APPENDIX A

TERMS OF REFERENCE FOR CONSULTING FIRMS
TERMS OF REFERENCE FOR CONSULTANTS

The key objectives set out the basis for the Terms of Reference for consultants. More particularly the consultants were guided in their task by a statement of the scope of the proposed study and by a prescribed outline. The idea of constraining the consultants to a fairly rigorous format was to ensure ease of comparison of the reports and to prevent the consultants deviating too far from the specified study area in a field which is very complex and has numerous closely associated functions.

The full text of the Terms of Reference can be supplied; however, the section that outlined the scope of the study is reproduced below:

The technical content of each study report will be the responsibility of the appointed consultant, based on the project outline submitted by the Commission. The study teams will not be conducting an audit or an in-depth analysis, but a technical review. The Commission does not consider that any field examination should be carried out at this time. The scope of this technical review requires the study teams to check the basis of data and procedures resulting in the current AAC level of the study area assigned. From this information, professional judgement should be applied to provide conclusions as to the accuracy and appropriateness of the inventory, and AAC, and make recommendations for improvements.

The tasks set for the HST Consortium, the co-ordinating team were to:

- Refine the specifics of the Terms of Reference to ensure all prospective consulting firms would be bidding to well defined criteria;
- Review proposals submitted by invited consulting firms;
- Recommend consulting firms to undertake the studies;
- Arrange for information meetings with members of the Commission and with the Ministry of Forests;
- Co-ordinate and monitor the progress of consultants;
- Review and analyze consultant reports;
- Prepare an overview report for the Commission summarizing the findings of the consultants and specialist consultants.
EXECUTIVE SUMMARY

Introduction

This report, undertaken for the British Columbia Forest Resources Commission, provides a technical review of the Forest Inventory and Allowable Annual Cut for the GOLDEN TSA.

At the onset it must be stated that:

1. The inventory was conducted to 1968 specifications which were designed to meet the needs at that time.

2. The Timber Supply and AAC were initially conducted in 1981 to specifications and standards in effect at that time, and

3. The nature of demands on the land base, information requirements and management objectives have changed significantly from those at the time of the inventory and Timber Supply Analysis.

These factors have contributed to many of the concerns regarding the Inventory, Timber Supply and AAC.

During the course of the review we were very impressed with the degree of knowledge, commitment and dedication exhibited by the people involved in both the Inventory and Timber Supply Analysis.

Review Objectives

For the purpose of this study the Forest Inventory and Timber Supply Analysis procedures, information and results were reviewed in the context of past and current forest management requirements.

Identified Shortcomings

Based on the evaluations of the Inventory and Timber Supply Analysis, a number of areas which have the potential for significant improvement are documented and possible courses of action to implement these improvements are outlined.

Forest Classification

The current forest classification was designed to provide Unit Level inventory estimates. This is no longer adequate in terms of current information requirements. The inventory must have the capability to provide stand-specific estimates. This will require collection of such parameters as:

- Species per cent;
- Actual stand height and height distribution;
- Actual stand age;
- Density in terms of basal area and/or stems per hectare;
- Stand diameter and diameter distribution;
- Log grade and quality; and
- Revision of ESA's.

Yield Estimation

The yield estimation procedures should allow more precise and accurate estimates of gross and net volume and log size and quality. They should be capable of estimating parameters on a stand-specific basis.

Data Access

The capability of Districts to access and report on inventory statistics and timber supply analyses is limited. Local Regional and District data summary capabilities addressing local needs should be available.

Other Resource Values

Insufficient emphasis was placed on the inclusion of resource values in the past.
Rationalization of NSR Statistics

Both Inventory and Silviculture maintain information on NSR through two different reporting systems which report different statistics.

Operational and Strategic Planning Needs

The current Timber Supply Analysis System addresses strategic planning needs and does not address the needs of operational managers. The system should allow the determination of timber supplies and AAC by local units and be capable of addressing geo-referenced stands and monitoring adherence to the TSA Plan.

The current system has become too complex and involved.

Aggregation Procedures

The demonstrated volume variances associated with aggregation will always exist. It is an artifact of a system restriction and results in the inappropriate treatment of data.

Net Down Procedures

Checking procedures for the allocation of net downs are regarded as being inadequate. The use of Low Site as a criteria for net downs and the reduction for unclassified roads, trails and landings and site degradation should be critically examined.

Rationalization of Information from Other Sources

The Timber Supply Analysis relies on information from other sources such as Silviculture NSR statistics and Protection estimates of unsalvaged losses. The Timber Supply Analysis should reflect similar figures.

Levels of Uncertainty

The quoted and documented levels of uncertainty in the Timber Supply Analysis are regarded as being unacceptable.

Recommendations for Substantial Improvements

Based on the evaluations of the inventory and Timber Supply Analysis, a number of areas which have the potential for significant improvement are documented and the following recommendations are presented:

1. A reclassification of the Golden TSA is an immediate requirement.
2. ESA's need to be revised.
3. Yield estimation, both for volume and decay, waste and breakage, requires upgrading.
4. Existing cruise plots should be included in the data base.
5. Volume estimates should be based on taper equations.
6. Differences between cruising and inventory volume estimates should be resolved.

7. Volume estimates should allow the changing of utilization standards.

8. Enhanced capability to report on inventory statistics should be provided. Local Regional and District data summary capabilities addressing local needs should be available.

9. Increased emphasis should be placed on the inclusion of resource values other than forest resources.

10. The dual NSR record keeping of Silviculture and Inventory should be resolved.

11. A Timber Supply Analysis System which is designed to meet both operational and strategic planning needs is regarded as being essential.

Such a system must allow the determination of timber supplies and AAC by local units, be they planning cells, watersheds or any other specified unit. The system must also be capable of addressing geo-referenced stands and must include the capability to handle Local Resource Use Plans and Total Chance Plans.

It must also include a monitoring system linked to the forest inventory to allow monitoring adherence to the TSA Plan; monitoring of operator performance including operator area profile versus harvest profile, silviculture activity, etc.; monitoring harvest rates, i.e. planned and actual areas and volumes harvested; be capable of monitoring the harvest rate in relationship to the AAC; and addressing other operational concerns and issues. In addition, the system should include a "gaming" or "simulation" capability for scenario testing.

12. It is strongly recommended that the Ministry undertake the development of this system rather than attempt to modify existing systems that may not meet their needs.

13. Data Aggregation procedures should be avoided.

14. A "Test Bed" system for checking the allocation of net downs is regarded as being essential.

15. The Use of Low Site as a criteria for net downs and the reduction for unclassified roads, trails and landings and site degradation should be critically examined.

16. Rationalization of information from other sources that is used in the Timber Supply Analysis is essential.

17. The quoted and documented levels of uncertainty in the Timber Supply Analysis are regarded as being unacceptable. They require resolution.

18. Analysis capability to evaluate changes and trends between analyses is regarded as highly desirable.

19. It is strongly recommended that data sources and changes in the data be fully documented.

20. It is recommended that the lead role in the Timber Supply Analysis be taken by the District. Responsibility for data and processing quality assurance should rest with a single individual.

21. It is also recommended that the Inventory and Planning process be re-integrated at the Branch Level.

22. It is recommended that the District be provided with the required personnel and access to equipment to allow (1) access to data, (2) reporting capabilities and (3) monitoring capabilities. Equipment should include a Geographic Information System.

23. Timber Supply Analyses should not take more than one year from start to completion.

The priorities for funding were considered and prioritized as shown below:

1. Provision of District capability to access and report on data.

2. Implementation of a Timber Supply Analysis System that addresses operational as well as strategic planning needs.

3. Re-inventory of the Golden TSA.
EXECUTIVE SUMMARY

This is an executive summary of a report, "Technical Review of Forest Inventory and Allowable Cut Determination for the Sunshine Coast TSA". The report was prepared by Fortrends Consulting Inc. in compliance with the requirements of a RFP from the B.C. Forest Resources Commission.

The report is a technical review of:

- Procedures used in the development of the inventory database; and,
- Techniques and procedures used in yield analysis for the Sunshine Coast TSA.

The following summarizes the major findings and recommendations of the report. For more detail and backup information, see the individual sections of the report.

Findings

The findings fall into two categories: those dealing with the overall information system being used by the MOF to support TSA analyses, and those dealing with specific issues in inventory and related databases.

- There is no overall quality assurance/quality control (QA/QC) system in place and operational within the MOF. Such a program is needed immediately to ensure standards of definition and compatibility within and across databases, provide transaction-based control of the data update/change process and provide version and release date control of all major databases.

- The MOF should establish "official", release-dated versions of its data files which are used for planning and analyses. Considerable difficulty was experienced in getting a clean, consistent inventory database file from the MOF due to updates being made continually to the data by groups within the MOF.

- There is considerable pressure within the MOF to begin localized, site-specific planning using GIS technology. The MOF is moving in this direction, however the implementation of this technology appears slow. This project should be sped up in order to begin the build-up of skills at the region and district levels in the application of GIS technology in planning and land use analyses.

- Coupled with the shift to more localized, site-specific planning is the need to upgrade all resource databases and history files. While the unit-level surveys were excellent for their intended purpose, they do not meet acceptable information requirements. Specifically, the planned 1990 re-inventory of the Sunshine Coast TSA does not include any allowance for ground sampling. Our experience has been that at least 20% of the individual stands must be ground sampled if the resulting resource database is to support site-specific, GIS-based planning and analysis. This will require a major re-emphasis in data collection and data management within the MOF.

- One excellent source of supplementary field sample data is via the operational cruise information developed for cutting permits. These data appear directly usable in upgrading the forest inventory, yet they are discarded once the cutting permit for which they were established is approved. Several million dollars are spent annually on cutting permit operational cruises with no benefits accruing to the MOF inventory information system. This seems an obvious opportunity for some efficiency gains.

- In order to properly evaluate yield analysis options, it is essential to have valid, consistent, second-growth natural and managed-stand growth models (yield tables). In the Sunshine Coast TSA analysis, only Douglas-fir was considered for intensive silviculture as this was the only managed-stand growth model the MOF had available internally. This approach is unacceptable. It is essential when dealing with such a vital subject as yield analysis for a TSA, that all applicable and available growth models for as many major species as can be found be used in the analysis.

- The typical planning horizon in TSA analyses is 200-250 years. All information on inventory volumes, growth, silvicultural response and timber characteristics for any yield analysis that goes beyond about 40 years (liquidation of current old-growth) is 100% based upon the growth models (yield tables) used in the analysis process. If the MOF does not have reliable, validated growth models for the silvicultural treatments and species being managed, can these analysis results be considered valid or reliable?

- As part of the upgrade of inventories, it will also be necessary to upgrade the decay, waste and breakage factors for each species. In the Sunshine Coast TSA, only four samples from a 1954 decay study and one from 1979 are within the TSA boundaries.
Recommendations

Only four general recommendations are summarized, others are contained within the text of the report. Most of these would necessarily involve several individual tasks. All are difficult and expensive to achieve, but are essential if the MOF is to conduct appropriate and publicly acceptable TSA yield analyses in the future.

1. The MOF should immediately begin the process of upgrading their basic resource inventories and silvicultural record-keeping systems in order to meet the information requirements of localized, site-specific planning and management.

As part of this process, the MOF should establish a joint-industry task force to establish guidelines on what data should be collected, the precision levels required and the priorities/importance of the parameters to be sampled.

2. It is recommended that the MOF immediately begin the task of establishing and implementing a Ministry-wide Quality Assurance/Quality Control (QA/QC) program which would be used across all resource and planning databases. Such a QA/QC program would ensure compatibility and consistency among parameters within and between databases, would maintain a transaction-based control system for the update/change process and provide version and release date control.

3. The MOF must immediately begin the process of acquiring and calibrating all available (including models developed external to the MOF Research Branch), successful, regional, natural and managed-stand growth models for all major tree species in the province. It is inappropriate to conduct yield analyses without appropriate natural-stand and managed-stand growth models for all major species present in the TSA.

4. Polygon-level, site-specific planning using GIS technology is already being attempted. The MOF have already acquired such technology, but implementation has been slow. It is recommended that the MOF accelerate implementation of this technology, starting at the region level. In this way a pool of qualified, experienced staff will be available to apply the technology as soon as adequate data is available.
EXECUTIVE SUMMARY

This technical review of the Quesnel TSA is intended to advise the Forest Resource Commission whether there is significant technical grounds for public concern about inventory and Annual Allowable Cut.

The consultants found that the forest inventory was appropriate at the time it was done but is marginally adequate today. The maintenance and update of the inventories has been neglected, resulting in low confidence by users. The total TSA needs a general re-inventory and then enhancements should be focused on areas which warrant the need.

The Ministry of Forests put a lot of effort into the yield analysis. Regional staff tried long and hard. Good co-operation with the industry and limited co-operation with the Ministry of Environment was achieved. The yield analysis took too long, was too complicated and the end results were disappointing. There is a real need to disentangle land use policy and technical calculation procedures. Simpler, faster and more revealing analytical techniques than those used now should be adopted. This report includes the following subjects:

- History;
- Assessment of inventory maps;
- Assessment of the inventory data base;
- Assessment of the overall accuracy of inventory data;
- Assessment of yield analysis procedures;
- Variability of yield analysis results;
- Discussion of the Quesnel TSA allowable cut;
- Related factors;
- Recommendations.

The consultants have made the following eight recommendations:

1. The forests of the Quesnel TSA should be re-inventoried as soon as possible with emphasis on younger stands and forest types which are recently an adequate base inventory for all forest resources in the TSA.

2. Forest inventory procedures should be improved so that inventory and data can be used with confidence at a watershed and development plan level. The present re-inventory process is not adequate. These re-inventories are elaborate updates.

3. New volume plots should be weighted to immature stands and other known gaps in our data (for example, important high elevation types). This new data would be incorporated in the new volume estimation and yield projection system for natural stands, developed by the MOF. Yield projections for managed stands must be improved.

4. Regular comparisons should be made of inventory versus cruise versus scale volume estimates. Causes of discrepancies should be identified, and recurring problems in estimating techniques should receive corrective action.

5. It should be recognized that the AAC calculation is not a surrogate for forest land management. The political aspects of the calculation (e.g. land use policies) should be separated from the technical, computational aspects. Policy matters should be dealt with by a separate, local body which is authorized to make public policy decisions. Once this has been done, technical matters, like yield analysis calculations, can proceed with clear objectives and fewer impediments.

6. The calculation process should be simplified. A forest simulation model should be substituted for linear programming techniques and MOF planners should be encouraged to use the model to understand the dynamics of the forests under analysis.

7. The allowable cut calculations should be done in the MOF regional office by regional and district staff. The Victoria function should be data preparation and manipulation, and auditing regional calculations.

8. The quality of analysis must be improved. It should be focused on specific problems. The analysis should provide an informed description of these problems and discover at least one practical solution for each. The analysis should be prepared to find surprises which may alter pre-conceived notions. A rigid mechanical process will not satisfy requirements. The process should use the intelligence and understanding of local professionals in the thinking part of the analysis.
Industrial Forestry Service Ltd.
EXECUTIVE SUMMARY

This report provides a technical review of the current Allowable Annual Cut (AAC) of the Fort St. John Timber Supply Area (TSA) as well as a review of the inventory data analyzed in support of the AAC.

Recent history of inventory and analysis procedures is included to provide an understanding of the derivation of the current inventory and analysis procedures investigated as part of this review.

Assessment of Inventory

- Forest inventory maps lack sufficient detail to be used for operational use but are adequate for yield analysis purposes.

- Forest cover type labels are not very accurate partly due to policies and procedures in place at the time of inventory and partly due to changing species composition over time. The latter is a problem unique to the mixed-wood forest types of the Peace Region of the Province. The potential impact on yield does not exceed ±10%.

- Environmentally sensitive areas (ESA's) are adequate, considering the scale of photography used for delineation. There is, however, a potential for up to 6% more of the net land base to be classed as environmentally sensitive due to sensitive soils which may be identified in Pre-harvest Silviculture Prescriptions (PHSP's).

- The current reinventory covering a large portion of the TSA was prompted in part by the need for an improved classification of deciduous types. The reinventory, however, has shown that the coniferous classification was also inaccurate.

- Volume can be assigned to the individual forest cover types in the inventory using the Ek-Payandeh volume-ratio model. Estimates of volume and species composition are generally within the range of acceptable values on a TSA basis using "capped" Ek-Payandeh curves, but volumes are rarely accurate on a site-specific basis.

- Coniferous loss factors applicable to the Fort St. John TSA cover many forest inventory zones (FIZ's) and may be unreliable. Deciduous loss factors are extremely variable and tend not to be correlated to external tree indicators but on average are reasonable.

- The procedures used to calculate unavoidable waste (W2) loss factors for application to Volume-Over-Age Curves (VAC's) appear to under-estimate the resultant loss factors, but the impact on the AAC is not significant.

- The procedure used to calculate site index for individual forest types is not very accurate because class-based variables must often be used for age and height. However, over the total TSA the use of mid-points of classes instead of actual values has a minimal effect on the AAC.

Assessment of Yield Analysis Procedures and AAC

- The current AAC is based on two separate analyses:
  1. The coniferous AAC for the Fort St. John District analyzed as part of the Peace TSA.
  2. The total AAC (coniferous and deciduous) analyzed as the Fort St. John TSA.

The deciduous AAC has been calculated as the difference between the two analyses.

- The current AAC for the TSA is:

  Coniferous: 900 162 m³
  Deciduous: 915 000 m³

- The entire coniferous AAC is presently allocated and utilized. The deciduous AAC is allocated and not utilized at this time.
Reductions made to determine the net land base may not be adequate for the following reasons:

1. The allowance of 5.5% of the current land base to non-productive following the first harvest may not be adequate. Although the impact may be lessened due to the high proportion of winter logging, up to 15% of many sites may be adversely affected by harvesting. In addition, significant areas of the TSA are being lost to rights-of-way and seismic activity.

2. Problem forest type reductions for coniferous types are comparable to other TSA's and are probably reasonable. Deciduous reductions do not appear to be realistic as shown in the following table:

<table>
<thead>
<tr>
<th></th>
<th>Coniferous</th>
<th>Deciduous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Potential Land Base (ha)</td>
<td>1045 811</td>
<td>581 126</td>
</tr>
<tr>
<td>Problem Types (ha)</td>
<td>648 000</td>
<td>33 000</td>
</tr>
<tr>
<td>Net Land Base (ha)</td>
<td>397 011</td>
<td>548 126</td>
</tr>
<tr>
<td>% Problem Type Reductions</td>
<td>62%</td>
<td>6%</td>
</tr>
</tbody>
</table>

3. The impact of planned range burning for domestic cattle and wildlife does not appear to be adequately allowed for, resulting in an overestimate of the deciduous AAC.

The deciduous AAC may be overestimated by about 400 000 m³ due to the above problems.

- The use of "uncapped" Ek-Payandeh VAC's overestimates current coniferous mature growing stock. Correcting for this problem would reduce the number of years to commencement of falldown from 50 to 10.

- The use of "uncapped" Ek-Payandeh VAC's also overestimates the current deciduous growing stock but the impact of this problem is minor compared to the overstatement of yield caused by failure to allow for deciduous problem forest types.

### Table 1

<table>
<thead>
<tr>
<th>AAC</th>
<th>Potential Impact of Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coniferous</td>
<td>Provides minor conservative margin</td>
</tr>
<tr>
<td>Modelling - 910 000 m³</td>
<td>Provides minor conservative margin</td>
</tr>
<tr>
<td>Current - 900 168 m³</td>
<td>Provides minor conservative margin</td>
</tr>
<tr>
<td>Additional area in net coniferous land base</td>
<td>Provides minor Conservative margin</td>
</tr>
<tr>
<td>VAC's overestimate mature volume</td>
<td>Reduces years to falldown from 50 to 10</td>
</tr>
<tr>
<td>Intensive Silviculture (if carried out in initial 30 years)</td>
<td>Permits extensions of years to falldown from 10 to 30 and increases LRSY by 226 000 m³/yr</td>
</tr>
<tr>
<td>Unsalved Losses underestimated</td>
<td>Eliminates falldown and increases LRSY after 110 years to 1 057 000 m³/year</td>
</tr>
<tr>
<td>Residual Types excluded</td>
<td>Potential increase LRSY by up to 3600 m³/yr</td>
</tr>
<tr>
<td>Loss Factors</td>
<td>No measurable impact but factors are potentially inaccurate</td>
</tr>
<tr>
<td>Rights-of-way may be underestimated</td>
<td>Potential reductions to AAC of about 2%</td>
</tr>
<tr>
<td>Deciduous</td>
<td>Minor conservative margin</td>
</tr>
<tr>
<td>Modelling - 950 000 m³</td>
<td>Minor conservative margin</td>
</tr>
<tr>
<td>Current - 915 000 m³</td>
<td>Minor conservative margin</td>
</tr>
<tr>
<td>Problem Type Area Inclusion Factors not applied</td>
<td>Possible reduction to LRSY of about 400 000 m³</td>
</tr>
<tr>
<td>VAC's overestimate mature volume</td>
<td>Minor reduction to short-term harvest but no effect on LRSY</td>
</tr>
<tr>
<td>Range Burning</td>
<td>Reduction to LRSY of about 5% but not a factor if problem types allowed for</td>
</tr>
<tr>
<td>Residual Types excluded</td>
<td>Potential increase LRSY by up to 10 500 m³/year</td>
</tr>
<tr>
<td>Rights-of-way may be underestimated</td>
<td>Potential reductions to AAC of about 2%</td>
</tr>
</tbody>
</table>
Planned basic silviculture regimes for coniferous stands cause stand conversions following the first harvest which do not affect the long-term harvest. However, planned conversions in deciduous stands result in an approximately 6% decrease in Long-Run Sustainable Yield (LRSY). This suggests a need for a review of the silviculture regimes.

Intensive silviculture programs originally planned to increase LRSY in the future are included in the yield analysis but have not as yet materialized.

A significant increase in the coniferous land base appears in the 1987 MOF analysis of the combined yield for both coniferous and deciduous stands compared to the coniferous yield analysis carried out in 1985. This provides a substantial potential increase in yield to offset the impact of the overestimate of the current coniferous growing stock.

Unsalvaged losses are overestimated for the coniferous AAC because fire losses are much less than previously estimated, are usually salvaged and were accounted for in the allowance for non-satisfactorily restocked and non-commercial brush areas. The reduced requirement for non-recoverable losses provides an additional offset for the overestimate of the volume of the current mature timber.

Table 1 summarizes yield analysis impacts.

Other Technical Issues Investigated

Other technical issues investigated which did not impact on AAC included:

Inventory

- Classification
- Disturbance updates
- Inventory ground truthing
- Base mapping
Analysis Procedures

- Crown land lost to timber and forage production prior to the analysis
- Aggregation of forest types into analysis units
- Stocking factor adjustments
- Forest estate model used

Recommendations

- Extend the current re-inventory to cover major concentrations of coniferous.
- Initiate increased local sampling for volume in mature and immature stands.
- Localize loss factors to the Fort St. John TSA.
- Develop VAC's which reflect actual mature volume for the first rotation.
- Develop VAC preparation procedures which allow for species succession.
- Incorporate residual types in the yield analysis if they can be utilized.
- Apply coniferous AIF's to deciduous types until experience in utilizing deciduous types can be used to define the deciduous net land base.
- Examine mixed-wood management opportunities to maximize recovery of minor species components.
- Ensure that the planned and intensive silviculture programs are carried out as modelled.
- Re-evaluate planned silviculture regimes because they appear to produce a small net decrease in overall yield.
- Monitor losses so that unsalvaged losses can be updated at the next analysis of the AAC.

- Investigate land base and productivity losses due to soil degradation from harvesting operations for input to the next analysis.
- Monitor seismic activity and make appropriate adjustments to the land base for the next analysis if necessary.
- Acknowledge the fact that forest inventory will be used for more detailed planning purposes and investigate the possibility of modifying procedures to provide more localized and reliable data for GIS applications.
- Future analyses should evaluate the coniferous and deciduous AAC's separately because the apportionment and the commitments under licences are separated.
EXECUTIVE SUMMARY

Sterling Wood Group Inc. was commissioned to conduct a review of the inventory and the procedures leading up to the determination of an allowable cut for Tree Farm Licence 35 (TFL 35).

TFL 35 is a relatively small management unit located just north of Kamloops. It is well accessed, all the productive land area is operable, and the timber growing capabilities of the land is said to be above average for the area.

Weyerhaeuser Canada Ltd. has held the licence since 1970 (it was renewed for 25 years in 1980), but the TFL was first issued in 1959 to B.C. Interior Sawmills Ltd.

This review has focused on Management and Working Plan No. 7, recently prepared by the licensee and approved by all technical levels of the Forest Service. It awaits completion of the public review process and final approval by the Chief Forester. The current Management and Working Plan No. 6 is now in its eighth year. It is obsolete and there was little point in reviewing it except in an historical context.

The review process has included a thorough evaluation of the timber inventory, including forest classification, photo interpretation, sampling for data and transfer of information onto forest cover maps. Information to supplement the inventory, such as loss factors and growth and yield curves have also been reviewed. These were all used by the licensee quite recently to conduct a timber yield analysis which provided a forecast of future yields and harvest levels. This in turn was used to determine the proposed AAC. We have also examined the yield analysis process - particularly, the assumptions used and the management obligations embedded in the process. This report comments on the adequacy and accuracy of the inventory and its supplements, and documents the concerns felt by the licensee, the Forest Service and ourselves. Finally, the report lists the shortcomings of the inventory, yield analysis and AAC determination process and sets out some recommendations for change.

In our assessment of the current inventory, the maps and timber type labelling we found that the last full re-inventory was done in 1978. This has been augmented with updates which reflect the harvesting, planting, etc. that has taken place in the meantime. While the inventory is now quite old and should have been replaced during the last Management and
Working Plan Period, we found that the photo information, classification and mapping had been done very accurately. The quality of the photos was mediocre but the skill of the photointerpreters seems to have overcome this handicap so that there would have been very little change to the inventory had the photos been of better quality.

A noticeable gap in the inventory is any proper allowance for Environmentally Sensitive Areas (ESA's). Some acknowledgement is made for soils and slopes susceptible to erosion on a separate resource folio map and a land base adjustment is made in the yield analysis. No allowances at all are made for constraints that might be imposed to protect fish, wildlife, recreation or water quality or for areas which could be difficult to regenerate.

The inventory data base is based on the Forest Cover maps and is up to date. Not all silviculture history information has been transferred to the data base although it is complete and on the forest cover maps.

A concern to many is the use of the Managed Stand yield curves developed by the Forest Service Research Branch. They result in very significant increases in forecast growth making many inventory professionals nervous because they are difficult to substantiate or refute. On the other hand, we have noted instances where extra pains have been taken to be conservative, and there are other professionals who believe the yield curves underestimate the potential yield.

There is a complete lack of data on fish and wildlife populations on the TFL (as is the case on almost all management units in B.C.). In the long run, this will become intolerable as more and more timber management decisions are made to accommodate other forest uses.

Weyerhaeuser has its own yield analysis model developed by its parent U.S. company. This High Yield Forestry (HYF) model is similar to those commonly used by the Forest Service who have tested it and found it to give similar results. We are satisfied that it is adequate to carry out the yield analysis and to help in the determination of the AAC. A number of allowances and deductions are standard procedure for TFL and TSA yield analyses. We reviewed these, including: allowances for decay, waste and breakage; area deductions; volume deductions for deciduous timber; and allowances for non-recoverable losses. Apart from inadequacies of ESA allowances, the allowances appeared to be more than adequate. The licensee attaches a great deal of importance to the application of a higher standard of silviculture on the TFL. It plans to regenerate areas earlier, plant more, control stocking and regenerate areas which have been disturbed but not reskidded for many years (Backlog NSR). The silviculture aspirations of the licensee are realistic but will require an increased level of effort and money to achieve. The Forest Service will be monitoring the performance of the licensee to ensure that the assumptions are being fulfilled and, as a safeguard, the proposed new AAC will not come into force until 1993 after a report on performance.

The licensee used the yield analysis to test a base case scenario, where a basic forestry regime was employed, and an incremental forest management scenario, where all the extra silvicultural and management assumptions were used. In the basic option, the model simulated the management of the TFL so that all currently logged areas are managed as necessary to ensure that they meet basic forestry requirements. No backlog NSR areas are treated. In the incremental forest management scenario, the model simulates a management regime where all currently logged areas are managed as necessary to ensure they are producing at or near their biological potential. Some treatments are carried out on backlog NSR.

We are satisfied that the yield analysis has been carried out properly, the deductions and assumptions are realistic (if conservative) and that it forms an adequate basis upon which to determine the AAC for TFL 35.

The licensee is seeking final approval for an allowable annual cut of 130 000 m$^3$ for the present TFL area. This is in contrast to the existing AAC of 88 000 m$^3$. Actually, there is to be a reduction of TFL area by about 5% as an allotment to the Small Business Forest Enterprise Program. This will result in an AAC for the remaining area of 125 600 m$^3$. The 50% increase in cut being proposed is alarming to some. First of all, the public may be astonished when such an increase is proposed at a time when there is a general perception that our forests are being overcut. A satellite photograph of the TFL is attached at the back of this report and at first glance, lends weight to the overcutting argument. However, the image enhancement of the photograph shows all areas of disturbance regardless of their age. Many of these areas are now well toward production of their second crop and the dimension of time should be used to temper the impressions given by the photo.

The local Fish and Wildlife officer is also concerned about the increase in harvest level. The licensee is being required to undertake a study of the impact of the higher harvest level on fish and wildlife habitat. The adoption of the proposed AAC in 1993 is dependent on a satisfactory outcome to this study.
Finally, there are Forest Service officers who are sceptical of the Managed Stand yield curves which have contributed so much to the forecast increase in yield which has in turn enabled a much higher harvest level to be justified. Their fears will only be confirmed or allayed with time and the collection of more data.

In the report, we recognize that forest yield prediction is an inexact science, that there are those who would feel more comfortable with a more conservative approach, and there are those who feel it is time to operationally test the predictions and forecasts made by foresters and biometricians.

Our assessment is that forest management will be better served by taking the step toward a higher level of silviculture. Inevitably, adjustments to the forecast yields and AAC will be required. We have observed how the process has used a lesser figure or a higher deduction at times when there is some uncertainty. These conservative measures could well compensate for any overestimation of yield. In any event, we would anticipate little actual harm being done should the yields turn out to be overly optimistic, provided this can be detected reasonably quickly.

We have therefore concurred with the licensee and the Forest Service that the AAC for TFL 35 should be increased to 125,600 m³ contingent on the licensee fulfilling the obligations and expectations for silviculture and for fish and wildlife planning.

We have commented on some shortcomings in the inventory, data base and yield analysis and expressed an opinion of the consequences. There were no major shortcomings identified. Perhaps the most significant is the lack of information on Environmentally Sensitive Areas. We also point out that the inventories of other resource values - particularly fish and wildlife - is inadequate.

Finally, the report suggests some recommendations for improvement to the inventory, data base and yield analysis. In summary, these include:

- A re-inventory of the TFL using new photos;
- Delineation of ESA's;
- New inventory sample plots positioned to provide maximum coverage;
EXECUTIVE SUMMARY

A review has been carried out to assess the accuracy of timber inventory data, and to assess validity of the allowable annual cut for Tree Farm Licence No. 6 held by Western Forest Products Ltd.

Accuracy of the timber inventory was assessed by reviewing inventory procedures used by the Licensee. Each step in preparing the inventory, from forest classification through field sampling, and volume compilation was examined, and conclusions were drawn regarding adequacy of the procedures. Methods used to update the inventory were also examined. It was found that proper inventory and update procedures have been used by the Licensee, and that high work standards have been maintained throughout. The use of high standards is borne out by a low sampling error of less than 1%.

Accuracy of the timber inventory was also assessed by carrying out two extensive checks in which inventory volumes were compared with actual volume harvested. These checks indicate that the volume of mature timber shown in the inventory may be overestimated by 10-12%.

In view of the high work standards, and the very low sampling error, it has been concluded that the most likely cause of any overestimate in volume of mature timber is the use of MOF global volume equations and loss factors which have not been adjusted for local use on TFL 6.

Scope of the review did not permit any checks to be made concerning accuracy of the inventory of second-growth stands. Since the cut for the next four decades will come from liquidation of old-growth stands, any minor inaccuracies in the second-growth inventory will not significantly affect the allowable cut during the near term.

Accuracy of the allowable cut cannot be tested numerically until the need of the first rotation. However, the process used by the Licensee to determine the cut was reviewed, and conclusions were drawn regarding validity of the methods and results.

The Licensee carried out a single yield analysis for the status quo option as part of the preparation of the current Management and Working Plan (No. 7, 1987-1991). The analysis was done using a standard computer growth model known as the Multiple-Use Sustained
Yield Calculator. The review consisted of examining the input data used such as site classification, yield tables, and harvesting age, and reviewing the correlation between management assumptions and actual practice. Results from the computer run were also examined and the allowable cut calculated by the computer model was compared with the proposed allowable cut.

It was found that the proposed allowable cut is reasonable and supportable, based on using the available site curves and yield data. Results of the review indicate that existing global site and yield data may not be reliable for local use on TFL 6.

Confirmation of the accuracy of site curves and yield data for local application is a matter that requires immediate attention. Reliable growth and yield data is essential for proper long-term attention. Reliable growth and yield data is essential for proper long-term management, even though changes in the forest inventory, or growth rates, are not expected to result in a significant change to the AAC during the near term.

In summary, it is concluded that, while the timber inventory was properly carried out by the Licensee, it appears that the volume of mature timber may have been overestimated by 10-12% as a result of using volume equations and loss factors that are not applicable to TFL 6. It is also concluded that the proposed AAC is proper, and can be supported during the next few decades.

Recommendations are summarized as follows:

1. Further studies should be carried to confirm the volume of old-growth timber on TFL 6.
2. Site curves and yield tables should be confirmed for use on TFL 6.
3. On completion of the above two steps, the improved data should be used to rerun the yield analysis.
4. Present disincentives to mensurational studies being carried out by industry should be eliminated by introducing new Ministry of Forests policy.
5. A central agency, with long-term funding, should be established to plan and carry out urgently needed mensurational studies.
EXECUTIVE SUMMARY

Summary of the Conclusions

The technical review of the inventory data and the AAC analysis is covered in Part II of this report, and certain aspects are dealt with at depth in Appendices D and E. The principal conclusions and recommendations arising out of the technical review are summarized here. The management issues underlying these conclusions and recommendations are discussed in the following section.

Scope of the Review

During the course of its work, the Forest Resources Commission has been often told that:

- The forests are being overcut;
- Forest inventory data is incorrect.

In order to determine whether or not there is any basis in fact for these statements the Commission has embarked on a review of inventories and allowable cut analyses for a sampling of forest management units - four Timber Supply Areas, and three Tree Farm Licenses (TFL’s). TFL #51 is one of the units selected.

The terms of reference that the Commission set down for the study centre around two major questions about the inventory and allowable cut analyses:

- How accurate and appropriate is the inventory and growth and yield data that has been available for allowable cut analysis, and how good has the analysis been?

- Given the decisions that have to made for allowable cut, other uses of forest land resources, and wise public resource conservation, are the inventory and growth and yield standards and procedures appropriate, and do they yield data that is accurate and sufficient to support the decisions?
Principal Conclusions

- The inventory data and allowable cut analysis used in the present working plan are weak but sufficient to determine an allowable cut that does not jeopardize future management of the TFL.

- Timber harvesting comes into conflict with other resource management objectives, and the integration of these objectives in forest management planning is inadequately served by present data and analysis.

- Although the present allowable cut is appropriate, the forest has been overcut in the past. Inadequate stocks of good quality mature timber now remain to allow a smooth transition to managed forest.

- Planning assumptions about forest management are inconsistent with the reality of the natural forest succession that exists in the region, and with the standards applied in practice.

- Current silviculture guidelines, based on biogeoclimatic interpretation, are inconsistent with harvesting practice and planning assumptions, and are not supported by financial analysis.

Principal Recommendations

- Inventory data and forest management planning procedure should be based on integrated resource management objectives.

- Integrated resource management should be the responsibility of the license holder.

- Inter-agency regulation of resource management should be consolidated beyond the referral system that currently exists.

- Regulation of forest harvests should be stratified by forest type, and area cut regulation should be considered as an alternative to volume cut control.

- Growth and yield study should concentrate on the natural stand succession that characterizes the forests in this region.

- Financial analysis should be applied in the development of silvicultural regime prescriptions under the biogeoclimatic interpretation system.

Discussion of the Underlying Management Issues

The investigations connected with this review have identified a number of issues that are critical to forest management and forest management planning at this time. These issues are discussed here so that the Commission can formulate forestry policies that will ensure rational, productive, and socially acceptable management of public timberlands.

Integrated Resource Management

TFL #51 is situated in a forest region where significant multiple use demands have to be accommodated by forestry management. In addition to timber management, the area is very important for fisheries, wildlife management, tourism, and native cultural heritage. Timber harvesting objectives and practice have often conflicted with other forest land uses and these conflicts are escalating.

In order for forest management planning to deal effectively with these issues, a number of information requirements can be identified:

- Clarification of the non-timber resource user demands and management objectives;

- Interdisciplinary assessment of the forest management activities required to sustain non-timber resource production and protection;

- Determination of the opportunity costs to forestry management of implementing practices that facilitate integrated resource management.

The present non-timber resource inventory data is very weak, and is inadequate to support integrated resource management planning in the future. The present ESA mapping only highlights areas where protection of non-timber resource values has to be considered either by non-disturbance, or by extra care in the timber development. ESA mapping does not provide any information about the quantities non-timber values that the land can produce - tonnes of salmon per year, user-days of camping, moose and deer units, etc.

Forestry management objectives have to be reassessed in light of greater recognition of the multiple benefits that the forest provides. An example of this is the brush problem in the Cranberry valley bottomlands. Past harvesting practices created the problem. These lands have considerable timber-growing value, and the timber management objective is to rehabilitate them to commercial timber production. However, from a non-timber resource perspective, the Cranberry flats may offer enhanced values in their present state. They are
visually very attractive in the tourist season, and the fisheries and wildlife management values are high.

Although public timberland, TFL #51 is privately managed for timber. This gives rise to several questions about the administration of the TFL for integrated resource management:

- Who should pay for this additional inventory and planning work?
- Who should be responsible for ensuring that the integrated resource management plans are implemented?
- How will the opportunity costs for forestry be reflected in timber pricing?

The present inter-agency referral process used in all stages of harvesting planning is not adequate for future resolution of integrated resource management. The interdisciplinary effort in forest management planning must be more cohesive and pro-active. Re-alignment of resource legislation and responsibilities in government agencies may be necessary to sustain the cohesion needed. Additionally, the forest land managers need to be given greater responsibility and accountability over all the resource management activities that occur on the management units that they supervise.

One lingering social question remains. How will the reduction in public revenues, resulting from greater integrated resource management, be compensated for - increased revenues from other resource uses or what?

Harvesting Practice

The forest profile in the region is diverse due to centuries of fire disturbance, and the range in timber stand values is large. In the present century, this disturbance has been greatly accelerated by farming and logging activity. The initial logging focus was primarily the large spruce that existed in the valley bottoms. The extensive upland decadent hemlock forests were avoided, as well as the seral aspen and lodgepole pine stands. In short, the most accessible and profitable timber stands have been exploited - the forest ‘profile’ has been ‘highgraded’.

The pattern of past timber harvesting is abundantly clear on the ground, in the harvesting records, and on the inventory maps. The result of these past practices is also abundantly clear - sustaining profitable timber harvesting into the future is going to become difficult. This will require much better inventory information and more refined planning practices than have been used in the past.

Although pulp production was fostered by government in the early days, partly as a means of utilizing the decadent forest component, the regional forest industry is currently very much sawing oriented. There is no or little market for deciduous, and there is insufficient demand (and price) for pulplogs. As with the interior pulp industry, the pulp furnish is mostly chip residue from lumber production. The inability of the forest industry to utilize the full profile of the forest must be a major consideration in forest planning.

The harvest regulation policies under which allowable cuts are developed and administered have aggravated this "highgrading" pattern of development. Cut control policies that are inconsistent with the realities of market cycles for forest products have exerted upward pressure on harvest volume, which has had to be compensated by even greater concentration of harvest in the best timber.

The allowable cut has always been a global limit, with no distinction being made about how the harvest is distributed over the inventory profile of the forest. Harvest planning and regulation should apply constraints on the distribution of the harvest, so that sufficient high value timber is conserved for future needs.

Harvest regulation need not be by volume. If it was by area, then some of the problems would be reduced. It is recommended that the effect of forest regulation policies on the pattern of forest development be investigated by the Commission.

A significant weakness of the present inventory is the information available to determine the future limits to economic accessibility. The present operability lines are inadequate, and need to be replaced by soils and slope class mapping, and access engineering, so that accessibility can be re-evaluated under changing economic conditions.

Not only will planning for future harvests have greater difficulty in identifying an adequate harvest schedule, but the harvesting and manufacturing methods will probably have to change to generate maximum recoveries from the stands scheduled for harvest. Large clearcuts have been favoured in the past, but the older immature forest that will increasingly be harvested in the future is usually a seral stage of forest development, and it may be
necessary to harvest the short lived deciduous species and the pine without destroying the younger hemlock dominated stand that is developing. This may mean radically different harvesting practices. Additionally, the overmature hemlock forest that has been avoided in the past is very decadent, and the sawlog output may be very limited. This poses some challenges to manufacturing re-constituted board products instead of sawnwood? All these complicated aspects of future timber utilization have to be considered in working plan development.

Silviculture, Growth and Yield

Today, it is everywhere apparent that forest development is highly influenced by a natural succession through pine and deciduous cover, to the shade-tolerant and longer living hemlock, spruce, balsam, and cedar. Planting of pine and spruce may accelerate this succession, but it does not supplant it, without significant stand tending treatment.

Earlier logging was usually followed by slashburning for site preparation, and then planting with pine or spruce. Birch and other hardwoods have colonized these burned areas, and a spruce leader weevil is a significant problem. Below the deciduous cover the natural regeneration of hemlock and spruce is significant. In recent years slashburning has been virtually eliminated. A mix of pine and spruce is planted, sometimes with microsite selection being left to the planters.

The Ministry of Forests publishes biogeoclimatic (BGC) interpretation guides that contain silvicultural guidelines. These guidelines generally are followed in the preparation of pre-harvest silvicultural prescriptions (PHSP’s), and have been adhered to reasonably well on TFL #51. These silvicultural guidelines make some presumptions about subsequent stand management and return on investments that the consultants cannot accept as valid.

For example, hemlock is the premier climax species over most of the TFL and will in time colonize most regenerated sites. Yet spruce and pine are recommended as the preferred species for planting in nearly all BGC associations. This just does not make sense, as it commits forest management to a lifetime of fighting the hemlock ingrowth, and in the case of pine plantations, it dooms the thrifty young hemlock understory to serious damage when the pine is removed.

Aspen and birch will quickly colonize new plantations in the TFL, and the spread of aspen in clearcut areas is aggravated by the limited slashburning. Although spruce plantings may usually hold their own against the deciduous, pine may often succumb to the competition from the aspen. Although the BGC guides suggest brushing and weeding may be a necessary follow-up activity to pine and spruce planting, the TFL management will be highly reluctant to make the expenditures if the stand can just make it to “free growing” without them.

The present practice of planting admixtures of pine and spruce must also be seriously questioned. With the aspen, birch, and hemlock ingrowth, these plantations will become multi-storied seral stands that will be very difficult to manage. Aspen and pine utilization will have to occur significantly before spruce and hemlock utilization, if the merchantable growing stock of the stands is to be fully utilized. On the other hand, if the intent is to harvest these stands on a single entry clear-cut, then a significant amount of the merchantable growing stock will be lost, and the return on management investment may be seriously impaired. It will take far more innovative and sophisticated approaches to harvesting to obtain maximum utility from these stands than have been applied to date.

Why not grow hemlock, and help it along by brushing and spacing? It will be a much cheaper and easier to manage?

The BGC guidelines for bottomland associations, where spruce and cottonwood management are favoured, seem to be reasonable. However, the management of these bottomlands will be very complicated, as the cottonwood study for the TFL has indicated. The single species stands that can be developed in these associations will be in very small patches. Again, forest harvesting practices in the future will have to be radically different from what they have been in the past if commercial forest crops are going to be successfully managed in these areas.

None of the BGC silvicultural guidelines seem to be supported by rigorous development of technical regimes, yield tables, and financial analysis. It is highly appropriate that the BGC interpretations lead to rational prescriptions for future management, but these prescriptions have to have a much surer footing than they do now. The consultants strongly recommend that growth and yield research efforts focus on the development of silvicultural regimes that make sense from a financial management perspective, as well as being biologically sound.
The management assumption used in the AAC analysis were inconsistent with both present regeneration practice and the BGC guidelines. While this had no appreciable impact on the AAC volume determined, future management and working plans should be based on a more plausible set of management assumptions.
ALLOWABLE ANNUAL CUT: Abbreviated AAC, the allowed annual rate of harvest from a forest estate. MOF policy states that AAC for all TFL's and TSA's will be reviewed at least every five years.

AAC Rationale: The long-term timber supply objectives and the broad management assumptions and strategies upon which an AAC is based. These include, for example, the harvest forecast, the net land base, timber harvesting priorities and constraints, timber utilization levels and standards, levels or unsalvaged losses.

Analysis unit: A term used in timber supply analysis to define the aggregations of timber inventory data used in the analysis process. It is the basic building block around which inventory data is assembled for use in forest estate models.

Area inclusion factor: Abbreviated AIF, a percentage that is applied to the productive land base used in the yield analysis to reduce the land base and reflect environmentally sensitive areas, inoperable areas, loss of productive land base due to harvest activities, etc.

Biogeoclimatic zone: Abbreviated BGCZ, a definition of an area that has similar biological, geographic and climatic conditions.

Culmination of mean annual increment: Abbreviated CMAI, the point at which a timber stand reaches its maximum annual volume growth for a defined utilization standard.

Data assumptions: Analytical approximations and representations of the physical, biological and economic characteristics of the forest resource and its development over time. These include, for example, the forest inventory, yield projections and reforestation costs.

Environmentally sensitive area: Abbreviated ESA, this definition is an inventory criterion to account for and protect forest resource values other than timber.
Extended grid area file: Abbreviated ECAF, the file name used by the MOF to define inventory data base files that are grid based, not polygon based. These files predate FIP files and are in the process of being converted to FIP files.

Forest estate: A term used to define the gross land base of a particular forest resource management unit.

Forest estate model: An analytical computer-based model that successively "harvests and grows" forest stands within a forest estate over a period of several decades according to specific data and management assumptions.

Forest inventory planning (file): Abbreviated FIP, the file name used by the MOF to define inventory data base files that are polygon specific.

Forest inventory zone: Abbreviated FIZ, there are 12 FIZ in the Province. They were established as an inventory strata to define areas with similar individual species growth and yield functions.

Geographic information system: Abbreviated GIS, a tool that allows for the combining of computerized map information with data base information.

Growth model: A model that "grows" individual forest stands to predict possible growth and yield outcomes from a variety of treatments.

Inventory polygons: A group of trees that have similar characteristics in terms of species composition, age, density and growth potential.

Mean annual increment: Abbreviated MAI, a measure of the average annual volume growth, to a defined utilization standard, of a stand to a particular age.

Net Productive Land Base: The portion of the total land area of a management unit which is considered to contribute to, and be available for, long-term timber supply. The net land base is defined for an option by reducing (or "netting down") the total (or "gross") land base in a manner consistent with the management assumptions for that option.

Multiple Use Sustained Yield Calculation: Abbreviated MUSYC, a linear programming forest planning model developed by the U.S. Forest Service. MUSYC is currently used as the MOF standard forest estate model for carrying out TSA timber supply analyses.

Natural stands: A term given to stands that have originated from natural events.

Mean annual increment: Abbreviated MAI, a measure of the average annual volume growth, to a defined utilization standard, of a stand to a particular age.

Net Productive Land Base: The portion of the total land area of a management unit which is considered to contribute to, and be available for, long-term timber supply. The net land base is defined for an option by reducing (or "netting down") the total (or "gross") land base in a manner consistent with the management assumptions for that option.

Non-commercial brush: Abbreviated NCBr, a definition given to a forest stand that is NSR and overgrown with non-commercial brush species.

Not Sufficiently Restocked: Abbreviated NSR, a definition given to a forest stand that does not contain a sufficient number of acceptable species to meet reforestation standards.

Public Sustained Yield Unit: Abbreviated PSYU, were administrative units defined by the MOF for the purposes of yield analyses and AAC determinations.

Regeneration delay: The number of years between the denudation of a forest stand by harvesting or natural causes and the establishment (germination) of the next crop. The point at which the next crop is regarded as established must be consistent with the origin of the yield projection which will be assumed to describe the yield development of the next crop.
Site index: A measure of site productivity. Site indices are based on tree height as a function of stand age and usually expressed graphically as site index curves.

TSA Plan: The forest management plan developed for a TSA. The TSA Plan establishes the long-term supply objectives and the broad management strategies for the timber, range and recreation resources in the TSA. For the timber resource, the TSA Plan establishes an AAC and 20-year licensee operating areas.

Unit survey: Term used to define the MOF's inventory design and program started in the mid-1960's.

Yield projections: Forecasts of future yields from forest stands or timber types. Yield projections can be developed for stand volume, stand diameter, and for empirical (averagely stocked), normal (optimally stocked) or managed stands. Yield projections can be based on a number of mensurational approaches and procedures, including the use of site index curves and generalized growth models.