TIMBER INDUSTRY GROWTH AND HARVEST STUDY: AN EVALUATION OF CALIFORNIA'S INDUSTRIAL FOREST LANDOWNERS' TIMBER INVENTORIES

Final Report for CDFFP Contract 8CA06732

WILDLAND RESOURCES CENTER
DIVISION OF AGRICULTURE AND NATURAL RESOURCES
UNIVERSITY OF CALIFORNIA

Report 31
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Corrections

This report on the Timber Industry Growth and Harvest Study has been repaginated from the draft seen by the oversight and technical team members. Because of this change, the comments of Marilyn and Ray West refer to page 12, which is now page 8; and the comments by Louis Blumberg refer to page 19, which is now page 17. Also, the dates referred to by Blumberg for various letters in the first paragraph of his response should be 1992 instead of 1993, and the table he refers to as Table 6.6B is Table 5.6B on page 14.

September 1993
TIMBER INDUSTRY GROWTH AND HARVEST STUDY: AN EVALUATION OF CALIFORNIA'S INDUSTRIAL FOREST LANDOWNERS' TIMBER INVENTORIES

Final Report for CDFFP Contract 8CA06732

William McKillop and Bruce Krumland
College of Natural Resources
University of California, Berkeley

WILDLAND RESOURCES CENTER
DIVISION OF AGRICULTURE AND NATURAL RESOURCES
UNIVERSITY OF CALIFORNIA
Davis, California 95616
(916) 752-8070

Report 31
August 1993
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Preface

Accurate information about the growth and harvest of California’s industrial timberlands is increasingly necessary for statewide decisions concerning forest policy. A major issue to date has been the strength and applicability of existing survey data for drawing implications about trends in California’s forest lands. Although private timber companies collect much of the sort of data useful in addressing many of the questions of forest policy, heretofore the information has not been accessible for public tabulation, review and use. The study reported here represents an important milestone for cooperation among most of the state’s large industrial timber owners, the University of California (through the UC Wildland Resources Center), and the State of California (through the Department of Forestry and Fire Protection) to provide and analyze such information.

The bulk of the study was conducted by Professor William McKillop and his associate Dr. Bruce Krumland, Department of Forestry and Resource Management (Environmental Sciences, Policy, and Management), University of California, Berkeley. Their analysis, which constitutes the first section of this report, was based on confidential information provided voluntarily by 17 industrial timber companies which together own more than 80 percent of the industrial forestland in California. The work was guided by two teams. A technical team, made up of individuals with expertise in forest measurements, inventory, growth, biometrics, and system models from academia, industry and the California Department of Forestry and Fire Protection, provided critical review of the methodological approach, assumptions, and general statistical framework of the study. An oversight team was drawn broadly from members of the public, environmental groups, academia, industry, and the state, who were familiar with the policy concerns and general technical problems encompassed by the study. This team reviewed all elements of the study and worked to ensure that the findings would be understandable to as broad an audience as possible. The names of members of both teams are included in the appendix. Their thoughtful review and criticism were instrumental in helping to refine the final product. But as in all such efforts the sections in the final report are the sole responsibility of the authors.

The second section is an independent review of the McKillop report by Professor Keith Gilless, Department of Forestry and Resource Management, UC, Berkeley. Dr. Gilless was asked to follow samples of the basic data through each step used in the study, scrutinize computations and assumptions, and provide, to the extent possible in a limited sample, a complete check of the validity of the analysis.

Section three presents comments some members of the technical and oversight teams wished to include as part of the formal record of this study, and Dr. McKillop's response.

I wish to acknowledge the commitments of time and energy the technical and oversight team members devoted to this study. Drawn from a wide range of viewpoints concerning the nature and potential pitfalls of the work, they nevertheless kept closely to the purpose of making the study as accurate, understandable, and as useful as possible for general and technical audiences alike. I also wish to thank Dr. Robert Ewing, Director of Strategic Resources Planning, California Department of Forestry and Fire Protection for his regular consultation and advice during the course of this project and to Elizabeth Frey for her tireless efforts in coordination and organization of the reports.

Don C. Erman
Director
August 25, 1993
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1. Background and objectives of the study

This timber inventory, growth and harvest (TIGH) study is a joint project between the California Department of Forestry and Fire Protection's FRRAP program (the contracting agency), the University of California Wildland Resources Center, the California Forestry Association and cooperating forest industry landowners in the state.

The study was initiated because several major industrial timberland owners took the position that FRRAP projections (California Department of Forestry and Fire Protection, 1988) substantially underestimated forest industry "inventory growth". The term "inventory growth" signifies growth of merchantable timber, as opposed to growth of trees that have not yet reached merchantability standards such as 8" d.b.h (diameter at breast height). In response to that position, FRRAP agreed to fund a contract with the U.C. Wildland Resources Center to allow Professor William McKillop to collect timber inventory and growth data from participating timber companies. The California Forestry Association agreed to seek the cooperation of its members and other timber companies.

The contract with FRRAP required that study procedures be reviewed by a Technical Team and an Oversight Committee. A draft final report was reviewed by each committee and their comments addressed by the lead investigator (William McKillop) before this final report was submitted.

As specified in the workplan, the basic purpose of the study is to: "1) assess timber inventory and growth conditions on industrial landownerships through the use of data and statistics collected by individual companies; 2) evaluate the reliability, accuracy, coverage, and consistency of the data as a basis for assessing current and future conditions of industrial forestland; and 3) suggest strategies to incorporate individual company and FIA data in the FRRAP analysis procedures."

These objectives are to be accomplished through the following tasks:

Task 1 - "Review and describe acceptable techniques to gather relevant timber inventory data, and develop protocols to compare and evaluate different data sets for reliability, accuracy, consistency, and coverage".

Task 2 - "Compile from industrial landowners the best available information on current levels of timber inventory, growth, and acreage by timber stratum where available and feasible. Strata are to be based where feasible on forest type, site, size class, and stocking class".

Task 3 - "Assess the quality and utility of individual data sets in comparison to standards and protocols developed in Task 1 and through interviews and examination of records and procedures of individual companies".

Task 4 - "Aggregate information by timber supply regions and present statistics representing current inventory, growth, harvest, and acreage by timber stratum where available and feasible. Prepare report on current conditions of industrial timberland, including all information and analyses enumerated in Tasks 1 - 4".

Task 5 - "Evaluate the potential to use the companies' plot, site, and aggregate data to augment FIA statistics to assess current and future conditions of industrial landownerships. Recommend in a report to FRRAP ways to improve the program's approach for assessing timber inventory and supply trends".
2. Techniques and Protocols

Introduction

The major focus of this study with regard to techniques and protocols is how to utilize forest inventory, growth and harvest data which have been already been collected by participating timber companies for management purposes to develop aggregate estimates of inventory, growth and harvest for industrial forest ownerships in each major timber-producing region of the state. Types of estimation methods for standing volume and growth used by participating timber companies are described in a later section. Appropriate procedures for designing and conducting timber inventories on a specific private ownership depend on the objectives of the owner and the level of funding available for the task. Appendix A presents material from Wensel (1992) relating to the design of sample surveys on individual tracts of forest land. A major element in the design of such surveys is the need to strike a balance between precision and cost in developing estimates of growth and standing volume.

Regional timber supply assessments to date (California Department of Forestry and Fire Protection, 1988; Krumland and McKillop, 1987 and 1990) have utilized the U.S. Forest Service's Forest Inventory and Analysis (FIA) data base. The FIA studies are based on the measurement of sample points located in a grid pattern on private land and public land outside the National Forests. The California FIA survey of forest industry growth and standing volume uses data from approximately 500 sample points, with each point consisting of five variable (prism) plots, as described in Colclasure et al. (1986b), Hiserote et al. (1986) and Lloyd et al. (1986b). To date, FRRAP projections have been based on FIA data.

A major reason for undertaking the TIGH study was concern for the accuracy of regional projections of aggregate standing volume and growth that is attainable using the FIA data base. The TIGH study also provided information on the relationship between timber growth and harvest levels on industrial forest lands in California, which has been an issue in recent debates over forest policy in the state.

As noted below, the TIGH aggregate estimates of standing volume are based on approximately 350 thousand sample points on forest industry lands. Because of this very large data base, they are likely to be much more precise than FIA ones. An approximate indication of the sampling errors of TIGH aggregate estimates relative to FIA ones is given by the inverse ratio of the square roots of the number of sample points in the respective studies. This inverse ratio is 1 to 27 for the state as a whole which means that sampling errors associated with TIGH estimates are likely to be very much lower than those for FIA estimates.

The TIGH Task 5 report deals with recommendations to FRRAP on ways to improve the program's approach for assessing timber inventory and supply trends. In addition to providing information on recent levels of standing volume, growth and harvest, this report on Tasks 1 to 4 provided useful background material for Task 5.

As approved by the Technical Team on September 10, 1991 and the Oversight Committee on September 12, 1991, the following techniques and protocols were observed in gathering and evaluating data.

A sample questionnaire was sent to cooperating timber industry companies in August 1991, soliciting comments and suggestions about its form and content. No formal suggestions were received from cooperators but the questionnaire was revised on the basis of comments from the Technical Team and the Oversight Committee. The final questionnaire was sent out on September 19, 1991.

It was evident from previous experience that most cooperators had significantly different methods of estimating standing volume (inventory) and growth. Accordingly, no attempt was made to develop a standardized "fill-in type" format for the questionnaire. Instead, each company was asked to respond to a list of questions in a systematic way, following numbered items in sequence. A copy of the final questionnaire is attached.
Quality categories for standing volume estimates

Forest land owners and managers may choose from a wide range of accepted forest inventory techniques in seeking to strike a balance between precision and cost in estimating standing volume or growth. Sample surveys of standing volume will almost always be used in preference to 100 percent inventories, unless the standing timber is extremely valuable, as in the case of prime old-growth redwood. Sample surveys are most conveniently described by the following characteristics:

- Sample point location - systematic pattern, or purely random
- Stratified sampling by timber type, or unstratified sampling
- Tree selection at sample points - all trees within a predesignated perimeter (fixed "radius" plot) or trees chosen for measurement with probability proportional to diameter by means of a cruising prism (variable radius plot)
- Shape of fixed "radius" plot - circular, rectangular etc
- Size of fixed "radius" plot - one-quarter acre, one-fifth acre etc.

The best combination of these general characteristics will depend on the objectives of the inventory, the nature of the property and the need to balance cost and precision.

The wide variety of available inventory techniques made it obvious that, where possible, the quality of the inventory systems of individual companies should be judged by the "targeted" statistical precision they were designed to attain rather than the particular type of inventory procedure used. Intensity of sampling was used as an alternative measure of quality in cases where companies did not design their inventory system on the basis of targeted levels of statistical precision.

The protocol developed in consultation with the Technical Team and the Oversight Committee for assessing quality and utility of data was that the acreage inventoried by each company in each FRRAP region would be split into quality/utility categories. Categories for standing volume estimation were named S1, S2 and S3.

A system for estimating standing volume (an "inventory" system) was considered to be in the S1 category if it was designed to estimate total volume for a company's total holding or inventory sub-unit within a FRRAP region

- to within +/- 10% (or less) with 95% confidence,
- to within +/- 5% (or less) with 90% confidence, or
- a sampling fraction at least 1 sample point per 2 acres for a 1,000 acre or larger tract. This is approximately equal to a 1 acre sample area per 10 acres.

An inventory system was considered to be in the S2 category if

- it was designed to be accurate to within +/- 10% with 67% to 90% confidence,
- it had a sampling fraction of 1 sample point per 5 acres for a 1,000 acre or larger tract. This is approximately equal to a 1 acre sample area per 25 acres.

A system was classified as S3 if it depended mainly on a small base of primary data, or on adjusted estimates from secondary sources, or on out-dated information (such as old acquisition cruises) that had not been adjusted to allow for changes in forest conditions.
Quality categories for growth estimates

Estimation errors for growth analyses are likely to be considerably greater than those for surveys of standing volume. For example, suppose the standing volume on a tract is estimated to within +/- 5% with 95% confidence in a particular year, and then is re-inventoried 10 years later, also to within +/- 5%. In this case a growth estimate based on the difference between the two surveys will only be accurate to within +/- 10%. If logging, fire, or significant attack by insects or disease has taken place on parts of the tract in the meantime, the error is likely to be very much greater.

It is expensive to assess the estimation error on growth studies that are conducted for operational (management) purposes for a large tract of timber, as opposed to an experiment that is designed to compare the accuracy of growth estimation methods in a research organization. It should be noted that almost no operational procedures for growth estimation used by timber companies provide internal measures of accuracy for individual properties, such as the confidence intervals associated with standing volume estimation. For example, no timber growth estimation procedures used in California for individual forest properties can be said to be similar to the S1 inventory system. The same is true for most forest properties in other countries or regions of the U.S.

Accordingly, only two categories of growth estimation procedures, G2 and G3 were considered. Growth estimation procedures were classed as G2 if they used clearly defined, generally accepted methods in a systematic way. Such methods include use of yield tables, stand table projection and the application of a carefully-derived growth percentage factor to the standing volume estimate for an inventory unit or management unit. In general, the accuracy of these methods are unknown, although one cooperating company reported that for a 100,000 acre tract, its growth projection method yielded an 10 year growth estimate that was within 7 percent of the estimate obtained by comparing results of successive cruises.

Growth estimation procedures were classed as G3 if they included the use of data, from publications or other ownerships, that were adjusted on a judgmental basis. They were also classed as G3 if they used yield tables or growth percentage factors that did not appear to have been developed in a systematic way.

Accuracy of aggregate estimates

S1 and S2 inventory systems adopted by participating companies are designed to be accurate within specified limits (e.g. plus or minus 5%) for individual inventory or management units. Where an inventory system is designed to be accurate to within a certain percentage with a given confidence level, this accuracy is based on a preliminary estimate of the statistical variance within the inventory unit. After the inventory is completed, individual companies may or may not compute the accuracy actually attained. The percentage accuracy actually attained may be either greater or less than the designed accuracy.

It should be noted that quality categories represent the likely degree of sampling error in the estimate of standing volume for the inventory unit to which the estimate applies. Estimates for a whole property will be of greater reliability than estimates derived for individual management or inventory units within that property. For example, one company whose system was designed to be accurate to within +/- 10% with 67% confidence for individual management units has attained an accuracy of +/- 2.5% with 95% confidence for a 33,000 acre tract. Similarly, estimates developed for aggregations of properties, such as estimates for a whole region, will be of greater reliability than estimates for individual properties.

As described in a later section, TIGH inventory estimates were based on over 100 thousand sample plots in the North Coast, over 150 thousand in the Northern Interior and over 80 thousand in the combined Sacramento and San Joaquin regions. With such a large number of observations contributing to the aggregate regional estimates, aggregate sampling errors will be very low.
3. Compilation of information

Degree of response

In response to invitations from the California Forestry Association, 22 companies, or regional divisions of large companies, initially agreed to cooperate in the study. Ultimately, four of these companies were unable to provide any data and one provided only partial data. (These five companies owned a total of approximately 92 thousand acres combined). Seventeen companies or divisions of companies provided complete data as requested in the questionnaire. These seventeen will be referred to as "participating companies".

U.S. Forest Service Forest Inventory and Analysis (FIA) reports, by Colclasure et al. (1986a & b), Hiserote et al. (1986) and Lloyd et al. (1986a & b), define industrial forestland ownerships simply as forest land owned by forest industry (large companies with or without mills). The FRRAP report defines industrial forestland owners as "individuals or companies that have 5,000 or more acres nationwide, and either own a wood-using manufacturing plant, or employ a permanent forestry staff and a system of regular timber harvests". All owners cooperating in the study met this definition.

The distribution of size of holding of the participants by region is shown in table 3.1. Of the 17 companies participating, seven reported for their holdings in the North Coast, two in the Central Coast, eight in the Northern Interior, eleven in the Sacramento region, and two in the San Joaquin region. This gave a total of 30 reporting units for all five regions combined.

<table>
<thead>
<tr>
<th>Table 3.1 Number of reporting units by FRRAP region by size of unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>North Coast</td>
</tr>
<tr>
<td>Central Coast</td>
</tr>
<tr>
<td>N. Interior</td>
</tr>
<tr>
<td>Sacramento</td>
</tr>
<tr>
<td>San Joaquin</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Table 3.2 shows the acreage covered by this study by region in comparison to U.S. Forest Service Forest Inventory and Analysis (FIA) results as reported by Colclasure et al. (1986a & b), Hiserote et al. (1986), Lloyd et al. (1986a & b).

Disparities between FIA acreage estimates and TIGH ones may be due to differences in land classification, accuracy of estimation methods and number of companies covered by the studies. Table 3.2 suggests that a high rate of participation, in terms of acreage covered, was obtained for the Northern Interior and Sacramento regions. In the North Coast and San Joaquin regions, the acreages covered by the TIGH study were 73 and 48 percent respectively of the FIA estimates. Acreage estimates are discussed further in a later section.
Table 3.2 Number of acres (thousands) owned by participating companies compared to U.S. Forest Service acreage estimates (1)

<table>
<thead>
<tr>
<th>Region</th>
<th>This study (TIGH)</th>
<th>USFS &quot;Forest industry&quot;</th>
<th>TIGH/USFS %</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Coast</td>
<td>953</td>
<td>1301</td>
<td>73</td>
</tr>
<tr>
<td>Central Coast</td>
<td>2</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>N. Interior</td>
<td>1654</td>
<td>1757</td>
<td>94</td>
</tr>
<tr>
<td>Sacramento</td>
<td>779</td>
<td>708</td>
<td>110</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>81</td>
<td>167</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>3466</td>
<td>3957</td>
<td>88</td>
</tr>
</tbody>
</table>

(1) Colclasure et al. (1986a & b), Hiserote et al. (1986), Lloyd et al. (1986a &b)
Totals are sums of unrounded values.

It is clear, that because of the low acreage and number of companies reporting for the Central Coast, the information for that region is of no significant value. Accordingly, the following discussion will deal only with the 28 reporting units in the four other regions. It is also clear that the San Joaquin region must be combined with the Sacramento region to provide confidentiality for the two companies who provided information for that region.

Timber strata

The vast majority of companies were unable to supply data by timber type/timber strata, either because they do not have their lands typed in any systematic way or because their record-keeping system summarizes data by section or management unit rather than by timber type. In addition, it was apparent from the data that was supplied by timber type that there is a wide variety of typing systems being used and that future efforts to obtain information of this nature would have to be preceded by an intensive effort to standardize timber types, at least by broad classes.

Types of standing volume estimation methods

The principal type of information supplied by each participant in response to the questionnaire was acreage, inventory, growth and harvest data by region. Other information dealt with inventory methods, such as the use of fixed radius versus variable radius (prism) plots or utilization standards for inventory purposes. Utilization standards vary from company to company. For example, while all companies use a 16 foot log length, some companies use an 8" minimum tree d.b.h. (diameter at breast height), and others 10", 11" or 12" d.b.h.. Some go to a 6" top log diameter inside bark (d.i.b.), others to 8" d.i.b. Some use only a combination of top diameter and length, others use only a combination of d.b.h. and log length.

Most companies used variable plot (prism points), with full inventory information being taken on at least 33% of the plots. Full inventory information refers to, at least, d.b.h., species, and tree heights. Cull factors, form class, Dunning tree class, and live crown ratios may also be estimated. In addition, age and site index may be determined for one or two trees on a subsample of plots. A full inventory plot is also called a "measured" plot as opposed to a "count" plot where the number of "in" trees is simply counted using a cruising prism and then multiplied by the prism factor to obtain an estimate of basal area per acre.

Thirteen of the 28 reporting units for the four regions combined have inventory systems that are designed to give estimates of standing volume for the reporting units (or for smaller units within them) to within +/- 5% or +/- 10% with 90% or 95% confidence.

Three of the 28 reporting units use a sampling fraction of 1 plot per 2 acres. Seven use a sampling fraction of 1 plot per 5 acres. One of the 28 reporting units uses a grid of large (1 acre) permanent plots.
systematically located throughout its property, at the rate of 1 plot per 152 acres; another uses a systematic grid of prism plots over its very large holdings at the rate of one per 10 or 20 acres; two use a sampling fraction of 1 plot per 10 acres; and one is in the process of replacing old acquisition cruise estimates with data from a new inventory system.

**Types of growth estimation methods**

Three companies (with large holdings in the North Coast) use proprietary (company) yield tables to make estimates of growth for their even-aged stands.

Seven reporting units, for at least part of their growth estimation procedure, use a formal stand table projection method where growth rates are applied to stand tables by species and diameter classes. These growth rates are obtained by increment borings on one or two trees per measured sample plot during an inventory of standing volume.

A majority of reporting units use a growth percentage method, where a growth percentage factor is applied to the standing volume estimate for an inventory unit or management unit. For at least part of their analysis, ten reporting units used permanent growth plots to develop growth factors by stand type, nine used the U.C. Berkeley CRYPTOS or CACTOS growth and yield model, and eleven used a modified stand table projection method where diameter increment information was applied by management or inventory units rather than by individual stands.

**4. Quality and utility of data sets**

**Field interviews**

The purpose of the field interviews was to examine representative samples of field data to trace the incorporation of that field data into aggregate estimates provided by each company in its response to the questionnaire, and to assess the quality and utility of the aggregate estimates.

Field interviews were conducted with 16 of the 17 companies who provided usable responses. The company which has not been subject to field interview has had its inventory and growth studies conducted by an large, independent, highly reputable consulting and appraisal company to exact specifications. The timber company indicated that, if there was any doubt about the reliability of the data supplied, it would arrange for me to inspect the inventory information held by the consulting firm.

The typical form of each field interview was as follows:

- First of all, a general discussion was held with the company representative (inventory forester) responsible for the forest inventory system, going over the information supplied on diskette or in written form, and asking supplementary questions where necessary.

- The lead investigator would then ask to see a sample of original sample plot field records (cruise cards), which show individual tree and plot data as recorded in the field. This usually involved going to a storage area and pulling out boxes for one or more inventory units. The lead investigator would then have the inventory forester explain any items on the cards whose meaning was unclear.

- The lead investigator was then shown micro-computer files or mainframe computer printouts which show individual plot records and the aggregation of these records into successively higher levels of summaries (by section, management unit, district etc.).

- In the case of growth estimates based on formal stand table projection, the lead investigator was shown stand tables giving number of trees by diameter class and species for each stand or unit of growth estimation. In the cases where yield tables were used the lead investigator would inspect those and discuss the ways in which they were developed. Where a growth percentage method was used, there would be a discussion of any particular features of the specific projection method.
Categorization of standing volume and growth estimates

Table 4.1 shows the distribution of number of reporting units, acres and volume estimates by quality classes. As noted above, standing volume and growth estimation systems were categorized as representing either $S_1$, $S_2$ or $S_3$ inventory procedures, or $G_2$ or $G_3$ growth estimation procedures. The categorizations in table 4.1 refer to the quality of procedures used in individual reporting units and not to the quality of the regional estimates derived by aggregating them. As noted earlier, estimation errors for each region will be very low because the aggregate regional estimates were based on a very large number of observations (over 100 thousand sample plots in the North Coast, over 150 thousand in the Northern Interior and over 80 thousand in the combined Sacramento and San Joaquin regions).

The acreage of each reporting unit in each region was allocated to quality classes on the basis of field interviews and descriptions of inventory procedures and standards reported by companies in response to the mail questionnaire.

Budgetary and time limitations precluded calculation of sample variances or statistical confidence intervals by the lead investigator or his associates using data from the approximately 350 thousand individual sample plots that formed the basis of the aggregate inventory estimates. Information on confidence intervals was provided by participating companies, and used to place inventory units into quality classes after authentication by the lead investigator.

Table 4.1 Quality of procedures

A. Number of reporting units by region (1)

<table>
<thead>
<tr>
<th></th>
<th>$S_1$</th>
<th>$S_2$</th>
<th>$S_3$</th>
<th>$G_2$</th>
<th>$G_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Coast</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>N Interior</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Sacramento</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(1) Owners may have more than one inventory or growth estimation system in a region.

B. Percentage of acres by region

<table>
<thead>
<tr>
<th></th>
<th>$S_1$</th>
<th>$S_2$</th>
<th>$S_3$</th>
<th>$G_2$</th>
<th>$G_3$</th>
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</thead>
<tbody>
<tr>
<td>North Coast</td>
<td>38</td>
<td>59</td>
<td>3</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>N Interior</td>
<td>77</td>
<td>21</td>
<td>2</td>
<td>97</td>
<td>3</td>
</tr>
<tr>
<td>Sacramento</td>
<td>75</td>
<td>22</td>
<td>3</td>
<td>78</td>
<td>22</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>89</td>
<td>0</td>
<td>11</td>
<td>89</td>
<td>11</td>
</tr>
</tbody>
</table>
Table 4.1 Quality of procedures cont.

C. Percentage of inventory and growth volume by region

<table>
<thead>
<tr>
<th></th>
<th>Inventory procedures</th>
<th>Growth Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1</td>
<td>S2</td>
</tr>
<tr>
<td>North Coast</td>
<td>44</td>
<td>54</td>
</tr>
<tr>
<td>N Interior</td>
<td>83</td>
<td>15</td>
</tr>
<tr>
<td>Sacramento</td>
<td>75</td>
<td>23</td>
</tr>
<tr>
<td>San Joaquin</td>
<td>91</td>
<td>0</td>
</tr>
</tbody>
</table>

The estimation of standing volume was categorized on most of the acreage in every region as being of S1 or S2 quality. This means that aggregate estimates of standing volume for all participating holdings combined are likely to be quite reliable, especially in view of the large numbers of sample plots on which regional estimates were based.

The estimation of growth was categorized on 87% or more of the acreage in each region as being G2 in quality except for the North Coast, where it was judged that the growth estimation was of G3 quality on 25% of the acreage. There is not evidence at this time to indicate whether the growth estimate for this 25% of the North Coast reporting acreage is an underestimate or an overestimate of the actual growth.

5. TIGH estimates of forest industry inventory, growth, and harvest

Estimates of inventory, growth and harvest levels from this study (TIGH) are presented in table 5.1. They were obtained by summation of aggregate (total) estimates for each reporting unit as supplied by participating companies, after the authenticity of these aggregate estimates was verified through field interviews and inspection of data by the lead investigator.

6. Alternative estimates of forest industry inventory, growth, and harvest

The USDA Forest Service Forest Inventory and Analysis reports by Colclasure et al (1986a & b), Hiserote et al. (1986) and Lloyd et al. (1986a & b) provided estimates of forest industry inventory and growth in California for the period 1984-85, based on the measurement in 1981-84 of approximately 500 sample points for all industry lands in the state, with each point consisting of five variable (prism) plots. Forest Inventory and Analysis (FIA) estimates for timberland acreage, conifer inventory and growth are shown in tables 5.2 to 5.4 for the North Coast, Northern Interior and the combined Sacramento/San Joaquin regions.

The FIA data base was used by Krumland and McKillop (1987) in their report to FRRAP based on the California Timber Supply (CATS) model. Subsequently, a later version of the CATS model was used to develop the Krumland and McKillop (1990) conifer estimates shown in tables 5.2 to 5.5. They are similar to the 1987 results.

The Krumland and McKillop (1987) results were reported as Scenario Two in the FRRAP report (California Department of Forestry and Fire Protection, 1988). In addition, FRRAP used the growth and yield portion of the CATS model and the FIA data to obtain the Scenario One estimates shown in tables 5.2 to 5.5. For comparison, the FRRAP Sacramento, Central Sierra and San Joaquin sub-regions are combined into the single Sacramento/San Joaquin region. The combined FRRAP Sacramento and Central Sierra regions cover the same area as the FIA and CATS Sacramento region. Other FRRAP regions are the same as the FRRAP and CATS ones.
Table 5.1 Estimates from the TIGH study - participating forest industry ownerships

<table>
<thead>
<tr>
<th>Region</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timberland in 1990 (thous ac)</td>
<td>953</td>
<td>1654</td>
<td>860</td>
<td>3466</td>
</tr>
<tr>
<td>Conifer sawtimber inventory, 1990 (billion bf)</td>
<td>8.780</td>
<td>12.024</td>
<td>11.234</td>
<td>32.038</td>
</tr>
<tr>
<td>Conifer sawtimber growth, 1990 (million bf)</td>
<td>399</td>
<td>514</td>
<td>358</td>
<td>1271</td>
</tr>
<tr>
<td>Conifer harvest (million bf)</td>
<td>1485</td>
<td>681</td>
<td>447</td>
<td>1492</td>
</tr>
<tr>
<td>1985</td>
<td>681</td>
<td>447</td>
<td>363</td>
<td>1492</td>
</tr>
<tr>
<td>1986</td>
<td>638</td>
<td>502</td>
<td>421</td>
<td>1561</td>
</tr>
<tr>
<td>1987</td>
<td>749</td>
<td>560</td>
<td>381</td>
<td>1690</td>
</tr>
<tr>
<td>1988</td>
<td>834</td>
<td>567</td>
<td>427</td>
<td>1828</td>
</tr>
<tr>
<td>1989</td>
<td>668</td>
<td>435</td>
<td>354</td>
<td>1458</td>
</tr>
<tr>
<td>1990</td>
<td>550</td>
<td>424</td>
<td>395</td>
<td>1368</td>
</tr>
<tr>
<td>1991</td>
<td>481</td>
<td>391</td>
<td>421</td>
<td>1293</td>
</tr>
</tbody>
</table>

Table 5.2 Comparison of forest industry total reported timberland area with other studies (thousand acres)

<table>
<thead>
<tr>
<th>Region</th>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timberland in 1990 (thous ac)</td>
<td>TIGH</td>
<td>1990</td>
<td>953</td>
<td>1654</td>
<td>860</td>
<td>3466</td>
</tr>
<tr>
<td>Conifer sawtimber inventory, 1990 (billion bf)</td>
<td>FIA</td>
<td>1984-1985</td>
<td>1301</td>
<td>1757</td>
<td>875</td>
<td>3933</td>
</tr>
<tr>
<td>Conifer sawtimber growth, 1990 (million bf)</td>
<td>CATS</td>
<td>1985-1995</td>
<td>1104</td>
<td>1579</td>
<td>980</td>
<td>3663</td>
</tr>
<tr>
<td>Conifer harvest (million bf)</td>
<td>FRRAP</td>
<td>1980-2000</td>
<td>1196</td>
<td>1573</td>
<td>967</td>
<td>3736</td>
</tr>
</tbody>
</table>
Table 5.3A Comparison of forest industry total reported conifer sawtimber inventory with other studies (billion board feet)

<table>
<thead>
<tr>
<th>Region</th>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIGH</td>
<td>1990</td>
<td></td>
<td>8.78</td>
<td>12.02</td>
<td>11.23</td>
<td>32.038</td>
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<tr>
<td>FIA lower bound</td>
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<td>12.93</td>
<td>13.94</td>
<td>44.98</td>
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<tr>
<td>FIA upper bound</td>
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<td></td>
<td>25.94</td>
<td>16.21</td>
<td>19.57</td>
<td>61.63</td>
</tr>
<tr>
<td>CATS</td>
<td>1985-1995</td>
<td></td>
<td>16.40</td>
<td>12.20</td>
<td>15.06</td>
<td>43.66</td>
</tr>
<tr>
<td>FRRAP</td>
<td>1980-2000</td>
<td></td>
<td>15.40</td>
<td>11.86</td>
<td>14.45</td>
<td>41.72</td>
</tr>
</tbody>
</table>

Table 5.3B Comparison of forest industry conifer sawtimber inventory per acre with other studies (thousand board feet/acre)

<table>
<thead>
<tr>
<th>Region</th>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1990</td>
<td></td>
<td>9</td>
<td>7</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>FIA</td>
<td>1984-1985</td>
<td></td>
<td>17</td>
<td>8</td>
<td>19</td>
<td>14</td>
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<tr>
<td>FIA lower bound</td>
<td></td>
<td></td>
<td>15</td>
<td>8</td>
<td>17</td>
<td>12</td>
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<tr>
<td>FIA upper bound</td>
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<td></td>
<td>19</td>
<td>9</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>CATS</td>
<td>1985-1995</td>
<td></td>
<td>15</td>
<td>8</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>FRRAP</td>
<td>1980-2000</td>
<td></td>
<td>13</td>
<td>8</td>
<td>15</td>
<td>11</td>
</tr>
</tbody>
</table>
### Table 5.4A Comparison of forest industry total reported conifer sawtimber growth with other studies (million board feet)

<table>
<thead>
<tr>
<th>Region</th>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TIGH</td>
<td>1990</td>
<td>399</td>
<td>514</td>
<td>358</td>
<td>1271</td>
</tr>
<tr>
<td></td>
<td>FIA</td>
<td>1984-1985</td>
<td>667</td>
<td>505</td>
<td>473</td>
<td>1645</td>
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<td></td>
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<td>445</td>
<td>391</td>
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<tr>
<td></td>
<td></td>
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<td>566</td>
<td>555</td>
<td>1901</td>
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<td>1985-1995</td>
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<td>338</td>
<td>296</td>
<td>1075</td>
</tr>
<tr>
<td></td>
<td>FRRAP</td>
<td>1980-2000</td>
<td>380</td>
<td>298</td>
<td>285</td>
<td>963</td>
</tr>
</tbody>
</table>

### Table 5.4B Comparison of forest industry conifer sawtimber growth per acre with other studies (board feet/acre)

<table>
<thead>
<tr>
<th>Region</th>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TIGH</td>
<td>1990</td>
<td>419</td>
<td>311</td>
<td>416</td>
<td>367</td>
</tr>
<tr>
<td></td>
<td>FIA</td>
<td>1984-1985</td>
<td>512</td>
<td>288</td>
<td>540</td>
<td>418</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FIA lower bound</td>
<td>448</td>
<td>267</td>
<td>484</td>
<td>374</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FIA upper bound</td>
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<td>306</td>
<td>589</td>
<td>457</td>
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<tr>
<td></td>
<td>CATS</td>
<td>1985-1995</td>
<td>399</td>
<td>214</td>
<td>302</td>
<td>294</td>
</tr>
<tr>
<td></td>
<td>FRRAP</td>
<td>1980-2000</td>
<td>318</td>
<td>189</td>
<td>295</td>
<td>258</td>
</tr>
</tbody>
</table>
Table 5.5A Comparison of forest industry total reported conifer sawtimber harvest with other studies (million board feet)

<table>
<thead>
<tr>
<th>Region</th>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TIGH</td>
<td>1990</td>
<td>550</td>
<td>424</td>
<td>395</td>
<td>1368</td>
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<td></td>
<td>FIA</td>
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<td>not av.</td>
<td>not av.</td>
<td>not av.</td>
</tr>
<tr>
<td></td>
<td>CATS</td>
<td>1985-1995</td>
<td>799</td>
<td>492</td>
<td>511</td>
<td>1802</td>
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<td></td>
<td>FRRAP</td>
<td>1980-2000</td>
<td>857</td>
<td>399</td>
<td>467</td>
<td>1723</td>
</tr>
</tbody>
</table>

Table 5.5B Comparison of forest industry conifer sawtimber harvest per acre with other studies (thousand board feet/acre)

<table>
<thead>
<tr>
<th>Region</th>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TIGH</td>
<td>1990</td>
<td>577</td>
<td>256</td>
<td>459</td>
<td>395</td>
</tr>
<tr>
<td></td>
<td>FIA</td>
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<td>not av.</td>
<td>not av.</td>
<td>not av.</td>
<td>not av.</td>
</tr>
<tr>
<td></td>
<td>CATS</td>
<td>1985-1995</td>
<td>724</td>
<td>312</td>
<td>522</td>
<td>492</td>
</tr>
<tr>
<td></td>
<td>FRRAP</td>
<td>1980-2000</td>
<td>717</td>
<td>254</td>
<td>482</td>
<td>461</td>
</tr>
</tbody>
</table>
### Table 5.6A Forest industry conifer sawtimber growth as a percent of inventory

<table>
<thead>
<tr>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIGH</td>
<td>1990</td>
<td>4.5</td>
<td>4.3</td>
<td>3.2</td>
<td>4.0</td>
</tr>
<tr>
<td>FIA</td>
<td>1984-1985</td>
<td>3.0</td>
<td>3.5</td>
<td>2.8</td>
<td>3.1</td>
</tr>
<tr>
<td>CATS</td>
<td>1985-1995</td>
<td>2.7</td>
<td>2.8</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>FRRAP</td>
<td>1980-2000</td>
<td>2.5</td>
<td>2.5</td>
<td>2.0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

### Table 5.6B Forest industry conifer sawtimber harvest as a percent of growth

<table>
<thead>
<tr>
<th>Study</th>
<th>Period</th>
<th>NC</th>
<th>NI</th>
<th>Sac/SJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIGH</td>
<td>1990</td>
<td>137.7</td>
<td>82.4</td>
<td>110.3</td>
<td>107.6</td>
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<td>FIA</td>
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<td>not av.</td>
<td>not av.</td>
<td>not av.</td>
</tr>
<tr>
<td>CATS</td>
<td>1985-1995</td>
<td>181.2</td>
<td>145.6</td>
<td>172.5</td>
<td>167.6</td>
</tr>
<tr>
<td>FRRAP</td>
<td>1980-2000</td>
<td>225.2</td>
<td>134.1</td>
<td>163.7</td>
<td>178.8</td>
</tr>
</tbody>
</table>
7. Comparison of absolute estimates

Introduction

The FIA, CATS and FRRAP four-region estimates are based on a sample area of about 500 acres of industry timberland. On the other hand, the TIGH estimates are based on a sample area of about 50,000 acres. This TIGH sample area is based on 313 thousand "measured" plots (plots on which tree diameters and heights are measured) and 36 thousand "count" plots (on which basal area is estimated by a cruising prism). Furthermore, the FIA estimates refer to 1985, and the CATS/FRRAP are based only on decade-averages from a computer projection model, whereas the TIGH estimates refer to 1990 and are not based on a computer model. The discussion is intended to examine the validity of the FIA, CATS and FRRAP estimates by comparing them to the TIGH ones. It is important to examine why the FIA, CATS and FRRAP estimates deviate from the TIGH ones in order to lay a foundation for Task 5 of the contract which is to "evaluate the potential to use the companies' data to augment FIA statistics", and to "recommend ... to FRRAP ways to improve the program's approach for assessing timber inventory and supply trends".

Acreage of timberland

The TIGH study covers a total of 3.466 million acres for the four regions combined (North Coast, Northern Interior, Sacramento and San Joaquin). The FIA study estimated that there were 3.933 million acres of forest industry timberland in the four regions. The CATS model used an estimate of 3.663 million acres (based on timber type acreages developed by FRRAP). The acreage figure used by FRRAP Scenario One was 3.736 million acres. The FRRAP estimates were based on FRRAP mapping of forest land and ownership classification. The CATS acreage was based on earlier estimates developed by FRRAP. The FIA acreage of forest industry ownership was obtained by multiplying the estimate of total forest land in a region by the ratio of the number of forest industry ownership points to total ownership points.

The difference between the FIA estimate and the TIGH one is partly explainable by the fact that not all forest industry companies took part in the TIGH study. However, it should be noted that, in the Sacramento region, where there was a high degree of forest industry participation in the TIGH study, the TIGH acreage estimate is greater than the FIA one. This may be partly because the FIA estimate excluded the area occupied by roads. In addition, the TIGH acreage was based on owners' records, while the FIA figure was a sample estimate (based on classification of a large number of aerial photo points using county assessors' records). Upper and lower bounds for 90 percent confidence intervals for FIA estimates of acreage are shown in table 5.2.

Inventory level - four region total

Inventory (standing volume) estimates are for conifer sawtimber in board foot Scribner measure. An insufficient number of companies had volume compilations that provided hardwood estimates for the TIGH study. In the FIA compilation, coniferous trees must be at least 9.0" diameter at breast height (d.b.h.) and must contain at least one 12’ sawlog with a top (minimum scaling) diameter of at least 6” inside bark (d.i.b). Forest industry standards are generally higher, with a majority of companies using 11.5" d.b.h, 16’ log length and a 6” minimum scaling diameter. Inventory and growth estimates made using these standards will be less than FIA estimates for the same tract of timber, although the difference is not likely to be great because of the low board-foot content of trees under 11" in d.b.h.

The four-region TIGH estimate of 1990 conifer inventory (standing volume) is 32.0 billion board feet, as opposed to the FIA estimate of 53.3 billion for 1984-85, the 43.7 billion CATS average 1985-95 estimate, and the FRRAP average 1990-2000 estimate of 41.7 billion. Differences are due partly to the following factors:
• The FIA figure includes all forest industry lands (estimated at 3.933 million acres). TIGH covers only participating companies with an estimated timberland acreage of 3.466 million.

• The FIA estimate was based on data collected in 1981-84 and updated to 1984-85; the TIGH estimate is for 1990.

• The generally-lower FIA diameter and log length criteria will give slightly higher total volume estimates than TIGH ones.

• The FIA estimates are for gross volume as opposed to the TIGH estimates which are "net scale" (i.e. deduction is made for timber defect). The CATS estimates, and therefore the FRRAP ones, are also net scale, with an approximate deduction for defect of 10 percent.

• The FIA estimates, and therefore the CATS and FRRAP estimates, are based on approximately 500 sample points for all forest industry timberland in the four regions. (The total number of TIGH plots was 349 thousand). The approximate FIA 90% confidence interval is plus or minus 16 percent. As shown in table 5.3A, this gives a possible lower bound for the FIA estimate of approximately 45 billion board feet. Ignoring projection error, and applying this same 16 percent error to the CATS 1985-95 average gives a CATS possible lower bound of approximately 37 billion. A corresponding lower bound for the FRRAP 1980-2000 average is 35 billion. If the projection errors for the CATS and FRRAP studies were known and added to the FIA-derived sampling error, the resulting overall estimation error would be substantially greater. As a consequence, CATS and FRRAP confidence intervals would undoubtedly overlap the TIGH four-region inventory estimate of 32 billion board feet.

• The total TIGH 1985-90 harvest level was 9.5 billion. If annual growth over the six year period was the same as the 1990 level, the 1985-90 total growth would amount to 7.2 billion. The difference between the two figures could account for an approximate disparity in inventory estimates of 2.3 billion between the FIA and TIGH studies.

Regional inventory levels

For the North Coast, the FIA estimate of 22 billion b.f. is substantially greater than the others, especially the TIGH estimate of 9 billion. The lower 90% confidence bound for the FIA estimate is 18 billion b.f. Reasons for differences in the estimates are similar to those mentioned for the four region estimate. For example, if annual growth over the six year period was the same as the 1990 level, the 1985-90 total growth would amount to 2 billion. The total TIGH 1985-90 harvest level was 4.1 billion. The difference between the two figures could account for an approximate disparity in inventory levels of 2.1 billion. Higher TIGH measurement standards could account for part of the remaining difference. In addition, one large nonparticipating company is generally believed to have substantially higher levels of standing volume than is typical for other companies in the region. Nonparticipation of this company means that the TIGH estimate may considerably underestimate total standing volume in the region.

Inventory estimates for the Northern Interior are similar to each other, but the Sacramento/San Joaquin ones are more variable, with FIA being highest at 16.8 billion and TIGH lowest at 11.2. The lower FIA confidence bound is approximately 12.1 billion b.f. If annual growth over the six year period was the same as the 1990 level, the 1985-90 total growth would amount to 2.1 billion b.f. The total TIGH 1985-90 harvest level was 2.3 billion, for an approximate inventory increase of only 0.2 billion. Part of the unaccounted-for difference between the TIGH figure and the FIA lower bound could be explained by the different measurement standards.

Growth

TIGH four-region conifer sawtimber growth for 1990 is 1.3 billion b.f. This excludes growth for two large ownerships and a number of smaller ownerships who did not participate in the study. The CATS projection for 1985-95 is 1.1 billion. The FRRAP average annual projection for 1980-2000 is 960 million. The FIA estimate for 1984-85, covering more acreage than TIGH, was 1.6 billion. It has a 90% confidence interval
of approximately plus or minus 16 percent, which gives a lower possible bound of 1.4 billion. It should be
recalled that FIA used lower diameter and log length limits than most TIGH cooperators used. This,
together with the difference in ownership covered, may partly account for the higher FIA estimate.

For the North Coast, growth estimates for TIGH, FIA, CATS and FRRAP are respectively 399, 667, 441
and 380 million board feet. The lower 90% confidence bound on the FIA estimate is 554 million b.f. It
should be noted that the acreage of participating ownerships on the North Coast was only 73 percent of
the FIA acreage estimate which may account for a significant part of the difference.

For the Northern Interior, growth estimates for TIGH, FIA, CATS and FRRAP are respectively 514, 505,
338 and 298 million b.f. For the Sacramento/San Joaquin region, growth estimates for TIGH, FIA, CATS
and FRRAP are respectively 358, 473, 296 and 285 million b.f. FIA sampling error could account for part,
but not all, the difference between TIGH and FIA figures. The FIA lower bound is 391 million b.f. The fact
that CATS and FRRAP projections for both the Northern Interior and Sacramento/San Joaquin regions
are lower than both the TIGH and FIA estimates suggests that the CATS and FRRAP methods may have
underestimated growth in those regions.

### Harvest levels

The TIGH 1985-91 average harvest level was 1.5 billion board feet for the four regions combined. For 1990
and 1991, it was 1.4 and 1.3 billion board feet respectively, as opposed to the CATS 1985-95 average
projection of 1.8 billion, and the FRRAP 1980-2000 average projection of 1.7 billion. The difference is
explainable by the fact that not all companies participated in the TIGH study and that the CATS and
FRRAP estimates are only computer model projections based on a small number of sample plots. The FIA
study did not estimate harvest levels.

TIGH, CATS and FRRAP estimates are closer for the Northern Interior (424, 492 and 399 million b.f.
respectively), but more diverse for the Sacramento/San Joaquin region (395, 511 and 467 million b.f.
respectively). They are quite different for the North Coast with the TIGH level (550 million) being
substantially lower than CATS (799 million) and FRRAP (857 million). Part of the difference is due to the
fact that not all companies took part in the TIGH survey and that, as noted above, the CATS and FRRAP
estimates are decade-average projections from a computer model based on a small number of sample plots.

State Board of Equalization harvest data are not presented in this report. The BOE publishes annual private
timber harvest levels but does not report them separately for industrial and nonindustrial ownerships.

### 8. Comparison of per acre and proportionate estimates

Tables 5.3B, 5.4B and 5.5B show inventory, growth and harvest on a per acre basis. This type of
presentation has the advantage that it allows for differences in acreage covered by the different studies, but it
should be viewed with care because it represents merchantable volume divided by total acreage, rather than
volume divided by the acreage on which the merchantable timber occurs. It is not an indicator of the volume
per acre found in merchantable stands.

The TIGH estimates of standing volume per acre are the lowest in all regions and the FIA estimates are the
highest in the North Coast and the Sacramento/San Joaquin regions. FIA growth per acre estimates are
highest for the North Coast and the Sacramento/San Joaquin regions. TIGH growth per acre estimates are
highest for the Northern Interior. CATS/FRRAP growth per acre estimates are lowest for all regions. Per
acre harvest estimates are lowest for TIGH in the North Coast and the Sacramento/San Joaquin regions, and
for FRRAP in the Northern Interior. They are highest for CATS in all regions. FIA reports showed Board of
Equalization levels of harvest for all private ownerships combined but did not provide estimates for forest
industry alone.

Table 5.6A shows conifer sawtimber growth as a percent of inventory. FIA, CATS and FRRAP estimates
of growth as a percent of inventory are noticeably lower than TIGH ones. They are some 83, 66 and 62
percent respectively of the TIGH estimates for the four regions combined. For the North Coast, these
respective percentages are 81, 72 and 66; for the Northern Interior they are 81, 65 and 59; and for the
Sacramento/San Joaquin region they are 89, 62 and 62 percent of the TIGH growth/inventory percent estimates.

Table 5.6B shows harvest levels as a percent of merchantable growth (cut/growth percents). CATS and FRRAP cut/growth percents are noticeably greater than the TIGH ones. They are respectively 156 and 166 percent of the TIGH estimates for the four regions combined. For the North Coast they are respectively 132 and 164 percent; for the Northern Interior 177 and 163 percent; and for the Sacramento/San Joaquin 156 and 148 percent of the TIGH estimates.

9. Conclusion

This report has presented TIGH estimates of forest industry standing volume and growth by region, and compared them with FIA, CATS and FRRAP estimates. Differences in the estimates appear to be mainly attributable to statistical sampling and projection errors, and to differences in acreage estimates used by the various studies. An important role of Tasks 1 to 4 was to provide information for addressing Task 5. Task 5 is the subject of a forthcoming report.

As noted earlier, Task 5 is to "Evaluate the potential to use the companies' plot, site, and aggregate data to augment FIA statistics to assess current and future conditions of industrial landownerships. Recommend in a report to FRRAP ways to improve the program's approach for assessing timber inventory and supply trends". The information provided by Tasks 1 to 4 on the nature and extent of inventory and growth data, and the estimation procedures of individual companies is an essential basis for undertaking Task 5.

10. References


Appendix A - Timber inventory estimation procedures

This material is excerpted from chapters 3 and 4 of "Wildland resource sampling" © 1992 by Lee C. Wensel, Department of Forestry and Resource Management, University of California, Berkeley CA 94720. For additional details, refer to the document and the literature cited by it.

Design of the sample survey

The object of sample survey design is to choose a sampling system that will provide the information needed for the least cost. In simplified terms we might define our informational needs by stating that we want to estimate the total of some attribute of a population (e.g., total forage on a range, total timber volume on a forest, the number of deer on a winter range, etc.).

Even with this simplified definition of our informational needs there are still a large number of interrelated design questions that must be answered:

• What is the target population to be sampled?
• What is the sampling unit to be employed?
• What accuracy and precision limits are required?
• How many samples will be taken?
• How will the samples be selected?
• What equation will be used to compute the estimates?
• What budget is available for the project?

These decisions must be made so as to construct a feasible sampling system that is efficient, i.e., it can be implemented physically and it will provide the required information, within the required limits of precision and accuracy, for a cost that is minimum over feasible alternatives.

Accuracy and Precision Limits

As defined earlier, accuracy refers to the amount of bias that exists in the estimator and precision refers to the variability that exists in the estimator. Bias can be reduced by careful measurement of the attributes of interest and by use of unbiased estimation techniques. Precision refers to variation in the estimator, with precise estimates being those with little or no variance. For a given sample design, precision can be increased by using large sample sizes. Ideally, we would want to obtain accurate estimates that are without bias and which have very small variances.

Desired precision limits are usually specified by stating the desired level of confidence and the half-width of the confidence interval. While this topic is discussed in more detail in Chapter 4, we should point out that it is common practice to require relatively high levels of precision (±2 to 5% at the 95% level of confidence) when estimating quantities for sale and relatively lower levels (±10% at 90% level of confidence) when estimating quantities for general resource management. For general reconnaissance, the precision required could be as low as, say, ±50% at the 80% level of confidence.

Setting the accuracy and precision limits for a given survey is an important task that must be undertaken with knowledge of the importance of the information being obtained and resources available to do the necessary sampling and measurement.
Sampling units

Since the cost of sampling, the bias (if any), and the sampling distribution depend upon this choice of sampling unit, the choice will determine the overall efficiency of the sample survey. Further, the choice of which sampling unit is "best" is made by evaluating alternative sampling systems, of which the sampling unit is only a part. The important concepts that must be considered simultaneously in selecting the basic sampling unit to be used are

- the variance of the sampling distribution,
- the cost of sampling, and
- the amount of bias, if any, that is likely to occur.

The type, size, and shape of the sample unit must be considered as well as how many units to be sampled (section 3.4). The type of unit refers to whether individuals are to be chosen individually, in groups (e.g., plots), or in clusters of groups (e.g., plot clusters). The size of the sample unit refers how large the group is, how much of an area is covered by each group, and/or how many groups are in each cluster. Finally, shape refers most commonly to plots, whether they are circular, square, or rectangular.

Stratified Sampling

The most commonly applied use of auxiliary information in wildland resource sampling is to divide up the population into subpopulations, or strata, that are individually less variable than the overall population. In vegetation sampling, for example, areas that have similar species composition and size distributions will be grouped together for sampling. Aerial photographs of the areas to be sampled can be used for this purpose, although some modifications of the resulting boundaries may be necessary to account for the changes that have taken place since the photographs were taken.

The estimation procedures for stratified sampling, outlined in detail in Chapter 4, are quite simple in principle. After the boundaries of the strata are defined, each stratum is sampled independently using whatever sampling methods seem appropriate. The estimates of the total (timber volume, forage, number of deer, etc.) from the individual strata are then added to obtain an estimate of the total for the entire population.

Forest sampling

In order to make reasoned management decisions, it is necessary to have reliable and timely information about the forest resource. Further, the cost of obtaining this information should be small, certainly no larger than the benefits to be gained by its collection.

Since the decisions that the wildland manager must make are numerous and varied, so too are the possible ways of obtaining that information and the form in which the information is presented. While in many cases the information that the manager needs can be obtained from data already in hand, sampling is frequently required to either provide the data needed or simply to supplement the data already available. As far as forest sampling is concerned, emphasis is usually placed upon the larger trees (timber sampling) with less emphasis on other characteristics of the forest. This is not to say that other characteristics are ignored, just simply that the precision of the sampling design is usually controlled for the major product derived from the forest, and in most forests that has been timber.

Since sampling is costly both in terms of time and money, the overall objective of sampling is to provide the required information (i.e., with the specified precision) at the least possible cost. Where this is not possible, or where the precision requirements cannot be specified, the objective is to provide the maximum amount of information for some specified cost.

In determining the precision to be required and the sampling design to be used, the manager must consider the following:
• the use to which the information is to be put,
• the balance between measurement and sampling errors,
• the time frame that is involved,
• the resources (personnel, equipment, and time) available for the actual sampling, and
• the time and resources required for the analysis and reporting of the sample data.

Estimation of change or growth

Perhaps the most important use of a forest sampling system is the estimation of the change that has taken place over time. Studying past changes in the forest, coupled with information on management activity during the period, provides the manager with a basis for assessing the effectiveness of his or her management activity. Also, it helps to detect new management opportunities and problems such as increased insect activity, ingrowth of undesirable species, reduced growth of mature trees or of stands that are becoming too dense, etc.

In estimating the total net change, two variables are of principal interest: numbers of trees and volume, both summarized by species, size, or age, and type of change. The types of change which are usually of interest are:

• survivor growth -- growth of trees that were present and measured at both points in time,
• ingrowth -- growth on trees that were not present (or not merchantable) at the beginning of the period,
• mortality -- trees that were present at the beginning of the period but subsequently died (summarized by cause), and
• cut -- trees that were harvested during the period.

There are two principal methods of sampling to estimate the net change in the forest. One is to sample the forest at a single point in time and then to infer, on the basis of sample growth rings and other observations, what the plots looked like at some earlier period. This method must be used when no earlier measurements are available.

The second method involves measurements on sample trees at two points in time. That is, it is possible to measure the change directly by first locating a series of plots for measurement and then periodically remeasuring these plots to obtain the change that actually took place.

(There is a) statistical advantage of using remeasured sample plots when estimating the net change in a forest. However, there are other advantages of using remeasured plots. As mentioned above, it is the only reliable way of assessing ingrowth and mortality. Also, the remeasurement of sample plots tends to reduce measurement errors since the same trees are measured more than once. The gains that one receives in using remeasured plots to estimate the net change are costly in terms of the resulting decrease in the precision of estimating the standing volume at any one point in time. The establishment and relocation of remeasured plots can be time consuming in the field. Also, the field records must be kept in such a way that the previous measurements on the sample trees can be made available to the crew doing the remeasurements some years later. This more costly sampling procedure reduces the number of remeasured plots that can be taken for a given budget, as compared to the number of temporary plots that could be taken.

Associated with the use of remeasured plots is the danger that they may not be representative of the rest of the forest. While this is true of any sampling design, it is more critical when remeasured plots are used since (1) not as much new information about current stocking is gained by remeasurement, and (2) the plots that are marked in the forest may receive different treatment just because they are marked.
Appendix B - Questionnaire

Department of Forestry and Resource Management
University of California, Berkeley CA 94720
FAX: 510-643-5438 Phone: 510-642-0469 or 3765(messages)

To: Cooperators and potential additional cooperators on the Timber Inventory, Growth and Harvest (TIGH) Study


Dear Cooperators,

As Gil Murray of the California Forestry Association explained in his February 22, 1991 letter to you, the California Department of Forestry and Fire Protection's FRRAP unit, with the encouragement of CFA, has asked the University of California Wildland Resources Center to gather, and objectively evaluate and analyse, best available information from forest industry companies for the purpose of developing regional estimates of timber inventories, growth, and harvests. (The draft questions sent to you on August 9, 1991 have now been slightly revised on the basis of comments by our advisory committee).

Company-level information will be kept strictly confidential. Only I, as principal investigator, will know the identity of the company providing a particular response, and only I or a member of my immediate research staff will have access to completed responses and supplementary data. Reports to the CDF and advisory committees will show only aggregate forest industry data for the following FRRAP regions within the state:

North Coast region consisting of Del Norte, Humbolt, Mendocino, and Sonoma counties.

Northern Interior region consisting of Siskiyou, Modoc, Trinity, Shasta, and Lassen counties.

Sacramento region consisting of counties south from Tehama and Plumas to Sacramento and El Dorado.

San Joaquin region consisting of counties from San Joaquin, Amador, and Alpine south to Kern, Tulare, and Fresno.

Central Coast region consisting of counties from Marin and Solano south to San Benito and Monterey.

Because of a low level of industrial forest acreage, Southern California, and probably the Central Coast region, will be excluded from the final analysis. However, in the meantime, I would appreciate receiving Central Coast information where available.

Given the great variety of forest inventory systems and methods of growth estimation, it will be a major task to combine information from different companies and to categorize the accuracy of estimates. Based on preliminary phone contacts with most cooperators, the situation appears to be as follows:

1. Standing volume estimates

Some companies have recent inventory systems (call them type 1) that are designed to estimate gross standing volume within plus or minus 5 or 10 percent with 95 percent confidence for the whole property or working circle. Others use systems (call them type 2) that have been developed from cruises made at various times in the past, for various parts of the property, and adjusted for cut and growth since the cruise date. Systems intermediate between these will be called type 3.

My current plan is, for region (and timber type where available) to
(a) describe inventory types 1, 2 and 3 in as much detail as feasible (including estimation of accuracy where possible)

(b) aggregate individual company estimates of standing volume into a single number, with allowance where possible for different standards of log and tree minimum sizes and units of measurement (board feet or cubic feet)

(c) list the percentage of each aggregate regional volume estimate that was derived from each of the three inventory types.

2. Volume growth estimates

Companies appear to use one, or some combination, of the following methods of growth estimation:

(a) remeasurement of permanent plots

(b) CRYPTOS/CACTOS analysis

(c) adjustment of yield table estimates where stands are even-aged

(d) derivation of percentage growth factors by other means and application of them to estimates of standing volume.

The current plan is, by region and timber type where available, to
(i) describe the growth methods in as much detail as feasible (including estimated accuracy where possible),
(ii) aggregate individual company estimates into a single number, and (iii) list the percentage of each aggregate growth estimate that has been derived by each method.

The contract between the CDF and the University requires assessment of data quality and utility through interviews and examination by me of company inventory records and procedures. This phase is essential to ensure the credibility of the study. After receiving a sufficient number of responses to the attached questions, I will be phoning to arrange a suitable time to visit your company. Again, all information on individual companies will be held in strictest confidence.

Please answer the attached questions to the best of your ability. I would appreciate it if, by November 1, you could give me your response both in printed (hard copy) form and on a DOS diskette (3.5” or 5.25”, high or medium density) in text (ASCII) form suitable for processing on an IBM personal computer or IBM clone. We can also handle Lotus or Excel spreadsheet files. You will note that I am asking for information separately for each FRRAP region, and for each part of your property within each region for which the inventory or growth estimation method is significantly different.

Please do not hesitate to call or FAX me if any questions or procedures are unclear. Thank you for your cooperation on this important study.

Sincerely,

William McKillop
Professor
Timber inventory, growth and harvest study

Please send by November 1, 1991 your best available information (by hard copy and diskette) on the following items to William McKillop, Dept. of Forestry & Resource Management, Univ. of California, Berkeley CA 94720. FAX: 510-643-5438 Phone: 510-642-0469 or 3765(messages)

Please provide information by indicated number, separately for each FRRAP region and for each part of your property within each region for which the inventory or growth estimation method is significantly different.

1. Name of company; name, phone and FAX number of contact person

2. FRRAP region (see cover letter for description) and name of the part of your property to which the following information applies.

3. Please list the timber types (if any) you use for this part of property and describe the criteria used for designating each type, such as site, species, age-class, crown closure, volume, minimum size typed etc.

4. Please list fee acreage by timber type for this part of the property. Please explain how the acreage of types was estimated (e.g. dot grid).

5. Inventory method

Please describe by categories (a), (b), (c) etc, shown below, the inventory system used for this part of your property. (Use NA if not applicable). Include, where possible, a copy of any field manuals or cruise specifications and a summary of the purpose of the inventory.

(a) strata/timber type used
(b) any use of photoplots, satellite imagery, multistage sampling etc.
(c) type of sample plot (fixed or variable/prism); and prism factor or shape and size of fixed plots
(d) information taken on each plot (including species included or excluded, minimum tree d.b.h, width of d.b.h classes, total or merchantable height, minimum top diameter, seedling or sapling count, increment or age borings, site index etc.
(e) use of subplots (please describe)
(d) sampling fraction (number of plots per 40 or acres per plot etc)
(g) method of locating plots (fixed grid, random lines etc)
(h) dates of inventory and planned number of years until next one.
(i) measurement standards for volume computation (e.g. 11" d.b.h and greater to 6" top for board foot volume; 5" d.b.h and greater and total height for cubic volume etc)
(j) any procedures for quality control, including training of crews, check cruising etc.
(k) any aspects not described above

6. Method of growth estimation

Please describe by categories (a), (b), (c) and (d) shown below, details of the growth estimation method for this part of your property. (Use NA if not applicable). If you describe more than one growth estimation method for this part of your property show the percentage of the acreage to which each method applies.

(a) Use of permanent (CFI) sample plots, including number and placement of them, frequency of remeasurement, type of measurements taken, method of applying results to get an estimate of total growth for this part of the property etc

(b) Use of CRYPTOS or CACTOS, including source of data such as ingrowth and live crown percents, any modification of growth parameters, method of applying results to get an estimate of total growth for this part of the property etc
(c) Use of yield tables, including how proprietary yield tables were developed, method of adjusting published yield tables, modifications to handle mixed-age stands, method of applying results to get an estimate of total growth for this part of the property etc.

(d) Derivation of growth percentage estimates by other methods. Please describe how they were derived and how they were used to get an estimate of total growth for this part of the property.

7. Estimate of standing volume

(a) Please list by timber type where feasible, the board foot standing volume, and the cubic foot volume if available, for this part of your property as of December 31, 1990.

(b) Please describe how you derived this estimate from your inventory information. If you cannot give it for December 31, 1990, please state the date to which your estimate applies and, if possible, suggest how we can adjust it to December 31, 1990 so that we can have a uniform date for aggregation across companies. Please include in your response a description of the type of tree volume tables used, taper equations, adjustment for defect etc.

8. Estimate of current growth

(a) Please list by timber type where feasible, the board foot volume growth, and the cubic foot growth if available, for this part of your property for calendar year 1990.

(b) Please describe how you derived this estimate from the information described earlier. If you cannot give it for 1990, please state the year to which your estimate applies and, if possible, suggest how we can adjust it to 1990.

9. Harvest levels

Please list the levels of harvest, separately for conifers and hardwoods, for each calendar year from 1985 to the latest year available. If this information is not available for this part of your property, please give it for your whole property or relevant management unit or working circle. Also, please explain how standing volume estimates are adjusted to account for harvesting.

10. Please add any additional information or comments that might be useful to the study.

Thank you.
1. Objectives

The basic purpose of the timber industry growth and harvest (TIGH) study is to: 1) assess timber inventory and growth conditions on industrial landownerships through the use of data and statistics collected by individual companies; 2) evaluate the reliability, accuracy, coverage, and consistency of the data as a basis for assessing current and future conditions of industrial forestland; and 3) suggest strategies to incorporate individual company and FIA data in the FRRAP analysis procedures.

The following tasks were undertaken to accomplish those objectives:

Task 1 - "Review and describe acceptable techniques to gather relevant timber inventory data, and develop protocols to compare and evaluate different data sets for reliability, accuracy, consistency, and coverage".

Task 2 - "Compile from industrial landowners the best available information on current levels of timber inventory, growth, and acreage by timber stratum where available and feasible. Strata are to be based where feasible on forest type, size, and stocking class".

Task 3 - "Assess the quality and utility of individual data sets in comparison to standards and protocols developed in Task 1 and through interviews and examination of records and procedures of individual companies".

Task 4 - "Aggregate information by timber supply regions and present statistics representing current inventory, growth, harvest, and acreage by timber stratum where available and feasible. Prepare report on current conditions of industrial timberland, including all information and analyses enumerated in Tasks 1 - 4".

Tasks 1 to 4 were addressed in a previous report (McKillop, 1993) which provides the necessary background for Task 5 - "Evaluate the potential to use the companies' plot, site, and aggregate data to augment FIA statistics to assess current and future conditions of industrial landownerships. Recommend in a report to FRRAP ways to improve the program's approach for assessing timber inventory and supply trends".

This report on Task 5 first discusses which technique appears to be most suitable for analyzing and projecting California private timber inventory and supply trends.

2. Analysis and projection technique for timber inventory and supply trends

Introduction

Assessment of future timber inventory and supply trends involves projecting standing volume, growth and harvest by decade for each major region within the state. This requires assembling a study team, selecting a projection model and developing a data base. The specific issue addressed in this report is the extent to which timber company data can be used to augment U.S. Forest Service Forest Inventory and Analysis (FIA) data.

The type of projection model to be used must be selected before data requirements can be discussed. Previous studies used the California Timber Supply (CATS) model which was developed to handle the special characteristics of the California forest resource, with its great diversity of timber types and
management regimes (Krumland and McKillop 1987 and 1990). It combines the CRYPTOS/CACTOS approach (Krumland, 1982; Wensel, Daugherty and Meerschaert, 1986; Wensel, Krumland and Meerschaert, 1987; Wensel, Meerschaert and Biging, 1987) for estimating the growth and yield of major stand types under various management regimes with a linear programming module (CATSLP) for controlling the allocation of acreage to management regimes and for imposing harvest flow constraints. The growth and yield portion of the model (CATSYG) was used by FRRAP (California Department of Forestry and Fire Protection, 1988) to develop its Scenario I projections.

Because it was designed for the purpose and has been tested through its use in prior studies, the CATS model appears to be the most appropriate system for analyzing and projecting trends in aggregate timber inventories and supplies. Therefore, the report will focus primarily on recommendations for developing information and data bases for this model.

It should be recognized that other systems may be potentially useful in estimating future states of the California forest resource such as SARA developed at UC Berkeley under the direction of Professor Lawrence Davis (Scott, 1991) and PROGNOSIS developed by the U.S. Forest Service (Wykoff et al., 1982). The utility of these systems should be evaluated. Information requirements of either approach will be similar to those for the CATS system. The approach of the CACTOS and CRYPTOS models is fundamental to any system for analyzing growth and yield of California forests. The CATS system or any other system used to project regional growth and yield should make full use of the most recent developments of these models.

Data and information requirements

Implementation of a CATS type analysis requires the following general kinds of information: (1) designation of the ownerships to which the analysis applies, (2) specification of the timber stand types that are to be handled by the model, (3) acreage of the specified timber types, and aggregate acreages covered by the analysis, (4) data required by the CRYPTOS/CACTOS approach, and (5) categorization of owners' management regimes and harvest practices. Data and information requirements are discussed in more detail below.

Cooperation of landowners

Task 5 calls for evaluation of "the potential to use the companies' plot, site, and aggregate data". It is recommended that a procedure for seeking owner cooperation similar to the one employed for Tasks 1 to 4 be used in seeking an extended data base for future analyses. In other words, the California Forestry Association should again be asked to contact its membership and any other potential cooperators with a request that they provide needed data and related information.

A key element in getting access to these data is the reassurance of timberland owners that the confidentiality of company level data will be preserved. This was an important part of the agreement whereby data were provided to undertake Tasks 1 through 4. To preserve confidentiality of cooperator data, access to these data should be limited to an independent third party consisting of well-qualified persons who are employees of neither the cooperators nor the California Department of Forestry and Fire Protection.

An additional necessary element is that cooperating owners are assured that the data will be used in an effective manner and that any resulting reports will present a rigorous assessment of the current and future state of the California private forest resource. Consideration should be given to setting up an advisory committee of cooperators to review the potential effectiveness and rigor of procedures that are proposed for assessing timber inventory and supply trends.

Rules of the Board of Forestry adopted on October 16, 1992 call for landowners who submit a sustained yield plan (SYP) to make available, for confidential audit, inventory data utilized in the plan and to describe how inventory estimates by major vegetation types will be improved over time, "with the goal of achieving standard errors that are no greater than 15 percent of their respective inventory estimates within the effective period of the SYP". In the case of those owners who submit SYP's, the focus on preparing inventory

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estimates by major vegetation types may assist in the development of suitable data bases for regional timber supply analysis.

3. Designation of ownerships to be covered

As noted in the report on Tasks I to 4, the U.S. Forest Service Forest Inventory and Analysis (FIA) reports by Colclasure et al. (1986a & b), Hiserote et al. (1986) and Lloyd et al. (1986a & b), define industrial forest landownerships simply as forest land owned by forest industry (large companies with or without mills). The FIA unit maintains a list of specific companies that it classifies as industrial forest owners.

The FRRAP report defines industrial forestland owners as "individuals or companies that have 5,000 or more acres nationwide, and either own a wood-using manufacturing plant, or employ a permanent forestry staff and a system of regular timber harvests" (California Department of Forestry and Fire Protection, 1988). This definition appears to be suitable for the purposes of selecting a set of owners who will be asked to cooperate by supplying data. It appears that all California ownerships which currently have useful inventory data will meet this definition, but it is possible that not all owners who meet this definition will be able to provide useful inventory data.

4. Forest cover types

It was determined, in the course of fulfilling Tasks I to 4, that the vast majority of companies were unable to supply aggregate data by forest cover type/timber strata, either because they did not have their lands typed in any systematic way or because their record-keeping system summarizes data by section or management unit rather than by timber type. In addition, it was apparent from those data that were supplied by timber type that there is a wide variety of typing systems being used. It will be necessary to adopt a common set of cover types before future analyses of aggregate timber inventory and supply trends can be undertaken.

Rules of the Board of Forestry adopted on October 16, 1992 call for Sustained Yield Plans to use the WHR (Wildlife Habitat Relationships) classification of forest cover (California Department of Fish and Game, 1988a and b). The rules state that the "major WHR types include all tree-dominated habitats in size classes 4, 5, and 6 with canopy closure classes of S, P, M, or D". These WHR types appear to be suitable for developing appropriate growth and yield projections, but extensive discussions should take place between those conducting the assessment and private forest managers and owners to ensure that the best possible designation of stand types is achieved for the purpose of estimating future forest conditions. In addition, forest cover types based on the WHR classification should include submerchantable tree size standards 1, 2 and 3 to permit projection of the growth and yield of stands that are not currently merchantable. They should also include cover types which describe younger stands with a multi-layered or uneven-aged structure. The 1988 WHR types do not include such cover types.

5. Estimates of acreage by forest cover types

A major source of disparities between CATS/FRRAP, TIGH and FIA estimates of growth may be differences in estimates of acreage by forest cover types. Close attention must be paid to improving this aspect before further analyses and projections are undertaken. Rules of the Board of Forestry adopted on October 16, 1992 call for Sustained Yield Plans to provide estimates of acreage by WHR types. This may greatly assist in developing more accurate area estimates by cover type.

6. Units of measure

At the current time, only a few companies keep track of growth or standing volume in cubic foot terms. All California companies use board feet as the predominant unit of measure, but this will change as the forest sector completes its transition from private old-growth and larger second-growth to utilization of smaller
trees. It is recommended that board foot measure be used in initial analyses of forest conditions but that cooperators be encouraged also to supply data in cubic measure.

7. CRYPTOS/CACTOS type of data

CATSYG, the growth and yield component of the CATS model, uses the CRYPTOS/CACTOS distance-independent tree-model approach to projecting growth and yield. This approach is described in Appendix A. CRYPTOS/CACTOS type of information is essential to any successful modeling effort.

Desirable CRYPTOS/CACTOS information for inventory plots includes:

- for each tree - tree identifier, species, d.b.h, total height, crown ratio or height of crown base, crown class, estimated percent defect, trees-per-acre expansion factor.
- in addition, for growth trees - tree identifier, species, total height, periodic d.b.h growth, and if possible, periodic height growth
- for each plot - plot identifier, plot location, measurement date, timber type, site index by major species.

Only one cooperator in the TIGH study collected full CRYPTOS/CACTOS information on inventory plots, as opposed to growth plots. As noted in the report on Tasks 1 through 4, nine reporting units (companies or regional divisions of large companies) applied CRYPTOS/CACTOS to their growth plots. However, a number of companies expressed interest in collecting full CRYPTOS/CACTOS information on at least a portion of inventory plots when their inventory systems are revised. It is recommended that further analyses be undertaken to determine the degree to which CATSYG data needs can be met by company inventory systems that may be developed in response to rules of the Board of Forestry adopted on October 16, 1992.

Even if CRYPTOS/CACTOS information is not available for cooperators' inventory plots, they should be requested to supply information of this type from growth plots to expand the U.S.F.S. FIA data base for estimating parameters of the CATSYG increment equations.

8. Survey of management regimes and harvest practices

Krumland and McKillop conducted a survey of management regimes and harvest practices of California owners as part of their 1987 study for FRRAP and developed nine potential basic management options (treatments) for each stand for each decade in the 1985-2055 period of analysis. These options, which are described in Appendix B, reflected the combined effects of economic, administrative, legal and biological criteria followed by owners in the management of their properties.

An updated set of management and harvest regimes needs to be developed through a survey that is similar to, but more detailed than, the one for the 1987 report. In particular, special attention must be paid to the types of activities required by spotted owl regulations and Board of Forestry rules adopted on October 16, 1992. Estimates of acreages of each ownership/timber type combination to which specific silvicultural and harvesting regimes may be applied should also be sought.

9. Estimation of model parameters

It is highly desirable that a major effort be made to improve the accuracy of the parameters of the CATSYG model or any other growth and yield simulator that might be used. This will require re-estimating increment equations using data supplied by cooperators as well as new FIA data.
10. Assessment of model accuracy

The accuracy of the 1987-90 CATS model was examined on a stand-by-stand basis by extrapolating 1981-84 FIA plot volumes back to the early nineteen-seventies where feasible, and comparing them with corresponding plot volumes from the earlier FIA survey plots. Future modeling should continue this plot-by-plot assessment of accuracy.

Assessment of the accuracy of aggregate estimates was not carried out in the 1987-90 model, except by comparing simulated aggregate harvest levels for each region with annual average Board of Equalization timber harvest estimates for 1978-85. Future analyses should compare regional growth and harvest estimates with externally-derived aggregate estimates, such as the TIGH estimates described in the report on Tasks 1-4.

The results of the forthcoming U.S. Forest Service FIA analysis should also be compared to the TIGH estimates, and any significant disparities investigated before the FIA data are used in a timber supply projection model. As noted in the report on Tasks 1 through 4, the TIGH estimates of standing volume are based on about 350 thousand sample plots whereas the FIA estimates for industrial lands are based on about 500 sample points with five plots per point. This means that sampling errors for TIGH aggregate estimates are likely to be very much lower than FIA ones.

After adjustment for acreage covered, the TIGH estimates should be used to assess FIA accuracy. FIA plots are permanently located and intensively checked for accuracy of measurement, whereas almost all TIGH plots are temporary ones. It is unlikely, given the wide variety of inventory methods used by cooperating companies, that aggregate TIGH estimates contain any type of systematic error.

The sampling frame for the FIA survey is totally different from the TIGH one. The TIGH estimation procedure is equivalent to a stratified sample where the primary strata are individual ownerships. It does not appear that anything would be gained by attempting to combine the two sets of standing volume and growth estimates. However, as noted above, growth information from FIA plots should be pooled with similar information from cooperators to re-estimate growth and yield parameters for future modeling efforts.

11. Major recommendations

The major recommendations of this report are:

- Specify forest cover types that are to be handled by the model. The WHR classification of forest cover described in the rules of the Board of Forestry adopted on October 16, 1992 appear to be suitable for developing appropriate growth and yield projections, but extensive discussions should take place between those conducting the assessment and private forest managers and owners to ensure that the best possible designation of stand types is achieved in relation to estimating future forest conditions. In addition, forest cover types based on the WHR classification should include submerchantable tree size standards 1, 2 and 3 to permit projection of the growth and yield of stands that are not currently merchantable. They should also include cover types which describe younger stands with a multi-layered or uneven-aged structure.

- As was done for Tasks 1 to 4, the California Forestry Association should be asked to collaborate on the project by contacting its member companies and any other potential cooperators with a request that they provide needed data and related information. To preserve confidentiality of cooperator data, access to these data should be limited to an independent third party consisting of well-qualified persons who are employees of neither the cooperators nor the California Department of Forestry and Fire Protection.

- These data and information should include
(a) Acreage of the specified timber types

(b) Data required by the CRYPTOS/CACTOS approach, including at a minimum:

- for each tree - species, d.b.h, total height, crown ratio, tree expansion factor
- for each plot - site index by major species.

(c) Descriptions of typical management regimes and harvest practices by timber type. Special attention should be paid to the types of activities required by spotted owl regulations and Board of Forestry rules adopted on October 16, 1992. Estimates of acreages of each ownership/timber type combination to which specific silvicultural and harvesting regimes may be applied should also be sought.

Cooperators should be requested to supply any CRYPTOS/CACTOS type information they may have collected on growth plots.

- Parameters of the CATSYG model, or any other growth and yield simulator that might be used, should be re-estimated using both new FIA data and data supplied by cooperators.

Inventory, growth and yield estimates derived from the projection system for a base period should be compared with independently derived estimates for the purpose of validating or calibrating the model. This should be done on an aggregate basis for region/owner classes, where feasible, as well as on a plot-by-plot basis.

12. Conclusion

Forest landowners, the logging and wood processing industries, governmental entities and other groups with an interest in forest policy and planning will benefit significantly from objective and rigorous assessments of the future state of California private timber growth, yield and inventories. Producing such assessments requires that the best possible data bases on current forest conditions be developed and that detailed discussions be held with a wide range of private forest managers and owners to assure that the structure and assumptions of projection models provide an appropriate representation of reality both in terms of the state of the resource and the decisions that will be made for its management.

These events will occur only if close cooperation and a feeling of mutual trust is achieved between forest landowners and state government. The TIGH project represents an important first stage in securing such cooperation and trust. Substantial mutual benefit will accrue from undertaking similar joint efforts to address the technically complex task of analyzing the current and future state of California's forest resources.

13. References


Appendix C - CRYPTOS/CACTOS procedures

CATSYG, the growth and yield component of the CATS model, uses the CRYPTOS/CACTOS distance-independent tree-model approach to projecting growth and yield. CATSYG uses the same type of species-specific "increment equations" as CRYPTOS/CACTOS, with coefficients re-estimated where appropriate. The first equation predicts growth in the square of d.b.h. (diameter at breast height) as a function of total height of the tree, site index, crown ratio, and stand crown closure at 66 percent of the height of the tree. The second equation predicts the height growth of the tree as a function of the height growth of a dominant tree of equivalent age, crown ratio and stand crown closure at 66 percent of the height of the tree in question. The third equation predicts change in crown ratio as a function of the estimated height growth of the tree, stand crown closure at the height of the tree's crown base, and crown ratio. The fourth equation predicts the probability of death of the tree as a function of its d.b.h., the ratio of tree d.b.h. to mean stand d.b.h., and trees per acre. (Krumland and McKillop, 1990).

The CATSYG modelling process starts with a tree list, which identifies each individual tree in the stand by its various characteristics such as d.b.h., height, crown size, etc., and then applies the increment equations to it to generate an updated tree list for the particular projection in question. Tree removals due to harvest are also included in the tree list update with their effect on the remaining trees being represented via the increment equations.
Appendix D - Management regimes and harvest practices

Stand treatment options available in the 1987-90 version of the CATS model included harvesting to a diameter limit, removal of slow growing trees whose volume growth rate is less than a pre-specified rate, and removal of fixed amounts of stand volume. A provision was also available for treating a certain percentage of the acreage of each stand type under different management options.

Krumland and McKillop conducted a survey of management regimes and harvest practices of California owners as part of their 1987 study for FRRAP. This survey indicated that nine potential basic management options (treatments) for each stand for each decade in the 1985-2055 period of analysis should be modeled. These were:

- Do nothing (no harvests, just let the stand grow).
- Special zones: cut half the merchantable volume over 16 inches d.b.h., ensuring that the remaining stand meets the legal minimum stocking standards. Stands must have at least 5,000 board feet to the acre to be considered for harvesting.
- Poor sites: do an "economic" clearcut; regenerate to meet legal minimum stocking standards. Repeat clearcutting and regeneration whenever standing volume exceeds 5,000 board feet per acre.
- Well-stocked, even-aged young growth conifer stands with at least 80 percent of the stand volume in trees of 11 inches d.b.h. or greater: clearcut and regenerate with 400 conifers per acre.
- Commercial thinning of well-stocked young growth conifer stands with a clearcut final harvest 20 years later and restocking with 400 conifers per acre.
- Well-stocked uneven-aged young growth conifers: partial cutting to maintain current stocking and d.b.h. distribution.
- Nonindustrial private stands not described above: remove one-third of the standing volume in trees 16 inches d.b.h. and greater, provided the conifer harvest volume is greater than 3,000 board feet per acre; meet minimum stocking standards following harvest.
- Industry old-growth stands or nonstocked and marginally stocked conifer stands or predominantly hardwood (merchantable) stands on good sites: clearcut and regenerate with 400 conifers per acre.
- Industry stands not described above:
  (a) Remove one-third of the volume in trees 16 inches d.b.h. and greater, provided conifer volume removed exceeds 3,000 board feet per acre, or
  (b) During the first three decades, clearcut and regenerate better sites with 400 conifers per acre if the understory is predominantly hardwoods or if the conifer understory is inadequate to produce future crops.

In addition, in the 1987-90 runs of the model for industrial ownerships, hardwood and brush competition was assumed to be controlled so that conifer regeneration was free to grow. The model has the capability to simulate competition from undesirable vegetation but this was not used on the assumption that the use of herbicides or "brush-rake and burn" would achieve the necessary conifer release.
To: Don Ernan  
Director, Wildland Resources Center  
University of California

From: J. Keith Gilless  
Department of Forestry and Resource Management  
University of California, Berkeley

Re: Draft reports on CDF contract 8CA06732, "Timber industry growth and harvest study: An evaluation of California's industrial forest landowners' timber inventories"

At your request I have reviewed Professor McKillop's work on this contract, and submit the comments below for your consideration. I am available to make revisions or for further consultation on the matter after the Technical Advisory Team, Professor McKillop, and yourself have had time to review my comments.

In conducting my review:

• I reviewed Professor McKillop's draft report on Tasks 1-4 dated 12/22/92, his final report on Tasks 1-4 dated 6/11/93, and his draft reports on Task 5 dated 4/26/93, 6/13/93, and his final report on Task 5 dated 7/7/93.

• I met with Professor McKillop to discuss his work, and to review his aggregation of the data.

• I made field visits to four of the cooperating forest landowners, meeting with:
  
  Dr. Dan Opalach (Simpson Timber Company),  
  Ed Murphy (Sierra Pacific Industries),  
  Dave Loveless (W.M. Beaty & Associates), and  
  Syd Dearborn (Louisiana Pacific).

The purpose these visits was to: (1) assess the cooperators' inventory and growth projection systems, (2) review the information they had provided to McKillop, and (3) establish the consistency of the information provided with the underlying inventory and growth projection systems.

In deference to any representations of confidentiality made to the cooperating forest landowners, I did not ask Professor McKillop to share with me any of the individual cooperator's responses to his questionnaire, nor did I represent myself to the cooperators I visited as having a right to review their responses. However, each of the four cooperators I visited voluntarily provided me with access to their responses, greatly facilitating my review. I have retained copies of none of these responses.
Tasks 1-4

On the basis of my review of McKillop's draft and final reports on Tasks 1-4, I feel that he deserves credit for providing an objective and useful representation of the data provided to him by the cooperators. I found his categorization of the quality of the inventory and projection systems to be accurate, in some cases perhaps even conservative. The data provided to him by the four cooperators I visited was clearly the same data upon which they base their internal decisionmaking.

I further find that he makes a convincing case that:

...the CATS and FRRAP methods may have underestimated growth in those {Northern Interior and Sacramento/San Joaquin} regions.

The utility of the report as a check on the overall timber inventory and growth situation in California, however, is severely limited by non-reporting from some industrial landowners. That this underreporting is most significant for the North Coast region is particularly disappointing, and significantly limits the utility of the study to address some of the questions surrounding the timber supply situation in the state. Any future cooperative assessment efforts, however, must overcome this problem with nonreporting, and compensate appropriately. Otherwise, we will never be able to break out of the present situation where we have a number of timber supply studies which cannot be directly compared.

It should be noted that in the interim between the time at which the data was supplied to McKillop and the present, several of the largest industrial landowners have made or started to make significant investments in improving the quality of their data, reinforcing the difference in the quality of the proprietary and public information on timber inventory and growth on these ownerships. These improvements notwithstanding, McKillop accurately notes that the inability of many industrial ownerships to supply data by timber type/strata will limit the utility of proprietary data and the degree to which assessments and projects based upon WHR classifications can be made.

Task 5

I agree with Professor McKillop (Task 5 Final Report, 7/7/93) that:

Substantial mutual benefit will accrue from undertaking similar joint efforts to address the technically complex task of analyzing the current and future state of California's forest resources.

However, I feel that a clearer definition of the goals and protocols of such a joint effort is needed before I would concur with his conclusion that:

Because it was designed for the purpose and has been tested through its use in prior studies, the CATS model appears to be the most appropriate system for analyzing and projecting trends in aggregate timber inventories and supplies.

The workplan for this study does not clearly identify the ends to which the CDF's monitoring and projection of timber inventory and supply trends should be directed. Are they to provide:

- Annual statements of inventory, harvest, and growth?
- Periodic (5-10 year intervals) statements of inventory, harvest, and growth?
- Assessments or forecasts of the timber supply situation with an explicit economic dimension going beyond utilization limits (e.g., cost of availability or price responsiveness of owners)?
- A more timely, accurate, or otherwise superior alternative to USFS assessments of timber supply, a cooperative effort directed towards improving their assessments, or an independent assessment to serve some validation purpose?
A projection system for responding to requests for input into the evaluation and formation of forest policy in California? And if so, to be maintained by and accessible to who?

Without clear answers to these questions, I feel that a recommendation for utilization of a particular methodology or analyst is premature. Answering these questions, of course, would require the cooperation of all stakeholders in the forestry community, facilitated by either the CDF, the University of California, or some other entity.

Furthermore, with respect to proceeding with analysis employing the existing version of the CATS model, I have the following reservations:

- The model uses a naive timber availability assumption that may not, in its present form, adequately reflect price responsiveness of NIPF ownerships, or spatial and wildlife habitat constraints on industrial ownerships. While this does not necessarily limit the model's accuracy as a predictor of biological productivity, it is relevant to the credibility and interpretation of its use to forecast harvest levels. (Of course, similar limitations apply to other existing models.)

- The dramatic improvements being made by some of the largest industrial ownerships in their timber inventory and growth projection systems, coupled with the documentation provisions of the regulations recently adopted by the State Board of Forestry may provide a defensible rationale for developing a system of self-reporting for these ownerships, coupled with CDF/University projections for NIPF ownerships and ownerships unwilling or unable to provide data of comparable quality. That is to say, depending on the agreed-upon purposes and reporting formats for CDF assessments of timber inventory and growth, the rational for using a single, less accurate projection model over all industrial and non-industrial ownerships rather than a hybrid system of self-reporting and residual projection needs further consideration.

Regardless of the methodology or system employed by the CDF to perform its monitoring and projection responsibilities (once they have been clearly defined), I believe that several guiding principles are clearly necessary to lend credibility to the discharge of these responsibilities:

- Clear disclosure guidelines would need to be developed with respect to the utilization of proprietary data, similar to those employed by the state and federal governments in dealing with annual employment and wage information or periodic census of manufactures data. Consolidation of industrial ownerships will only exacerbate this need.

- Clear procedural guidelines would need to be developed with respect to the use of non-proprietary data (e.g., FIA plots) where industrial cooperation was not forthcoming in order to provide assessments that were comparable over time and to USFS assessments.

- All modeling assumptions employed need to be clearly and publicly documented. Ideally, these assumptions should reflect a consensus of the stakeholders, and be agreed upon prior to the adoption of any particular methodology or system.

- All computational algorithms employed should be clearly documented, along with the procedures used to make all key parameter estimates and information on the reliability of those estimates. This would include complete disclosure of source code for any computer programs utilized, and public access to the model to the extend that this is possible without release of data covered by the agreed-upon disclosure guidelines. (Note: I am not referring here to the inventory and growth projection systems used by individual landowners.)

- Maintenance of models and data by the academic community might be considered to increase procedural credibility, subject to a widely-based oversight body. The periodic timber supply studies undertaken by the faculty of Oregon State University provide a useful model in this respect, involving extensive faculty participation. In the California case, it would obviously be useful to
involve faculty from both the UC system and the CSU system in some kind of corporate responsibility for providing this service through some coordinating agent such as the Wildland Resources Center. On the other hand, I am not alone in respecting the objectivity and capacity of the CDF staff, and in having confidence in their ability to discharge any responsibilities for timber supply assessment and monitoring assigned to them.

Finally, while Professor McKillop (Task 5 Final Report, 7/7/93) notes that:

*The results of the forthcoming U.S. Forest Service FIA analysis should also be compared to the TIGH estimates, and any significant disparities investigated before the FIA data are used in a timber supply projection model.*

I would go further to say that the U.S. Forest Service must engage in a constructive dialog with the CDF, forest industry, and others to see if modifications should be made in the procedures to be employed in future U.S. Forest Service assessments of the timber supply situation in California. However, without assurances of continuing cooperation between forest industry and the CDF, any requirement to withhold analysis performed by the CDF using FIA data pending resolution of disparities is neither justified by Professor McKillop's study nor an acceptable constraint on the discharge of its responsibilities by a public agency.
Oversight and technical team members

Oversight team

Louis Blumberg
Kenneth L. Delfino
Ray Flynn
Robert Hrubes
Gil Murray
Jeffrey M. Romm
Ralph Warbington
Marilyn and Ray West

The Wilderness Society
California Department of Forestry and Fire Protection
Humboldt County Assessor's Office
LSA Associates
California Forestry Association
University of California, Berkeley
U.S. Forest Service
Private Citizens, Camp Nelson

Technical team

Gregory S. Biging
Helge Eng
Edward Murphy
Philip W. Rundel
Raul Tuazon

University of California, Berkeley
California Department of Forestry and Fire Protection
Sierra Pacific Industries
University of California, Los Angeles
California Department of Forestry and Fire Protection
July 16, 1993

Dr. Don C. Erman, Director
Wildlands Resources Center
145 Mulford Hall
University of California at Berkeley
Berkeley, CA 94720

re: Timber Industry Growth and Harvest Study (TIGH)

Dear Dr. Erman:

I am writing to let you know that from my perspective, the final draft of Bill McKillop's TIGH report does not respond adequately to most of the concerns raised by the Technical and Oversight Committees. More specifically, many of the issues raised in letters by the California Department of Forestry and Fire Protection (August 28, 1993), Dr. Robert Hrubes (September 10, 1993), and The Wilderness Society (September 11, 1993) have not been addressed.

In addition, I would like to reiterate a comment made by Dr. Gillis, that because of non-reporting by some landowners, the "utility of the report as a check on the overall timber inventory and growth situation in California, however is limited ...." Not only is it limited, it is quite likely that the report is misleading. Those industrial landowners not reporting are more likely those who have been most aggressively logging their lands, well above sustainable levels.

While I agree that differences in statistical sampling and projection errors, and differences in acreage estimates have produced different estimates of inventory and growth (Final report, p. 19), the report does not provide the information necessary to conclude that these factors are the main factors as is claimed on page 19.

As has been a concern from the inception, this report is already being grossly misrepresented by industry advocates. At a minimum, this is the second time this has happened. A member of the Board of Forestry has already claimed in public session that the "McKillop report" has been released, has received the endorsement of the advisory committees, and has established that "all is well" with respect to industry
harvesting levels. Due to the apparent lack of adequate control of the interpretation of this report, I request to be present at any presentation of the report before the Board of Forestry.

Given this premature public misrepresentation of the report, a few observations are warranted, despite the limited utility discussed above. It is noteworthy that this TIGH study, which is based on significantly more sample plots and more recent data than the FIA study, reports less inventory, both total and per acre, (tables 5.3A & B) than all other methods analyzed. Also, it appears that, based on this partial survey, the rate of harvest exceeds the rate of growth (Table 6.6B). The TIGH data still paint a picture of overharvesting. Average harvesting statewide over the past seven years is over 120 percent of total growth, even given the data that puts the industry in the most favorable light. On the northcoast, the TIGH data reveal harvests to be 165 percent of growth.

Additional comments:

1) Mr. McKillop's recommendation to exclude CDF from future access to industry data is unsupported by any information or basis in the report. CDF should have access to the proprietary data. Such access is compatible with the BOF's new sustained yield planning rules and with the effort to create trust of which this TIGH study is part.

2) According to the TIGH report, the statewide percent of inventory growth rate is four percent. This rate strains credulity and serves as an indication of the overall lack of reliability of the report and therefore an example of the lack of utility of the report.

At this juncture, with no express measures to assure our participation in any public presentation of the report, which is needed to insure accurate portrayal, The Wilderness Society must reluctantly conclude that our participation in the review process has unfortunately and improperly lent a degree of acceptability and credibility to the final report that is not supported by the final product.

Sincerely,

Louis Blumberg
Assistant Regional Director
August 3, 1993

Dr. Don Erman, Director
Wildland Resources Center
University of California
Berkeley, CA 94720

Dear Don,

Below is our review of the final TIGH report. It is our understanding that these comments will be attached to the final report to be submitted to the CDF. We apologize for the delay, but previous personal commitments precluded an earlier response.

In July, 1991 we agreed to serve as members of a committee to oversee a study being conducted by the University of California to investigate the inventory, growth and harvest rate of timber on California industrial forestland. Although neither of us have formal training or job-related experience in timber management, we have a long standing interest in National Forest land management, and are familiar with the terminology and concepts used in the TIGH study. Our participation was as private citizens volunteering a public service.

The oversight committee met on 4 occasions between Sept 1991 and June, 1993 where the details of the study and related issues were described and discussed with Dr. William McKillop, the lead investigator. Dr. McKillop presented draft reports and committee members made oral and written comments on and asked questions about these reports. At no time did the oversight committee review samples of raw data or compilations of raw data from the study, nor was any member of the oversight committee present at any of the actual data-gathering field work.

All readers of the final TIGH report should clearly understand that not a single acre of land was directly measured by the lead investigator or his staff. The heart of the TIGH study in essence is a compilation of confidential data voluntarily submitted by those companies who chose to participate in the study. Even the confidence intervals that determined the placement of data inventory quality categories were provided directly by the participating companies. The lead investigator stated in the first oversight meeting that a statistically significant number of industry plots could not be independently re-measured as a check by his staff because of the high cost involved. With regard to the raw data supplied by the cooperators, "Budgetary and time limitations precluded calculation of sample variances or statistical confidence intervals by the lead investigator or his staff" (page 12). These observations should not be interpreted as a criticism of the conduct of the study, but reveal limitations inherent in the study itself.
We are concerned that this report, because it was conducted under the auspices of a prestigious university, will be seen for more than what it clearly is—a compilation of voluntarily submitted timber industry data. The value we see in the study is in the stimulation of corporate, public and academic discussion regarding measurement of long-term timber production in California.

The lack of data available to the investigators to estimate timber type/strata is another weakness of the study. Nevertheless the remarkably high reported total percent inventory growth of 4.0% shown in Table 5.6A is consistent with a population of young, rapidly growing trees and a dearth of mature slower growing trees containing high quality lumber. Knowledge of age, size and species of trees is critical in understanding the present and future condition of California forestlands.

Data on overall harvest rates on industrial timberlands can probably be obtained from the California Board of Equalization, Timber Tax Division. Although the BOE does not publish or compile such figures, the raw data exist from which industry ownership harvest data can be pulled with no compromise of confidentiality. If the cost of such compilation is not too great, it may be worth while to do as a check on the harvest data shown in Table 5.1.

The fact that significant industrial ownership did not participate seriously limits the usefulness of the study. It is our understanding that there is one large non-cooperating company with very high harvest rates, high inventory and low growth rate (due to a high percentage of old-growth). We can only speculate that the inclusion of this company in the TIGH study could well have pushed all 3 categories of data toward the CATS and FRRAP figures.

There appear to be significant differences between the TIGH, FIA, CATS and FRRAP figures. We hope there will be constructive discussion as to the reasons for these differences. However, the data presented in Table 5.6B and Table 5.1 show there has been considerable harvesting in excess of growth, regardless of the set of data considered. The TIGH figures in Table 5.1, for example, shows an average annual harvest for all regions of 1527 million board feet since 1985, while growth in 1990 is estimated to be 1271 million board feet. The CATS and FRRAP projections shown in Table 5.6 show a higher rate of overcutting, 167.6% and 178.8% of harvest as a percent of growth, respectively. If one of the purposes of the TIGH study was to alleviate fears of overcutting on industrial timberland, the opposite effect was achieved, even considering the inherent problems with the study described above.

sincerely,

Marilyn West
Ray West
Dr. Don Erman  
Wildland Resources Center  
145 Mulford Hall  
Berkeley, Ca. 94720  

Re: McKillop Report  

Dear Don,  

I have reviewed the final drafts of the work by Drs. McKillop and Gilless and offer the following comments.

Overall, I believe this a very good report and Bill did a good job combing a wide variety of information sources in an informative and useful data set. I also think Keith raised some good questions about why are we collecting data and what questions did we seek to answer.

In addition to the actual data provided, I believe the value of this report is the foundation it establishes for cooperation between the public and private sectors in sharing information. Both sectors have useful data that can and should be shared in a cooperative manner, efforts similar to this report should foster more sharing in the future.

My only criticism is in the process used to review Dr. McKillop's work. This was a technical report dealing with hard data. However, the review by some members of the committees seemed to focus on policy and political views. Those issues and debates are more appropriate in another forum and at another time. The long delays and needless hassles could have been avoided if the review was focused on the technical aspects of the report.

Sincerely,

Gil Murray  
Vice President  
Private Lands Division

GM:bhs
Re: Response to comments on report for CDFFP contract 8CA06732

Dear Don,

Some of the comments on the final reports for CDFFP contract 8CA06732 require a response.

1. Issues raised in August and September 1992 letters.

These letters were submitted in 1992 (not 1993) by the California Department of Forestry and Fire Protection, Robert Hrubes and the Wilderness Society in response to our request for comments on my July 1992 draft report. I incorporated all technically valid suggestions in the final report, and, as you will recall, provided 23 single-spaced pages in response to the letters. Technical and Oversight Committee members were given the opportunity to discuss those comments and offer further ones in Committee meetings in November 1992 and June 1993.

2. Comparison of 1990 growth estimates with harvest levels in prior years.

There was agreement by a majority of Committee members in November 1992 that it was improper to present harvest-growth ratios using growth for 1990 and harvest levels for years other than 1990. As predicted in University of California Bulletin 1931 by Bruce Krumland and myself, timber harvests levels on industrial lands have been declining in recent years. It is not analytically correct to compare 1990 growth with the average harvest level since 1985.

3. Growth as percent of inventory.

There is no valid reason to object to the finding that TIGH estimates of board foot growth as a percent of inventory are around 4 percent. A majority of timber companies use an 11.5 inch tree diameter at breast height as the minimum standard of merchantability. Many of their timber stands are currently moving into the merchantable class, so growth as a percent of volume is obviously going to be high.
4. Absolute levels of growth.

Even though they represent only 88 percent of the industrial acreage for the state as a whole, TIGH estimates of growth in the Northern Interior region, the Sacramento/San Joaquin region and all regions combined are substantially greater than the CATS and FRRAP estimates.

Even in the North Coast, where TIGH covers only 73 percent of the industrial acreage, the TIGH estimate of 399 million board feet is greater than the FRRAP one and only slightly below the CATS one. If an allowance were made for non-reporting ownerships, it is entirely plausible that the U.S. Forest Service FIA lower bound of 554 million board feet would be reached.

Sincerely,

[Signature]

William McKillop
Professor