OLD GROWTH FOREST IN SOUTH-EAST QUEENSLAND

QUEENSLAND RFA STEERING COMMITTEE

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BACKGROUND

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EXECUTIVE SUMMARY

This report builds on the previously published *Assessment of old-growth forest in south-east Queensland: interim report* (DNR 1996). The methods described in this report include developments foreshadowed in that report, as well as improvements and other modifications introduced subsequently. The report describes the results of broad scale application of these methods to assess old growth forests throughout the South-East Queensland biogeographic region. This project is part of a Comprehensive Regional Assessment conducted to provide the basis for negotiation of a Regional Forest Agreement between the Queensland State and Australian Federal Governments.

The South-East Queensland Biogeographic Region

The South-East Queensland biogeographic region (referred to below as the 'SEQ bioregion') covers a total land area of 6 219 148 hectares of which 3 545 237 hectares (57 per cent of the SEQ bioregion) is native forest. The forests have regional, State, and national importance as sources of both commercial products such as timber and non-timber forest products, and for the protection of non-commercial values such as biodiversity. They make an important contribution to the economic, social, and environmental welfare of people living within the region, elsewhere in Queensland, and throughout Australia.

Old growth forests are considered to be an important component of these environmental values because of their important role in supporting a unique array of animal and plant life and because of their aesthetic properties, fragility, and rarity.

Methods

The methods used in the South-East Queensland old growth forest assessment project have built on experience gained in similar projects in other States of Australia and overseas. In particular, important lessons have been learned from old growth assessments conducted in East Gippsland, Victoria (DCNR 1990) and northern New South Wales (RACAC 1996).

The approach used to assess old growth in East Gippsland was based principally on the use of aerial photograph interpretation (API) to classify forests according to the growth stage characteristics of canopy trees as demonstrated by crown form. This approach assumes that all eucalypts progress through identifiable growth stages characterised by morphological features of the crown structure, as first described by Jacobs (1955). The subtropical forests of South-East Queensland are generally quite complex, with a diverse range of ages and species, and differ significantly from East Gippsland forests in their composition and function. At the commencement of this project it was already recognised that an API-based crown-form assessment, such as was used in East Gippsland, was unlikely to be directly transferable to the forests of South-East Queensland (Norman 1995). Consequently considerable effort was directed in this project both towards establishing the limits to which such an approach could be reliably applied in South-East Queensland, and in investigating alternative approaches that could be used to identify old growth in forest types that lay beyond those limits. In response to this, the project team tailored an approach that incorporated both crown form and other indicators of disturbance, with varying emphases and thresholds depending on the nature of the forest ecosystem and of the disturbance environment.

As in other similar studies API was the primary source of mapped data for the project. It provided forest structural information (e.g. crown form, canopy density) and permitted the mapping of disturbance from other visual clues. Floristic composition was also mapped for a limited range of communities (e.g. rainforests) to supplement the broad scale vegetation community mapping conducted as part of a parallel project undertaken by the Queensland Herbarium of the Department of Environment

API conducted as part of this project included all forms of land tenure, and was able to cover the majority of the forested area of the SEQ bioregion. Where possible, the remaining forest was mapped using other data sets.

Historical records of various forest management activities, in particular timber harvesting, fire, and grazing, were major sources of information. Management history, captured from a range of sources, was the primary source of disturbance information used in the study. The project compiled a comprehensive Geographical Information System of digital coverages of historical records for multiple-use forest (State forests and designated timber reserves). A lesser level of information was available for conservation reserve tenures, and information for other tenures such as freehold was even more limited. Where gaps existed, such as across freehold land, disturbance history was inferred from relationships with tenure, accessibility and productivity.

Analysis and interpretation

Field research, literature review, desktop studies and expert opinion were used to develop ‘decision rules’ (see Section 2.1 below) to define and interpret old growth from the range of data sources available to the project. Wherever possible, emphasis was placed on the use of quantitative relationships and on cross-validation between multiple data sets. The decision rules classified forests into ‘old growth’ and ‘non old growth’, ‘likely old growth’ and ‘likely not old growth’.

Results

Approximately 43 per cent of the forested area of South-East Queensland was assessed by this project. Areas not assessed by the project include plantation and non-eucalypt natural forest, largely rainforest and some eucalypt communities where disturbance information was unavailable or API was not performed. These areas were excluded either because it was inappropriate to assess them or because it was not possible within the resources available to the project to apply or interpret a definition of old growth relevant to them.

Based on the analysis contained within this report, the total area of class 1 (‘Yes’ old growth) old growth forest within the SEQ bioregion is 97 201.6 hectares or 2.7 per cent of the total area of forest. The total area of class 2 (‘Likely yes’ old growth) old growth forest is 204 325.8 hectares or 5.8 per cent of the total area of forest.

Old growth forest (classes 1 ‘Yes’ old growth, and 2 ‘Likely yes’ old growth) within the bioregion is concentrated within conservation reserves (3.3 per cent of forest areas in SEQ) with a lesser proportion within State forest (1.3 per cent of forest areas in SEQ), with an approximate total of 3.8 per cent on forested tenures other than State forest or conservation reserves.

1 INTRODUCTION

1.1 GENERAL

This report is a synthesis of the work of a team of 16 scientists conducted over the past three years (1995–98). The project brought together expertise in fields as diverse as forest ecology, Geographical Information Systems (GIS), environmental modelling, remote sensing and aerial photograph interpretation (API), and forest history. In the course of preparing the precursor to this document *Assessment of old-growth forest in south-east Queensland: interim report* (DNR 1996) and this final report on the old growth forest inventory of South-East Queensland (SEQ), the team also reviewed, collated and analysed work from a number of published and unpublished sources including studies conducted in Queensland, in other Australian States, and in certain overseas countries (in particular the United States of America and Canada).

The interim report mentioned above, which was published in October 1996, identified the need for additional work to address a number of critical issues. These included:

- problems with the application/interpretation of the definition of old growth in respect of mixed forests such as dry eucalypt communities
- technical mapping issues including the exploration of disturbance modelling techniques to rapidly enhance the limited data available for some areas; the development of techniques to capture information on disturbances other than logging, in particular grazing and fire; and the possibility of amending existing API specifications to increase the rate of interpretation.

Details of the outcomes from these studies are contained in the chapters and appendices that make up the body of this report. The following sections (1.2–1.3) provide a brief summation of each of these areas of work.

1.2 APPLYING THE ‘OLD GROWTH’ DEFINITION TO MIXED FORESTS

The interim report (DNR 1996) contained an extended discussion of the definition of ‘old growth’. It concluded by accepting the definition, for the purposes of this assessment, put forward by the Commonwealth Government in March 1996. This definition is as follows:

Old growth forest is ecologically mature forest where the effects of disturbances are now negligible.

In the application of this definition the following principles are applied:

- ecological maturity is defined by the characteristics of the older growth stages which would be reached by a particular forest ecosystem within a regional context
- assessment of the significance of disturbance effects must be made in the context of relevant data availability on the structural, floristic and functional qualities that would be expected to be characteristic of the ecologically mature forest ecosystem
- negligible disturbance effects will be manifested in most forests by a significant proportion of trees with age-related features, and a species composition characteristic of the ecologically mature forest ecosystem.

The concept of ‘ecological maturity’ upon which this definition is based, implies forest ecosystems pass through an ordered sequence of discrete successional phases which are characterised by changes in the composition, structure and function of the ecosystems. In applying this definition to the range of forest ecosystems encountered within SEQ it became apparent that for the most extensive of these – the mixed-age or dry eucalypt forests – the concept of ‘ecological maturity’ was of questionable value. The concept neither adequately described the ecological processes of the dry forest nor adequately captured the impacts of disturbances on such forests.

Dry forests exist as a very fine-scaled mosaic of well-spaced (generally around 30 per cent ‘crown cover projection’ or CCP), mixed-age, mixed-species trees with a discontinuous understorey commonly containing a high proportion of annual and perennial grasses. The mixed-age canopy structure of dry forests is indicative of a dynamic equilibrium with respect to their age-class / growth-stage composition, reflecting more or less continuous single-tree recruitment/mortality following frequent repeated disturbances (generally fire) and climatic conditions suitable for regeneration. Whilst the age-class/growth-stage composition of the canopy structure fluctuates around the equilibrium in response to disturbance events such as severe drought or wildfire, it would appear that sufficient established trees generally survive to rapidly achieve a composition approaching the equilibrium.

Except where the canopy is completely removed due to agricultural or urban development, disturbances affecting mixed-age forests are generally selective in their impacts on the canopy structure. Mixed-aged forests contain a high proportion of defective or non-commercial trees unsuitable for logging, and the impacts on the stand structure of low-intensity single-tree harvesting practised in these forests is often masked by the background variation. Nevertheless, these disturbances and others (such as grazing and low-intensity fire) were observed by the project team to have significant ecological impacts on the forest ecosystem as a whole.

1.2.1 Ecological integrity

In response to these concerns it is proposed to extend the interpretation of the Commonwealth Government definition of old growth forest quoted above to include the concept of ‘ecological integrity’.

Ecological integrity is defined as:

> *An ecosystem with ecological integrity is one which possesses those structural and compositional elements that indicate the ecosystem is functioning within the bounds of a natural disturbance regime i.e. not subject to human induced disturbance such as logging, treatment, grazing impacts and/or prescribed burning.*

This removes the implication of an ordered sequence of discrete successional phases, removes the emphasis on maturity, and promotes a more holistic view of the forest ecosystem. In other words, it removes the undue emphasis on overstorey canopy structure that dominates the popular perception of 'old growth' forest. An 'ecologically integral' dry forest is one that has a mix of age classes of trees and is neither dominated by regrowth nor by overmature trees; it is largely free of exotic species in both the overstorey and the understorey.

The development of quantifiable attributes to describe and rate levels of 'ecological integrity' is a major task and beyond the scope of this study. In lieu of this the project team has developed a pragmatic approach, firmly based on extensive fieldwork, to interpret available disturbance information. Thus a dry forest ecosystem that has a long history of grazing and fire is considered to possess low 'ecological integrity', and hence to not be old growth, whilst one which has been lightly logged but is ungrazed and not subject to repeated low-intensity fire is considered to possess moderate 'ecological integrity', and hence likely to be old growth.

1.3 TECHNICAL MAPPING ISSUES

1.3.1 Disturbance modelling

Investigation of relationships between available environmental data sets was conducted in a separate study sponsored by the project team in collaboration with the Queensland University of Technology. The study took note in particular slope and roads as indicators of accessibility for logging and known logging history where available, such as from the Area Information System (AIS) of the Department of Primary Industries Forestry (QDPI–Forestry) and/or aerial photograph interpretation (API). The study found that strong correlations did exist, but that there were limitations in extrapolating these into firm predictions.

The results of the disturbance modelling study were used in limited areas where direct measures of disturbance were unavailable and to identify areas of possible old growth where the balance of probability suggested that there would be none, for example on freehold land.

With further research this technique of disturbance modelling could form an important tool in forest management planning.

1.3.2 Mapping disturbances other than logging

In the final 12 months of the data collection phase, increasing emphasis was placed on the capture of data related to grazing and fire. Fire information was generally limited to State forest and conservation reserves and usually covered only the most recent 10 years or so. The quality of information was variable, with only a few districts complete and verified. API was used to supplement and validate some of the more recent information.

A workshop held at Gympie early in 1997 confirmed the importance of collecting grazing information to supplement information relating to other disturbances. The boundaries of existing grazing lease and licence areas were digitised to identify a broad envelope of forest likely to have been grazed, while API identified grazing impacts through visual clues such as the presence of dams, fences, roads, and clearing and thus provided a further source of information.

The project team recognised the deficiencies that existed in these data sets; however, there were insufficient resources or time available to develop the data sets further. Consideration of these deficiencies is accounted for in the mapping process by reduced accuracy reported in areas where these data sets are used.

1.3.3 Revised API specifications

A major change to API specifications made following publication of the interim report (DNR 1996) was the introduction of a '**D**' disturbance code within the API decision pathway. This allowed the disqualification of large areas where disturbance was very obvious to the interpreter, from further consideration in the API process. The **D** disturbance code could be used where visual clues such as the presence of human infrastructure, an only partially intact canopy or a high level of regrowth were present. It was used only where the disturbance was clearly apparent. A subsidiary code, such as '**l**' for logging, was used in conjunction with the **D** to indicate a likely cause of the disqualifying disturbance for later validation.

For areas where the interpreter was uncertain as to its significance, a disturbance was documented as an 'under the line' code. Unlike those labelled **D**, these areas were coded for the full range of API attributes, including growth stage, and the disturbance information was only considered where supported by other sources such as field validation or historical records.

Introduction of the **D** disturbance code considerably simplified and accelerated the API process. Field checks indicated that these assessments possessed a high degree of reliability, with more than 80 per cent of those polygons subjected to 'ground-truthing' found to posess a correct interpretation of the forest condition.

2 METHOD

2.1 GENERAL

A methodology for mapping old growth forest in South East Queensland was described in the *Assessment of old growth forest in south-east Queensland: interim report* (DNR 1996). An amended methodology, based on recommendations from the interim report, is described below.

The methodology is a synthesis of information collected over two years of intensive API, field research, disturbance information collection and validation. Map 1 summarises the components of the method and the interaction between those components.

As was the case for old growth assessment projects in other states of Australia, API provided the primary layer in the interpretation of the forest stands of South-East Queensland. In this assessment, forests are categorised on crown structural attributes, i.e. growth stage and/or presence of disturbance for eucalypt forests and includes broad stratification of non-eucalypt types. Extensive field validation of API polygons took place in order to assess the accuracy of API across a range of forest types. Polygons assessed as a result of this work were used directly in the mapping process in order to establish the limits to which such an approach could be applied, and in investigating alternative approaches that addressed inadequacies in the method. In addition, more intensive field research was performed in an attempt to resolve the issue of old growth delineation within dry mixed-age forests, and resulted in the construction of a set of ‘decision rules’ for these forests.

Disturbance information was collected in the study and involved intensive consultation with district staff, management of a large database and digitisation of a great number of hard-copy maps into a format suitable for inclusion in a GIS. The process of data collection, coupled with field validation, revealed that there were differences between districts and data types in the accuracy of the data.

Accessibility modelling was used as a surrogate for disturbance information in limited areas within the bioregion where there was no other available information. Access modelling provides an indication of the likelihood of areas being subjected to logging disturbance based on presence of roads, ridgelines and barriers to mechanical logging such as escarpments and cliffs, and is discussed in Section 3.2.2.

Data sets compiled from these sources were then processed through decision rules to produce a set of classes or groups ranging from most ecologically mature to least ecologically mature with varying degrees of confidence depending on the data sets used. Different rules for defining the level of disturbance and ecological maturity were used depending on the underlying vegetation, as defined by the Department of Environment's herbarium vegetation coverage.

These groups were then categorised into 4 classes ranging from areas most likely to be classifiable as old growth to disturbed areas not classed as old growth. Section 2.6 provides a discussion of the decision rule process.

2.2 AERIAL PHOTOGRAPH INTERPRETATION

Introduction

The basis of the methodology for API for the assessment of forest stands in South-East Queensland (SEQ) has been outlined in the interim report (DNR 1996). It is the aim of this section to address and review the changes that were developed and adopted for the majority of the project.

New API procedures were developed in an attempt to:

- reduce the potential for ambiguity when assessing forest stands
- optimise coding to improve the determination of old growth characteristics
- improve the consistency and speed of API
- assist with the mapping of rainforests
- develop coding that would be of assistance in interpretation
- develop a transparent and repeatable process.

The main changes that have been implemented since the publication of the interim report (DNR 1996) include:

- the removal of the height class and the forest type class for eucalypt types
- the definition of clear polygon decision rules
- alterations to the Crown Cover Projection (CCP) code (see Section 2.2.4)
- the introduction of an unassessed "Senescent, Mature, Regenerating" (SMR) code
- the introduction of a disturbance code for rainforest stands
- the inclusion of a disturbed forest stand coding
- alterations to the coding format.

2.2.3 API techniques

Considerations of scale, quality and date of photography were outlined in the interim report cited above.

Minimum polygon size

The minimum polygon size for aerial photograph mapping depended on several factors:

- the minimum polygon size that can be practically marked and coded on 1:25 000 photographs

- time constraints
- digitising and dataset limitations.

Consideration of these constraints led to a proposed change in the minimum polygon size from 4 to 20 ha. This size was chosen as a compromise between the following three factors:

- the homogeneity of forest areas in relation to the parameters being assessed
- the practical API minimum at a scale of 1:25 000, which is 5 ha
- API and data management speed and efficiency considerations.

However, as a result of these constraints it was viewed that small patches of forest with old growth characteristics may remain unmapped. Recognition that these patches could be important refuges for flora and fauna resulted in polygons smaller than 20 ha being made in the case of:

- areas of rainforest or other non-eucalypt dominant forest stands within a contiguous forest area
- areas of obvious disturbance >5 ha in extent in extensive areas of undisturbed forest
- small areas or point locations of non-forest such as quarries, sawmill sites, clearings, etc.
- areas exhibiting an obvious lack of disturbance >5 ha in extensive areas of obvious disturbance.

Analysis of the API codes at the end of the project revealed that the great majority of polygons were in actual fact less than 10 hectares in size.

2.2.4 Forest assessment codes

The coding of each API polygon is based on a number of attributes and the coding system associated with forest attributes is explained in the following sections.

Interpretation

The following amended coding sequence has been adopted since the publication of the interim report in October 1996:

Step 1 – delineation of non-forest areas and broad non-eucalypt forest types
Step 2 – delineation of areas of obvious disturbance
Step 3 – subdivision by growth stage
Step 4 – subdivision on disturbance
Step 5 – estimation of CCP over polygon
Step 6 – recording of the presence of other canopy species.

This process is depicted in Figure 2.2.1, the API decision pathway.

Non-forest and non-eucalypt forest types

Non-forest and non-eucalypt forest types are delineated into the following categories, coded in upper-case letters:

W waterbodies > 50 ha
J topographic shadow
K cloud or smoke-obscured

N non-forest areas: these include areas of < 30 per cent eucalypt cover, agricultural lands, rural residential areas, non-contiguous forest stands on private land of < 50 ha, linear vegetation features < 100 m wide and areas of highly fragmented and disturbed vegetation
P plantations (both exotic and native), tree trial plots and experiments
A wattle with < 30 per cent eucalypt cover present
Q casuarina with < 30 per cent eucalypt cover present
M melaleuca with < 30 per cent eucalypt cover present
H heath with < 30 per cent eucalypt cover present
C coastal complexes and riverine complexes with < 30 per cent eucalypt cover present.

Rainforest and disturbance

Areas of rainforest are delineated and where disturbance is apparent then the polygon is subdivided and coded appropriately.

The code letter **R** is followed by one of a range of lower-case letter subcodes:

l logging, i.e. recent logging, snig tracks, logging dumps, gaps in canopy, etc.
e grazing, i.e. stock-watering dams, yards, fences, cattle tracks, clearing, etc.
r > 30 per cent regrowth
w weeds, primarily lantana.

In cases where two or more lower-case subcodes are placed with the **R** code, it is to be assumed that the first is present over the greater proportion of the polygon, but with influences of the subsequent code(s) apparent in at least 30 per cent of the polygon.

‘Disturbance only’ polygons

‘Disturbance only’ polygons are those forest areas that display obvious signs of disturbance (easily discernible by API) affecting the forest at two levels: in the canopy, and on the ground. Disturbance is recorded in two ways to represent the different levels of disturbance, and is described below.

To reduce the area requiring full interpretation and coding and as a means of streamlining the API process, areas exhibiting obvious high-intensity disturbance were delineated and coded with a simple ‘disturbance only’ code. The coding system assumes that the level of disturbance would be well within the significant disturbance range and would therefore preclude the polygon from being considered to be old growth forest. Polygons labelled with a **D** often exhibit evidence of multiple disturbances.

The features used to determine areas of obvious disturbance must affect > 50 per cent of the polygon. In the case of regrowth, it is >30 per cent. Primary indicators of obviously disturbed areas include:

- partial removal of the canopy
- infrastructure of human activity
- high levels of regrowth (> 30 per cent).

To code the disturbance polygon, the upper-case letter **D** is followed by a choice of lower-case subcodes:

l logging, i.e. evidence of recent logging such as snig tracks, roads, log dumps, and bare or disturbed ground

e grazing, i.e. stock-watering dams, yards, fences, cattle tracks, clearing, etc.;

r > 30 per cent regrowth

f obvious fire damage (this code must be used in conjunction with another code, as API is unable to determine whether fire has had a significant influence on the forest structure, as interpretation is strongly influenced by the age of the photo in relation to a fire event)

q mining, quarries, sawmills, recreation, and power lines.

In cases where two or more codes are placed with the **D** it is to be assumed that the first is more apparent, but with influences of the subsequent code(s) apparent in at least 30 per cent of the polygon. It is important to note that the code **Dr** (regrowth > 30 per cent) replaces SMR codes that are dominant (> 50 per cent) for regrowth, and also reduces the range of polygons coded as subdominant (10–49 per cent) to (10–30 per cent).

Secondary disturbance

Where disturbance is still observable but is less apparent (ie affecting less than 50 per cent of the polygon) than the 'disturbance only' areas described above, it is recorded as part of a full code that contains full growth-stage information, or in combination with a rainforest-dominated code. Secondary disturbance codes are used in cases where:

- the canopy cover has remained relatively intact, although some level of disturbance is evident
- the canopy has recovered from a disturbance event to a degree where a legitimate SMR code is appropriate, e.g. a logged area where the logging regrowth has advanced to the mature stage where the regrowth is < 30 per cent, or where the disturbance is made up of scattered small areas of obvious disturbance which make up < 50 per cent of the total area.

The individual secondary disturbance codes used include:

l Logging

Indicators for older or selective logging events may be included where a combination of two or more indicators is observed, e.g. roading, snig tracks and log dumps, gaps in the overstorey filled by regrowth, or abrupt changes in growth stage.

e Grazing

Primary indicators include grazing infrastructure such as stockyards, dams and fence lines. Secondary indicators are cattle tracks, small clearings and abrupt changes in CCP (see Section 2.2.4) over small areas. Other indicators of disturbance such as proximity to cleared country and contextual evidence such as growth stage ratios between adjacent polygons have not been included.

f Fire

This code applies to severe wildfire and not generally to control burning. Indicators are crown scorch and crown burn (recent fires), epicormics on the crown, dead standing trees, abrupt crown pattern changes, and supplejack (regenerating *Lophostemon confertus*) dominance. Regrowth from fire is taken into account in the SMR code.

g Gaps

Gaps created by partial clearing for reasons not covered by other disturbance codes, or where indeterminate. Examples are old indeterminate clearings, prospecting sites, or Aboriginal significant sites such as bora rings (initiation sites). To qualify for this coding the gaps need to cover more than 10% of the total area and be evenly spread over the polygon.

s Dead standing trees

Dead standing trees ("stags"), the product of ringbarking, drought or dieback, are coded in this section. If the stags are from a fire event then an **f** coding is also applied.

q Mines, quarries, sawmills, recreation and power lines

This code is used as an indicator of where small-area disturbance is intense but does not exclude the rest of the polygon from full assessment and coding.

w Weeds

Primarily lantana, indicative of a previous disturbance the cause of which may or may not be determinable.

z Rocky and/or steep

This is more an indication of no disturbance, due to access restrictions.

Growth stage

Changes to the growth stage coding include:

- the additional growth stage code of **u**, for 'unassessed', which is used where it is not possible to interpret the growth stage of a particular component of the stand. Examples of the use of this code include:
    - **uuu** for polygons dominated by brush box where the eucalypt component is < 30 per cent CCP
    - **uuu, uu-, uut** and **uus** for forest types on poor quality sites where the growth stages are indistinct
- a change in the upper limit on the **s** to 20 per cent for SMR combinations involving two **d**s and an **s** i.e. **dds**. If the proportion exceeds 20 per cent then the code changes to either two **s**s, one **d** or an **sss** code
- recognition of the fact that the adoption of **Dr** polygons makes the **d** code for the regrowth component redundant, and narrows the range of the **s** code for regrowth from 10–49 per cent to 10–30 per cent.

Crown Cover Projection

Crown Cover Projection is a measure of crown foliage cover for the forest as a whole, as developed by McDonald *et al*. (1990). The changes to coding Crown Cover Projection include the removal of Classes 1 (< 10 per cent) and 6 (cleared). These are now accounted for in Step 1 (See Figure 2.2.1). The subsequent subdivision of Class 0 has been outlined in Step 1.

Table 2.2.1 Crown cover projection classes

Class	Cover – range/type
2	10–29%
3	30–49%
4	50–79%
5	80–100%

'Other species' codes

This field is used to record presence of other canopy species. 'Other species' codes are used in conjunction with full growth stage and disturbance codes where the eucalypt component is greater than 30 per cent. Several other species have been included since the interim report (DNR 1996) was published. If more than one are present they are coded in descending order of overstorey canopy dominance.

R rainforest
A wattle
Q casuarina
M melaleuca
H heath
C coastal complexes and riverine complexes
B or **b** brush box (*Lophostemon confertus*) (see below).

In the case of polygons where brush box is present, the CCP code includes the brush box component. If the brush box is dominant a capital **B** is used, if eucalypts are dominant a lower case **b** is used.

Those polygons dominant in brush box and with < 10 per cent eucalypt were still fully coded, but using the SMR code **uuu**, which refers to an unassessable level of eucalypt.

Coding of polygons

An 'above and below the line' coding system is used in the project, where essential codes are recorded above the line and optional codes below.

for example:

<u>4sdt</u> ⇒ CCP Class 4, SMR code of **sdt**
gR ⇒ disturbance indicated by gaps, rainforest present

<u>5tds</u> ⇒ CCP Class 5 (eucalypts + brush box), SMR of **tds**
sBR ⇒ disturbance indicated by stags, brush box dominant and rainforest present

<u>3uus</u> ⇒ CCP Class 3, with no distinction possible between senescing and mature growth stages. No other species or disturbance.

Acceptable SMR codes

Below is a tabulation, in no particular order, of the range of SMR codes accepted for use in polygon labelling:

d--	*dt-*	*ds-*	*dtt*	*dst*	*dd-*
ddt	*dds*	*dss*	*dts*	*d-t*	*d-s*
sd-	*sdt*	*td-*	*tdt*	*sss*	*sds*
tds	*-d-*	*-dt*	*-ds*		
uuu	*uu-*	*uut*	*uus*		

2.2.5 Field verification and conversion of API to digital coverage.

API was validated and verified in a multi-stage process aimed at improving the quality of the overall interpretation by providing feedback to the interpreters on potential errors in their coding. Initially, field verification by the interpreter is important in developing the skills of the interpreter and provides an opportunity for amendment of codes based on field inspection. Coding of the photos is followed by conversion into a digital coverage. This coverage then provides the basis for the production of field maps that are subjected to systematic validation by the field ecologists.

2.2.6 Accuracy of the API

Results from the field validation were used to investigate the accuracy of the API by comparing the field estimates with the API of stand structure. Appendix 3.2 provides greater detail on the results of this analysis, while a summary is provided below.

A comparison was made between the API of forest structure and disturbance, and the field estimates of these features. Analysis included:

- comparisons between codes within a 1:50 000 map sheet
- accuracy of API in the interpretation of different code combinations
- accuracy of API in different vegetation types.

Comparisons between codes within a 1:50 000 map sheet

This analysis was performed in order to ascertain the accuracy levels of different interpreters by comparing API and field estimates within a 1:50 000 map sheet, and to highlight particular sources of error within a map-sheet area. The analysis was performed by comparing the API estimate with field estimates and acknowledging variation between the codes.

Results varied between map sheets and ranged from 74.4 per cent to 100 per cent for polygons within one code or in direct agreement with field estimates. Potential sources of error were attributed to different forest types, primarily the drier forest types, and occurred on the sheets that were coded in the early stages of the project during the interpreter training period.

Accuracy of API in the interpretation of different code combinations

Further analysis was performed in order to reveal potential sources of error in the API in interpreting different combinations of the SMR coding. The results showed whether API was under or overestimating a particular component of the SMR code.

The analysis revealed that API had difficulty in interpreting dry, low-productivity forest types containing, for example, narrow-leaved red ironbark (*Eucalyptus crebra*) (NRI) and silver-leaved ironbark (*Eucalyptus melanophloia*) (SLI). It was assumed that API misinterpreted the small crowns of NRI as regenerating trees, and was either overestimating the proportion of regenerating stems, or trying to compensate for the dry forest type by underestimating the proportion of regenerating stems.

Analysis of the 'disturbed' polygons (areas ruled out by API as exhibiting significant disturbance and therefore unworthy of further consideration as old growth) revealed a high level of accuracy (> 80 per cent) when a comparison was made between the API and field inspections. Problems with polygons coded as **De** (disturbed by grazing), however, arose where it was assumed API interpreted the naturally open dry forests to have been affected by grazing. Further, examples occurred where **Dl** (disturbed by logging) polygons were found not to be logged. In these areas species recorded included spotted gum (*Corymbia citriodora*) (SPG), NRI, grey ironbark (*Eucalyptus siderophloia*) (GRI) and red bloodwood (*Corymbia intermedia*) (RBW), indicating that API is misinterpreting the open nature of these forest types as disturbed by logging.

Accuracy of API in different forest types

Further analysis to investigate any difficulties in the interpretation of different forest-type groups occurred across the bioregion. Results were calculated in order to show if API was over or underestimating different components in the SMR coding. Analysis was based on five broad forest type groups, ranging from wet, high site-quality to dry, low site-quality forests.

The results reinforced the previous analysis that showed the most significant difficulties were experienced in the drier forest types. For example, in SPG/NRI forest where API coded a polygon as being subdominant in regenerating stems, 65.5 per cent of cases were overestimated by one code i.e. only a trace of regeneration was actually present. Further, where API has labelled a polygon as dominant in regeneration, 51.9 per cent of cases were overestimated by two, where only a trace was actually present. Similar results were achieved in NRI/SLI forests.

Interpreters' accuracy assessment

It must be assumed that the interpretation of each polygon boundary label is 100 per cent accurate based on the best interpretation of that forest stand and its condition. As detailed above it is evident that some problem areas do however exist. Other problems are usually related to poor photograph quality and may include:

- sun spots
- abundance of shadows (dependant on the time of day at which the photograph was taken)
- runs of different colour
- age and colour of the photographs.

The accuracy of the API coverage has been assessed on a 1:25 000 map sheet scale.

Table 2.2.2 Guidelines for accuracy of API coverage

Class	Accuracy	Guidelines
1	High	Recent good-quality photographs; good access and field-checked for API accuracy; forest types easy to interpret
2	Above average	Good quality photographs; little or no field-checking; forest types easy to interpret
3	Average	Average quality photographs; little or no field-checking; forest type interpretation medium
4	Below average	Average quality photographs; good access and field-checked; forest types difficult to interpret
5	Poor	Poor quality photographs; no access; forest types difficult to interpret

2.2.6 Polygons not assessed by API

Some areas were not possible to assess for growth stage and disturbance by API. The first type includes areas obscured by topographic shadow, smoke or cloud. The second type includes **uuu** brush box-dominated polygons and a very small number of polygons where interpretation is hampered by a combination of low CCP, steepness and possibly some type of disturbance.

Obscured polygons were coded either by interpolation from surrounding polygons or with the aid of other data sets such as terrain mapping, vegetation mapping or from field-checking. These codes were tagged in the disturbance field by the original codes **J** or **K** to denote that they were only estimates of the forest stands and their condition, and therefore had lower accuracy ratings.

The second type of unassessed polygon (and any remaining uncoded obscured polygons) will have to be assessed by other data sources and will also have to be field-validated.

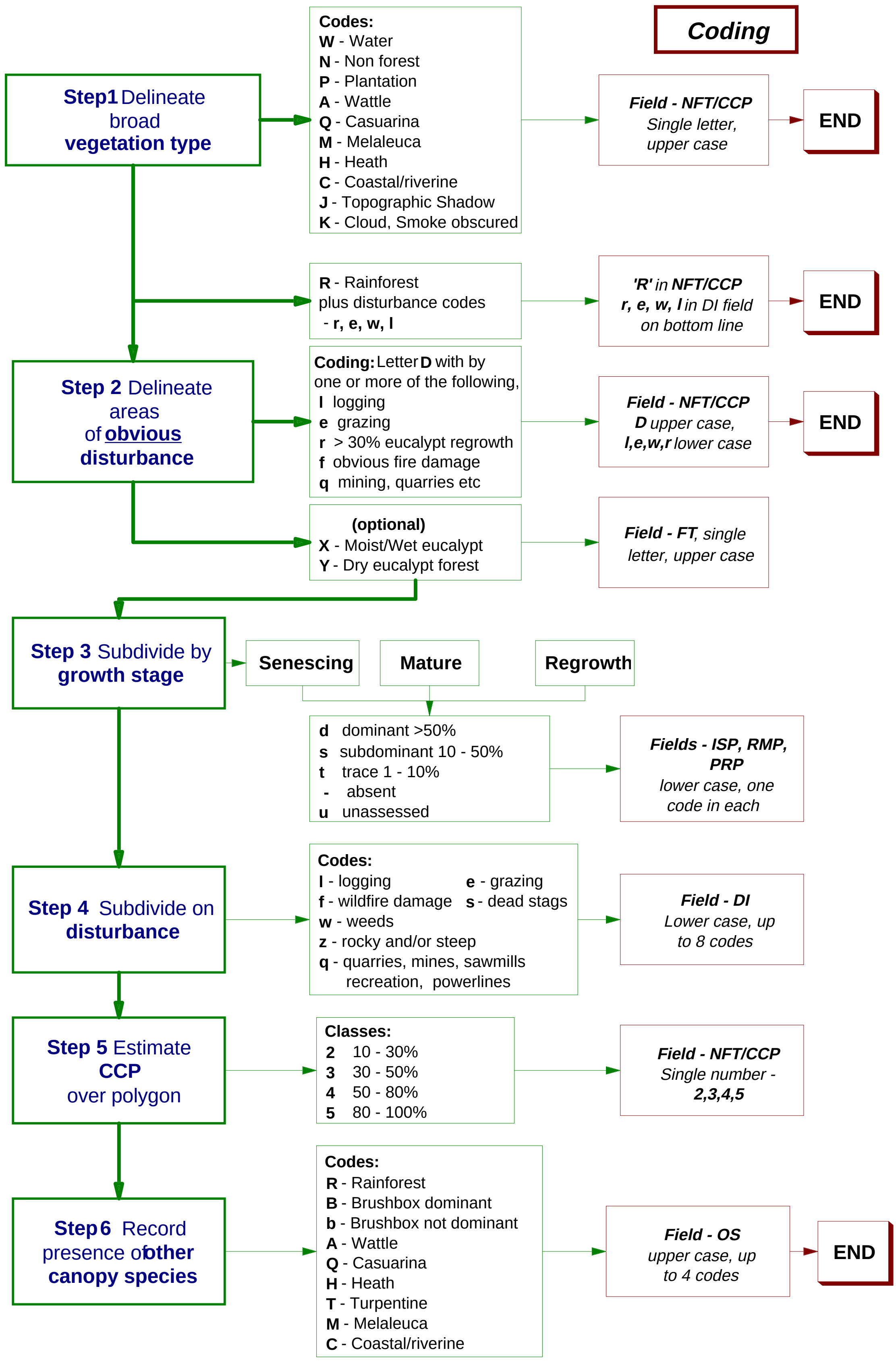


FIGURE 2.2.1 API DECISION PATHWAY

2.3 DEFINING BROAD FOREST TYPES FOR DISTURBANCE MAPPING

2.3.1 General definitions and concepts

In order to define an appropriate vegetation classification for application to eucalypt-dominated forest communities in a way which is meaningful for an analysis of their post-disturbance condition, it is necessary to understand several key points. These points include the nature and intensity of the disturbances to which they are most frequently subject, the 'natural' disturbance regime, and the patterns and processes of recovery from disturbance and how this affects structure, composition and function. In SEQ three main disturbance types have been identified as likely to exert a significant impact on the ecological condition of the forest. These are logging, grazing with grazing-related activities, and fire (both wildfire and prescribed burning). Several ecological concepts need to be discussed and defined to address and avoid the semantic confusion that often accompanies debates on the ecology of forest condition, particularly as they relate to old growth forest.

Ecosystem

The ecosystem concept (JANIS 1996) is clearly central to the mapping and analysis of old growth forest and therefore requires definition. An ecosystem is a unit consisting of living organisms (the biotic component) and their physical and chemical environment (the abiotic component) which can be identified by its structure and function. The ecosystem is a hierarchical system in which the functional relationships between organisms are expressed as trophic levels (Gilbertson, Kent & Pyatt 1990). However, these functional systems are delimited by arbitrarily chosen boundaries, which in space and time appear to maintain a steady yet dynamic equilibrium (Gliessman 1990).

Disturbance, stress, perturbation and stability

The terms disturbance, perturbation, and stress have been applied in various ecological contexts, often synonymously, inconsistently, and ambiguously. Few attempts have been made to define the concept of disturbance.

In ecological discussion 'disturbance' has often been used to refer to events that are massively destructive and rare. As Rykiel (1985) points out, 'the difficulty of constructing a satisfactory definition of disturbance is related both to the generality and ambiguity of the term; generality because "disturbance" is applied to a wide range of phenomena and ambiguity because the specific circumstances surrounding the occurrence of a disturbance are often implicit, and therefore dependent on the subjective context in which the term is used.'

The ordinary (non-ecological) meanings of disturbance and perturbation are the same. Disturbance suggests disorderly 'stirring' or disruption and perturbation implies excessive stirring or turning. Stress, on the other hand, indicates tension. These meanings are not adequate to convey ecological concepts. The following working definition of disturbance has been given by Rykiel (1985):

> *A cause that results in a perturbation, which is an effect (or change in system state). Disturbances can be categorised and quantified in terms of characteristics such as type, frequency and intensity, whereas perturbation (and stress) are measured in terms of deviations in steady-state variables. The occurrence of a disturbance (cause) presupposes the existence of a detectable perturbation (effect).*

The concept of stability has also provided the basis for much theoretical (and even some practical) discussion of the impact of disturbance, particularly 'generic' disturbance. However, stability has no intrinsic meaning without reference to the occurrence of disturbance. The question of stability in real ecological terms arises precisely because ecosystems are subject to disturbances and can potentially be altered or destroyed by a disturbance. Contemporary definitions of ecological stability refer to the ability of a community firstly to resist by maintaining ecosystem functions (resistance) and to recover to normal levels of function after a disturbance (resilience). Thus ecosystem stability does not represent a steady state, but rather a dynamic and highly fluctuating one which permits recovery following disturbance (Smith 1996).

Patterns and processes in succession

The concept of ecological succession is important to any discussion or analysis of forest disturbance. Succession refers to the orderly change in the composition of plant life of a particular area over time. The term refers to the period beginning with the initial colonisation of the bare area by pioneer species to the final establishment of the climax community. Within the context of forest successional responses to disturbance the concepts of 'pattern' and 'process' also need to be defined; they are often confused with each other and with the concept of succession itself. The pattern is simply a description of the change in community composition over time (post disturbance). The patterns may be predictable, but represent a succession of species occupying a site. The pattern of change should be separated from inference of the processes producing the change (Whelan 1995). Whelan also points out that description of a pattern of species change as a succession has a subtle influence that may lead to the anticipation of the processes. However, it is important to guard against the application of expected processes to familiar patterns that emerge after different sorts of disturbance in different regions or forest types. He suggests that it is more profitable to focus directly on the processes that might produce the observed pattern of community change after disturbance, than to infer them from an apparent fit of the pattern of post-disturbance community change.

Questions relating to the nature of disturbance are critical both to our understanding of ecological processes and to the management of forests (Attiwill 1994). Attiwill suggests that catastrophic events are increasingly being seen as part of the 'natural order' which preserves the heterogeneity of forests. This view is in contrast with 'older' ecological theories of succession which were preoccupied with the apparent 'changelessness of large trees with the notion that the natural progression of succession leads to a stable and self-perpetuating end-state' (Attiwill 1994, p. 2). He suggests that we are now increasingly aware that there is no such end-state. Forests are dynamic in time and space and, as with other ecological systems, maximum diversity is reached at some level of random disturbance (Attiwill 1994).

Issues of scale

In addressing these general ecological concepts and their relevance for assessing post-disturbance forest condition, the concept of scale becomes an important issue. The nature and impact of disturbance are related to both the hierarchical organisation of ecological systems ranging from individuals to ecosystems and the level of resolution used to characterise these structures (Rykiel 1985). The effect of a disturbance depends upon the organisational level used as a frame of reference, the scale at which the system is observed, and the ecological processes that can propagate the disturbance at levels across levels, at the specified scale. The ecosystem, however, is an abstract concept, the scale of which will vary according to that definitive attribute which in the case of the SEQ old growth project is the forest canopy (dictated by JANIS and the National Operational Definition). The question then arises as to which forest attributes are measured and whether we examine individual species' response to disturbance; focus on populations, communities, and ecosystems; or look at vegetation response at the landscape level.

Forest attributes

Within this context it is important to develop an understanding of those forest attributes which are affected by, and are therefore indicative of, disturbance, as discussed above. These will vary according to the scale of the study and will also determine whether or not the affect of the disturbance can be measured in a meaningful way.

The National Operational Definition for old growth forest requires the mapping and assessment of disturbance of 'individual forest ecosystems', within the context of 'background' successional cycles. It acknowledges that disturbances will have different effects on different forest ecosystems, and that specifications must be developed for attributes that enable discrimination between negligible and significant disturbance effects at a 'regional level'. These attributes, however, also need to be appropriate to 'individual forest ecosystems'.

Of the principles embodied in this definition, two are particularly relevant to the analysis of disturbance and the identification of forest attributes:

> *If data are available on the structural, floristic and functional qualities that would be expected to characterise an ecological mature forest ecosystem, these should be used in the assessment of the significance of disturbance effects;*
>
> *and,*
>
> *…negligible disturbance effects will be evident in most forests by a significant proportion of trees with age-related features and a species composition characteristic of the ecologically mature forest ecosystem.*
>
> (JANIS 1996)

Thus, those attributes which are necessary by definition for the assessment of forest disturbance, as it is relevant to the identification of old growth, are individual forest *ecosystems* (which are characterised by individual species), the structural, floristic (compositional) and functional qualities of those *ecosystem* types, and the regional context of those forest types and disturbances.

Therefore, if the issue of forest disturbance is to be tackled within the parameters and principles of the National Operational Definition and the JANIS criteria, not only must the structural characteristics of the forest overstorey be examined, but also the *structural, functional* and *floristic* characteristics of *all* levels within each identified forest ecosystem.

Clearly, to undertake an analysis of this magnitude is far beyond the scope of the SEQ old growth assessment project. Yet to focus purely on overstorey structure, as has tended to be the case with studies into forest condition (particularly those concerned with old growth forests), does not adequately address the apparently holistic perspective taken in both the National Operational Definition and within the JANIS criteria. Hence, within the context of the SEQ old growth forest assessment project, forest disturbance is being mapped in a way that allows analysis at a variety of levels and takes into account all forest attributes for all disturbances being assessed.

Disturbance characteristics

The characteristics of each disturbance which are important for the assessment of forest condition will vary. However, those which are important for all disturbance types (primary characteristics) are generally accepted to be intensity, frequency and spatial extent; secondary characteristics will be disturbance-specific. If these characteristics can be identified and measured at a scale that is relevant to the issue then we will be able to determine the relationships between forest disturbance and forest condition.

Those disturbances to forests which are being assessed as part of the SEQ old growth forest assessment project are logging and silviculture, grazing and associated activities, prescribed burning and wildfire. The logistics of data audit, collection and conversion have been outlined in the interim report (DNR 1996). Amendments to these processes, which resulted from a review of the pilot project outlined in the interim report, are presented in Section 2.5 of the present report.

This report examines the characteristics of each of these disturbances and their potential impact on different forest types. Further, it discusses those attributes of different forest types that make them prone to particular disturbances and the ways in which the forest types and the species within them persist through, and respond to, disturbances. The characteristics of each disturbance are presented below and a set of broad 'Disturbance Forest Types' is suggested. An examination of the way that these disturbances interact with each other is then made and the implications this has for assessing forest condition are discussed. Finally, a set of forest types is presented, based primarily on those characteristics that determine the ability of the forest to respond to the disturbances in combination.

2.3.2 Logging

An investigation of the tree-marking and harvesting guidelines for native hardwood forests, as devised by the QDPI–Forestry (DPI 1997) provides insight into those harvesting practices which are likely to affect forest condition.

Forest types and productivity by harvesting and marketing guidelines

Tree marking guidelines were first introduced to Queensland for the management of hardwood forests in 1937. These guidelines called for the removal of marginal trees which would otherwise have been left in the forest by loggers and which would be likely to interfere with the growth of regeneration. Subsequent modification has resulted from the need to ensure that trees in all size classes were capable of vigorous growth following logging.

Post-logging silvicultural treatments were generally carried out from the late 1940s to the 1960s. However, extensive operations of this type no longer occur as they are not economically viable. Consequently a carefully controlled logging program is the basic, and usually the only, silvicultural operation applied in most natural hardwood forests in Queensland. Thus the focus of logging operations is on the size and spacing of the stems permitted to remain.

The current objectives of tree-marking are:

- to remove the accumulated capital growth component of the forest while retaining a forest structure which is consistent with the objective of sustained yield management
- to comply with defined environmental guidelines
- to encourage regeneration in accordance with the principles of sustained yield management
- to manage species composition to improve growth and wood quality
- to allocate forest products according to the specified end-use priorities
- to encourage growth on favoured trees by removal of competing poorly formed or slower-growing trees.

Guidelines for tree marking are provided for different forest types. Four of these are considered below.

Wet sclerophyll forest types (excluding blackbutt)

Tall eucalypts and/or brush box and/or turpentine forest with a well-developed understorey in which rainforest components may be well represented and exceed 6 m in height. Grasses are absent or sparse in ground cover. Palms, ferns and shrubs are often present.

Types of stand in wet sclerophyll forest:

- *Virgin forest fully stocked forest*: in which large over-mature trees completely dominate the stand. Smaller stems occur as suppressed stems or in isolated clumps or as single trees in gaps created by natural causes
- *Areas previously cut over on a selective basis as poorly stocked virgin forest*: here a wide range of size classes is present, from over-mature trees bypassed in previous logging to patches of regeneration
- *Areas previously heavily logged within plentiful advanced regeneration to 30 cm dbh*: here mature and over-mature trees occur only as scattered overstorey to fairly dense advanced regeneration.

Of these, virgin stands that are considered to be in a ‘nil growth’ state are given the highest priority in logging sales to improve overall productivity. The lowest priority should be given to areas previously cut over on a selective basis and to poorly stocked virgin forest. However, it is recognised that it may be necessary to include two or all of these stages within a logging plan.

Blackbutt forest types

Blackbutt forest types are forests in which blackbutt (*E. pilularis*) is the major species. As a guide, when more than 50 per cent of the stems of > 20-cm dbh are blackbutt, the stand should be tree marked under the blackbutt guidelines. Blackbutt stands occur in both wet and dry sclerophyll forest types.

The tree-marking guidelines applied to blackbutt forest vary in accordance with past logging history and the stand’s stage of development. As with wet sclerophyll forest three main stages of development can be defined.

1. *Virgin forest fully stocked:* large overmature trees completely dominate the stand. Smaller trees may occur only as suppressed stems or in isolated clumps or in single trees in gaps created by natural causes
2. *Areas previously cut over on a selective basis or poorly stocked virgin forest*: a wide range of size classes is present, from overmature trees bypassed in previous logging to patches of regeneration
3. *Areas previously heavily logged with plentiful advanced regeneration to 30-cm dbh*: mature and overmature trees occur only as a scattered overstorey to fairly dense advanced regeneration.

As with wet sclerophyll forest types, virgin blackbutt forest fully stocked has the highest priority in logging with the objective of improving overall productivity. Interestingly, the tree-marking guidelines suggest that special attention should be paid to the size and design of logging 'fronts' due to 'the visual impact of extensive areas of logged virgin forest' (DPI, Harvesting and Marketing Manual, 1997).

Dry sclerophyll forest types (excluding blackbutt)

This group includes eucalypts and/or brush box. Grasses are usually well represented in ground cover, and the woody understorey is dominated by sclerophyll species and is normally sparse. Vines are absent or rare and rainforest components are either absent or infrequent in occurrence and less than 6 m in height.

For the purposes of tree marking and harvesting, dry sclerophyll forest is split into coastal and non-coastal forest types, the boundary being determined by the 1000 mm annual rainfall line.

Harvesting prescriptions do not vary with logging history (virgin, etc.) for dry sclerophyll forest. However, in uneven-aged forest, where there has been a history of logging and silvicultural treatment over many decades, the structure and condition of growing stock is often variable, reflecting differences in site factors, the structure and condition of the original forest, and the different effects of early logging, treatment regimes and wildfires. Silvicultural practice will almost inevitably affect the structure of the forest. Selection regimes will create a wider range of age classes. Where the selection of some stems has created large canopy gaps, advance growth readily regenerates (Florence 1996).

Rainforest

Rainforest is described as a moist closed community (with projective foliage cover of the tallest stratum exceeding 70 per cent) with mixed scrub tree species exceeding 25 cm dbh predominant. Community development may range from semi-evergreen vine thicket to complex mesophyll vine forest. Emergent *Eucalyptus*, *Lophostemon* or *Syncarpia* species are infrequent or absent. Ground cover vegetation is normally sparse, and grasses absent. Ferns, palms and mosses are common. Rainforest areas are protected from logging under all circumstances.

Harvesting of non-millable products

Harvesting of non-millable products such as poles, girders, posts and round timber also occurs within most forest types but with specific guidelines for each. These are summarised below.

Poles

Bloodwood poles of any size can be removed; any other species greater than 9.5 m in length which have reached their economic potential may also be removed; any stem containing a pole which has a severely declining crown may be removed. In areas containing more than 10 poles > 12.5m in length per ha:

- all species 21.5m+ in length
- bloodwood poles of any size
- turpentine and grey gum once they have reached maximum economic potential
- poles of any species 12.5 m+ once they have reached their maximum economic potential

Girders

The rules for girders are the same as for mill log tree-marking. Species commonly taken for girders are listed in Table 2.3.1 below.

Table 2.3.1 Species commonly taken for girders

Common name	**Botanical name**
Broad-leaved red ironbark	*Eucalyptus fibrosa* subsp. *fibrosa*
Grey ironbark	*E. siderophloia*
Narrow-leaved red ironbark	*E. crebra*
Spotted gum	*Corymbia citriodora*
Forest red gum	*E. tereticornis*
Grey gum	*E. biturbinata* *E. longirostrata* *E. propinqua* *E. major*
Gympie messmate	*E. cloeziana*
Tallowwood	*E. microcorys*
White mahogany	*E. acmenoides* *E. umbra*
White stringybark	*E. tindaliae*

The 'compulsory species' list

A 'compulsory species' list of hardwood species has been prepared for timber harvesters by QDPI–Forestry. Compulsory species are those required to be harvested within each forest type and QDPI–Forestry has also included diameter and espacement prescriptions which the loggers must adhere to. However, under the Nature Conservation (Wildlife) Regulations 1994, the logging of Blackdown stringybark (*E. sphaerocarpa*) and Dunn's whitegum (*E. dunnii*) can only be carried out consistent with an approved conservation plan for those species. Another species (non-compulsory) with commercial potential which is also protected under these regulations is Nanango ironbark (*E. melanoleuca*).

Compulsory species which fall within the study area for this project as identified in the Harvesting and Marketing Guidelines are presented in Table 2.3.2.

The significance of this information is in developing an understanding of the relationship between logging activities and their likely impact on forest structure, composition and function in different forest types. The distinction of four forest types – wet, dry, blackbutt and rainforest – broadly follows the lines taken in the pilot project for the South-East Queensland old growth forest assessment project. Nevertheless it is clear that with regard to harvesting and marketing of native hardwoods the wet forest and blackbutt forest types are considered to be the more productive forest categories, followed by coastal dry forest and then inland dry forest types. These guidelines do not make any distinction on an individual species basis and it is proposed that they should be broadened to incorporate the post-logging response of distinct forest types and species.

As tree marking guidelines were not introduced into Queensland until 1937, and post-logging silvicultural activities not until the late 1940s, the assumption has been made that prior to this date harvesting strategies did not result in careful maintenance of forest composition and structure for continued productivity. Further, the cessation of post-logging silvicultural treatment and the enhancement of harvesting guidelines (post-1960) have meant that careful logging practices (together with enrichment planting in some areas) have been the only continuous silvicultural activities in Queensland's native forests since 1937.

Table 2.3.2 'Compulsory species' falling within the south region as identified in the harvesting and marketing guidelines

Common name	Botanical name	Broad forest type	Productivity
Bailey's stringybark	*Eucalyptus baileyana*	dry	low
Bancroft's red gum	*E. bancroftii*	dry	low
Bimble box (poplar box)	*E. populnea*	dry	non
Blackbutt	*E. pilularis*	wet/dry	high
Blue-leaved ironbark	*E. fibrosa* subsp. *nubila*	dry	low
Blue mountain ash	*E. oreades*	wet	moderate
Broad-leaved red ironbark	*E. fibrosa* subsp. *fibrosa*	dry	high
Broad-leaved tea tree	*Melaleuca viridiflora*	dry	moderate
Brown bloodwood	*Corymbia trachyphloia*	dry	high
Brown hazelwood	*Lysicarpus angustifolius*	dry	low
Brush box	*Lophostemon confertus*	wet/dry	high
Carbeen	*C. tessellaris*	dry	moderate
Dunn's white gum	*E. dunnii*	wet	high
Forest red gum	*E. tereticornis*	dry	moderate
Fuzzy box	*E. conica*	dry	low
Grey box	*E. microcarpa* *E. moluccana*	dry dry	low low
Grey gum	*E. propinqua* *E. major* *E. biturbinata*	moist moist moist	high high high
Grey ironbark	*E. siderophloia*	dry	moderate
Gum-topped ironbark	*E. decorticans*	dry	moderate
Gympie messmate	*E. cloeziana*	wet	high
Messmate	*E. obliqua*	wet	high
Narrow-leaved grey box	*E. pilligaensis*	dry	
Narrow-leaved red gum	*E. seeana*	dry	
Narrow-leaved red ironbark	*E. crebra*	Dry	moderate
Needlebark stringybark	*E. planchoniana*	Dry	low
New England blackbutt	*E. andrewsii*	both	high
Queensland peppermint	*E. exserta*	dry	moderate
Red bloodwood	*Corymbia gummifera* *C. intermedia*	dry dry	moderate moderate
Red ironbark	*E. sideroxylon*	dry	moderate
Red mahogany	*E. resinifera*	wet	moderate
River red gum	*E. camaldulensis*	dry	moderate
River tea tree	*Melaleuca bracteata*	dry	moderate
Satinay	*Syncarpia hillii*	wet	moderate
Spotted gum	*Corymbia citriodora*	both	high
Swamp mahogany	*E. robusta*	dry	low
Sydney blue gum	*E. saligna*	wet	high
Tallowwood	*E. microcorys*	wet	high
Turpentine	*Syncarpia glomulifera*	wet	high
White mahogany	*E. tenuipes* *E. acmenoides* *E. umbra*	wet wet wet	high high high
White stringybark	*E. eugenioides*	dry	high
White-topped box/greybox	*E. quadrangulata*	moist	
Yellow box	*E. melliodora*	dry	high

The project team hypothesised that the existence of 'compulsory species' within an identified forest was an indication that this area was more likely to be subjected to logging disturbance. For example, spotted gum (*Corymbia citriodora*) is a compulsory species and is favoured for girder harvesting. Therefore, where spotted gum is dominant in a Regional Ecosystem (RE) (RE refers to a vegetation unit as defined by the Department of Environment and Heritage), the RE is more likely to be significantly disturbed by logging than an RE dominated by scribbly gum, which is a non-compulsory, non-productive species.

Based on the above information the suggestion is made that eucalypt forests could be grouped into six broad forest types with respect to forest harvesting:

1. **Productive (wet sclerophyll):** Forest containing species of high-value / high-quality timber, actively managed for sawlog timber, e.g. generally dominated by *E. grandis*, *E. microcorys*, or *E. saligna*, with or without *E. pilularis* or *Corymbia citriodora* in subdominant proportions.
2. **Productive (wet–mixed):** Forest dominated by *E. pilularis* but including other species such as *E. microcorys*, *E. acmenoides*, *C. citriodora* and *Syncarpia* spp. as subdominants.
3. **Productive – moderately productive (mixed–dry):** Forest dominated by *Corymbia citriodora* but including other species ranging from *E. pilularis* and *E. acmenoides* on higher-quality sites to bloodwoods (*C. gummifera*, *C. intermedia*), ironbarks (*E. crebra*, *E. fibrosa*) and *Angophora* spp. (*A. leiocarpa*, *A. floribunda*) on lower quality sites.
4. **Moderately productive:** Forest containing species of moderate value, e.g. for poles, round timber, posts, etc. (Examples include *E. tereticornis* *C. citriodora*, *E. crebra*, *C. intermedia*, *C. gummifera*).
5. **Low productive forest:** Forest species of low commercial value and rarely harvested (*E. tereticornis* *Melaleuca* spp., *E. populnea*, *E. racemosa* *C. intermedia*, *E. crebra*, *Angophora floribunda*, *A. leiocarpa*, *E. melanophloia*).
6. **Unproductive:** Forest of no productive value (For example *E. populnea*, *E. racemosa*, *C. intermedia*, *Melaleuca* spp., *E. bancroftii*, *C. tessellaris*).

2.3.3 Grazing in forests in Queensland

In Australia, and in Queensland in particular, grazing has always been regarded as compatible with timber production. The *Forestry Act 1959* (Qld), as amended, sets out the responsibilities, functions and powers of the Conservator of Forests with respect to the sustainable management of the State forests of Queensland. Considering that more than 70 per cent of Queensland's State forests are currently under grazing occupation and that modification of tree cover is permitted for certain species, the relationship between grazing activities and forest condition is important for the old growth forest assessment process.

Grazing is encouraged in open forest types for the following reasons:

- as a further source of revenue for QDPI–Forestry
- as a means of managing a potential fire hazard
- the grazing capacity is reduced, however, in commercial types because silviculture directed at wood production reduces grass competition as much as possible and litter reduction burning is aimed at keeping grass as well as forest fuel to a minimum
- forest areas supply the grazing industry with an important source of shade, shelter and forage
- the combination of forest and grazing (pasture cultivation) is one form of agroforestry system (silvi-pasture)
- the combination of trees and pasture is considered to be more productive than either land use on its own, due to more efficient use of soil, nutrients, moisture and light resources (resource-sharing)

- widely spaced trees are often considered to be an advantage when combining pasture with timber production.

This practice is facilitated in Queensland by the issue to forest graziers of permits to destroy and prescriptions on treatment levels.

Ecological impacts of grazing

Commercial grazing in eucalypt forests can have both direct and indirect impacts on the forest environment. These include:

- browsing or rubbing of vegetation
- soil compaction and erosion
- eutrophication of water sources
- increased fire frequency
- deliberate destruction of timber and other vegetation to enhance fodder production
- spread of weeds.

Grazing tends to have a very selective influence on plant communities and forest grazing must be carefully managed to ensure protection of the forest environment and compatibility with other values and uses of forests. Heavy grazing results in physiological damage to palatable species, causing them to lose competitive status and decline, a process called retrogressive succession.

Browsing/grazing itself is a disturbance regime occurring as an ongoing process within forests. However, the major effects of browsing on forest may be indirect—in the impact cattle have in association with other disturbance events. In combination with different treatment measures imposed by the grazier, the forest understorey may be opened up and the soil may experience overheating from insolation. Compaction of the soil will vary in its severity according to location and will, for example, be higher around watering points. Browsing on undergrowth may result in the loss of seedlings for regeneration and the destruction of roots and seeds through soil overheating. In addition, firing of forested areas to stimulate fodder regeneration may drastically alter the regenerative capacity of the forest.

Cattle cause more damage to trees in rural areas than other forms of livestock. Damage may be direct through browsing or trampling of young trees or through girdling of trees due to rubbing or stripping of bark. Damage may also be indirect – through root damage, soil compaction, decrease in water infiltration, increase in surface runoff and the accumulation of toxins through excreta.

The severity of these impacts is influenced by several factors:

- the extent, season and type of grazing
- the lessees' use of tree clearing and fire to enhance fodder production
- the lessees' establishment of tracks and fence-lines, the supplementary feeding of stock, and the erection of structures, yards and buildings
- the lessees' construction of water supply facilities.

Moore (1991) suggests that in areas grazed by cattle, browsing can affect the development of trees if it commences before trees have reached five years of age. It can be inferred from this that continuous browsing by cattle must affect the development of young trees and thus forest regeneration. Grazing animals select plants in order of palatability. High grazing pressure occurs where palatable species predominate and where water occurs. The proximity of water often overrides other factors.

Grazing by introduced species directly impacts on the floristic and structural characteristics of the forest understorey. It also directly impacts on the local ecology through management practices such as burning and application of herbicide to non-commercial tree species to encourage pasture.

Ecological impacts of treatments

Permits to destroy trees are issued by QDPI and DNR. The objectives of these permits are:

- to allow the use of timber for improvements on the leasehold land on which the timber is situated
- to increase or maintain livestock and/or agricultural production, while retaining sufficient tree cover for timber production, honey production, fodder trees, shade, shelter, erosion control and the preservation of important conservation areas.

Much of the land considered suitable for pasture development in northern Australia supports an open woodland community of predominantly *Eucalyptus* species with a perennial grass understorey. In north-eastern Australia thinning or removal of trees has been the primary form of pasture improvement because it results in increased grass production which enables higher stocking rates (Burrows *et al.* 1988). The enhanced grass growth resulting from tree killing is attributed to the elimination of competition for nutrients between the trees and the perennial grasses (Winter *et al.* 1989).

Selective clearing and fire are recognised as the major tools used to manipulate forage supply. It is also recognised that they have potential for major negative impacts on conservation values. Therefore, tree-clearing programs are only permitted under approval and in accordance with prescriptions provided by a supervising forest officer. They are not permitted where they will detract from other forest values, for example by causing erosion or damaging habitats. They may be allowed in commercial forests in accordance with tree-marking guidelines, but only if they leave not less than 50 per cent of the basal area of the untreated stand and only if they retain a stand that has a similar diversity of species and sizes as untreated forests in particular habitat trees. Mechanical clearing is not permitted. Chemical treatment, felling or ringbarking are preferred.

It is therefore obvious that grazing and grazing-related activities can have a significant impact on the eucalypt-dominated forests of SEQ. The following broad forest types are proposed based on the effects of grazing on those communities.

Grazing broad forest types

<u>Grazing Intensity 1:</u> Closed forest, littoral rainforest and heath are areas in which pastures are generally sparse or absent. Where they are found they are generally low in productive value. Grazing can however occur in these communities, particularly during dry periods, resulting in trampling of seedlings, preferential grazing and importing of pasture seeds. Therefore, for the purpose of this analysis, these communities are considered to be subject to low grazing pressure.

Grazing Intensity 2: Tall open to closed wet sclerophyll forest dominated by *Eucalyptus grandis*, *E. microcorys*, *E. saligna* and *E. cloeziana*, with *E. pilularis* in its wetter high rainfall areas. These forests have a well-developed understorey in which rainforest components may be well represented and exceed 6 m in height. Grasses are sparse but, where present, consist mainly of *Heteropogon contortus* (black spear grass). These forests are therefore subject to low grazing intensity.

Grazing Intensity 3: Tall to medium open forest types with mixed species in which grasses are moderately well represented in the ground cover with other understorey components. Dominant species in the canopy would include *E. pilularis* (on lower site quality), *Corymbia citriodora* (on high site quality), *E. acmenoides* and bloodwoods. Characteristic pasture species are *Themeda australis* and *Imperata cylindrica*. However, intensive use is not possible in the absence of extensive development. Thus these forest types would be subject to low to moderate grazing intensity particularly where site quality is low and canopies are more open.

Grazing Intensity 4: Medium to low open forest types dominated by *C. citriodora* and *E. tereticornis*, with *E. crebra*, *E. propinqua* and bloodwoods particularly on low site quality areas. In these forests grasses are well represented in the ground cover, and woody understorey (sclerophyll) species are sparse. Dominant pasture species include *H. contortus*, *Bothriochloa bladhii* and *T. australis*. These forest types are subject to moderate to high grazing intensity. Land use on these pastures is cattle-breeding and fattening and most areas are modified by ringbarking and poisoning of trees.

Grazing Intensity 5: Medium to low open forest to woodland dominated by *E. crebra*, *E. melanophloia*, *E. populnea* and *C. tessellaris*, with *Angophora floribunda* and *A. leiocarpa*. With an understorey dominated by grass species including *H. contortus* and *T. australis* these forest types are extensively grazed and modified for grazing activities. However, a combination of partial clearing, fire and grazing has tended to displace *T. australis* and other species in favour of *H. contortus* which is more fire-resistant and has more efficient seedling regeneration than *T. australis*. Deliberate firing (for green pick – young new grass growth etc.) has hastened the process of change (Humphreys 1987).

2.3.4 Fire

Nowhere is the dominance of ecosystems by fire more important than in Australia. In particular, fire has played a crucial role in the evolution of Australia's forests, producing the enormous diversity of species within the genus *Eucalyptus* which now dominates the forests (Attiwill 1994). The 'naturalness' of fire in the Australian environment has become the centre of debate, for since the advent of European settlement the frequency of this phenomenon has increased to an artificially high level. However, Taylor (1990) suggests that the present equilibrium in vegetation has not been 'isolated in time' from the pre-Aboriginal native vegetation of the late Pleistocene. It has descended from this late Pleistocene native vegetation through an unbroken sequence of autogenic and allogenic successional response to human-generated disturbance and other natural agents of landscape change. Humans are part of this natural system and, as Attiwill (1994) points out, our decisions as to how we treat our forests to suppress fires, to protect old growth qualities, to harvest for timber and other products are management decisions which will have their own consequences for forest development and therefore forest condition.

Fire affects forest in different ways depending on the characteristics of the fire, the forest type, the species mix and other environmental variables. How we determine a measure of significance for forest condition when a fire occurs is a challenge, and when the challenge made is to measure these levels within the context of forest function and composition as well as structure, meeting it becomes all the more difficult.

The approach taken here is one that investigates all components of forests, function, structure and composition. A review is made of models and individual cases of plant response to disturbance as it has been investigated in other studies. These are summarised below.

Structure

The structure of eucalypt forests is an important factor in determining fire behaviour and therefore its effect on these forest types. Degrees of structural complexity and openness are important variables in this.

In terms of complexity the forest structure can be broken into two or more strata, the canopy and the understorey or understoreys. Density of the upper canopy is described as crown cover projection (as described in Section 2.2) ranging in this study from CCP Class 1 (< 10 per cent), CCP Class 2 (10–29 per cent), CCP Class 3 (30–49 per cent) and CCP Class 4 (50–79 per cent) to CCP Class 5 (80–100 per cent). The complexity and nature of the understorey will also affect fire behaviour.

Tree canopy cover

Tree canopy cover has the effect of slowing wind velocity because of its large friction area. The openness of the canopy will affect the degree of wind penetration into the forest floor where it can affect fire behaviour. Hence there are differences in fire behaviour between wet (closed) eucalypt forest and dry (open) eucalypt forest.

Sudden changes in vegetation cover can also cause mechanical and thermal turbulence and allow increased or decreased wind penetration resulting in changes in fire intensity and predictability. Thus, as a fire moves from wet closed forest to dry open forest, or vice versa, changes in fire behaviour will occur and will affect the forest condition in different ways.

Functional groups

With regard to their response to fire, eucalypt forests are frequently split into two broad groups:

- fire-sensitive forest which develops into fast-growing single-aged stands of single species
- fire-resistant forest of slower-growing uneven-aged forest with a variety of species.

Taking the position of the 'life-form' approach to classification of adaptive responses of plants to fire, eucalypts can again be split into two groups:

- sprouters (dry/wet)
- non-sprouters / seed regenerators (usually wet only).

Gill (1981) classifies these further (particularly in relation to fire but this classification can also be used for other disturbances) into:

- non-sprouters:
  - seed storage on plant
  - seed storage in soil
  - no seed storage in disturbed area;
- sprouters:
  - subterranean regenerative buds:
    - root suckers, horizontal rhizomes
    - basal stem sprouts, vertical rhizomes;
  - aerial regenerative buds:
    - epicormic buds grow out
    - continued outgrowth of active aerial pre-disturbance buds.

Consideration of these classification schemes can be used as a basis for categorising forests into one of three types:

Forest depending entirely on seedling regeneration

- large wave seedling regeneration following major canopy disturbance and creation of suitable seedbed. Usually non-lignotuberous species (species in Queensland include *E. pilularis* and *E. grandis*)
- seedling regeneration of lignotuberous species on high-quality sites. A wet sclerophyll forest may contain little advanced growth and regeneration must come directly from seedling regeneration. As seedlings may develop slowly they are vulnerable to competition (particularly from fire-induced weed regeneration). Examples of this forest type are *E.microcorys/E.saligna* forest and the moist mixed hardwood forests and *C.citriodora* at the wetter end of the spectrum.

Regeneration based primarily on advanced growth

- regrowth comes totally or to a major extent from advanced growth. This may represent a slower process of regeneration – a continuous establishment of seedlings in the course of time related to periodic occurrences of suitable seedbeds and to favourable climates. Elsewhere seedling regeneration may enter a prolonged lignotuberous phase. Where site quality is lower, regeneration will come primarily from advanced growth (e.g. *C.citriodora* on dry sites, *E. acmenoides*, *E. propinqua*, *E. crebra*, *E. siderophloia* and *E. resinifera*).

Regeneration based on a mix of components

- much of the eucalypt forest contains some advanced growth but it may be inadequate to restock the forest, or may be weighted towards one species in a mixed-species forest. In either case it will be desirable to supplement the advance growth with new seedling regeneration. Within this context Florence (1996) suggests that we are dealing with a continuum in the regeneration process, from total reliance on seedling regeneration at the one extreme, to total dependence on advance growth at the other.

Florence (1996) goes into some detail about the regeneration response of different eucalypt species (characteristic of different forest types). However, it is widely recognised that much of the research on forest regeneration has been directed at determining techniques that will ensure adequate regrowth of a single or preferred species over the greater part of a broad forest type. Florence notes that there has been little critical work on the response of the "whole community" to different types of disturbance, or on appropriate regeneration processes for more complex and variable mixed species forests. By investigating the regeneration responses of particular species to disturbance we may be able to form some generalisations about the way that groups of species, communities and broad forest types regenerate after disturbance.

Seed regenerators and their response to fire

Due to the fragile nature of the eucalypt seedling, the undisturbed forest floor is not suitable for the establishment of seedlings. One of the major contributing factors to this is the layer of leaf litter, which acts as a barrier preventing the seed from making contact with the mineral soil. If a fire burns away this barrier spectacular seed regeneration can result. Seeds falling on a mechanically disturbed forest floor can also experience rapid and successful germination, but to a lesser extent than on a burned floor. Gaps in the canopy coupled with disturbance of the soil (e.g. logging) may fill up with regeneration in a few years without fire. Browsing by native and introduced vertebrates can result in a substantial loss of eucalypt seedlings or disrupt seedling growth. Florence discusses the implications of post-selective logging and seedling regeneration for increases in number of browsing mammals, focusing on native species. He suggests that reduction in coupe size results in increased populations of species in smaller areas and therefore increased pressure on seedlings.

In mature *E. pilularis* forest, for example, the growth of seedlings may be poor due to microbial antagonistic effects (Florence & Crocker 1962 in Ashton 1981). It has been suggested that part of the inhibitory property of mature forest soil *in situ* is due to an inhibition of the nitrifying bacteria by leachate concentration from the eucalypt leaves. Other research has suggested that it may be the close proximity of old living root systems. In either case the effects of severe fire are such that these restrictive elements will be eliminated and regeneration can proceed. This, together with the removal of the physical barrier of the leaf litter and the addition of nitrogen to the soil through its incineration all result in the so-called 'ash bed effect' which promotes seed regeneration.

Repetitive burning within the primary non-flowering period of an obligate seed-regenerating species can result in its complete elimination from a site. Throughout the tall open forest, even-aged stands ranging from pole form to mature trees occur, with each such even-aged stand related to a specific fire history. Partially damaged forest however may show two or even three distinct age-classes (Ashton 1981).Surface fires (e.g. prescribed burns) in the ground stratum and the shrub understorey may leave the eucalypts undamaged, yet initiate even-aged strata of undergrowth seedlings or coppiced shoots.

Regeneration from advance growth

As described previously a common regeneration strategy for dry forest eucalypts is to sprout from lignotubers (subterranean buds) or coppice from cut stumps.

Lignotuber regenerators are characterised by the following:

- their ability to survive fire depends on species, development stage and fire severity
- they may develop slowly even in gaps due to sensitivity to overstorey trees
- they may develop rapidly after fire but remain as suppressed saplings or revert to lignotuberous state
- their ability to survive for long periods declines along the dry sclerophyll – wet sclerophyll gradient.

Non-lignotuberous species (e.g. *E. grandis*, *E. pilularis*) are characterised by the following:

- epicormic-like growth occurs at the root–shoot interface but is highly fire-sensitive, even to light prescribed burning
- advance growth may be found in virgin *E. pilularis* forest but is more likely in disturbed forest (e.g. subject to frequent cutting).

Coppice:

- can sometimes be the primary means of regenerating a cut-over eucalypt forest. Even-aged forest may be maintained totally by a coppice rotation system
- most eucalypts produce coppice shoots. In other species coppicing ability depends on age. For example *E. pilularis* coppices vigorously after fire when young, but less so later in life
- for most species it is likely that the ability to coppice is related to their age or size.

Florence summarises the response of mixed moist forests to disturbance in the following ways:

- many lignotuber species on high-quality sites may not have sufficient early vigour, expressed through capacity for rapid height growth, to beat competition from fire-stimulated successional species
- the lack of early vigour may also reflect the sensitivity of the seedlings to competition from advanced growth, coppice and residual overstorey trees
- small differences in site factors may exert strong control on the competition of mixed-species forest.

Where a fully stocked mature forest has not been disturbed for a long time, both species diversity and biological productivity may decline (Florence 1996). This may be due to limited fertility (as it shifts from soil to living biomass) and a decline (with time) in ecosystem nutrient processes. Disturbances to the system may help to rejuvenate these processes in the following ways:

- Fire leads to partial sterilisation of soil and may stimulate microbial processes and release of nutrients leading to seedling regeneration.

- Fire together with mechanical disturbance may stimulate the development of a shrub stratum (from dormant seeds) and lead to increased species diversity followed by a slow decline.

Florence (1996) identified the approximate environmental range of major commercial forest types. With modifications by the present author, this is presented in Table 2.3.4 below.

Table 2.3.4 Environmental range of major commercial forest types (Florence, 1996 with modifications by author)

Rainforest	**Eucalypt-rainforest ecotone**	**Eucalypt forest**		
		Wet sclerophyll		**Dry sclerophyll**
		Regeneration depends on severe site disturbance	Decreasing resilience on site disturbance for regeneration	Adequate regeneration accumulates naturally
Obligate seed regeneration				Facultative root regeneration
Subtropical RF				
Warm-temperate RF				
Lophostemon confertus – E. saligna – E. microcorys				
		E. acmenoides -- E. microcorys -- E. siderophloia		
		E. pilularis		
			E. andrewsii	
			C. citriodora – E. siderophloia	
			C. citriodora – E. crebra – C. tessellaris	

The fire regime

The response of vegetation to burning will depend not only on the presence or absence of fire but on the fire regime—the season of burning, fire intensity, and fire frequency. A report on fire research (Hughes 1986) discussed the effects of different fire regimes in three sites in SEQ: two of these were in Scientific Area (SA) No. 1 in Beerwah, and one at Mt Bilewilam, Cooloola. The experiment examined the effect of three fire regimes on vegetation composition and structure: no burning; low intensity fire every three years in autumn/winter; and moderate intensity fire every five years in winter/spring.

Of major interest in this research was the effect that fire frequency was shown to have on the regeneration of species. This is particularly important for species that have limited means of propagation. For example, species which are obligate seed regenerators (i.e. only seed regeneration) as distinct from species that are obligate root re-sprouters (i.e. can regenerate by vegetative means only) and others that regenerate by both means (facultative root re-sprouters).

The survival of obligate seed regenerators under a fire regime will be closely linked to fire frequency. If the time between fires is less than the period needed for individuals to reach sexual maturity and produce a viable seed store, repeated fire may completely eradicate the species. Species of obligate root re-sprouters can also be adversely affected where frequent fires over a long period exhaust the regenerative store in their lignotubers. The same can occur with species of facultative root re-sprouters, particularly where fire cycles are less than the period required to reach sexual maturity. These species would also be eliminated, leaving no seedling regeneration to replace them.

There are many factors other than fire frequency that also influence regeneration strategies, for example seed stores in soil, season of burning, and seed predation. Current evidence, however, suggests that a two-year burning cycle combined with a high burn coverage will adversely affect a number of species. Such a regime will also be of advantage to some species, particularly aggressive annuals and perennials.

2.3.5 Forest disturbances in combination: Disturbance Forest Types

Forest ecosystems are subjected to a complex interplay of multiple disturbances. Grazing and prescribed burns, prescribed burning after logging, logging and grazing and wildfire and any of the above can all occur in eucalypt-dominated forests of Australia simultaneously – and frequently do. The ecological implications of this for forest condition, 'disturbance significance', old growth status, wilderness, and wood production as well as several other related values, depend on the compounding or negating effects of disturbances in combination. There has been very little research that has addressed the issues and implications of multiple disturbances to individual forest ecosystems in Australia. Such research as has been carried out, particularly with regard to logging, grazing and fire, is reviewed above.

In order to facilitate this process of data analysis eucalypt-dominated forests in SEQ have been categorised into nine broad forest types or 'Disturbance Forest Types' (DFTs) which relate directly to the ability of species within those forests to persist through and respond to different disturbances. These are outlined below. This classification is based on the review of literature and research conducted in eucalypt-dominated ecosystems Australia-wide and which is summarised above. For the purpose of analysis, however, based on expert opinion these Disturbance Forest Types have been split into subclasses more appropriate to each disturbance type.

Disturbance Forest Type 1a

Wet sclerophyll forest containing species of high value / high quality timber, actively managed for sawlog timber (e.g. *E. grandis*, *E. microcorys*, *E. saligna*, *E. cloeziana*, *E. campanulata*, *E. dunnii*, *Syncarpia glomulifera*) but not dominated by *E. pilularis* or *Corymbia citriodora*. Forest dominated by species of seed-resprouters with only little advanced and lignotuberous growth present in the understorey when in an undisturbed state. Forest types as tall closed forest with a well-developed understorey in which rainforest components may be well represented and exceed 6 m in height. Grasses are absent or sparse in ground cover. Ferns and palms dominate the understorey and therefore this forest type is generally subject to a low grazing intensity. Site quality is high. Understorey species dominated by sclerophyll shrubs. Fire-sensitive species which develop into fast-growing even-aged stands of single species. Where the dominant species are *E. pilularis* or *C. citriodora* these forest types will be assessed separately (see Forest Types 2, 3a and 3b below).

Disturbance Forest Type 1b

Wet sclerophyll forest containing *E. grandis* ± *Lophostemon confertus* and *Syncarpia glomulifera* on lowland alluvials actively managed for sawlog timber. A well-developed understorey dominated by rainforest species and/or sclerophyllous shrubs. Subject to low grazing intensity.

Disturbance Forest Type 2

Wet to mixed forest dominated by *E. pilularis* but will include other species such as *E. microcorys*, *E. acmenoides, C. citriodora* and *Syncarpia* spp. as subdominants. Forest type is tall to medium with open to closed canopies of mixed species. An inability to reproduce from lignotuberous growth is a feature of this forest type, although regeneration from coppice in early years after fire is possible. "Large wave" seedling regeneration following major canopy disturbance with a suitable seedbed present is the dominant form of regeneration. Advance growth is rarely present in undisturbed forests and only marginally more likely to occur in disturbed forest. Grasses may be well to poorly represented in the understorey. Characteristic pasture species are *Themeda triandra* and *Imperata cylindrica*; however, intensive use is not possible in the absence of extensive development. Thus these forest types would be subject to low to moderate grazing intensity particularly where site quality is low and canopies are more open.

Disturbance Forest Type 3a

Mixed forest on higher quality sites dominated by *Corymbia citriodora* but including other species ranging from *E. pilularis* to *E. acmenoides. Eucalyptus siderophloia* has the ability to produce seed or regenerate from advanced growth after disturbance but regrowth is normally from lignotubers and this ability increases with increased openness of the canopy and decreased site quality. Thus subdominant species in these higher site quality areas are usually non-lignotuberous species. Shrubs and ferns generally occur in the understorey of these areas of higher site quality. Where present, pasture species are dominated by *T. triandra* and *I. cylindrica* in areas of higher site quality, however, as with blackbutt forests, intensive use is not possible in the absence of extensive development. Spotted gum forest under these conditions is subject to low to moderate grazing.

Disturbance Forest Type 3b

Dry forest on lower quality sites dominated by *Corymbia citriodora* but including other species ranging from bloodwoods (*C. clarksoniana, C. intermedia*) and ironbarks *E. crebra, E. fibrosa, E. exserta* and *Angophora* spp. (*A. leiocarpa* and *A. floribunda*). Subdominant species of this forest type are generally lignotuberous species. Grass can be well represented in the understorey. In drier, lower site quality areas where the canopy is more open, the dominant pasture species include *Heteropogon contortus* (black spear grass), *Bothriochloa bladhii* and *T. triandra*. These forest types are subject to moderate to high grazing intensity.

Disturbance Forest Type 4a

Mixed forest containing species of moderate value (*E. propinqua*, *E. acmenoides, E. siderophloia*, *C. citriodora*, *E. campanulata*, *E. tereticornis*, *E. crebra*, *C. intermedia, E. moluccana* [mixed on ridges with *E. longirostrata*], *E. carnea*) with a high proportion of defective (suppressed) trees present. Open to closed forest varying in means of persistence and regeneration depending on dominant species in canopy, with some advanced growth. Much of this forest type contains some advanced growth but it is often inadequate to restock the forest or is weighted towards one species in a mixed forest. Lignotuberous species will tend to displace non-lignotuberous species where disturbances to the canopy and forest floor are insufficient to give the latter species a comprehensive advantage. Monocalyptus and bloodwoods occupy the more infertile forest soils and may be progressively or abruptly replaced by Symphyomyrthus species and/or *C. citriodora* on more fertile soils, with forest types progressing towards Forest Type 1. The understorey composition is varied depending on site quality, ranging from ferns in sites of higher quality to sclerophyllous shrubs and grasses in drier areas. Where the understorey is dominated by *H. contortus* and *T. triandra* these forest types are extensively grazed and modified for grazing activities. However, a combination of partial clearing, fire and grazing has tended to displace *T. triandra* and other species in favour of *H. contortus* which is more fire-resistant and has more efficient seedling regeneration than *T. triandra*. Deliberate firing (for green pick etc.) has hastened the process of change (Humphreys 1987). Grazing intensity varies accordingly.

Disturbance Forest Type 4b

Mixed forest dominated by *E. tereticornis* on lowland river flats. Other species include *Corymbia intermedia, C. tessellaris, C. clarksoniana* and *Angophora subvelutina.* Generally intensively managed for grazing with a notably absent shrub understorey dominated by grasses. *Heteropogon contortus* is the most characteristic grass species, although *B. bladhii* and *T. triandra* can sometimes dominate.

Disturbance Forest Type 5a

Low to unproductive coastal forest dominated by *E. racemosa* or woodland (*E. bancroftii*). Other species include *E. umbra, E. tindaliae, C. gummifera,* ± *Angophora leiocarpa.* The grass flora of these lowland areas is low in diversity. *Themeda triandra* is the most common grass, although *I. cylindrica* often becomes dominant when some clearing has taken place (Tothill and Hacker 1973). Intensive use for grazing is not possible in the absence of expensive land development (Weston 1988).

Disturbance Forest Type 5b

Low to unproductive forest or woodland of species with low commercial value (*E. crebra, E. melanophloia, E. populnea, C. intermedia, E. planchoniana, E. decorticans, E. dura, Angophora floribunda, A. leiocarpa, E. tereticornis* ± *Melaleuca* spp.), infrequently harvested for sawlogs. Medium-to-low open forest types in which grasses are well represented in the ground cover and woody understorey (sclerophyll species) are sparse, and are thus subject to high grazing intensity. Open forest types are dominated by species favouring lignotuberous and advanced growth regeneration in which there may be a prolonged lignotuberous phase where site quality is low. This represents a slower process of regeneration coming primarily from advanced growth. Continuous establishment of seedlings may occur in the course of time, related to periodic occurrences of suitable seedbeds (from disturbance) and a reduction in grazing pressure. Thus some seedling regeneration may occur. Frequently burnt, the open forest types verge on woodland. Where the understorey is dominated by *H. contortus* and *T. triandra* these forest types are extensively grazed and modified for grazing activities. Again, a combination of partial clearing, fire and grazing has tended to displace *T. triandra* and other species in favour of *H. contortus* which is more fire-resistant and has more efficient seedling regeneration than *T. triandra*. In forest areas with *Melaleuca* spp. or *E. populnea,* other pasture grasses such as *Aristida* spp. start to occur and grazing intensity can be moderate to high.

Disturbance Forest Type 6

Rainforest: protected from timber harvesting, and fire-sensitive. Closed forest and littoral rainforest are areas in which pastures are generally sparse or absent. Where they are found they are generally low in productive value. Therefore, for the purpose of this analysis, they are considered to be subject to no grazing pressure. For the purpose of the south-east Queensland old growth forest mapping project, rainforest is not mapped in terms of ecological maturity and will thus be considered as one type. However, for the purpose of additional analysis, rainforest can be divided into 4 broad groups:

6a. upland cool complex notophyll vine forest / mesophyll vine forest
6b. lowland and mid complex notopyll vine forest and notophyll vine forests on the sand islands and in gully situations
6c. araucarian notophyll/microphyll vine forest
6d. semi-evergreen vine forest.

Disturbance Forest Type 7

Notophyll vine forest with eucalypt emergents: closed forest protected from timber harvesting (although it may have had some eucalypts taken in the past), with fire-sensitive eucalypt species and subject to low grazing intensity due to minimal grass cover in the understorey. Not classified as eucalypt forest.

Disturbance Forest Type 8a

Melaleuca forest of lowland coastal areas.

Disturbance Forest Type 8b

Other non-eucalypt forests including brush box (*Lophostemon confertus*), *Callitris* spp., *Casuarina* spp., or brigalow (*Acacia harpophylla*).

Disturbance Forest type 9

Non-eucalypt, non-forest vegetation (heathland, *Banksia* forest, mangrove, low coastal complex < 5 m in height).

Disturbance Forest Type 10

Non-vegetated (sand blows, waterbodies, etc.).

2.4 FIELD RESEARCH AND VALIDATION: ASSESSMENT OF FOREST STANDS

2.4.1 Introduction

Initial field work, as presented in the interim report, investigated those forest attributes considered most useful in the delineation of old growth forest.

In summary:

- The collection of diameter at breast height (dbh) and individual growth stage information was useful in determining a set of decision rules for the delineation of old growth stands in the wetter, higher site quality forests, as a statistically significant difference was found between logged and unlogged forest in SMR growth-stage proportions. A similar trend was evident in moist forests, although it was not statistically significant, possibly due to the limited sample size. Acknowledgement of the need to investigate this relationship in dry forests was made necessary, as no relationship between logging history and stand structure was evident in the few dry forest sites available for sampling on the Nambour map sheet.
- A visual estimate of the relative proportions of SMR was found to be comparable with measured estimates, and was therefore applied to subsequent field work.
- A quantitative method for estimating the intensity of logging was not found due to the degree of spatial variability found within polygons, and due to the nature of the proposed field work which would not allow time for detailed measurements and access to the whole polygon. It was therefore proposed that future studies would be limited to a field evaluation of logging history as either light, medium or heavy.
- Variability in the volume of woody debris was also found to be high. No trend was evident suggesting a link between logging history and the amount of woody debris, and assessment of this attribute was therefore excluded from further sampling.
- Detailed assessment of floristic composition and faunal habitat were recognised as important components in the assessment of old growth, although they were considered beyond the scope of the project due to time constraints. It was proposed that future floristic assessment would be restricted to the species composition of the overstorey trees.

2.4.2 Operational assessment

Following this initial work it was envisaged that validation of the API-derived polygons would be an important component in the production of the final forest condition maps. Based on observation of the attributes above, a methodology was developed that could be applied over a broad biogeographic area.

Draft field maps were produced based on a set of decision rules derived from the overlay and analysis of several data sets including API polygon coverages, tenure boundaries, logging history, and other disturbance information where available. The results of this validation were used as a means of improving the mapping process and to generate statistics on the reliability of the API as presented in Section 2.2.6.

Accuracy of the field estimates

Appendix 1.1 contains a copy of the field proforma used to assess the API polygons. Data collection involved assessment of the dominant species, assessment of the API coding, a visual assessment of logging intensity, grazing effects, fire effects, silvicultural/grazing treatment and other disturbance impacts. A decision on the likelihood of the polygon possessing old growth values was included based on the previous assessments. Appendix 1.1 also contains a description of the categories used to describe the disturbance impacts.

For analysis purposes, each polygon validated was assigned an accuracy code based on the ecologists' ability to access the polygon. Table 2.4.1 describes the accuracy assessment process.

Table 2.4.1 Accuracy of information in field validated API polygons

Accuracy index	Characteristics
1(high)	Where the polygon is readily accessible and has been assessed from a number of points within the polygon
2	Where the polygon is large and access is restricted to assessment at only one or two points within the polygon
3(low)	Where the polygon is viewed from a distance, i.e. through binoculars

2.4.3 Field surveys in dry sclerophyll forest

Initial fieldwork, as described in the interim report (DNR 1996), aimed at establishing a set of decision rules for delineation of old growth across a range of forest types. An absence of suitable dry sclerophyll forest in the study area resulted in a need to conduct further research aimed at establishing a set of decision rules for this group of forest types.

Field studies were concentrated in Detailed Yield Plots (DYPs) and Native Forest Permanent Plots (NFPPs) established by QDPI-Forestry (QDPI Forest Service 1995). The growth stage of each tree within the plot was recorded. The size class distribution and growth stage proportions (SMR) were calculated and compared with species/productivity classes and logging history.

SMR proportions of total basal area per hectare were calculated. The results suggest that there is no significant difference between logged and unlogged sites within the higher productivity dry forest sites. Insufficient data were collected in medium productivity sites and low productivity sites for analysis.

Using the results, stand tables were constructed for vegetation and productivity classes with dbh size class intervals of 10 cm over the range 10–100 cm. The results suggest that there is no distinction in stand structure between logged and unlogged stands on medium or high productivity dry forest sites.
In addition, further research aimed at investigating a relationship between crown area and diameter at breast height (dbh) was carried out. The study was based on the understanding that measurement of crown area of each tree in a plot or prism sweep is impractical. Dbh could be used as a surrogate for crown area if a relationship between the two was proved. This hypothesis was first tested in wet and moist forests by comparing crown diameter

(measured in at least two directions) with dbh in individuals of varying maturity class. A linear relationship was found in *Eucalyptus pilularis* and *E. siderophloia*. Crown area relationships were similarly studied in some dry forest species.

Crown and stem diameter was compared in bloodwoods (*C. intermedia*, *C. trachyphloia*), ironbarks (*E.siderophloia*, *E. crebra*, *E. fibrosa* subsp. *fibrosa*), *E. acmenoides*, *C. citriodora* and *Angophora leiocarpa.* There is a wide range in both crown diameter and growth stage for any particular stem size. The lack of relationship between growth stage and crown diameter is particularly evident in the ironbark species with mature to overmature individuals evident at stem sizes of 40 cm.

Analysis indicates that the relationships found for stand structure, growth stage proportions and stem/crown diameter in wet and moist forests are not evident in the dry forest. The lack of relationship, or inconsistency in the case of species/crown ratio data, requires further investigation. Insufficient data have been collected in the low productivity vegetation class, i.e. in *E. propinqua* and *E. crebra* communities, and no clear conclusions can be drawn from this analysis.

Present indications suggest that growth-staging alone is insufficient to delineate old growth stands in dry forests. It is therefore important to consider the disturbance history of a particular site. NFPP plots could form the basis for future work in validating disturbance data currently held in the Area Information System in the case of logging and silviculture, grazing leases and fire records. NFPPs currently record the years of logging, treatment, storms and fire. The number and volume of logs removed from the plot are also recorded and can be extracted from the database. Field surveys in areas surrounding NFPPs of known disturbance history would determine the intensity and extent of such activities.

As a result of these studies the project concluded that a normal expression of ecological maturity in these forests is often reflected by a lower composition of older or senescing trees than in the wetter higher site quality forests. This feature has been reinforced by field observations where forests appear to have no obvious signs of disturbance yet have a mixed composition of growth stages. Decision rules for these forest types therefore include a broader range of classes that are considered ecologically mature than in the wetter forests. More detailed discussion of this research is provided in Appendix 1.3.

2.4.4 Growth-staging in dry forests

During the course of the team's studies in dry forests it was recognised that growth-stage assessment in these forest types was more difficult than in the wetter, higher site quality forests. Growth-stage assessment, originally developed by Jacobs (1955), was modelled on features primarily recognised in blackbutt (*Eucalyptus pilularis*) and other species found in higher site quality forest. Thus, features associated with the different growth stages are representative of the higher site quality species, and cannot necessarily be applied to the drier-site species.

Dry forest trees are continually subject to strong competition for available water. In order to minimise the effects of periodic water scarcity, eucalypts have evolved certain morphological and physiological processes, expressed through reduced crown leafiness during periods of drought and a large proportion of trees with weak, competition-affected crowns (Florence 1996). Effects on the condition of the crown and the bole of the tree would lead to a decrease in our ability to confidently growth-stage the tree. For example, features such as 'crown extension', as described in RACAC (1996), would be less pronounced in a drier forest. Irregular growth rates could potentially reduce the length of time when the tree would be exhibiting a vigorously growing extending crown, characteristic of a 'pole' or 'early mature' tree. As a result, the condition of the tree may influence the interpretation of growth stage at a later stage.

Another feature in dry forest that is not easily discernible or that is indicative of a particular growth stage is evidence of 'branch death' (RACAC 1996). It is assumed that branch death would be accentuated by fluctuations in leaf area, a factor influenced by moisture availability that varies over time (Florence 1996). Thus in times of low moisture availability when leaf area is reduced there would be a tendency to assess a tree as belonging to a later growth stage due to the degree of branch death.

Further to this argument, 'primary branch size' and loss of 'broken shaping branches' (RACAC 1996) are features which would be less obvious in drier forest species. These attributes, which are commonly used in the assessment of growth stage, are obvious in the higher site quality forests where favourable conditions lead to the development of large primary limbs formed as a means of increasing the structural framework of the crown. Eventually, over time, these limbs become weak and break due to mechanical stress, resulting from the increased weight of branches, shading from other parts of the crown and an inability of the tree to translocate water and nutrients long distances (RACAC 1996). These attributes therefore form a useful basis for discerning the older growth stages in better site quality forest, a feature that is not always apparent in drier forest species.

As a result a separate study aimed at identifying more relevant features is required in these forests to identify useful features for the delineation of growth stage. Alternatively, identification of a separate growth stage class defined as 'indeterminate' could be applied in these forests where growth stage is not apparent. Trees of this type are generally below the average size of the stand, non-vigorous and are often subject to strong environmental or spatial competition from surrounding trees.

2.4.5 Other related research

Additional research was conducted in association with the project and is presented in Appendix 2: *Related research*.

The research includes the following

- a discussion paper on the application of the old growth concept to non-eucalypt communities
- a summary of a consultant's report on forest growth stage class modelling
- a preliminary study comparing three methods of tree age assessment.

2.5 DISTURBANCE MAPPING AND ANALYSIS TECHNICAL ISSUES

2.5.1 Introduction

This section details the technical and procedural aspects of data capture, conversion and management further to the interim report (DNR 1996) for the mapping and analysis of disturbance history information. Although necessary components of the interim report are reiterated to some extent, it must be emphasised that this section has been written assuming some prior knowledge of the project on the part of the reader.

2.5.2 Project methodology

In order to identify and map old growth forest in South-East Queensland, a process is required to identify and delimit disturbances which have significantly impacted upon the structure, floristics and function of individual forest ecosystems in the region (JANIS 1996).

The processes developed and adopted to facilitate the mapping and analysis of disturbance information have been largely iterative, requiring full cooperation from a variety of data custodians (including QDPI-Forestry, Department of Environment and QDNR).

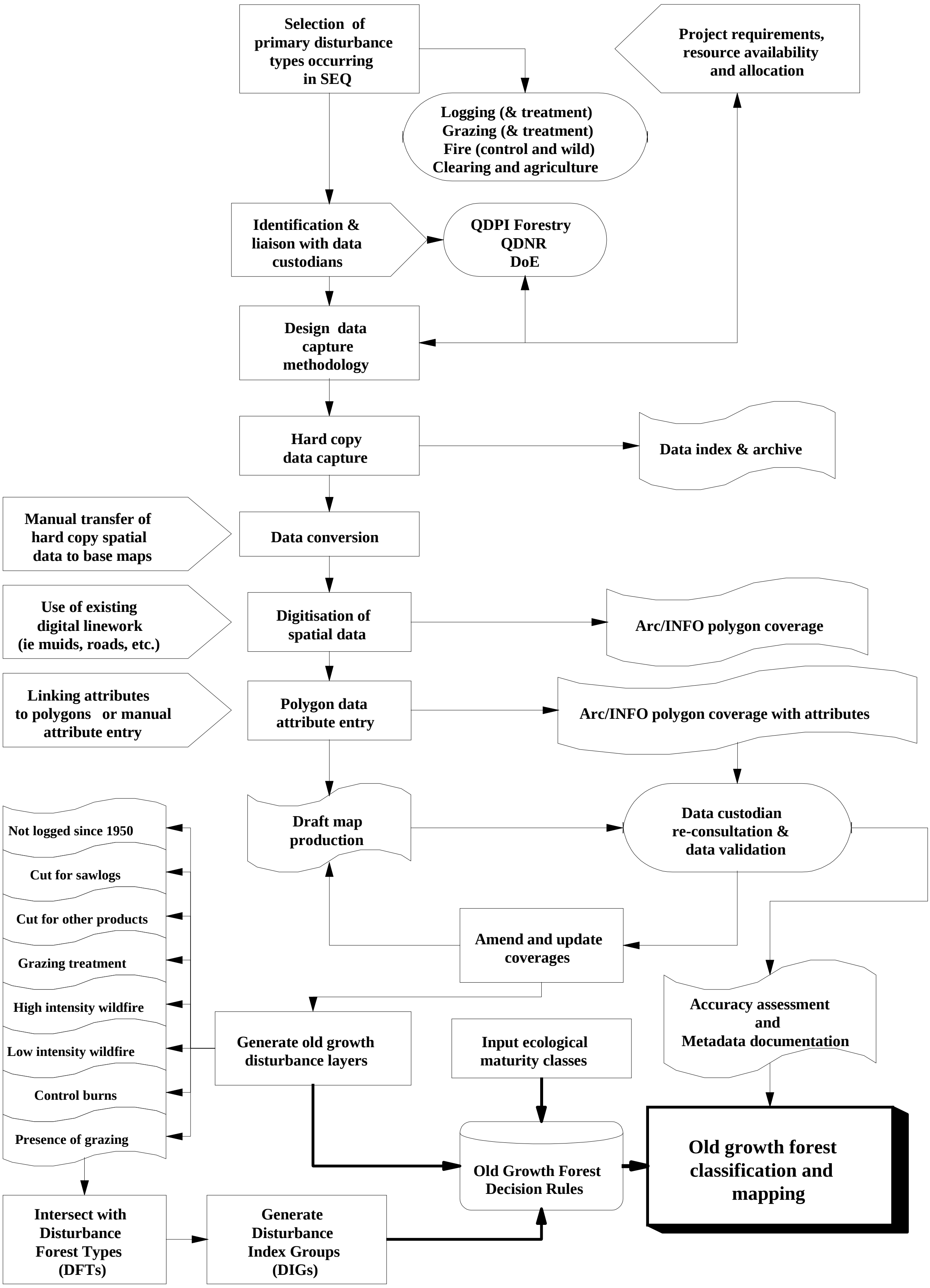
The broad methodological procedures include (as summarised in Map 2):

1. identification of primary disturbance layers
2. data audit; to identify existing data sources and their usefulness for the objectives of the project
3. data collection, conversion and digital capture
4. preliminary map production
5. validation (office- and field-based) and re-consultation
6. amendment and updating of digital coverages
7. generation of old growth disturbance coverages
8. assessment and documentation of data accuracy
9. integration of RE mapping (DFTs) to generate disturbance surface
10. incorporation into old growth decision rules
11. generation of old growth maps and individual disturbance coverages
12. completion of metadata.

The project guidelines identify a number of disturbance types that are considered likely to have significant impacts on the condition of eucalypt-dominated forest ecosystems in South-East Queensland. These include:

- logging and silviculture
- grazing and associated treatments
- fire (controlled burning and wildfire)
- clearing and agriculture.

Each of these disturbance types is addressed in detail in the interim report (DNR 1996), which is available at http://www.dnr.qld.gov.au/fiqweb/forests/assess/report.htm


Selection of primary disturbance types occurring in SEQ
Project requirements, resource availability and allocation
Logging (& treatment)
Grazing (& treatment)
Fire (control and wild)
Clearing and agriculture
Identification & liaison with data custodians
QDPI Forestry
QDNR
DoE
Design data capture methodology
Hard copy data capture
Data index & archive
Manual transfer of hard copy spatial data to base maps
Data conversion
Use of existing digital linework (ie muids, roads, etc.)
Digitisation of spatial data
Arc/INFO polygon coverage
Linking attributes to polygons or manual attribute entry
Polygon data attribute entry
Arc/INFO polygon coverage with attributes
Not logged since 1950
Cut for sawlogs
Cut for other products
Grazing treatment
High intensity wildfire
Low intensity wildfire
Control burns
Presence of grazing
Draft map production
Data custodian re-consultation & data validation
Amend and update coverages
Generate old growth disturbance layers
Input ecological maturity classes
Accuracy assessment and Metadata documentation
Old Growth Forest Decision Rules
Old growth forest classification and mapping
Intersect with Disturbance Forest Types (DFTs)
Generate Disturbance Index Groups (DIGs)

Thematic history

In order to understand the importance of these disturbance types to the condition of eucalypt-dominated native forests in SEQ it is necessary also to understand the patterns and themes of human settlement and exploitation within forests and forested areas. To this end a thematic history of the SEQ bioregion, based on shires and forestry districts, has been written to give an overview of the history of human involvement with forest resources in this area. This history was written by the Cultural Heritage Branch of the Department of Environment (Kowald 1996).

The report includes:

- patterns of first European settlement
- pastoral and agricultural activities and associated legislation
- timber-getting (including sawmilling) activities and associated legislation
- commercial forestry activities
- patterns of road and railway construction
- mining, quarrying and other activities
- forest reservation and associated legislation.

Data audit

An audit of data relating to forest management and disturbance was undertaken to determine the availability and usefulness of existing sources of information and to identify those areas for which data needed to be collected. Through this process it was established that there were few existing data sets which could be used by the old growth forest assessment project in their existing formats, and that most data existed over State forest/timber reserves or in some cases national parks only, with little or no information over freehold land. It was found, however, that consistent information was available for some disturbance types, resulting in the development of a methodology for the collection of this data. This methodology took into account the current format of the original data collected as well as the time and resources needed to convert it into a form compatible with other old growth data sets and into the storage format (DNR 1996).

Criteria used to determine the 'usefulness' of information were whether:

- it was able to be represented spatially with all relevant attributes attached
- it was relatively consistent between districts and over the whole bioregion
- it was able to be assessed for accuracy
- it was able to be collected for the whole bioregion within the set time frame, given existing resources
- the data records were reasonably complete
- it was compatible with existing datasets and other datasets being collected
- it could be assessed as being useful in the identification, delimitation and analysis of disturbance within the context of the definition of old growth forest (DNR 1996).

The application of these criteria to existing data demonstrated that all primary disturbance data would have to be collected and collated from a combination of hard-copy spatial information as well as digital and hard copy attribute information. Digitisation of spatial information was, therefore, identified as an essential component of this process.

The final set of disturbances for which information has been collected were identified as:

- logging and silviculture (State forests, and national parks where recently converted from State forests)
- grazing and treatment (State forests, timber reserves, other Crown land)
- term leases (State forests, timber reserves, other Crown land)
- wildfire (State forest, timber reserves and national parks)
- prescribed burning (State forests, timber reserves and national parks).

Other disturbances for which information has also been collected (where available) are:

- agriculture and clearing (all tenures, based on satellite imagery)
- sawmills, mines and quarries (all tenures)
- railways, roads and rivers (all tenures)
- recreation (State forests)
- various stochastic events (all tenures).

The following sections discuss each of the main disturbance types in relation to the process of data collection, data conversion, accuracy assessment, and potential utility for analysis of disturbance for the mapping of old growth forest attributes of forest in SEQ.

Data collection

The process of data collection required considerable interaction with, and assistance from, district officers from a number of Government agencies. These included the Department of Primary Industries and the Department of Environment, and several district offices of the Department of Natural Resources. This process of consultation assisted in the identification of useful information and attributes for each data set, as well as ensuring the validity and accuracy of the information collected.

Logging and silviculture

Logging and silvicultural activity are considered to be significant disturbance factors for native forest in South-East Queensland. The most common logging activities in native forests are selective logging for milling, and cutting for other products such as poles, girders and round timber.

Information about forest management activities in State forests is held by a number of sources in Queensland. The Area Information System (AIS) operated by QDPI–Forestry is the primary management information system for State forests. The AIS subdivides forests into ‘Management Unit Identifiers’ (MUIDs) and ‘Subunit Identifiers’ (SUIDs), the data for each of these two major groupings being available separately. MUID data relate to the broad administrative information (tenure, parish, State forest, etc.) whereas the SUID information outlines the actual forest attributes for each individual stand. Definitions are as follows:

> A MUID discrete (but not necessarily contiguous) parcels of land delineated by logical operational boundaries and approximating that area of land which would normally be expected to be logged at one time. It is desirable that a single MUID

> be logged over as short a period as possible to avoid problems with future yield scheduling of areas. Logging over a period of five years is acceptable. Any MUID in which sawlog removals are expected beyond five years, should be broken down into a number of smaller MUIDs.
>
> A SUID (Subunit Identifier) is that area wholly contained within a Management Unit consisting of a single forest stand…[which] is uniform with regard to forest type, productivity, accessibility, and management intent. SUIDs form the basic strata for sampling for inventory purposes.

(DPI Field Procedures Manual 1995)

The process of collecting and converting AIS-based information into the 'logging history' database for old growth forest mapping is as follows:

- A filter is applied to the AIS to identify those SUIDs which are most likely to contain areas of forest undisturbed by logging. This filter identifies SUIDs by the year they were last logged (L_log) and by their last logging rule (Last_LR). Also taken into account are the productivity (prod), accessibility (access), management intent (MGT) and forest type (FORTYPE). Through this filtering process, the team identifies those SUIDs which were last logged before 1950 ('pre-1950'), have no record of ever being logged (VI = 'virgin'); have an "unknown" logging history (?); or were last logged for 'girders' (Cg), 'poles' (Cp) or 'round timber' (Cr).

- The information that is generated as a result of this filter is then confirmed through consultation with QDPI–Forestry district officers in an attempt to make sure only the most current information is being collected.

- Sketches of those SUIDs which have been confirmed as being unlogged (V = unlogged) or not logged since 1950 (F = last logged before 1950) are collected from the district offices. The sketches are photocopied and coloured according to a specified key. Particular attention is given to SUID boundaries and labelling, consistency between existing digital MUID boundaries and those on the hard-copy sketches, and the proximity of each MUID to plantation boundaries. This ensures consistency and ease for the digitising process. Once copied, checked and coloured the sketch is ready for digitising. Hard copies are then archived according to forestry district.

- The relevant SUIDs are digitised and coded by the DNR's Spatial Information and Mapping Section as 'V' and 'F' SUIDs, with the unique MUID–SUID identifier, date of capture and an accuracy rating also attached to each polygon.

Issues pertaining to the choice of the 1950 logging cut-off date, as well as the limitations to the homogeneity of SUIDS have been identified and attempts to address these issues detailed below.

The decision to select 1950 as the cut-off year, was made for a variety of reasons:

- There was a change in technology with the advent of chainsaws after the Second World War

- Investigation of the AIS database revealed that very few records existed for areas that had been logged prior to 1950
- Ecological investigations (see interim report) found a significant difference in stand structure between forests logged prior to 1950 and those logged from 1950 to 1970.

During the process of data compilation a number of problems with the AIS were identified. A recorded logging sale over a subject MUID does not delineate the exact spatial extremities of the logging activity. A 'logged' MUID may contain slivers or patches of uneconomically productive forest due to factors such as slope, difficulty of access and forest type. While MUIDs are represented spatially with attribute information within the database (with the QDPI–Forestry as the custodian), SUID-level information is only available in a non-spatially referenced, attribute-based form within the AIS. Spatial representation of SUID boundaries exists in hard copy only, with the relevant forestry district office acting as custodian. As a result SUID-level information has been collected from each district, checked and converted to digital polygon coverage. A number of problems occurred during this process:

- there were time and resource constraints in collection
- information accuracy and currency were at times questionable
- there were digital versus hard-copy MUID boundary discrepancies due to scale of capture.

Grazing and treatment

State forest is commonly leased for grazing purposes under stock grazing permits (SGPs) and special or term leases (SLs or TLs). Although restrictions apply to the use of forest under both forms of lease, some activities that affect forest structure are permitted. These activities, known as 'treatment activities'", take the form of cutting, clearing, poisoning, ringbarking and burning, and are granted under 'permits to destroy' by QDPI–Forestry. SGPs are issued by QDPI–Forestry for the specific purpose of grazing within State forest for a period of seven years. The issuing of term leases, however, is not specific to grazing or grazing-related activities, with land uses such as recreation and infrastructure development also being permitted. These special or term leases can be issued for a period of up to 50 years.

SGPs enforce a stricter measure of control over lessees, with the limited seven-year term of tenure and the number of beasts per hectare being specified. This is based on environmental assessment of the area to be leased undertaken by the Department of Primary Industries.

Details of grazing and treatment history have been collected for each forestry district office from hard-copy maps and files held by each district. The grazing and treatment information collected includes details of:

- the first year a permit was issued
- the last year a permit was issued
- the year of first treatment
- the year of last treatment
- the carrying capacity
- the number of head of cattle grazed per hectare
- the area of the permit.

Problems that have been identified in relation to the collection of grazing and treatment information are as follows:

- Not all records are kept in current files. Only past information that is still in the active file is recorded. Time constraints and the form in which historical data are kept both inhibit the collection of historical data.
- Although written permits are kept on file, spatial records of treatment activities are not kept in all districts. As a result the ‘treatment coverage’ is not complete for all forestry districts.

The retrieval of details of individual SGPs has been made possible with the development of a two-part identification number (e.g. 94/87) that is unique for each separate SGP polygon within the data set. The first pair of numbers records the last year of permit renewal, and the second is a sequential identifier which is unique for SEQ. The development of these unique identifiers is essential for the continuous update and retrieval of SGP-related information and will enable these data to be maintained as a dynamic and up-to-date tool for the project.

Fire

There has been some debate about whether fire and other stochastic events should be included as ‘significant disturbance’ types for this project. The debate revolves around the concept of naturalness as described in Chapter 2.3, ‘Defining broad forest types for disturbance mapping’.

Old growth forest assessment studies carried out in East Gippsland and New South Wales included fire as one of the disturbance types mapped. The East Gippsland study identified fire as having a major influence on forests in the region due to the recurrent nature of wildfires in this environment. Fuel-reduction burning was also identified as having significant effects on certain biological values. Similarly, in New South Wales, fire was also discussed in terms of wildfire and controlled burns. This project however, did not consider fire a disturbance which in itself would necessarily detract significantly from the old growth condition. In Queensland both prescribed burning and wildfires do occur. However, Queensland infrequently experiences extensive high-intensity bushfires, at least in comparison with the southern states.

An important point to note is that in the case of both New South Wales and Victoria, reliable maps and records of fire were available for interpreting and mapping forest structure and composition in order to assess the old growth condition as it relates to fire. In Queensland, such mapping is limited and poorly recorded.

It was initially decided that fire information would not be collected for State forests or for forests on private land. However, reconsideration of the issue resulted in an attempt to collect and collate fire information for two forestry districts and enter it into a spatial format as a trial. This trial was assessed, considered to be successful, and it was decided to collect data on a wider basis.

Wildfire reports are found in QDPI–Forestry files (File No. 619) ‘Fire Outbreak and Investigations’. These provide detailed information about the nature and extent of each fire reported, including the following attributes which are entered into the fire database: forest district, State forest number, area burnt (ha), fire number (allocated by the district), date of fire, wind direction, drought index, fuel weight, fire danger rating, wind strength and direction, temperature, costs involved, forest type and the cause of the fire. The quality of the mapped spatial extents of each recorded fire varied from poor; where rough sketches were made on poorly reproduced paper base maps, to moderately high; where accurate base maps were used and detailed fire boundaries generated. An accuracy rating was devised and employed for each fire and for all disturbance data sets compiled during the project. This rating system is outlined in Table 2.5.1.

The next stage in this process was to reformat the hard-copy spatial data collected from the district offices, in preparation for digital capture. An initial trial approach involved the production of 1:25 000 scale transparent map overlays containing State forest boundaries, an access coverage, drainage layers and any linear features that might be used to define fire boundaries. Wildfire report sketches of compatible scale to the base map were then manually traced to the overlays digitised and labelled with a unique identifier.

This procedure was found to be moderately successful; however, due to problems of identifying appropriate control points on to poorly reproduced or non-scaled maps, it was found to be more efficient and accurate to digitally extract existing line work from the various reference data layer coverages. However, in the few cases where limited reference line work was available, control points were located (with a minimum of four points) and manually digitised.

Accuracy assessment

The issue of accuracy assessment in compiling the disturbance data was addressed using a variety of techniques including field validation, cross-validation with the API coverage, re-consultation with district officers who assessed and detailed required changes where they occurred, and the development of an accuracy ranking system which is summarised in Table 2.5.1. The accuracy ranking has further been detailed in the metadata, which were compiled from the data collection phase, and an accuracy score was allocated to each polygon within the disturbance coverages. To maintain the integrity of the data, the data sets were generated using conversion and digitising techniques that would reduce the likelihood of adding error to the data as well as documenting any limitations to them. When combining data for the purpose of map overlay, analysis and/or modelling, it was considered essential that the data collected are as accurate as possible and that the limitations are known and accounted for prior to any modelling or analysis.

Limitations relating to the validation methods employed during data capture and conversion process were encountered and documented. Issues of resource availability particularly with field checking were the primary constraints to the comprehensive assessment of data accuracy. Devising a methodology for identifying the presence of some disturbances on forests is difficult given the general paucity of information about associated ecological processes. Grazing and grazing treatment activities are the obvious examples: while it is recognised that browsing and treatment are likely to be significant activities in the disturbance of old growth values, and some reasonable information about the status of these activities in State forest is available, the impact of these activities is largely unknown, making measurement difficult. Similarly, the ecological impacts of each disturbance type will vary with forest type.

Cross-validation with district forestry office employees was found to be essential in the validation of the data sets, as local knowledge proved extremely useful when records were lost, incomplete and/or out of date.

In an attempt to address the problem of data accuracy, and as part of the metadata collection process, accuracy and update frequency information for each disturbance data set have been recorded as the data are collected. A combined list of accuracy criteria for the three main disturbance data sets is presented in Table 2.5.1.

Table 2.5.1 Accuracy criteria for disturbance data sets

Class	Logging history	Grazing	Fire
1	High-quality information—high-intensity assessment associated with intensive strip work or harvesting stratification	Field-validated polygons with all attributes present	Field-validated polygons with all attributes present
2	Low-intensity formal assessment—restratification of areas identified as incorrect from post-1970-type maps during pre-harvesting field inspections	1:10 000–1:25 000 scale of capture on topo map and/or 75% of attributes filled. 75%+ of line work from existing sources[2]	1:10 000 and 1:25 000 source maps, with 75% or greater existing linkwork used, and/or 75% or more of attributes filled
3	Field inspection confirming accuracy of post-1970 type map details or API work with follow-up ground truthing	1:25 000–1:50 000 scale of capture and/or 50% of attributes complete. 50–75% of line work from existing sources	1:25 000 and 1:50 000 source maps, with 50–75% existing line work used, and/or 50% of attributes filled
4	General field inspection of pre-1970-type map information	1:100 000 scale or less and/or less than 50% of attributes complete. 50% or less of line work from existing sources	Original source maps at 1:50 000 scale and/or transferred to overlay with less than 50% of attributes filled
5	Guess without field inspection	Hand-drawn maps at various scales with no attributes	Hand-drawn maps at various scales with no attributes. Polygons taken from block maps with 1:50 000–1:100 000 scale

2.5.3 Data set extent

The final extent of data captured during the project has been spatially represented in the following extent maps, detailing the spatial occurrence of the fire, logging, grazing, and grazing treatment coverages as well as the API and field-validated coverages. These data sets represent a ‘snapshot’ of disturbance over SEQ in 1996–97 that will become outdated as new leases are issued or expire, new fires occur, logging continues and grazing treatment activities take place. The issue of currency about these coverages is being addressed, and a program of data update is anticipated. All forestry districts were covered during the project, and all available relevant data from the district offices were retrieved, assessed and incorporated in the project database; this represents the first complete inventory of forest-related disturbance over SEQ to be compiled.

2.6 DECISION RULES FOR THE GENERATION OF ECOLOGICAL MATURITY MAPS

2.6.1 Introduction

A list of Disturbance Forest Types as per Section 2.3 “Defining broad forest types for disturbance mapping” was used as a basis for the derivation of the decision rules. Groups were based on species composition, commercial timber values, means of reproduction and grazing potential. Disturbance rankings were defined for the first nine of these forest types (grouped into five, based on their response to disturbance) which are eucalypt-dominated.

2.6.2 Disturbance ranking for use in decision rules

Disturbances were ranked in order of their impact on the forest for one forest type, two forest types and the nine Disturbance Forest Types (DFTs). The order of ranking was based on matrices of forest response to disturbance, based on the literature review detailed in Section 2.3 and expert knowledge. The matrices included the effects of a range of disturbances on different structural, functional and compositional attributes of the forest. Table 2.6.1 is an example of one of these matrices.

Rankings derived from the matrices were re-assessed by taking into account the frequency and the likelihood of the different disturbance types occurring within the range of forest types. Table 2.6.2 shows the results of this assessment process.

For the purposes of mapping it was decided that the division of the forest estate into nine eucalypt-dominated forest types (with amalgamation of these groups into five for the purposes of the decision rules) was the most ecologically appropriate. Consideration of the effect of disturbances on different forest types conforms with the national operational definition of ‘Old growth’ which acknowledges that the effect of disturbances will differ between ecosystems (JANIS 1996).

For the purposes of this analysis the vegetation coverage used in the decision-rule process was provided by the Queensland Herbarium’s vegetation mapping and survey study. The Herbarium’s vegetation coverage was modified to produce the 10 DFTs recognised in the decision rules of the mapping process. This process was complicated by the heterogeneous nature of the vegetation polygons which makes it difficult to apply decision rules for a particular DFT when RET types within one polygon can belong to differing DFTs.

Labelling of the heterogeneous polygons into one DFT is based on the vegetation type that is dominant in proportion (> 50 per cent of the area of the polygon). Polygons that contain < 50 per cent of one type were placed into a separate group (DFT 11). These polygons were treated separately in the decision rules by applying the disturbance ranking rules for the one generic forest type.

2.6.3 Calculation of disturbance index groups

The disturbances within the ranking table (Table 2.6.2) were then converted to a numeric value based on their position in the table. A formula was then developed that calculated an overall value or 'disturbance index' for each 25 m grid cell. The index was derived by intersecting through each of the disturbance coverages and totalling the numeric values. The resultant disturbance index figures for each grid cell were then grouped into five groups – Disturbance Index Groups or DIGs – ranging from no recorded disturbance information to considerable disturbance. These groups were then used to generate a coverage for the bioregion, and were applied to areas where API coverage existed and where it did not.

Table 2.6.1 Example of forest-type matrix used in the derivation of the disturbance ranking table

Disturbance	Un-disturbed	Browsing	Grazing treatment[1]	Logging (sawlogs) (immediate)	Logging (sawlogs) (5–10 years)	Logging (other) (immediate)	Logging (other) (5–10years)	Silvi - treatment	Wildfire (immediate)	Wildfire (1 year)	Wildfire (10 years)	Prescribed burns 1 burn (immediate)	Prescribed burns 1 burn (1 year)	Prescribed burns 3 burns (15 years)
Forest attribute														
Structural:														
Senescing trees	0	0	–1	–3	0	–2	0	–2	–2	0	–1	0	0	0
Mature trees	0	0	–1	–2	1	–2	1	–1	–1	0	1	0	0	0
Juvenile trees	0	0	0	0	2	0	2	0	–3	–2	2	0	0	0
Seedlings	0	–1	1	0	1	0	1	2	–3	3	1	–1	1	1
Advanced growth	0	0	1	0	1	0	1	1	–3	1	1	0	1	1
Lignotubers	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Compositional[2]:														
Canopy	0	0	–1	–3	0	–1	0	–2	0	0	0	0	0	0
Understorey	0	–1	–1	1	0	1	1	1	–3	0	1	–2	–1	–2
Grasses	0	+1	–1	1	–1	1	–1	1	–3	0	0	–3	1	2
Functional[3]:														
Seed production	0	0	–2	–2	1	–2	1	–1	3	0	1	1	0	0
Seed bed	0	–1	–1	3	0	1	0	1	3	1	1	1	0	0
Lignotubers	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Total	**0**	**–2**	**–6**	**–5**	**5**	**–4**	**6**	**0**	**–11**	**5**	**8**	**–3**	**3**	**3**

Where the scale of impact significance is from –3 reduced significantly, to 0 = no impact, and +3 = increased significantly

[1] Including cutting, clearing, poisoning, ringbarking – any activity with a direct impact on the trees. Burning for green pick is included within the 'prescribed burns' class.

[2] Changes in species mix

[3] Ability to regenerate by that means

Table 2.6.2 Disturbance ranking for use in decision rules

	Wet sclerophyll	Dry sclerophyll	DFT 1a and 1b	DFT 2	DFT 3a and 3b	DFT 4a and 4b	DFT 5a and 5b	One generic forest type (DFT 11)
Most impact	Wildfire high	Wildfire high	Wildfire high	Wildfire high	Wildfire high	Wildfire high	Wildfire high	Wildfire high
	Sawlogs (SUID_type = l)	Sawlogs (SUID_type = l)	Sawlogs (SUID_type = l)	Sawlogs (SUID_type = l)	Sawlogs (SUID_type = l)	Sawlogs (SUID_type = l)	Prescribed burns	Sawlogs (SUID_type = l)
	Other products (SUID_type = c)	Other products (SUID_type = c)	Pre-1950 logging (SUID_type = f)	Prescribed burns	Other products (SUID_type = c)	Other products (SUID_type = c)	Other products (SUID_type = c)	Other products (SUID_type = c)
Moderate impact	Pre-1950 logging (SUID_type = f)	Grazing treatment	Other products (SUID_type = c)	Pre-1950 logging (SUID_type = f)	Prescribed burns	Pre-1950 logging (SUID_type = f)	Grazing treatment	Pre-1950 logging (SUID_type = f)
	Prescribed burns	Prescribed burns	Grazing treatment	Other products (SUID_type = c)	Grazing treatment	Grazing treatment	Sawlogs (SUID_type = l)	Grazing treatment
	Wildfire low	Pre-1950 logging (SUID_type = f)	Prescribed burns	Grazing treatment	Pre-1950 logging (SUID_type = f)	Prescribed burns	Pre-1950 logging (SUID_type = f)	Wildfire low
	Grazing treatment	Wildfire low	Wildfire low	Wildfire low	Browsing	Wildfire low	Wildfire low	Prescribed burns
Least impact	Browsing	Browsing	Browsing	Browsing	Wildfire low	Browsing	Browsing	Browsing

2.6.4 Ecological maturity coverage

For areas where API was performed, decision rules were generated based on homogeneous areas of forest structure. Four classes of ecological maturity (Ecological Maturity Classes – EMCs) were developed, ranging from most ecologically mature to significantly disturbed. Separate rules were developed for the wetter, higher site quality forests as opposed to the drier, lower site quality forests, where different growth-stage proportions can occur in forests that otherwise appear to be undisturbed. In these forests lower proportions of senescing stems were accepted within the defined ecologically mature class than in the higher site quality forests.

Production of a final coverage of 'old growth' mapping for the majority of the SEQ bioregion, involved the development of a set of decision rules that amalgamated the coverages of EMCs from API with the Disturbance Index Groups (DIGs) from the disturbance data sets.

Refinement of the coverage was carried out using the database of field sites (approximately 4 000 over SEQ) with the aim of reducing classes of contention where the API contradicted the disturbance information, and to confirm areas of 'ecological maturity'.

2.6.5 Mapping of Fraser Island

A separate system of mapping was devised for the mapping of old growth forest on Fraser Island. Several data sets obtained from work conducted as part of the Fitzgerald Inquiry (1989) were used in a decision-rule process aimed at delineating areas of likely old growth and areas that are more likely to be disturbed. Aerial photograph interpretation of the blackbutt (*Eucalyptus pilularis*) forest types, as defined by Stanton (1979), was carried out; this produced broad structural groups ranging from younger regenerating types to older mature forest. Delineation of areas was based on extensive field work and local district national park and forestry staff consultation. Based on this classification, polygons were assigned old growth classes of either 'Likely yes' or 'Likely no' depending on the structural attributes present, and the presence of certain disturbances such as mining and logging. As validation of the data sets did not occur by the project team and as a result of the assumption-based decision rule process, lower levels of accuracy are associated with this mapping coverage.

3 OLD GROWTH FOREST IN SOUTH-EAST QUEENSLAND

3.1 OLD GROWTH MAPS OF SOUTH-EAST QUEENSLAND

Included in this section is an example from Cooloola National Park of the final mapping product produced by the project, including old growth classes. An old growth forest map for the whole SEQ bioregion is available upon request from FERA, 80 Meiers Road, Indooroopilly QLD 4068).

3.2 APPLICATION OF THE MAPPING

3.2.1 Project deliverables

Output layer specification

The output layers provided by the South-East Queensland Old Growth Project for the purposes of the South-East Queensland Comprehensive Regional Assessment are characterised as follows. The GIS layer outputs available are classified into two groups based on the process of derivation used.

Base layers	Modelled layers
Aerial Photograph Interpretation	Logging accessibility layer
Logging history	
Grazing history	
Treatment history	
Fire history (Prescribed burns and wildfire)	
Woody/non-woody mask (NFI)	
Grouped vegetation mapping (DoE)	

Data capture

Specific details on the source of all data layers are contained within the coverages metadata.

Aerial photograph interpretation

API of forest structural characteristics was performed using 1:25 000 aerial photography dating from between 1987 and 1996. Line work was then digitised and orthorectified using a 50m SEQ DTM (Digital Terrain Model) via the DMS (Digital Mapping Software) aerial photo digitising software. Data were then integrated into ARC/INFO where spatial attributes and topology were built.

Disturbance data (logging history, fire history, grazing history and treatment history)

Collation of disturbance records was first done by gathering paper-based records of disturbance information from QDPI–Forestry regional offices, and where available from DoE National Parks and Wildlife district offices. The data were then converted to electronic form by vector digitising of line work with subsequent importation into ARC/INFO and assignment of attributes and building of topology.

Woody/non-woody vegetation mask

This grid-based data set is available as a product from the National Forest Inventory and is based on Landsat ™ satellite imagery from around 1991. The woody/non-woody vegetation threshold is defined as being vegetation with a canopy density of 20 per cent of surface area or more.

Grouped vegetation mapping

This data set was compiled and supplied by the DoE's Queensland Herbarium. The data set contains information on vegetation communities within SEQ mapped at a scale of 1:100 000.

Logging accessibility layer

This layer is a very basic index of accessibility in order to try and gain some insight into topographic barriers to logging operations. The index uses existing roads and ridge lines as access points and is weighted by slope and distance away from roads and ridges. The index was applied to less than 1 per cent of those areas where no information was available.

Data structure

In order to expedite processing and to simplify the process of classification a raster data structure was employed for the calculation of the final old growth layer. Although the base data sets initially were captured into a vector format, the raster environment was deemed the most appropriate data model for the generation of output overlays. The decision was based on the following considerations:

- Multiple layer queries were more efficiently produced (computationally) in a raster environment.
- Sliver polygons on shared boundaries below the realistic accuracy of the data cease to become a significant problem in the raster environment (if the appropriate grid cell size is used).
- A 25 m grid cell size was specified (1/16th of a hectare) as it depicted an appropriate level of spatial detail inherent in the most detailed and accurate input coverage (the API coverage).

Old growth layer specification — c*lassification*

Classification of forested areas into 'old growth' categories was applied to five distinct data types using three methods:

Calculation of ecological maturity classes using the decision rules documented in Section 2.6 was carried out for the category areas ‘API and Disturbance’ and ‘API only’ (See below). Calculation of perceived disturbance impact was applied in those areas for which disturbance information was available. In areas which had both API and disturbance data, both data sets were combined using a set of decision rules to produce a single output layer (see Section 2.6 for details). In those forested areas where no realistically obtainable information of any type existed, an accessibility index was applied to less than 1 per cent of those areas to identify areas that might provide significant topographic barriers to logging.

The classification scheme employed for the old growth output layer–file name: OG_CONF-G

Code	Classification	Confidence level
1	Yes old growth	1 or 2 or 3 or 4 or 5
2	Likely yes old growth	1 or 2 or 3 or 4 or 5
3	Likely no old growth	1 or 2 or 3 or 4 or 5
4	Not old growth	1 or 2 or 3 or 4 or 5
12	Plantation	0
13	Wattle	0
14	Casuarina	0
15	Melaleuca	0
16	Heath	0
17	Coastal complex/riverine	0
18	Topographic shadow	0
19	Cloud/smoke	0
20	Rainforest	0
30	Unclassified national park	0
31	Unclassified State forest	0
90	Unclassified forest	0

Derived category detailed description

The ‘confidence level’ describes the category area that any particular class of old growth has been derived from, and provides an indication of the level of accuracy or reliability of the data. The confidence listing is as follows:

Confidence label	Derived category areas
1	‘Field-validated API polygons only’ (> 95%)
2	‘API areas only’ (86%)
3	‘API and disturbance’ (variable–dependent on disturbance)
4	‘Disturbance only’ (variable—dependent on disturbance)
5	‘Fraser Island API polygons’ (unknown)
6	‘No data’ (unknown)

‘Field-validated API polygons only’

This mask area is defined as being those API-defined polygons that were visited and validated by a field team. These areas carry the highest level of confidence of all sites i.e. a confidence rating of 1.

The process for classification of this category is to firstly characterise the ecological maturity of each polygon, based on the ecological maturity decision rules as described in Section 2.6, into a single ecological maturity layer of four classes, then to use a classification field to break the polygons up into the output classes of ‘yes’, ‘likely yes’, ‘likely no’ and ‘no’.

Class	Classification
Yes	Ecological Maturity Class 1 + old growth field assessment
Likely yes	Ecological Maturity Class 2 + old growth field assessment
Likely no	Ecological Maturity Class 3 + old growth field assessment
No	Ecological Maturity Class 4 + old growth field assessment

‘API areas only’

This mask is defined as being those areas where API information on its own with no other data being available. These areas are classified as having the second-highest confidence rating after the field-validated API polygons, i.e. a confidence rating of 2.

This category depicts aerial photo grid cells categorised into ecological maturity classes 1–4. This level of information carries the second highest level of attribute confidence (> 80 per cent) (see Section 2.2) and is the most detailed remotely sensed forest structural information compiled by this section to date.

The process for classification of this category is to firstly characterise the ecological maturity of each polygon based on the ecological maturity decision rules as described in Section 2.6 into a single ecological maturity layer of four classes, then use a classification field to break the polygons up into the output classes of ‘yes’, ‘likely yes’, ‘likely no’ and ‘no’.

Class	Classification
Yes	Ecological Maturity Class 1
Likely yes	Ecological Maturity Class 2
Likely no	Ecological Maturity Class 3
No	Ecological Maturity Class 4

Disturbance only

This mask area is defined as being those areas where the only source of information is one or more records of disturbance. The accuracy of this information has not been formally quantified but is recognised to be highly variable, depending on the QDPI–Forestry district which recorded the information.

This category depicts a ‘score’ for each grid cell based on its vegetation type and on the disturbance data available for the cell. The score gives some indication of the collective impact that a single disturbance or a number of disturbances could potentially have in a particular forest type.

It should be noted that the disturbance information collected for the project is not complete – it simply reflects the availability of disturbance records. Disturbance data are only available for Crown and leasehold tenures and the absolute spatial and attribute accuracy is unknown. Compilation of the accuracy of the disturbance index group data sets is discussed in Section 2.5.

Class	Classification
Yes	Nil
Likely yes	Disturbance Index Group 1
Likely no	Disturbance Index Group 2, 3, 4, 5
No	Nil

API and Disturbance Only

This mask area is defined as being those areas where a combination of both API data and disturbance data exists. These areas are given a confidence rating of 3, behind 'API areas only' and 'disturbance only' due to the variability inherent in the disturbance data set.

This combination of Ecological Maturity Classes and Disturbance Index Groups is basically the intersection of the 'API areas only' and the 'disturbance only' area coverages in line with the project's adopted definition of 'old growth' i.e. ecologically mature with negligible disturbance. There is a total of 20 classes, resulting from the combination of the 4 Ecological Maturity Classes and the 5 Disturbance Index Groups. These are then re-grouped into the 4 component classes of 'yes', 'likely yes', 'likely no' and 'no'.

Confidence in this classification is variable depending on the Disturbance Index Group that each Ecological Maturity Class is combined with. With each increase in Disturbance Index Group rating the probability of the observation being correct increases. Disturbance classification into index groups 1 and 2 could conceivably be due to the location of a single disturbance type; however disturbance index groups 3, 4 and 5 must result from the presence of two or more disturbances at any one location. The presence of two disturbance records in any one location does not mean that the area is definitely disturbed, but that the probability that the area is not disturbed decreases.

Class	Classification
Yes	Nil
Likely yes	Disturbance Index Group 1
Likely no	Disturbance Index Group 2, 3, 4, 5
No	Nil

Fraser Island

This mask includes data obtained from work conducted as part of the Fitzgerald Inquiry in 1989. The data include classification of the blackbutt (*Eucalyptus pilularis*) types, based on vegetation mapping by Stanton (1979), into 'Frazveg' Maturity Classes . The classes have been reclassified into old growth classes based on interpretation of the maturity classes and species composition.

Class	Classification
Yes	Nil
Likely yes	Frazveg coding 4, 4D, 5, 5A
Likely no	Frazveg coding 4A, 4B, 4C, 4E
No	Nil

No data

This category includes all areas in the SEQ bioregion for which no API or disturbance information exists in our records. No other information source is likely to be discovered for these areas. However, a basic index of accessibility was developed to try and gain some insight into topographic barriers to logging operations. This index uses existing roads and ridge lines as access points and is weighted by slope and distance away from roads and ridges. The validity of this index in broad-scale partitioning of areas into logged and unlogged sites as well as any relationship with ecological maturity will be investigated.

Class	Classification
Yes	Nil
Likely yes	Accessibility > 15 000
Likely no	Accessibility < 15 000
No	Nil

Table 3.2.1 Summary table of old growth output confidence categories

Output class	Classes	Confidence	Class source	Tenure
'Field-validated API polygons only'	Disturbed areas Field team 'yes', 'likely yes', 'likely no', 'no' appraisal	> 95%	Ecological maturity decision rules	Any
'API areas only'	Ecological Maturity Classes 1–4 Disturbed Areas	> 80%	Ecological maturity decision rules	Any
'Disturbance only'	DIG Classes (1–5)	Variable depending on class grouping	Disturbance Index Group decision rules	SF, NP, LH
'API and disturbance only'	Ecological Maturity Classes / Disturbance Index Groups 1–20	Variable depending on class grouping	API + Disturbance decision rules	SF, NP, LH
'Fraser Island API polygons'	Non eucalypt, 'likely yes', 'likely no'	Unknown	Frazveg (external data source—Spatial Information and Mapping, DNR)	NP, LH, FH
'No data'	Accessibility Classes 1–5	Unknown	Accessibility surface	Any

3.2.2 Old growth classes within the mapping

Mapping outputs from the project will be one of five types: areas that have been field-validated, areas where there is API alone, areas where there is API and disturbance information, areas of disturbance information alone, and areas where the access cost model has been applied. Interpretation of the coverages for the Comprehensive Regional Assessment /Regional Forest Agreement can be guided by the following tables, 3.2.2–3.2.7:

Table 3.2.2 Areas that have been field validated

Ecological Maturity Class (EMC) and expert validation	Old growth status
EMC 1 + Y	'Yes' – most likely old growth
EMC 1 + LY	'Likely yes' – likely old growth
EMC 1 + LN	'Likely no' – likely not old growth
EMC 1 + N	Not old growth
EMC 2 + Y	'Yes' – most likely old growth
EMC 2 + LY	'Likely yes' – likely old growth
EMC 2 + LN	'Likely no' – likely not old growth
EMC 2 + N	Not old growth
EMC 3 + Y	'Yes' – most likely old growth
EMC 3 + LY	'Likely yes' – likely old growth
EMC 3 + LN	'Likely no' – likely not old growth
EMC 3 + N	Not old growth
EMC 4 + LN	'Likely no'– likely not old growth
EMC 4 + N	Not old growth

Table 3.2.3 Areas where there is API alone

Ecological Maturity Class (EMC)	Old growth status
EMC 1	'Yes' – most likely old growth
EMC 2	'Likely yes' – likely old growth
EMC 3	'Likely no' – likely not old growth
EMC 4	Not old growth

Table 3.2.4 Areas where there is aerial photography interpretation and disturbance information

Ecological Maturity Class (EMC) and Disturbance Index Group (DIG)	Forest structure and disturbance level	Old growth status
EMC 1 + DIG 1	Ecologically mature, negligible disturbance	'Yes' – most likely old growth
EMC 1 + DIG 2	Ecologically mature, negligible disturbance	'Yes' – most likely old growth
EMC 1 + DIG 3	Ecologically mature, significant disturbance	'Likely yes' – potential old growth; 'structural' old growth with disturbance records
EMC 1 + DIG 4	Ecologically mature, significant disturbance	'Likely no' – potential old growth; 'structural' old growth with disturbance records
EMC 1 + DIG 5	Ecologically mature, significant disturbance	'Likely no' – potential old growth; structural" old growth with disturbance records
EMC 2 + DIG 1	Mature forest, negligible disturbance	'Likely no' – potential old growth
EMC 2 + DIG 2	Mature forest, negligible disturbance	'Likely no' – potential old growth
EMC 2 + DIG 3	Mature forest, significant disturbance	'Likely no' – potential old growth, with disturbance records
EMC 2 + DIG 4	Mature forest, significant disturbance	'Likely no' – potential old growth, with disturbance records
EMC 2 + DIG 5	Mature forest, significant disturbance	'Likely no' – potential old growth, with disturbance records
EMC 3 + DIG 1	Structurally immature forest, negligible or no disturbance	'Likely no' – unlikely old growth
EMC 3 + DIG 2	Structurally immature forest, negligible disturbance	'Likely no' – unlikely old growth
EMC 3 + DIG 3	Structurally immature forest, significant disturbance	'Likely no' – unlikely old growth
EMC 3 + DIG 4	Structurally immature forest, significant disturbance	'Likely no' – unlikely old growth
EMC 3 + DIG 5	Structurally immature forest, significant disturbance	'Likely no' – unlikely old growth
EMC 4 + DIG 1	Disturbed forest from API, negligible or no disturbance	'Likely no' – unlikely old growth
EMC 4 + DIG 2	Disturbed forest from API, negligible disturbance	'Likely no' – unlikely old growth
EMC 4 + DIG 3	Disturbed forest from API, significant disturbance	Not old growth
EMC 4 + DIG 4	Disturbed forest from API, significant disturbance	Not old growth
EMC 4 + DIG 5	Disturbed forest from API, significant disturbance	Not old growth

Table 3.2.5 Areas of disturbance information alone

Disturbance Index Group (DIG)	Level of disturbance	Old growth status
DIG 1	Negligible disturbance	'Likely yes'
DIG 2	Some disturbance	'Likely no'
DIG 3	Significant disturbance	'Likely no'
DIG 4	Significant disturbance	'Likely no'
DIG 5	Significant disturbance	'Likely no'

Table 3.2.6 Fraser Island mapping

Frazveg coding	Old growth status
Frazveg 4, 4D, 5, 5A	'Likely yes'
Frazveg 4A, 4B, 4C, 4E	'Likely no'
Unassessed non-eucalypt areas	Not applicable

Table 3.2.7 Areas where there are no data

Accessibility index	Old growth status
Index > 15 000	'Likely yes'
Index < 15 000	'Likely no'

3.3 SUMMARY STATISTICS

General statistics

The currently defined South-East Queensland biogeographic region has been calculated to be approximately 6 219 147 ha in extent, of which 3 545 237 ha (57 per cent) contains forest of greater than 20 per cent crown cover (as defined by the National Forest Inventory 1996). State forest currently accounts for 927 839 ha (14.9 per cent of SEQ, or 26.2 per cent of forest areas in SEQ), and national parks occupy 353 580 ha (5.7 per cent of SEQ, or 9.8 per cent of the forested areas in SEQ).

As mentioned previously a total of 1 360 360 ha (approx. 43 per cent) of forested areas (not plantation) in the SEQ bioregion was assessed in some way during the old growth forest assessment project and from this total area the following old growth statistics have been calculated.

3.3.2 Old growth statistics by tenure

Tables 3.3.1 to 3.3.4 below present the breakdown of statistics for each old growth category ('yes', 'likely yes', 'likely no' and 'no') that occur within State forest, national parks and other tenures.

The figures represent only those areas that fall within one of the four old growth categories and therefore do not include those 'unassessed' areas or forests that are not eucalypt-dominated.

TABLE 3.3.1 Total area and percentages of each old growth class in the South-East Queensland biogeographical region

Old growth category	Area (HA)		As % of forest area in SEQ		As % of total area of SEQ
Total Yes OG	97201.63	or	**2.74**	or	**1.56**
Total Likely Yes OG	204325.81	or	**5.76**	or	**3.29**
Total Likely No OG	637882.50	or	**17.99**	or	**10.26**
Total No OG	680466.06	or	**19.19**	or	**10.94**

TABLE 3.3.2 Old growth forest within State forest

Old Growth category	Area (HA)		As % of forest area in SEQ		As % of total area of SEQ	As % of total OG
Total Yes OG in SF	19875.56	or	**0.56**	or	**0.32**	**20.45**
Total Likely Yes OG in SF	27171.69	or	**0.77**	or	**0.44**	**13.30**
Total Likely No OG in SF	346791.94	or	**9.78**	or	**5.58**	**54.37**
Total No OG in SF	204738.19	or	**5.78**	or	**3.29**	**30.09**

TABLE 3.3.3 Old growth forest in national parks

Old Growth category	Area (HA)		As % of forest area in SEQ		As % of total area of SEQ	As % of total OG
Total Yes OG in NP	42750.94	or	**1.21**	or	**0.69**	**43.98**
Total Likely Yes OG in NP	77813.06	or	**2.19**	or	**1.25**	**38.08**
Total Likely No OG in NP	41173.31	or	**1.16**	or	**0.66**	**6.45**
Total No OG in NP	17762.50	or	**0.50**	or	**0.29**	**2.61**

TABLE 3.3.4 Old growth forest not in State forest/national parks

Old Growth category	Area (HA)		As % of forest area in SEQ		As % of total area of SEQ	As % of total OG
Total Yes OG (not SF/NP)	34707.63	or	**0.98**	or	**0.56**	**35.71**
Total Likely Yes OG (not SF/NP)	99504.56	or	**2.81**	or	**1.60**	**48.70**
Total Likely No OG (not SF/NP	253585.13	or	**7.15**	or	**4.08**	**39.75**
Total No OG (not SF/NP)	235434.13	or	**6.64**	or	**3.79**	**34.60**

3.3.3 Old growth statistics by Regional Ecosystem type

Old growth forest identified in this project was combined with regional ecosystem data derived in the project EH 1.2B Forest Ecosystem Mapping and Analysis: Regional Ecosystems by members of the Forest Assessment Unit in the Department of Environment (DEH). The objective was to type areas of old growth in terms of forest ecosystem and hence determine the amount and distribution of old growth forest within the SEQ RFA region. Two methods were used to derive the associations required:

- large scale forest-type mapping
- homogeneous regional ecosystem mapping

Typing of old growth areas using the large scale forest-type mapping involved the manual overlay of old growth areas identified over hard copy maps of forest-types for all state forests and conservation areas that had suitable mapping available. Using associations between forest type, geology and regional ecosystem, ecosystems were derived for old growth areas. Typing of old growth using homogeneous regional ecosystem mapping involved a GIS intersection process to attribute areas of old growth with areas of regional ecosystems that contained only one ecosystem type. Due to the difference in scale of mapping between the two methods ie approximately 1:25 000 verses 1:100 000, the former method is deemed to be the more accurate and hence takes precedence where areas have been typed using both methods.

Analysis of the results indicate that approximately **60 per cent** of the total old growth identified as 'yes' or 'likely yes' has been typed to particular regional ecosystems. Although typing occurred in areas across the whole bioregion, there is an uneven distribution of typing across tenures found in the bioregion. Approximately **85 per cent** of old growth occurring on conservation reserves was typed and approximately **50 per cent** of old growth occurring on state forest/timber reserves was typed. There was also approximately **20 per cent** of old growth typed that occurred on other tenures.
The following table indicates summary statistics for ecosystem typing of the old growth areas in the RFA region. This region includes Blackdown Tableland and Fraser Island as well as the SEQ bioregion. The total amount of old growth typing that has occurred is indicated for state forest/timber reserves and for conservation reserves/reserve proposals. Differences in area of old growth between these figures and those presented in sections 3.3.1 and 3.3.2 can be attributes to the different tenure coverage (DEH included a proposed national park coverage with the national parks) and the Geographic Information System (GIS) data format used by DEH (a vector environment as opposed to a raster one).

Table 3.3.5 Summary statistics for typed old growth polygons

	SEQ region (including Blackdown Tableland and Fraser Island)
Area of old growth **typed** in SF/TR (% of total old growth in SF/TR) - Yes - Likely Yes	9,400 (48%) 17910 (68%)
Area of old growth **typed** in NP/NPP (% of total old growth in NP/NPP) - Yes - Likely Yes	24,270 (57%) 106,820 (93%)
Area of old growth **typed** in non SF/NP/NPP (% of total old growth in non SF/NP/NPP) - Yes - Likely Yes	6,900 (21%) 13,700 (24%)

The following table (3.3.6) indicates the amount of typing that has occurred on an ecosystem level. For each forest ecosystem, a number of statistics are presented:

- the amount of ecosystem old growth that has been typed for the RFA region. This includes Blackdown Tableland and Fraser Island.

- the percentage of ecosystem old growth in respect to the total aerial extent of ecosystem remaining in the RFA region
- the area of ecosystem old growth that occurs on state forests and timber reserves
- the percentage of ecosystem old growth in respect to the total aerial extent of ecosystem found on state forests and timber reserves
- the area of ecosystem old growth that occurs in conservation reserves or reserve proposals occurring in the RFA region
- the percentage of ecosystem old growth in respect the total aerial extent of ecosystem found on conservation reserves or reserve proposals.

Table 3.3.6 Old growth statistics by regional ecosystem type

Regional Ecosystem	Area of ecosystem old growth in Bioregion (ha)	% Ecosystem old growth per Total Remnant Area of RE	Area of ecosystem old growth in SF/TR (ha)	% Ecosystem OG per Total Area of RE in SF/TR	Area of Ecosystem old growth in Conservation Reserve(CR) (ha)	% Ecosystem OG per Total Area of RE in CR
11.5.2	49.9	**1.12**			49.9	1.26
11.10.5	1113.8	**5.89**	460.2	4.25	653.6	8.22
11.10.13	1134.4	**7.03**	321.8	7.21	812.5	7.00
12.2.4	242.7	**2.50**			242.7	8.69
12.2.5	14210.9	**51.75**			14101.5	68.00
12.2.6	40268.3	**53.52**	83.3	58.66	39978.8	75.17
12.2.8	5947.8	**29.92**			5877.6	79.34
12.2.9	49536.9	**85.20**	20.0	48.78	49420.4	88.80
12.2.11	562.6	**3.22**			186.1	3.14
12.3.2	1037.2	**7.49**	480.4	8.52	334.2	37.64
12.3.3	281.9	**0.39**	17.7	0.13		
12.3.4	445.2	**2.65**			342.2	6.93
12.3.5	310.6	**1.60**			262.9	5.12
12.3.6	25.1	**0.25**	5.6	0.47	19.5	0.32
12.3.7	6.8	**0.05**				
12.3.9	44.5	**7.23**	44.5	27.47		
12.3.11	208.7	**0.42**	5.9	0.04		
12.3.12	168.9	**1.07**	159.6	16.52	9.3	0.28
12.3.14	1002.5	**15.98**	72.8	9.96	929.7	31.03
12.5.1	431.8	**2.40**	374.6	6.97		
12.5.3	51.9	**0.75**			19.1	3.24
12.5.4	178.4	**2.65**			124.4	4.75
12.5.6	21.9	**0.58**	21.9	1.00		
12.8.1	1212.2	**14.05**	240.8	11.94	824.3	20.24
12.8.2	429.3	**100**			429.3	100
12.8.8	130	**2.02**			83.3	10.83
12.8.9	335.6	**6.37**	130.8	35.91	204.8	6.19
12.8.10	82.8	**18.50**	82.8	85.36		
12.8.11	48.9	**24.45**			48.9	68.87
12.8.12	16.5	**3.77**				
12.8.14	5271.7	**13.21**	1417.4	34.98	1792.5	19.81
12.8.16	4177.3	**11.95**	668.2	13.91	1593.3	28.38
12.8.20	342.7	**5.20**	7.4	1.16	145.5	7.86
12.8.24	83.4	**8.63**			61.8	17.91
12.8.25	559.9	**16.59**	41.6	40.31	513	79.40
12.9-10.1	134.7	**6.86**	126.2	13.26		
12.9-10.2	2068.1	**2.54**	98.5	1.21	273.5	13.40
12.9-10.3	224.4	**1.02**	33	0.45		
12.9-10.4	4100.7	**10.52**	215.1	2.01	3138.6	31.25
12.9-10.5	478.9	**1.67**	7	0.13	172.6	64.24
12.9-10.7	451.5	**1.33**	132.5	3.91		
12.9-10.14	221.1	**1.73**	48.3	1.27	85.8	31.09
12.9-10.17	1484.1	**2.30**	340	1.52	605.8	24.66
12.9-10.19	125.8	**0.25**	36.4	0.11		
12.9-10.20	1269.1	**23.60**	528.7	11.78	740.4	88.16
12.9-10.21	452	**2.63**	452	3.49		

12.11.2	1740.7	**10.39**	1032.1	17.46	604.4	25.14
12.11.3	7327	**7.36**	5992.7	10.46	321.3	11.04
12.11.5	7673	**9.62**	6477.2	25.59		
12.11.6	2416.9	**1.10**	182.8	0.27	189.6	16.56
12.11.7	1297.9	**2.29**	313	3.55		
12.11.9	269.9	**6.77**	108.9	9.18	161	17.41
12.11.14	29.5	**1.12**				
12.11.15	140.4	**1.34**				
12.11.16	46.2	**0.96**	31.2	1.86		
12.11.17	121.7	**0.29**	30	0.25		
12.11.18	289.5	**1.25**	105.8	1.56		
12.11.19	665.3	**6.27**	655.8	10.60		
12.12.2	1043.6	**4.93**	814.9	6.75	162.5	45.35
12.12.3	1128.9	**1.82**	377.7	1.51	616	64.50
12.12.4	67.4	**0.39**	39	1.01		
12.12.5	591.2	**0.39**	251.9	0.65		
12.12.6	143	**13.63**	26.8	6.61	85.2	
12.12.7	1367.3	**1.89**	149	0.97	32.6	4.18
12.12.9	586.3	**4.61**			497.9	18.49
12.12.11	1719.8	**2.01**	304.1	1.58	40	0.81
12.12.14	121.5	**4.62**	99.9	5.86		
12.12.15	993.8	**2.77**	961	4.92		
12.12.20	541.4	**8.60**	282.3	5.38		
12.12.23	270.1	**0.97**	53.1	0.76		
12.12.25	22.6	**0.25**	22.6	0.53		
12.12.27	735.6	**3.84**	66.5	2.74	518.7	11.02
12.12.28	15.1	**0.09**	15.1	0.36		

Thirty-three (33) or 31 per cent of the forest ecosystem that occur in the SEQ RFA region have no old growth identified within the region. These are listed below:

11.10.1	**11.10.2**	**11.3.4**
11.9.5	**12.1.1**	**12.2.7**
12.2.10	**12.3.10**	**12.5.2**
12.5.5	**12.5.7**	**12.5.8**
12.5.10	**12.5.11**	**12.5.12**
12.7.1	**12.7.2**	**12.8.17**
12.8.23	**12.9-10.6**	**12.9-10.8**
12.9-10.9	**12.9-10.12**	**12.9-10.13**
12.9-10.18	**12.9-10.23**	**12.9-10.24**
12.11.8	**12.12.8**	**12.12.12**
12.12.21	**12.12.22**	**12.12.24**

3.3.4 Old growth statistics by Disturbance Forest Type (DFT)

Disturbance Forest Types (DFTs) were used as a surrogate for Regional Ecosystem Types in order to determine the total area and percentages of old growth that fall within broad vegetation units. The DFT coverage has been used over other vegetation coverages for this project due to the nature of the analysis carried out and as a result of the absence of a suitable scale mapping coverage at the time of analysis. The emphasis on disturbance in the assessment of old growth forest enabled the meaningful class distinctions made in the DFT coverage to be readily applied when relating the existence of old growth forest to a particular broad vegetation type.

Tables 3.3.7 and 3.3.8 illustrate the breakdown of each old growth class into each of the DFT classes described in Section 2.3.

3.3.5 The definition of Rainforest and Wet Sclerophyll Forests

The definition of rainforest, as it relates to the scope of this project, was debated within the Environment and Heritage Technical Committee of the RFA. The debate centered around whether forests categorised as wet sclerophyll (DFT types 1a and 1b) should be included in the rainforest coverage, and therefore not included in areas assessed within the project.

The total area of ‘yes’ and ‘likely yes’ old growth assessed in South-East Queensland is 270 205.63 hectares. Exclusion of DFT 1(which includes 1a and 1b) results in 258, 313.31 hectares of forest that remains classified as old growth. Therefore 4.4 per cent of the total area of old growth assessed by the project was contained within DFT’s 1a and 1b.

TABLE 3.3.7 Old growth class by DFT (old growth classes 'Yes' Old Growth, And 'Likely Yes' Old Growth)

DFT num.	DFT area total (ha)	% forest >20% CCP	% SEQ bioregion	OG Yes OG class 1 (area ha.)	% DFT	% forest >20%CCP	% SEQ bioregion	OG LY OG class 2 (area ha.)	% DFT	% forest >20% CCP	% SEQ bioregion
1	**55964.25**	1.58	0.90	7355.13	***13.14***	0.21	0.12	4537.19	***8.11***	0.13	0.07
2	65714.88	1.85	1.06	6497.88	***9.89***	0.18	0.10	4536.75	***6.90***	0.13%	0.07
31	47923.06	1.35	0.77	579.25	***1.21***	0.02	0.01	2454.69	***5.12***	0.07	0.04
32	672925.56	18.98	10.82	11241.38	***1.67***	0.32	0.18	24704.31	***3.67***	0.70	0.40
4	584562.63	16.49	9.40	22913.00	***3.92***	0.65	0.37	27476.63	***4.70***	0.78	0.44
5	753421.31	21.25	12.11	39851.94	***5.29***	1.12	0.64	118057.50	***15.67***	3.33	1.90

Table 3.3.8 Old growth class by DFT (old growth classes 'Likely No' Old Growth, And 'No' Old Growth)

DFT num.	DFT area total (ha)	% forest >20% CCP	% SEQ bioregion	OG LN OG class 3 (area ha.)	% DFT	% forest >20% CCP	% SEQ bioregion	OG Not OG class 4 (area ha.)	% DFT	% forest >20% CCP	% SEQ bioregion
1	**55964.25**	1.58	0.90	13973.94	***24.97***	0.39	0.22	18974.75	***33.91***	0.54	0.31
2	65714.88	1.85	1.06	24463.44	***37.23***	0.69	0.39	24060.13	***36.61***	0.68	0.39
31	47923.06	1.35	0.77	8141.25	***16.99***	0.23	0.13	6418.31	***13.39***	0.18	0.10
32	672925.56	18.98	10.82	197599.63	***29.36***	5.57	3.18	237428.88	***35.28***	6.70	3.82
4	584562.63	16.49	9.40	210162.44	***35.95***	5.93	3.38	163188.94	***27.92***	4.60	2.62
5	753421.31	21.25	12.11	134491.75	***17.85***	3.79	2.16	130306.56	***17.30***	3.68	2.10

4. CONCLUSIONS

4.1 CONSERVATION AND MANAGEMENT OBJECTIVES IN SOUTH–EAST QUEENSLAND

The policy basis for the conservation and management of old growth forests in South-East Queensland (SEQ) lies in the National Forest Policy Statement published by the Commonwealth of Australia in 1992, JANIS, 1996 and in the agreed framework for a Regional Forest Agreement for SEQ as outlined in the (unpublished) Scoping Agreement prepared by the Department of Natural Resources in 1997.

National Forest Policy Statement (NFPS)

The forests of South-East Queensland are managed for a range of purposes including timber production, recreation, water catchment protection and biological diversity conservation. With the signing of the NFPS in 1992, the Queensland Government committed itself to the ecologically sustainable management of the native forest estate, and to the protection of old growth and wilderness values (DNR 1996).

The NFPS proposed the establishment of a 'comprehensive, adequate and representative' (CAR) conservation reserve network for forests. It outlined a process for the determination of targets for such a reserve system based on the recommendation of a joint State and Commonwealth Government Committee (JANIS). Specifically with respect to the conservation and management of old growth forests, the NFPS stated (p. 11) that 'the Governments have agreed to a strategy designed to conserve and manage areas of old growth forests…as part of the reserve system'. It goes on to state (p. 16) that 'Australia will continue to use old growth timber for many years. It will come from disturbed forests containing some old growth trees and from old growth forests that are not required for the nature conservation reserve system'.

JANIS

The JANIS process established by the NFPS produced a discussion paper in late 1994 that contained general recommendations with respect to the targets for establishment of a CAR reserve network. The National Forest Conservation Reserves – Commonwealth Proposed Criteria built on the JANIS paper in outlining the Commonwealth Government's position on the composition of the CAR reserve network for forests and contained more explicit targets for the reservation of old growth (Commonwealth of Australia 1995).

In September of 1996 however JANIS released its criteria for the establishment of a CAR reserve system for forests in Australia. Criteria established in relation to old growth include:

(1) *Where old growth forest is rare or depleted (generally less than 10% of the extant distribution) within a forest ecosystem, all viable examples should be protected, wherever possible. In practice, this would mean that most of the rare or depleted old growth forest would be protected.*

(2) *For other forest ecosystems, 60% of the old growth forest identified at the time of assessment would be protected, consistent with a flexible approach where appropriate, increasing to the levels of protection necessary to achieve the following objectives:*

- *The representation of old growth forest across the geographic range of the forest ecosystem*
- *The protection of high quality habitat for species identified under the biodiversity criterion*
- *Appropriate reserve design*
- *Protection of the largest and least fragmented areas of old growth*
- *Specific community needs for recreation and tourism.*

These targets have been accepted in some states for the purposes of Regional Forest Agreements (RFAs). In Queensland the 1997 Scoping Agreement (referred to earlier) which established the basis for an inter-governmental approach to the development of an RFA in SEQ states that 'the application of the criteria to achieve a dedicated and secure CAR reserve system will be based upon scientific assessment, not upon the application of benchmarks' (paragraph 16).

4.2 LIMITATIONS OF THE SEQ OLD GROWTH FOREST ASSESSMENT STUDY

In the process of conducting the project and in the production of the report, the project team recognised that there are several limitations to the study.

- It was not possible to validate the accuracy of, or assign accuracy ratings to the individual disturbance data sets. Accuracy of the disturbance data sets was known to be highly variable across the districts and between disturbance types. Quantification of the level of accuracy did not occur as a result of this variation and it would have been unworkable to incorporate this into the decision-rule process given the complexity of the process as it stands (some 3 000 lines of AML coding). Accuracy for the disturbance data sets was considered to be equal, and was defined as being lower than the API. The team is still endeavouring to quantify the level of accuracy associated with these data sets.

- Limitations in the time and resources available to the project (and the other priority demands on them) precluded the digital capture of all SUID boundaries. Therefore logging history data was restricted to virgin SUIDS and those logged prior to 1950. In recognition of the relative lesser confidence in the logging history layer the decision rules developed by the project to identify and classify old growth were conservatively designed to make it unlikely that any area be excluded from being old growth based on logging history coverage alone.

- Disturbance information was only available for Crown land such as State forests, timber reserves and to a limited extent in leasehold and national park areas. Categorisation of freehold land into old growth classes was therefore based on API only, and was restricted to those areas where API was applicable.

- In areas where no disturbance information was available, non-eucalypt forest was not assessed, as it was not possible to 'growth-stage' these forest types.

- Time and resourcing considerations restricted the amount and level of field validation. Inspection of polygons varied from 6 to 28 per cent of the API polygons per 1:50 000 map sheet. Accessibility was the major constraint on the validation of polygons.

- Inability, within the time and resources available, to implement quantitative indicators of disturbance. In particular, the lack of basic ecological knowledge of the impacts of grazing and fire limited the extent to which the project was able to clearly identify the ecological significance of changed grazing/fire regimes following European settlement.

- Assessment occurred at one point in time. The project team recognises that forests are dynamic and that the data from the project reflect forest condition as it was at the time of data collection only. Data derived from the project will thus become less relevant as time goes on.

- Unavailability of regional ecosystem mapping at the same detailed resolution (1:25 000) as the growth-stage mapping meant it was not possible to develop highly refined decision rules.

4.3 CONCLUSIONS

The assessment of old growth forest in Australia has undergone significant advances since the concept was first introduced in the early nineties. Initial studies were primarily based on the assessment of growth stage by aerial photography, with methodologies placing little emphasis on the collection of field data (Woodgate *et al*, 1994; North East Forest Alliance, 1994; and State Forests of NSW (1994, 1995).

Direct translation of this method to the forests of north-east NSW and South-East Queensland was not possible due to the differences in forest types and the disturbance regimes that the forests are subject to. Processes for increasing the accuracy of the mapping were therefore investigated in both NSW and QLD, and included the following studies;

- Preston *et al*, 1993

A pilot study was conducted using API to map growth stages in an approach similar to the Victorian study. The method differed however by using satellite imagery in an effort to automatically generate the boundaries between different patches of forests. This approach was initially unsuccessful due to the coarse topography found in the study area, and was thus revised to a system of overlaying aerial photos with unique map units then labelling the photos with the Victorian growth stage classes. The resultant maps were found to be of low reliability when compared to logging history records and field checking. Results showed that API assessment of growth stage was limited in the drier forest types as many species did not exhibit the strong senescing characteristics observed in Victorian ash. Many species found in these areas possessed smaller crowns and exhibited less severe signs of crown decline and were thus difficult to accurately growth stage. The study therefore recognised that the inclusion of disturbance information and the collection of site data were important components in the process of old growth mapping.

- House *et al*, 1994

As a result of the above work it was recognised that a systematic approach to the acquisition of field data was needed. House *et al* developed guidelines of site inventory for old growth assessment in eucalypt forests that included a section on estimating growth stage of individual trees. Growth stage classes included those used in the Victorian study with the further addition of a suppressed class for those trees experiencing growth restriction. The study recognised that these trees needed special consideration in the assessment process. Consideration was also given to the differences found between species in their morphological expression of age, resulting in the collection of some preliminary observations of the growth stage characteristics for individual species.

- RACAC, 1997

This study, administered by NSW National Parks and State Forests, was initiated to develop and document a methodology that could be used for the operational identification and delineation of old growth in the forested regions of NSW. The study proposed that a combination of remotely assessed variation in canopy surface structure (from API) should be linked to detailed ground observations of individual trees. The results of this work could be used to generate growth stage profiles of stands, which are then correlated with API polygons and other environmental and historical data on aspects such as disturbance. In terms of API, the study found interpretation of 1:25,000 scale photos was only reliable for regrowth stands and that reliability of growth stage assessment was forest type specific, particularly in drier forest environments where lower reliability was found. Field based growth stage assessment was based on the development of dichotomous keys. Development of the keys was proposed as a means of providing a greater level of objectivity in the trees assessment, and as a means of producing greater consistency between recorders. This involves the analysis of a data set of individual morphological attributes, including an expert assessment of growth stage, for a species or species group. The attributes collected for the development of keys were initially based on work by House et.al (1994) and Jacobs (1955), but were amended based on research done by the project and included more detailed descriptions of each attribute.

The establishment of the South-East Queensland old growth forest study in 1995 resulted in a need to develop an operational methodology for the identification of old growth forest across the South-
East Queensland bioregion. Findings from previous studies were investigated in the process of developing the methodology, which following initial development, evolved through a process of expert opinion and field surveys. Considerable attention was directed in the project towards establishing the limits to which an API approach could be applied and in identifying methods for the improved delineation of old growth stands in South-East Queensland. Disturbance data collected at a district level, an intensive field assessment process and decision rules with varying emphases and thresholds depending on forest type and disturbance regimes were some of the initiatives used to improve the accuracy of the mapping process.

The project was able to delineate the extent of old growth forest across the majority of the bioregion, with varying degrees of accuracy depending on the data sets available. As a result of this process it became obvious that the distribution of old growth forest in South-East Queensland was limited in extent and was largely patchy and fragmented in distribution and that representative patches of old growth of all forest types may not remain.

APPENDIX 1 FIELD RESEARCH

APPENDIX 1.1 Field Proforma for validation of API polygons

POLYGON ASSESSMENT PROFORMA
Date:
Mapsheet:

Polygon No./AMG	Dom.Spp	API Coding	Field coding	Logging intensity	Grazing	Fire	Treat-ment	Other	Is Poly OG?	Notes
				0=Absent 1=Light 2=Medium 3=Heavy	0=Absent 1=Light 3=Heavy	1=Light 3=Heavy	0=Absent 1=Light 3=Heavy	0=Absent 1=Light 3=Heavy	Y=Yes LY=Likely yes LN=Likely No N=No	

Polygon/ disturbance assessment in draft map polygons

LOGGING:
Absent **–** No stumps in view, absence of soil disturbance and absence of logging debris. [Exceptions include 1–2 stumps near edge of road/polygon or few stumps found along fence lines]
Light **–** 1 – 2 stumps in view at a selection of points within the polygon and/or 1–2 tree heads or reject logs in view.
Medium **–** 3 – 5 stumps in view at a selection of points within the polygon. Snig tracks evident within polygon and/or evidence of soil disturbance and/or presence of logging debris. Regenerating stems found in sub-dominant proportions within stand.
Heavy **–** 6 or more stumps in view at a selection of points within the polygon. Current logging activity as evidenced by open earth and freshly cut stumps. Regenerating stems dominant. Two or more distinct logging events as evidenced by stumps of different rates of decay.
GRAZING:
Absent **–** Grass unbrowsed, No cow trails, No cow 'excreta', Unpalatable ground cover
Light **–** Some browsing of grass, some cow trails within polygon, fences within polygon.
Heavy **–** Ground 'criss-crossed' by cow trails, obviously heavy browsing, close proximity to dam, yards present.
FIRE:
Light **–** Low scorch heights on trees, some charring on coarse woody debris.
Heavy **–** Scorch heights evident in canopy, Epicormics along branches and trunk still observable from most recent event. Basal fire scars evident in many trees. Premature mortality, based on height and diameter, of a number of trees.
TREATMENT:
Absent **–** No evidence of treatment [i.e. tree poisoning, ringbarking, push-pulled trees, ringbarking, mechanical clearing, burning or cutting of small regenerating stems].
Light **–** 1 – 2 trees treated in view at a selection of points within the polygon.
Heavy **–** 3 or more trees treated, including a variety of diameters and treatment events i.e. large stags obviously treated pre 1950s for silvicultural practices, smaller stems.
OTHER: i.e. weeds, mines
Light **–** disturbance type affecting a small portion of the polygon.
Heavy **–** disturbance type affecting the majority of the polygon such that natural processes are inhibited.
IS POLY OG?
Yes **–** No obvious logging, grazing, fire, treatment or other disturbance evident. A dominant or sub-dominant proportion of senescing trees.
Likely yes **–** Light disturbance, where the effects are not seen to compromise the values of the stand. A dominant or sub-dominant proportion of senescing trees. Where the effects on the understorey are indeterminate.
Likely no **–** Medium disturbance, where the effects are seen to compromise the values of the stand, so that the effects of the disturbance are evident within the growth stage proportions of the overstorey.
No **–** Heavy disturbance. Where the regenerating proportion of the stand is dominant or where there is an absence of senescing trees.

APPENDIX 1.2: Analysis of API Accuracy

Analysis of Results

A comparison was made between the API of forest structure and disturbance, and the field estimates of these features. Analysis included:

- comparisons between codes within a 1:50 000 map sheet
- accuracy of API to interpret different code types
- accuracy of API in different vegetation types.

Comparisons between codes within a 1: 50 000 map sheet

This analysis was performed in order to ascertain the accuracy levels of different interpreters, by comparing API and field estimates within a 1:50 000 map sheet, and to highlight particular sources of error within a map sheet area. The analysis was performed by comparing the API estimate to field estimates and acknowledging variation between the codes.

Validation of the API polygons occurred across all map sheets and aimed at assessing 10 to 20 per cent of the polygons. Table A1.2.1 includes a summary of the percentage of each map sheet validated, which varied depending on size of polygon, road access and slope within each polygon.

Results varied between map sheets, ranging from 74.4 per cent to 100 per cent for polygons within one code or in direct agreement with field estimates. Potential sources of error were attributed to different forest types, primarily the drier forest types, and on the sheets interpreted in the early stages of the project during interpreter training i.e. Nambour.

Table A1.2.1 Accuracy of API within map sheets

1:100 000 Map Sheet	1:50 000 Map Sheet	% Correct + % Within 1 code of being correct	% Correct	% Within 1 code of being correct	% Differing by 2 codes	No.of Polygons checked	% Of sheet checked	Year of Photo
Caloundra – 9544	Caloundra – 3	83.3	76.7	6.7	16.7			1991
	Maroochydore – 4	80.0	63.3	16.7	20.0	75	23.5	1991
Goomeri – 9345	Barambah – 3	91.4	60.0	31.4	8.6	40	22.7	1993
	Goomeri – 4	91.1	75.6	15.6	8.9	49	15.2	1993
	Manambar – 2	92.5	69.9	22.6	7.5	211	20.2	1993
	Woolooga –1	91.0	65.2	25.8	9.0	109	13.7	1993
Laguna Bay – 9545	Cooloola – 4	77.8	20.8	56.9	22.2			1993
	L. Bay – 3	69.0	31.0	37.9	31.0	113	27.0	1993
Monto – 9148	Builyan – 1	74.4	50.0	24.4	25.6	98	8.6	1995
	Monto – 3	86.4	60.9	25.5	13.6	120	26.7	1995
	Mt.Buckanally – 4	88.2	66.2	22.1	11.8	83	7.7	1995
	Mt.Goondicum – 2	82.8	60.9	21.8	17.2	96	10.4	1995
Rosedale – 9248	Mt.Gaeta – 3	88.9	60.3	28.6	11.1	68	8.3	1993
	Toweran – 4	90.5	71.6	18.9	9.5	74	8.4	1993
Nambour – 9444	Kilcoy – 3, Nambour – 1, Kenilworth – 4,	76.3	50.9	25.4	23.7	187	6.9	1991

	Woodford – 2							
Nanango – 9344	Nanango – 4	91.3	71.3	20.0	8.8	99	24.4	1993
	Jimna – 1	88.4	57.6	30.8	11.6	256	26.5	1993
	Moore – 2	98.2	94.6	3.6	1.8	59	13.4	1993
	Blackbutt – 3	85.1	55.4	29.7	14.9	112	21.9	1993
Gympie – #9445	Imbil – 3	90.3	64.6	25.6	9.7	226	24.0	1993
	Wolvi – 1	94.9	75.2	19.6	5.1	227	28.3	1993
	Cooroy – 2	95.5	77.6	17.9	4.5	320	25.6	1993
	Gympie – 4	95.0	74.4	20.6	5.0	200	33.6	1993
Murwillumbah – #9541	Burleigh – 1	93.4	52.6	40.8	6.6	226	18.3	1993
	Canungra – 4	94.9	70.9	24.0	5.1	196	12.2	1993
Mt Lindsey – #9441	Woodenbong – 3	95.8	77.1	18.8	4.2	49	6.8	1993
Calliope – #9149	Clewey's Gap – 3	98.3	73.3	25.0	1.7	60	4.8	1996
	Ubobo – 2	100.0	83.8	16.2	0.0	73	6.5	1996
	MEAN	88.7	64.7	24.0	11.3			
	STD.DEV	7.7	15.0	10.1	7.7			
	Total					3426		

Accuracy of API to interpret different code combinations

Further analysis was performed in order to reveal potential sources of error in API to interpret different combinations of the SMR coding. Analysis therefore concentrated on those polygons where there was a difference between the API estimate of SMR and the field estimate and were grouped on the basis of the proportion of senescent stems. Accuracy levels were calculated by transferring each code into a numeric value and calculating the difference between the field and API estimates. The resultant figure showed whether API was under or over estimating a particular component of the SMR code.

Two 1:100 000 map sheets, Monto and Nanango, were analysed and results shown in table A1.2.2.

Discussion

Analysis was performed in order to reveal potential source of error in API within different forest stands. Results of this analysis could then be used for cautious interpretation of those stands identified within the process.

Polygons with no proportion of senescent trees – Polygons where the API code was incompatible to field verified sites and this code was out by two or more codes, were sites of dry forest types containing *Eucalyptus crebra*. It was assumed that API misinterpreted the small crowns of *E. crebra* as regenerating trees, and was either over estimating the proportion of regenerating stems, or trying to compensate for the dry forest type by underestimating the proportion of regenerating stems.

Polygons with a trace of senescent – The majority of polygons with differences between API and field estimates were dry *E. crebra* forests where the senescent or regenerating proportion was under or over estimated, possibly suggesting that the interpreter was overcompensating for the dry forest type or misinterpreting the regenerating proportion. Some examples were out in both the senescent and regenerating codes. These examples include *Eucalyptus fibrosa, Corymbia citriodora*, *Eucalyptus acmenoides* forest and *C. Citriodora / E. crebra* forest.

Table A1.2.2 Accuracy of API in different code combinations

Polygon type	Underestimation by 2	Underestimation by 1	In agreement with field estimates	Overestimation by 1	Overestimation by 2
Polygons with no proportion of senescing stems	9%	–	33%	42.9%	15.1%
Polygons with a trace of senescing stems and subdominant in regenerating trees	–	20.5%	47.7%	–	–
Polygons with a trace of senescing stems and a trace of regenerating trees	–	–	62.9%	18.6% in the regenerating proportion 6.2% in the senescent proportion	6.2% in the senescent proportion
Polygons subdominant in senescing stems with a trace of regenenerating stems	–	–	57.4%	–	–
Polygons subdominant in senescing stems with a subdominant proportion of regenerating stems	–	41.6%	25%	–	–
Polygons dominant in senescing stems	–	–	66.6%	–	–

Polygons Sub-dominant in senescent – Where API underestimated or overestimated a proportion of the stand, it was difficult to identify any relationship in this combination of codes, due to the absence of species data. Examples where species were recorded were dry forests, although some examples are out in both the senescent and regenerating codes and include *C. citriodora / E. crebra*, *C. citriodora / E. acmenoides* and *Eucalpytus melanophloia* forest.

Polygons dominant in senescent – Problems were caused by the interpretation of different species i.e. where the polygon is rainforest, and API has mistaken rainforest trees for Eucalypts and also where the polygon are within dry *E. crebra* forest.

Disturbed polygons – Analysis of the disturbed polygons was performed over all map sheets (Table A1.2.3). These polygons were areas ruled out by API as exhibiting significant disturbance and therefore unworthy of further consideration as old growth.

Table A1.2.3 Accuracy of API disturbed polygons

Polygon type	API 'D' Polygons where the disturbance type was incorrect	API Disturbed polygons not considered significantly disturbed in the field	Confirmed	Polygons coded with an SMR Code but considered significantly disturbed in the field
Total Disturbed polygons	13.4%	14.9%	67.6%	2.2%
'Dr'polygons (n=283)	13.5%	18.6%	67.8%	–
'De'polygons (n=366)	19.8%	9.2%	71%	–
'Dl'polygons (n=65)	12.1%	15.6%	72.3%	–
'Dle/Dler/Dlr' polygons (n=167)	17.3%	24%	58.7%	–
'Der/Dre' polygons (n=203)	8.4%	6.9%	84.7%	–
Rainforest polygons	–	–	84.8%	–

Dr polygons – Polygons coded as Dr (Disturbed with more than 30 per cent regenerating stems) include examples where overestimation of the regenerating portion of the stand occurred and included examples of both moist and dry forest types including *E. fibrosa / C. citriodora* forest or *E. crebra* / *E. melanophloia* forest. In some examples, it was believed that API was mistaking casuarinas as regenerating stems. A further example was found of a *E. crebra* / *C. citriodora* forest where the polygon was not dominant in regenerating trees rather was at least sub-dominant or dominant in senescent stems.

De polygons – Where polygons coded as De (disturbed by grazing) were not in agreement with field estimates it is assumed in the field, that API was mistaking the naturally open dry forests as affected by grazing.

Dl polygons – There were numerous examples of Dl (Disturbed by logging) codes on polygons where no logging had occurred. Species recorded included *C. citriodora, E. crebra, Eucalyptus siderophloia* and *Corymbia intermedia,* indicating that API is misinterpreting the open nature of these forest types as disturbed by logging. One example however is a wetter forest type of *Eucalyptus saligna* / *E. acmenoides*.

Rainforest polygons – 84.8 per cent of the rainforest codes were confirmed in the field while 3.9 per cent changed from a rainforest code to coded with an SMR code. This occurred when the eucalypt component was greater than 30 per cent, and thus excluded from the rainforest definition. 3.6 per cent of polygons were changed from an 'R' code to a 'D'(disturbed) code where the polygon was highly disturbed. 3.6 per cent changed from a eucalypt coded polygon to rainforest where it was assumed that API was overestimating the Eucalypt component of the stand.

Accuracy of API in different forest types

Further analysis within different broad forest types (BFT) (outlined in proceeding section) was undertaken to obtain accurate figures on the percentage of polygons where API was over or under estimating the different proportions in the SMR coding. Analysis was performed in order to reveal whether API had a difficulty in the interpretation of some forest types more than others. The data sets consisted of those polygons where the species were recorded, and were divided into one of five broad forest type groupings. The analysis was performed by considering each component of the SMR code in isolation, as no meaningful results could be obtained from the SMR codes in combination, due to the limited data sets available.

Results and Discussion

The examples discussed in this section are only those where API is consistently over or under estimating a particular component of the stand.

Broad Forest Type One – Stand comprised of a majority of trees that have large crowns and exhibit progressive Jacobsian ageing, typically with a rainforest understorey. SMR easily recognised in both field and API.
Examples of these forest types are:

Eucalyptus pilularis open-forest on moister sites
E. acmenoides open-forest on moister sites
E. grandis +/- E. microcorys open-forest

Table A1.2.4 Results for broad forest type one

Relative % for senescent proportion									
		-3	-2	-1	0	1	2	3	n
	t	0	0	9.5	88.1	2.4	0	0	42
	s	0	0	5.6	52.8	38.9	2.8	0	36
	d	0	0	0	75	12.5	12.5	0	8
Relative % for mature proportion									
		-3	-2	-1	0	1	2	3	n
	d	0	0	0	94.3	4.6	1.1	0	87
Relative % for regenerating proportion									
		-3	-2	-1	0	1	2	3	n
	t	0	2.3	18.6	79.1	0	0	0	43
	s	0	0	4.3	78.3	15.2	2.2	0	46
	d	0	0	0	60	30	5	5	20

Where API has indicated there is a subdominant proportion of senescent stems 38.9 per cent of samples were overestimated by one. Of further interest is the 30 per cent of samples that overestimated the regenerating proportion by one where API coded the polygon as dominant in regeneration.

Broad Forest type Two – Stand comprised of trees with smaller crowns and exhibiting progressive Jacobsian ageing. The SMR values were easily recognised in the field but less confidently by API. Examples of these forest types are:

Mixed open-forests with *E. pilularis* and/or *E. acmenoides E. siderophloia +/- E. propinqua* etc
racemosa, E. pilularis, C. intermedia open-forest to woodland

Table A1.2.5 Results for broad forest type two

Relative % for senescent proportion									
		-3	-2	-1	0	1	2	3	n
	-	14.3	0	23.8	61.9	0	0	0	21
	t	0	2.7	13.1	77.5	6.8	0	0	222
	s	0	0	8.7	64	24.9	2.4	0	253
	d	0	0	0	58.5	26.8	14.6	0	41
Relative % for mature proportion									
		-3	-2	-1	0	1	2	3	n
	s	0	0	50	42.9	3.6	3.6	0	28
	d	0	0	0	95.1	4.3	0.6	0	506
Relative % for regenerating proportion									
		-3	-2	-1	0	1	2	3	n
	-	0	0	0	100	0	0	0	5
	t	0	0.9	9.8	87.7	1.6	0	0	317
	s	0	0	4.5	63.2	31.8	0.5	0	220
	d	0	0	0	31.5	25.9	40.7	1.9	54

BFT 2 polygons coded with no senescent stems are underestimating the proportion of these stems by one, whereby a trace is present in 23.8 per cent of polygons. Where the polygon is coded as sub or dominant in senescent stems the polygons are 24.9 and 26.8 per cent respectively overestimated by one class. Polygons coded as subdominant in mature stems are underestimating the proportion by one in 50 per cent of cases, whereby the polygon should be coded as dominant in mature. Polygons coded as subdominant in regenerating stems are overestimating in 31.8 per cent of cases by one, whereas polygons coded as dominant in regeneration are overestimating by one class 25.9 and 40.7 per cent by two classes.

Broad Forest Type Three – Stand comprised of a mixture of smaller crowns some of which exhibit progressive Jacobsian ageing and some where the ageing process is less evident. SMR estimated with major reference to the Jacobsian species both in the field and by API. Examples of these forest types are:

C. citriodora +/- E. crebra open-forest to woodland

E. umbra or *E. carnea* +/- other species open-forest to woodland

tereticornis, E. crebra +/- E. melliodora woodland

Table A1.2.6 Results for broad forest type three

Relative % for senescent proportion									
		-3	-2	-1	0	1	2	3	n
	t	0	3.2	12.9	83.9	0	0	0	31
	s	0	0	5	60	20	15	0	20
Relative % for mature									
		-3	-2	-1	0	1	2	3	n
	d	0	0	0	96.4	3.6	0	0	55
Relative % for regenerating									
		-3	-2	-1	0	1	2	3	n
	t	0	4.0	8.0	84.0	4.0	0	0	25
	s	0	0	0	34.5	65.5	0	0	29
	d 'D'r	0	0	0	44.4	3.7	51.9	0	27

In BFT 3 when API codes a polygon as having a subdominant proportion of senescent stems 20 per cent are actually a trace and 15 per cent of polygons possess no senescent stems. When API has coded a polygon as being subdominant in regenerating stems 65.5 per cent of cases were overestimated by one. Where API has labelled a polygon as dominant in regeneration 51.9 per cent of cases were overestimated by two classes.

Broad forest type Four – Stand comprised of a majority of trees which do not exhibit progressive Jacobsian ageing. More than 50 per cent of trees in indeterminate classes between EM and LM due to setbacks such as competition, fire, damage etc. SMR cannot be confidently assessed either in the field or by API. Examples of these forest types are:

E. crebra and/or *E. melanophloia* woodland
C. citriodora, E. crebra woodland on drier ridges
E. racemosa mid-high woodland to open-forest in Cooloola area

Table A1.2.7 Results for broad forest type four

Relative % for Senescent proportion									
		-3	-2	-1	0	1	2	3	n
	t	0	27.3	12.1	60.6	0	0	0	33
	s	0	0	20	46.6	33.3	0	0	15
Relative % for Mature proportion									
		-3	-2	-1	0	1	2	3	n
	d	0	0	0	94.3	5.7	0	0	53
Relative % for Regenerating proportion									
		-3	-2	-1	0	1	2	3	n
	t	0	0	7.1	92.9	0	0	0	42
	s	0	0	0	44.4	55.5	0	0	9
	d	0	0	0	52	4	44	0	25

BFT 4 polygons coded as subdominant in the senescent proportion are overestimating 33.3% of cases whereby they should be labelled a trace, while 20% of cases are underestimated by one, where they should be labelled dominant in senescent stems. Where polygons are labelled as subdominant in regeneration 55.5% of cases have been overestimated by one, while polygons coded as dominant in regeneration have been overestimated by two in 51.9% of cases.

Broad forest type Five – Stand consisting of eucalypt species with special ageing characteristics or dominant in non-eucalypt species. Examples of these forest types are:

E. moluccana open-forest to woodland
Stands dominant in *Lophostemon* spp, *Syncarpia* spp, *Angophora* spp etc.

Vegetation types such as Rainforest, Melaleuca, Coastal Complex, etc are not considered part of this class.

Table A1.2.8 Results for broad forest type five

Relative % for senescent proportion									
		-3	-2	-1	0	1	2	3	n
	t	0	5.26	10.5	84.2	0	0	0	19
	s	0	0	0	80	20	0	0	5
Relative % for mature									
		-3	-2	-1	0	1	2	3	n
	d	0	0	0	96	4	0	0	25
Relative % for regenerating									
		-3	-2	-1	0	1	2	3	n
	t	0	10.0	15.0	75.0	0	0	0	20
	s	0	0	14.3	42.9	42.9	0	0	7
	'D'r	0	0	0	68.4	15.8	15.8	0	19

In BFT polygons labelled as subdominant in regeneration, 42.9 per cent of cases have overestimated the polygon by one, where the polygon should be labelled with only possessing a trace.

APPENDIX 1.3 Field Surveys In Dry Sclerophyll Forest

With the aim of producing a set of decision rules for delineating old growth, research was conducted in dry sclerophyll forests across SEQ. Field studies were concentrated in Detailed Yield Plots (DYPs) and Native Forest Permanent Plots (NFPPs) established by DPI–Forestry (QDPI Forest Service 1995).

The first DYPs were established in the 1950s and all trees greater than 20 cm dbh were tagged in an area of 0.4 ha . All DYPs established since metrication are 0.5 ha in area. Tree attributes recorded include species, dbh, height, and merchantability class. Plots have been re-measured at approximately 5 year intervals. In the 1980s a Grimes Crown Score (index of crown size, position and leaf area) was recorded for all trees >40 cm dbh. Since 1993, all stems >10 cm dbh, regeneration within sub-plots, presence and distribution of hollows, and soil information has been recorded in both newly established NFPPs and pre-existing DYPs. All plots are now termed NFPPs.

Permanent plots are established according to species associations and site productivity. Four vegetation types are recognised on the basis of the basal area of the dominant species within the plot: wet sclerophyll A and B, dry sclerophyll C and D. Site productivity is based on total basal area and is designated as low, medium or high. This system has been adapted for stratifying the dry forest plots studied to date by including the ‘B’ species of white mahogany and grey gum into the ‘C’ class. The logging, treatment and disturbance (fire and storm) history of each plot is also recorded.

Table A1.3.1 Species associations and site productivity classes used in NFPPs

		Dry ‘C’	**Dry ‘D’**
SPECIES		BRI BBW FRG GRI GRG GTI RBW SGU SPG WMY	GBX NRI
PRODUCTIVITY	LOW	<10	<8
(BA ha^{-1})	MED	10-16.9	8-13.9
	HIGH	17+	14+

Field surveys were conducted within recently measured NFPPs. The growth stage of each tree within the plot was recorded. The size class distribution and growth stage proportion (SMR) was calculated and compared within species/productivity classes and logging history. Grimes crown scores were compared with growth stage classes in some plots.

Field surveys were also made within SUIDs of known logging history. At least 50 trees were selected using the Bitterlich prism sweep method and tree attributes recorded.

Both visual and API assessments of SMR are based on the proportion of total crown cover of individual trees in each maturity class. Whilst the measurement of crown area of each tree in a plot or prism sweep is impractical, dbh could be used as a surrogate for crown area if a proven relationship between the two was evident. This hypothesis was first tested in wet and moist forests by comparing crown diameter (measured in at least 2 directions) with dbh in individuals of varying maturity class. A linear relationship was found in *Eucalyptus pilularis* and *E. siderophloia*. Crown area relationships were similarly studied in some dry forest species.

Field data was supplemented by DYP/NFPP data stored in the 'qfrcs' database and down loaded for further analysis. This has enabled data from plots that have not been field surveyed to be incorporated into the current dry forest study. Sites visited and DYP/NFPP data downloaded to produce stand tables are listed below (table A3.10 –A3.11):

Table A1.3.2 Total field sites and DYP/NFPP data used in the study to generate stand tables

State forest		DYPs/NFPPs		Prism sweep
No.	Name	Field Survey	Data base	Sites
0012	Thinoomba	2		1
0012C	Cherbourg	5	17	
0028	Coominglah		3	
0054	Bania	6		4
0057	St. Mary	7	11	
0057B	Nour Nour	2		
0309	Enoggera	2		3
0343	Squirrel Creek	4		
0616	Lockyer	1		11
0632	Marodian		2	
0958	Bauple		11	
0986	Yabba	1		
1239	Mapleton	4		
1294	Warrah	2	8	5
1344	Mt. Walsh			1
1355	Dundas	1		1
Total field sites visited		37		26
Total sites in data analysis		37	52	26

Table A1.3.3 Field studies within dry forest plots (* – stand tables in NFPPs were calculated from the qfrcs database)

	Native forest permanent plots					Prism sweeps	
Vegetation Code	Productivity Type	Stand Table*	Grimes Score	Crown diameter	SMR	Crown diameter	SMR + Stand Tbl
C	H	27	2	3	15	2	12
	M	30	1	5	5	2	11
	L	3	0	1	1	0	1
D	H	6	1	0	3	1	2
	M	4	1	0	1	1	0

Results

Size class distribution

Stand tables were constructed for vegetation and productivity classes with dbh size class intervals of 10 cm from 10 to 100 cm. Figures A1.1–A1.3 suggest that there is no distinction in stand structure between logged and unlogged stands on medium or high productivity sites.

Growth increment

Annual growth increments were downloaded from the qfrcs database. Increments are calculated from the dbh measures of tagged trees since plot establishment. The data set was therefore restricted to long established DYPs (Figure A1.4). The most productive sites were in the Bauple and St. Mary State Forest.

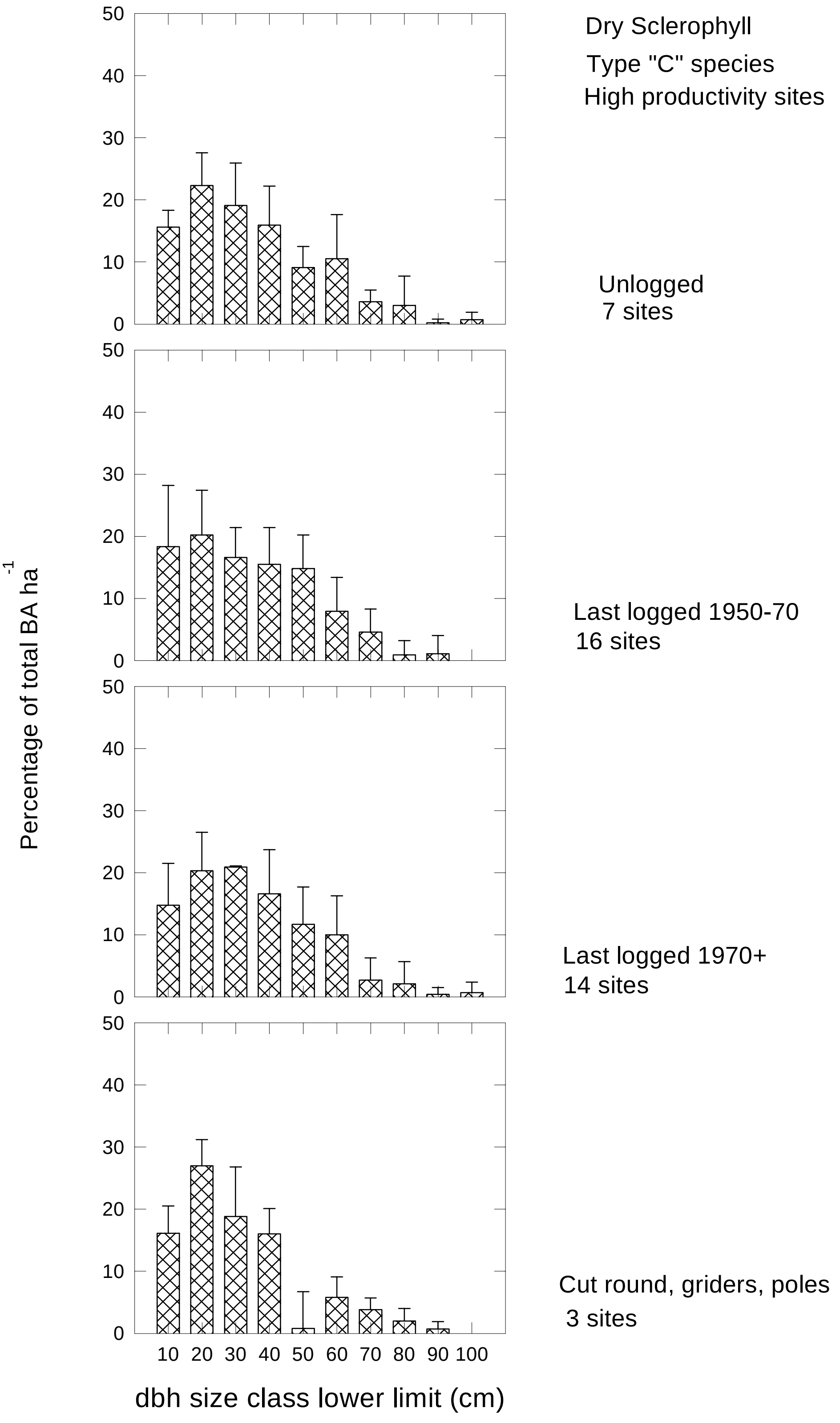


FIGURE A1.1 Size class distribution of high productivity, dry schlerophyll forest (type C).

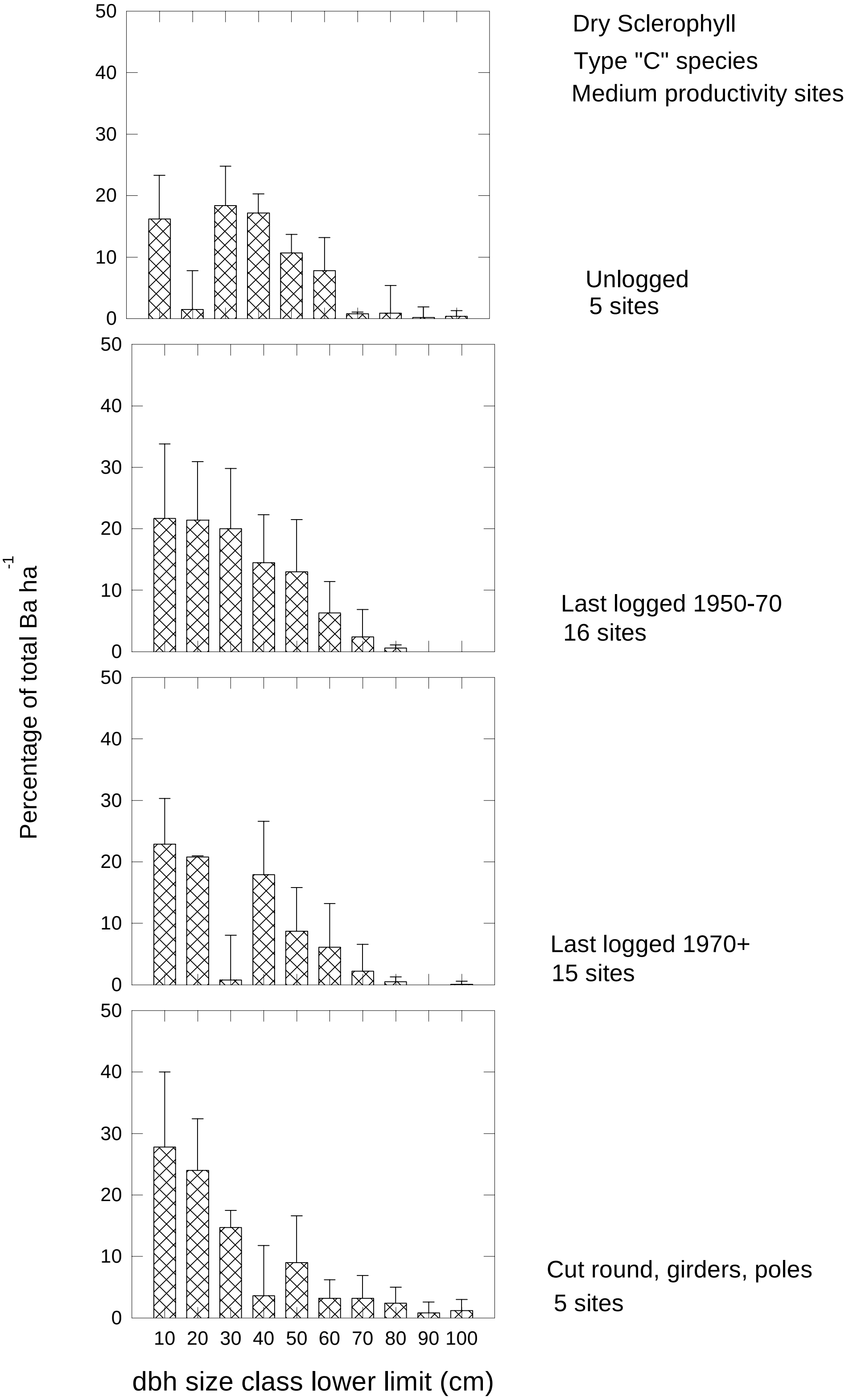


FIGURE A1.2 Size class distribution of medium productivity, dry schlerophyll forest (type C).

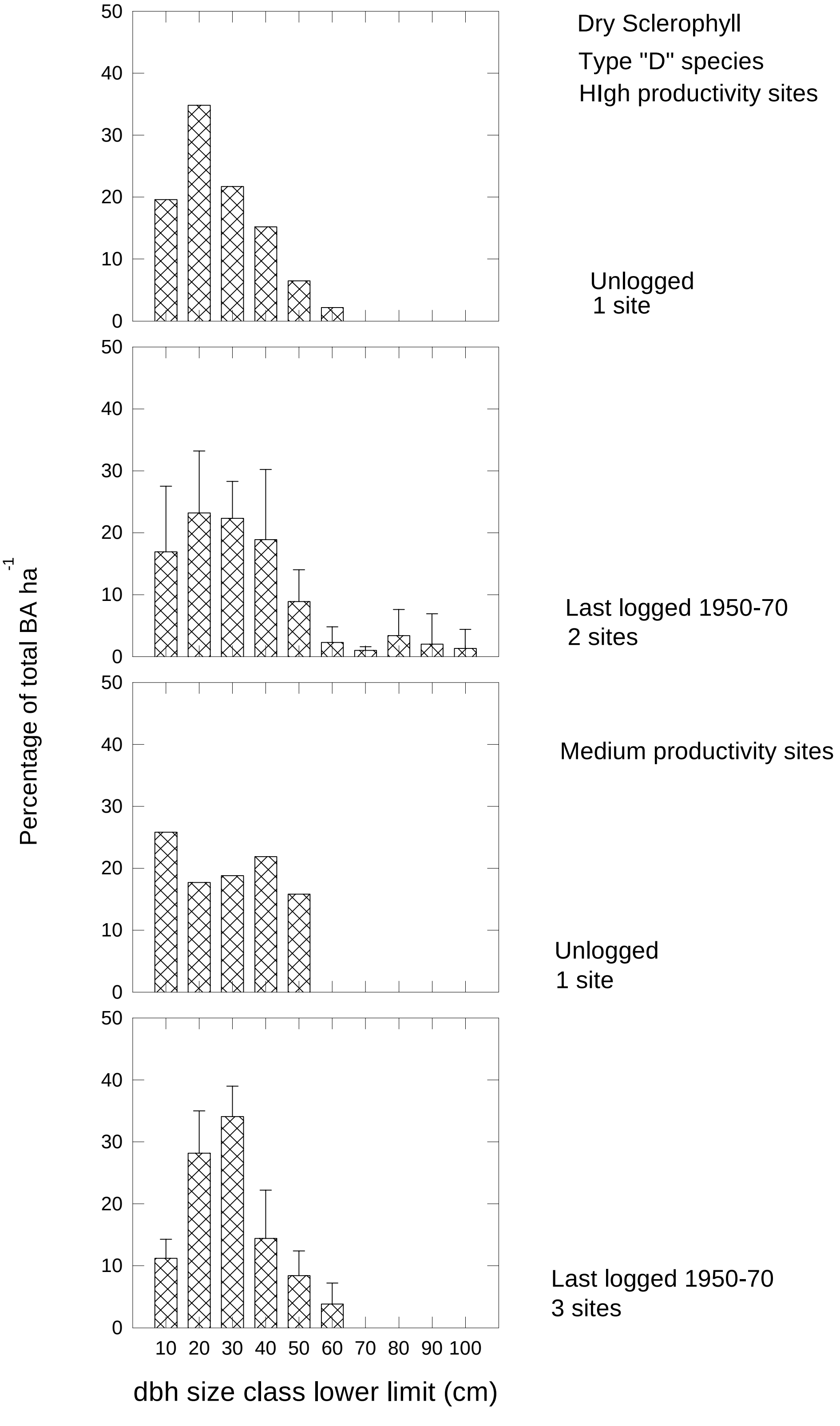


FIGURE A1.3 Size class distribution of high prductivity, dry sclerophyll forest (type D).

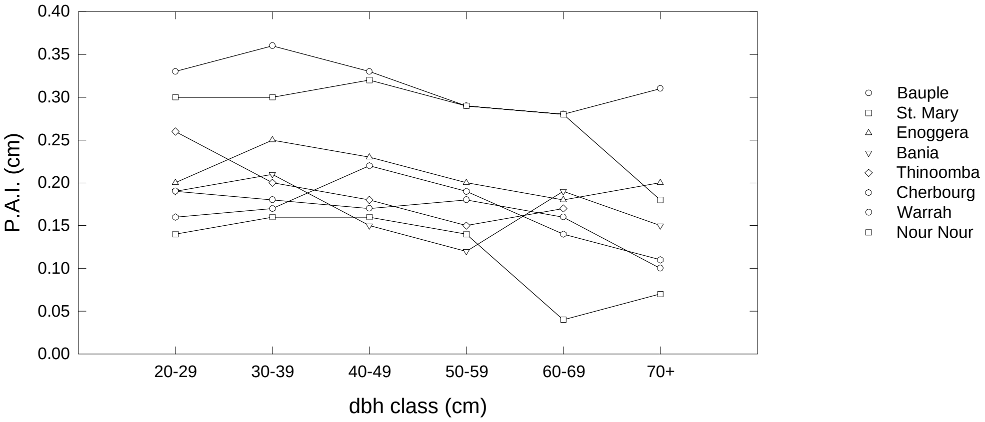


FIGURE A1.4 Per annual increment cm (PAI) in detailed yield plots within State forests of SEQ

Growth stage relationships

SMR proportions of total basal area per hectare were calculated. Figures A3.5 and A3.6 suggest that there is no significant difference between logged and unlogged sites within 'C' species high productivity sites. Insufficient data has been collected to date in vegetation class 'C' on medium productivity sites and class 'D' for analysis.

Crown area relationships

Crown and stem diameter was compared in bloodwoods (*E. intermedia, E. trachyphloia*), ironbarks (*E. siderophloia, E. crebra, E. fibrosa subsp. fibrosa*), *E. acmenoides*, *C. citriodora, Angophora leiocarpa.*

Figure A3.7 indicates crown area relationships within species groups; combined over all sites. There is a wide range of both crown diameter and growth stage for any particular stem size. The lack of relationship between growth stage and crown diameter is particularly evident in the ironbark species with mature to overmature individuals evident at stem sizes of 40 cm.

The bloodwood and spotted gum groups were subdivided into productivity classes and the crown ratio calculated by linear regression (Figure A3.8):

Table A1.3.4 Calculated crown ratios for the bloodwood and spotted gum groups

SPECIES	SITE	CROWN
	PRODy	RATIO
Bloodwoods	H	19
	M	11
Spotted gums	H	9
	M	18
Ironbarks	H	25
	M	18

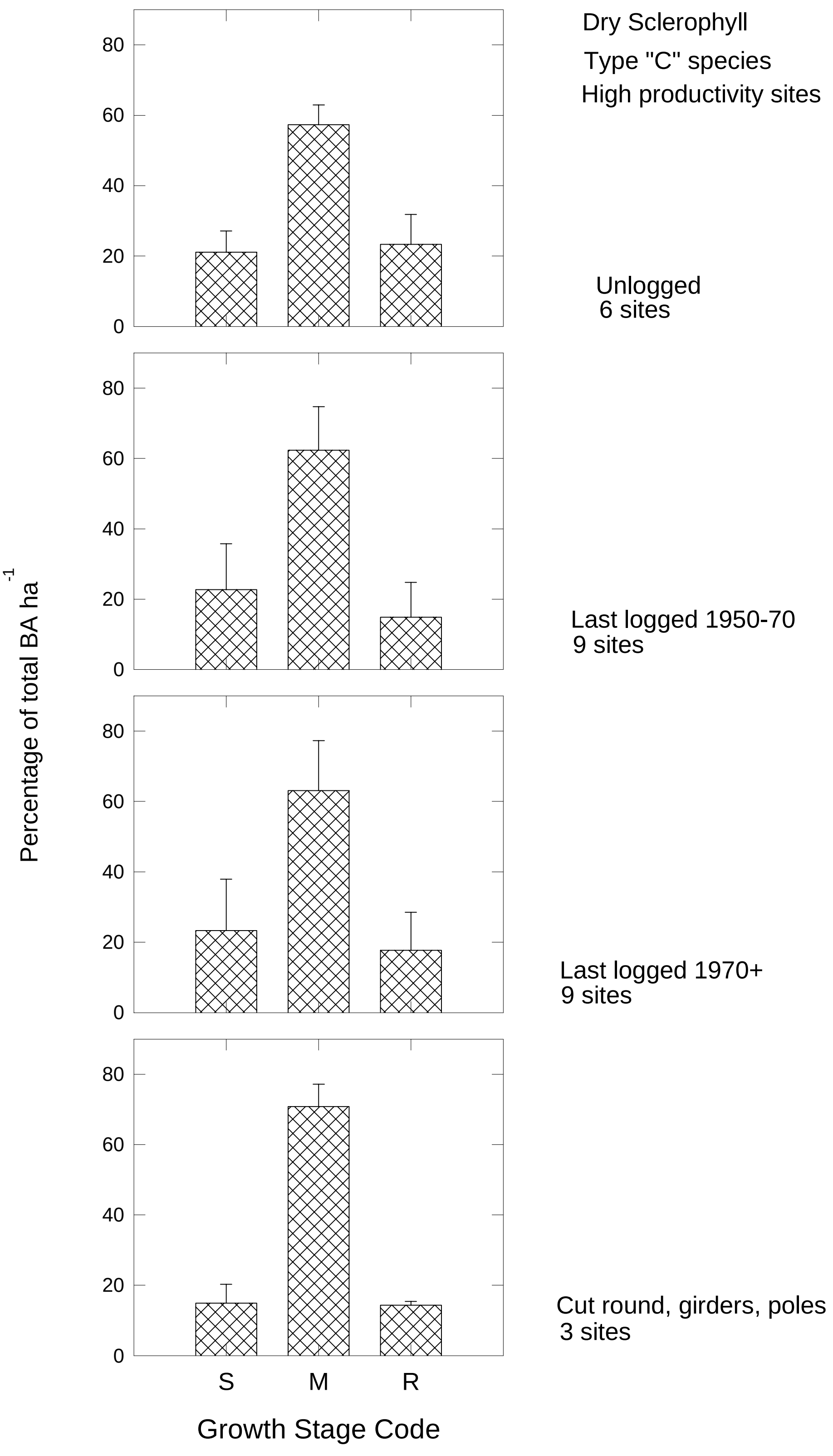


FIGURE A1.5 Growth stage distrubution of dry sclerophyll, high productivity forest (type C)

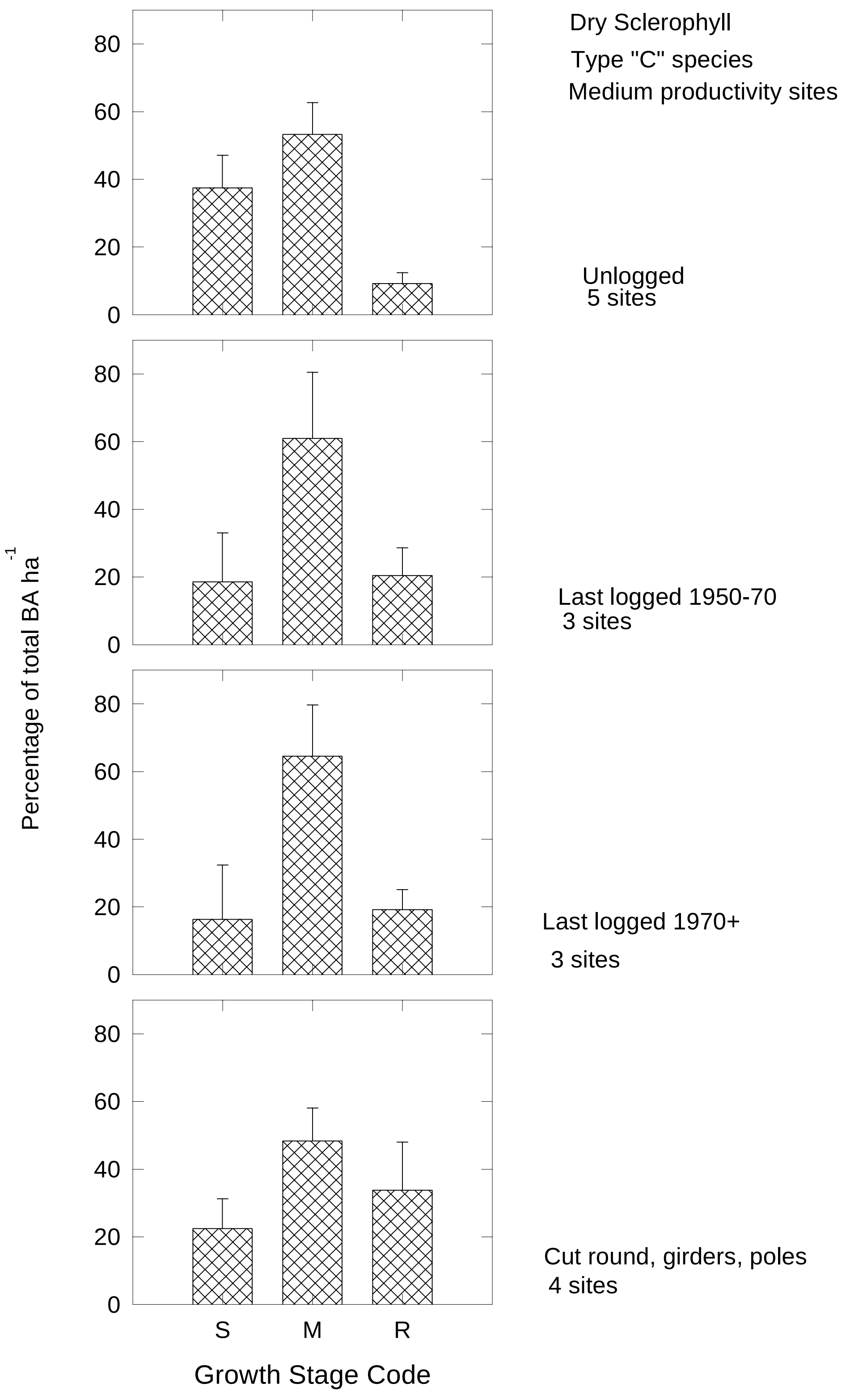


FIGURE A1.6 Growth stage distribution of dry sclerophyll, medium productivity forest (type C)

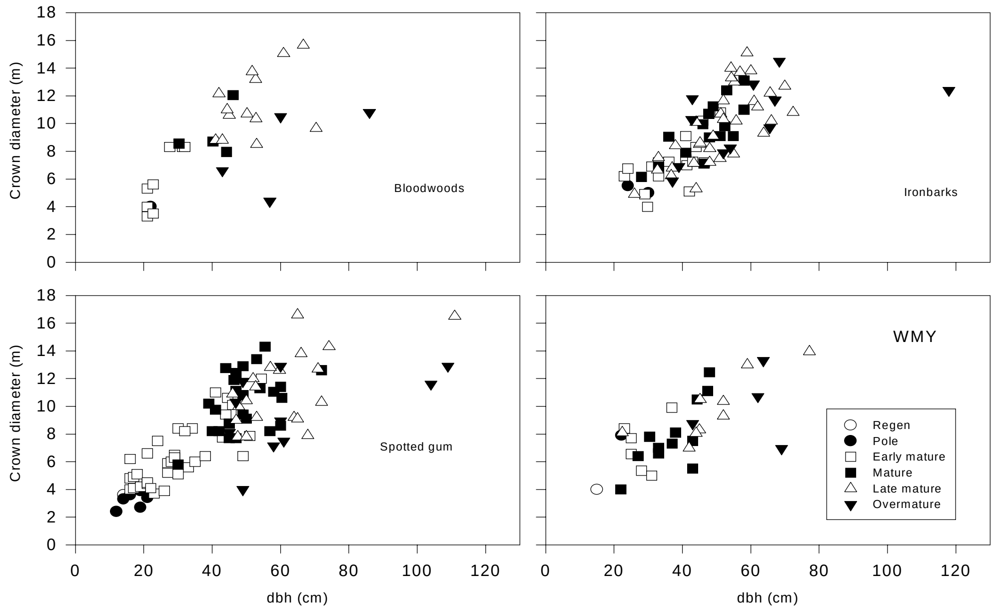


FIGURE A1.7 Relationship between tree dbh, crown diameter and growth stage in dry schlerophyl forest.

Crown ratios calculated by Jacobs (1955) were found to vary with stand denisty and tree age, being high in open grown and young stands, and lower in closely spaced and old stands. A crown ratio close to 18 was found in free-growing young trees. A species difference was also found with *Eucalyptus camaldulensis* .and *Eucalyptus propinqua* having a crown ratio of 13 and 20 respectively.

Results from the present study show a difference with site productivity with a higher crown ratio on more productive sites, except in the case of spotted gums where the reverse is the case.

Conclusions

Access to both NFPP sites and the qfrcs database has proved to be a significant resource for the study of forest structure. Growth staging of all individuals within 0.5 ha plots, as well as prism sweeps, has meant that a far larger database has been assembled than was produced in the wet and moist forests within the Nambour pilot study(See *interim report*).

Analysis indicates that the relationships found for stand structure, growth stage proportions and stem/crown diameter in wet and moist forests are not evident in the dry forest. The lack of relationship, or inconsistency in the case of species/crown ratio data, requires further investigation. Insufficient data has been collected in the 'D' vegetation class, i.e. *E. propinqua*, *E. crebra* communities, and no conclusions can yet be made.

The NFPPs and SUIDs analysed during this study cover a wide geographical area, and it may be inappropriate to group sites by the species/basal area method used. Other surrogate measures of site productivity such as maximum dbh, maximum height, or soil type and depth could be used to stratify site data. Soils information is currently recorded by QDPI Forest Service staff. Access to this information is now available, but yet to be incorporated in the current analysis. Present indications suggest that growth staging alone is insufficient to delineate old growth stands in dry forests. It is therefore important to consider the disturbance history of a particular site. NFPP plots could form the basis for future work in validating disturbance data currently held in the Area Information System in the case of logging and silviculture, grazing leases and fire records. NFPPs currently record the years of logging, treatment, storms and fire. The number and volume of logs removed from the plot are also recorded and can be extracted from the database. Field surveys in areas surrounding NFPPs of known disturbance history would determine the intensity and extent of such activities.

The study concluded that the nature of these forests, as reflected by their mixed age composition warranted separate decision rules in the mapping process. Therefore a more liberal approach was adopted whereby stands containing a trace of senescing trees were still considered as likely old growth candidates.

APPENDIX 2 RELATED RESEARCH

APPENDIX 2.1 Applying The Old Growth Concept To Non-Eucalypt Communities

Introduction

The generally accepted concept of old growth is derived from studies of Douglas-fir forest in the Pacific North-West of the United States. The concept is not restricted to the chronological age of a forest but involves a suite of structural, functional and aesthetic characteristics. In Australia, old growth forests have been defined by the National Forest Policy Statement as 'forest that are ecologically mature and have been subjected to negligible disturbance'. The forests that we intuitively describe as old growth typically have large, old trees, are structurally complex and lack evidence of human disturbance. Old growth forests are, by their very nature, rare and therefore of intrinsic value. They are generally characterised by high levels of biodiversity and provide habitats for specific flora and fauna. The public perception of such forests is one of timelessness and wilderness value.

The identification and mapping of old growth is generally achieved by seeking measurable attributes that are surrogates for those values that cannot be objectively quantified. In the case of eucalypt forests, Jacobs (1955) described distinctive growth stages within a 'normal development sequence' from seedling to late mature and senescence to classify trees with forest stands. These morphological growth stages are relatively easy to identify in tall and/or wet eucalypt forests where tree age can be correlated with size, as measured by diameter at breast height (dbh) or crown diameter, and the presence of features such as broken shaping limbs, crown retraction and branch death (See interim report). However, individuals that are growth restricted by competition from neighbouring trees or by low environmental site quality may not be readily categorised by growth stages. In these situations, trees of similar diameter may vary greatly in age and growth potential. The Jacobsian relationship between tree age and stem and crown morphology does not necessarily apply for dry sclerophyll forest, and is even more tenuous for non-eucalypts with widely differing morphology and physiology. Thus, while chronological age correlates with the expression of old growth characteristics, it does not determine them.

The old growth concept in non-eucalypt forest

Burgmann (1995) notes that an old growth forest is not necessarily defined by the presence or absence of old trees, stags or logs, they do not necessarily house species that depend on them exclusively, or are necessarily rich or diverse in species. Rather, each old growth forest type will have a set of characteristics that distinguish it from other forest types and from earlier developmental stages within a particular forest type. In non-eucalypt forests it is necessary to determine the successional stage which has characteristics that are perceived as being of value, and therefore worthy of conservation. Such stages may not necessarily be the oldest, or show evidence of negligible disturbance. For example, biodiversity in heathlands is closely linked to fire regimes with highest floristic species richness occurring in the immediate post-fire period (Specht 1994). It is unlikely that a single attribute could be found to determine old growth status across a range of non-eucalypt types.

In determining the old growth status of non-eucalypt stands, the concept of ecological maturity is hindered by the limited data available on plant and community processes. The prime indicator of old growth forest status for most stands may be the absence of unnatural disturbances. Disturbance at many spatial scales is central to the ecology of most, if not all, old growth forests, and this is especially true of Australian forest where fire is the single most important factor determining the ecological dynamics of most forests (Burgmann 1995). Old growth forests are not static, but are shaped by periodic random disturbances. The disturbance regime is defined by the average time between events, the variability of the time between events and the spatial extent of each disturbance. Ages of old growth forest stands quoted in the literature usually represent an estimate of the time since the last major disturbance. Old growth forests typically show relatively long intervals between disturbance. The age at which a stand may be designated as old growth depends on the forest type, the site qualities and the disturbance regime.

Vegetation classification and the non-eucalypt forest types in SEQ

Vegetation patterns at the bioregional scale are designated as regional ecosystems (REs). REs integrate vegetation mapping units recognised at 1:100 000 with major environmental variables, in particular geology, rainfall and land form. A total of 140 REs are currently recognised in the South-East Queensland bioregion, of which 40 are non-eucalypt forest (>30 per cent crown cover?).

The major broad non-eucalypt forest types to be considered for old growth assessment are rainforest and coastal communities dominated by melaleuca. Stands dominated by brush box or turpentine, with riparian species and mangroves occuring to a limited extent.

Old growth assessment of non-eucalypt forests

In the South-East Queensland old growth assessment process, an API SMR code denoting the proportion of senescent, mature and regrowth crowns was applied to all forest areas with >30 per cent CCP of eucalypt species. An ‘other species’ code was used to distinguish forest with a significant proportion of non-eucalypt species i.e. brush box, rainforest , turpentine, lantana, plantations, melaleuca, casuarina, wattle and coastal complexes. All other areas were classed as non-forest (N) and include areas with <30 per cent canopy cover, agricultural crops, linear features <100 m wide, non-contiguous forest stands on private land of <50 ha and on State Forest <20 ha, heathlands, and areas of highly fragmented or disturbed vegetation.

Rainforest

An ecological continuum exists between rainforest and other forest ecosystems. Mixed forests, a transitional stage between non-rainforest and rainforest, consist of an overstorey of non-rainforest trees above a closed subcanopy dominated by rainforest species. In differentiating these mixed forests from rainforest, a precise definition must be formulated. In order to standardise vegetation classification, a national operational definition of rainforest has been proposed as follows (Environment Australia 1997):

> *Rainforest in Australia is forest where the tallest tree stratum is usually closed, that is, with a crown cover of greater than 70 per cent.*
> *Rainforest plant species are adapted to regenerating in the low light conditions experienced under the closed canopy of in localised gaps caused by recurring*

disturbances which are part of the natural rainforest ecosystem, and are not dependent on fire for successful regeneration.
Ecologically, rainforest includes rainforest species and the late successional stages of transitional and seral communities with non-rainforest emergents in their older growth stages, where the community is of similar botanical composition to mature rainforests in which these emergents are absent.

This definition may be refined by adopting a threshold percentage of non-rainforest emergents that may be present in the rainforest canopy. For example, in the current assessment of old growth in South-East Queensland rainforest is defined as having less than 30 per cent emergent eucalypts in the overstorey, while the Broad Old Growth Mapping Project (BOGMP) identified rainforest using the State Forests of NSW definition, i.e. forest with a closed canopy with less than 10 per cent crown cover of pyrophytic emergents (National Parks & Wildlife Service 1996).

A total of 30 Regional Ecosystems in the South-East Queensland biogeographic region are dominated by rainforest species and these communities range from vine thickets to complex rainforest. No attempt to delineate rainforest areas on the basis of structure and/or floristic composition was made during the API old growth assessment. Eucalypt emergents were growth staged and a code denoting the presence of a rainforest canopy added. Stands with less than 30 per cent eucalypts were classed as 'rainforest'. A disturbance code was applied to polygons signifying the presence of regrowth, logging or weed invasion.

Coastal communities

In coastal South-East Queensland, nine REs dominated by non-eucalypt species have been identified. During the old growth assessment process such areas were identified by API as melaleuca, coastal complex or non-eucalypt forest. In mixed stands, the eucalypt component was growth staged and a species code denoting the presence of other types applied. The delineation of API polygons in coastal communities proved difficult due to the overall mosaic of forested/non-forested patches with varying proportions of eucalypts and other species. Applying both API growth staging and disturbance codes to such areas proved problematic and was probably inappropriate due to the complexity of forest structure and composition.

Other non-eucalypt forest types

The growth staging of other non-eucalypt forest types by API in previous studies has been disputed. The Joint Old Growth Forest Project (JOGFP) used API to apply structural attribute codes to eucalypt and species with 'similar growth stage morphologies' (i.e. *Syncarpia glomulifera*, *Lophostemon confertus* and *Angophora* spp). However, the assumption that turpentine and brush box could be classified into growth stages by API did not hold as these species were found to have dense, full pointed or regular crowns irrespective of growth stage (RACAC 1997). In the current SEQ assessment an API 'other species code' was applied to these stands.

Of the remaining non-eucalypt types, riparian zones were delineated by API but neither growth stage or disturbance codes applied. Such linear features were often below the limit of mapping resolution.

Suggested approach to identifying and mapping forest condition in non-eucalypt communities

Given the difficulties in assigning a growth stage to non-eucalypt species, this approach should not be attempted from API. However, the absence of unnatural disturbance is an indicator of old growth forest status, and is appropriate for the determining forest condition in non-eucalypt communities. The effects of logging, grazing and fire can be determined from API and a coding system based on the visual impact of such disturbances applied to each polygon.

Information pertaining to logging history, grazing leases, occurrence of wildfires and prescribed burning across all vegetation types has been collated from State forest and national park records for South-East Queensland. The spatial extent and frequency of such disturbances therefore can be added as a GIS layer for mapping disturbances within non-eucalypt communities.

Whilst such information is unavailable for private land tenure, it can be assumed that disturbances, particularly logging and treatment for pasture production, has occurred. This hypothesis has been confirmed by both API and field observations made to date within eucalypt forest stands and is presumed to hold for non-eucalypt stands. A minimum area of 20 hectares has been used for API assessment based on the principle that small areas of fragmented forest surrounded by cleared land will not be viable in the long term.

API structure and disturbance coding, where available, and disturbance records form the primary GIS layers in the assessment of forest condition. Vegetation mapping will be used to delineate the non-eucalypt Regional Ecosystems, and their current extent. A further consideration in the evaluation of forest condition is that of patch size. This is particularly relevant in coastal communities where fragmentation due to urban development and the encroachment of more frequent fires will degrade forest condition. Patch size must be sufficient to both preserve biodiversity and allow practical management within any reserve design.

The identification of ‘old growth’ non-eucalypt forest will rely on field assessment and expert knowledge to determine the relevance of particular disturbance regimes to a particular RE. Emphasis should be placed on the time to recovery of dominant species and communities as a whole to a particular disturbance, and the frequency of both natural and unnatural disturbance events. Disturbance matricies will produce an index of forest condition rather than an ‘old growth’ assessment *per se*.

In the case of rainforests, it should be noted that stands in South-East Queensland have a long history of utilisation (Swain 1928, Francis 1981) and that changes in floristic composition will have occurred. The ecological maturity of such stands may be compromised, yet the wilderness quality may be high. Documenting such changes is beyond the scope of the current project and therefore old growth status, or forest condition, can be applied only in general terms. Field observations suggest that the API disturbance codes provide an accurate description of disturbance effects on forest canopy structure and can be used to distinguish between intact and degraded types.

The suggested approach for assessment of forest condition in non-eucalypt stands is summarised as follows:

Forest type	**Basis for forest condition assessment**
Wet eucalypt	API growth stage, disturbance history
Dry eucalypt	API growth stage, disturbance history
Rainforests	API disturbance, disturbance history
Coastal complex	Disturbance history
Other non-eucalypt	Disturbance history

APPENDIX 2.2 Forest Growth Stage Class Modelling

Summary

Data collected in the initial pilot study and from the Detailed Yield Plots / Native Forest Permanent Plots (DYP/NFPP) plot study was used in a separate study aimed at developing a linear model for the prediction of growth stage from diameter. The study was conducted by Trevor Parker, a private consultant commissioned by Forest assessment to investigate if a relationship exists between growth stage and diameter across a range of species. The study investigated a range of models and concluded that a generalised linear model (GENMOD) was the most appropriate analysis system for this form of analysis. Growth stage classes were aggregated from six to 3 growth stage classes due to limitations in sample ranges for most species.

Results/ Conclusions

Table A2.2.1 gives the results for the analysis and shows that the most reliable species useful for the prediction of growth stage included *E.saligna*, *E.pilularis* and *E.grandis.* In the case of *E.pilularis* sufficient data was available for the prediction of six growth stages using individual tree trunk diameter measurements. The model appears to be particularly useful for prediction of growth stage in species associated with wetter higher site quality forests, and will form a useful tool in the classification of forests.

Table A2.2.1 Accuracy of GENMOD for the linear and quadratic fit

The percentage of incorrect predictions is shown in ascending order in the two right hand side columns.

Species	Linear fit	Quadratic fit
E.saligna	0.17	0.32
E.pilularis	0.22	0.32
E.grandis	0.23	0.32
E.racemosa	0.24	0.35
S.glomulifera	0.27	0.37
E.microcorys	0.30	0.41
E.propinqua	0.31	0.46
E.intermedia	0.32	0.43
E.acmenoides	0.34	0.46
E.siderophloia	0.38	0.54
L.confertus	0.43	0.54

APPENDIX 2.3 Assessing Tree Age A Preliminary Comparison of Three Methods

Introduction

In order to understand the successional processes and long term dynamics of forest ecosystems it is necessary to obtain information on tree age and growth rates. Relative estimates of tree age can be made by comparison of individual trees within a stand by observing age related features such as size and crown form, this provides little information however on the rate of successional processes or the time scale of forest dynamics. Absolute age of individual trees can be used to calibrate the rate of successional processes within the canopy and provide essential time scales for sound forest management.

The most widely applied method of measuring tree age is the counting of annual growth rings across a radius of the cross section of the tree bole. Most dendrochronological work in Australia has been in cold climate areas where seasonality has engendered the annual production of distinct bands of early and late wood. However, this method is of limited applicability to Australian east coast eucalypts due to the lack of distinct, annual growth rings in many species (Ogden 1978, Turner 1984).

Queensland's Department of Primary Industries (DPI) Forestry has established a series of Detailed Yield Plots (DYP) in native hardwood forests over the last 46 years in order to determine, amongst other things, individual tree and forest stand growth rates. DYPs are located in commercial forest areas and are managed no differently from the surrounding forest. Periodic measurements of the plots have provided data enabling calculations of Periodic Annual Increment (PAI) of diameter at breast height (dbh). PAI and species MAI can be used to estimate the age of individual trees from the plots.

Another method is the use of radiocarbon dating. Samples are taken from the heartwood centre of the tree and dated through the analysis of C^{14} levels in the cellulose. Radiocarbon dating has been used extensively to register and confirm dendrochronology work (Gill 1971, Ogden 1978, Turner 1984).

A preliminary comparison was made by dating 10 samples by the three different methods.

Methodology

Recently logged (last four years) DYPs were identified from the DPI Forestry DYP database. Logged trees were identified and sample trees chosen. Eight trees were chosen to provide a variety of species from different areas. Two cypress pine, *Callitris glauca*, trees which were not from within a DYP plot, were also dated by radiocarbon dating and ring counting. Cross-sectional discs were cut from the stumps to provide radiocarbon dating samples and ring counting surfaces.

1) Ring Counting

Discs were planed smooth and lacquered with satin estapol to provide an even surface of highlighted rings. Where a complete disc was available the longest diameter was marked. The diameter at right angles to this was also marked, providing four radii along which the latewood rings were counted. Two operators counted independently two radii each, using a 3x magnifying glass. Sample 3 had only a small section of a disc and was once by each operator. Samples 4 and 10 had only half a disc each, resulting in two radii being counted. Sample 5 had three radii counted due to defect to part of the disc. Results are shown in Table A2.4.1.

2) Radiocarbon Dating
Samples of approximately 60 grams were taken from the centre of the discs. Care was taken to take wood unaffected by rot or parasite. The position of the sample wood from the centre was recorded. Preparation and radiocarbon dating of the samples was done by the Quarternary Dating Research Centre at the Australian National University, Canberra using the Radiocarbon Calibration Programme developed by Stuiver and Reimer (1993). Results were recorded as *calibrated age* BP $\pm$ *error*, where BP is 1950 (2a). These ages were adjusted for sample distance from the centre by extrapolation of tree growth rate from the remainder of the tree, and updated from 1950 to date of last dbh measure (2b). No adjustment was made for the difference between sample (stump) height and breast height. Results are recorded in Table A2.4.1.

3a) Individual Tree Growth Data Extrapolation
Each sample tree had from 25 to 42 years of periodic dbh measurement. From these measurements periodic annual increment (PAI) can be determined. By assuming that each tree has been growing at this rate of diameter increment for the whole of its life an estimate of it age can be made. Results are listed in Table A2.4.1.

3b) Detailed Yield Plot Analysis
DPI Forestry analysis of their DYP data has established diameter growth trends for individual tree species, (Queensland Forest Service 1992), in the form of PAI per 10 cm dbh classes. A subset of the data, and the calculated PAI per diameter class, from plots in the coastal forests was used to calculate age per 10 cm class. Sample tree ages were then estimated from their last dbh measurement. Table A2.4.2 shows the cumulative ages per diameter class per species and Table A2.4.1 shows the sample tree estimates.

Results and Discussion

Table A2.4.1: Tree age as estimated by three methods: 1) Counting of annual growth rings, 2a) and 2b) Radiocarbon dating of tree core, 3a) and 3b) Extrapolation of tree and species diameter growth data.

2b) Radiocarbon dates are adjusted from 1950 to date of last dbh measure, and for distance of sample from centre.

The counting of growth rings was consistent between operators with less than 10% difference except for trees 2, 5 and 7. However, most discs showed only slight differences between early and latewood bands in colour and density. This may have resulted in narrower latewood bands being uncounted due to their indistinctness. The two cypress pine samples showed rings more clearly with distinct, narrow, dark latewood bands.

Samples 1, 2, 3, 5, 7 and 8 showed little similarity between ring counting, radiocarbon dating or growth plot analysis. Samples 4 and 6 had agreement between radiocarbon dating, 2b), and extrapolation of species growth data, 3b). Samples 9 and 10 (no growth plot data), showed no agreement between ring counting and radiocarbon dating.

Table A2.4.1 Growth trend data for sample species showing PAI, years of growth and cumulative years per 10cm dbh classes.

Derived from Queensland Forest Service, Resources Bulletin No.6, 1992, page 115

Sample No.	**DYP Plot**	**Tree No.**	**Species**	**Last DBH cm**	**1) Age by ring count**	**2a) Age by Radiocarbon dating**	**2b) Adjusted Radiocarbon date**	**3a) Age by DYP data 1**	**3b) Age by DYP data 2**
1	5	PO19	Grey Gum *Eucalyptus propinqua*	54.60	107±7	240±70 BP	302±70	187	212
2	5	PO62	Red Bloodwood *E. intermedia*	49.20	40±7	300±70 BP	377±70	836	194
3	8	35	Rose Gum *E. grandis*	82.50	108	140±60 BP	219±60	467	343
4	8	57	Rose Gum *E. grandis*	53.00	79±2	191±47 BP	254±47	144	243
5	213	70	Grey Ironbark *E. siderophloia*	51.40	68±13	240±60 BP	283±60	162	193
6	213	73	Grey Ironbark *E. siderophloia*	43.80	61±5	100±58 BP	144±58	1135	162
7	213	67	White Mahogany *E. acmenoides*	52.90	91±14	220±50 BP	284±50	128	181
8	213	60	Tallowwood *E. microcorys*	48.80	61±5	190±59 BP	250±59	95	128
9	–	–	Cypress Pine *Callitris glauca*	28.25	84±3	134±59 BP	193±59		
10	–	–	Cypress Pine *C. glauca*	60.50	169±16	192±67 BP	247±67		

Table A2.4.2 Growth Trend Data

	Dbh classes								
Grey Gum	0–10cm	10–20cm	20–30cm	30–40cm	40–50cm	50–60cm	60–70cm		
DBH PAI	0.197	0.252	0.319	0.292	0.307	0.194	0.161		
Years	50.76	39.68	31.35	34.25	32.57	51.55	62.11		
Cumulative	50.76	90.44	121.79	156.04	188.61	240.16	302.27		
Red Bloodwood	0–10cm	10–20cm	20–30cm	30–40cm	40–50cm	50–60cm	60–70cm		
DBH PAI	0.202	0.28	0.27	0.259	0.277	0.176	0.195		
Years	49.50	35.71	37.04	38.61	36.10	56.82	51.28		
Cumulative	49.5	85.21	122.25	160.86	196.96	253.78	305.06		
Rose Gum	0–10cm	10–20cm	20–30cm	30–40cm	40–50cm	50–60cm	60–70cm	70–80cm	80–90cm
DBH PAI	0.084	0.233	0.337	0.435	0.443	0.496	0.409	0.239	0.129
Years	119.05	42.92	29.67	22.99	22.57	20.16	24.45	41.84	77.52
Cumulative	119.05	161.97	191.64	214.63	237.20	257.36	281.81	323.65	401.17
Grey Ironbark	0–10cm	10–20cm	20–30cm	30–40cm	40–50cm	50–60cm	60–70cm		
DBH PAI	0.223	0.336	0.335	0.315	0.238	0.262	0.174		
Years	44.84	29.76	29.85	31.75	42.02	38.17	57.47		
Cumulative	44.84	74.6	104.45	136.2	178.22	216.39	273.86		
White Mahogany	0–10cm	10–20cm	20–30cm	30–40cm	40–50cm	50–60cm	60–70cm		
DBH PAI	0.295	0.305	0.327	0.308	0.311	0.306	0.271		
Years	33.90	32.79	30.58	32.47	32.15	32.68	36.90		
Cumulative	33.9	66.69	97.27	129.74	161.89	194.57	231.47		
Tallowwood	0–10cm	10–20cm	20–30cm	30–40cm	40–50cm	50–60cm	60–70cm		
DBH PAI	0.279	0.343	0.474	0.539	0.613	0.425	0.408		
Years	35.84	29.15	21.10	18.55	16.31	23.53	24.51		
Cumulative	35.84	64.99	86.09	104.64	120.95	144.48	168.99		

The trends shown by the comparison of the three methods for samples 1 to 8 are:

- Ring counting results in consistently lower estimates of tree age than radiocarbon dating or extrapolation of growth plot data.
- Radiocarbon dating, 2b), showed higher results than species growth data, 3b), for samples 1,2,5,7 and 8. The Rose Gum samples 3 and 4 where the species growth data estimates were greatly influenced by the 119 year period in diameter class 0–10 cm (see table A5.6).
- Individual tree growth data extrapolation showed the most widely fluctuating results with least similarity to the other methods

Sample 6, whilst showing agreement between 2b) and 3b) also showed the largest range of all estimates from 61±5 years to 1135 years.

Radiocarbon dating is unreliable below about 200 years (Dr. John Head *pers comm*) where the carbon isotope ratios become muddied by increased human activity. Many of the radiocarbon estimates were in the vicinity of 200 years and should be treated with circumspection.

The results show little correlation between the methods of estimating tree age and no conclusive age can be given for any of the samples.

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