Identification of Old Growth Forests

Field Identification on Private Land

Department of Environment and Conservation (NSW)

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Purpose and use of this recommended old growth identification process

The aim of this guide is to provide a summary of background information and a recommended assessment process and criteria for the identification and validation of old growth forest at a site level on private lands. Its purpose is for use by consent authorities in determining old growth forest, and for validating and prioritising old growth forest for property vegetation plans and private land incentives.

The guide uses as a basis the criteria and process which derived the Candidate Old-Growth (COG) and other successional stages forest map layer for north eastern NSW, a project undertaken as part of the Comprehensive Regional Assessment (CRA) process. Information in this guide is drawn from previously published and unpublished reports and research papers undertaken as part of the Natural Resources Audit Council's Joint Old-Growth Forests Project (1995), the Broad Old Growth Mapping Project (1996), and both the Aerial Photographic Interpretation (API) and Old-Growth Forest related projects (including COG mapping) undertaken as part of the upper and lower north-east NSW regions CRAs (RACD 1997, 1999a).

The guide outlines the history of the definition and mapping of old-growth forest in north-eastern NSW and provides material on the methodology used to map COG forest during the CRA process. Of particular importance is detailed information on the API pathways and coding methodologies used in deriving the map layer. Summary text or tables are included where appropriate, however readers are referred to project reports listed in the reference section for full details on methodological descriptions.

This guide should be used as a summary document providing an overview of factors relevant to old growth forest mapping on private land and how issues relating to clearing applications and the COG layer should be addressed in the assessment process. It aims to provide the information necessary to facilitate a site level verification process.

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1 Old-Growth Forest Definition

The definition and delineation of old-growth forest has been a contentious and protracted debate with a number of similar, but variable in detail, definitions of old-growth forest having been used in the past.

There have been several different mapping projects undertaken within north-east NSW to either trial and refine old-growth mapping methodology and/or map the distribution of old-growth forest. The most recent being the old-growth related projects carried out for the upper and lower north-east regions of NSW as part of the Comprehensive Regional Assessment (CRA) process. For the purpose of these projects and mapping of old-growth forests on private lands the following definition is relevant.

The Joint ANZECC/MCFFA[1] National Forest Policy Statement Implementation Sub-committee (JANIS) (1997) definition was the operational definition used for identifying old-growth forest in NSW for the CRA process. This was:

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

In applying this interpretation to a forest ecosystem, the following principles apply:

- Ecological maturity is defined by the characteristics of the older growth stages.
- Where data is available on the structural, floristic, and functional qualities that would be expected to characterise an ecologically mature forest ecosystem, this data should be used in the assessment of the significance of disturbance effects.
- 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.

1.1 Characteristics of Old-growth Forest

The above definition includes the key criteria of 'ecological maturity' and 'negligible disturbance'. These concepts have been central to the old-growth definition and the following is a brief discussion of these concepts.

1.1.1 Ecological Maturity

Ecological maturity can be assessed at a variety of scales ranging from forest communities, their component species or individuals, as well as ecological processes such as nutrient cycles and stream flows (McCarthy and Burgman 1995).

The above authors identify that ecological development and vegetation succession is intricately linked to definitions of ecological maturity. They discuss ecological maturity in relation to two sorts of models of change:

[1] ANZECC – Australian and New Zealand Environment and Conservation Council. MCFFA – Ministerial Council on Forestry, Fisheries and Aquaculture.

i. Equilibrial dynamics where change i.e. forest development is essentially linear and progressive and ecologically maturity is defined by the ‘climax community’ which is determined largely by prevailing climate and a balance between variables such as mortality, recruitment and growth (McCarthy and Burgman 1995). A typical example of such a climax community is the Douglas fir forests of Northern USA.

ii. Non-equilibrial dynamics where disturbance effects result in more complex cycles between stages in forest development compared with the linear model. An understanding of disturbance regimes is important to understanding forest maturation and states of ecological maturity especially in the Australian context.

The literature refers to attributes or components which may define ecological maturity rather than simply relying on periods of time since prior disturbance to define a ‘mature state’. These are often discussed under the headings of structural, compositional and functional attributes (Dyne 1992, McCarthy and Burgman 1995, Love *et. al.* 1995, Clode and Burgman 1997).

Structural attributes refer to the physical characteristics of trees, stands of trees and how these are distributed throughout the forested landscape. Structural attributes are the easiest aspects to measure in a forest. Examples of the structural attributes of old-growth forest include many large, old trees, dead standing trees or stags, fallen logs, and deep multi-layered canopy (Franklin *et al* 1981, Scotts 1991, Milledge 1993). Forest growth stage is one feature which has been used to measure ‘ecological maturity’, and this can be mapped using available aerial photography.

1.1.2 Compositional features

A unique characteristic of old-growth is that the rates of vegetation change (in structure and composition) are slow when compared to other developmental stages (Burgman 1996). Changes in the floristic composition of the overstorey and understorey are related to vegetation succession and to disturbance regimes. Detailed data on changes in floristic composition are not available for most vegetation types.

Compositional components of old-growth forests referred to in the literature consist of epiphyte, vertebrate and invertebrate assemblages, the relative abundances of different species, and the presence of features that provide habitat for various species. Many of these structural and compositional attributes provide important fauna habitat (refer to Table 1).

Table 1: Examples of native vertebrate fauna dependent on hollows likely to occur in North East NSW (adapted from Lamb *et. al*. (1998) and Gibbons and Lindenmayer (1997)).

Common name	Species	Guild
Possums and Gliders		
Feathertail glider	*Acrobates pygmaeus*	1
Sugar glider	*Petaurus breviceps*	1
Squirrel glider	*Petaurus norfolcensis*	1
Yellow-bellied glider	*Petaurus australis*	1
Greater glider	*Petauroides volans*	1
Common brushtail possum	*Trichosurus vulpecula*	1
Mountain brushtail possum	*Trichosurus caninus*	1
Common ringtail possum	*Pseudocheirus peregrinus*	1
Eastern pygmy possum	*Cercartetus nanus*	1
Brush-tailed Phascogale	*Phascogale tapoatafa*	1
Scansorial mammalian fauna		
Spotted-tailed quoll	*Dasyurus maculata*	3
Yellow-footed antechinus	*Antechinus flavipes*	1
Brown Antechinus	*Antechinus stuartii*	1
Dusky Antechinus	*Antechinus swainsonii*	1
Bush rat	*Rattus fuscipes*	1
Microchiropteran bats		
Yellow-bellied Sheathtail bat	*Saccolaimus flaviventris*	2
White-striped Freetail bat	*Nyctinomus australis*	2
Beccari's Freetail bat	*Mormopterus beccarii*	2
Eastern Freetail bat	*Mormopterus norfolkensis*	2
Southern Freetail bat	*Mormopterus planiceps*	2
Eastern Long-eared bat	*Nyctophilus bifax*	2
Lesser Long-eared bat	*Nyctophilus geoffroyi*	2
Gould's Long-eared bat	*Nyctophilus gouldi*	2
Greater Long-eared bat	*Nyctophilus timoriensis*	2
Chocolate Wattled bat	*Chalinolobus morio*	2
Hoary Wattled bat	*Chalinolobus nigrogriseus*	2
Gould's Wattled bat	*Chalinolobus gouldii*	2
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	2
Greater Broad-nosed bat	*Scoteanax ruepellii*	2
Eastern Broad-nosed bat	*Scotorepens orion*	2
Inland Broad-nosed bat	*Scotorepens balstoni*	2
Little Broad-nosed bat	*Scotorepens greyii*	2
Large Forest bat	*Vespadelus darlingtoni*	2
Eastern Forest bat	*Vespadelus pumilus*	2
Southern Forest bat	*Vespadelus regulus*	2
Little Forest bat	*Vespadelus vulturnus*	2
Large-footed Myotis	*Myotis adversus*	2
Avifauna		
Nankeen kestrel	*Falco cenchroides*	1
Peregrine Falcon	*Falco peregrinus*	3
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	3
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*	3

Common name	Species	Guild
Sulphur-crested Cockatoo	*Cacatua galerita*	2
Galah	*Cacatua roseicapilla*	2
Double-eyed Fig-Parrot	*Cyclopsitta diopthalma*	2
Rainbow Lorikeet	*Trichoglossus haematodus*	2
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	2
Musk Lorikeet	*Glossopsitta concinna*	2
Little Lorikeet	*Glossopsitta pusilla*	2
Australian King-Parrot	*Alisterus scapularis*	1
Crimson Rosella	*Platycercus elegans*	1
Red-rumped Parrot	*Psephotus haematonotus*	1
Turquoise Parrot	*Neophema pulchella*	1
Powerful Owl	*Ninox strenua*	3
Southern Boobook	*Ninox boobook*	1
Barking Owl	*Ninox connivens*	3
Sooty Owl	*Tyto tenebricosa*	3
Masked Owl	*Tyto novaehollandiae*	3
Barn Owl	*Tyto alba*	2
Australian Owlet-nightjar	*Aegotheles cristatus*	1
Laughing Kookaburra	*Dacelo novaeguineae*	1
Sacred Kingfisher	*Todriamphus sanctus*	1
Forest Kingfisher	*Todriamphus macleayii*	1
Dollarbird	*Eurystomus orientallis*	1
Welcome Swallow	*Aegotheles cristatus*	2
Scarlet Robin	*Petroica multicolor*	1
Flame Robin	*Petroica phoenica*	1
Tree Martin	*Hirundo nigricans*	2
White-throated Treecreeper	*Cormobates leucophaea*	1
Red-browed Treecreeper	*Climacteris erythrops*	1
Brown Treecreeper	*Climacteris picummus*	1
Striated Pardalote	*Pardalotus striatus*	2
Spotted Pardalote	*Pardalotus punctatus*	1
Buff-rumped Thornbill	*Acanthiza reguloides*	1
Southern Whiteface	*Aphelocephala leucopsis*	1
Dusky Woodswallow	*Artamus cyanopterus*	1

Guilds are classified as: '1' denotes territorial species with small or medium home ranges, '2' denotes species that may breed in clusters and 3 denotes species with very large home ranges.

1.1.3 Functional features

Functional properties of old-growth forest include characteristic levels of gross and net productivity, nutrient cycles, high litter production levels in dynamic equilibrium, low or negative biomass increment, low rates of change in composition, structure and function, reduced transpiration and high soil moisture and dry season stream flows (Burgman 1996, Dyne 1992, Clode and Burgman 1997, Milledge 1993, Scotts 1991).

In the Australian context these functional attributes have not usually been measured in broad old-growth mapping projects as they involve complex and detailed measurements over time. Such measurement is not practical for large numbers of vegetation types or forest ecosystems over large geographic areas.

1.1.4 The role of disturbance

Old-growth forest definitions use the key criteria of negligible disturbance. However, disturbance is a feature of old-growth forests in that the age that a forest displays old-growth characteristics is dependent on a number of factors such as the forest type and site qualities as well as the characteristics of recent disturbances.

The type of disturbance, the frequency of disturbance events, the intensity or severity of an event and the interval between events as well as the spatial extent of events are all important components in a disturbance regime for any area or vegetation type. Disturbance regimes are intricately associated with vegetation succession and with the maturation of trees, stands of trees and of forests as a whole. For a more detailed discussion of the concepts surrounding ecological succession and disturbance see Clements (1949), Attiwil (1994), JOGFP (1996) and McCarthy and Burgman (1995).

Types of disturbance relevant to the identification of old-growth forest include logging, severe fire, and other activities such as mining etc. Moderate to intense disturbance regimes will alter the structure, composition and function of a forest stand and remove it from an old-growth state.

2 Methodology used in identifying Old-growth Forest

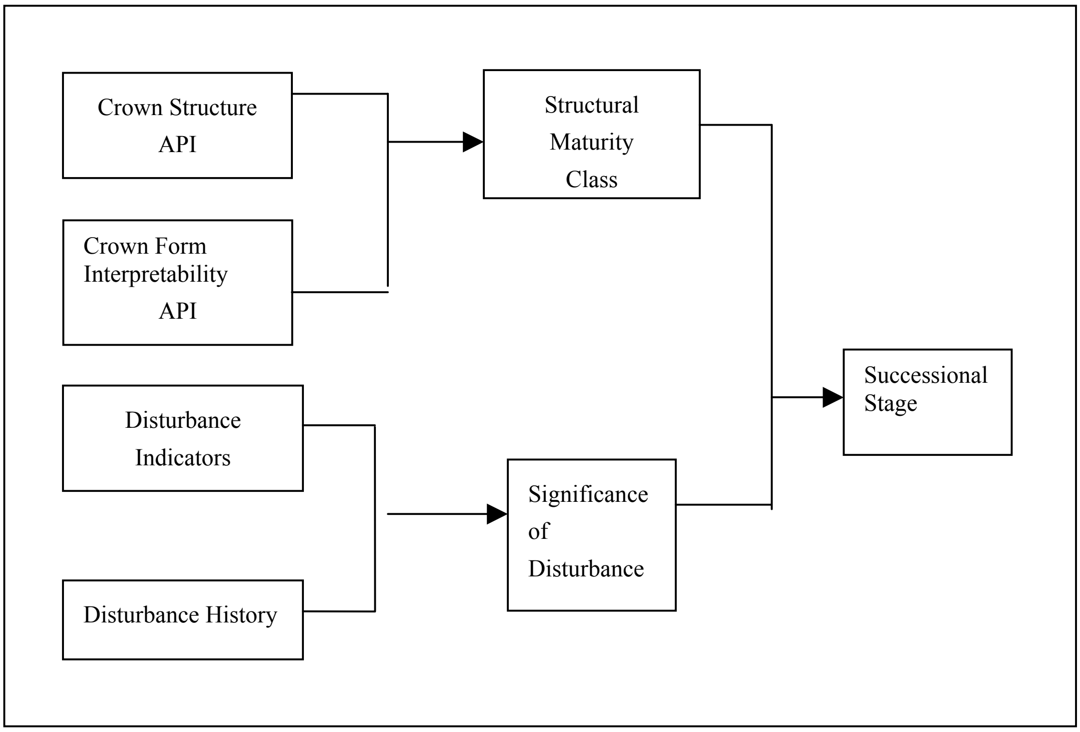
The processes for mapping and identifying old-growth forest are outlined schematically in Figure 1 below. The pathway involves three steps. The first step assigns a measure or surrogate measure of the ecological maturity of the forest to forest stands. This is referred to as 'structural maturity' and is based on aerial photograph interpretation (API) of crown forms. The second step involves assigning a disturbance significance level to forest stands using mapped historical records and qualitative API assessment. The final step assigns old-growth status to forest stands based on their structural maturity and their assessed disturbance level. When information on the spatial extent of rainforest and post-photo disturbance is taken into account, the resultant layer defines old-growth forest and other successional stages over the entire mapped forest.

2.1 Aerial Photographic Interpretation

The mapping of Candidate Old-Growth (COG) forest on private lands was derived primarily through API based on an agreed methodology to determine forest growth stage (estimate of relative age or structural maturity) and disturbance factors. For a full description of this process refer to published material from the Broad Old-Growth Mapping Project (BOGMP) report and the CRAFTI[2] API manual (NPWS 1996, CRAFTI 1997).

Aerial Photography Interpretation (API) mapping

Figure 1: General outline for steps involved in Identification of Candidate Old-Growth Forest and other successional stages during the Upper and Lower North East CRA process.



[2] CRAFTI stands for 'Comprehensive Regional Assessment Forest Type Inventory'. CRAFTI was designed as part of the CRA to provide raw data on floristics, growth stage and distribution of eucalypt forests for upper and lower north-east NSW.

2.1.1 Growth Stage

Jacobs (1955) recognised five stages in the morphological development of eucalypt species that could be recognised in the field. These are juvenile, sapling, pole, mature and overmature. Woodgate *et. al.* (1994) refined the description of these stages and recognised two more stages being early mature and late mature.

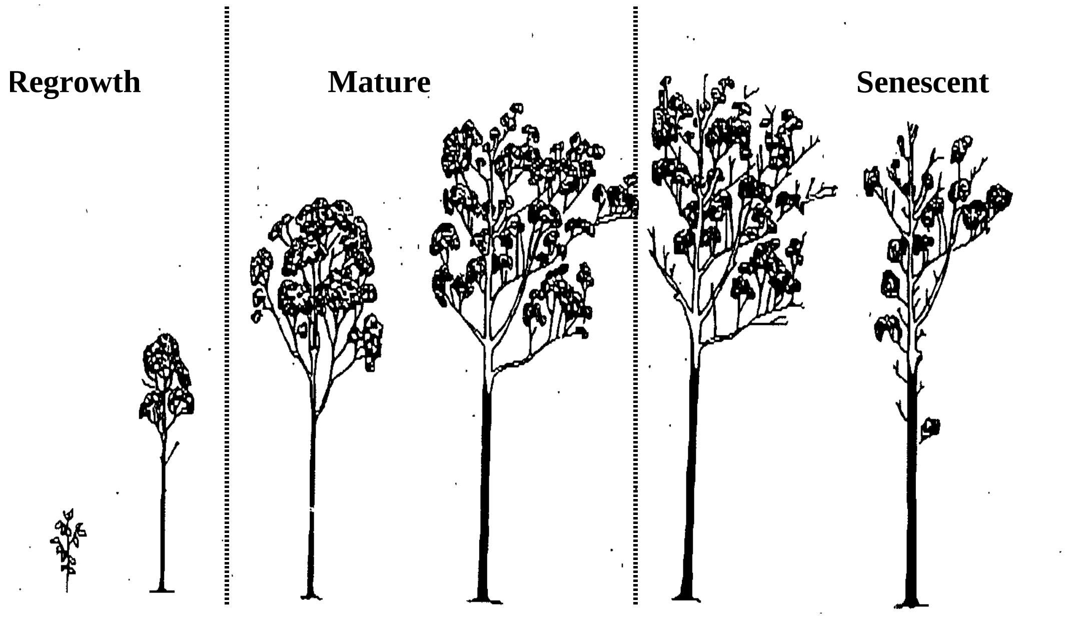
For the purpose of mapping forest structure by the interpretation of aerial photographs Woodgate *et. al.* (1994) amalgamated these seven stages into three as follows: regrowth, mature and senescing. Table 2 below outlines the relationship between different growth stage classifications.

Recognition of growth stages, particularly in the field, is aided by an understanding of six of the seven growth stages with the juvenile stage being excluded as being too small to be of consequence. These growth stages are a fundamental aid to the categorisation of forest stands (trees) into the three amalgamated major growth stages **- regrowth, mature, senescing -** used in the CRA mapping project.

Table 2: Relationship between growth stage classifications

<table>
<tr><th>COG Growth Stage (used in BOGMP and CRAFTI)</th><th>Minor Growth Stage from Woodgate et al (1994)</th><th>Jacobs (1955) Growth Stage</th></tr>
<tr><td></td><td></td><td>Juvenile</td></tr>
<tr><td rowspan="2">Regrowth</td><td>Sapling</td><td>Sapling</td></tr>
<tr><td>Pole</td><td>Pole</td></tr>
<tr><td rowspan="2">Mature</td><td>Early Mature</td><td rowspan="3">Mature</td></tr>
<tr><td>Mature</td></tr>
<tr><td rowspan="2">Senescing</td><td>Late Mature</td></tr>
<tr><td>Overmature</td><td>Overmature</td></tr>
</table>

Table 3: Characteristics associated with different growth stages and discernible from API of 1:25,000 colour photography (NSW NPWS 1996).

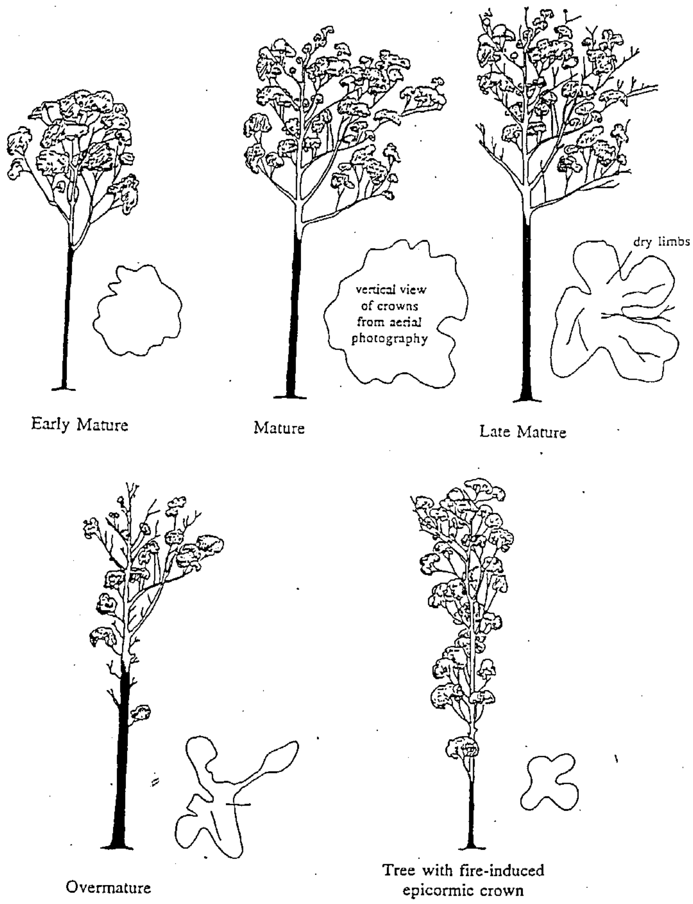


<table>
<tr><td>Characteristics detectable from aerial photographs</td><td colspan="3">Pointed Crowns
Low height</td><td colspan="2">Rounded crown. Crown opening up view Crown limbs still Healthy

Reasonable height compared to regrowth</td><td colspan="2">Good proportion of limbs dead or dying but not fallen
Stagheaded. Crown view no longer rounded

Crown shapes may be distorted due to exposure</td></tr>
<tr><td>API growth stages (nor Jacobs)</td><td colspan="2" rowspan="3">Regeneration</td><td rowspan="3">Regrowth</td><td colspan="2">Mature</td><td colspan="2">Not detectable from API</td></tr>
<tr><td>API growth stage (Jacobs)</td><td colspan="2">Regeneration Mature</td><td colspan="2">Senescing</td></tr>
<tr><td>Modified Jacobs (1999)</td><td>Early Mature</td><td>Mature</td><td>Late Mature</td><td>Overmature</td></tr>
<tr><td>Jacobs (1955) growt stages</td><td>Juvenile</td><td>Sapling</td><td>Pole</td><td colspan="3">Mature</td><td>Overmature</td></tr>
</table>

Figure 2: Diagrammatical representation of the morphological relationship between tree shape and crown form as viewed from aerial photographs for the mature growth stages of Jacobs (from Woodgate *et al.* 1994 in NSW NPWS 1996).



The use of colour 1:25,000 scale aerial photographs enables the interpretation of the growth stage of forest stands through the assessment of crown form characteristics of individual trees, groups of trees and forested stands across the landscape (see Figure 2 above). Table 3 above also highlights the fact that there are eucalypt species that do not follow the Jacobs growth stage development sequence and therefore it is difficult to use tree crown form characteristics to discriminate between senescing and mature growth stages. API requires good stereo vision and is a subjective process. Field site assessment will usually be needed to reconcile mapped interpretations with actual ground features. Additional information regarding the field identification of eucalypt growth stages can be found in Appendix 4a.

Table 4 below outlines the primary growth stage classes used during the CRAFTI project and which would apply to any additional API work.

Table 4: Summary of Attribute Codes for Growth Staging

Code	Relative Crown Cover %	
	Regrowth Trees	**Senescent Trees**
tA	<10%	>30%
tB	<10%	10-30%
tC	<10%	<10%
sA	10-30%	>30%
sB	10-30%	10-30%
sC	10-30%	<10%
eN	>30%	no value recorded (as N)

2.1.2 Disturbance

Due to the lack of mapped logging history records on private property, disturbance (negligible or significant) was derived using a different ruleset from that used for public land. In this methodology, additional CRAFTI API indicators were evaluated as significant disturbance. The CRA successional stages derivation used three separate types of disturbance information to assess levels. These were growth stage, relative stand density and specific disturbance indicators. These attributes were determined through the API mapping process for all eucalypt (and related) forest communities on all land tenures. A more detailed description of the relative stand density and disturbance indicators is contained in Appendix 2.

2.1.3. Relative Stand Density (RSD)

Relative stand density (RSD) is the crown cover within each polygon expressed as a percentage of the crown cover of a fully stocked stand for the particular forest type.

3 Field Validation Techniques

Field assessment of forest growth stages is a hierarchical system of assessing and confirming the proportions of each growth stage in any forest stand.

Point to plant methodology

This field method requires measurements of growth stage and canopy at a set number of points along a transect within the application area. It is considered an accurate field verification process. It can also be used for confirmation of growth stage proportions in forest stands when other methods are inconclusive, or for calibration of other methods (discussed below) when different types of forest are encountered.

It should be noted that the difficulty with any field assessment process is the efficacy of the sampling design to account for heterogeneous forests or API polygons. That is, the accountability and survey effort time required to deal with forest and/or polygon variation across the sampling site. Accordingly, the precautionary principle should be taken into account. The above technique should be used in any site visits to assess API growth stage mapping, as described in the next section.

Specific methodologies, minimum survey sampling requirements, analysis of results and site survey proforma sheets are detailed in Appendices 4a – 4c inclusive. Examples of the layout of different point to plant transects in the field are depicted in Appendix 4c as well as Figures 8 and 9 which indicate sample transect orientation and spacing. Sampled area can vary according to site conditions, stand condition, patch size and available resources. It should be noted that the minimum transect length is 270 metres straight line distance and samples an area of approximately 1.3 hectares.

3.1 Recommended process for site identification of Candidate Old-Growth Forest

The following steps are recommended for the review and field identification of Candidate Old-Growth (COG) Forest. The stepped process begins with the CRA map of COG Forest and proceeds to a site survey if sufficient evidence is found to conclude that photograph interpretation error exists or post photograph disturbance of the site has occurred. In some instances the process may be useful in identifying old-growth forest areas that have not been previously mapped or for verification/prioritisation of old-growth forest areas for conservation incentives.

The steps set out below are also shown in the flowchart in Figure 3.

Step 1. Accuracy of CRA COG Forest map layer questioned or area of old-growth forest requires site validation either by landowner or through assessment process.

Step 2. For background information on old-growth forest and concerns with the COG mapping of old-growth forests the landowner should firstly consult the Department of Environment and Conservation (DEC) Natural Resource Management Advisory Series Note 10 'Old-growth Forest'.

If accuracy is still in question the landowner should provide a full description of the land parcel in question detailing the mapping problem and any past disturbances in the area (eg type, start and finish dates of known disturbance activities, location and photos to show recent disturbance events).

Potential concerns/problems with the COG mapping may include post photograph disturbance where the original API mapping on dated photography does not accurately reflect current forest stand structure or include recent disturbances. Additionally, the boundary of COG mapping may be disputed or the classification disputed due to current condition (level and intensity of disturbance). This may include impacts of logging, fire and other disturbances, which have modified the forest structure to such an extent as to 'disqualify' the area from being considered 'old growth'.

Step 3. The assessing officer checks the date of photographs used in the CRAFTI COG mapping for this site against the availability of the latest photography for the site (see Appendix 3). Where later photography is available proceed to Step 4. If Landsat Imagery gross cover change is available this may be used to identify any gross disturbance (eg total clearing).

If no later photography is available for the site a Site Inspection will be needed (see Step 5).

Step 4. Where aerial photography dated later than the time of the claimed disturbance is available for the site, the assessing officer should firstly undertake a desk top API assessment of the site to confirm or reassess forest structure characteristics and disturbance levels as per claims made by the landowner in Step 2.

The assessing officer should consult Table 3 and review the availability of recent photography and reassess forest structure characteristics and disturbance levels on recent photos as per claims made by landowner in Step 2 where it can be shown that the:

1) area of claimed disturbance is 2 hectares or greater (2 hectares approximates the minimal sampling unit area); or
2) area that has been totally cleared (bare earth) is 1 hectare or greater.

From the above steps four possible outcomes are anticipated as discussed below.

Scenario A.
If the revised API clearly identifies that there has been recent (post CRAFTI COG photograph interpretation) clearing or heavy disturbance (using a >50% canopy removal threshold or indicators of bare earth, logging tracks and just scattered remnant trees standing) then these areas can be delineated if they comprise greater than a 1 hectare minimum patch size.

In this example the area previously mapped as COG should be revised and the map polygons (i.e. outer boundary of recent disturbance) delineated so that the original CRAFTI COG map layer can be updated.

Scenario B.
Where there is evidence of disturbance over an area > 2 hectares in size, and in applying the CRAFTI disturbance ruleset disturbance indicators this disturbance is visible by API on recent aerial photographs (eg canopy gaps plus regrowth clusters or native pioneers or woody weeds in combination with the gaps or constructed tracks, signs of past clearing, regrowth etc.) (refer to Appendix 4 Table B), then a Site Inspection is required to verify actual levels and extent of disturbance using methods described in Appendices 4a - 4c.

Scenario C.
Where revised API detects some disturbance indicators but it affects an area less than 2 hectares and appears minimal (or the forest is clearly not disturbed), and the surrounding forest is COG, then it is recommended that the delineation of COG at this site remains unchanged. A site inspection may need to occur to reconcile differences between the API assessment and the landholder but this is anticipated to be an exception rather than the rule.

Scenario D.
This includes areas that have previously not been mapped as part of the CRAFTI mapping project coverage but which local knowledge or a site visits indicates may be old-growth forest. A Site Inspection and application of recommended site survey methodology as set out below should be undertaken. For such areas 10 hectares is the recommended minimum patch size for mapping.

Step 5. Site Survey

Objective. Validate original CRAFTI API assessment of COG Forest for areas > 2 hectares and check accuracy of API by checking mapped polygon coding and line placement (extent of area). Refer to Figure 4 - Site Survey Flowchart.

Key points – Check stand structure (growth stage and site disturbance factors) by using the Point to Plant survey method (refer to Appendices 4a - 4c).

Recommended Process

i) Validating disturbance criteria and their extent throughout the polygon. This assessment should be undertaken with reference to the Site Assessment Flowchart, Site Inspection Guidelines and Site Information Proforma sheets. If any individual disturbance indicators are recorded for six out of 10 or eight out of 15 sampling points (refer to Table C in Appendix 4b and Figure 4) then the surveyed forest area/mapped polygon should be downgraded to another successional growth stage (see Table C).

The above site assessment considers the type and extent of disturbance as well as the intensity and duration of the impact and the likely recoverability of the forest (level and extent of old-growth characteristics disturbed or removed). Where sufficient evidence is documented that the mapped polygon is significantly disturbed (refer to Table C in Appendix 4c), then the forest should be downgraded accordingly (refer to details in Table E in Appendix 4c).

It should be emphasised that non pervasive evidence of disturbance (eg. a track or number of stumps) which indicate some tree removal in the past or a restricted presence of weeds would not be sufficient for a forest stand to be removed from consideration as COG. It must be demonstrated that at least 50% of the overall stand has been affected by the localised disturbances, and that both old-growth structure and function have been compromised.

ii) Validating growth stage. The site inspection should aim to validate the API growth stage ratios (for regrowth and senescent as per Table 4) for the forest stand in question by using the Point to Plant survey method. More information on the site inspection and the methodology to calculate field growth stage associated with the Point to Plant survey technique is presented in Appendix 4b and 4c.

The stand should only be downgraded if the new calculated growth stage code is not tA, tB, or sA as per Appendix 4b Table E.

Steps

Step1.
Area depicted as COG forest on the map layer is questioned at property scale

Step 2 Old-growth Forest Advisory Note has been consulted and areas of concern have been documented ie nature of the differences with the mapping, area where mapping is incorrect including details of disturbance.

For example, where there has been post photo logging or disturbance the landowner should provide documented evidence of the nature/type of the disturbance, the dates (start and finish) of the disturbance and the location of the disturbance in relation to the COG forest mapped area.

Step 3. The assessing officer checks date of disturbance against latest available aerial photos using Appendix 3 as a guide.

Step 4. Where more recent aerial photography is available, the assessing officer uses this most recent API (at similar scale to the CRAFTI work) and undertakes API assessment of recent disturbance (delineate the recently disturbed area) using the following criteria:

a) patches > 2 hectares where >50% canopy removal has occurred and where disturbance indicators are evident over the majority of the mapped polygon.

b) areas > 1 hectare where disturbance has been so intense that only scattered trees or bare earth remains.

API Triggers

Scenario A. API assessment of latest aerial photography unequivocally identifies that the boundary or part of COG has been heavily disturbed (eg. only scattered trees remain or totally cleared)

Scenario B.

Revised API on latest photography does not identify gross disturbance (eg total clearing) but identifies CRAFTI disturbance attributes which potentially exclude the polygons from COG forest status.

This would include:
Disturbance features being a combination of any of the following CRAFTI codes
g + z, g + a, g+w, L, W, s, d ,c
b, o or j, p

Growth stage and RSD feature codes
tC, sC, sB in combination with any of the above disturbance indicators (see Appendix 3 for explanation of codes)
or
e > 30% regrowth or less than RSD = 1 or 2 irrespective of disturbance indicators.

Scenario C

Revised API may detect some disturbance but affects an area less than 2 hectares and appears minimal and surrounding forest is COG.
OR
Revised API supports mapped growth stage and disturbance indicator coding of the original mapping.

Scenario D
New mapping of old-growth forest in previously unmapped areas
Minimum patch size of 10 ha

Actions/What Ifs

(Scenario A →) Polygons delineated, recoded and digitised and data provided periodically to data custodians DIPNR and DEC for official update of CRAFTI and old-growth data layers.

(Scenario B →) Undertake **Site Inspection** to field check the extent of disturbance and assess growth stage.
See Figure 4 Site Survey Flowchart

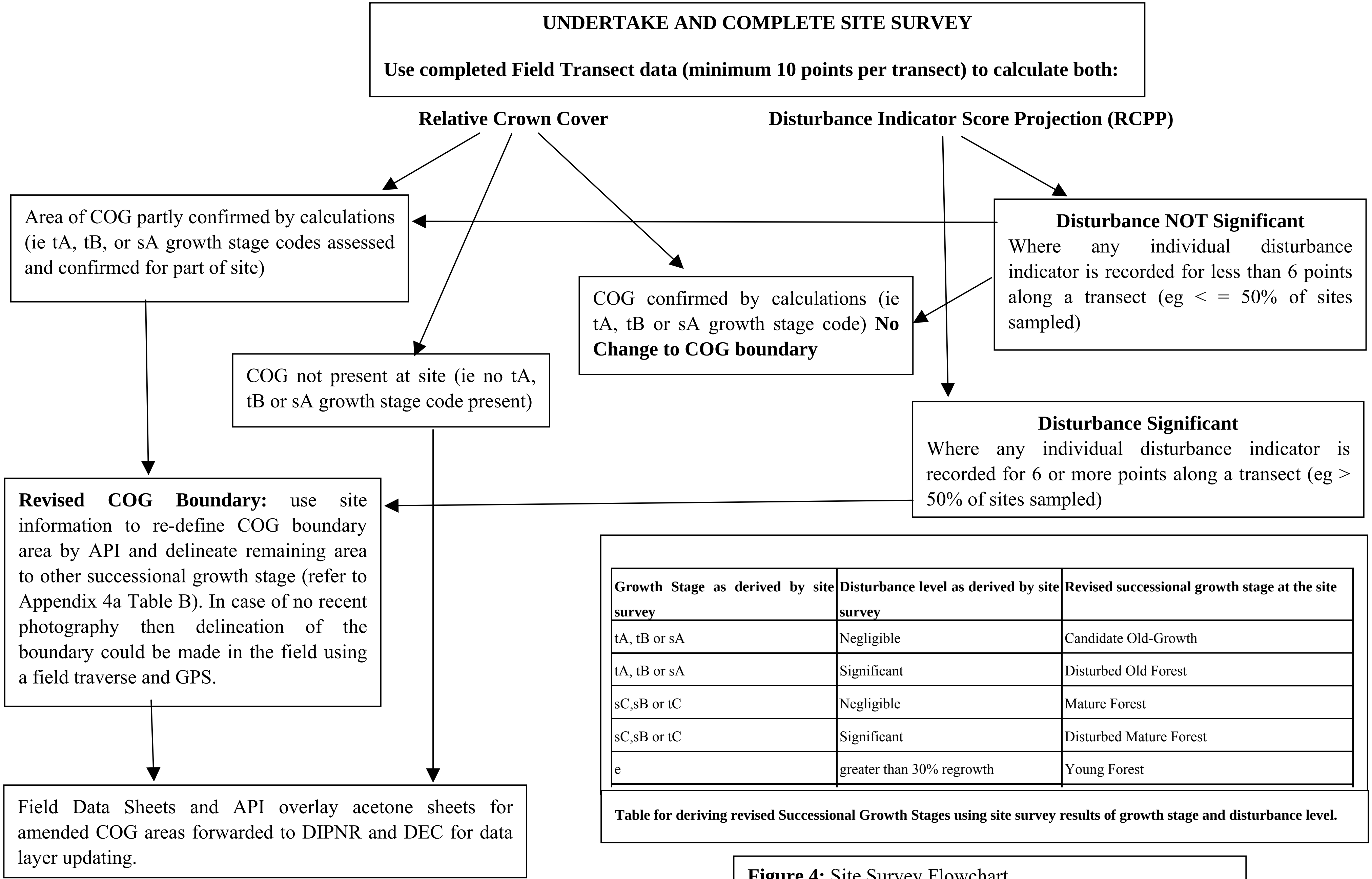
COG Boundary Outcomes

Revised COG boundary (less areas identified as heavily disturbed)

COG boundary verified for site – no change to boundary (may require site inspection in some cases)

New mapped Old-growth area

Figure 3: Process for review of Old-growth Forest on Private property



Growth Stage as derived by site survey	Disturbance level as derived by site survey	Revised successional growth stage at the site
tA, tB or sA	Negligible	Candidate Old-Growth
tA, tB or sA	Significant	Disturbed Old Forest
sC,sB or tC	Negligible	Mature Forest
sC,sB or tC	Significant	Disturbed Mature Forest
e	greater than 30% regrowth	Young Forest

Table for deriving revised Successional Growth Stages using site survey results of growth stage and disturbance level.

Figure 4: Site Survey Flowchart
Successional Growth Stage and Disturbance Indicators

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APPENDIX 1: Glossary of terms and acronyms

API	Aerial Photographic Interpretation.
API pathway	Sequence of decisions and coding relating to API growth staging.
Atypical crown form	Refers to those tree species displaying non Jacobsian developmental characteristics.
Bole	The main stem of a tree.
BOGMP	Broad Old-growth Mapping Project. Broadscale mapping project undertaken to identify likely Old-Growth Forest for the Interim Assessment process.
Compositional Attributes	Biotic or secondary attributes of old-growth forest including features such as the presence of certain indicator species or life forms such as epiphytes as well as a high diversity of fauna and flora species.
Crown	The leaf bearing branches of a tree.
Crown form	The shape or outline of a crown as detected from API. Generally described as being apical (pointed), regular (round) or irregular.
Crown Cover	The vertical projection of the periphery of tree crowns (crowns assumed to be opaque) within a designated area. Crown Cover was estimated in terms of percentage classes of apical, regular or irregular crowns as a proportion of total crown cover.
CRA	Comprehensive Regional Assessment Process.
CRAFTI	Comprehensive Regional Assessment Aerial Photographic Interpretation project undertaken for the UNE/LNE and Southern CRAs.
Dbh/dbhob	Diameter at breast height/diameter at breast height over bark.
Extending crown	Crown containing healthy leaf bundles at the end of branches and where expansion of the crown is still occurring.
Floristic	Pertaining to the plant species composition of an area.
Forest Type	The unit of forest classification based upon overstorey species and structure developed by State Forests of NSW for the forests of NSW. Also known as ‘Baur’ or Research Note 17 forest types.
Forest Ecosystem	The unit of forest classification used for the CRA process and based on an analysis of all floristics not just canopy species.

Functional attributes	Attributes of old-growth forest such as reproduction, nutrient cycling, regulation of water flow and energy flow.
GIS	Geographic Information System. Computer software allowing the storage, retrieval and analysis of mapped and point locality information.
Growth Stage	An estimate of the maturity of a tree based on assessments of indicators of relative age such as tree height, crown form, crown shape and vigour and presence of dead branches. Growth stages were classified under three groups; regrowth, mature and senescent.
Interpretability	Classification of floristic types based on whether mature and senescing crown forms can be readily discriminated using 1:25,000 scale colour Aerial Photographs. "Easy" denotes they can. "Difficult" denotes they cannot.
Jacobsian	Tree species or forest types for which the classic signs of development and senescence (Jacobs 1955) of the crown are detectable from API.
JANIS criteria	Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and representative Reserve System for Forests in Australia prepared by the Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-Committee.
Non - Jacobsian	Tree species or forest types for which the classic signs of development and senescence (Jacobs 1955) of the crown are not detectable from API.
Linework	Mapped attributes and polygons generated by API.
Pyrophytic	Vegetation adapted to fire (including eucalypts, brush box and turpentine).
Polygon	Area delineated by interpreters on photo overlays and consisting of homogenous crown appearance interpreted from 1:25,000 aerial photographs within which growth stage was estimated.
Post-photo disturbance	Disturbance that has occurred after the date the photography had been flown and which therefore will not be represented on the photo. Could take the form of logging, clearing, fire, windthrow from severe storm events, and localised defoliation by insects etc.
Primary branches	The major or forming branches of the crown that branch from the main stem of the tree, above the height of crown break. Also known as first order branches.
NFPS	The National Forest Policy Statement (Commonwealth of Australia 1992) is an agreement by the Commonwealth, State and Territory Governments on broad goals for the management of Australia's forests.

Secondary branches	Branches arising from primary branches whether by normal bifurcation, or by epicormic resprouting from a primary branch (equivalent to second order).
Stable crown	Crowns having a stable width and height of the crown.
Structural attributes	Characteristics of old-growth forest such as large, live old trees, large standing dead trees or stags, large fallen logs on the forest floor, deep litter layers, multiple strata and a complex understorey.
Succession	The change in the composition and structure of an ecosystem as competing organisms respond to and modify the environment.
Typical crown form	Refers to those species displaying Jacobsian developmental characteristics.
Retracting Crown	Crown extent is contracting due to an increase in branch death and declining leaf area.
Vegetation type	Refers to a classification of plant communities based on structural and floristic characteristics other than Research Note 17 types.

APPENDIX 2: Detailed discussion of API disturbance Attributes (from CRAFTI Manual RACD 1997)

Relative Stand Density (RSD)

Relative stand density (RSD) is the crown cover within each polygon expressed as a percentage of the crown cover of a fully stocked stand for the particular forest type. This attribute is somewhat complex in concept and implementation in that there are two different assessments for different end uses, depending on the amount of regrowth and its timber production potential. Public lands polygons were assessed for one or the other, not both, where site height was > 20m. **However, on other tenure and public lands where site height is < 20m, regrowth RSD is not recorded (i.e. 'e' polygons)** and will not be discussed in detail below.

The important difference between the two assessments is that the mature and older assessment is over the whole polygon while the regrowth assessment is only over the area covered by regrowth. The reason for this is that the former is a measure of the intensity of polygon disturbance while the latter is a measure to be used for timber inventory and is aimed at identifying disturbed areas of poor regrowth response.

The CRAFTI trial found that it was difficult to interpret consistently an actual estimate of crown cover percentage (CCP), and field assessment proved too time consuming to be practical. The alternative of assessing relative stand density was used instead. It is not intended to be a measured attribute (photo or field), but rather an estimated, or interpreted, one.

This approach uses nominally undisturbed forest canopies as standards against which to compare all other polygons. The 'standard' is assigned a relative stand density of 100% and adjacent polygons are compared to the 'standard'. The comparison is one of density of the stand under assessment *relative* to the standard. The standards are reference forest stands which were provided to interpreters by way of photo demonstration areas. Standards were fully stocked, mature stands with little or no regrowth with no disturbance apparent from API.

Standards were set up as the mapping progressed. The process involved an interpreter scanning in photos in a particular area and assessing variability to perceive a broad overview of what standards are required. In conjunction with experienced interpreters and the supervisor, suitable and acceptable standards were set. These will then be marked on overlays and recorded in a database for use by the interpreters in adjoining areas and for future reference.

There will be variation between some species, but this may be more in terms of crown structure and individual crown density rather than significant differences in crown cover projection. To eliminate some of the variability it was proposed to have standards in each area or locality. The API units for mapping will be the 1:100,000 mapsheets. These will be regarded as units for establishing standards. If there is a marked change across the sheet eg foothills to tablelands, then the unit could be subdivided and reference to adjacent units should also be conducted. Different standards are required for extremely different types of forests and these will be developed initially for tall moist forests, dry forest on gentle terrain and steep dry forest.

RSD is not estimated in the field, it is purely an office procedure of comparing the polygon being examined to a standard. In the field an estimate is made of the 'total tree stocking'. This is a qualitative estimate of stocking as seen on the ground, and is used by the interpreter when assessing the stand in the office for RSD and disturbance indicators. For example, if the field assessment is that the stand is well stocked then an office assessment of RSD could be expected to be high, and indicators of disturbance less evident. On the other hand a low field stocking rate for a similar site may be expected to relate to a low RSD, with more evidence of disturbance apparent. Field stocking rate and RSD are not the same thing but are related.

Mature and Older RSD

The first assessment is intended to be a reflection of disturbance intensity and attention is directed at the mature and older components of an existing canopy. The mature and older canopy components of a polygon are assessed for the amount remaining in the polygon compared to the standard. Assessment is made in reference to the whole area of the polygon The amount of mature and older trees per polygon area is estimated as a percentage of the mature and older component of the standard (100%) for that type of forest. The regrowth is ignored as it is part of the 'gap' for this assessment.

Applies only for polygons with < 30% regrowth rccp (growth stage codes **t** and **s**)

Senescent dominated stands may present a problem as some of the trees may have fallen over to create large gaps. Some care will need to be taken in such stands when assessing them for standards and when comparing them to standards.

Coding

Both assessments use the same quartile class widths:

Code	**1**	< 25%
	2	26 - 50%
	3	51 - 75%
	4	> 75%
	N	no assessment (**e** growth stage codes)

Disturbance Indicators

Disturbance indicators measured from API that disqualify an ecologically mature forest from Candidate Old-Growth status.

Public and Private Indicators

X evidence of recent logging - this represents an obvious pattern on aerial photographs where regrowth after the logging event is not yet visible and all the following features are visible: bare and disturbed ground, snig tracks, log dumps, canopy removal.

C evidence of older logging in the form of snig tracks, and log dumps still apparent on the aerial photographs but regrowth of trees and understorey have obscured some or most of the evidence of logging.

GZ irregular clusters of crown gaps in the tallest canopy stratum, regrowth is +- present in the gaps at a lower height than the canopy. There may be a high proportion of uneven crown heights (two or more distinct strata with a significant height difference that is apparent from an aerial perspective).

GA irregular clusters of crown gaps in the tallest canopy stratum with thick regeneration of native pioneers apparent such as acacias, calicoma or tabaco bush.

GW irregular clusters of crown gaps in the tallest canopy stratum with thick regeneration of native pioneers apparent such as lantana, privet and camphor.

W High proportions of other exotic weeds, such as privet.

L Lantana is visible in patches on the photography this may be viewed as a point source or in the understorey over at least 50% of the canopy.

S A high proportion of dead standing trees (stags) in the canopy, a high proportion is considered to be >5 per ha. The presence may be due to ringbarking, fire, prolonged drought, and/or other environmental stresses.

D dieback is visible, being manifest by spars foliage on an otherwise dense stands, dead branches and dead trees.

P evidence of grazing activities by way of reduction of crown cover/partial clearing, pasture improvement and infrastructure construction such as dams, tracks, yards. More than one such feature must be present.

Additional Private Rules Indicators

B Landslips

O evidence of past clearing, now regenerated. Includes features such as windrows, tracks and shaped vegetation patterns.

J Constructed tracks and transmission lines

Other disturbance indicators measured as part of the CRAFTI project

e Erosion
b Landslips
m Mining including mine sites, tailing dumps, top soil removal
R Rural/residential subdivisions
J Other - particularly used for tracks and evidence of disturbance in non-forest polygons, but also for other forms of disturbance not listed.

APPENDIX 3: Date of photography details for 1: 100,000 Map Sheets for the UNE and LNE indicating date of photography used in the CRAFTI project and the latest available photography.

UNE 1:100,000 Map Sheet Name	Date of CRAFTI Photography	Year of latest 1:25,000 Aerial Photography	Year of latest 1: 50,000 Aerial Photography
Tweed Heads	1997	1997	2000
Murwillumbah	1997	1999	2000
Mount Lindesay	1991	1999	2000
Warwick	1993	1999	2000
Stanthorpe	1994*	2000	
Drake	1993	1999	2000 (part available)
Bonalbo	1997	1999 (some)	2000
Lismore	1997	1997	2000
Ballina	1997	1997	2000
Ashford	1994 *	2000	2000
Clive	1994	2000	
Tenterfield	1993	2000	
Coaldale	1994	2000	2001
Woodburn	1993	1998	2001
Inverell	1994	2001	1997
Glen Innes	1993	2001	
Newton Boyd	1997		1997 (some 2000)
Grafton	1994	2002	2000
Bare Point	1993	1998	2000
Bundarra	1992	2001	Some 2001
Guyra	1993	2001	2001
Ebor	1993	2002	2001
Dorrigo	1994	2002	2000
Coffs Harbour	1994	2002	2000

LNE 1:100,000 Map Sheet Name	Date of CRAFTI Photography	Year of latest 1:25,000 Aerial Photography	Year of latest 1: 50,000 Aerial Photography
Cobbadah	1992	2001	1997
Bundarra	1991	2001	Some 2000
Guyra	1993	2001	2001
Ebor	1993	2001	2001
Dorrigo	1994	2002	2000
Coffs Harbour	1994	2002	2000
Bendemeer	1993	2002	1993
Armidale	1994	2001	2002
Carrai	1991		2002
Macksville	1997	2003	2000
Nambucca	1997	2003	2000
Tamworth	1993	2003	
Nundle	1997	2002	
Yarrowitch	1993	2002	
Cowarral	1997	2003	1997
Kempsey	1997	2003	1997
Korogoro Point	1997	2003	1997?
Murrurundi	1994	2001	
Ellerston	1993	2001	Some 2002 1:40K
Upper Manning	1993	2001	Some 2002 1: 40K
Wingham	1991	2003	2001
Camden Haven	1997	2002	2001
Muswellbrook	1993	2003	
Camberwell	1993	1999	2002 1:40K
Dungog	1992	1999	2002 1:40K
Bulahdelah	1997	2003	2001
Forster	1997	2003	2001
Cessnock	1994	2000	Some 2002 1:40K
Newcastle	1993	2001	1998
Port Stephens	1993	2001 - 03	1998

APPENDIX 4a: Background and summary of Information relevant to the identification of Growth Stages in the field.

1. **Branching Habits of Eucalypts**

Essential to the identification of eucalypt growth stages is an understanding of the formation, growth and resprouting of branches. The first branches a tree produces are simple, single stems carrying a leaf bundle at the tip. These primary branches are quickly shed as the tree rapidly gains height. When the tree is in the pole stage some of these branches persist and undergo thickening and bifurcation. These are still primary branches but are termed semi permanent branches. The semi permanent branches characteristically occur below or at the base of the crown of pole stage trees.

The survival of a branch is dependent on it continuing to get enough light and branches must always push outwards to retain a leaf bundle in an unshaded position. However, there is a limit to how far it can grow as a primary branch with the leaf unit becoming inefficient at a long distance from the main stem (Jacobs 1955) and the branch will die or break somewhere along its length. As a crown unit becomes shaded by neighbours or adjacent trees and where there are few crown units on a long branch the loss of one of these may mean that the total respiration for the branch exceeds photosynthesis (negative carbon balance) and the branch will die. This results in the frequent occurrence of dead branches in the crowns of vigorous trees (RACAC 1996). Therefore the occurrence of dead branches in eucalypts is not a good indicator in itself of the growth stage but should be used as part of the assessment of crown vigour.

Epicormic shoots will develop from dormant buds on the top or sides of the branch. These shoots will then grow out as secondary branches and carry leaf bundles as part of the crown with the bundle nearest the end of the primary branch usually continuing as the main extension of the branch. This is different to normal branch formation from bifurcation as a branch grows outwards. The primary branch becomes larger from this secondary growth and this gives eucalypts the characteristic 'elbows' in their branch structure. The larger this branch becomes the more likely it is for hollows to form from each successive breakage/dying off. This process may be repeated several times in the formation of a large shaping branch in a fully mature eucalypt crown and it usually begins with the primary branches at the bottom of the crown and progresses upwards. With age the large shaping branch becomes weaker from fungal and insect attack and successive breakages are lower down the branch eventually leaving a large, hollow stub with much smaller epicormic branch(es) rising from it. The crown becomes increasing irregular as different branches are at different stages of retraction/redevelopment of leaf bundles at any point in time.

Terminology

- Primary branches – branches arising from the tree bole. (equivalent to first order branches). Secondary branches – branches arising from primary branches whether by normal bifurcation, or by epicormic resprouting from a primary branch, (equivalent to second order).
- Epicormic branches – arising from the sprouting of epicormic buds in response to branch tip death. Can be secondary or lower order.
- Semi permanent branches – (see Jacobs 1955), can be primary, secondary or later order branches.

2. **Identification of growth stage in the field**

Jacobs (1955) recognised five growth stages in the morphological development of eucalypt species that could be distinguished in the field: juvenile, sapling, pole, mature and overmature. The criteria used to identify these stages have been refined and two further stages have been recognised and described by Woodgate et al. (1994) and JOGFP (RACAC 1996), including early mature and late mature. The seven stages so defined are described below and summarised in Table A (RACAC 1996).

The partitioning of the continuum of tree life and structure into such classifications is an artificial construct. Correspondingly, the boundaries between growth stages are not naturally defined and there is a grey area around each boundary, the interpretation of which will vary from person to person. **To minimise this inconsistency it is necessary that all interpreters are practised and competent at picking the morphological features of trees characteristic of each growth stage, in the field and on the photos, and making the same decisions as other interpreters**. Experience and local knowledge is required to recognise variations that cannot be accounted for in a generic set of decision rules.

Structural characteristics of trees change with age; crown size, height, bole diameter, branching pattern, leaf shape and size, the extent and pattern of vegetative resprouting, and response to competition and disturbance. Each tree species has its own combination of these characteristics, however there are some generalisations that can be made as identified by Jacobs (1955), Woodgate et al. (1994) and JOGFP (RACAC 1996) and are outlined below.

The primary aim of field recognition of growth stages is to consistently pick the boundary between major growth stages, i.e. the boundary between regrowth and mature and the boundary between mature and senescing, and to be able to relate this to photo appearance. However the assessment of morphological characteristics is only a secondary measure of a tree's age with the assumption that development of these characteristics is due to age on a scale comparable to other trees and other stands. This is not always the case as certain morphological features can be due to, or precipitated by, other factors, particularly suppression or competition by other trees and disturbance events such as wildfire (see Figure 5 and associated discussion below).

Most attention is paid to the branch and crown formation to determine growth stage. However this should always be part of an overall assessment that includes other morphological and site features. In many cases relying on just branch and crown formation will be inconclusive due to the species, site and disturbance effects. Assessment of branch and crown formation will take a more minor role in these stands with the determination of growth stages relying on a broader assessment of features.

Juvenile stage

- all leaves have a juvenile form and grow on the main stem.
- as the seedling exceeds around 60cm in height, second and third order branches develop.

Sapling stage

- the crown is made up of small branches that are shed from the bottom of the crown as the tree gains height.
- competing branches vying for dominance form a crown of many small branches, of roughly the same size, which is typically pointed in profile; narrow, conical and compact.
- the leaves may be a combination of juvenile, intermediate and mature forms.

Pole stage

- strongly developed main stem with a crown of small branches; lower crown branches are retained for a longer period than at the sapling stage.
- these semi-permanent branches (growing on the main stem below the upper crown) become larger than sapling stage branches, grow like modified saplings and retain foliage in terminal bundles; leaves are mostly mature.
- crown is still apically dominated (pointed), with the majority of branches lying at an acute angle to the main stem and overall height still increasing.
- a young eucalypt enters this stage after it has gained a certain height, and the age at which it enters this stage is dependent on site quality.

Early mature stage

- crown is no longer apically dominated.
- larger, stronger, permanent ‘shaping’ branches develop laterally and form the framework of the crown.
- semi-permanent branches grow not only from the main stem but also from these permanent branches.
- the tree approaches maximum height during this stage.
- crown still substantially primary or with first order branches, whereby nearly all leaf bearing units are found at the end of shaping branches

Table A. General features of growth stages (adapted from Woodgate *et al.* (1994) and JOGFP (RACAC 1996)

Broad stage	**Regrowth**		**Mature**		**Senescent**	
Field growth stage (Woodgate *et. al.* 1994)	**Sapling**	**Pole**	**Early Mature**	**Mature**	**Late Mature**	**Over mature**
Main Axis	dominant	prominent	not prominent	lost	lost	lost
Crown Outline	very pointed	pointed	rounded	flattened	irregular	very irregular
Height	rapid increase	rapid increase	slow increase	no change	slight decrease	distinct decrease
Total Leaf Area	very small	small to medium	medium to large	large	medium to large	small to medium
Leaf area change	rapid increase	rapid increase	slow increase	no increase	slow decrease	rapid increase
First order branches	very small, extending	small to medium, extending	large, extending	large, stable	large, broken	mostly fallen
First order branch angle	acute, uniform	acute, uniform	acute, distal arching	variable, arching from trunk	variable, arching from trunk	indistinct
Primary branch crown units	not evident	whole crown	most of crown	branch extremities	few	none
Epicormic crown units	none	none	few, at branch bases	base and middle of branches	most of crown	whole crown
Dead branch frequency	very common in lower crown	common in lower crown	few through crown	few through crown	common through crown	very common through crown
Dead branch size	very small	small	small	small to medium	small to large	small to large
Branch hollows	none	none	none	few, very small	common, small to medium	abundant, small to large
Tree vigour	very vigorous	very vigorous	very vigorous	vigorous	not vigorous	moribund

Mature stage

- the longest period in the tree's life.
- persists for a long time, and, although branches thicken, height and crown spread may change very little over this time in dense stands.
- as branches grow further from the main trunk and lose their apical dominance, secondary or epicormic shoots develop from dormant buds on the top and sides of the shaping branches closer to the main trunk.
- the crown is made up of many individual leaf bundles.
- there may be some branch death and breakage (i.e. death or dropping of 1/4 or more of 1 or 2 shaping branches), but branch death and breakage does not become major.
- the crown achieves maximum size towards the end of the mature stage.

Late mature stage

- this stage begins when most of the crown is made up of epicormic crown units and the rate of loss of structural branches begins to exceed the rate of crown redevelopment from epicormic shoots.
- retaining most of the shaping branches with large numbers of 'bayonets' (dead branches from deceased leaf-bearing units), but there is also a general increase in the occurrence of dead lower order branches and may be some dead or broken shaping branches.
- hollows are more common from the greater numbers of crown breaks and larger branches breaking.
- warts and burls begin to form on the trunk.

Overmature stage

- characterised by declining crown leaf area i.e. overall retraction of the leaf bundles from the previous extent of the crown.
- as the crown retracts the foliage is made up of leaf bundles from smaller epicormic branches leaving the larger branches carrying less and less foliage.
- as major shaping branches are shed, epicormic growth develops from the trunk, to replace the lost leaf area, but which is never as persistent as the permanent shaping branches.
- the trunk and shaping branches are eventually weakened by fungal attack, causing many shaping branches and often the top of the tree to fail and break leaving a crown of broken or dead larger branches.
- the trunk or tree bole is characteristically covered in burls and bumps and hollows are common.

Growth stage assessment key

The assessment of growth stage in the field is primarily an assessment of the vigour and structure of the tree crown. It involves deciding on which side of the threshold between two possible growth stages the tree lies. A growth stage assessment key was adopted from the JOGFP (RACAC 1996) to assist in the identification of growth stages of trees in the field, and is presented in Figure 5 below.

Extending crowns contain healthy leaf bundles at the end of branches and are where lateral extension of the crown still is occurring. Stable crowns are where the width and height of the crown are stable and includes crowns that have an even balance of retracting and extending crowns. Retracting crowns are crowns where the extent is contracting due to a greater increase in branch death from accelerated structural decay and an overall decline in leaf area. Figure 6 outlines the shape of these crowns. To minimise inconsistency it is necessary that all interpreters are experienced at identifying the morphological features of each growth stage, in the field and on the photos, and making the same decisions as other interpreters.

The following procedure is recommended to assist assessment of growth stage in the field and refine draft mapping work by assisting the correct identification of field growth stage (and the perceived or measured calibration with API growth stage obtained as a result of field work.):

1. **Is the tree approaching the regrowth-mature threshold or the mature-senescent threshold?**

For regrowth-mature:

- Is the crown pointed with a strong main leader? Are there few semi-permanent branches in the lower crown growing only at acute angles from the main stem? **If yes to both - regrowth.**

- Is the crown beginning to broaden out, become round and lose its pointed shape? Are the semi-permanent branches abundant and also possibly growing from larger persistent branches forming the framework of the lower crown? **If yes to both - mature.**

For mature-senescent:

- Is the majority of the crown foliage carried by primary branches showing no signs of major breaks/dying off? **If yes - mature.**
- Is the majority of the crown foliage carried by epicormic branches arising after branch breakage/dying off? Is the crown retreating from its maximum extent and no longer as vigorous i.e. are leaf bundles located well inside the dead tips of 3 or more branches? **If yes to both - senescent.**

2. **Has the tree been subject to fire, logging, storm, insect or drought damage, which causes it to display atypical crown structure and foliage?** The damage needs to be recognised to reduce the overestimation of the senescent component in the stand. If the damage was recent it doesn't present too many problems. If the damage is not recent:

    - Has the tree responded vigorously (for that site quality) to re-establish the crown after the damage event? **If yes - mature; if no - senescent.**
    - If only part of the crown was damaged use the rest of the crown to assess growth stage.
    - If recently burnt estimate growth stage on the basis of branch formation which indicates the distribution of pre-fire foliage.

Is the tree observable from the air and does it show evidence of previous or current restriction? If ***yes****, assess the level of branch death attributable to restriction (i.e. it may be localised), and the ability of the tree to respond vigorously upon removal of the restriction (this is not an easy assessment to make).*

Figure 5: Simplified growth stage assessment key for the determination of field growth stages (from BOGMP 1996)

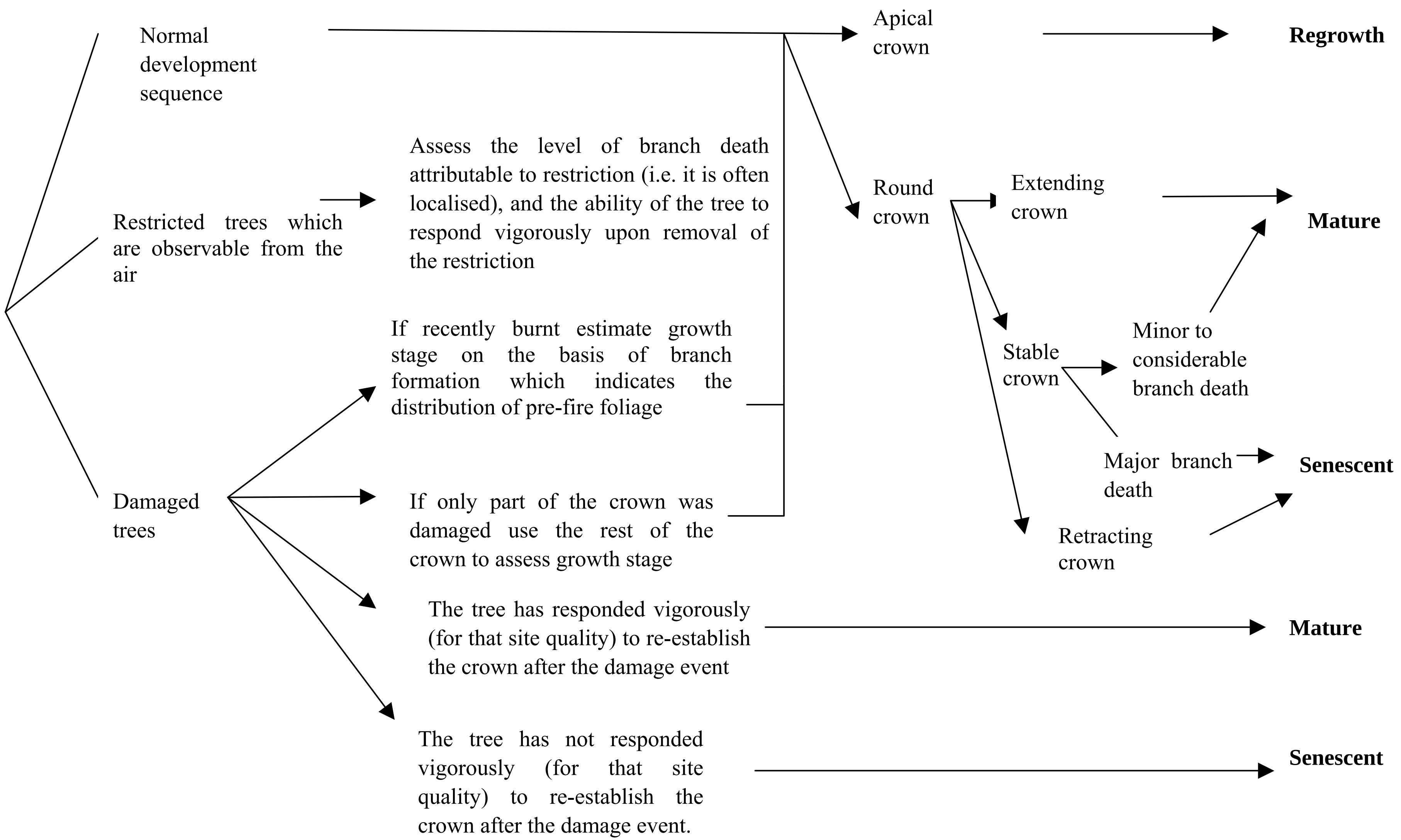
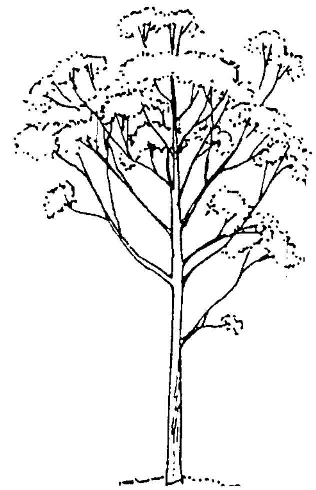
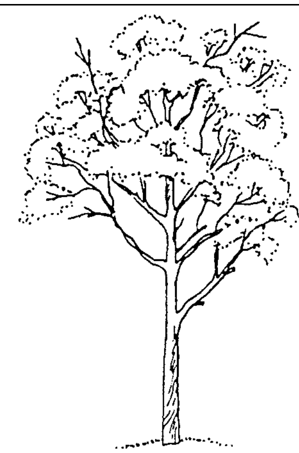
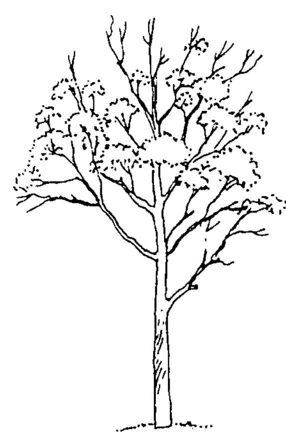


Figure 6: Crown types and extension in generalised pyrophytic tree species (from RACAC 1996)

Extending crown Healthy leaf bundles at the end of branches, with lateral extension of the crown still occurring.	
Stable crown Width and height of crown stable (leaf bundle at same distance as dead tips, with fluctuation of the crown as branches die and are replaced by new crown units). Includes crowns that have an even balance of extending and retracting crown elements.	
Retracting crown Crown extent is contracting, resulting from a greater increase in branch death due to accelerated structural decay and an overall decline in leaf area. Leaf bundles are located well inside the dead tips of 3 or more branches.	

Identification of physical damage and restrictive competition in the field

The interpretation of tree growth stages is often significantly muddied by the effects of tree damage and competition. Damage and competition alter the normal development of tree form and the features characteristic of each growth stage do not necessarily apply. Subdominant or overtopped trees have had their growth restricted by dominant trees in the stand and have poorly formed crowns. Branch death is often more prevalent in growth restricted trees as a result of reduced light availability (RACAC 1996). It is difficult to determine whether the dead branches and poor crowns of suppressed trees are due to it being suppressed or to its senescence.

It is important that interpreters consider the extent to which a tree's crown function has been affected by the branch loss resulting from restriction as well as that caused by the tree's senescence, in order to assess the relative age of the tree in terms of its expected lifespan (RACAC 1996). For example, are branches broken only in the vicinity of the area of greatest restriction. The interpreter should also make an assessment of tree vigour, i.e. would the tree respond with growth in height and crown size if the trees overtopping it were removed. If yes, and if branches in the vicinity of the region of greatest restriction have broken, then the tree is not senescing and visa versa.

Restricted trees are usually not observable from the air and generally should not be considered when assessing aerial photograph interpretations in the field. However, in situations where disturbance events have removed previously overtopping trees, a forested area may be dominated by restricted or previously restricted trees. Therefore, it is important to differentiate between crown features caused by restriction and those caused by senescence in these cases.

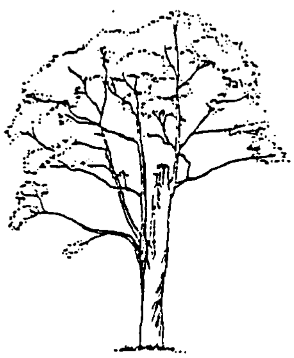
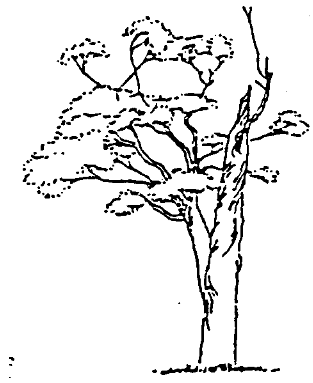
Damage to tree crowns can be caused by fire, wind (storm), lightning, insects, logging or drought and is often expressed by dead and broken branches, defoliation and/or epicormic shoots on the trunk or main shaping branches - unfortunately primary features in the identification of the senescent growth stage. Unless taken into account an overestimation of the senescent growth stage will result.

A quick estimate of the effect of damage again relies on an estimate of the vigour of the tree, i.e. whether there will be vigorous regrowth of the crown. If the damage was several years ago the vigour will be evident in the epicormic or other branches that responded to the damage. If only part of the crown was damaged the rest of the crown can be used to assess growth stage. However the site quality will affect the vigour and must be taken into account when assessing relative crown vigour.

Recently burnt crowns will have a fuzz of epicormic growth along the bole and branches. Growth stage can be estimated from the branch formation which will indicate the extent and distribution of pre fire foliage. The longer the time since the crown fire the harder it is to determine whether dead branches are due to fire or natural attrition. Use of indicators such as other trees with a similar pattern of dead branches, eg. dead crown tops and dead stags will indicate crown fire in the past.

Defoliation of tree crowns from insect attack is relatively easy to pick as more than one tree in an area will be affected. Branch structure can be used to determine growth stage. Branch breakage due to storms or logging damage is hard to discern from normal branch breakage. Wind damage usually occurs on exposed upper slopes and ridges and it is rare that only one tree is affected. Other damaged and fallen trees are good indicators and should be used to determine whether branch breakage is due to normal branch shed or storm damage (Figure 5). Similarly with logging damage where other evidence will indicate logging in the area.

Figure 7: Long-term damage - Tree that has been seriously and permanently damaged (from JOGFP 1996)

	
Long-term damage intermediate	**Long-term damage significant**
Effect on crown moderate and permanent. Only affected a portion of the crown e.g. the falling of a tree adjacent to the damaged tree has resulted in a broken shaping branch.	Effect on crown significant and unrecoverable. Crown is unlikely to redevelop to an optimal functioning state e.g. falling of an adjacent tree has resulted in total loss of crown and of epicormics on main stem.

APPENDIX 4b: Field validation procedures and methodologies.

The following discussion (for more information refer to the CRAFTI manual) outlines the recommended techniques for estimating the field growth stage of a forest stand that should be utilised during any site inspections aimed at resolving Candidate Old-Growth forest status on private lands.

Estimating Growth Stage Proportions

Field assessment of growth stages is a hierarchical system of assessing and confirming growth stage proportions at any site. Field assessment should use the:

Point to plant methodology.

All field estimates **must** be done with most recent aerial photos at hand and the area identified on the photos.

The point to plant methodology has been used to measure density or stocking of regeneration. It was used during the BOGMP to validate mapped growth stage attribute codes. The point to plant methodology measures the structural characteristics of the forest to identify growth stage. Refer to the CRAFTI manual (RACD 1997), NPWS (1996) or RACAC (1996) for further information on the assessment of growth stage in the field.

The basis of this method is to lay out a transect and sample plots measured at regular intervals along a transect.

Field Methodology

1. Select homogenous/representative location for the transect (including the direction compass bearing) within the application areas from API on most recent photos. Transect should be designed to provide an unbiased sample of polygon variation.
2. Locate transect starting point in the field from API and take GPS reading at transect starting point. Use compass to derive predetermined transect direction.
3. At each 50m interval along the transect (including the starting point), measure the distance in metres from the point to the centre of the nearest regrowth, mature and senescent pyrophytic trees that would be visible if viewed by API from above (i.e. >50% of crown is not obscured from above). Please note it is essential to choose the closest tree from the measuring point.
4. At each point record these measurements on the Point to Plant pro-forma sheet provided. If a regrowth, mature or senescent tree is not present within the 30m radius of the point then record as a null score. Slope will affect the distance measured from a transect point to sampled trees. Use of the slope correction table (Table B) will allow for the corrected horizontal distances to be utilised in the calculation of tree stocking rates.
5. As the distance to each tree is measured, also measure and record the diameter of the crown as it extends along the same axis as the tape (from the central measuring point). Note that an alternate method of taking 2 cross sectional crown measurements along the maximum and minimum diameter of the tree crown can be employed when the former does not give an accurate representation of the crown dimensions eg. leaning trees with contracting crowns. Whatever method is employed it is important to accurately measure the crown width. The use of a clinometer by the observer to ensure they are standing vertically under to the canopy edge may assist in achieving a consistent measurement of this variable.
6. At each point also record presence of disturbance indicators if any are visible within 30 metres (refer to Table C below for details of disturbance indicators)

7. Conduct measurements of at least 10 points along any transect (which may need to change direction to follow most homogenous/representative area). The length of each transect should be the same even if the transect changes direction. It is most important to collect data for at least 10 points along each transect.
8. Minimum sampling requirements for any site are as follows:
   For areas up to 25 Hectares - 1 Point to Plant Transect of minimum 10 points
   For areas 25 – 50 Hectares - 2 Point to Plant Transects of minimum 10 points each
   For area 50 – 100 Hectares - 3 Point to Plant Transects of minimum 10 points each.
   For areas > 100 Hectares - An extra 3 sites/100 hectares is recommended.

Examples of the layout of different point to plant transects in the field are depicted in Figures 7 and 8 indicating that transect orientation, spacing and sampled area can vary according to site conditions, stand condition, patch size and available resources.

Point to Plant survey point measuring to nearest regrowth, mature and senescent tree and recording site disturbance, if any, within 30m radius

Table B: Slope Correction Table - Slope distances (m) for horizontal lengths.

SLOPE	10m	20m	30 m	40 m	50 m	60 m	70 m	80 m	90 m	100 m	Horizontal distance
5°	10.0	20.1	30.1	40.2	50.2	60.2	70.3	80.3	90.3	100.4	----
10°	10.2	20.3	30.5	40.6	50.8	60.9	71.1	81.2	91.4	101.5	|
15°	10.4	20.7	31.1	41.4	51.8	62.1	72.5	82.8	93.2	103.5	|
20°	10.6	21.3	31.9	42.6	53.2	63.9	74.5	85.1	95.8	106.4	| **Slope**
25°	11.0	22.1	33.1	44.1	55.2	66.2	77.2	88.3	99.3	110.3	> **distance**
30°	11.5	23.1	34.6	46.2	57.7	69.3	80.8	92.4	103.9	115.5	| **in metres**
35°	12.2	24.4	36.6	48.8	61.0	73.2	85.5	97.7	109.9	122.1	|
40°	13.1	26.1	39.2	52.2	65.3	78.3	91.4	104.4	117.5	130.5	|
45°	14.1	28.3	42.4	56.6	70.7	84.9	99.0	113.1	127.3	141.4	----

Table C: Disturbance Indicators - Site descriptions

Disturbance Indicator	Site characteristics present within 30m of sample point
1	**Recent logging**: evidence of recent logging activity within the last 10 years denoted by bare earth, snig tracks, log dumps, logging debris. Due to the recent nature of disturbance there is little or no regrowth present and often large open areas and associated canopy gaps.
2	**Older logging**: visible evidence of older logging activity such as stumps, log dumps and/or constructed snig tracks which have not occurred within the last ten years. Can cover a range of logging intensities and intervals since last logging. It is not the intention that evidence of historic logging per se is indicative of a significant impact on the structure and floristics of the forest stand in question. Quantitative assessment of 'older logging' should include only stumps > 40 cm diameter IF there is visible disturbance to the canopy in the form of canopy gaps PLUS regrowth clusters or native pioneers or woody weeds. This indicator therefore must be a combination of stumps > 40cm diameter PLUS gaps AND clusters or regrowth OR thick regeneration of native pioneers and weeds.
3	**Exotic woody weeds**: >30% spatial cover within the 30m radius sample area of exotic woody weeds such as Blackberry, Camphor Laurel, Lantana, Privet etc.
4	**Ringbarked or dead standing trees**: this includes ringbarked trees and trees affected by dieback or bell bird activity where canopy gaps are present. Generally these dead trees will be > 40 cm diameter and not be dead from natural causes.
5	**Grazing infrastructure**: This must include the presence of fencelines, yards, dams or other watering points and does not include only the presence of cattle, their tracks or camps. There must be a noticeable and significant impact on the structure (presence of gaps and regrowth) and floristics of the forest stand.
6	**Constructed tracks**: This includes constructed tracks that have required the removal of canopy trees resulting in linear strips of regrowth clusters of native pioneers or woody weeds and does not include temporary farm or bush tracks.

Calculations of growth stage (crown cover projections)

The data collected during the transect is used to average the distance measured for each growth stage and to calculate the stocking rate using the following formula:

$$N = \frac{10000}{(2D)^2}$$

Where N = stocking in trees/ha
D = average distance from point to tree centre.

***Example*:**

STEP ONE: Average distance of senescing trees =16.65m
applying formula = 9.01 senescing trees/ha

STEP TWO: Correct stocking rate (N) for null scores by multiplying by the conversion factor from Table 12.

Null records are expressed as a ratio of null counts to total counts:
eg. 10 survey samples
1 null counts = 10% = 1/10 = 0.1
conversion = 0.78 (on table)
senescing trees/hectares = 0.78 x 9.01 (stocking rate)
N = 7 senescing trees/ha

STEP THREE: Crown area per hectare is then calculated separately for each of the regrowth, senescent and mature components of the stand. This is done by taking an average of the two crown radii (longest and shortest) squaring it and multiplying by π (the formula being πr^2 denoting the area of a nominal circular crown) for each sample point. The resultant average is then multiplied by the stocking.
For example:

Senescing crown area per/hectares = 9 (denoted by N) x 307 (307 is calculated by squaring all radius measurements and multiplying by π for each transect point, and **THEN** averaging these answers)
= 2158 $m^{2/}$ha

STEP FOUR: The relative crown cover percentage of each of the regrowth, mature and senescent components is then formulated. The crown area/hectares of each component is divided by the total crown area/hectares for all components put together. For example, where:

Regrowth crown area = 117
Mature crown area = 3078
Senescent crown area = 2158

Then the total crown area= 117 + 3078 + 2158 = 5353

And the relative crown cover for regrowth = 117/5353 x 100 = 2.2%

and the relative crown cover for mature =3078/5353 x 100 = 57.5%

and the relative crown cover for senescent = 2158/5353 x100 = 40.3%

Interpretation of Results for Growth stage and disturbance indicators

The results are used to determine the relative crown cover percent of the regrowth, mature and senescent components of the stand. This then enables a verification of the growth stage as assessed from the air. For example, as per the above calculations, if the results of the field survey indicate a regrowth relative crown cover of 2.2% and a senescent relative crown cover of 40.3%, then the growth stage category is tA. (refer to Table D below).

Calculation for Disturbance Indicators

If any individual disturbance indicators (refer Table C and the Site Assessment Flowchart) are recorded for 6 out of the 10 or 8 out of 15 site sampling points (i.e. > 50%) then disturbance level should be considered significant. Where individual disturbance indicators are recorded at less than 6 out of the 10 or 8 out of 15 sample sites then disturbance should be considered as negligible. Table E below should be used to determine revised growth stage for the sampled site based on revised growth stage code and level of disturbance indicators.

Table D: Summary of Attribute Codes for Growth Staging

Code	**Relative Crown Cover%**	
	Regrowth Trees	**Senescent Trees**
tA	<10%	>30%
tB	<10%	10-30%
tC	<10%	<10%
sA	10-30%	>30%
sB	10-30%	10-30%
sC	10-30%	<10%
eN	>30%	no value recorded (as N)

Table E: For deriving revised Successional Growth Stages using site survey results of growth stage and disturbance level.

Growth Stage as derived by site survey	**Disturbance level as derived by site survey**	**Revised successional growth stage at the site**
tA, tB or sA	Negligible	Candidate Old-Growth
tA, tB or sA	Significant	Disturbed Old Forest
sC, sB or tC	Negligible	Mature Forest
sC, sB or tC	Significant	Disturbed Mature Forest
e	Greater than 30% regrowth	Young Forest
Post photo disturbance	Recent disturbance	Recently Disturbed Forest

Figure 8: Examples of Point to Plant transects including location and sampling variation.
Note that the minimum transect consists of 10 points with a 30 metre spacing between points and sampling a radius of 20 metres at each point.

Candidate Old-growth forest on Private lands Site Inspection

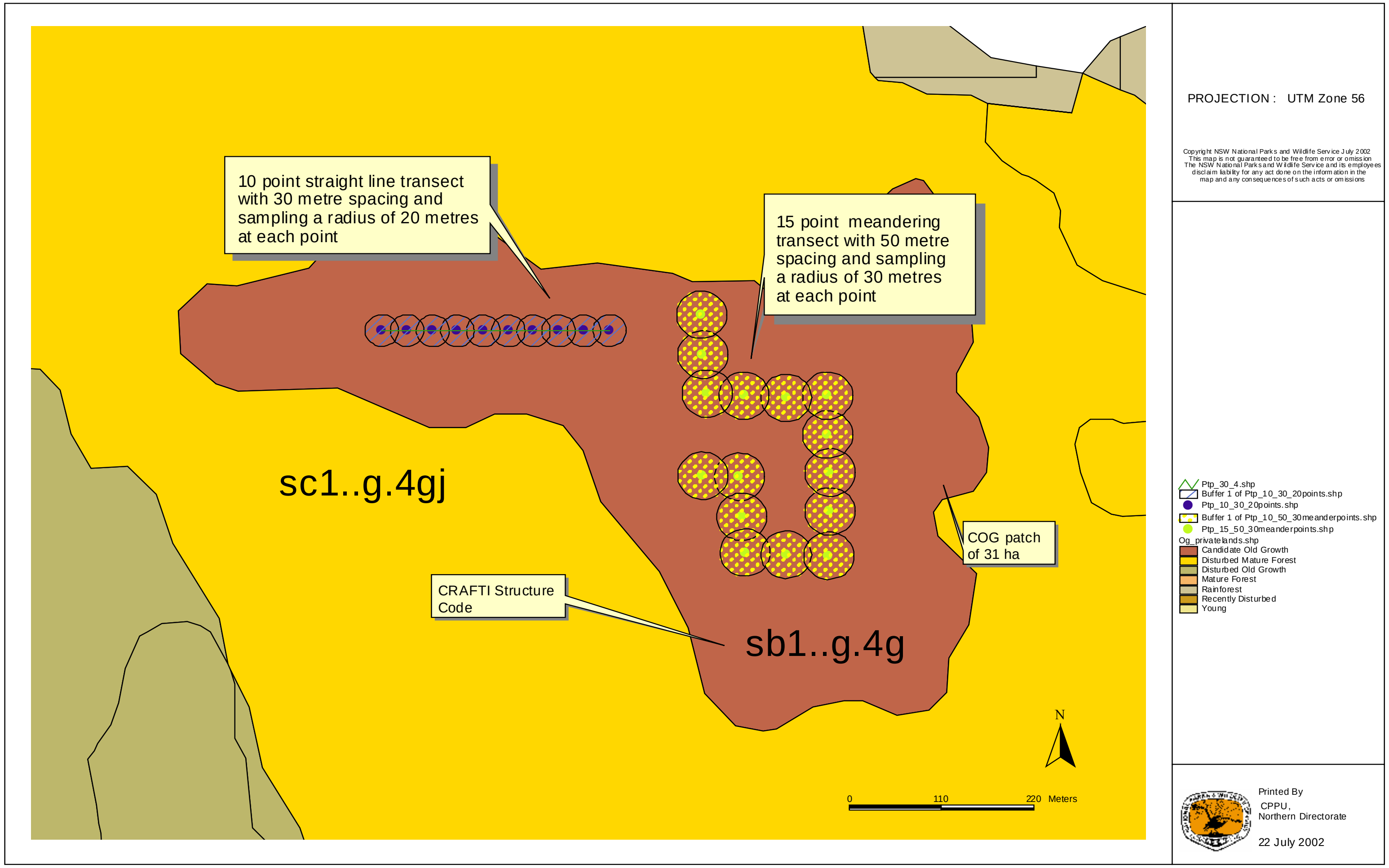
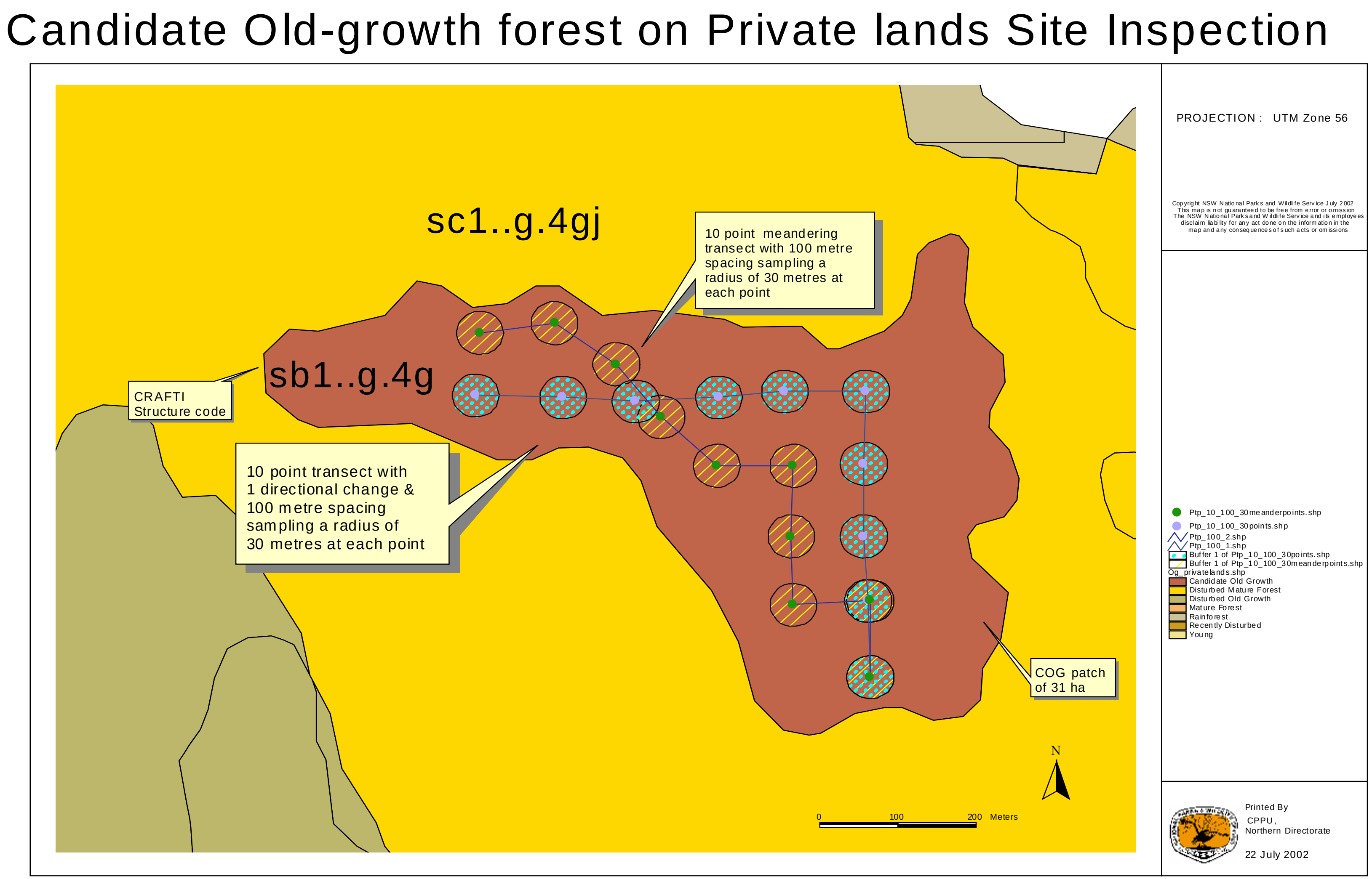


Figure 9: Examples of Point to Plant transects including location and sampling variation.
Two ten point transects with 100 metre spacing are depicted with different locational layouts but each having a 100 metre spacing and sampling a 30 metre radius at each point. Note the transects cross each other and share two sampling points



APPENDIX 4c: Candidate Old-Growth Private Property Site Inspection Proforma

DATE: ……………………………………………..…Point # and Bearing information **Recorders: ………………………………………..**

Land holder…………………………………………………………………………….. **API code:…………………………………………..**

Photography/year…………………………………………………………………… **25k mapsheet:…………………………………….**

Location ……………………………………………………………………………… **Transect No:……………………………………….**

Starting Point: EASTING ………………………Finishing Point:EASTING ………………. Note r = the average of the longest and shortest crown radius

NORTHING ……………. NORTHING………………… D = distance to nearest tree in that growth stage visible by API

Point	**Regrowth**		**Mature**		**Senescent**		**Disturbance Indicators**					
	D	r	D	r	D	r	Recent Logging	Older Logging	Exotics	Stags or dieback	Grazing infrastructure	Constructed tracks
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
Total												

Disturbance indicator descriptions

1. **Recent logging**: Evidence of recent logging activity within the last 5 years denoted by bare earth, snig tracks, log dumps, logging debris. Little or no regrowth present, large open areas and associated canopy gaps present.
2. **Older logging**: Visible evidence of older logging activity such as stumps, log dumps and/or constructed snig tracks. Older logging could be evident in the form of very lightly logged forest to stands logged more heavily and on a number of occasions up to ten years ago. It is not the intention that evidence of historic logging per se is indicative of a significant impact on the structure and floristics of the forest stand in question. Quantitative assessment of 'older logging' scores only stumps > 40 cm diameter IF there is visible disturbance to the canopy in the form of canopy gaps PLUS regrowth clusters or native pioneers or woody weeds. This indicator therefore must be a combination of stumps > 40cm diameter PLUS gaps AND clusters or regrowth OR thick regeneration of native pioneers and weeds.
3. **Exotic woody weeds**: >30% spatial cover within the 30m radius of exotic woody weeds such as Blackberry, Privet, Camphor Laurel etc.
4. **Ringbarked or dead standing trees**: This includes ringbarked trees and trees affected by dieback or bell bird activity. Generally these dead trees will be > 40 cm diameter and not be dead from natural cases**.**
5. **Grazing infrastructure**: This must include the presence of fencelines, yards, dams or other watering points and does not include only the presence of cattle, their tracks or camps. There must be a noticeable and significant impact on the structure (presence of gaps and regrowth) and floristics of the forest stand in question.
6. **Constructed tracks**: This includes constructed tracks that have required the removal of canopy trees resulting in linear strips of regrowth clusters of native pioneers or woody weeds and does not include temporary farm or bush tracks.

Calculations of growth stage (crown cover projections)

The data collected during the transect is used to average the distance measured for each growth stage and to calculate the stocking rate using the following formula:

$$N = \frac{10000}{(2D)^2}$$

Where N = stocking in trees/ha

D = average distance from point to tree centre.

Example:

STEP ONE: Average distance of Senescing trees =16.65m

applying formula = 9.01 senescing trees/ha

STEP TWO: Correct stocking rate (N) for null scores by multiplying by the conversion factor (table below).

Null records are expressed as a ratio of null counts to total counts:

eg. 10 survey samples

1 null counts = 10% = 1/10 = 0.1

conversion = 0.78 (on table)

senescing trees/hectares = 0.78 x 9.01 (stocking rate)

N = 7 senescing trees/ha

STEP THREE: Crown area per hectare is then calculated separately for each of the regrowth, senescent and mature components of the stand. This is done by taking an average of the two crown radii (longest and shortest) squaring it and multiplying by π (the formula being πr^2 denoting the area of a nominal circular crown) for each sample point. The resultant average is then multiplied by the stocking.

For example:

Senescing crown area per/hectares = 9 (denoted by N) x 307 (307 is calculated by squaring all radius measurements and multiplying by π for each transect point, and **THEN** averaging these answers)

= 2158 m^{2}/ha

STEP FOUR: The relative crown cover percentage of each of the regrowth, mature and senescent components is then formulated. The crown area/hectares of each component is divided by the total crown area/hectares for all components put together. For example, where:

Regrowth crown area = 117

Mature crown area = 3078

Senescent crown area = 2158

Then the total crown area = 117 + 3078 + 2158

= 5353

And the relative crown cover for regrowth = 117/5353 x 100 = 2.2%

and the relative crown cover for mature =3078/5353 x 100 = 57.5%

and the relative crown cover for senescent = 2158/5353 x100 =40.3%

Interpretation of Results for Growth stage and disturbance indicators

The results are used to determine the relative crown cover percent of the regrowth, mature and senescent components of the stand. This then enables a verification of the growth stage as assessed from the air. For example, if the results of the transect indicate a regrowth relative crown cover of 2.2% and a senescent relative crown cover of 40.3%, then the growth stage category is tA. (refer to Tables B above)

Calculation for Disturbance Indicators

If any individual disturbance indicators (refer Table A above and the Site Survey Flowchart) are recorded for 6 out of the 10 or 8 out of 15 site sampling points then disturbance level should be considered significant. Where individual disturbance indicators are recorded at less than 6 out of the 10 or 8 out of 15 sample sites then disturbance should be considered as negligible (refer Table C).

No/NT	CF	No/NT	CF	No/NT	CF	No/NT	CF
0.01	0.97	0.26	0.57	0.51	0.33	0.76	0.15
0.02	0.94	0.27	0.59	0.52	0.32	0.77	0.14
0.03	0.92	0.28	0.55	0.53	0.31	0.78	0.13
0.04	0.89	0.29	0.54	0.54	0.31	0.79	0.13
0.05	0.87	0.30	0.53	0.55	0.30	0.80	0.12
0.06	0.85	0.31	0.52	0.56	0.29	0.81	0.11
0.07	0.84	0.32	0.51	0.57	0.28	0.82	0.11
0.08	0.82	0.33	0.50	0.58	0.28	0.83	0.10
0.09	0.80	0.34	0.49	0.59	0.27	0.84	0.10
0.10	0.78	0.35	0.48	0.60	0.26	0.85	0.09
0.11	0.77	0.36	0.47	0.61	0.25	0.86	0.08
0.12	0.75	0.37	0.46	0.62	0.24	0.87	0.08
0.13	0.74	0.38	0.45	0.63	0.23	0.88	0.07
0.14	0.72	0.39	0.44	0.64	0.22	0.89	0.06
0.15	0.71	0.40	0.43	0.65	0.22	0.90	0.06
0.16	0.69	0.41	0.42	0.66	0.21	0.91	0.05
0.17	0.68	0.42	0.41	0.67	0.20	0.92	0.04
0.18	0.67	0.43	0.40	0.68	0.19	0.93	0.03
0.19	0.65	0.44	0.39	0.69	0.18	0.94	0.03
0.20	0.64	0.45	0.37	0.70	0.18	0.95	0.02
0.21	0.63	0.46	0.36	0.71	0.17	0.96	0.02
0.22	0.62	0.47	0.36	0.72	0.17	0.97	0.01
0.23	0.61	0.48	0.35	0.73	0.16	0.98	0.01
0.24	0.59	0.49	0.34	0.74	0.15	0.99	
0.25	0.58	0.50		0.75			

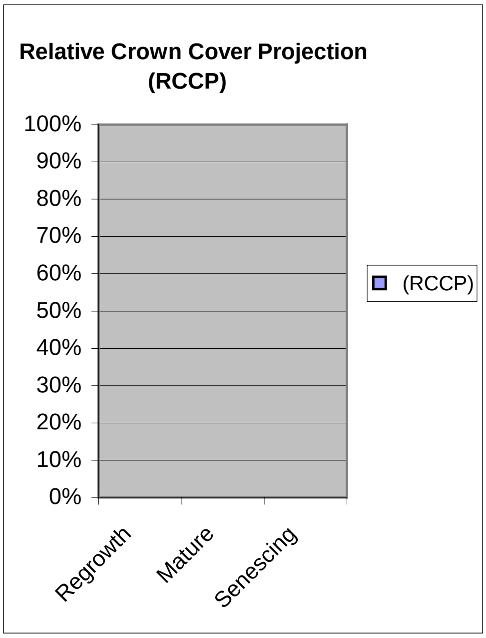
Correction Factor (CF) Table for nil records (Point to Plant Surveys).

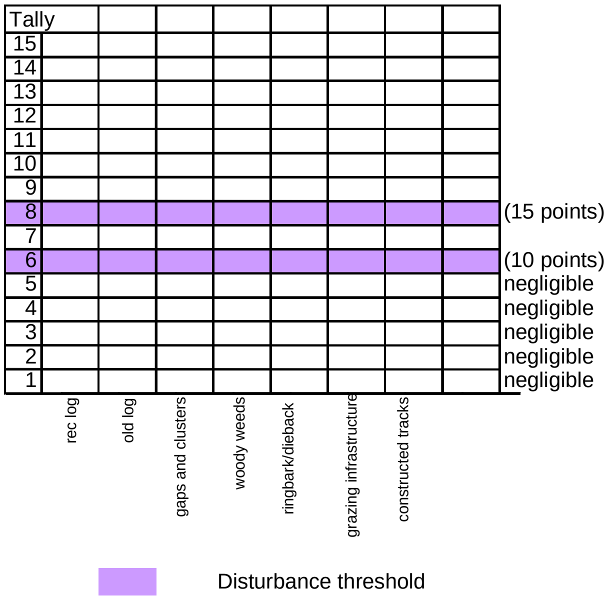
Site Survey Calculations and Results Proforma

Stocking (N) = [10 000/(2d)^2] x Null Score Conversion Factor

	Reg.	Sen	Mat.	Total
N				
CA (ha)				
rCCP%				
Code				

Field Growth Stage





Field Survey

Point to Plant transects………………………………………………………………………….

Other disturbance at site eg. Fire ……..………………………………………………………

Calculated Site Details

Growth stage	Disturbance Level	Successional Growth Stage

APPENDIX 5: Question and Answers regarding the field validation procedure.

Question 1. When is it necessary to undertake a site inspection?

Answer. It is necessary to undertake a site inspection and undertake transects when there is:

a) no previous growth stage mapping available for the site;
b) revised API mapping using updated photography and interpreted CRAFTI growth stage or disturbance features indicate that potentially this area should be excluded from Candidate Old-Growth (COG) status. These codes are outlined under Scenario B in Figure 3; or
c) validation of old-growth forest is required for provision of incentives at the property scale.

Question 2. What equipment is required to undertake an inspection or field transect?

Answer. The following equipment is required to undertake a point to plant field transect.

Field Data Sheets, Clipboard and Pencil
Set of most recent Aerial Photographs and a stereoscope to locate transect in the field by API
Acetone overlay with API coding from desktop assessment
Topographic map and GPS for accurate georeferencing
Tape Measure (50 metres recommended), compass, clinometer, flagging tape
Camera for visual recording of forest structure over transect. *Optional
Calculator or Laptop Computer (recommended) for calculation of results in the field.

Question 3. What level of sampling is required?

Answer. Sampling is not required when the API reassessment obviously indicates that the area has been recently disturbed as outlined in Figure 3 and/or the forest is not Candidate Old-Growth due to the growth stage and/or disturbance indicators.

Recommended minimum sampling requirements for any site are as follows:

For areas up to 25 Hectares -	1	Point to Plant Transect of minimum 10 points
For areas 25 – 50 Hectares -	2	Point to Plant Transects of minimum 10 points each
For area 50 – 100 Hectares -	3	Point to Plant Transects of minimum 10 points each.

For areas > 100 Hectares – An extra 3 sites/100 hectares is the recommended ideal

Question 4. How do I select the location of sampling transects and can sample transects cross vegetation gradients?

Answer. After completion of the API reassessment the interpreter will know what part(s) of the questioned/mapped polygons (if any) need to be visited in the field. If a site inspection is required the relevant part of the mapped polygon requiring validation needs to be identified prior to the inspection (from API if available). This should be primarily based on identifying representative photo patterns of homogenous areas. Transect locations should be selected to best represent the overall pattern and should be oriented approximately and marked out on the photos (including potential start points) prior to visiting the site.

In the field the transect should be accurately located with a GPS if available (or with aerial photos and topographic maps). It is permissible to cross vegetation boundaries as often the polygon or section of the questioned polygon may also cross vegetation types. Ideally if time/resources were not a limiting factor then sampling could be stratified according to vegetation and/or other variables but given practicality this is not generally realistic.

Question 5. After completing a transect how are the final calculation done and interpreted?

Answer. Provided the steps outlined under Appendix 4 are followed and the necessary data has been collected the results can be inserted into the spreadsheet (this is an Excel spreadsheet which can be electronically provided by the DEC) which will automatically store the data digitally and undertake the necessary calculations to determine stocking rates and overall field growth stage and disturbance level. It should be noted that the spreadsheets should be saved as another name to denote the relevant location. It should be stressed, however, that the accurate and objective assessment, measurement and recording of the trees at each sampled point is critical to obtaining a reliable result.

Question 6. What happens if the transect results vary noticeably along the course of the transect or between transects at a site? How does the proponent/field assessment officer interpret this?

Answer. This will not be an uncommon situation as both ecological considerations and past management history will lead to changes in forest structure and condition and this hopefully will be detected by the sampling. The main objective of the point to plant transects is to calibrate the qualitative API mapping with quantitative assessments on the ground so that API can be reassessed and boundaries and coding of the COG polygon be modified accordingly. The results of the transects should confirm or reject the coding and/or line placement. Revision of the linework and coding should be undertaken post sampling to best reflect the sampled results. If a transect detects high levels of disturbance over the last third of a transect and a less disturbed intact structure over the remaining area of the transect any modification of the COG boundary should best reflect these differences.

It is acknowledged, however, that in areas up to 25 hectares with a heterogeneous structure, it will often be difficult to average the crown components over the entire polygon using API. This also underscores the importance of a representative selection of the transect location for overall calibration. Given an unbiased transect selection and sampling technically the results can be applied to the mapped polygon. In practice, however, it is envisaged that line modification would occur to improve the accuracy of the mapping and intended operations where desirable or applicable.

Question 7. If one application is received for property X and the API is revisited, recommended field sampling requirements are undertaken and shortly after an adjacent property owner submits an application which requires a field investigation to verify the revised API, do we have to go through the field sampling procedure again?

Answer Provided aerial photographs for the new area and the former API linework are compatible, (i.e. same date photographs, scale etc), then the field results from the earlier assessment can be used to inform the interpretation of the neighbouring property without additional sampling. If there is uncertainty, however, a site inspection should occur to at least assess whether the stands are compatible and results are translatable to the 2nd property.

APPENDIX 6. Description of Successional Growth Stages.

Candidate Old-Growth (COG) Forest

These are forest stands where the senescing component (i.e. where the late mature or senescent trees as applied by the modified Jacobs growth stage assessment) is greater than 10% relative crown cover projection (RCCP) and there is generally negligible regrowth (i.e. less than 10% RCCP). Greater than 10% regrowth can occur but only in stands where there is > 30% RCCP of the senescing component.

Depending on the forest ecosystem and site in question COG forest may vary in its structural expression due to site quality considerations. COG in very productive sites (i.e. moist eucalypt forests) will usually attain high site heights > 40metres, be dominated by trees with a large girth (i.e. > 100cm dbhob) and extensive (& retracting) crowns and have a number of distinct sub canopy strata (i.e. a mid and a lower storey which is usually dominated by Rainforest species). There is usually also standing dead trees (stags) and/or logs on the forest floor or in streams (Scotts 1991).

At the other end of the productivity spectrum there will be stands (dry forests and woodlands) where the site quality dictates developmental and successional restrictions due to either low site fertility (e.g. shallow soils), growth restrictions and/or natural disturbance frequency i.e. fire. In these stands trees will usually be less than 25 metres in height and not necessarily of a large diameter i.e. < 100cm dbhob. While these trees may bear hollows it may be generally more difficult to assess tree senescence from the ground. These stands are characterised by an open forest structure with a sclerophyllous, grassy or heathy understorey and there will be smaller diameter dead woody material on the forest floor.

In terms of disturbance these forests appear undisturbed in terms of the upper canopy and do not exhibit the signs of old or recent logging or clearing, canopy gaps and native pioneers and/or uneven crown heights, are not generally weed infested or dominated by dead standing trees in areas greater than 5 hectares (either through Bellbird dieback or ringbarking). Where stands may have experienced prior disturbance the timing, extent and level (intensity) is such that the stand is no longer affected by the disturbance event or is recoverable in the short – medium term. It should be emphasised that non pervasive evidence of disturbance (either in isolation or collectively) be it a track or some stumps which indicate some tree removal in the past or a restricted presence of weeds would not be cause for a stand to be removed from consideration as COG per se. It must be demonstrated that the overall stand has been so affected (by the localised disturbances) that both old-growth structure and function have been compromised.

Disturbed Old Forest

These stands will be characterised by similar growth stage ratios as those described above for COG but there will be more obvious disturbance to the upper canopy despite the stands having many large old trees (>100 cm dbhob). There will also be signs of subcanopy disturbance as evidenced (over the majority of the area) by signs of recent and/or old logging (e.g. stumps, snig tracks) such that there are visible logging related canopy gaps and uneven crown heights and occasional occurrence of native pioneers and/or lantana and other weeds. There may also be > 5 standing trees per hectare due to previous ringbarking or other disturbance such as dieback.

Mature Forest

Forest dominated by mature trees where the influence on the stand of the late mature or senescing component is considered negligible. For the easy to interpret Forest ecosystems these stands will be dominated by mature trees and have from 40 through to 90% RCCP of the mature tree class (generally < 100cm dbhob and with regular healthy crowns) and anywhere from 10 to 30% RCCP for the regrowth and senescing growth stages.

The signs of forest disturbance will be more evident than for COG as mature forest has generally come about through previous disturbance (mainly logging or clearing) of one sort or another. The stand in general does not exhibit the signs of old or recent logging or clearing, canopy gaps and native pioneers and/or uneven crown heights, are not weed infested or dominated by dead standing trees greater than 5 hectares (either through Bellbird dieback or ringbarking). For these stands a number of disturbance indicators may not be observable through the canopy of a fully stocked stand on a photograph, however a site inspection will confirm previous logging history.

Disturbed Mature Forest.

Forest dominated by mature trees where the influence on the stand on the late mature or senescing component is considered negligible. These stands will be mature dominated stands have from 40 through to 90% RCCP of the mature tree class and anywhere from 10 to 30% RCCP for the regrowth and senescing growth stages.

There will be more obvious disturbance to the upper canopy and the lower layers as evidenced (over the majority of the area) by signs of recent and/or old logging such that there are visible logging related canopy gaps and uneven crown heights and possibly localised areas where the understorey is dominated by native pioneers and/or lantana and other weeds.

Young Forest

Young forest occurs where stands are dominated by greater than 30% regrowth RCCP following a logging event (or severe fire event). These are areas characterised by intensive past disturbance such as gap creation etc. While there may be dispersed retained senescing trees in the stand these stands are primarily comprised of even-aged regrowth. A range of disturbance indicators in addition to the growth stage will be visible on site.

Recently Disturbed Forest

Areas where post photo or intensive recent logging disturbance has occurred where > 50% and often greater than 80% canopy removal has occurred including removal of understorey and topsoil elements.