on which CFI is being used
	<u>Number</u>	<u>Number</u>	<u>Acres</u>
Private:			
Pulp and Paper Corporations	34	44,604	19,177,118
Lumber Companies	22	8,537 ^{1/}	3,983,354
Miscellaneous Wood Producers	14	19,485	3,816,647
All Private	70	72,626 ^{2/}	26,977,119
State:			
State Forests	18	14,129 ^{3/}	5,918,894
Educational Institutions	4	1,016	22,824
All State	22	15,145 ^{4/}	5,941,718
Federal:			
Forest Service Regions	8	43,903	51,234,504
Other Federal	5	4,102	1,003,310
All Federal	13	48,005	52,237,814
All Ownerships	105	135,776 ^{5/}	85,156,660

^{1/} Includes 19 of 22 companies answering this question.

^{2/} Includes 67 of 70 respondents answering this question.

^{3/} Includes 16 of 18 respondents answering this question.

^{4/} Includes 20 of 22 respondents answering this question.

^{5/} Includes 100 of 105 respondents answering this question.

Table 4. Representation of CFI plots in the United States and Canada, 1960.

Ownership Class	Number : of CFI :		Number of Acres : Systems: Total : Average :		Number of Plots : Total : Average :		Acres : per : Plot	
	- - No. - - - -	Acres - - - -	No. of Plots - -	Acres				
Private:								
Pulp and Paper Corporations	34	19,177,118	564,033	44,604	1,312		430	
Lumber Companies	22	3,983,354	181,062	8,537 ^{1/}	449 ^{1/}		279 ^{1/}	
Miscellaneous Wood Producers	14	3,816,647	272,618	19,435	1,392		196	
All Private	70	26,977,119	385,387	72,626 ^{2/}	1,084 ^{2/}		349 ^{2/}	
State:								
State Forests	18	5,918,894	328,827	14,129 ^{3/}	883 ^{3/}		391 ^{3/}	
Educational Institutions	4	22,824	5,706	1,016	254		22	
All State	22	5,941,718	270,078	15,145 ^{4/}	757 ^{4/}		366 ^{4/}	
Federal:								
Forest Service Regions	8	51,234,504	6,404,313	43,903	5,438		1,167	
Other Federal	5	1,003,319	200,664	4,102	820		245	
All Federal	13	52,237,823	6,604,977	48,005	6,308		1,412	
All Ownerships	105	85,156,660	811,016	135,776 ^{5/}	1,358 ^{5/}		612 ^{5/}	

^{1/} Includes 19 Of 22 lumber companies answering this question.

^{2/} Includes 67 of 70 respondents answering this question.

^{3/} Includes 16 of 18 states answering this question.

^{4/} Includes 20 of 22 respondents answering this question.

^{5/} Includes 100 of 105 respondents answering this question.

Inventory Methods Used Prior to CFI

Ready access to all information concerning the enterprise is one characteristic which often distinguishes a profitable from an unprofitable business organization. Since supplies of raw materials are so important to continuity and stability of operation in industrial firms, major emphasis is placed on the reliability of periodic raw material inventories. The kind of information needed and the methods used to obtain this information for a forestry enterprise can best be decided by the forest manager.

A wide variety of information can be obtained about living trees, which comprise the raw materials of forestry enterprises. Extreme care must be taken in forest inventory to obtain all data needed for managing the forest, and at the same time to minimize costs by requiring no more than the necessary information. Unfortunately, not all forestry organizations realize the need for exacting inventories.

Among forest ownerships now using CFI was a tremendous diversification of inventory methods prior to CFI. Because of this great variation, it is difficult to group them for comparison. However, the more common methods are grouped as follows: (1) general periodic cruises; (2) no scheduled cruises, with information obtained as needed from field work; (3) inventory based on estimates of experienced foresters; and (4) no standardized inventory procedures.

The general periodic cruise was the method most frequently used

by most organizations before the advent of CFI. Over one-third of the respondents reported that this method or a modification of it had been used. Organizations using periodic cruises were distributed fairly uniformly among all ownership classes.

Forest ownerships which had no scheduled cruises, but obtained information from field work as needed, were actually keeping just one step ahead of the immediate needs of the forest manager. Also, ownerships using this type of inventory procedure acknowledged the fact that they did not consider inventory important enough to justify prior planning.

Some forest organizations accept estimates of timber inventories made by experienced foresters. Surprisingly, some concerns had absolutely no definitive inventory systems at all. Others were using outdated and antique systems, e.g., "take the original cruise and subtract the cuts."

Even though tremendous advances in mensurational techniques have been made to increase the efficiency of forest inventory systems, these techniques must be accepted and used before they will benefit forest management. Many organizations have discarded their ancient, outmoded inventory systems in favor of CFI. While it is not proposed that every forest ownership use CFI, every progressive forestry organization should utilize the latest and most efficient techniques in forest inventory and management.

Inventory Methods Used to Supplement CFI

CFI can provide a reliable inventory for large areas, but it cannot be expected to give satisfactory information for small areas or individual stands. An adequate forest inventory program should provide for supplemental data gathering activities on small areas for which detailed information is required. A general periodic cruise, additional point-samples, or a detailed cruise of areas where silvicultural stand treatment is to be applied, will enable the forest manager to designate the proper priority for treating stands. Permanent sample plots on large forest areas, i.e., over 50,000 acres, yield reasonably accurate inventory data for the total area, but supplemental inventories of some kind are needed to relate CFI data to specific stands.

Over one-half of the CFI users made cruises in specific areas prior to stand treatment. Supplemental inventories of this kind actually separate that part of the inventory data associated with a particular forest condition, and enable the forester to relate the treatment of the stand to the over-all management program. There would be no need for supplemental inventory activities if permanent plots were located densely enough for each stand to be adequately sampled. Obviously, the cost of such coverage would be prohibitive in today's forest management.

General cruises to supplement the CFI inventory are frequently utilized by private forest ownerships, but are seldom applied to the large public landholdings. Obtaining additional data by point-sampling

on either the entire forest or a specific portion of it is another common supplement to CFI. Also, combinations of two or more different supplemental inventory methods are fairly common. Over 80 percent of the respondents replied that some type of supplemental inventory was needed to utilize CFI data to the maximum.

A common misconception about CFI is that a recurring inventory system will provide the data for answering all questions concerning forest management. Almost 20 percent of the respondents of this study reported no source of forest inventory data other than from permanent plots. Most of this group was made up of the more experienced CFI users. Since the original purpose of CFI was not to replace other inventory methods, but rather to supplement them, forest organizations that rely entirely upon the data from permanent plots may place unreasonable demands on CFI systems. As an ideal combination of both CFI and detailed cruises, specific areas should be included in the forest inventory program so that all data needed for proper forest management will be available.

Costs of CFI

This analysis of CFI costs is only a generalized comparison between current CFI systems and forest inventory methods used prior to CFI. Direct comparison is not valid in many cases because different amounts and kinds of information were obtained by each method. Nevertheless, an empirical examination of the data indicates that private organizations

find CFI procedures less expensive than previously used forest inventory methods (Table 5).

Using the sign test with the null hypothesis (Freund, 1960), a comparison of the "more" and "less" columns of Table 5 was made. There were no significant differences between CFI cost data for public agencies. For both private and all ownership categories, however, highly significant differences were found. These differences indicate the null hypothesis can be rejected, and the alternative, that a decrease in cost is more likely than an increase, can be accepted. In other words, respondents to this survey consider that CFI is more economical than other forest inventory methods.

Since most of the CFI cost data is based on costs for the initial installation, and since the cost of the initial establishment is usually the largest expense encountered in this system, it appears that once the CFI installation is accomplished, its long-term cost will be even lower.

In the Southern and Lake States regions, the majority of respondents signified that cost of CFI was less than preceding methods of inventory. At the other extreme, California and the Central States were the only regions where a majority of the respondents reported that CFI costs were greater than that of former inventories. The returns from California, however, represented primarily public ownerships, while those from the Central States were largely from the smaller ownerships.

Federal and state ownerships reported that costs of forest

Table 5. Comparison of costs between CFI and inventory methods used prior to CFI.

Ownership Class	Number of Owners Who Compared CFI Cost to Previous Inventory Cost				
	Cost Less	Cost More	Cost Same	Other ^{1/}	All Owners
Private:					
Pulp and Paper Corporations	19	4	4	7	34
Lumber Companies	9	9	3	1	22
Miscellaneous Wood Producers	9	2	--	3	14
All Private	37	15	7	11	70
State:					
State Forests	6	7	1	4	18
Educational Institutions	--	--	1	3	4
All State	6	7	2	7	22
Federal:					
Forest Service Regions	2	3	1	3	9
Other Federal	2	2	--	--	4
All Federal	4	5	1	3	13
All Ownerships	47	27	10	21	105

^{1/} Includes "unknown" and blank answers.

management using permanent plots were higher than previous management costs. Earlier installations made prior to 1950 also appeared to have been more costly. However, over-all costs show CFI as being more economical than previous inventory methods. Even if the initial cost of CFI were the same or slightly higher than ordinary cruise methods, CFI procedures would still be more economical than other inventory methods, because the variety and amount of information obtained from permanent plots are much greater than information from conventional methods of inventory.

Field Procedures Used in CFI

Description and discussion of field procedures include general characteristics of sampling techniques, information on the area surrounding each plot, data recorded for each plot and tree, time intervals between field measurements, and tally methods used. While each of these items forms a separate mensurational technique and could be thoroughly described and discussed quite apart from CFI, in combination they form the procedures for gathering CFI data.

Plot Location and Characteristics

Some of the most controversial subjects in continuous forest inventory procedures are the size, kind, and number of plots to install. Should fixed radius plots or point-samples be used, and if plots -- what size? Is the bias associated with systematic plot or point-sample

location and marked plots or points important enough to warrant the extra cost of installing random locations or hidden plots? These questions are answered by analyzing data from CFI systems currently being used in American forest management.

Plots and Point-Samples

Until the introduction of point-sampling, fixed-radius permanent sample plots were used in most CFI installations. However, several recent CFI systems are using variable-radius plots.

In the early 1950's, the use of basal area in timber cruising became increasingly popular among foresters in the United States. Grosenbaugh (1952) explained and expanded point-sampling techniques and adapted them to use in recurring inventory procedures. Advantages of point-sampling over fixed-radius plots for CFI use are the increased speed of sampling, the fewer observations required per sample, the greater efficiency in field work per man-hour, and the ease of selecting sample trees. All of these factors are important in every successful inventory system.

In point-sampling, the disadvantage of obscured visibility due to dense brush can be overcome by cruising in the winter, or by using a wider critical angle for the point-sampling instrument. Although "border-line" trees must be carefully checked, and corrections for slope must be made on questionable trees, the efficiency of point-sampling is still high because of the small number of trees measured

per plot. One factor that remains a problem in point-sampling for CFI systems is the change in plot size when trees not formerly tallied become large enough to be measured for the first time. However, all tallied trees are well marked, new trees can easily be added, and the sampling error re-computed at each measurement.

In 1956, the first American CFI system using point-samples was installed, and another system changed from plots to points. Since that time, 9 additional systems have been installed using points, and one other organization changed from plots to points. Eight of the 12 CFI systems now using point-samples were started in 1959 and 1960. This includes about one-fourth of the total number of CFI systems established during these two years.

Point-sampling techniques in CFI appear to be established in all regions except California, the Central States, and the Northeast. These regions contain large areas of diversified forest land to which point-sampling should be well-suited. Point-sampling appears to be especially well-suited to the large timber in California, instead of the large concentric plots now commonly used. Although the majority of the CFI systems in the Central and Northeast States were established before the advent of point-sampling, the predominance of hardwood forest types in these regions suggests that a more economical and efficient sampling design might have been provided with point-samples instead of fixed-radius plots.

Almost 75 percent of all CFI systems use one-fifth-acre plots

as Stott of the U. S. Forest Service recommends (Table 6). Deviations from the one-fifth-acre plot size are most common in the Northeast, Canada, and the far West regions. Larger plots are needed to adequately sample the larger trees commonly found in the West. In the past three years, smaller plots of one-seventh and one-tenth-acre are increasingly being used in Canada and in the Northeast region where the average tree size is somewhat smaller than in other regions.

Average plot size for all recurring inventory systems is one-fourth of an acre. The average was .26 acres for private ownerships, .23 acres for federal, and .24 acres for state ownerships. By regions, variations were most pronounced in California, where the average plot size was .44 acres, and in the Central, Southeast, and Lake States where the mean was .19 acres.

Eight CFI systems, all on private ownerships, use plot sizes larger than one-fourth-acre. Larger plot sizes are useful in timber types containing an irregular distribution of very large or valuable trees. The predominant form of these larger plots is a series of concentric plots, the largest of which is ordinarily employed for measuring mortality and seed source trees, the smallest for reproduction and stocking, and the middle-sized ones for volume and basal area.

Spurr (1952) and other foresters state that concentric plots corresponding to as many as 4 or 5 d.b.h. groups are theoretically desirable. For practical reasons, the number of concentric plots is generally held to 2 or 3. When plot size is adjusted to tree size,

Table 6. Size of plot and point-samples used by CFI systems in the United States and Canada, 1960.

Year CFI Established	BAF 10 Points	Plot Size in Acres								Total
		$\frac{1}{10}$	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{1}{2}$	1.0	
1928					1					1
1945	1 ^{1/}								1	2
1946				1						1
1948				1						1
1949				1						1
1950		1		1						2 ^{2/}
1951					1				1	2
1952		1		5						6
1953			1	3						4
1954	1 ^{3/}			5					1	7
1955				4					1	5
1956	1		1	7	1					10
1957	1			8		1				10
1958	1		3	11	1		1	1	1	19
1959	3		1	8	1			1		14
1960	4	1	1	12	1					19
All Years	12	3	7	67	6	1	1	2	5	104 ^{4/}

^{1/} This system was established in 1945, but changed to points in 1956.

^{2/} Three systems established in 1950, but one used a variety of plot sizes.

^{3/} This system was established in 1954 with plots, but changed to points in 1960.

^{4/} One questionnaire did not include the specific sample type or size.

point-samples produce results far more accurate than any single fixed-radius plot or even a series of concentric plots.

Stage (1958) states that it would take an infinite number of concentric plots to obtain the degree of accuracy in adjusting plot size to tree size obtained by using point-sampling.

While point-sampling is not now employed in a major portion of CFI systems, it offers a statistically sound and theoretically valid method of sampling trees in relation to their importance in the forest.

As a rule, plot shape is circular, but even though the cost of establishing square plots is greater, a few installations use square plots with 4 marked corners to facilitate relocation.

Systematic and Random Locations

Systematic sampling has always enjoyed popularity among foresters, and it has been widely used in locating permanent sample plots. However, analysis of data from systematic samples by using formulas theoretically applicable only to data from random samples is a procedure not accepted by many statisticians. Since sample plots based on a logical systematic grid will generally yield results more accurate than a random selection of plots, and computed reliability levels for the systematic sample are considered conservative, systematic plot location is more widely used than randomization in CFI systems. While the opinions of foresters do not carry the support of statistical formulation, the advantages of uniform plot distribution, such as lower costs of plot establishment,

and ease of administration, have been instrumental in making systematic plot location so widespread in CFI. The simplicity of the method and its greater accuracy, especially in long-term projects where forest changes are important, also favor systematic plot location. Stott and others experienced in CFI, are firmly convinced that systematic location with random starts is the only broad-scale design suitable for establishing permanent sample plots. They believe the complexity and extra cost of random location are not justified.

Results of this study indicate that most CFI users located their plots systematically. Only 15 of the total use strictly randomized locations. The only deviation occurred among the federal ownerships, where over half the CFI systems used randomized or a combination of random and systematic plot locations.

Comments accompanying the returned questionnaires indicated that those who utilized a combination of random and systematic location would prefer a single systematic scheme. A uniform system, whether random or systematic, would appear to be preferable to a combination.

Stratification Prior to Sample Location

Stratification is the subdivision of a population into a number of groups or "strata." A random sample is then normally taken from each stratum. It adds to the efficiency of sampling when there is a high degree of uniformity in the units within each stratum, and considerable diversity between strata. The purpose of stratification is to increase

the accuracy of population estimates and to assure adequate sampling of each segment of the population. In a timber cruise, stratification is often used to more adequately estimate the volume of timber in a specified area, i.e., a large number of plots are taken in those timber types with the largest volume or value. An inherent advantage of stratification is that it eliminates the non-productive areas such as roads, lakes, and permanently open land from consideration. Sometimes even non-commercial lands are removed from the total sample area. A forester who knows his area can normally obtain better results in a single cruise by putting a greater proportion of the plots in the more important stands.

If equal representation is desired for each breakdown of the forest, a systematic plot location will ordinarily be employed. Many studies have shown that systematic sampling is more accurate and efficient for the entire area than stratified sampling, but when areas with greater volume, value, or importance need to be sampled with greater intensity than surrounding areas, stratified sampling techniques will usually increase the efficiency of the estimate. Some of the ways in which areas may be stratified are as follows:

Volume, tree diameter, and/or value -- If one or more of these items are important enough to warrant extra weight in sampling, extra plots within that group will furnish better estimates for that condition. However, a stratification process which yields more accurate information in one inventory may yield less information from subsequent measurements

of the same plots, because these areas with the largest volume, value, age, or size in one inventory, will often be the areas harvested before the next remeasurement.

Stratification based on value depends largely upon current or future utilization standards and markets. A change in available future markets may find that the more heavily sampled areas in the first measurement will have less valuable products in the future, and areas less well sampled may have products in higher demand.

Type and species -- A forest type is frequently used to delineate area sub-divisions of the forest, and as such provides a satisfactory means for stratifying a forest area. Stratification by type, however, is not suitable as a basis for permanent plot installation. Due to the frequent change in type boundaries resulting from silvicultural practices, fires, floods, storms, and plantings, stratification based on forest types would need to be periodically revised. Any plot installation intended to be permanent must ignore as many temporary forest conditions as possible. While a broad category of types, such as hardwoods and softwoods, might be useful if the type boundaries are expected to be fairly permanent, a systematic location of plots more nearly fits the principle of permanence upon which CFI is founded.

Density and condition class -- Any systematic sample is designed to equally represent each segment of the population. When a portion of the population has a more uniform density than the remainder of the forest, e.g., an even-aged pine plantation, uniform sampling of the whole forest

will give much more reliable data for the pine plantation than for less uniform types. In situations of this nature, stratification can be utilized to reduce the total number of plots, while still attaining the same statistical accuracy, by allocating plots in proportion to the density or uniformity of the individual stands.

On this basis, stratification by density or condition class will obtain the maximum information in any one survey with less plots. However, the possibility of rapid changes in density or condition class lessens the value of stratification for permanent forest sampling techniques where measurements will be repeated in the future.

Topography, physiography, or site -- Relatively unchanging features of the earth's surface are possible bases for stratification to increase the efficiency of sampling with permanent plots. Vegetation growing in an area may change, but if the potential productivity of an area can be measured without using vegetation as the major criterion, permanent sample plots may be effectively stratified accordingly. Unfortunately, sufficient data are not yet available to enable all forested areas to be classified for site quality without using the changing element of vegetation.

Actual stratification used in CFI -- Over three-fourths of the CFI users did not stratify their areas for sampling. Of those who did, density and type were the bases on which areas were most often sub-divided. Permanent plot installations with stratification are most common among the larger land ownerships in the more diversified timber types of the

Western region and the public ownerships. There also appears to be a trend toward increased stratification during the past few years, for almost half of the stratified plots were established since 1957. This indicates that while stratification is not yet dominant in CFI systems, it is widely applied and is apparently highly regarded by many organizations with permanently located plots.

The combined use of stratification and aerial photographs to locate plots can provide a simplified permanent plot system similar to that used in the U. S. Forest Survey, where sometimes only a specified percentage of the old plots are taken at each remeasurement. The number of stratification layers in a forest must be as few as possible so that less plots can be used to obtain the desired statistical accuracy. For instance, if a forest were stratified by 10 types, 4 density classes, and 4 topographic categories, there would have to be 160 divisions of the forest, e.g., one division could be the southern pine type, high density, and ridge topography. Each of these strata are normally expected to have a minimum of 20 samples. This requires a minimum of 3,200 plots to accurately sample such an area. If an organization plans for only 500 plots, stratification is out of the question. If less than 20 plots per division are taken, the results will have a very large standard deviation, and the stratification effort will have been wasted.

Complete stratification may nullify some of the major advantages of a permanent system of plots. Stratification often works contrary

to the objective of measuring silvicultural change in all aspects of the forest; it is generally thought to increase cost of plot establishment; and it may reduce future value of data concerning forest change in species, composition, size, and value. For measuring forest change, especially over long periods of time, such as one or more rotations, the number of plots per type or other forest class should not be dependent upon some current temporary classification scheme. The plots should be uniformly distributed throughout the forest so that change can be measured in all parts of the forest both now and in the future. It is true that in any one survey, stratification can be used to increase the accuracy of the forest estimate, but in the long run, the advantages of stratification become less and less with each succeeding remeasurement as the original stand is modified by growth and other natural and silvicultural influences.

Use of Aerial Photographs

Aerial photographs were initially utilized in forestry for the reconnaissance of remote timbered areas and for initiating forest management practices in such areas. As photo interpretation and photogrammetric techniques were improved, the use of aerial photographs in forestry increased slowly but steadily. Spurr (1960) stated that after forest mapping and reconnaissance, the most important use to which aerial photographs are put by foresters is in forest inventory work. While the field of aerial timber cruising has definite limitations, aerial photographs can be used to help organize and simplify ground surveys. The most

efficient forest inventory will be one in which aerial photographic and ground techniques are properly coordinated.

A study by Avery (1962) showed that about 6 percent of the industrial forest owners in the United States reported less than 10 percent of their area covered by aerial photographs. Similarly, about 6 percent of the private timberland owners reported coverage from 40 to 69 percent. These data indicate that about one-fifth of the industrial forest owners in the United States do not make appreciable use of aerial photographs in their forest management programs. Complete aerial photographic coverage of these same lands are available from federal agencies.

Although one state and one federal organization reported that photographic coverage of their lands was not available for use in forest management, the use of aerial photographs was the lowest on private lands. Almost 30 percent of all CFI users did not use aerial photographs in the installation of their CFI systems. Of those who did, very little emphasis was placed on the help provided by photographs. Comments on many of the questionnaires suggest that practically the only use made of photographs in CFI is to help in the initial selection of plot locations.

Examination of the items which are measured on sample plots and points provides further evidence that there are too few CFI users who plan to increase photographic usage in the future. Items directly measurable on aerial photographs, such as crown diameter and stand density, were seldom recorded. When recorded, these measurements were generally

not used for aerial photographic interpretation.

While stratification is not generally recommended in locating permanent sample plots, aerial photographs provide an ideal media for stratifying when such is done. Bickford (1961) states that on forest areas of over 40,000 acres, stand differences will normally be great enough to warrant a stratification of the forest. Resulting savings in time and money can be expected to more than cover the cost of obtaining the photographs.

It would seem that statistical errors of 10 to 15 percent or even larger in estimates common in many CFI systems could be lessened through the use of aerial photographs. A large number of plots measured on good recent photographs will provide information at less cost and with greater statistical accuracy than a small number of ground plots. Hough (1954) suggested combining double-sampling of initial ground plots with the use of aerial photographs. While a double-sampling system is not suited to a program of remeasuring permanent sample plots, it does emphasize the utility of using aerial photographs to increase the precision of the sampling design and to better utilize the information taken on each ground plot.

Marked or Hidden Plots

Each sample plot represents a portion of the total area being sampled. For actual forest changes to be correctly determined, each permanent sample plot must be treated exactly like the surrounding portion of the total forest which it represents. If the measurements of each

sample are accurate, if the plots are uniformly distributed over the total area, and if there are enough plots, reasonably accurate estimates applicable to the total area can be made. For measuring changes in the forest, the same plots are remeasured at a later date. Differences between two inventories signify the changes since the last measurement.

When the sample plot is differentiated from the rest of the forest by conspicuous markings on each tree, the question arises whether or not the plot receives unbiased treatment. In the past, the standard answer to this question has been that the absolute necessity for treating the sample plots exactly like the surrounding areas was thoroughly explained to the field crews. It was also pointed out that after the field men encounter these plots a few times, they will not be biased by them in their work. While these are good suppositions, they do not eliminate the problem of possible biased plot treatment.

When timber markers and cutting crews encounter permanent plots which they know will be checked at some later date, they may do an extra good job on these sample plots. The accuracy of their work will be at least as good and maybe better than their treatment of the surrounding area. A positive error will result because equally exacting work may not have been applied to the remainder of the forest. The timber markers are probably responsible for more of these errors than the felling crews who have only to cut the marked trees.

To eliminate possible biased plot treatment by timber markers

and cutters, "hidden" plots are sometimes used. A hidden plot is one which the average timber marker will not recognize as a permanent sample plot. If a center stake is used, it would be as inconspicuous as possible. It should not protrude over one foot above the ground and should be referenced to an identifiable object. One means of reference is to mark an obvious approach to the vicinity of the plot. The plot is then located a given distance and direction from the end of the approach.

The individual trees on a hidden plot may be identified on a map prepared for the plot, or by small metal tags attached to the bases of the trees. The point of d.b.h. measurement may be designated by a small inconspicuous horizontal scribe mark.

In contrast, a marked plot usually has a prominent center post, a painted line of approach to the plot, and several witness trees marked so they can be seen from all directions. Most frequently, numbers are painted above breast height on all plot trees, or metal tags are attached above breast height with nails. Square plots usually have stakes at all four corners. When easy plot relocation is considered to be more important than bias in plot treatment, marked plots are used.

For determining mortality and ingrowth in a sample plot, each individual tree must be identified. Without making a costly plane table map of each plot, it is difficult to "hide" a plot and still identify each tree. A point-sampling procedure with its relatively small number of trees per point, can be utilized to overcome this

difficulty in establishing hidden plots. The azimuth and distance of each tree from the center-point are recorded (Grosenbaugh, 1959).

Almost 90 percent of all current CFI systems use marked plots. This signifies that thus far, ease of plot relocation has been considered more important than the possibility of biased plot treatment. Only 14 CFI systems in the United States use hidden plots, 11 of which were established since 1957. In the South, 5 systems with hidden plots are located in the Gulf region, and 3 are in the Southeast region. The Central and Northeast States have no systems with hidden plots. It appears that the use of marked plots, and the small amount of bias in treatment which may result, are not considered serious problems of CFI. As better procedures are developed for relocating hidden plots more easily, and as more significance is attached to bias in plot treatment, the number of systems with hidden plots will probably continue to increase.

Acres per Sample

CFI is sometimes considered to be a system utilizing permanent sample plots which provide information that will answer all questions concerning the characteristics of the forest. A limitation of CFI frequently pointed out in this study, is that permanent sample plots provide adequate information for the whole forest, but they do not provide data which can be used in the management of individual stands of the forest. For obtaining data applicable to a given stand, the number of plots would need to be large enough to sample the variation

within that stand. Such plot density is not economically feasible in current forest management practice. If smaller sample plots are used, or if more intensive forestry is to be practiced, using more plots may become feasible.

The average number of acres per plot for all current CFI systems is 627 (Table 7). It is obvious that data from such a small sample will be of little use in the management of individual stands. Based on an average plot size of one-fifth acre, this sampling intensity corresponds to a coverage of 0.030 percent.

U. S. Forest Service regions average only one plot per 1,167 acres. Even though a wider dispersion of plots is acceptable on the very large areas generally found in federal ownerships with CFI, the sampling intensity used is extremely light. A much lower average of 22 acres per plot is used by colleges and universities; however, these systems are on areas of less than 20,000 acres, and have teaching and research as their major objectives.

Figure 4 is a histogram presenting the frequency distribution of areas represented by each permanent sample plot. Both the median and mode occur in the 301 to 400 acres-per-plot class. The most common sampling intensity of 2 plots per section, or 320 acres per plot, is also located in the same class as the median and mode. The class with the next largest number of systems is the smallest or 0 to 100 acres per plot class. All the educational institutions are included in this class. The third and most important measure of central tendency,

Table 7. Average number of acres per CFI sample, by ownership class, 1960.

Ownership Class	Number of ^{1/} Ownerships	Average Number of Acres per Sample
Private:		
Pulp and Paper Corporations	34	430
Lumber Companies	19	279
Miscellaneous Wood Producers	14	196
All Private	67	349
State:		
State Forests	16	391
Educational Institutions	4	22
All State	20	277
Federal:		
Forest Service Regions	8	1,167
Other Federal	5	245
All Federal	13	1,088
All Ownerships	100	627

^{1/} Includes only those respondents answering this question.

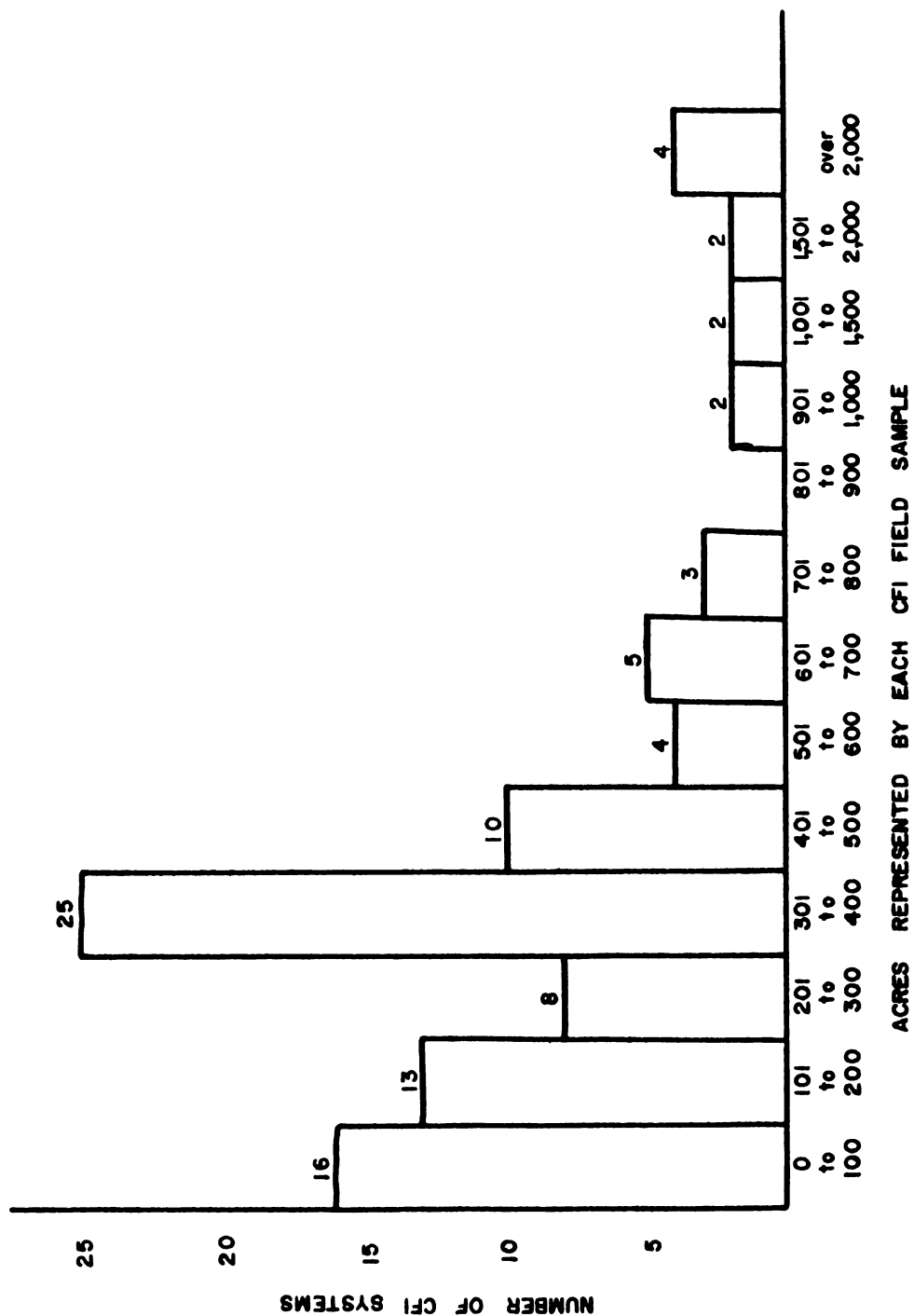


FIGURE 4: NUMBER OF CFI SYSTEMS WITH SIMILAR AREAS REPRESENTED BY EACH SAMPLE LOCATION, 1960

the mean, is located in the 401 to 500 acres-per-plot class. Even though the mean, median, and mode do not vary greatly, the distribution is not normal, but is skewed toward the lower end of the scale.

The number of acres per plot on private and state land and on Indian reservations is somewhat lower than the general average. By regions, the lowest averages are found in California and the Central States, while the largest are in the West, Lake States, Northeast, and Gulf regions. The average number of acres per plot shows a reduction from the general mean in all the years since 1955.

Clustered Sampling

When more than one plot is taken at each sample location, the plots are considered to be clustered. Among current CFI installations, the number of plots per cluster ranges from 2 to 5 (Tables 8 and 9).

Clustered sampling is economical when the cost of measuring a plot is relatively low and the cost of reaching each plot location is relatively high. It has its greatest advantage when there is great heterogeneity within clusters. If all plots in each cluster are the same, there is no advantage in measuring more than one of them. Statistical formulas are available for determining the approximate optimum size of each cluster.

About one-fourth of the CFI systems use cluster sampling (Tables 8 and 9). The greatest use of clustered plot locations is in the West and the Lake States regions, where there is great variation

in timber types. Also, most of the CFI systems with clustered samples were installed by pulp and paper corporations, U. S. Forest Service regions, and State Forests (Tables 8 and 9). Rough topography of the West increases travel time; consequently, clustered sampling is used in this region to reduce total measurement costs.

Of the 55 CFI systems that use clusters of plots, only 4 were established since 1957; one of these was installed in 1959, and one in 1960. Although cluster sampling is more economical than taking single plots in areas with a large variety of timber types and rough topography, the trend indicates that clustered samples in CFI is declining.

Tally Methods

The data from permanent sample plots in most CFI installations are so voluminous that manual or "longhand" methods of compilation and analysis are not feasible. Generally, electric tabulating machine processing is used. This means that prior to processing, all field data must be inserted into tabulating cards. Methods of getting the field data into the cards include: (1) field listing followed by office key punching, (2) mark-sensing, (3) port-a-punch, and (4) other methods.

Field listing and office key punching -- In this procedure, the data are listed in the field on a suitable tally sheet as measurements and observations are made. Later, the data are transferred into tabulating cards in the office by the operator of an electric key-punching machine. Accuracy of the transfer is verified by having a different key-punch

Table 8. Use of clustered sampling in CFI systems, by regions, 1960.

Region	Number of Plots Taken at Each Sampling Location						
	1	2	3	4	5	Variable and Unspecified	Total
----- Number of CFI Systems -----							
Atlantic States	11						11
California	9			2			11
Canada				1		1	2
Central States	5	1				1	7
Gulf States	16						16
Lake States	7	4	1		2	3	17
Northeast States	4						4
Southeast States	21				1	1	23
Western States	5	3	4		1	1	14
All Regions	78	8	5	3	4	7	105

Table 9. Use of clustered sampling in CFI systems, by ownership Class, 1960.

Ownership Class	Number of Plots Taken at Each Sampling Location						
	1	2	3	4	5	Variable and Unspecified	Total
----- Number of CFI Systems -----							
Private:							
Pulp and Paper Corporations	26	3	1	1	2	1	34
Lumber Companies	17	--	1	2	1	1	22
Miscellaneous Wood Producers	12	1	--	--	--	1	14
All Private	55	4	2	3	3	3	70
State:							
State Forests	12	2	1	--	1	2	18
Educational Institutions	4	--	--	--	--	--	4
All State	16	2	1	--	1	2	22
Federal:							
Forest Service Regions	4	2	1	--	--	1	8
Other Federal	3	--	1	--	--	1	5
All Federal	7	2	2	--	--	2	13
All Ownerships	78	8	5	3	4	7	105

operator repeat the key-punching, thus locating and correcting errors made by the first operator. The cards are then ready for processing.

Field listing followed by office key-punching corresponds most nearly to the traditional method of recording field data in timber cruising. The field listing does not require any special training or instruction beyond having the tallyman list the data on the tally sheet in the same sequence in which it will be placed later onto cards. Compared to other methods, it is a fairly costly procedure primarily because the field listing, office key-punching, and verifying constitute three handlings of the data before the cards are completed.

Mark-sensing -- Marks signifying the data being recorded are made with a soft-leaded pencil in the field directly on the tabulating cards in appropriate spaces. Later in the office, the cards are passed through a reproducing punching machine equipped with a mark-sensing feature which electrically senses the pencil marks and punches the data into the cards. The cards can then be processed in the usual manner.

This method is widely used because of its simplicity, flexibility, and relatively low cost. It cannot be used in inclement weather because the cards would be damaged. The marks made with a soft pencil are quite easily smeared, and incorrect punches may result. The pencil marks must not overrun the allotted spaces or incorrect punches will also result. Only 27 spaces are available for mark-sensing of the face of the card, but this can be doubled by using the reverse side of the card.

Port-a-punch -- Specially prepared cards are used in which punches in the 40 columns have been preperforated. Data are inserted into the cards in the field by punching out the appropriate preperforations with a stylus. The card holder is compact, light-weight, and can be carried easily in the coat pocket. These cards can be used for all subsequent processing steps, or the data can be transferred to standard tabulating cards, in the office, by a reproducing punch.

Generally, the data are transferred to standard cards for processing because the port-a-punch cards are overly flexible due to preperforations, and do not withstand numerous handlings very well. Also, transfer to standard 80-column cards is necessary if 40 columns will not accomodate the field data and later insertion of volumes and similar data in the office. If more than 40 columns of data are recorded in the field, two cards must be used. If an incorrect perforation is punched out, the card must be replaced.

Other methods -- There has been some use of a portable field key punch for punching the field data directly into the cards (Rudolph, 1957). This procedure eliminates the office key-punching and verifying steps. However, the key punch weighs 15 pounds so that it is somewhat inconvenient to move about from plot to plot.

A dictaphone has been used to record data in the field, and the cards were prepared later in the office from the recordings (Beers et al., 1957). It proved to be somewhat faster than mark-sensing in the field, and could be used in adverse weather. It was not flexible, in

that the data had to be recorded and transcribed in a designated sequence. Also, it still required the preparation of cards in the office from the recordings.

Where the volume of data to be gathered and processed is relatively small, the measurements can be recorded on "key-sort" cards, such as the well-known "McBee" cards. After punching the key-sort edges of the cards, they can be used directly in sorting and compiling the data.

Field listing is the most widely used method in recording CFI data. Forty-nine of the present 105 CFI systems use a field tally and office key-punching procedure. Either this method is still considered the best even after development of the other methods, or foresters responsible for choosing the method to be used in their CFI systems resist change. Several returned questionnaires indicated that field listing followed by office key-punching was considered to be slower and less accurate than mark-sensing and port-a-punch methods. Four CFI users returned to field listing methods after having tried mark-sensing.

Mark-sensing is used in 32 CFI systems. Other tally methods replaced mark-sensing in 9 CFI systems. One CFI user is trying out all 3 tally procedures: field listing, mark-sensing, and port-a-punch methods; another was experimenting with a portable tape recorder.

Although the port-a-punch procedure has been used in some industries for many years, it was first used to record CFI data in one CFI installation in 1956. In 1958, a second CFI system was using port-a-punch methods. Four new systems used this method in 1959, and 8 out of 19 new

CFI installations established in 1960 used port-a-punch procedures. Also, in 1960, 5 installations discarded mark-sensing in favor of port-a-punch methods, while 1 port-a-punch user switched to field listing. The increasing popularity of the port-a-punch indicates that it will probably continue to replace older methods of tallying CFI data in the field.

Plot Data Recorded

For a CFI system to be accurate and stable, there must be thorough planning before the system is installed. The value and ease of using permanent plot data for forest management purposes depend upon measuring and recording appropriate attributes of the forest. The characteristics to be measured are those which will best provide data needed by the forest manager. Items such as plot number are common to every CFI system. In other cases, however, questions arise whether to measure and record some item or not. A compromise must often be made to obtain the maximum of desired data, while at the same time keeping the total number of measurements to a minimum.

Plot data are usually recorded on a plot card and tree data on a separate tree card. However, if the number of entries per plot is small, the plot data are sometimes gang-punched into each tree card. General characteristics of the stand on the sample plot and adjacent areas are recorded in the plot data. Some of the plot data are items of a general nature, and personal judgment is often required in classifying each item

into numerical terms. Adequate guides must be supplied for classifying each item so that the interpretation of stand conditions is accurate and consistent.

Results of this study show that in addition to plot number, the 8 most frequently recorded items of plot information, in decreasing order of importance, are: stand age or tree size, reproduction, site class, density, condition class, silvicultural treatment, operability, and soil type.

Stand Age or Size

One of the most important ways in which a forest stand can be described is by means of its age or tree size class relationships. Tree size classes are usually used to differentiate the developmental stages of even-aged stands. Stages in even-aged stand development include seedling, sapling, pole, and young and mature timber. The age or size of an even-aged stand, or the number of ages or size classes in an uneven-aged stand, may indicate the kind of, and need for, future silvicultural treatment. Stand age and size data are also used to evaluate other stand characteristics such as site index. Tree quality, vigor, and cull are also indirectly related to age.

This study shows that stand age or size data are recorded more often than any other item. The majority of CFI users apparently regard this element as the most important contribution from plot data. There is exceptionally high usage of stand age and size data in the California and Southeast regions. Also, practically all systems established since 1958 record this information.

Reproduction

While equal annual yields from a forest area can be obtained for the present rotation without additional reproduction, future yields are dependent upon prompt regeneration of the stands as they are harvested. For forest management to be successful in the long run, much consideration must be given to stand regeneration. In uneven-aged stands, an indicator of future forest production potential is the current reproduction. The reproduction status of even-aged stands is significant only in mature stands or areas recently harvested.

The use of reproduction data from CFI plots is second only to stand size or age. It is the most often reported plot data taken by private owners with CFI; less use is made of it by public agencies. Reproduction data have exceptionally high usage in the California, Southeast, and Gulf regions, and much lower use in the Central and Western States. Possible reasons for the low use of reproduction information in the Central and Western States are: (1) adequate reproduction is common in the predominantly hardwood timber types of the Central States, so that it is not a major consideration in forest management; and (2) some forestry operations in the West place more emphasis on harvesting stands than on provisions for regenerating them.

A more favorable method for evaluating reproduction is needed. A desirable method should not only express seedling density, but seedling distribution as well.

Site Class

To identify the quality of a forest site, a combination of individual tree data and plot data is required. Height and age of the dominant trees are used if such trees are present. When no trees are available for measurement, combined environmental factors must be evaluated to arrive at an estimate of the site quality.

The importance of site was judged as moderate by CFI users. It was consistently recorded by all classes of owners in most regions and in most of the years when CFI systems were established, especially since 1957.

Density

Along with age and site class, density is another of the important bases for differentiating forest stands. The simplest and most widely used measure of stand density is average basal area per acre. It can be used to indicate accurately and consistently the degree to which a given species growing in a stand of a given age on a given site is utilizing the area.

Another simple measure of stand density is the number of trees per acre. It is correlated with the stand age and site quality, but may differ widely without actually affecting stand density.

Still another method for expressing density is by volume per acre. However, volumes are usually not computed directly in the field, but represent a major portion of the results of compiling plot data.

A reliable measure of stand density which can be used with aerial

photographs is crown closure. It relates the **relative** nearness of the crowns of individual trees in the stand, and is normally expressed as a percent of total crown closure. The determination of stand density based on crown closure is made by comparing the aerial photographs of the stand with a standard crown closure index. The degree of crown closure is generally believed to express a reliable measure of stocking without regard to age or size of trees in a stand.

Aerial volume tables are usually based, in part, on crown closure. Together with crown diameter and the total **tree** height, it can be measured on aerial photographs and on the ground, and is highly correlated with stand volume.. Any organization interested in estimating stand volumes from aerial photographs would certainly obtain on-the-ground stand density estimates from permanent sample plots for comparison with the appearance of the same plots on aerial photographs.

The use of density in CFI systems ranked fourth in order of importance. For both silvicultural and mensurational purposes, density is an item which shows promise of becoming one of the more important items of information obtained from permanent plot data.

Condition Class

According to Meyer, Recknagel, and Stevenson (1952), stand condition classes are general timber size class divisions normally used for the preliminary classification of timber types on aerial photographs to aid in the efficient organization of the cruise. For management

purposes, general size classes, such as immature, mature, and overmature timber, are easily delineated on aerial photographs, and may be helpful in compiling the cutting budget. Each condition class area is determined and the total allowable cut distributed by condition class over the various subdivisions of the forest. Condition class ranks fifth among the 8 plot data items most frequently recorded. Use of this comparatively new forest descriptive item was found to be concentrated in the California, Southeast, and Lake States regions. It also appears to be used most often in CFI systems established since 1956.

Silvicultural Treatment

For its main objective, the original control method developed in Europe sought to provide information on which silvicultural recommendations could be based. Current CFI systems have this objective in part also, since many foresters believe that the person taking plot data is in a very good position to evaluate the area surrounding each plot, and to make on-the-ground silvicultural recommendations. In this manner, two jobs can be completed at the same time -- the periodic inventory is made, and a small amount of silvicultural data is taken to help in the management of a few forest stands. To be most effective, however, silvicultural recommendations must be related to specific stands. The average sampling intensity in CFI of one plot for each 627 acres seriously limits the effectiveness of any silvicultural recommendations for individual stands based on CFI plot data.

Over half of the CFI users report that silvicultural treatment is recorded as plot data. It is taken primarily by industrial organizations in the South and Lake States. While permanent sample plots may be adequate for making general marking rules or broad silvicultural decisions, they do not provide enough information for prescribing the silvicultural treatment of individual forest stands. This may explain in part the variation in satisfaction levels with the use of this item in CFI.

Operability

An operability class is used to designate whether or not the trees in the stand will be harvested and used (Hall, 1959). Although the trees in a stand may be sound, they might not be used because they are so scattered, limby, or difficult to harvest that cutters will ordinarily leave them. Also, the stand may be isolated from other cutting areas, or actually be inaccessible. Some foresters suggest that such trees or stands be disregarded in calculating volume, growth, and allowable cut. However, since CFI is a long-term procedure, and since future utilization standards, demands, and prices are largely unknown, it would appear foolish to delete information for trees and stands simply because they are not operable at the present time.

Operability may be closely related to density, for some stands cannot be harvested economically because of the low density and low timber volumes available. Thus, operability and density could be

combined into one item in some CFI systems. Operability is recorded in approximately half of the CFI systems. The majority of the CFI users recording operability data are located in the Southeast and Lake States regions and established their systems in 1958 and 1960. A knowledge of forest areas classified by operability status may be of temporary value to the forest manager, but it should not be necessary to record this item of data at each remeasurement of the permanent sample plots.

Soil Type

An evaluation of site quality for forestry must consider the type of soil, either directly or indirectly. Evaluation of site quality based on existing tree growth naturally includes the effects of the soil. When forest vegetation for measuring site quality is not present on an area, an analysis of various soil characteristics may be used to evaluate the site for some species. Of the 8 most frequently recorded items of plot information, the least importance was placed on soil type or other soil data. Soil data were recorded in less than one-third of the CFI systems. Soil type was recorded by most CFI users in the Lake States, but even in this region, the information was seldom highly considered.

There is little interest in this subject, primarily because soil-site relations have been defined for relatively few species. The collection of soil information for each plot is time-consuming, and adds to costs of the inventory. The field men taking data must have some training in soils

to obtain reliable information on this item, and obviously, the forest manager who is to make use of the data must have some competence in soil analysis. Some forestry organizations do not have men sufficiently trained in soils for them to recommend that soil data be taken as the plots are being established. It appears that it is advisable to take soils information in CFI data, but there are still many difficulties facing widespread recording and the use of such data.

Other Plot Data

The recording of additional plot information was so variable as to preclude analysis. Some of the other data taken occasionally included information on underbrush, past treatment of stands, and management potential. If an organization has need for these or other plot data, the recording is justified, but they must be useable and used by the forest manager.

Tree Data Recorded

Several dimensions and characteristics are usually recorded for each tree on a permanent sample plot. Some items are directly measurable while others are determined by the judgment of the observer. For directly measurable items, standardized techniques must be used in the initial and succeeding inventories. For items involving personal judgment, specific guides must be followed to insure accuracy and consistency. At each measurement, the data for each individual tree are usually inserted into a separate tabulating card. The number, d.b.h., and species are universally recorded for each tree. In addition, the 8 most frequently recorded items of individual tree data, in decreasing order of importance, are cull class, merchantable height, tree vigor, tree quality, total height, form class, tree value, and crown diameter.

Diameter Breast Height

For reliable volume and growth data, the diameter of each tree must be accurately and consistently measured at each inventory, with the same kind of instrument, in exactly the same way, at exactly the same place on the tree stem. Diameter tapes are used most frequently because they are easily carried, and uniform and comparable readings can be obtained with them for trees of all sizes.

Species

Usually the species of each tree is recorded, even though later

compilation and processing may combine data for several similar species into one group.

Cull Class

For most management purposes, estimates of timber volume must be on a net, and not gross, basis. In the past, many timber cruisers applied a general deduction for cull to the entire gross volume, based on their experience. In CFI procedures, net volume is computed by applying a cull factor to the gross volume of each tree.

The cruiser must be able to identify the presence of decay and other defects, diagnose their extent, and classify the tree into its proper cull class. He must be experienced in evaluating the amount of cull in the timber types of his area. For the species in a given region, deductions for cull are made by applying average cull class percentages to gross volumes for various conditions of the trees.

Over 90 percent of all CFI systems record cull class data. Only two systems omit this item. Estimation of cull in standing timber is an important part of obtaining reliable volume and growth data, so that cull data will continue to be recorded in the better CFI systems.

Merchantable Height

An ocular estimate of the usable length of a tree and its measured d.b.h. provide the data for computing an estimate of tree volume. To make the volume estimate more accurate, a hypsometer may be used to measure the usable tree length to a prescribed minimum diameter, or to

the location of large limbs or some other limiting stem deformity. Merchantable heights up to about 26 feet can be accurately measured with a cane pole. Attempts to mark the upper minimum diameter limit with darts from a .22 caliber air rifle or with paint spots from a .50 caliber air rifle have proven unsuccessful. Merchantable heights can also be estimated for trees of various d.b.h. from regional taper tables.

Approximately 85 percent of the current CFI systems include merchantable height measurements. Thus, merchantable height data are second in importance to cull class data. Merchantable height is recorded by most CFI users in the South, Lake States, and Central States regions, while CFI users in the West, California, and Canada record it least often. Merchantable height was also recorded most often in CFI systems established before 1956, and was again used frequently in systems set up in 1960. Even though current methods of determining merchantable height leave much to be desired, such information is still recorded and used for volume computation in most CFI systems.

Tree Vigor

The relative accuracy of classifying trees into vigor groups depends on the experience and ability of the cruiser. For more uniform grading, basic considerations which must be included are: decay, cankers, crown class and size, leaf density and condition, bole form, risk, and severe suppression. Species is not considered in vigor classification. Each tree must be viewed from at least two sides at a reasonable distance

for consistent and satisfactory results. Tree vigor information is important in preparing marking rules and in making broad silvicultural recommendations.

Tree vigor is another item consistently recorded by CFI users. The greatest use of tree vigor data is in the South and Lake States regions and in CFI systems established before 1951 and since 1956.

Tree Quality

Many forest managers consider volume data grouped by species, tree size, area, or any other desired category, the most important information obtained from CFI. Volume data can be converted to a value basis, and in doing this, some measure of tree quality must be included. Each sample tree is usually graded, and its grade indicates its approximate value. Tree quality is usually more important in hardwoods than in softwoods. Such volume and value information enables the forest manager to spend more time and money on those parts of the forest which are producing the most return on the investment.

Arguments advanced by some foresters against grading tree quality have been summarized by Stott (1961) as follows:

1. Grading tree quality increases the cost of the inventory because grading each tree is a time-consuming exacting task. This difficulty, however, is reduced if only the butt log is graded.
2. Tree quality grading rules vary between regions of the country, and are at present, incomplete and inadequate.
3. Tree quality grading rules are complicated and difficult to learn. While the description of each tree grade may

be long and complicated, a definite pattern of grades exists which can be learned quickly.

4. In some areas, especially the South, tree grade is not given much consideration in selling timber. Expenses chargeable to tree grading in these areas are lost unless the better grades of timber are sold for enough more to at least cover the added expense of grading.
5. Tree grading processes are inaccurate. Accurate grading depends primarily upon the ability and experience of the cruiser, and with increased experience, accuracy of grading should increase.

Although tree quality ranks fourth in importance among the tree data usually recorded, it is almost as frequently recorded as tree vigor and merchantable height. This item is recorded in CFI systems in all regions. All systems in the Central States, the Northeast, and in Canada record tree quality. More and more of the CFI systems started each year include this item, and since 1956, all new systems have recorded tree quality data.

In a simple CFI system in which major emphasis is placed upon volume data and less upon additional data for the forest, some of the data, such as tree quality and cull class, might be omitted. But, if present trends of taking more plot and tree data continue, the use of tree quality will increase.

Total Height

The main advantage in measuring total height instead of merchantable height is that the point to which total height is measured is usually well defined. However, the tips of some hardwood species

are poorly defined and difficult to distinguish.

While the correlation between total height, d.b.h. and volume is not as good as that between merchantable height, d.b.h. and volume, the difficulty in selecting the point on the stem where merchantability terminates causes many organizations to use total height. Some CFI systems reach a compromise by using total height for coniferous species, and merchantable height for hardwoods. Hardwoods are generally limited in merchantability by stem deformities or large branches rather than stem taper.

On large forest areas where aerial photographs are used routinely in forest management, total height serves two purposes. First, total height and d.b.h. are used to compute estimates of timber volumes from ground cruises, and second, total height measured directly on aerial photographs is used in making timber volume estimates from the aerial photographs.

The predominant use of total height is by industrial forest organizations with CFI. There is a noticeable absence of total height measurements among CFI systems in the Central and Lake States, where hardwoods constitute a major portion of the timber types.

Over 45 percent of all CFI systems record both merchantable and total height measurements. Possible future conversions to cubic-foot volume measurement may increase the use of total height data, but at the present time, merchantable height measurements are preferred if only one tree height is taken.

Form Class

Tree form is important in volume computations because the actual volumes of trees with the same diameter and merchantable height may differ considerably due to differences in form. The three principal elements which affect tree form are upper bole taper, root swell, and bark thickness (Bruce and Shumacher, 1950). The form quotient, which compares diameter at the midpoint of the tree to d.b.h., includes only two of these variables, bark thickness and upper bole taper. In addition, diameter at the mid-point of the tree is often very difficult to obtain on standing trees. The Girard form class is a ratio of d.b.h. outside bark and the diameter inside bark at the top of the first 16-foot log. It reflects bark thickness and root swell, and provides a reliable measure of taper in the first log. Since the first log contains over 50 percent of the volume in an average tree, the Girard form class is widely used by American foresters.

For a fairly large area, the average form class for all sample trees is usually used. For specific or small areas, large errors may ensue if an average form class is used, so that form class by species or sizes should be used.

The time required and the difficulty involved in obtaining form class data apparently reduce its use in CFI systems. Form class is recorded in less than one-fourth of all CFI systems. The West is the only region where a majority of the CFI systems record form class. None of the systems in the Northeast or Canada records form class.

Chronologically, substantial use of form class data is being made in CFI systems established before 1951, in 1957, and in 1960.

Since form class measurements substantially increase the cost of taking tree data, and since an average form class is generally satisfactory for use in estimating volumes on large forest areas, the use of this item will probably not increase in importance.

Tree Value

If the volume of each sample tree of a given quality is multiplied by the monetary value of a unit of volume of that quality, the product is tree value. The values of trees suitable for various products can be combined to provide estimates of the value of specific products which could be obtained currently from the forest.

Tree value data are given little consideration in most CFI systems, for only 13 installations, widely dispersed among all regions, report making tree value estimates. Some forestry organizations may have a strong interest in tree value data, but it is not widely used.

For tree value to be meaningful, a market must exist for the product for which the tree is suitable, and it must be feasible to harvest the tree and deliver the product to the market. The actual value of each tree depends on many factors, some of which are difficult, if not impossible, to consider adequately.

Crown Diameter

The crown diameter of each dominant tree is another characteristic

of the forest which can be directly measured both on the ground and on aerial photographs. While little silvicultural significance is generally given this item, crown size is directly related to tree vigor and tree size. Little use has been made of crown diameter in forest management, but the possibility of combining various data from aerial photographs and ground measurements lends more importance to this attribute of the forest.

Crown diameter is seldom measured on permanent sample plots. Only 6 CFI users record crown diameter. Only 2 private ownerships with CFI, one in the Gulf region and one in Canada, make crown diameter measurements. Apparently, crown diameter data will not be recorded in additional CFI systems until it can be used for purposes other than aerial photo interpretation.

Other Tree Data

Other tree data recorded by some CFI users include tree status, tree operability, and tree injury. The value of these items to any particular CFI user depends on the objectives of the CFI installation, and the specific interests of the forest owner.

Remeasurement Interval and Number of Remeasurements

The full use of recurring inventory data can be realized only after remeasurement information has been compiled and compared to previous information. In all surveys after the first, changes in the forest are recorded, and the full effects of management practices can be recognized.

The length of the remeasurement interval has much to do with the utility of CFI data. For the longer intervals of ten years or more, the use-value of the data may decrease because variations in growth rates, mortality, ingrowth, and cutting, accumulate. On the other hand, the utility of such data may increase because there is more time for short-term variations to smooth out. Since periodic increment is directly proportional to the number of years in the period, the longer the period, the smaller the percentage of error. A major disadvantage of long intervals between remeasurements, however, is the delay in obtaining the initial reinventory data.

Meyer (1934) laid the mathematical foundation for relating errors to length of remeasurement interval and size of forest subdivisions. He showed that the greater the accuracy of the field measurements, the greater may be the size of the subdivisions and the length of the remeasurement period without seriously affecting the accuracy of the survey. In short, the remeasurement period may be as long as desired, if all field measurements are highly accurate. However, errors of measurement under controlled

conditions are frequently large in comparison to growth over a short period of years; therefore, longer periods usually result in greater accuracy.

Advantages of shorter remeasurement periods are: (1) better correlation between surveys, (2) shorter time in which errors can be corrected, and (3) closer check on stand development for planning purposes. These advantages, combined with the absence of growth data until the initial remeasurement, have been instrumental in the adoption of five years as the most commonly used interval.

Some public agencies are currently reinventorying their permanent sample plots at 10- to 12-year intervals, which correspond to their management plan periods. While 10 years is a fairly long interval between measurements in the shorter rotations of the East, this period often produces satisfactory results on extensive areas with large timber and longer rotations which are common in the West. It also reduces the work load on the foresters. The inherent disadvantages of the longer remeasurement period, however, remain the same.

Most large private and public forest organizations have an annual budget which limits the amount of work that can be done each fiscal year. Some of these ownerships made long-range plans for short resurvey periods, but received inadequate financial budgets to fulfill their plans. This forced the period between measurements to be extended.

Since one of the main uses of recurring inventories is to measure growth, the remeasurement period is sometimes related to the growth rate

of the most numerous or important species. A shorter period is thus associated with faster growing species, and a longer period with slower growing species. Some compromise must be made when a large variety of species and growth rates are present.

Another approach for selecting the remeasurement period is to match the resurvey interval to the time between thinnings. Each survey measures the silvicultural development of the stands as well as the efficiency of the thinning program. However, stand development may require that thinning intervals be five years in early life, 10 years later on, and 20 years still later. Also it may be improper to recommend a uniform interval between thinnings for all species and for all conditions.

The statistical validity of CFI may be influenced on any property where the remeasurement period and the period between cuttings are the same. Finney (1950) showed an unexplainable periodic variation in systematic samples taken at intervals which corresponded to cutting intervals. He was able to offer no explanation for this occurrence, but suggested that care should be taken to avoid the use of any sampling interval which is a multiple of any regular management practice. Since identical periods often mean that plot measurements will come at a set period of time after each cutting, erroneous projections of plot data to the entire property may result.

First Remeasurement Interval

The initial inventory of permanent sample plots provides in-

formation that can be used for volume computations, stand and stock tables, volume tables, and many other uses. It is not until the second inventory, however, that full use of permanent plot data can be attained. At this time, growth, mortality, ingrowth, and stand change can be measured, and management practices fully evaluated.

For growth data, the interval between measurements is of great importance. Osborne (1950) stated that a big disadvantage of continuous inventory as a method of growth measurement was the necessity for a period to elapse before growth could be determined. Other methods of growth prediction or field estimates must be used during this time. Organizations which place major emphasis on obtaining growth data from CFI plots generally use a short remeasurement interval, or make the first interval shorter than subsequent ones.

Almost one-fourth of the CFI users have the first interval between measurements shorter than the following ones. Another group of about 10 percent was undecided on subsequent remeasurement intervals. These facts indicate the importance that some organizations put on making the first remeasurement as soon as possible. In fact, four of the companies used an initial interval of one year. Several others measured only a portion of their plots after one year's growth. Only one company planned a permanent one-year remeasurement interval.

With the exception of one system in the Lake States and one in the Northeast, initial remeasurement intervals longer than five years were exclusive to the West (Table 10). The relations between the long

Table 10. Remeasurement intervals of CFI systems by regions of the United States and Canada, 1960.

Regions	Remeasurement Interval (years)								
	1	2	3	4	5	7	10	Other ^{1/}	Total
<u>Initial Interval</u>									
Atlantic	1		5	1	4				11
California				1	6		1	3	11
Canada					2				2
Central	1				6				7
Gulf	1		1	1	12			1	16
Lake			2	3	11		1		17
Northeast	2					1		1	4
Southeast	1	1	8	4	8			1	23
West					5		9		14
All Regions	6	1	16	10	54	1	11	6	105
<u>Subsequent Interval</u>									
Atlantic	1		1	1	8				11
California				1	5			5	11
Canada					1			1	2
Central					5			2	7
Gulf					15			1	16
Lake				1	13		1	2	17
Northeast					3			1	4
Southeast			3	4	14			2	23
West					5		6	3	14
All Regions	1	0	4	7	69	0	7	17	105

^{1/} This column includes the blank and "unknown" answers.

remeasurement period, the large timber, and the extensive public forest ownerships that are commonly found in Western North America, are obvious. Only one private organization planned for a reinventory period longer than five years. This company was located in the western region and had a large area of scattered timberlands.

Over one-half the current CFI systems used a 5-year interval for remeasurement. This interval is popular because (1) it is short enough that results can be anticipated, yet long enough to measure periodic changes in the forest: (2) it is a submultiple of most rotations and cutting cycles: and (3) it is an interval often used for thinnings in intensively managed stands.

Remeasurement periods shorter than five years were most often found in the South. Site, species, stocking of the forest, and the intensity of forest management are factors which ordinarily have the greatest influence on the length of the remeasurement interval. Intensive forest management requires continual data for the forest, and the shorter remeasurement intervals more fully provide this information. Short rotations and rapid growth rates help to emphasize the need for numerous evaluations of stand development.

Subsequent Remeasurement Intervals

The length of the subsequent remeasurement periods usually remains the same as the first. In all cases where changes are made, the subsequent intervals are longer than the first. The most common change is from a period of less than five years to a 5-year period.

Where only about 10 percent of the continuous inventory users were unable to state the interval at which they planned their first remeasurement, almost three times as many respondents were unable to state their planned remeasurement period subsequent to the first. Most of the blanks or answers of "unknown" came from the California and Western regions and could be construed to indicate that time was needed to evaluate CFI before commitment to a fixed remeasurement interval. Also, absence of an answer may indicate lack of planning prior to installing a CFI system.

Number of Remeasurements

Another criterion for evaluating CFI systems is experience in use. This standard records actual experience in handling the remeasurement data and in encountering both shortcomings and strong points of CFI. Satisfaction or dissatisfaction with CFI cannot be evaluated truly until data from permanent samples are obtained and applied.

Thirty of the 105 CFI installations have progressed far enough to make their first remeasurement, but only 9 made 2 or more remeasurements (Tables 11 and 12). With their longer remeasurement periods, the California and Western regions contain only 3 CFI systems that have made remeasurements. Other well-established systems are uniformly distributed throughout the eastern part of the United States and throughout the ownership classes (Tables 11 and 12).

The Lake States and the pulp and paper corporations have the

Table 11. Regional distribution of CFI systems with remeasurement data, 1960.

	Number of CFI Systems With --		
	One Remeasurement	Two or More Remeasurements	Total CFI Systems
Atlantic	3	2	11
California	2	1	11
Canada	0	0	2
Central	5	1	7
Gulf	4	0	16
Lake	7	2	17
Northeast	2	1	4
Southeast	6	2	23
West	1	0	14
All Regions	30	9	105

Table 12. CFI systems with remeasurement data, by ownership class, 1960.

Ownership Class	Number of CFI Systems With --		
	One Remeasurement	Two or More Remeasurements	All CFI Systems
Private:			
Pulp and Paper Corporations	12	4	34
Lumber Companies	6	2	22
Miscellaneous Wood Producers	3	1	14
All Private	21	7	70
State:			
State Forests	5	1	18
Educational Institutions	1	0	4
All State	6	1	22
Federal:			
Forest Service Regions	3	0	8
Other Federal	0	1	5
All Federal	3	1	13
All Ownerships	30	9	105

largest total number of systems with remeasurement data. Within any region, the largest percentage of systems with remeasurement data is found in the Central States and the Northeast (Table 11). While the southern regions have the largest total number of CFI systems, they do not have a large percentage of systems with remeasurement data. This signifies that experience with CFI in the South is somewhat limited.

Office Procedures

The cost of processing the quantities of information obtained from permanent sample plots is one of the main considerations prior to installing a CFI system. Among the problems involved are the statistical accuracy desired and the cost of obtaining it. Should the data be processed by desk calculator or by a high speed computer? Would it be better to rent or own the machines involved? These are some of the questions that may be best answered by trial and error. In this survey, data processing experiences of current CFI users were evaluated.

Data Processing Methods

The advent of high-speed computers has made possible the processing of voluminous data from measured and remeasured individual trees on permanent sample plots. Electronic computers are instruments whose mathematical achievements are limited to adding and subtracting, one number at a time. These two processes, however, can be done at a tremendously rapid rate, and can be converted to most other mathematical

processes, such as dividing and multiplying. More advanced models can even draw curves for given equations that have been previously solved by the same machine.

The problems to be solved by electronic computers must be set up in detailed sequence by a process known as programming. This slow and tedious process by which each problem is programmed for each type of machine is followed by incredibly fast execution when the field data are placed in the computer's memory. It follows then, that to be economically feasible, the problem solved by electronic computers should involve a large number of computations or be an exercise that is encountered repeatedly. Freese (1953) suggests that in general, a problem can be economically solved by high-speed computers if it meets the following conditions: (1) there is a well defined problem, (2) there is a mathematical analysis, (3) the computations are long and involved including a large mass of data, or the problem is frequently solved, (4) the speed of machine computations is sufficient to offset the cost of programming and rental.

When considering the advisability of using high-speed computers, one of the outstanding advantages is the lack of errors. Rarely do machine errors occur in data processing. Stott (1957b) reported that worn machine brushes sometimes fail to correctly reproduce mark-sensed cards.

It is doubtful if electronic data processing machines will aid in greatly increasing the size or development of recurring inventory

systems. A limitation here has generally been in the collection of field data rather than in processing (Freese 1958). No matter how rapidly the field data can be assembled and computed by data processing machines, the speed and accuracy of the total inventory still depends upon the methodical, accurate collection of field measurements.

For those foresters who do not understand the principles of electronic computers, the mystery of how the data is to be processed must be clarified with the help of private consultants, or with specialists in the U. S. Forest Service who are available for consultation on CFI. Lack of understanding data processing principles apparently has kept several organizations from changing from the slower more familiar inventory procedures to a recurring type of inventory. Even among current CFI users, 10 of them rely on the desk calculator alone for making computations. Two members of this group are public agencies working on widely scattered areas under separate supervision. Eight private concerns computing CFI data on desk calculators are concerned with smaller areas or have systems with a small number of plots, and are located in the West and South. Both the California and Atlantic States regions have three systems in which desk calculators alone are used. Chronologically, the number of CFI systems using desk calculators, although still small, was highest before 1951 and after 1958, indicating that CFI is becoming more prominent on small properties which have limited access to electronic computers.

International Business Machines Corporation produces most of the

high-speed computers generally used in processing data from permanent sample plots. Machines from this company are ordinarily used because:

- (1) IBM was the first electronic computer used in forestry work,
- (2) IBM machines are most often found in forestry organizations which have permanent plots, and (3) IBM has been most willing to help set up programs for forestry purposes.

Eighty-five of the 105 CFI systems use IBM equipment. The next most numerous computers are Remington-Rand, used by 6 installations; 3 of these also use some IBM equipment. Most companies that produce high-speed computers are reluctant to obtain orders from forestry concerns. The processing of CFI data usually composes only a small fraction of the total work load for an electronic computer, and cannot be expected to form a regular task like monthly merchandise inventories or company payrolls. On the other hand, the organizations which have CFI are usually large enough to operate their own computer, or to supplement the CFI work with other data processing jobs. The current lead held by IBM and Remington-Rand in the field of electronic computers is now being expanded to the Royal-McBee computer, a transistor machine. Further development of more advanced computers that are faster and have larger memories will not aid the processing of CFI data, because existing machines can handle the data from all current CFI systems very adequately. A computer that is relatively inexpensive, that has a large memory, and that need not make speedy computations, would best fit forestry needs.

Accuracy Determinations

An estimation of statistical accuracy standards is usually one of the first steps in compiling CFI data such as: growth, mortality, and volume. In research work, the level of probability which the data must fit is usually set at ± 1 or 5 percent. For forest inventory purposes, however, this accuracy level is often lowered to 10 or 15 percent or even lower, depending on various factors such as: area size, number of plots which can be taken, and variation in the forest stands. A ± 10 percent sampling error is commonly acceptable in CFI data, and signifies that estimates are within 10 percent of the true value without regard to the probability level. For example, growth may be estimated at the 10 percent level of probability with a 5 percent error. This specifies that growth estimates will be within ± 5 percent of the actual growth 9 times in 10. With a ± 5 percent allowable error, the chances are 2 out of 3 that the growth estimate will be within $2\frac{1}{2}$ percent of the actual. In many instances, the error will be less than 1 percent.

Barton and Stott (1956) reported that the three variables having the most important effect on the statistical accuracy of timber estimates are: size of the timber tract, density of stocking in commercial trees, and uniformity of the arrangement of the timber tract. Other factors affecting the accuracy of the estimates are: shape of the sample unit, and the efficiency of the cruising design. A cruising design using

stratification, or one that has cruise lines at right angles to the stand strata will usually result in smaller coefficients of variation than the application of other designs.

While the chief use of statistical procedures in CFI has been to determine the proper number of samples to give the desired accuracy, this in no way means that such accuracy determination is a prerequisite to CFI. Data from CFI can be used in a forest management program without computing the statistical accuracy of such data. This is indicated by the fact that almost half the respondents in this survey did not answer the question on accuracy determination in their CFI systems, or stated that the accuracy level is unknown. Once a CFI system is organized and in working order, without considering its statistical accuracy, curiosity may lead the forester to find the accuracy of his system. If the accuracy limits of an established system are too broad for acceptance, additional plots can be installed to increase the accuracy.

Most CFI systems use a 5 percent statistical accuracy level. Three systems had an accuracy of under $2\frac{1}{2}$ percent, and slightly over one-third of the systems had an accuracy level of $2\frac{1}{2}$ to 5 percent. About one-fourth have an accuracy of 5 to 10 percent, while 7 systems used accuracy levels greater than 10 percent. Although statistical accuracy should be the prime consideration in computing the number of plots necessary for a given area, 16 of the recurring inventory systems reported that statistical accuracy was not computed; 12 of these are on installations made after 1957. Three of these systems along with 9 systems which re-

turned bland or unknown answers to this question, are in the 19 CFI systems established in 1960.

Over one-half of the CFI systems in California do not compute statistical accuracy. The majority of the remaining western organizations generally use 5 percent statistical limits. Systems in the Lake and Central States appear to place the most emphasis on statistical accuracy. These results indicate that statistical accuracy for CFI systems is receiving less emphasis than many other phases of CFI, or that CFI systems are installed, and then later, their statistical accuracy is computed to see if more plots are needed.

Area or Volume

Limits of statistical accuracy in CFI can most readily be determined for volume or area estimates. For determining the accuracy of volume data, the individual volumes on each sample plot are computed and inserted in statistical formulas. Similar computations for area estimates utilize the number of plots or the area represented by each plot as related to the total (Barton 1960). Limits of error for a combination of area and volume can also be calculated (Stott 1960a).

Statistical accuracy limits for volume alone were computed in about 40 percent of the CFI systems, while statistical limits for area were computed in only 4 CFI systems. In another 12 systems, or about 10 percent of the total, the combination of volume and area accuracy limits were computed.

Ownership of Computers and Tabulating Machines

Electronic data processing machines are currently used for administrative functions by most larger industries. Initially, electronic computers were available on a rental basis only. Although it is now possible to purchase such machines, the usual policy is still to rent them. Normally included in the rental price are maintenance and computer replacements as more advanced machines become available.

Organizations that do not have electronic computers of their own have data processed in one of three ways: (1) service bureaus in several large cities in the United States provide processing services on a fee basis; (2) data can be taken for processing to electronic machines available at many colleges and universities in the United States; educational institutions are often allowed to rent their machines to help pay for their use; (3) the data can be sorted by McBee Key-Sort, and laboriously compiled on electric tabulating machines that are owned by organizations with recurring inventory systems.

Most CFI systems are part of organizations which control electronic computers within the company. Ten CFI systems use not only their own machines but also have some data processed by service bureaus.

Those organizations which have widespread land holdings in several regions of the United States often have data processed by service bureaus because company computers are not always available when needed. The heavy regular work load placed on most company controlled high-speed computers is another reason why some firms are forced to rent the services of other computers, even though the company may have its own computer equipment. Since most computer centers normally operate on an 8-hour working day, the additional and infrequent task of processing data from permanent sample plots is sometimes accomplished during weekends and at night.

Service bureau computers are used to process all the data of 10 CFI systems. Five of these are located in the South. All the systems using service bureaus, except one, use IBM service centers. A single system using a Remington-Rand service bureau also makes some use of an IBM center.

Since electronic equipment is available at many educational institutions and service centers throughout the United States, and because these machines are needed for only a short period of time during those years when permanent plots are remeasured, there is no need for an organization to obtain the full-time use of a computer for processing the permanent plot data alone. But, where electronic computers are controlled by a company with an established forest inventory control system, these computers are generally used, even if the data must be processed at night or on weekends.

Purposes For Which CFI Data Have Been Used

Before a CFI system is established, foresters in the average organization generally have only a vague notion of all the uses of data from permanent plots. Forest inventory control systems are generally expected to provide information on present volume, growth, mortality, and ingrowth. An enterprising forester may envision many other items which data from permanent plots can provide. However, the basic uses which make a continuous inventory system attractive to most large forest organizations are relatively few. Additional uses beyond a basic inventory (determining present volume) and the components of growth are generally found only after field data are processed and the results made available to the forester. This means that in each individual CFI system, there must be some experimentation with the field data to find all possible ways of using it in forest management practices. In this manner, several forest organizations are investing in practical forest research for the first time.

In the questionnaire, current CFI users were asked to indicate whether they utilized CFI for 17 basic uses or purposes, and to rate the importance of each use. The results show that inventory (determination of the present volume) is the most common purpose, followed closely by growth, and information for top administrative management (Table 13).

By ownership types, private CFI users utilize permanent plot data for inventory, growth, and top administrative management. State systems

Table 13. Important uses to which CFI has been placed, 1960.

Ownership Types	Answers	Inven- tory	Growth	Top Admin. Mgmt.	In- growth	Mortal- ity	Top Wood- land Mgmt.	Compu- tation of Cutting Budget	Stand and Stock Table	Type or Class Areas	Stand Classifi- cation
Private (70 Users)	Yes	52	50	52	44	42	49	42	39	31	27
	No	2	4	4	7	6	7	9	9	14	17
	Blank	16	16	14	19	22	14	19	22	25	26
State (22 Users)	Yes	18	18	12	17	18	13	14	16	15	14
	No	2	1	7	2	1	6	6	2	3	6
	Blank	2	3	3	3	3	3	2	4	4	2
Federal (13 Users)	Yes	12	11	11	11	11	9	12	12	9	10
	No	--	1	--	1	1	1	--	--	2	1
	Blank	1	1	2	1	1	3	1	1	2	2
All Ownerships (105 Users)	Yes	82	79	75	72	71	71	68	67	55	51
	No	4	6	11	10	8	14	15	11	19	24
	Blank	19	20	19	23	26	20	22	27	31	30

generally use CFI data for mortality, growth, and inventory. Uses commonly emphasized in systems on federal ownerships are stand and stock tables, computation of cutting budgets, and inventory.

While the value to the forest manager of any single use of CFI data is a judgment that varies with the management objectives of each organization, the combined benefits derived from a continuous inventory system are indicated by the number of uses to which data from each system is put. The number of uses of CFI data in an installation ranges from 3 to 16, and averages 10 per installation. Private CFI users average a slightly lower number of uses, while the average number of uses was slightly higher on public ownerships. An array of the average number of organizations reporting each use category indicates that the data do not fit a normal curve, but are fairly evenly distributed throughout the range.

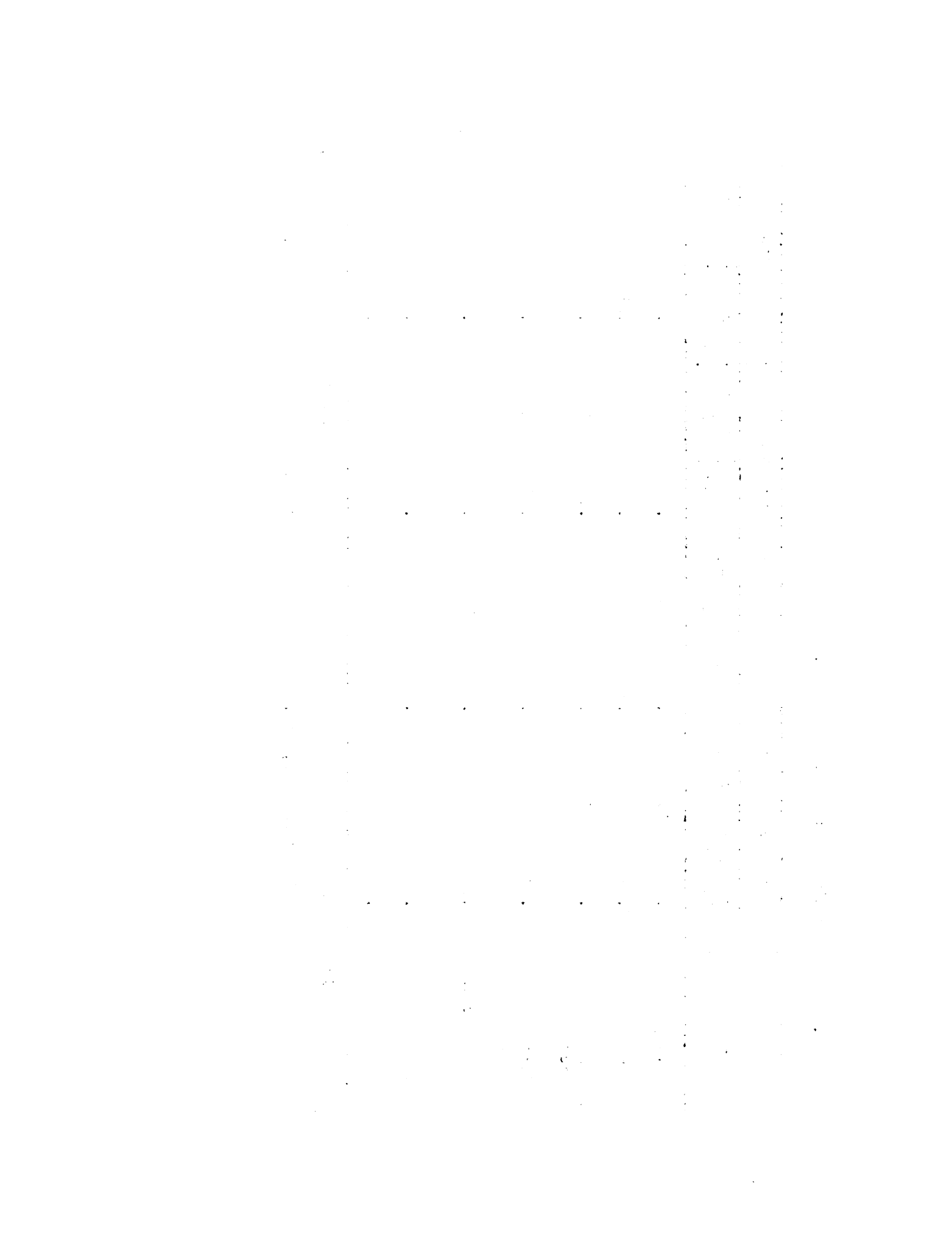
Each CFI user rated the value of each CFI use or purpose to his forestry organization (Table 14). The most important use was rated as number one, the next most important, number two, and so forth. The individual uses were thus placed in a rank order with respect to the rated value of that use. This is feasible when it is possible to say that one use value is higher than another, but not how much higher. To analyze the results, rank correlation was employed (Kendall, 1948). The rank correlation coefficient of concordance for all CFI systems is .21. The "F" test shows this to be highly significant. Thus, the sets of ranks show agreement far beyond that expected from sampling variance.

Table 14. Average rating of uses of CPI, 1960.

Uses of CPI	Private		State		Federal		All Ownerships	
	Average Rating ¹ / Ratings	Number 1 Ratings	Average Rating ¹ / Ratings	Number 1 Ratings	Average Rating ¹ / Ratings	Number 1 Ratings	Average Rating ¹ / Ratings	Number 1 Ratings
Inventory	2.52	19	2.92	4	1.78	6	2.50	29
Growth	2.45	26	2.62	4	2.75	2	2.51	32
Cutting Budget	3.80	5	3.17	2	3.17	1	3.52	8
Woodland Management	3.70	4	3.50	3	4.13	1	3.72	8
Administrative Management	4.36	1	4.08	2	4.50	0	4.29	3
Mortality	4.76	0	4.39	0	4.71	0	4.67	0
Tax	5.46	7	N/A	N/A	N/A	N/A	5.46	7

1/ The items in this column were rated by the CPI users on a basis of 1 for the most important use,

2 for the next most important use, etc. Tabular figures are averages of these figures.



The best ranking of the sums of the ranks is the best ranking in the least square sense (Kendall, 1948). This means that when the ranks of each use are totaled, the smallest sum indicates the most important use.

On this basis, inventory was the most important use served by data from permanent sample plots. However, use of data for growth determinations is slightly more important on private and state holdings, while inventory holds a decided advantage on federal ownerships.

To determine which uses are significantly more important than the others, each of the six major uses was paired with the others and analyzed by the Chi-Square test, using the null hypothesis (Table 15). The difference between the two foremost uses, inventory and growth, is non-significant. This indicates that the null hypothesis should be accepted, and that no significant difference is demonstrated between the importance of inventory and growth data to the users of CFI. Inventory is significantly more important than all other uses except growth, and growth is significantly more important than woodland management, administrative management, and mortality (Table 15).

In answer to the question as to which single use of data was considered valuable enough to cover the full cost of a permanent system of plots, current CFI users listed inventory most often, followed by growth, cutting budgets, woodland management, and administrative management, in that order. Each respondent listed its valuable uses, and most of these lists included 2 or more uses. For all systems, there was a combined average of 2.7 uses per CFI system. This indicates that

Table 15. Paired comparisons of major CFI uses, 1960

Uses	Growth	Cutting Budget	Woodland Management	Administrative Management	Mortality
- - - - - Values of Chi Square - - - - -					
Inventory	0.62 n.s.	5.59*	11.66**	19.93**	22.34**
Growth		3.38 n.s.	5.59*	13.52**	50.28**
Cutting Budget			0.00 n.s.	1.72 n.s.	6.90**
Woodland Management				6.90**	1.72 n.s.
Administrative Management					0.28 n.s.

Significance at the 1 percent level is indicated by **.

Significance at the 5 percent level is indicated by *.

Non-significance is indicated by n.s.

respondents of this survey signified that almost 3 uses of CFI data are judged valuable enough to be the sole basis of establishing CFI plots. However, almost 13 percent of the respondents state that no single item is sufficiently valuable to them to justify a CFI system.

Inventory

An adequate inventory of the forest growing stock is important in all stages of forest management. In its early stages, an initial inventory is often thought to be the first step in developing a forest management program. In the intermediate and advanced stages, a knowledge of the forest inventory enables the forester to better evaluate and prescribe good forestry practices.

Since the need for inventory data is so widespread, it is understandable that this item has the most utility. It is used by industrial and public organizations, both in the initial and advanced phases of forest management. The widespread use of permanent plot data to compute forest inventory is emphasized by the few negative responses to this item in the questionnaire. Only 2 companies stated that inventory data are not collected.

Growth

Net growth is a composite of several things. Increment on trees of usable size and form, plus the volume of trees that are attaining such size and form, are on the positive side. On the negative side are

losses of volume through mechanical injury, insects, decaying trees of usable size and form, and complete loss of such trees from the merchantable classification as a result of the activities of these agencies. According to Gilbert (1954), some of the elements of growth include the following: accretion, mortality, ingrowth, net growth, and production. Accretion is growth on the individual tree. It includes the growth on trees harvested during the period, and ignores growth of trees that have died, but includes their previous volume. In general, accretion is the best measure of the immediate results of a silvicultural treatment. Mortality is the volume of trees previously tallied which have died since the previous measurement. Ingrowth is the volume at the end of the period of those trees that grew into the lowest measured diameter class during the period. Net growth is accretion minus mortality. Production is the sum of accretion and ingrowth; it is the change in volume during the period and gives the best estimate of how much timber may be harvested during the period.

Three general methods commonly used to determine growth are (1) comparison of successive cruises, (2) analysis of increment borings, and (3) comparison of successive measurements on permanent sample plots. It is difficult to obtain accurate growth information from successive cruises, for there is a small ratio of growth to total volume, sampling errors for each cruise are large, and it is difficult to reproduce the condition of the first cruise a second time. The sampling error of the difference between 2 successive cruises is very large, for it includes

the sampling error of both inventories, as well as that resulting from different sampled areas (Hall, 1959).

Data from increment borings are often used to calculate growth, but this method measures only accretion on relatively few trees. Data from borings cannot be used to measure the other components of growth, such as mortality, net growth, ingrowth, or production.

Since growth on permanent sample plots is computed from the difference between 2 successive measurements, its statistical precision is the sampling error of a difference. The pairing of permanent plot locations has reduced the standard error inherent in temporary plot data, and the required number of plots is drastically reduced (Hall, 1959). There are several formulas for calculating growth from permanent plot data. That used by Gurnaud and Biolley was:

$$Z = V_2 + N - V_1 - P.$$

Where Z = the increment of the forest

V_1 and V_2 = volumes of the first and second inventories

N = the volume of the felled timber

P = a combination of recruitment and ingrowth (Knuchel, 1949).

Meyer (1953) combined 5 terms - - gross growth, mortality, net growth, net increment, and yield - - into 3 formulas as follows:

Gross growth = net growth plus mortality.

Net growth = net increase plus yield.

Net increase = the difference in growing stock of the forest between 2 successive inventories.

The term ingrowth must be added to or deleted from each formula as is believed necessary; it is usually included in net growth, net increment, and yield.

Beers (1960) combined the Gurnaud-Biolley formula with those of Meyer as follows:

$$\text{Gross growth of initial volume} = V_2 + N + C - I - V_1.$$

$$\text{Gross growth including ingrowth} = V_2 + N + C - V_1.$$

$$\text{Net growth} = V_2 + C - V_1.$$

$$\text{Net growth of initial volume} = V_2 + C - I - V_1.$$

$$\text{Net increase} = V_2 - V_1.$$

Where V_1 = the volume of trees measured at the first inventory.

V_2 = the volume of trees measured at the second inventory.

N = the initial volume of trees dying during the period between inventories.

C = the initial volume of trees which were cut during the period between inventories.

I = the volume of trees at the second inventory, which were below merchantable size at the first inventory.

Measurements taken on permanent sample plots provide information for computing the component parts of growth for a given period. Growth computed from permanent plot data provides a contrast with estimates and predictions which are based on single measurements, such as yield tables and stand projection. Also in this category are estimates based

on independent periodic cruises where new sample plots are measured at each new cruise. Forecasts of future growth from CFI data involve an assumption that each future period will produce the same amount as the preceding one. Probably the outstanding disadvantage of obtaining growth data from recurring inventories is that a growth period must elapse before growth information becomes available. Where remeasurement intervals are 10 years or longer as in the West, growth data for management purposes are lacking during this initial interval.

In the early stages of forest management, precise growth information is not necessary to initiate good forestry practices. An estimate of gross annual increment, based on increment core data, will usually provide an adequate growth estimate at low cost. Even where intensive forestry is being practiced, there are factors which influence the use of growth estimates. Guilkey (1954) and others have reported that use of growth consistently overestimated the desirable cut in young stands and consistently underestimated it in old stands. Thus, allowable cut should be dependent not only on the growth rate, but upon the proportion of young and mature growing stock as well. In addition, for computing allowable cut, the percentage of growth that is sound, or net growth, should be used.

The number of CFI systems using data from permanent sample plots to calculate growth is second only to those using CFI for inventory. However, growth is more important than inventory in state and private CFI systems. Two-thirds of these state and private systems rated growth

as the most important use.

Top Administrative Management

The investments of a corporation in forest lands, and the rate of return on these investments, are of prime importance to stockholders, the business manager, and the accountants in each organization. For each of these to understand the value of the forest as part of the business, a common language must be used. CFI can help to present forestry in terms familiar to each.

The interest of stockholders in a business is generally limited to the dividends paid and the prices of stocks. The accountant prepares the balance sheet listing assets and liabilities and the income statement showing debits and credits. With the advent of CFI, an accountant can now compute accurately the working capital invested in forests, and the rate of return on the investment. The speed with which data can be processed allows business statements to be prepared rapidly, showing reasonably accurate investments and income information.

CFI allows the forest manager to focus his attention on the general condition of the forest investment, and it keeps him better informed about more of the forested area. A general picture of effectiveness of management policies as indicated by data from permanent plots provides the basis for closer cooperation between top woodland and administrative management. This may be construed as a disadvantage by some older foresters who were happier when administrative personnel had little if

any knowledge of forests and foresters. However, such an attitude will not build confidence by administrative management in the forest enterprise and the forest management staff.

The use of CFI data for administrative management is the most frequent use of CFI in private industry and is rated third in importance for all ownerships (Table 13). This indicates the strong interest in this information by industrial personnel not directly concerned with forest management. This use also ranks fifth among the major uses when ranked in order of value to forest management (Table 14). Three organizations stated this use is the most prominent contribution of CFI data.

Ingrowth

Ingrowth is defined by Chapman and Meyer (1949) as follows:

"The entire volume of trees now below the minimum merchantable diameter limit that will grow into and above this diameter during a definite future period of years plus growth that these trees make after reaching merchantable size during the period indicated."

The term ingrowth is inherent in volume computations in which trees of a stated minimum diameter are included. On a cubic-foot basis, or in inventories using point-sampling, all trees may be included in computing volume. The lower diameter limits for measuring board-foot and cubic-foot and cord volumes depend in large part upon current utilization practices. As utilization becomes more intensive and smaller trees are utilized, trees now considered potentially ingrowth trees will be measured and included in routine inventories.

According to Knuchel (1949), forestry practices in uneven-aged stands under the control method in Europe include ingrowth in the growth computations. Cuttings are then controlled to keep growth at an optimum rate. This permits all increment in the stand to exert an influence upon the silvicultural treatment of the stand.

For permanent point-samples, growth at the end of each remeasurement period is computed only for the trees measured in the previous inventory. Newly tallied trees are not part of the volume compared to the initial inventory data, but such volume must be added to the volume data that will be used in computing growth in the next inventory.

The majority of the CFI systems use ingrowth data, and its use ranks fourth in value to forestry concerns (Tables 13 and 14). It was most frequently used by public agencies (Table 13). Most organizations not using ingrowth data from CFI are located in the West, the Southeast, and the Gulf regions. Eight of the 10 non-users of ingrowth data are CFI systems established since 1958. Ingrowth information also appears to be more important in the older, more experienced CFI systems.

Mortality

Mortality is another item of information normally obtained from permanent plots only after remeasurement data have been summarized. Essentially the same advantages and disadvantages are involved as in the use of permanent plot data for growth information. Several CFI users stated in the questionnaire that mortality, growth, and ingrowth are so

closely related that the three should be combined as one use.

Mortality information is necessary before net growth can be calculated accurately. Mortality can be expected to follow specific trends in thrifty, middle-aged stands, but in either young or old timber, as well as in stands with abnormal conditions, mortality is apt to be large, and may also be erratic and difficult to predict. Estimates of stand mortality are generally based on an inspection of stand conditions and are usually limited to the past 10 years. To accept broad estimates based on the experience of one person leaves much to be desired. Hervey (1936) lists several methods which are helpful in determining the lapse of time since the death of trees. For fallen trees, he recommends (1) examining the bushes and saplings bent down by the fallen trees and counting the nodes of the upturned growth, (2) noting bruises on nearby trees, and (3) boring nearby trees to find any marked change in the growth rate, especially if the major part of the crown has been destroyed. In standing trees, he suggests (1) comparing conditions of bark and twigs to known mortality, (2) noting the progress of saprophytes and fungi, especially the fruiting bodies, and (3) noting increased growth of ground cover.

The most reliable source of information on mortality is a history of stand development as recorded by permanent sample plot data. Such information is accurate and can be readily obtained for use in growth computations.

Mortality can be caused by natural factors such as competition,

fire, wind, snow and ice, disease and insects, and animals, or by logging damage. One company in the South related that information from CFI plots showed they were losing 30,000 cords of wood annually due to logging damage. Much of this volume could have been saved if proper precautions had been taken. Two companies in the Lake States reported that almost half the gross growth was lost due to mortality. They immediately took steps in their cutting practices to reduce this loss by harvesting more of the trees which would have become mortality. Although mortality cannot be eliminated by silvicultural practices, it can be reduced.

These conditions have shown that mortality figures are not only important in calculating growth but are also helpful in formulating the silvicultural policies of the company.

All CFI systems except 8 make use of CFI data to obtain mortality information (Table 13). In order of value in use, mortality ranks sixth (Table 14). Although no organization ranks mortality as the most important use of CFI data, nor was it important enough to warrant the setting up of the system, it is an important use of CFI data in most systems in all regions of the United States.

Woodland Management

As forest management progresses from the exploitative stage to true forest management, more detailed reports of the forest assets are needed. Information must be obtained that will enable the forest manager

to plan the management program intelligently so he can be reasonably assured of success in attaining the company's objectives. Sustained yield assumes long-range planning, but data for each step in the future must be supplied when it is needed. Such pertinent facts can be gathered and made available as needed only by data from permanent plots processed by electronic machines. Even then, a waiting period is required for remeasurement data.

Changes in the forest are accurately measured in a recurring inventory system. Production goals can be set more easily, and emphasis can be placed where work needs to be done in the forest. Where the woodland manager is continuously informed of the forest situation, future planning is better and more easily accomplished through newer and better guides. Remeasurement data reveal how well the forest assets have been managed, and provide the information for making adjustments.

Information concerning all the attributes of the forest is assembled from permanent plot measurement by the forest manager and used to increase forest production. Thus, providing information for the forest manager is a general objective of CFI that includes most specific uses of the data. Certain individual applications - like inventory, growth, mortality, or ingrowth - may be the single most valuable use made of CFI data. Therefore, "woodland management" has probably been lightly rated in this survey because many respondents did not interpret that individual uses of CFI data are part of woodland management.

Providing information for top woodland management is the sixth

most important use of permanent plot data in all CFI systems. This use is considered somewhat more important by private forest owners (Table 13). Eight CFI systems state that the main use of CFI is to provide data for top woodland management (Table 14).

Cutting Budget

To determine the allowable cut, annual or periodic data must be available concerning the total volume of timber that can be harvested. In addition, the specific kind, quality, and size of timber that is to be cut and where it is located should be known (Davis, 1954). This information must come from a thorough knowledge of conditions in the forest. Such knowledge is commonly attained through experience in applying forestry techniques and is supplemented by data from permanent sample plots.

When properly set up, CFI can provide data for both area and volume control of the allowable cut. It can be used to provide information on growing stock and increment that is necessary for volume control and to delineate forest stands, areas, and types as necessary for area control. CFI emphasizes close familiarity with the forest. Information is provided for adjusting to changes in growth and growing stock periodically. Adjustments in the cutting budget can be properly evaluated and regulated to fit existing conditions in the changing forest.

The use of CFI data in compiling the cutting budget is closely related to some other uses. Since growth, mortality, and ingrowth are

so important in calculating the allowable cut, these four items are considered to be one combined use in many continuous inventory systems. Most woodland managers consult with administrative management before using these items in computing the cutting budget, because differences may arise in interpretation of results and in methods of applying data. For the forest manager who has frequent harvest cuttings, CFI can provide valuable information in a short time for use in calculating volumes to harvest.

Permanent plot data are widely used in calculating cutting budgets by organizations of all types and ownerships and are especially important in CFI systems on public ownerships. The relative importance ascribed to CFI in preparing a cutting budget is indicated by its number three ranking among the major uses (Table 14). This includes 8 respondents who stated that this is the most significant use of CFI data. Based on the number of CFI systems in which data are used for this purpose, however, this item ranks eighth (Table 13). This indicates that many organizations consider this use to be one of the outstanding features of CFI, while several others do not use their data in this manner. Management objectives normally play a major role in determining whether this use of CFI data will be valuable or not to each CFI user.

Tax Information

The ability of CFI to provide data for computing taxes has a twofold use. Most commonly, the inventory data are used as a base on

which to compute income tax. The other use is in computing general property taxes.

The general property tax is more burdensome on depleted lands than on well stocked lands. Tax per unit of volume of current annual increment decreases as the density of the growing stock increases. From both an economic and a biological standpoint, permanent plot data emphasizes that well-stocked stands are the best investment.

With two exceptions, the basic income tax law applies to forestry in the same way as to other enterprises. These exceptions permit the taxpayer to report as capital gains the income derived from the sale of timber on lands owned over six months (Williams, 1953). Principal features of this law are the reporting of expenditures as current expenses and capital investment. Since receipts from a forest are treated as a capital gain rather than as ordinary income, the maximum tax will be only 25 percent of the gain. In most cases, this results in substantial savings of tax dollars.

From an income tax standpoint, two broad types of costs are recognized: charges against income, and charges against capital. Charges against income are usually expenses of managing the forest which are treated as deductions from gross income. These items include operating expenses, carrying charges, developmental expenditures, and depreciation allowances. Carrying charges and developmental expenditures can be either expensed or capitalized as the owner chooses, providing that a consistent practice is followed from year to year. Some

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities related to the project. It emphasizes the need for transparency and accountability in the financial management of the project.

2. The second part of the document outlines the specific procedures and controls that will be implemented to ensure the integrity of the financial data. This includes the use of standardized accounting practices and the establishment of a robust internal control system.

3. The third part of the document describes the roles and responsibilities of the various stakeholders involved in the financial management of the project. It clarifies the lines of authority and communication, ensuring that everyone understands their contribution to the overall success of the project.

4. The fourth part of the document provides a detailed overview of the financial reporting requirements, including the frequency and format of reports. It also discusses the process for reviewing and approving these reports, ensuring that they are accurate and reliable.

5. The fifth part of the document addresses the issue of budgeting and cost management. It outlines the process for developing a realistic budget and the strategies for monitoring and controlling costs throughout the project lifecycle.

6. The sixth part of the document discusses the importance of regular communication and reporting to the project sponsor and other key stakeholders. It emphasizes the need for timely and accurate information to support decision-making and ensure that the project remains on track.

7. The seventh part of the document provides a summary of the key findings and recommendations. It highlights the areas where further attention is needed and offers practical suggestions for improving the financial management of the project.

8. The eighth part of the document includes a list of references and a glossary of terms. This section provides additional context and definitions for the concepts discussed in the document, ensuring that all readers have a clear understanding of the terminology used.

9. The ninth part of the document is a conclusion that reiterates the importance of the financial management of the project and expresses confidence in the team's ability to successfully complete the project within the allocated budget.

10. The tenth part of the document is a final section that provides a brief overview of the project's progress and the next steps. It serves as a summary of the document and a call to action for the project team to continue their efforts towards achieving the project's goals.

11. The eleventh part of the document is a list of appendices, which include additional information and data that support the findings and recommendations of the document. These appendices provide a more detailed look at the financial data and the underlying assumptions used in the analysis.

12. The twelfth part of the document is a final section that provides a brief overview of the project's progress and the next steps. It serves as a summary of the document and a call to action for the project team to continue their efforts towards achieving the project's goals.

13. The thirteenth part of the document is a list of appendices, which include additional information and data that support the findings and recommendations of the document. These appendices provide a more detailed look at the financial data and the underlying assumptions used in the analysis.

14. The fourteenth part of the document is a final section that provides a brief overview of the project's progress and the next steps. It serves as a summary of the document and a call to action for the project team to continue their efforts towards achieving the project's goals.

15. The fifteenth part of the document is a list of appendices, which include additional information and data that support the findings and recommendations of the document. These appendices provide a more detailed look at the financial data and the underlying assumptions used in the analysis.

16. The sixteenth part of the document is a final section that provides a brief overview of the project's progress and the next steps. It serves as a summary of the document and a call to action for the project team to continue their efforts towards achieving the project's goals.

17. The seventeenth part of the document is a list of appendices, which include additional information and data that support the findings and recommendations of the document. These appendices provide a more detailed look at the financial data and the underlying assumptions used in the analysis.

18. The eighteenth part of the document is a final section that provides a brief overview of the project's progress and the next steps. It serves as a summary of the document and a call to action for the project team to continue their efforts towards achieving the project's goals.

of the items included in developmental expenditures include reforestation, stand improvement, and fire protection (Wohlenberg, 1950). When items are charges against capital (capital expenditures), they become part of the total value of the property that will be depleted periodically as the timber is harvested in the future.

Depletion is the write-off of the original value of the timber adjusted for any later capital additions or deductions. Such write-offs are made only when the timber is harvested. They are usually found by calculating the value per unit of volume, and then multiplying by the volume of timber cut or sold. This gives the depletion allowance that can be claimed in computing federal income taxes.

Wohlenberg (1940) reported that accelerated depletion is permitted when higher values are removed first; it is calculated on the percent of value removed from the forest stand rather than on percent of volume removed. Such conditions will normally be found in partially cut stands of mature timber.

Because of the diversity of information collected in CFI systems and the variety of sampling intensities and techniques, it is impossible to say that a depletion rate derived from permanent sample plot data will always be accepted by federal tax experts. However, recurring inventory systems provide comparable and reasonably accurate depletion rates at a minimum cost. For this reason, CFI systems installed to provide information for the accountants of the organization will provide a maximum of information for tax purposes. To change from the usual method of

the first of these is the fact that the system is not a simple one, but a complex one, in which the various parts are interrelated and interdependent. The second is that the system is not a static one, but a dynamic one, in which the various parts are constantly changing and evolving. The third is that the system is not a closed one, but an open one, in which the various parts are constantly interacting with the environment. The fourth is that the system is not a linear one, but a non-linear one, in which the various parts are constantly interacting with each other in a non-linear fashion. The fifth is that the system is not a deterministic one, but a probabilistic one, in which the various parts are constantly interacting with each other in a probabilistic fashion. The sixth is that the system is not a simple one, but a complex one, in which the various parts are interrelated and interdependent. The seventh is that the system is not a static one, but a dynamic one, in which the various parts are constantly changing and evolving. The eighth is that the system is not a closed one, but an open one, in which the various parts are constantly interacting with the environment. The ninth is that the system is not a linear one, but a non-linear one, in which the various parts are constantly interacting with each other in a non-linear fashion. The tenth is that the system is not a deterministic one, but a probabilistic one, in which the various parts are constantly interacting with each other in a probabilistic fashion.

calculating taxes to that utilizing data from CFI plots requires first, that permission be obtained from the federal government. Secondly, once permission is granted for calculating taxes based on permanent plot data, that must be the method used until permission is obtained for using another method.

In general, the number of forest organizations using CFI data in computing taxes is small. Only about one-third of the private systems report this use. Of this group, however, 7 organizations, or 10 percent of the total private ownerships with continuous inventory systems, state that tax computation is the number one use of CFI data. Several of these companies indicate that tax use is important enough to be the sole justification for installing a permanent inventory system. Apparently, this use is considered to be very important by some companies, but of only slight importance to others, depending upon policies within the organization. Companies that make use of CFI data for tax purposes place this use at the top of the ratings, and those that do not, place this use at the bottom (Table 14).

Stand and Stock Tables

A stand table shows the number of trees per acre by diameter class for given stands. A stock table shows the volume in each diameter class (Chapman and Meyer, 1949). Stand and stock tables are useful because they give a more complete picture of the conditions in the forest. They show distribution and proportion of volume in any given

diameter class, for any given species, or for any other desired stand segment. Stand tables should normally have one diameter class represented that is below merchantable size. This permits potential and actual ingrowth computations to be made.

From stand tables, the number of trees presently in each class and species which can be expected to survive can be determined. Thus, stand tables are valuable in computing mortality data and are needed in calculating inventory and ingrowth. Stand tables are also used to expand the results obtained from sample plots to the entire forest. They are useful in subdividing the forest into types, site classes, stand classes, areas needing cultural practices. (TSI), and areas needing planting. They are also used in calculating cutting budgets and preparing marking rules.

Public agencies rate the use of CFI data for compiling stand and stock tables very highly (Table 13). State systems rate this use fourth (Table 13). All federal systems used CFI data for this purpose.

This use is usually not important enough to be the major reason for installing CFI. However, compilation of stand and stock tables provides supplemental information for other data.

Type or Stand Size Class Area

The use of permanent sample plots for designating type or class areas is a relatively inefficient method when based primarily on permanent plot locations alone. A small number of widely distributed plots

generally gives an adequate sample of many forest types. If forest type identification is done along entry lines to plot locations, the mapping is more efficient, though still incomplete. If used in conjunction with ground surveys and/or aerial photographs, data from permanent plots can be helpful in correctly determining type boundaries. But even so, determining forest type and class areas falls more within the mapping phases of general forest management in which aerial photographs are usually used, than in a system which uses widely scattered fixed plots through the forest. Nevertheless, this use of CFI data is often found in forest inventory control systems, and several organizations expressed the opinion that this was one of the more important uses of CFI. The major emphasis on using permanent plot data in determining types and classes is found in the Western and Lake States regions. This use is most common in CFI installations made since 1956.

Stand Classification

This item is closely related to forest cover type but is generally considered a finer division of the forest than the cover type. If a forest cover type is divided into stand classes, the practice of more intensive forest management is assumed. Similarly, if a recurring inventory system is used to subdivide a forest, a more intensive system of forest management is normally practiced using data from established permanent plots as the basis for this management.

Results of this survey show that almost half of the CFI systems

are making use of permanent plots in their stand classification. Slightly over one-third of the industrial organizations use stand classification information.

As with type and class area information, stand classification is most prevalent in the Western and Lake States regions. CFI systems in which this item is most important were established primarily in 1959 and 1960, indicating that the more recently established systems apparently employ finer divisions of their forest areas than types.

TSI and Planting

The next most important use of CFI data is for designating areas in need of timber stand improvement and planting. The installation of permanent plots requires that the total acreage be extensively covered in locating and establishing the plots. The extensive coverage of the forest area by permanent plots enables the forester to identify areas in greatest need of TSI and planting. While CFI data can be used to provide this data, it seems that an alert forest manager would learn the improvement and planting needs of his area by working in the forest, and would not need to collect such information in this manner. However, the pooling of information on the entire forest area for the top woodland manager may be advisable.

Forty-four of the 105 CFI systems use data from permanent plots to identify areas in need of TSI and planting. These are primarily grouped in private and state systems, while federal CFI systems

apparently make little use of this information. More respondents from the Lake States and Southeast regions reported that CFI data are being used for locating TSI and planting areas than from other regions. While this use is apparently not very important to the more experienced CFI users, its common use by the more recently established systems indicates this item is becoming more important in many forest organizations; they show a slight trend toward greater use of CFI data for this purpose.

D.B.H. - Height - Volume Curves

These curves can usually be made from data collected in a recurring inventory system. They are used primarily to make new volume tables and to supplement or check existing tables. Only about 40 percent of all current CFI systems make these curves. Public agencies generally prepare volume curves, while most industrial organizations do not. It is apparent that regions with the more readily available and more reliable volume tables - the Lake States, the Southeast, and the Gulf regions - do the most work on this item. Current work on volume tables appears to be increasing after a decided lag in the past decade. This lag is accentuated by the large proportion of the systems established in 1959 and 1960 which use CFI data to compile volume tables.

Timber Operating Schedules in Specific Areas

The use of data obtained from permanent sample plots in the

management of individual forest stands has, thus far, been generally lacking. For this to be practical, a number of plots must be located in each stand. For economic reasons, the number of plots required to yield adequate information for individual stands is too large. Although it is still desirable to use data from CFI to prepare timber operating schedules for specific areas, this survey shows that this idea, combined with present sampling techniques, is far from being practical.

Only 30 of the 105 CFI users are making any attempt to relate CFI data to specific stands. The degree of success which these forest managers have achieved is still doubtful. The greatest use of this item is in state organizations, where 9 of 22 systems are trying to relate permanent plot data to individual stands.

Local Volume Tables

A local volume table is one which correlates tree volume with diameter alone. When this table is accurately made for a given area, it normally gives accurate results for that area only. Use of a local volume table in CFI generally provides an adequately accurate estimate of volume for a given area, if the data on which the local volume table is based is from the same area.

The processing of permanent plot data by electronic machines has probably reduced the use of local volume tables. Complex formulas designed to calculate the exact volume of each tree and to sum up these

values to produce total volumes have been made and used in many CFI systems. The large number of trees encountered often taxes the memory capacity of most of the machines involved and forces additional programs to be made. It would have been simpler and probably just as accurate to use figures from local volume tables. Also, since one of the main uses of permanent plots is to measure change in the forest, comparisons of volumes derived from local volume tables will normally be as accurate as volumes derived from individual tree measurements. Local volume tables are thought to be accurate enough for the forestry practices of Europe. It seems they should be accurate enough for the less intensive forestry practices of North America.

The application of permanent plot data in making local volume tables is very limited at this time. Only 29 organizations prepare such tables from CFI data; almost half of these are public agencies. Local volume tables can be easily compiled from permanent samples because all information needed for this compilation is automatically recorded in a system of continuous inventory.

Instruction, Research, and/or Training

All educational institutions with CFI used this information in their instruction, research, and training programs. In addition, almost half the state, one-third of the federal, and 5 private organizations report that their systems are being used for research and/or training. Additional comments indicate that while some systems are not currently

being used for these subjects, changes are being made to correct this situation. This aspect may indicate that many CFI systems were installed without knowing to what extent data from CFI would be employed. To some extent, each CFI system must experiment with its data to find further applications for it.

In general, the 23 organizations employing CFI for instruction, research, and/or training reported that this use was providing additional benefits to the organization. Most organizations using their CFI systems for these purposes are located in the Gulf and Lake States regions. Systems established in 1960 are the ones which make most use of their data for this purpose.

Wildlife

The extent to which CFI data are used for wildlife purposes was included in the questionnaire for a twofold purpose:

- (1) To stimulate interest in the possibilities of using permanent plot data for making wildlife studies.
- (2) To find the degree to which wildlife information is considered a part of CFI data.

The potential for making wildlife studies a routine part of CFI is enormous. Studies could be made with ease concerning the effects of animal browsing, damage to vegetation, concentrations of wildlife species, trends in animal populations, and the location of game for hunters. These possibilities should be of high interest to

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the average game manager or hunter. A vast quantity of information that can be checked and rechecked for change and production is available. The current importance being placed on multiple-use forest management, especially by the public agencies, should be sufficient reason to record such information on each sample area. If specific studies are not desired, CFI can at least provide general information on underbrush and stand changes which will be of use to the game manager.

Data in this survey indicate that the forester and game manager do not work together in planning CFI systems. Only 7 systems, one of which is located on private land, mentioned wildlife in any way. Four of these organizations are in the Northeast and Lake States, and 3 of these were established before 1951.

When permanent plot measurements are taken, observations concerning wildlife effects and conditions can be made easily. Even though general wildlife studies may not be conducted adequately, if based on permanent sample plot data alone, much fairly accurate information is available requiring little additional work.

Other Uses

Several additional uses for CFI data were volunteered by various agencies. Among these, measuring change in the forest was mentioned most often. CFI is especially effective in measuring change in cover types such as ecological progressions. It can also be used to evaluate

mensurational techniques, and insect and disease damage. Such data are not usually available from other sources.

Data from permanent plots provide information concerning material available for potential and existing industries and to record commercial drain of forest products. Such information on raw materials can be accurately compiled in a relatively short period of time. Information to facilitate land exchange is also important to some organizations when such information is needed promptly.

A recurring inventory system can also be used to demonstrate forest management possibilities. Aerial volume tables are simple to compile if photographs are available at the time of plot remeasurement.

Undoubtedly, there are other potential and existing uses for CFI. Each forestry concern must fit its system to the existing conditions. Expansion and development of each CFI system must continue as future needs change and as old techniques become obsolete and newer ones are developed.

NON-USERS OF CFI

Results of this survey show that CFI is a proven, successful method of forest inventory, used primarily on large holdings. On areas of less than 50,000 acres, it appears to be somewhat less satisfactory.

Of the 138 private respondents to this survey that do not use CFI and that own or manage over 50,000 acres, 84 worked with at least 100,000 acres. Nearly half of these owners are favorably inclined to

the idea of CFI. Forty-six organizations are planning future CFI systems, and four others are currently installing a recurring type of inventory system (Table 16). Also, six companies owning less than 50,000 acres are planning future CFI systems.

Of those companies reacting favorably to the concept of CFI, 28 report that CFI is too expensive, and 25 state that CFI does not fit their particular type of forest management. Since about half of the non-users of CFI expressed some interest in future CFI installation, present indications are that the current increase in CFI usage will continue.

Companies that plan to install CFI systems in the future are distributed fairly uniformly throughout the United States; however, the largest numbers are located in the Western and Gulf regions. Organizations implying that CFI is too expensive are generally concentrated in the portions of the United States with the smallest number of CFI systems, the Northeast and Western regions. In contrast, the actual users of CFI in these two regions report the expense of CFI as less than that of previous methods of forest inventory.

On federal lands, one of the two U. S. Forest Service regions that does not use CFI plans to install CFI as soon as funds become available. While only 7 of 77 Indian reservations use CFI, they are installed on the larger reservations which have a large percentage of forest land. When funds become available, 4 additional systems are planned for other heavily forested reservations.

Table 16. Attitudes of the non-CFI users in the United States and Canada that own or manage over 50,000 acres of forest land, by ownership class, 1960.

Ownership Class	Reasons for Non-CFI Use										Number of CFI Systems			
	Plan Future CFI	Started CFI	CFI Too Costly	Does Not Fit Management	Await Better CFI	Never Heard of CFI	Studying CFI	Other	Total					
----- Number of CFI Systems -----														
Private:														
Pulp and Paper Corporations	13	1	6	7	4	0	0	0	5	36				
Lumber Companies	17	0	10	12	3	2	1	1	3	48				
Miscellaneous Wood Producers	15	3	12	7	6	2	3	3	6	54				
All Private	45	4	28	26	13	4	4	4	14	138				
State:														
State Forests	9	0	2	6	1	0	1	1	4	23				
Other State	1	3	1	3	1	0	0	0	1	10				
All State	10	3	3	9	2	0	1	1	5	33				
Federal:														
Forest Service Regions	1	0	0	0	0	0	0	0	1	2				
Other Federal	4	0	0	0	0	0	0	0	13	17				
All Federal	5	0	0	0	0	0	0	0	14	19				
All Ownerships	60	7	31	35	15	4	5	33	190					

CFI on state-owned lands is confined to 16 states generally located in the eastern part of the United States. Other CFI systems are planned on land owned by 12 other states, but their initiation will be dependent upon funds being made available through legislation.

Financial considerations are apparently the most common reason for not using CFI on large forest properties. Private corporations often consider CFI too expensive, and public agencies must have future budgeted funds for installing CFI. Other reasons for not using CFI on forested lands are small acreages, and large ownerships composed of small, widely-scattered tracts.

LIMITATIONS OF CFI

During the brief history of CFI in the United States, publications about CFI have generally indicated only how forest inventory with permanent plots has been helpful to forest organizations, and the advantages that CFI has over other comparable forestry activities. While many aspects of CFI present forest facts in a more understandable and reliable manner than similar forestry techniques, it must not be concluded that CFI has no shortcomings or limitations.

As originally developed, CFI was intended to provide a multitude of facts for owners of large forest areas for use in the management of their forests. Measurements taken on individual trees on systematically located permanent sample plots were to be processed by electronic machines. However, there are economic limitations to the uses of CFI data. When a forest organization decides to adopt a system of permanent sample plots, and to adapt this inventory technique to the needs of the forest management program, many of the original objectives of CFI are often ignored or deleted. Organizations which force CFI to conform to specific requirements cannot always expect this type of inventory system to be entirely satisfactory.

In this survey, two of the most frequently quoted limitations of CFI were that its cost is too high, and that information from CFI is applicable only to the entire forest. Permanent plot data are not generally applicable in the management of small stands or sub-compart-

ments. Since the original concept of CFI did not include the management of small areas, it is understandable that CFI has not proven entirely satisfactory in these cases. In the past, the cost of managing a forest in the United States has been very low, mainly because management intensity has been low. An increase in forest management expenditures brought on by a system of permanent plots is not always accepted. However, this survey shows that most users of CFI believe that it not only is more economical, but it provides more information than previous methods, once management decides that the information is worth having.

Other limitations of CFI that were mentioned by several respondents are as follows:

- (1) It is difficult to tally many items of tree and plot data consistently in a uniform manner. This includes such items as tree grade, merchantable height, and operability.
- (2) Biased plot treatment concerns many actual and potential users of CFI.
- (3) CFI is often oversold to top management as a means of answering all forest inventory problems.
- (4) Statistical errors are too large if costs are held to a minimum.
- (5) Human errors are often too large, especially if inexperienced field personnel is used to obtain field data.
- (6) Too much data are commonly taken on each tree and plot.

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- (7) Not enough plots are taken.

Additional general comments concerning CFI were also made as follows:

- (1) Permanent sample plots are initially installed for use without change over an extended period of years; however, future needs of the forest, and consequently, the CFI system, will undoubtedly change. Although it is generally desirable to stress continuity and uniformity of plot and tree data, measurements must sometimes be changed to provide for changes in utilization standards, management practices, and for technological advances in forestry.
- (2) A lack of follow-up has been noticeable in many CFI systems. Good planning for a well-rounded inventory system is wasted if personnel changes or a lag in enthusiasm causes parts of CFI to be deleted from practical use in the future.
- (3) For growth measurement, CFI has the inherent disadvantage that a growth period must elapse before the information becomes available. It also assumes that the growth rate for the future period will proceed at a rate identical to the past period.

Many criticisms of CFI made by obviously more experienced users

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fall into three groups: (1) CFI is useful only for forest management use on entire forest areas, (2) too few plots must be taken if cost is considered, and (3) merchantable height is a rather vague point in many trees.

Every system of forest inventory has its advantages and disadvantages, and CFI is no exception. The organization that initiates CFI must realize its limitations, and decide if this system is the most practical and economical method for its particular situation. Once CFI is established, the inadequacy of each system will be revealed in at least one of the three following ways:

- (1) Satisfaction with part or all of the original system will be subnormal;
- (2) Changes and improvements in the original system will be made to correct the difficulties; or,
- (3) The CFI system will be abandoned.

Suggested Changes and Improvements Needed in CFI

For continuity to dominate forest inventory, easily located permanent sample plots must be established and remeasured carefully at periodic intervals. The data recorded on each plot must satisfy the needs for information on the forest. Measurements must be made on exactly the same trees in exactly the same manner at each reinventory. Thus, considerable thought to the future must be given to the measurements taken, because any change after the first measure-

ment disrupts the concept of continuity.

Almost half the respondents in this survey reported that changes had already been made in the initial CFI system or were being planned. These changes may be due to inadequate planning prior to establishing CFI. Another reason is that technological improvements have shown how to manipulate field data more effectively. An example of such an improvement is the recently developed port-a-punch for recording field data.

Changes that were most commonly mentioned are as follows:

- (1) A shift from plots to points was often suggested. Such a change requires the establishment of an almost completely new CFI system including new programs for the computers; therefore, it has seldom been made.
- (2) There is a need for more plots to obtain more specific information pertaining to small stands and sub-compartments, and to increase the statistical accuracy. Four times as many samples are required to cut the sampling error in half. Even more samples are needed to enable forest management with CFI data to be carried down to the stand. Therefore, the expense involved in increasing the sample to that desired, is generally too great for the large forest properties.
- (3) Less data per plot is suggested to reduce costs and to permit taking more plots with the same budget. If a

smaller number of actual field measurements is selected prior to installing permanent plots, or if measurements taken but not utilized in established CFI systems are deleted, the continuity of CFI is not affected. But if a change in procedure is devised in an operating CFI system which uses fewer field measurements for compiling desired information, the measurement of change in the forest, and the continuity of CFI will be broken.

- (4) Better type maps are needed prior to establishing CFI. This will help in locating plots, and will eliminate the need for combining type mapping with CFI activities. Greater use of aerial photographs would be helpful in this respect.
- (5) Changes in the method of recording field data are fairly common. Since none of the actual field measurements is affected by a new process of field tally, the continuity of CFI is not affected.

In several CFI systems, the stipulation is made that modifications will be made as soon as they become necessary. Theoretically, this stipulation departs from the rigid framework of CFI, and allows a more flexible system to be maintained. However, a modification may cause added dilution of continuity which is a basic concept of CFI. A large number of modifications may cancel many of the advantages of permanent plots.

1. Introduction

The purpose of this study is to investigate the effects of the implementation of the new curriculum on the learning outcomes of students in the field of Mathematics. The study is based on a sample of 100 students from a secondary school in the city of Istanbul. The data was collected through a series of tests and questionnaires administered over a period of six months. The results of the study show that the implementation of the new curriculum has led to a significant improvement in the learning outcomes of the students. This is particularly evident in the areas of problem-solving and critical thinking. The study also found that the new curriculum has led to a more active and engaged learning environment. This is due to the fact that the new curriculum emphasizes the use of real-world examples and the application of mathematical concepts to solve problems. The study concludes that the implementation of the new curriculum has been successful in improving the learning outcomes of the students. This suggests that the new curriculum is a valuable tool for improving the quality of education in the field of Mathematics.

2. Methodology

The study was conducted using a quantitative research design. The data was collected through a series of tests and questionnaires administered over a period of six months. The tests were designed to measure the students' understanding of the concepts covered in the new curriculum. The questionnaires were designed to measure the students' attitudes towards the new curriculum and their perceptions of the learning environment. The data was analyzed using statistical methods to determine the significance of the results. The study found that the implementation of the new curriculum has led to a significant improvement in the learning outcomes of the students. This is particularly evident in the areas of problem-solving and critical thinking. The study also found that the new curriculum has led to a more active and engaged learning environment. This is due to the fact that the new curriculum emphasizes the use of real-world examples and the application of mathematical concepts to solve problems. The study concludes that the implementation of the new curriculum has been successful in improving the learning outcomes of the students. This suggests that the new curriculum is a valuable tool for improving the quality of education in the field of Mathematics.

Several proposed modifications deal with sampling procedures. Some forest managers with systematically located plots believe their areas are better suited to randomly located plots, and vice versa. Several forest owners desired clustered plots, rather than single plots, while some with clustered plots wanted single plots.

Other suggestions for improving CFI include the following:

- (1) Map out unproductive areas like roads, water, and administrative units.
- (2) Take all measurements in a single year if possible.
- (3) Use a field survey book for describing plot locations.
- (4) Make CFI systems more uniform so that comparisons with other installations can be made.

All actual and proposed changes reported by the respondents of this survey, except those referring to the port-a-punch system of field tally, involve aspects of CFI that were present at the time of its establishment on a given area. Thus, changes are made because the forester is dissatisfied with some component in question, because the proper information cannot be computed easily from the field data, or because other CFI organizations have displayed more appropriate ways of taking field data or of processing the information. Most of these cases imply that changes usually can be eliminated by planning more thoroughly the composition and field design of the CFI system before it is installed.

One of the greatest needs in CFI is a common communication

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author to the reader, in which he explains the purpose of the

document and the reasons for its existence.

2. The second part of the document is a list of the

main points of the document, which are as follows:

3. The third part of the document is a detailed

discussion of the main points of the document.

4. The fourth part of the document is a conclusion

in which the author summarizes the main points of the

document and expresses his final thoughts.

5. The fifth part of the document is a list of

references, which are as follows:

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medium for its users. The monthly U. S. Forest Service publication, "Forest Control by Continuous Inventory," written and edited by C. B. Stott, provides an excellent means of disseminating information about CFI. However, this series is mainly concerned with CFI development in the Lake States region. Without doubt, each organization with CFI, regardless of its regional location, has encountered and solved many problems not mentioned in any publication. For example, the need has been recognized that reproduction counts must be made in portions of the plot away from the much trampled area surrounding the plot center. Exchange of such information would be of interest and use to any firm contemplating or currently using CFI.

Finally, there is a need to make economic analyses of continuous inventory systems. Such analyses should include not only initial installation costs, but also subsequent operating charges, so that CFI costs can be compared more directly with costs of other forest inventory and management techniques. Specific suggestions for modifying the components of CFI could also be made based on the results of such analyses.

How Satisfactory is CFI?

In the published proceedings of various short-courses and meetings on CFI over the past decade, and in various other published reports on the merits of CFI, very few statements are included regarding any shortcomings or disadvantages of continuous forest inventory systems. In this survey, however, the statements of forest managers who actually

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work with data from permanent plots show that the satisfaction with CFI is not complete.

Most of the respondents admit that data from permanent plots cannot be used to fulfill completely the objectives for which it was installed. Others reported they are disappointed with the small amount of forest information that can be compiled from the field measurements.

To obtain an average satisfaction rating for each use or purpose of CFI, values as follows were assigned to the four ratings: Unsatisfactory = 1, Barely Satisfactory = 2, Satisfactory = 3, and Highly Satisfactory = 4. The average rating for each use indicates the relative value placed on that use by the organization using this item (Table 17). When compared to the mean of 2.50 for the basic ratings, all purposes or uses show ratings above average.

Some of the items with the highest satisfaction rating are used by only a comparatively small number of CFI systems. This emphasizes the tremendous influence that forest management objectives exert on the value of information obtained from permanent plots. When continuous inventory systems are specifically designed to provide data for certain management objectives, there seems to be greater confidence in the reliability of the results, and consequently, high satisfaction ratings. On the other hand, one of the lowest satisfaction ratings is that for growth, one of the most frequently applied uses of CFI. This may indicate that precise growth estimates are not as important as was originally considered before CFI was installed. It may also indicate

Table 17. Satisfaction rating of CFI purposes and uses, 1960.

Purpose or Use	Number of Ratings ^{1/}	Average Rating
Instruction	13	3.54
Local Volume Table	14	3.36
Tax	18	3.22
Wildlife	5	3.20
Inventory	57	3.16
Administrative Management	54	3.15
Ingrowth	42	3.14
DBH - Height - Volume Curves	23	3.13
Mortality	43	3.12
Cutting Budget	46	3.02
Stand and Stock Tables	49	3.02
Type or Class	36	2.97
Top Woodland Management	51	2.96
Stand Classification	36	2.94
Growth	48	2.94
TSI and Planting	27	2.78
Timber Operating Schedules in Specific Areas	20	2.70
All Ratings	582	3.02

^{1/} This column includes only respondents who rated each use or purpose.

that growth from continuous inventory data may often be difficult to compute if all measurements needed for its calculation are assumed to have been taken but were not specifically included when the plots were established.

The highest satisfaction rating given any use of CFI data was for making local volume tables. The ease of compiling local volume tables from permanent sample data is apparent from the fact that every CFI user making such tables reported a satisfactory or highly satisfactory rating for this use. Another exceptionally high satisfaction rating was expressed with the use -- teaching, research, and/or training. All educational institutions announced they were well satisfied with this use. In addition, almost three-fourths of the 23 organizations employing CFI for teaching, research, or training rate this use as highly satisfactory.

Satisfaction with Plot and Tree Data

The satisfaction with use of plot and tree data was evaluated in the same way as were the major CFI uses. While more ratings were made for plot data, the satisfaction with tree data is generally greater than with plot data. The greater satisfaction with tree data is largely due to the more common use of measurements taken directly on trees. Also, a smaller number of widely accepted measurements describe a tree adequately, in contrast to a wider range of less uniform items generally recorded for a plot.

In Tables 18 and 19, items most commonly recorded on both plot and tree cards are arranged in decreasing order of use. In Table 20, plot and tree items are arrayed by satisfaction of usage, disregarding the total number of ratings. From these tables, it is apparent that current CFI users are better satisfied with plot and tree data items that are included in the survey with a definite purpose. In other words, an organization that includes items such as tree value or form class in their measurements does so with a given purpose. Thus, that company is generally well satisfied with the results obtained.

A summary of the significant findings in the plot and tree data ratings is as follows:

Plot Data:

- (1) Density, and Stand Age or Size showed the highest combined usage and satisfaction rating. Over half of the respondents reported satisfactory or highly satisfactory ratings for these items. Condition Class had the highest individual satisfaction rating, but it was recorded less often than Density or Stand Age or Size. These 3 items apparently are considered to be the most valuable means of describing timber stands.
- (2) Reproduction, and Site Class receive moderate usage and satisfaction ratings. However, there is a need for a more efficient method for evaluating reproduction which will adequately express both density and distribution of

• *How can we make the most of the time we have?*

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Table 18. Plot data recorded, and satisfaction expressed by CFI users, by ownership class, 1960.

Plot Item	Private (70 Users)				State (22 Users)				Federal (13 Users)				All Ownerships (105 Users)			
	Owners Who Record		Owners Who Were Satis- fied/		Owners Who Record		Owners Who Were Satis- fied/		Owners Who Record		Owners Who Were Satis- fied/		Owners Who Record		Owners Who Were Satis- fied/	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Stand Age or Size	57	81	53	86	19	86	54	54	12	92	62	62	88	84	54	54
Reproduction	61	87	41	64	14	64	36	36	9	69	46	46	84	80	41	41
Site Class	52	74	37	91	20	91	46	46	10	77	54	54	82	78	41	41
Density	52	74	53	82	18	82	54	54	10	77	54	54	80	76	54	54
Condition Class	44	63	41	64	14	64	41	41	8	62	38	38	66	63	41	41
Silvicultural Treatment	40	57	30	54	12	54	36	36	7	54	38	38	59	56	32	32
Operability	34	49	21	50	11	50	27	27	7	54	31	31	52	50	24	24
Soil Type	21	30	14	32	7	32	14	14	3	23	15	15	31	30	14	14

1/ This column includes the respondents who indicated a satisfactory or highly satisfactory rating.

Table 19. Tree Data recorded, and satisfaction expressed by CFI users, by ownership class, 1960.

Tree Item	Private (70 Users)				State (22 Users)				Federal (13 Users)				All Ownerships (105 Users)			
	Owners Who Record		Owners Who Were Satis- fied ^{1/}		Owners Who Record		Owners Who Were Satis- fied ^{1/}		Owners Who Record		Owners Who Were Satis- fied ^{1/}		Owners Who Record		Owners Who Were Satis- fied ^{1/}	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cull Class	63	90	56	91	20	91	50	50	12	92	62	62	95	90	55	55
Merchantable Height	60	86	49	86	19	86	59	59	10	77	54	54	89	85	51	51
Tree Vigor	56	80	51	77	17	77	50	50	9	69	46	46	82	78	50	50
Tree Quality	56	80	49	77	17	77	54	54	7	54	8	8	80	76	45	45
Total Height	42	60	33	55	12	55	27	27	6	46	38	38	60	57	32	32
Form Class	15	21	16	36	8	36	27	27	3	23	23	23	26	25	19	19
Tree Value	7	10	6	18	4	18	14	14	2	15	15	15	13	12	9	9
Crown Diameter	2	3	1	18	4	18	14	14	0	0	0	0	6	6	4	4

^{1/} This column includes the respondents who indicated a satisfactory or highly satisfactory rating.

Table 20. Satisfaction ratings for CFI plot and tree data, 1960.

Item	Number of Ratings ^{1/}	Average Rating
<u>PLOT DATA</u>		
Condition Class	46	3.04
Density	58	3.02
Stand Age or Size	63	2.98
Silvicultural Treatment	40	2.85
Reproduction	57	2.82
Site Class	59	2.80
Operability	36	2.78
Soil Type	23	2.61
All Plot Items	382	2.89
<u>TREE DATA</u>		
Form Class	21	3.24
Tree Value	9	3.22
Tree Vigor	57	3.09
Merchantable Height	60	3.08
Total Height	40	3.08
Cull Class	64	3.06
Tree Quality	52	3.06
Crown Diameter	5	2.80
All Tree Items	308	3.09

^{1/} This column includes only respondents who rated each item.

• • •



seedlings. Site Class is widely used, but the moderate satisfaction rating indicates a widespread need for an acceptable, reliable measure of site quality.

- (3) Operability, and Soil Type are plot items with small utility and poor satisfaction ratings when compared to the other items. Even so, these data may provide valuable information to some forestry organizations.

Tree Data:

- (1) The highest degree of satisfaction was expressed for Tree Vigor, Form Class, and Tree Value. Of these 3 items, only Tree Vigor was recorded and used by an appreciable percentage of the respondents.
- (2) Over half of the total respondents gave a satisfactory or highly satisfactory rating to Cull Class, Merchantable Height, and Tree Vigor. It appears that these 3 characteristics provide the most valuable means of evaluating each tree.
- (3) While Total Height had only an average satisfaction rating, CFI systems in Canada, the Western, and South-eastern regions, as well as systems established in 1960, generally gave it a highly satisfactory rating.
- (4) The lowest satisfaction rating was given to Crown Diameter. Cull Class also received very low ratings by systems established after 1957.

The utility of CFI in adequately providing data for managing the forest apparently is satisfactory to the majority of CFI users. Individual measurements or elements of CFI may not be satisfactory for some forest management systems, but total results indicate general satisfaction with CFI.

Abandoned CFI Installations

Two CFI systems, both located in the Western region on less than 50,000 acres, have been abandoned. Reasons given for abandonment in both cases were that the systems had been poorly installed. Remarks on one questionnaire stated that poor paint used in marking trees had faded, and that permanent plot data had not been fully utilized.

The inability of foresters to foresee and predict all the problems that accompany a continuous inventory system is of concern to all current and prospective CFI users. Once a system is established, changes are difficult and expensive to make; therefore, the planning process must be inquisitive and thorough. A complete study of each component of CFI before installing the plots will resolve most major problems. Even if mistakes are made in planning a CFI program, the hasty evaluation and summary rejection of a complete CFI system because of a few miscalculations, before the full potential of the system has an opportunity to materialize, may easily nullify much fruitful thinking and a potentially sound CFI system.

THE AVERAGE CFI SYSTEM

When any organization contemplates establishing a new system of business management, one of the first steps in the planning process is to study the contents and utility of other similar systems. All current information concerning the utility of CFI data indicates that permanent plots provide information needed in managing the forest. An outline of an average CFI system may help the forest manager decide whether or not to install a continuous inventory system, and what measurements to take which will satisfy his forest management needs and objectives.

An average of all CFI systems can also be used as a standard for comparing established CFI systems. Weak elements of operating systems can sometimes be identified in this manner. Each part of an active CFI system must serve a specific purpose of forest management. Before any single measurement can have value in a given system, regardless of its value in others, it must satisfy some need in the forest management program. This need is generally related to the forest management objectives.

From the data of this survey, an average for each component of CFI was computed, by region, type of ownership, and specified years of establishment (Tables 21 and 22). While there is general uniformity for most items in the categories shown, the largest deviations occur

Table 21. Average CFI systems in the United States and portions of Canada, by ownership types and selected years, 1960

Components of CFI	Ownership Types			All Owner- ships	Years	
	Private	State	Federal		Before 1952	1960
Number of Systems	70	22	13	105	11	19
Cost of CFI	Less	More	More	Less	More	More
First Remeasurement Interval (years)	4.3	5.2	7.6	4.9	6.2	4.5
Subsequent Intervals (years)	4.8	5.4	9.2	5.4	7.1	5.2
Plot Size (acres)	0.26	0.22	0.23	0.25	0.37	0.19
Percent Systematic Plots	65.7	63.6	38.4	61.9	60.0	63.2
Average Number Plots per Cluster	1.4	1.4	1.6	1.4	1.6	1.1
Percent Stratifying Plots	15.7	35.4	53.8	24.8	27.3	5.3
Percent With Hidden Plots	15.7	9.1	7.7	13.3	0.0	15.3
Average Number of Plots	1,059	776	3,000	1,306	3,485	785
Acres per Plot	387	340	818	447	820	299
Statistical Accuracy (percent)	7.61	7.88	8.18	7.75	8.12	8.57
Tally Methods <u>1/</u>	FT	MS FT	FT	FT	FT	FT PP
Most Important Use	Inven.	Inven. Growth Mort.	Inven. Cutting Budget	Inven.	Inven. Growth Mort.	Inven.
Most Important Plot Data	Repro. Cull	Site Cull	Size Cull	Size Cull	Site Cull	Repro. Mer. Ht.
Most Important Tree Data	Cull	Cull	Cull	Cull	Cull	Mer. Ht.

1/ Field Tally is abbreviated FT, Mark Sense by MS, and Port-a-Punch by PP.

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Table 22. Average CFI systems in the United States and portions of Canada, by regions, 1960.

Components of CFI	Regions								
	Atlan- tic	Calif.	Canada	Central	Gulf	Lake	North- east	South- east	West
Number of Systems	11	11	2	7	16	17	4	23	14
Cost of CFI	Same	More	Same	More	Less	Less	Less	Less	Less
First Remeas. Interval (yrs)	3.6	5.5	5.0	4.4	4.5	4.9	6.0	3.6	8.2
Subsequent Interval (yrs)	4.3	4.8	5.0	5.0	5.0	5.3	5.0	4.4	7.7
Plot Size (acres)	0.28	0.45	0.20	0.19	0.28	0.19	0.21	0.19	0.28
Percent Systematic Plots	45.4	63.6	50.0	71.4	68.8	64.7	75.0	56.5	71.4
Average Plots per Cluster	1.00	1.18	4.50	1.17	1.00	2.00	1.00	1.18	2.29
Percent Strati- fying Plots	27.3	54.5	50.0	14.3	12.5	5.9	25.0	8.7	42.9
Percent With Hidden Plots	9.1	10.0	0.0	31.2	5.9	0.0	0.0	13.0	14.3
Average Number of Plots	390	453	6500	427	294	998	1471	1397	1339
Acres per Plot	334	230	960	128	398	363	877	395	798
Statistical Accuracy (%)	5.5	6.2	7.5	11.0	7.7	7.2	7.5	7.9	6.7
Tally Methods <u>1/</u>	FT	FT MS	FT	MS	MS	MS	FT	PP	FT
Most Important Use	Grth Inven	Inven	Inven	Grth Mort	Grth	Inven	Grth Mort	Inven	Inven
Most Important Plot Data	Size	Site	Size	Site	Repro	Size Dens	Silv	Repro	Size
Most Important Tree Data	Mer Hgt	Cull Vigor	Tot Hgt	Qual	Mer Hgt	Vigor	Cull	Mer Hgt	Mer Hgt

1/ Abbreviations are FT for Field Tally, MS for Mark Sense, and PP for Port-a-Punch.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters. The text suggests that organizations should implement robust systems to track every detail, from small expenses to major investments.

2. The second part of the document addresses the challenges of data management in a rapidly changing environment. It highlights the need for flexible and scalable solutions that can adapt to new technologies and evolving data requirements. The author argues that investing in modern data infrastructure is crucial for staying competitive and making informed decisions.

3. The third part of the document focuses on the role of leadership in driving organizational success. It stresses that effective leaders must inspire their teams, set clear goals, and foster a culture of innovation. The text provides several examples of successful leadership practices and offers practical advice for aspiring leaders.

4. The fourth part of the document explores the impact of globalization on business operations. It discusses the opportunities and challenges posed by international markets and the need for organizations to develop a global mindset. The author suggests that embracing diversity and cross-cultural collaboration can lead to significant growth and innovation.

5. The fifth part of the document discusses the importance of continuous learning and development. It argues that in a fast-paced world, individuals and organizations must constantly update their skills and knowledge to remain relevant. The text offers various strategies for promoting a learning culture, such as providing training opportunities and encouraging self-directed learning.

6. The sixth part of the document addresses the issue of sustainability and its impact on business. It highlights the growing importance of environmental, social, and governance (ESG) factors in decision-making. The author suggests that organizations should integrate sustainability into their core business strategy to create long-term value and reduce risk.

7. The seventh part of the document discusses the role of technology in transforming business processes. It explores how digital tools and automation can improve efficiency and productivity. The text also touches on the challenges of digital transformation, such as data security and talent acquisition, and offers solutions to overcome these obstacles.

8. The eighth part of the document focuses on the importance of customer experience. It argues that in a competitive market, providing exceptional customer service is a key differentiator. The text provides insights into how organizations can gather customer feedback and use it to improve their products and services.

9. The ninth part of the document discusses the importance of financial management and budgeting. It emphasizes that sound financial practices are essential for the long-term survival and growth of any organization. The author offers practical advice on how to create and manage a budget effectively.

10. The tenth and final part of the document provides a summary of the key points discussed throughout the text. It reiterates the importance of maintaining accurate records, embracing change, strong leadership, globalization, continuous learning, sustainability, technology, customer experience, and financial management. The author concludes by expressing optimism about the future and encouraging readers to take action on the advice provided.

in systems on federal ownerships, and in those in the Central and Northeast regions. The large size of most federal ownerships is the cause of many of these differences. In the Central and Northeast regions, the small number of systems, the preponderance of merchantable hardwood timber, and the early establishment of CFI systems, are general reasons for the deviations found in these 2 regions.

THE FUTURE OF CFI

As a basic tool in forest management, CFI is firmly established in American forestry practice. Despite some limitations, the satisfaction with using recurring inventory systems is very high, and the number of new systems has increased steadily each year.

In forestry, any rigid management procedure has usually enjoyed only brief popularity. Thus, future CFI systems will probably deviate from the rigidity that is currently advocated by some of its strong proponents. Deviations will probably involve the number and type of measurements taken on sample locations, or the techniques used to select sample areas.

Future sampling designs will be: (1) similar to present systems, with well distributed samples on which a fairly large number of items are periodically measured; (2) more complicated, with more field measurements taken on each sample; or (3) simpler systems with fewer observations per sample and/or less samples.

Each continuous inventory system is tailored to fit a given forest

QUESTION

1. The following table shows the number of people who attended the 2010 World Cup in South Africa, categorized by country and gender. The data is presented in a 2x2x2 contingency table, where the first two dimensions represent gender (Male/Female) and the third dimension represents country (USA/Other). The rows represent the gender categories, and the columns represent the country categories. The values in the table are the number of people who attended the event.

Gender	Country	Number of People
Male	USA	120
Male	Other	180
Female	USA	90
Female	Other	150

2. The following table shows the number of people who attended the 2010 World Cup in South Africa, categorized by country and gender. The data is presented in a 2x2x2 contingency table, where the first two dimensions represent gender (Male/Female) and the third dimension represents country (USA/Other). The rows represent the gender categories, and the columns represent the country categories. The values in the table are the number of people who attended the event.

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management program. As long as this program remains relatively unchanged, the initial procedure should provide information adequate for achieving the forest management objectives. But, if management objectives or techniques change, an inflexible CFI system may become less useful, and eventually become obsolete. Adequate consideration of future needs during the planning of CFI will prolong its usefulness. But even so, a forest inventory system cannot be truly continuous unless provisions are made in the original framework for changes and modifications as they become necessary.

To minimize the number of future changes required in a CFI system, data could be taken on all dimensions and characteristics of the forest that might have possible use in present or future forest management practices. Such a procedure would be costly, but would eliminate future changes in recording field data. However, much of the data in such a system probably would not be used.

CFI can be intensified by taking more samples, or by using sampling designs more complicated than the customary systematic design. More plots may provide statistically reliable data for relatively small subdivisions of the forest. Unless the amount of information taken on each plot is reduced to a minimum, however, it would not be economically feasible to measure enough plots for reliable data on a forest subdivision as small as a compartment.

A double-sampling concept of remeasurement with partial replacement of samples is being applied in portions of the Forest

The Role of the Teacher

The teacher is the central figure in the classroom, responsible for creating a positive learning environment and facilitating student growth. This role is multifaceted, encompassing various responsibilities that go beyond simply delivering content. The teacher acts as a guide, mentor, and facilitator, helping students develop critical thinking skills, problem-solving abilities, and a love for learning. They are also responsible for assessing student progress and providing feedback to help them improve. The teacher's role is to ensure that every student has the opportunity to succeed and reach their full potential. This involves understanding each student's unique needs and strengths, and tailoring instruction accordingly. The teacher is also a role model, demonstrating the values and attitudes they want to see in their students. They are responsible for creating a safe and supportive classroom where students feel comfortable taking risks and asking questions. The teacher's role is to inspire and motivate students, helping them develop a growth mindset and a belief in their own abilities. They are also responsible for fostering a sense of community and collaboration among students, encouraging them to work together and support each other. The teacher's role is to ensure that the classroom is a place where every student can thrive and learn.

The teacher's role is also to ensure that the classroom is a place where every student can thrive and learn. This involves creating a positive learning environment that is safe, supportive, and engaging. The teacher is responsible for setting clear expectations and rules, and enforcing them consistently. They are also responsible for providing a variety of learning experiences that cater to different learning styles and interests. The teacher is also responsible for assessing student progress and providing feedback to help them improve. This involves using a variety of assessment methods, including formative and summative assessments, and providing specific and constructive feedback. The teacher is also responsible for fostering a sense of community and collaboration among students, encouraging them to work together and support each other. This involves creating opportunities for group work and peer learning, and encouraging students to share their ideas and experiences. The teacher's role is to ensure that every student has the opportunity to succeed and reach their full potential. This involves understanding each student's unique needs and strengths, and tailoring instruction accordingly. The teacher is also responsible for being a role model, demonstrating the values and attitudes they want to see in their students. They are responsible for creating a safe and supportive classroom where students feel comfortable taking risks and asking questions. The teacher's role is to inspire and motivate students, helping them develop a growth mindset and a belief in their own abilities. They are also responsible for fostering a sense of community and collaboration among students, encouraging them to work together and support each other. The teacher's role is to ensure that the classroom is a place where every student can thrive and learn.

Service's Forest Survey (Bickford, 1959). An excellent theoretical examination of continuous forest inventory with partial replacement of samples was made by Ware and Cunia (1962) when they proved mathematically several of the basic concepts of this method. However, while it can be proven mathematically that statistical formulas applicable to random samples should not be applied to systematic samples, most standard timber cruises still use a systematic location of samples. In the same manner, it is doubtful if private forestry concerns will turn from their present methods for locating permanent samples to this more recently developed concept of partial replacement of samples.

Stratified sampling, double-sampling, or a combination of both, are other possibilities for increasing the efficiency and reliability of CFI data. On large forest properties with only a few major forest types, stratified plot location may be feasible. Grosenbaugh (1959) advocates a relatively small number of permanent plots combined with additional temporary point-samples in areas where forestry operations are planned in the near future. These procedures may permit greater freedom in obtaining desired data, but they do not comply with customary CFI practices.

The concept of CFI includes the assumption that each item of data will be taken again at each remeasurement. However, some measurements need be taken only once since they are relatively stable, or they can be correlated with other data. Sample observations such as soil type, form class, and tree heights need be measured only once for a

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specific forest area. Individual studies, apart from CFI, can be made to obtain such data, so that these items can be removed from remeasured permanent plot data. Such a procedure would result in a more simplified CFI system in which species, d.b.h., and possibly a "cut or leave" classification would be the only items recorded. Thus, more samples could be taken, thereby increasing the statistical accuracy, without increasing the cost.

The number of new CFI systems established annually will probably continue to be relatively large, at least for the next several years. These will be primarily on smaller forest properties than previously because many of the larger forest organizations already have CFI, and there is a noticeable recent trend toward using CFI on forest properties smaller than 50,000 acres. In future systems, the number of items taken at each sample location will probably remain the same or be slightly reduced. The one-fifth-acre plot will still be common, but there is a definite trend toward the use of point-samples. Sampling designs will likely continue to be systematic, even though stratified and random sampling may be statistically more reliable. A longer interval between remeasurements, especially after the first interval, is also likely.

Permanent plot data will continue to be used for the same basic purposes. However, it will increasingly be recognized that CFI is a method of gathering forest facts to be used in the management of the forest, and not a method of forest management in itself.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities related to the project.

2. It also emphasizes the need for regular communication and reporting to ensure that all stakeholders are kept informed of the project's progress.

3. The document further outlines the various roles and responsibilities of the project team members, as well as the expected outcomes of the project.

4. Finally, it provides a detailed overview of the project's budget and financial resources, including a breakdown of the costs and a timeline for the project's completion.

5. The document also includes a section on risk management, which identifies potential risks and provides strategies for mitigating them.

6. In addition, it discusses the importance of maintaining a high level of transparency and accountability throughout the project's lifecycle.

7. The document further outlines the various communication channels and tools that will be used to facilitate the project's progress.

8. It also provides a detailed overview of the project's timeline, including key milestones and deadlines.

9. Finally, it includes a section on the project's evaluation and feedback mechanisms, which will be used to assess the project's performance and identify areas for improvement.

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CONCLUSIONS

CFI is a relatively new concept of forest inventory and management, based on sound business principles and scientific achievements that appeals to the field forester, the top woodland manager, and to administrative personnel who deal with forestry problems and records. Scientific techniques developed in other fields, such as high-speed electronic computing, are used to eliminate the drudgery of office work, and to make possible the processing of voluminous data required to properly inventory and classify investments in timber and land. Data concerning the contents of the forest are available quickly without need for a specific, long-term study of any forest attribute.

To select the most outstanding contribution of CFI is a difficult task. First place should probably go to the influence of CFI in bringing about more intensive forest management practices in North America. Through the use of permanent sample plot data, the intensity of forest management on large private landholdings has progressed more since the origin of CFI than during any similar period in all the previous history of forestry in North America. Data from permanent plots can provide detailed forest information that may not be found even in precise experimental work. If all the data obtained in CFI were thoroughly analyzed and the results used in forestry practice, the intensity of forest management in North America would

probably exceed that in Europe. Unfortunately, much data are computed, compiled, and filed away, not used. Frequently, only a fraction of the information is used by the forest manager.

While a recurring inventory system can provide the data necessary for intensifying forest management, the interpretation and use of this information may be a formidable work load for each organization. Throughout the development and use of each CFI system, its design, and the items measured in the field, are tailored to fit the needs of the forestry enterprise. With widely diversified timber types and management objectives among forestry concerns in North America, it is probable that no two CFI systems are identical. This survey found that when a company installed identical CFI systems on two separate areas under different forest managers, different uses were made of the CFI data, and different conclusions were reached. Probably the only characteristic common to all CFI systems was the compilation of permanent plot data for the total forest area. This procedure gave rise to a common complaint by forest managers that data from permanent plots was unsuitable for use in managing individual stands. Apparently, CFI was installed in many cases without recognizing the basic consideration that the data normally provide facts concerning the entire forest only. Organizations that did not expect CFI to solve all their inventory problems nevertheless decided that it could supply information valuable enough to justify its installation and maintenance.

Some periodic inventory systems are supplemented by other in-

• *Staphylococcus aureus* is a Gram positive cocci, which is found in the skin and nasal cavity of humans. It is a facultative anaerobe, which means it can grow in the presence or absence of oxygen. It is a pathogen, which means it can cause disease. It is a common cause of skin infections, such as abscesses, boils, and impetigo. It is also a common cause of food poisoning, such as staphylococcal enteritis. It is a common cause of hospital-acquired infections, such as pneumonia, sepsis, and endocarditis.

• *Streptococcus pneumoniae* is a Gram positive cocci, which is found in the lungs and blood of humans. It is a facultative anaerobe, which means it can grow in the presence or absence of oxygen. It is a pathogen, which means it can cause disease. It is a common cause of pneumonia, such as community-acquired pneumonia. It is also a common cause of meningitis, such as pneumococcal meningitis. It is a common cause of sepsis, such as pneumococcal sepsis.

• *Escherichia coli* is a Gram negative rod, which is found in the intestines of humans. It is a facultative anaerobe, which means it can grow in the presence or absence of oxygen. It is a pathogen, which means it can cause disease. It is a common cause of food poisoning, such as enteric fever. It is also a common cause of urinary tract infections, such as cystitis. It is a common cause of hospital-acquired infections, such as pneumonia, sepsis, and endocarditis.

• *Salmonella enterica* is a Gram negative rod, which is found in the intestines of humans. It is a facultative anaerobe, which means it can grow in the presence or absence of oxygen. It is a pathogen, which means it can cause disease. It is a common cause of food poisoning, such as enteric fever. It is also a common cause of urinary tract infections, such as cystitis. It is a common cause of hospital-acquired infections, such as pneumonia, sepsis, and endocarditis.

• *Shigella flexneri* is a Gram negative rod, which is found in the intestines of humans. It is a facultative anaerobe, which means it can grow in the presence or absence of oxygen. It is a pathogen, which means it can cause disease. It is a common cause of food poisoning, such as enteric fever. It is also a common cause of urinary tract infections, such as cystitis. It is a common cause of hospital-acquired infections, such as pneumonia, sepsis, and endocarditis.

• *Shigella sonnei* is a Gram negative rod, which is found in the intestines of humans. It is a facultative anaerobe, which means it can grow in the presence or absence of oxygen. It is a pathogen, which means it can cause disease. It is a common cause of food poisoning, such as enteric fever. It is also a common cause of urinary tract infections, such as cystitis. It is a common cause of hospital-acquired infections, such as pneumonia, sepsis, and endocarditis.

• *Shigella dysenteriae* is a Gram negative rod, which is found in the intestines of humans. It is a facultative anaerobe, which means it can grow in the presence or absence of oxygen. It is a pathogen, which means it can cause disease. It is a common cause of food poisoning, such as enteric fever. It is also a common cause of urinary tract infections, such as cystitis. It is a common cause of hospital-acquired infections, such as pneumonia, sepsis, and endocarditis.

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ventory activities; in other cases, data from permanent plots are used to supplement other inventory information.

Most trends in CFI usage indicate that this procedure is well established, and its application will continue to increase. At the time of this survey, several additional forestry concerns were planning to install CFI, either immediately, or in the near future. Some organizations are reluctant to invest in a recurring inventory system until further proof of its utility and value becomes available. Since most reports on the applications of CFI are favorable, its adoption by more and more forestry organizations appears assured.

Specific trends apparent in CFI procedures are as follows:

(1) Use of point-samples instead of fixed-radius plots is increasing rapidly. While the number of systems using point-samples is still small (12 systems in 1960), all those using point-samples were installed since 1956.

(2) Systematically located plots without stratification or clustering still predominate, although several organizations use randomization and stratification in their plot location. The basic objective of CFI, which is long-term measurement of change, can be adequately achieved with systematic, unstratified location procedures. However, statistically more reliable results may be achieved by double-sampling techniques with partial replacement of samples.

(3) Hidden plots have become more common since 1957. Hidden plots are used to eliminate the possibility of biased plot treatment

and to achieve identical treatment of the plot and its surrounding area. Forest managers who are using hidden plots apparently are well satisfied with their results.

(4) The more recently established systems (1957 to 1960) have tended to ignore statistical procedures for determining the required number of samples to achieve a desired accuracy level. This may indicate inadequate planning prior to plot installation, or the number of sample plots is limited by budgetary considerations, regardless of the resultant statistical accuracy. When statistical limits of accuracy are applied, a sampling error of approximately 5 percent is most common. For calculating statistical accuracy, volume data, not area data, are the basic values used.

(5) While field listing continues to be the major method of recording data, mark sensing and port-a-punching are increasing steadily. Resistance to change, recognition of some disadvantages in mark sense and port-a-punch procedures, and the hope that a more advanced technique will be developed for transferring field data directly to tabulating cards, are the reasons for the continued use of field listing as the most common data recording method.

(6) Electronic computers used by forestry concerns are almost exclusively IBM machines. The help given forestry organizations by International Business Machines personnel is one of the major reasons why IBM is the most common electronic computer used in forestry work. Several smaller ownerships used desk calculators for compiling their

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data. As simpler and more uniform CFI systems are developed, with universal pre-written computer programs, more small forest ownerships (50,000 acres or less) will invest in permanent plots and have their data analyzed by renting computer equipment.

(7) Remeasurement intervals are longest in the Western region and on public lands, and shortest in the South and on private lands. A short interval generally shows a better correlation between surveys, makes growth data available earlier, and permits errors to be corrected sooner. The reduced costs and more representative data obtained with longer intervals, however, suggest that longer intervals may become more common in the future. A compromise is often reached, with a short interval between the first two measurements, and a longer period between subsequent measurements.

(8) Most respondents expressed satisfaction with their uses of CFI data, including individual plot and tree items. The greatest satisfaction, however, was usually achieved for items included in the CFI system for a specific purpose. An organization considering installing CFI would do well to review critically its proposed uses of CFI data, and then specifically include those measurements that will serve these purposes.

Future forest management with continuous inventory in North America may approximate more closely the practices of the European "la methode du controle," where only diameter measurements are taken at intervals of 5 to 10 years and are used with local volume tables. A

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The twenty-fourth is the fact that the system is not in equilibrium.

The twenty-fifth is the fact that the system is not in equilibrium.

The twenty-sixth is the fact that the system is not in equilibrium.

The twenty-seventh is the fact that the system is not in equilibrium.

The twenty-eighth is the fact that the system is not in equilibrium.

The twenty-ninth is the fact that the system is not in equilibrium.

The thirtieth is the fact that the system is not in equilibrium.

simplified CFI system, similar to the European control method, could also be developed to include only diameter and species identification of numbered trees, and designation of "cut and leave" trees. Other tree and plot measurements generally taken on permanent samples, like soil type and cull class, are either relatively constant, or, like merchantable height and tree quality, are closely correlated with d.b.h. Separate studies may be made to establish these relationships. Thus, satisfactory inventory and growth data of adequate statistical accuracy, could be obtained at reduced cost.

The disadvantages of CFI are difficult to evaluate objectively, because the disadvantage associated with an attribute of CFI in one system may be viewed quite differently in another system. Therefore, only those items with which many CFI users were dissatisfied, can be construed as limitations. There was little general agreement that any one limitation of CFI was of outstanding importance. If a forest owner considers several limitations of CFI as strongly objectionable, then he should not invest in a CFI system. Most limitations deal with generalities pertaining to the basic nature of CFI. Since most forest owner-ships with CFI are well satisfied with their systems, it must be concluded that CFI provides an appropriate method of forest inventory for today's forest management objectives, provided its inherent limitations, such as the inapplicability of data to small areas or individual stands, are recognized.

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SUMMARY

Americanized continuous forest inventory (CFI) includes many fundamental features of the European control method ("la methode du controle"). In both, the same forest areas are measured periodically to supply complete and accurate information on growth and other forest changes. CFI presents a concise procedure for obtaining data on many characteristics of the forest. Each component of CFI is simply and fully described as to how it is to be obtained and used. Together, these simple components make up a complex but workable process that can be used to provide information quickly and accurately for most measurable attributes of a forest.

A survey was made by means of a mailed questionnaire to determine the extent of CFI usage on forest ownerships of 50,000 acres or larger in the United States and Canada. An additional objective was to determine how satisfactory this relatively new development is in serving the inventory needs of forestry today. In this survey, questionnaires were returned from over 95 percent of the 376 correspondents.

This investigation disclosed 105 systems in current operation. This number will probably continue to increase, because 67 forest owners were either in the process of installing CFI, or were planning for future installation. Forest ownerships with CFI average over 500,000 acres each, with over 1,300 permanent plots on each ownership. Each plot represents almost 450 acres of forest land. In approximately 30 percent

of all CFI systems there has been at least one remeasurement, and these owners can be considered as experienced CFI users.

The scope of CFI in forest management in the United States embraces approximately 85 million acres, over 17 percent of the total acreage of commercial forest land in the United States. Over 52 million acres with CFI systems are managed by federal agencies, about 26 million acres by private organizations, and about 6 million by state agencies. Almost 98 percent of the federal lands with CFI are administered by the U. S. Forest Service, and almost three-fourths of the private lands with CFI are managed by pulp and paper corporations. By regions, CFI installations are most common in the South, where 50 CFI systems are distributed in the Atlantic, Gulf, and Southeast regions; and in the Lake States, where there are 17 systems. The vast majority of these systems (94 of 105) were established after 1951; there is some evidence that the first continuous inventory system was installed as early as 1928.

The field design of most continuous inventory systems includes systematically located, well-marked, one-fifth-acre plots, one at each sample location. Fixed-radius plots were generally used instead of the theoretically more economical point-samples, even after the advent of point-sampling procedures. However, since 1957, point-samples have become more common. Clustered sampling is more economical in areas of rough topography and diversified timber types, but plot clusters were seldom used in such areas. Since 1956, hidden plots, which are more

необходимо, чтобы в процессе работы не возникало никаких задержек, а также чтобы работа была выполнена в срок. В противном случае работа будет считаться некачественной.

Важно также отметить, что работа должна быть выполнена в соответствии с требованиями заказчика.

В процессе работы необходимо соблюдать все требования заказчика, а также следить за качеством работы. В противном случае работа будет считаться некачественной.

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costly to install and relocate, have shown a marked increase in use.

The economics involved in each element of CFI were apparently given small consideration. Even so, there is general agreement among most CFI users that their overall costs are less than costs of previously used forest inventory methods. However, even if the cost of CFI is the same or slightly more than previous inventory costs, in most cases, it was still economical to install a permanent inventory system because it provides more information than ordinary, conventional timber cruises.

Other distinguishing characteristics of American CFI systems include an average remeasurement interval of about 5 years, with the initial interval being slightly shorter than subsequent ones. For recording information in the field, tally sheets are generally used, but mark sense and port-a-punch cards are also popular. For office computations, IBM was, by far, the most common electronic computer used. Several small ownerships still use desk calculators for their processing, and will probably continue to use them until CFI systems become uniform enough to use a standardized, simple, pre-written program with rented computer services.

For some ownerships, CFI is the sole forest inventory procedure used. In others, CFI is used only to supplement a well established forest management program based on other inventory procedures. The most common use of CFI data is, however, as a basic foundation for forest management and administration. Usually, additional periodic

cruises and other inventory techniques are used to supplement CFI as a forest management tool.

Data from permanent samples are used for approximately 10 purposes or objectives in each organization having CFI. The most important use is generally for inventory or growth determination. Other uses, in descending order of importance, are the use of CFI data by top administrative management, ingrowth, mortality, data for top woodland management, computation of the cutting budget, stand and stock tables, type or class areas, and stand classification. Although many respondents indicated that no single use of CFI was valuable enough to solely justify CFI, the majority reported that both inventory and growth, as well as some other uses, were important enough to justify the expense of installing CFI.

Satisfaction with CFI usage is usually high. The ease with which CFI data can be processed and analyzed for use in achieving forest management objectives is very important in comparing CFI costs, uses, and how satisfactory it is.

Other factors involved in the effectiveness of CFI are the individual plot and tree items recorded on each sample location. The most commonly tallied plot items are stand age or size, reproduction, site class, and density. Other items such as soil type and operability, are seldom recorded. All systems record tree diameter and species, and most of them also record cull class, merchantable height, and tree vigor. Crown diameter and tree value are seldom

the first of these is the fact that the system is not a simple one, but a complex one, in which the various parts are interrelated and interdependent. The second is that the system is not a static one, but a dynamic one, in which the various parts are constantly changing and evolving. The third is that the system is not a closed one, but an open one, in which the various parts are constantly interacting with the environment. The fourth is that the system is not a linear one, but a non-linear one, in which the various parts are constantly interacting with each other in a non-linear fashion. The fifth is that the system is not a deterministic one, but a probabilistic one, in which the various parts are constantly interacting with each other in a probabilistic fashion. The sixth is that the system is not a simple one, but a complex one, in which the various parts are interrelated and interdependent. The seventh is that the system is not a static one, but a dynamic one, in which the various parts are constantly changing and evolving. The eighth is that the system is not a closed one, but an open one, in which the various parts are constantly interacting with the environment. The ninth is that the system is not a linear one, but a non-linear one, in which the various parts are constantly interacting with each other in a non-linear fashion. The tenth is that the system is not a deterministic one, but a probabilistic one, in which the various parts are constantly interacting with each other in a probabilistic fashion.

recorded.

Widespread recording and use of an item did not necessarily indicate that this item and its use proved to be satisfactory. In several cases, the highest degree of satisfaction was expressed for seldom used items. This emphasizes the need for recording only those items that will be used effectively in the forest management program.

The general satisfaction with CFI is well above average, but most respondents were dissatisfied with one or more of its elements. Limitations of CFI as expressed by CFI users, in descending order of importance, were as follows:

(1) The data are applicable only to the entire forest area. Due to the light sampling coverage of the method, attempts to apply permanent sample plot data to specific stands or sub-compartments, usually result in disappointment.

(2) The cost is too high. Even though the average cost of CFI in most cases is less than costs for previous methods of obtaining forest information, many respondents indicated they believe CFI is too expensive for their forest management programs.

(3) The rigid procedures in CFI often hamper the forest manager when changes and modifications are needed. Although changes were common in present CFI systems, they were usually made during the initial measurement period. They become much more difficult to make and relate to previous surveys after the first measurement is taken.

1. The first step in the process of creating a new product is to identify a market need. This involves conducting market research to determine what consumers are looking for and what gaps exist in the current market. Once a need is identified, the next step is to develop a concept that addresses this need. This concept should be unique, valuable, and feasible. The concept is then refined through a process of prototyping and testing, where the product is built and evaluated by a group of potential users. This feedback is used to make improvements and ensure the product is well-suited to the market. The final step is to launch the product and monitor its performance in the market. This involves tracking sales, customer feedback, and market trends to ensure the product is successful and making adjustments as needed.

2. The second step in the process is to develop a business plan. This plan outlines the financial and operational aspects of the business, including the costs of production, distribution, and marketing, as well as the expected revenue and profit. The business plan is a critical document that provides a clear picture of the business's viability and helps to secure funding from investors or lenders. It also serves as a roadmap for the business, guiding decision-making and providing a benchmark for performance. The business plan should be updated regularly as the business evolves and new information becomes available.

3. The third step in the process is to secure funding. This involves identifying potential sources of capital, such as venture capitalists, angel investors, or banks, and presenting the business plan to them. The funding process can be challenging, as investors will want to see a clear return on their investment and a strong team to execute the plan. To increase the chances of success, entrepreneurs should focus on building a strong network of contacts and demonstrating a deep understanding of the market and their product. Once funding is secured, the next step is to begin production and distribution of the product.

4. The fourth step in the process is to launch the product and build a customer base. This involves developing a marketing strategy that promotes the product and reaches the target audience. The marketing strategy should be tailored to the product and the market, using a mix of traditional and digital marketing techniques. Once the product is launched, it is important to monitor sales and customer feedback closely. This allows the business to make adjustments to the product and marketing strategy as needed, ensuring the product remains relevant and competitive in the market. Building a strong customer base is key to the long-term success of the business.

5. The fifth step in the process is to scale the business. This involves expanding the production and distribution of the product to new markets and increasing the volume of sales. Scaling the business requires a combination of operational efficiency, marketing innovation, and financial management. Entrepreneurs should focus on streamlining their operations, reducing costs, and finding new ways to reach customers. They should also continue to invest in marketing and product development to stay ahead of the competition. Scaling the business is a challenging but rewarding process that can lead to significant growth and success.

(4) Intensive instruction of personnel is required so that various observers will measure, observe, and record plot and tree data uniformly. The use of experienced personnel for taking field measurements may eliminate much of this problem.

(5) Biased silvicultural treatment of easily identified sample plots concerns many forest managers. If the sample is not treated exactly like the surrounding area, it will not yield representative data. Hidden samples can be used to eliminate this problem, but the cost is thereby increased.

(6) In some cases, CFI has been oversold to top administrative management as a solution to all forestry problems. A forester who accepts this theorem and proceeds with his forest management program accordingly, violates the basic concept of CFI, and will probably be dissatisfied with the results.

(7) Growth information does not become available until one measurement interval has elapsed. Also, in using the growth information, the assumption is made that growth during the next period will be the same as during the past period.

(8) Several respondents suggested that too many measurements were taken on CFI sample areas which were not utilized in the forest management or forest administrative programs.

Some foresters would not consider these limitations as disadvantages of CFI. However, each alleged limitation should be considered carefully by the forest manager before a system of permanent plots is installed.

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APPENDIX

- 187 -

APPENDIX

CONTINUOUS FOREST INVENTORY QUESTIONNAIRE

DEPARTMENT OF FORESTRY, MICHIGAN STATE UNIVERSITY

Name of company _____ State _____

1. How much forest land do you own?

- () Less than 5,000 acres. () 5,000 to 50,000 acres.
() 50,000 to 100,000 acres () Over 100,000 acres.

2. Have you established a CFI system on your property? () YES, () NO.

a. If NO, check reason(s) below and return questionnaire.

- () Does not fit your type of management.
() System was too poorly set up.
() Too expensive for the data obtained.
() Plan for future CFI installation.
() Waiting for better CFI development.
() Other, specify _____

b. If YES and CFI has been ABANDONED, check reason(s) below and return questionnaire.

- () Does not fit your type of management.
() System was too poorly set up.
() Too expensive for the data obtained.
() Did not know how to use data.
() Other, specify _____

c. If YES and CFI has been RETAINED, complete questionnaire.

GENERAL INFORMATION

Year CFI established _____

1. Date first remeasurement completed _____;
second remeasurement completed _____.
2. Were samples points () or plots ()? If plots, specify size _____
3. Were locations single () or clustered ()? If clustered, how
many per location _____?
4. Were locations assigned randomly (), systematically (), a
combination ()?
5. Were locations stratified () YES, () NO? If YES, specify
method _____
6. How many acres are represented by each plot? _____
7. How many CFI plots are located on your land? _____
8. Was initial remeasurement interval one year (), Two years (),
three years (), four years (), five years (), other ().
If other, specify _____
9. Will subsequent remeasurement intervals be the same as the first?
() YES, () NO. If NO, specify _____
10. Tally method used: Port-a-punch (), Mark Sense (), Field
Tally (), Other (). If other or if method has changed,
specify _____
11. To compute the data, do you use your own machine () or rent
them ()?
12. Was machines used to compute data IBM (), Remington-Rand (),
Datatron (), Desk Calculator (), Other ()? If other,
specify _____

13. Statistical accuracy was computed as less than 2.5% error (),
2.5 to 5% error (), 5 to 10% error (), 10% or more error (),
not computed (). If computed, was it for volume (), area (),
or a combination ()?
14. Was the type of plot used hidden () or marked ()?
15. Were aerial photographs available at the time of CFI installation?
() YES, () NO.
16. Which of the following inventory methods are used to supplement
CFI?
() None () General Cruise
() Operational cruise in specific areas prior to treatment.
() Other, specify _____
17. Is the present CFI system unsatisfactory (), barely satisfactory
(), highly satisfactory (), satisfactory (), other ()?
If other, specify _____
18. Was inventory method previous to CFI unsatisfactory (), barely
satisfactory (), satisfactory (), highly satisfactory (),
other ()? If other, specify _____
19. As compared to previous inventory method(s), the cost of the
present CFI system is less (), more (), about the same ().
20. CFI is replacing which of the following inventory methods:
() General periodic cruise. () Estimates based on past experience.
() No scheduled cruise, but information obtained as needed from
field work.

() Other, specify _____

21. If you established your CFI system again, what changes would you make? _____

22. What, in your opinion, are the major weaknesses of the present CFI system? _____

Questionnaire Table 1. USES OF CFI:

USES	Has USE Been Adopted?		If USE has been adopted, how satisfactory was it?			
	YES	NO	Unsat	Barely Satis	Satis	Highly Satis
1. Computation of Cutting budget						
2. Tax Purposes						
3. Growth Data						
4. Mortality						
5. Ingrowth Data						
6. Local Volume Table						
7. Local Stand and Stock Table						
8. Data for Top Woodland Management						
9. Data for Top Administrative Management						
10. Inventory Purposes						
11. Stand Classification						
12. DBH-HT-Volume Curves						
13. Wildlife Management						
14. Teaching, Research and/or Training						
15. Timber Operating Schedules in Specific Areas						
16. Computation of Type or Class Areas						
17. Planning for TSI and Planting						
18.						

REMARKS:

1. From table 1, assign the order of importance to the following USES
(e.g., 1 for the most important USE, 2 for the next most important
USE, etc.)
 - () Tax Purposes.
 - () Growth Data.
 - () Mortality.
 - () Inventory.
 - () Computation of Cutting Budget.
 - () Data for Top Woodland Management.
 - () Data for Top Administrative Management.
 - () Other, specify _____
2. From table 1, which of the items alone provide information valuable
enough to cover the full cost of installing a Continuous Forest
Inventory system?
 - () Tax Purposes.
 - () Growth Data.
 - () Mortality.
 - () Inventory.
 - () Computation of Cutting Budget.
 - () Data for Top Woodland Management.
 - () Data for Top Administrative Management.
 - () Other, specify _____

Questionnaire Table 2. ITEMS recorded in CFI.

ITEMS	Has ITEM been adopted?		If ITEM is recorded, how satisfactory has it been?			
	YES	NO	Unsat.	Barely Satis.	Satis.	Highly Satis.

TREE DATA

1. Merchantable height						
2. Total height						
3. Form class						
4. Tree vigor						
5. Tree quality						
6. Tree value						
7. Cull class(soundness)						
8. Crown diameter						

PLOT DATA

1. Site class						
2. Reproduction data						
3. Silvicultural treatment						
4. Soil type data						
5. Stand size or age data						
6. Condition class						
7. Density						
8. Operability						

REMARKS:

Table 23. Calculations for rank correlation, CFI users on private ownerships.

Judges	Ranking of Judged Items ^{1/}						
	Growth	Mortality	Inventory	Cutting Budget	Woodland Mgmt.	Administrative Management	
1	5	6	1	4	2	3	
2	3	5	1	2	6	4	
3	1	6	3	5	4	2	
4	2	6	3	1	4	5	
5	1	2	5	4	6	3	
6	2	5	1	3	4	6	
7	3	6	2	4	1	5	
8	4	6	1	5	2	3	
9	2	3	1	4	6	5	
10	4	6	3	5	1	2	
11	3	4	1	6	2	5	
12	1	3	2	6	4	5	
13	1	2	6	5	3	4	
14	1	6	2	3	4	5	
15	5	6	1	2	3	4	
16	2	5	3	1	4	6	
17	5	6	1	4	3	2	
18	4	6	2	1	3	5	
19	1	2	3	4	5	6	
20	2	3	5	1	4	6	
21	1	3	2	6	4	5	
22	1	6	3	2	4	5	
23	1	2	5	3	4	6	
24	4	6	2	5	3	1	
25	1	2	5	3	4	6	
26	4	5	3	2	1	6	
27	5	6	4	3	1	2	
28	2	3	1	6	4	5	
29	3	4	1	6	5	2	
30	3	6	1	2	4	5	
31	4	5	3	6	1	2	
32	1	6	2	3	4	5	
33	2	3	1	6	4	5	
34	1	3	2	6	4	5	
35	2	6	1	5	4	3	
36	6	5	3	4	2	1	
37	1	6	2	3	5	4	
38	1	3	4	2	5	6	
39	1	3	2	5	4	6	
Sum of Ranks	96	177	94	148	138	166	Total 819
(Sum of Ranks) ²	9,216	31,329	8,836	21,904	19,044	27,556	117,885

^{1/} Order of importance ranked as 1 for the most important use, 2 for the next most important use, etc.

Table 24. Calculations for rank correlation, CFI users on federal and state ownerships.

Judges	Ranking of Judged Items ^{1/}					
	Growth	Mortality	Inventory	Cutting Budget	Woodland Mgmt.	Administrative Management
<u>Federal</u>						
1	1	3	2	6	5	4
2	1	4	2	3	5	6
3	5	6	4	2	1	3
4	3	4	1	2	5	6
5	5	6	4	2	1	3
6	3	4	1	2	6	5
7	2	6	3	1	4	5
Sum of Ranks	20	33	14	18	30	32
(Sum of Ranks) ²	400	1,089	196	324	900	1,024
						Total 147
<u>State</u>						
1	2	6	3	4	1	5
2	1	2	3	4	6	5
3	4	5	3	2	1	6
4	2	6	4	5	1	3
5	2	3	4	1	5	6
6	4	5	6	3	2	1
7	2	6	1	5	3	4
8	2	6	1	3	5	4
9	1	2	6	3	4	5
10	6	5	4	3	2	1
11	2	3	1	4	5	6
12	5	6	2	1	4	3
Sum of Ranks	33	55	35	38	42	49
(Sum of Ranks) ²	1,089	3,025	1,225	1,444	1,764	2,401
						Total 10,948

^{1/} Order of importance ranked as 1 for the most important use, 2 for the next most important use, etc.

Calculations for rank correlation coefficient of concordance ($\bar{R}$).

$$S = \text{Sum of (Ranks)}^2 - \frac{(\text{Sum of Ranks})^2}{n}$$

m = number of Judges

$$n_1 = n - 1 - \frac{2}{m}$$

n = number of judged items

$$n_2 = (m - 1) \left(n - 1 - \frac{2}{m} \right)$$

$$W = \frac{12S}{m^2 n (n^2 - 1)}$$

$$\bar{R} = \frac{(mW - 1)}{m - 1}$$

$$F = \frac{W(m - 1)}{1 - W} \quad \text{with } n_1 \text{ and } n_2 \text{ degrees of freedom.}$$

For CFI users on Private Ownerships

$$S = 117,885 - \frac{(819)^2}{6} = 6,091$$

$$m = 39$$

$$n = 6$$

$$W = \frac{12(6,091)}{(39)^2 (6)(6^2 - 1)} = 0.229$$

$$n_1 = 6 - 1 - \frac{2}{39} = 5$$

$$\bar{R} = \frac{39(0.229) - 1}{38} = 0.209$$

$$n_2 = (39 - 1)(6 - 1 - 2/39) = (38)(5) = 190$$

$$F = \frac{(39 - 1)(0.229)}{1 - 0.229} = 11.28 \quad ** \quad \frac{1}{/}$$

$$\text{Table } F_{01} = 3.11$$

1/ Significance at the 1 percent level is indicated by **, at the 5 percent level is indicated by *, and non-significance is indicated by n.s.

For CFI users on Federal Ownerships

$$S = 3,933 - \frac{(147)^2}{6} = 331$$

$$m = 7$$

$$W = \frac{12(331)}{49(6)(36 - 1)} = 0.386$$

$$n = 6$$

$$n_1 = 6 - 1 - 2/7 = 5$$

$$\bar{R} = \frac{7(0.386) - 1}{7 - 1} = 0.284$$

$$n_2 = (7 - 1)(6 - 1 - 2/7) = 28$$

$$F = \frac{(6)(0.386) - 1}{1 - 0.386} = 3.77^{**}$$

$$\text{Table } F_{01} = 3.76$$

For CFI users on State Ownerships

$$S = 10,948 - \frac{(252)^2}{6} = 364$$

$$m = 12$$

$$W = \frac{12(364)}{144(6)(35)} = 0.144$$

$$n = 6$$

$$n_1 = 6 - 1 - 2/12 = 5$$

$$\bar{R} = \frac{12(0.144) - 1}{11} = 0.66$$

$$n_2 = (12 - 1)(6 - 1 - 2/12) = 53$$

$$F = \frac{(11)(0.144)}{1 - 0.144} = 1.85 \text{ n.s.}$$

$$\text{Table } F_{05} = 2.39$$

For CFI users on All Ownerships

$$S = 259,600 - \frac{(1,218)^2}{6} = 12,346$$

$$m = 58$$

$$W = \frac{12(12,346)}{3,364(6)(35)} = 0.210$$

$$n = 6$$

$$n_1 = 6 - 1 - 2/58 = 5$$

$$\bar{R} = \frac{58(0.21) - 1}{57} = 0.196$$

$$n_2 = \frac{(58 - 1)(6 - 1 - 2/58)}{= 285}$$

$$F = \frac{(57)(0.21)}{1 - 0.21} = 15.15^{**}$$

$$\text{Table } F_{01} = 3.02$$

ROOM USE ONLY

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