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South East Queensland Private Native Forest Inventory

Department of Agriculture Fisheries and Forestry

Timber Queensland

20th November, 2003

Natural Heritage Trust

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An Australian Government Initiative

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Foreword

Thirty nine million hectares or 24% of Australia's forests are in private ownership and seventy six million hectares or 46% are managed under leasehold arrangements. These forests are an important source of timber in many regions and provide other goods and services, including grazing, honey, water, biodiversity conservation and carbon storage. Important private commercial native forests occur in Queensland, New South Wales and Tasmania with small areas in Victoria and Western Australia. South Australia and the Northern Territory have considerable areas of private forests, but only a small portion are considered to have commercial timber production potential.

In December 2000, the Bureau of Rural Sciences facilitated a national workshop on private native forest inventory requirements. At this workshop major gaps in knowledge of private native forests were identified and a national advisory committee of state, industry, grower group, farmer and environment representatives was formed that agreed on priorities for assessment. Funding from the Farm Forestry Program of the Natural Heritage Trust was provided to undertake a regional assessment and provide a methodology that could be used to assess a range of values for private forests in other regions. With the cooperation of Queensland government agencies and Timber Queensland, it was decided that this study would be undertaken in South East Queensland, where about 60% of resource requirements for the hardwood sawmilling industry are currently sourced from private native forests.

This report describes the inventory framework, testing in South East Queensland and its potential for application to other regions. The knowledge gained in this assessment substantially improves our understanding of the many values of privately owned forests of South East Queensland and provides a cost-effective methodology for application to other regions.

The regional private native forest inventory project has been a highly successful partnership between the Bureau of Rural Sciences, MBaC Consulting, Timber Queensland and a number of Queensland government departments. Through the South East Queensland Hardwood Timber Industry Growth and Development Strategy, the Department of State Development provided financial assistance to support Timber Queensland's participation. A technical committee of experts from state agencies and universities have provided extensive input and representatives from most States and Territories also provided valuable input.

This study will be of great value in providing a sound information base for policy and management decisions about private native forests in South East Queensland. It will also provide a basis for improved understanding of the assessment of privately owned native forests in other regions. I congratulate the team who worked on this project on an excellent product.

Dr Peter O'Brien
Executive Director
Bureau of Rural Sciences

CONSULTING

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&

Timber Queensland

November, 2003

Disclaimer

This report is issued by MBAC Consulting Pty Ltd (MBAC Consulting) to the Department of Agriculture Fisheries and Forestry (AFFA) and Timber Queensland for their own use. No responsibility is accepted for any other use.

The report contains the methodology applied and the results of the South East Queensland Private Native Forest Inventory undertaken by MBAC Consulting.

Acknowledgements

MBAC Consulting acknowledges the considerable support provided by Michael Ryan and Dr Rodney Keenan (AFFA), the Forest Policy Group within the Queensland Department of State Development and the Technical Advisory Group. Critical and timely inputs have also been made by Jim Burgess at Timber Queensland (TQ), DPI Forestry and Private Forestry Southern Queensland. As part of the study team, major contributions have been provided by the Environmental Protection Agency Queensland Herbarium, Forest Data, Australian Farm Forestry, MapInfo Australia, QASCO, Geoimage and AAM Surveys. Their contributions and involvement have enabled this project to be undertaken in a timely and professional manner.

MBAC also acknowledges the contribution of the Australian Greenhouse Office (AGO), for providing select SEQ Net Primary Productivity (NPP) national data for comparison with the Queensland-specific Statewide Land and Trees Survey (SLATS) data.

We also acknowledge the contribution of Dr. Cris Brack from the Australian National University in developing the LU and volume to FPC ratio concepts. These were instrumental in shaping the approach to the data processing and statistical analysis components and contributed in a large measure to the success of the project.

MBAC Consulting

Rod Meynink
Director

Chris Borough
Director

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GLOSSARY{ TC "GLOSSARY" }

AFFA	Agriculture Fisheries and Forestry - Australia
AGO	Australian Greenhouse Office
ALS	Airborne Laser Scanning
APAR	Active radiation absorbed by plant canopies
Benefit:cost	Benefit to cost ratio (benefits divided by costs)
BVG	Broad Vegetation Group
CCP	Crown Cover Percentage
CCPg	Crown Cover Percentage (ground)
CL or cl	Confidence level
CRA	Comprehensive Regional Assessment
CWD	Coarse woody debris
Dbh	Diameter breast height
DCDB	Digital cadastre database
DEM	Digital elevation model
DPI-F	Queensland Department Primary Industries - Forestry
E.	*Eucalyptus*
FH	Freehold
FPC	Foliage Projective Cover (equivalent to PFC Foliage projective cover)
FPC_A	Foliage Projective Cover (%) from ALS
FPC_S	Foliage Projective Cover (%) from SLATS (sometimes referred to as PFC)
GIS	Geographic information system
ha	Hectare (10 000 square metres)
LSAP	Large scale aerial photography
LU	Landscape unit
m	Metre
MARVL	Method of Assessment of Recoverable Volume of Logs
MGA	Map Grid Australia
MSS	Multi Spectral Scanner
NFI	National Forest Inventory
NFPS	National Forest Policy Statement
Non-Remnant Vegetation	Vegetation that does not meet the pre-requisite for classification as remnant vegetation
NPP	Net Primary Productivity
NRM	Natural Resources and Mines, Queensland Department of
NZFRI	New Zealand Forest Research Institute
P	Probability
PFC	Projective foliage cover - equivalent to FPC
PNF	Private native forest

PPS	Probability proportional to size
RE	Regional Ecosystem
Remnant Vegetation	Defined as vegetation where the vegetation's undisturbed predominant stratum is intact, i.e. has at least 50% of the FPC; and has more than 70% of the height of undisturbed vegetation.
RFA	Regional Forest Agreement
SD	Standard deviation
sed	Small-end diameter (under bark)
SEQ	South East Queensland
SEQ PNF-I	South East Queensland Private Native Forest Inventory
SLATS	Statewide (State) Landcover and Trees Survey
TM	LANDSAT Thematic Mapper
TAG	Technical Advisory Group (technical advisors to project)
TQ	Timber Queensland (previously Queensland Timber Board or QTB)
UVEG	Universal vegetation code
VBAR	Volume/basal area
VG	Valuer General
VMA	Vegetation Management Act (1999)
VRP	Variable radius plot

SUMMARY{ TC "EXECUTIVE SUMMARY" }

This Report describes the methodology applied and the results obtained from the inventory of the private native forest (PNF) in South-East Queensland (SEQ). The Project was undertaken by MBAC Consulting for Agriculture Fisheries and Forestry - Australia and Timber Queensland.

The Project was commenced in September 2002 and completed in November 2003.

The Report has three components reflecting the structure of the Project:

- Methodology
- Results
- Application

METHODOLOGY

APPROACH TO INVENTORY

For the inventory of the private native forests of SEQ (extensive, relatively low value resource) an approach was required that achieved an effective and statistically valid estimate of the resource at reasonable cost. A model-based approach was used to achieve this goal with the development of simple models relating limited ground data to remotely sensed data and using these relationships to extrapolate to the entire project area on remotely sensed data alone.

RESOURCE STRATIFICATION

The PNF resource of SEQ is located within an area of 6.2 million hectares extending from the New South Wales – Queensland border, to near Gladstone in the northeast and Toowoomba in the southwest.

The most likely tool to extrapolate ground information over the entire estate was the Statewide Land and Trees Survey (SLATS) Foliage Projected Cover (FPC_S) raster dataset derived from remotely sensed LANDSAT 7 data that includes all woody vegetation cover; both remnant and non-remnant. Regional Ecosystem (RE) mapping was used to provide a basis for floristic stratification and describe the bounds of the native forest.

The primary source of spatial floristic data in Queensland is the RE (woody remnant) vegetation layer developed by the Queensland Herbarium. The floristic strata used were the Queensland Herbarium's Broad Vegetation Groups (BVGs) combining geomorphology, species and vegetation characteristics. Each BVG contains a number of REs. Of the eleven commercial BVGs, five were targeted for sampling due to their importance.

The BVGs are supported by spatial information from the SLATS.

The Queensland Herbarium generated polygon maps depicting the woody non-remnant estate based on analysis of the SLATS database. BVGs were ascribed to these mapped areas based on likely pre-clearing species composition and structure.

The area of accessible PNF in SEQ (below 26° on land holdings greater than 5 ha and in continuous forest areas of greater than 20 ha) was estimated to be 987 785 ha. Of this area an estimated 731 450 ha was remnant woody vegetation and 258 825 ha non-remnant woody vegetation.

After eliminating those BVGs considered by MBAC to be non-commercial, the area of commercial PNF was estimated to be 900 000 ha (700 000 ha of remnant and 200 000 ha of non-remnant). The 700 000 ha became the sampled population. These areas were further modified post-inventory to account for stream reserves and many small areas of excessively steep PNF not identified pre-inventory by the coarse digital elevation model (DEM).

SAMPLING

Sampling sites were selected initially to provide broad geographic coverage and later to target under-represented forest types.

Properties were identified by intersecting a 5 km grid with the sampled area. Four hundred and fifty potential sampling points were identified and owner contact details derived from a combination of the Digital Cadastral Database, Valuer-General's database and TELSTRA White Pages telephone directory. The potential sampling points were reduced to 62, where landowners agreed to field crews accessing their properties. Gaining approval to access properties was one of the most difficult components of the Project.

On these 62 sites, large scale aerial photographs were captured and field crews collected data at each photo sample location. Up to 25 sample points were placed at each of the sampling sites ("plot").

Over 230 lineal km of airborne laser scanning (ALS) data were also captured, covering around 15 000 ha of PNF. Where possible, ALS data were collected over areas where data from both field sampling and aerial photographs had been undertaken.

The aerial and ground work was undertaken in two stages. The second stage, involving the capture of the ALS data and associated ground sampling, allowed a focus on areas under-represented in the first stage sampling. The focus of the second stage sampling was high density forest types within key BVGs.

FIELD SAMPLING DESIGN

The sampling design settled on a sample "plot" size of approximately 24 ha. Within each sample plot up to 25 sample points were located in a systematic grid across the plot.

RESULTS

FIELD SAMPLING

Access to private land proved to be a major constraint. Sampling sites were selected initially to provide broad geographic coverage and later to target under-represented forest types. The end result was the establishment of 62 sample plots covering the 700 000 ha of remnant, commercial and accessible PNF.

PRELIMINARY OBSERVATIONS

As expected, substantial floristic and structural variation was observed. A key component of the work was the need to develop a methodology to extrapolate field and other sample data across the entire forest estate. The SLATS database was considered to be the most valuable tool for this; the SLATS data is based on LANDSAT 7 satellite data combined with ground based measures (samples) of foliage projective cover or FPC_S. The SLATS database provided complete and recent coverage of the Project area.

USE OF LANDSCAPE UNIT AS THE BASIS FOR EXTRAPOLATION

The most convenient unit for presentation and analysis of data was a square of 25 ha (500 m x 500 m). The unit, referred to as a Landscape Unit (LU), was adopted for reporting all data over the entire estate.

CORRELATIONS

On the basis of strong correlations between FPC_S and total volume and basal area, it was concluded that FPC_S was a suitable tool for extrapolating volume over the entire forest area.

ALS technology was tested as part of the project. Data from a laser flight line 600 km long and 400 m wide were collected and summarised by LU to provide a consistent platform. Correlations between ALS data, SLATS data and ground data were strong.

AREA

The area of PNF is estimated to be 1.37 million ha, which is consistent with others estimates for this entire resource. However, after removing steep areas and providing for prudent reductions such as stream buffers and small scattered areas, the estimated net effective area of PNF in SEQ has been assessed as 750 000 ha.

Area statistics are presented in Summary Table 1.

Summary Table 1: Area

Component	Remnant (ha)	Non-remnant (ha)	Total (ha)
Land area SEQ			6 170 600
All Freehold >5 ha DCDB			4 200 000
All Regional Ecosystems	2 661 000	na	2 661 000
PNF native forest	1 085 618	284 000	1 369 618
PNF >5 ha DCDB; <26 degrees >20 ha RE (calculated from LU)	731 450	258 525	989 975
Commercial forest types (calculated from LU)	699 900	206 050	905 950
Commercial forest types (adopted)	700 000	200 000	900 000
Net area after allowing for inaccessible areas at the micro-level and environmental buffers	520 000	180 000	700 000
Net area after allowing for small (<20 ha) joined polygons which when combined exceed 20 ha	560 000	190 000	750 000

VOLUME

Relationship between volume and FPC_S

A model-based approach was adopted to relate volume and FPC_S. Applying this technique gives a ratio of total volume/FPC_S of 1.76 with an error of approximately ± 11% at the 95% confidence level. Similar ratios were developed for other volume parameters.

Determination of FPC_S over entire project area

FPC_S data are available over the entire project area. Each LU was populated with the mean FPC_S of the 400 cells of SLATS data that comprise an LU. The values (i.e. between 0 and 100) were then assigned into classes based on rounding of the mean.

Total volume

The area represented by each FPC_S class in each LU was multiplied by the respective total volume from the model to provide a weighted total volume estimate. The total volume across the entire estate is estimated at 46.2 million m^3.

Commercial Volume

Much of the total volume is uncommercial. The Method of Assessment of Recoverable Volume of Logs (MARVL) allowed external bole characteristics to be described. From these, the bole was characterised into products based on an hierarchy of value. Only 33% of the total standing volume was assessed as potential recoverable volume.

Volume statistics are presented in Summary Table 2.

Summary Table 2: Volume summary

			Potential recoverable volume (million m^3)						
Type	**Net Area (ha)**	**Total (m^3/ha)**	**Total**	**Net**	**Compulsory**	**Optional**	**Pole/Pile**	**Small round**	**Fencing**
Remnant	560 000	65.0	36.4	12.0	1.1	2.7	0.6	2.8	4.8
Non-remnant	190 000	51.5	9.8	3.2	0.3	0.7	0.2	0.8	1.3
Total	750 000	61.6	46.2	15.2	1.4	3.4	0.8	3.6	6.1
Precision			11%	14%	43%	19%	42%	24%	18%
% of net potential recoverable volume				100%	9%	22%	5%	23%	40%
% of total volume				33%	3%	7%	2%	8%	13%

Total volume is 46.2 million m^3 (±11%) and includes sawlogs, girders, piles, poles, small rounds and fencing timber. The net potential recoverable volume is 15.2 million m^3 (±14%). The volume of compulsory plus optional sawlogs is 4.8 million m^3 or 31% of the net potential recoverable volume. Reducing the compulsory sawlog minimum small end diameter under bark (sed) from 30 to 20 cm and the optional sawlog size from 28 to 20 cm increased the sawlog volume to approximately 9 million m^3.

These results are presented in a general sense as many other factors need to be considered other than merely reducing sed limitation for sawlogs when processing inventory data. These include processing capacities, wood age and density and other issues associated with processing smaller logs.

The project demonstrated there was 1.4 million m^3 (±43%) of sawlogs meeting current (DPI-F) "compulsory" criteria and a further 3.4 million m^3 (±19%) meeting "optional" criteria. A previous study on this resource estimated the total standing harvestable sawlog timber as 2.7 million m^3.

NON-WOOD VALUES

Dominance, crown condition, habitat trees and coarse woody debris (CWD) data were collected in most of the sample plots. The results were assessed against canopy density (i.e. FPC_S). No significant relationships could be found between any of the parameters assessed and FPC_S. Accordingly, only generalised extrapolations of the results from the plot level through to the estate level have been attempted.

There was a relationship between tree dominance and forest type. In the drier forests, the proportion of dominant to others (ie co-dominant and suppressed) was lower than in the taller wetter forests.

The taller, moister forests exhibited the range of all crown classes in similar proportions. In the drier forests the proportion of trees with full crowns was lower and the proportion with moderate crowns correspondingly higher.

The presence of existing habitat trees was greatest in the taller wetter forests, declining to almost zero in the shorter, drier, open forests, rising again in the red gum forests. Conversely, the existence of relaxed definition habitat trees was greatest in the drier open forests. The definition of habitat trees in the drier forests needs to be reassessed as the existing criteria are inappropriate.

The average coarse woody debris (CWD) is approximately 6 m^3/ha.

Most of the disturbance was related to domestic animal grazing. This is not surprising as much of the area is agricultural, where beef production takes precedence over wood production. Possibly related is the apparent high level of weed infestation (30% of the area), with a similar proportion of the area exhibiting previous harvesting effects and fire.

APPLICATION

INVENTORY APPROACH FOR BROAD SCALE

As discussed earlier, the traditional concept of accurately mapping forest types and sampling within forest type is neither cost effective nor practical for inventories of relatively low value, scattered forest such as found in SEQ. In many cases forest type mapping has been developed for other purposes, is out-of date or is simply unavailable.

The SEQ PNF inventory project has demonstrated that a cost-effective method using a combination of ground sampling, remote sensing, model-based sampling and extrapolating modelled results through the remotely sensed data can be applied effectively to SEQ forests. It is highly likely that this method could be applied effectively to many other forests of this nature.

While remote sensing was found to be an invaluable tool in this approach, remote sensing alone is insufficient. Ground sampling is imperative to:

- Provide the data to develop correlations between a measure such as canopy density (in the case of SEQ Foliage Projective Cover (FPC_S)) and volume or basal area
- Develop an understanding of the relationship between total volume and commercial volume by species and products for the particular forests under investigation
- Identify locally steep areas

MODEL BASED SAMPLING

A random or stratified random sampling approach to inventory is commonly thwarted on PNF when landowners refuse ground access. Model-based sampling does not require random sampling. In model-based sampling, the focus is more on sampling the entire range of values; in this case canopy density. This provides essential flexibility for ground sampling and allows such activities to be focused on a broad range of forest types. The approach also substantially reduces the problem of access to land.

The finding that total volume in SEQ is highly correlated with the two measures of canopy density – SLATS FPC_S data and the AGO NPP data – indicates that a model-based approach is possible and cost effective. It needs to be recognised, however, that there may be forest types in other areas that do not fit this general approach and care needs to be exercised by checking such issues before assuming that the principles will apply universally.

ALS

The project showed that ALS data was highly precise in estimating tree height and canopy density. However, relative to other tools available and the precision requirements for such projects, ALS was less cost effective and too precise for assessing canopy density or canopy height across such a large project area. The ALS data were valuable in providing additional information on canopy height and foliage projective cover but cost limitations precluded its use strategically to cover the variation in vegetation types over such a large area.

The use of model-based sampling does, however, provide the opportunity to use ALS data strategically to gather data on locations that are under-represented in the sample population. A lack of approval to enter land or the remote location of some critical forest types are examples of where sampling using ALS technology would be valuable. ALS data could also be collected over targeted areas towards the end of the project. Provided the relationships are developed on known sites, substituting some field plots with ALS derived data may be appropriate.

The substantial volume and detail of ALS data were not appropriate for this type of project. The use of ALS mounted on a fixed wing aircraft as a tool to cover a portion of the total area is not recommended for projects of this type and size.

ALS value lies primarily as a sampling tool to obtain additional quantitative data on targeted sites.

AERIAL PHOTOGRAPHY

The intended use of large format aerial photography in this project was to develop relationships between parameters measurable on the photos and those measurable from the ground – i.e. tree height. Once such relationships were developed, regression sampling was to be used to substitute field plots with lower cost measurement plots from aerial photos. However, in this project it was found that identifying individual trees both on the ground and on the photos was very difficult and time consuming. This was due, in part, to the steep topography and excessive tip and tilt of the aircraft flying at low altitude in summer. It was also due to the realisation that effective use of the SLATS FPC_S data was a more cost effective tool to identify stand parameters to which ground measurements could be related. Accordingly, large scale aerial photography was replaced by the spatial, digital data available for the entire population.

FIELD SAMPLING

Efficient sampling was obtained by clustering sample points within a sample plot and using the mean (and standard deviation (SD)) to describe and quantify the forest in a locality. The concept of a Landscape Unit (LU) was developed with a square representing 25 ha (500 m by 500 m) selected as an appropriate LU size. The mean of the clustered sample points was used to describe the forest within the LU.

LANDSCAPE UNIT

The development of models relating FPC_S (or the AGO NPP data) to volume and the use of LU provides a simple and cost effective tool to extrapolate limited ground sampled data over an entire project area. For each LU average FPC_S was determined and related to sampled volume, for example. In SEQ, there were 36 000 LUs with 63 LUs where volume was measured on the ground.

FPC/VOLUME RATIO

The ratios between average FPC_S and total and net volume for each LU were calculated where both datasets were available. The relationships derived were:

- Total volume = 1.761 x FPC_S
- Net potential recoverable volume = 0.580 x FPC_S

VOLUME DERIVATION

By applying these functions to the 36 000 LUs, total volume and net potential recoverable volume could be estimated with known precision.

- Total volume is estimated as 46.2 million m^3 ± 11%
- Net potential recoverable volume is estimated as 15.3 million m^3 ± 14%

Based on generally accepted current log specifications (30 cm sed) the volume of sawlogs, poles and piles is estimated as 5.6 million m^3.