

# NOTES - PNF OLD GROWTH FOREST FIELD VERIFICATION

## GROWTH STAGE

For the purpose of API mapping forest structure seven growth stages of juvenile, sapling, pole, early mature, mature, late mature and over mature were amalgamated into three as follows:

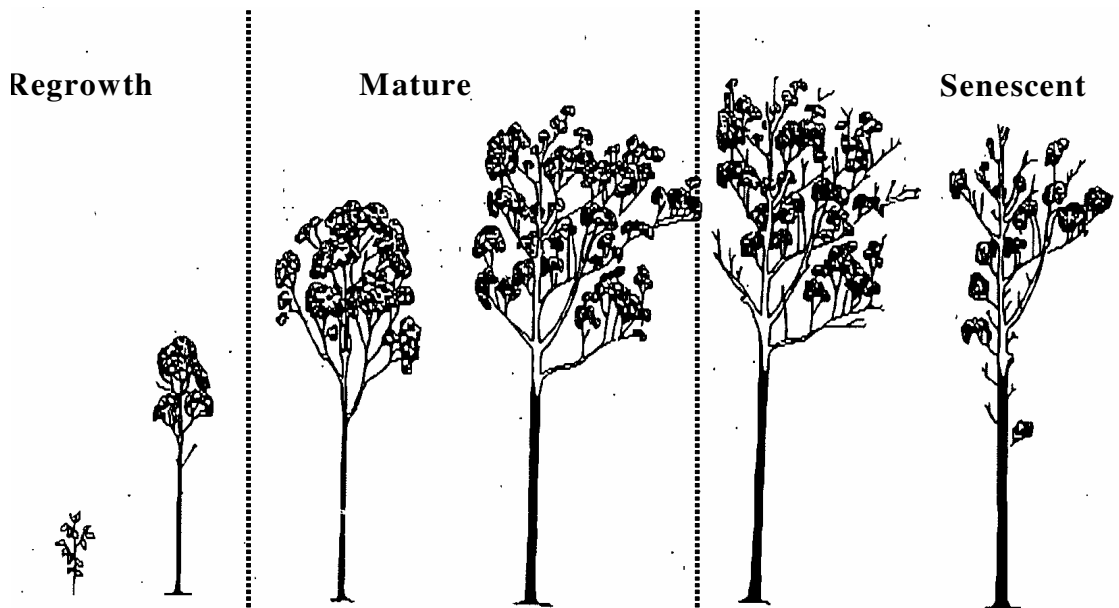
**regrowth, mature and senescing** (refer to Table 1 below).

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 due to being too small to be of consequence. These growth stages are a fundamental aid to the separation of forest stands (trees) into the three amalgamated major growth stages of **regrowth, mature, and senescing** used in API mapping.

**Table 1 Relationship between growth stage classifications**

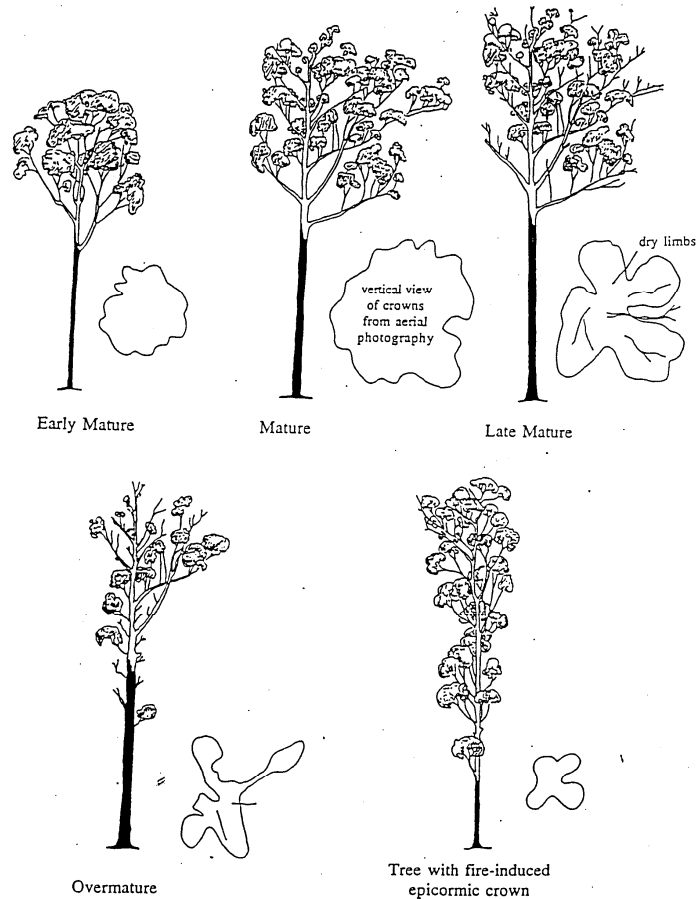
Three growth Stages for API and field verification	Minor Growth Stage from Woodgate <i>et al</i> (1994)	Jacobs (1955) Growth Stage
		Juvenile
<b>Regrowth</b>	Sapling	Sapling
	Pole	Pole
<b>Mature</b>	Early Mature	Mature
	Mature	
<b>Senescing</b>	Late Mature	Overmature
	Overmature	

**Table 2 . Characteristics associated with different growth stages for API and Field assessment**



Characteristics detectable from aerial photographs	Pointed Crowns Low height	Rounded crown, Crown opening up Crown limbs still Healthy Reasonable height compared to regrowth	Good proportions of limbs dead or dying but not fallen. Stagheaded. Crown view no longer rounded. Crown shapes may be distorted due to exposure
Modified Jacobs (1999)		Early Mature	Mature
Jacobs (1955) growth stages	Juvenile Sapling Pole	Mature	
			Overmature

**Figure 1.** Diagrammatically represents 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 NPWS 1996).



The use of colour 1: 25000 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 1 above). Table 2 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. Aerial Photographic Interpretation (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 is provided later in these notes.

Table 3 below outlines the primary growth stage classes utilized during the CRAFTI project adopted for old growth classification purposes and which would apply to any additional API work.

**Table 3 : Summary of Attribute Codes for Growth Staging in PNF Old Growth layer**

Code	Relative Crown Cover %	
	Regrowth Trees	Senescent Trees
<b>PNF layer codes</b>		
tA	<10%	>30%
tB	<10%	10-30%
<b>Non PNF codes</b>		
tC	<10%	<10%
sA	10-30%	>30%
sB	10-30%	10-30%
sC	10-30%	<10%
eN	>30%	no value recorded (as N)

# 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 increasingly 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

For the purpose of API mapping forest structure seven growth stages of juvenile, sapling, pole, early mature, mature, late mature and over mature were amalgamated into three as follows:

**regrowth, mature and senescing.**

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 due to being too small to be of consequence. These growth stages are a fundamental aid to the separation of forest stands (trees) into the three amalgamated major growth stages of **regrowth, mature, and senescing** used in API mapping.

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.**

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. These 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.

## **REGROWTH STAGE**

### *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.

## **MATURE STAGE**

### *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

### ***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 (ie 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.

### **SENESCING**

#### ***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 ie. 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.

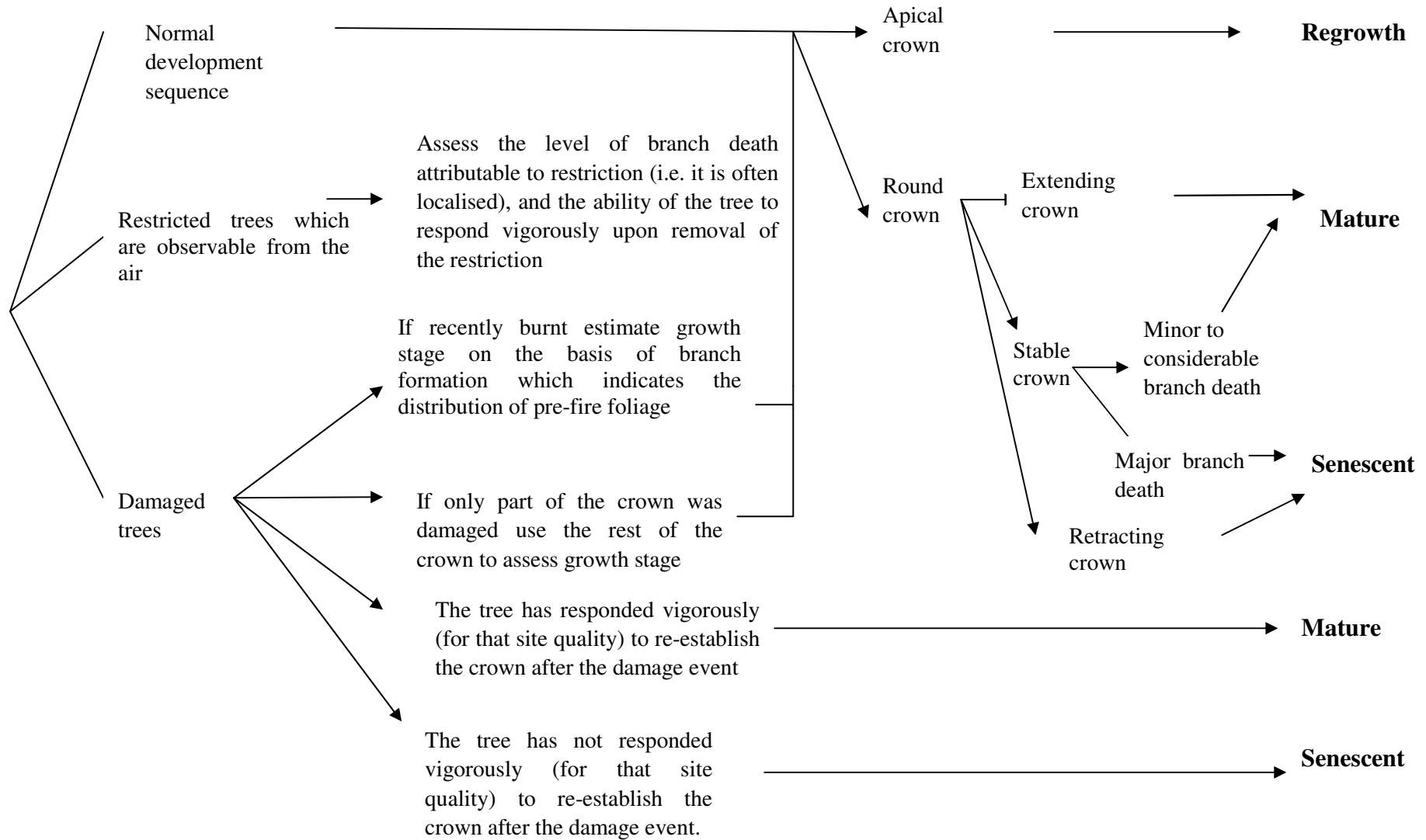
Extending crowns contain healthy leaf bundles at the end of branches and are where lateral extension of the crown still is occurring. Stable crowns are where the width and height of the crown are stable and includes crowns which have an even balance of retracting and extending crowns. Retracting crowns 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.):

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

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

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



# GROWTH STAGE KEY

## 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 ie 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:

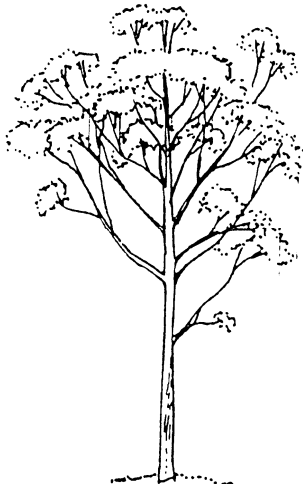
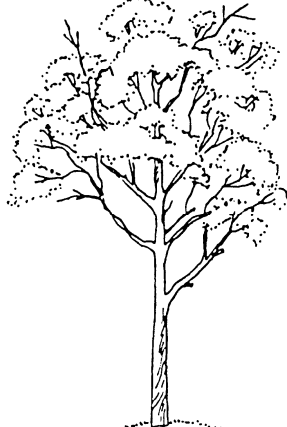
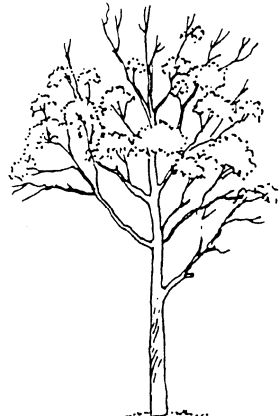
- Has the tree responded vigorously (for that site quality) to re-establish the crown after the damage event?  
**If yes - mature**  
**if no - senescent.**
- If only part of the crown was damaged, use the rest of the crown to assess growth stage.
- If recently burnt, estimate growth stage on the basis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

## 3. 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 (ie 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 6. Crown types and extension in generalised pyrophytic tree species (From RACAC 1996)**

<p><b>Extending crown</b></p> <p>Healthy leaf bundles at the end of branches, with lateral extension of the crown still occurring.</p>	
<p><b>Stable crown</b></p> <p>Width &amp; 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 which have an even balance of extending and retracting crown elements.</p>	
<p><b>Retracting crown</b></p> <p>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.</p>	

## **Identification of physical damage and restrictive competition in the field**

The interpretation of tree growth stages is often significantly muddled 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.

In this respect it is important that the interpreter's consider whether a tree's crown function has been affected by the branch loss resulting from restriction or 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.

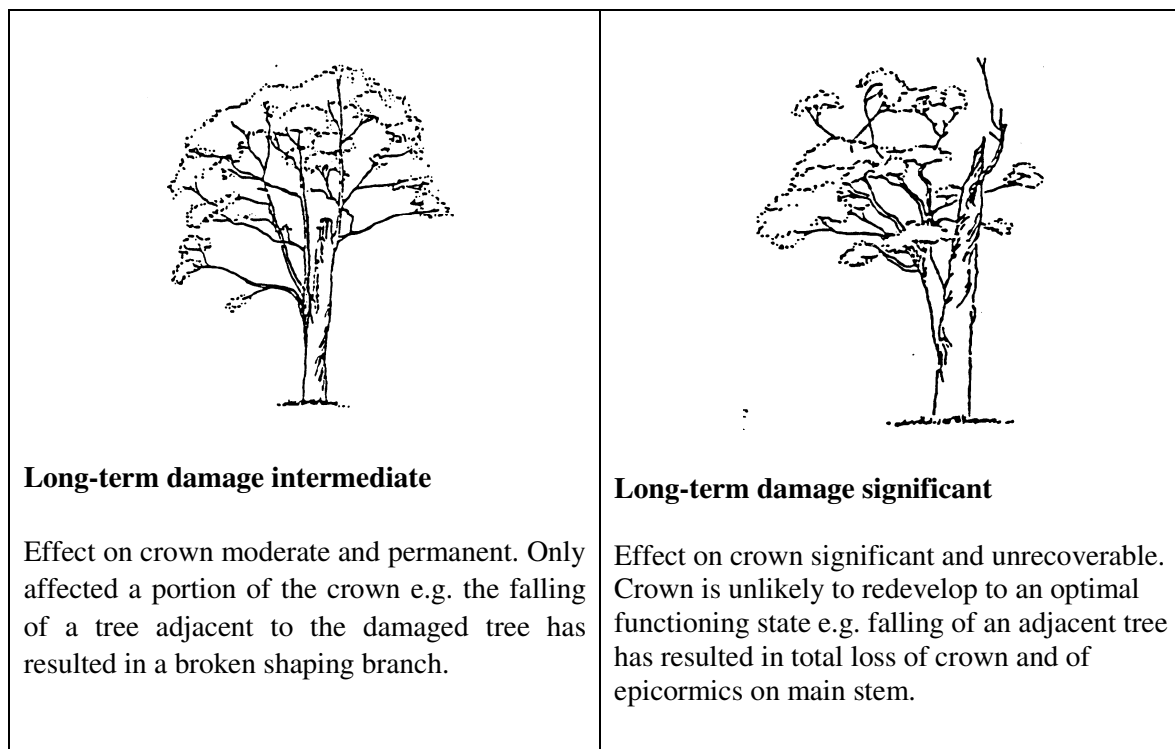
Damage to tree crowns can be caused by fire, wind (storm), lightning, insects, logging or drought and is often expressed by dead and broken branches, defoliation and/or epicormic shoots on the trunk or main shaping branches - unfortunately also primary features in the identification of the senescent 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)**



## 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 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 initially use the:

#### Point to plant methodology.

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

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 (ie. >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. 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 A) 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 B 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. Recommended sampling requirements for any site are as follows:
  - For areas up to 25 Ha - 1 Point to Plant Transect of minimum 10 points
  - For areas 25 – 50 Ha - 2 Point to Plant Transects of minimum 10 points each
  - For area 50 – 100 Ha - 3 Point to Plant Transects of minimum 10 points each.
  - For areas > 100 Ha – An extra 3 sites / 100 ha is recommended.

Examples of the layout of transects in the field are depicted in Figures 7 & 8 indicating that transect orientation, spacing and sampled area which can vary according to site conditions, stand condition, patch size and available resources. Whilst it is recommended that a 50m spacing with a 30m sampling radius be used, this can be varied depending on site conditions as depicted in the Figures 7 & 8.

**Table A: 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	Slope distance in metres
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	
25°	11.0	22.1	33.1	44.1	55.2	66.2	77.2	88.3	99.3	110.3	
30°	11.5	23.1	34.6	46.2	57.7	69.3	80.8	92.4	103.9	115.5	
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 B : Disturbance Indicators - Site descriptions**

<b>Disturbance Indicator</b>	<b>Site characteristics present within 30m of sample point</b>
1	<b>Recent logging:</b> 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	<b>Older logging:</b> visible evidence of older logging activity such as stumps, log dumps and/or constructed snig tracks which has 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	<b>Exotic woody weeds:</b> >30 % spatial cover within the 30m radius sample area of exotic woody weeds such as Blackberry, Camphor Laurel, Lantana, Privet etc.
4	<b>Ringbarked or dead standing trees:</b> 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	<b>Grazing infrastructure:</b> 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	<b>Constructed tracks:</b> 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 / ha = 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  $\pi$  (the formula being  $\pi r^2$  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/ha = 9 (denoted by N) x 307 (307 is calculated by squaring all radius measurements and multiplying by  $\pi$  for each transect point, and **THEN** averaging these answers)  
= 2158 m<sup>2</sup>/ha

**STEP FOUR :** The relative crown cover percentage of each of the regrowth, mature and senescent components is then formulated. The crown area/ha of each component is divided by the total crown area/ha 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 x 100 = 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 C below).

### Calculation for Disturbance Indicators

If any individual disturbance indicators (refer Table B and the Site Assessment Flowchart) are recorded for 6 out of the 10 or 8 out of 15 site sampling points (ie > 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 D 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 C : Summary of Attribute Codes for Growth Staging**

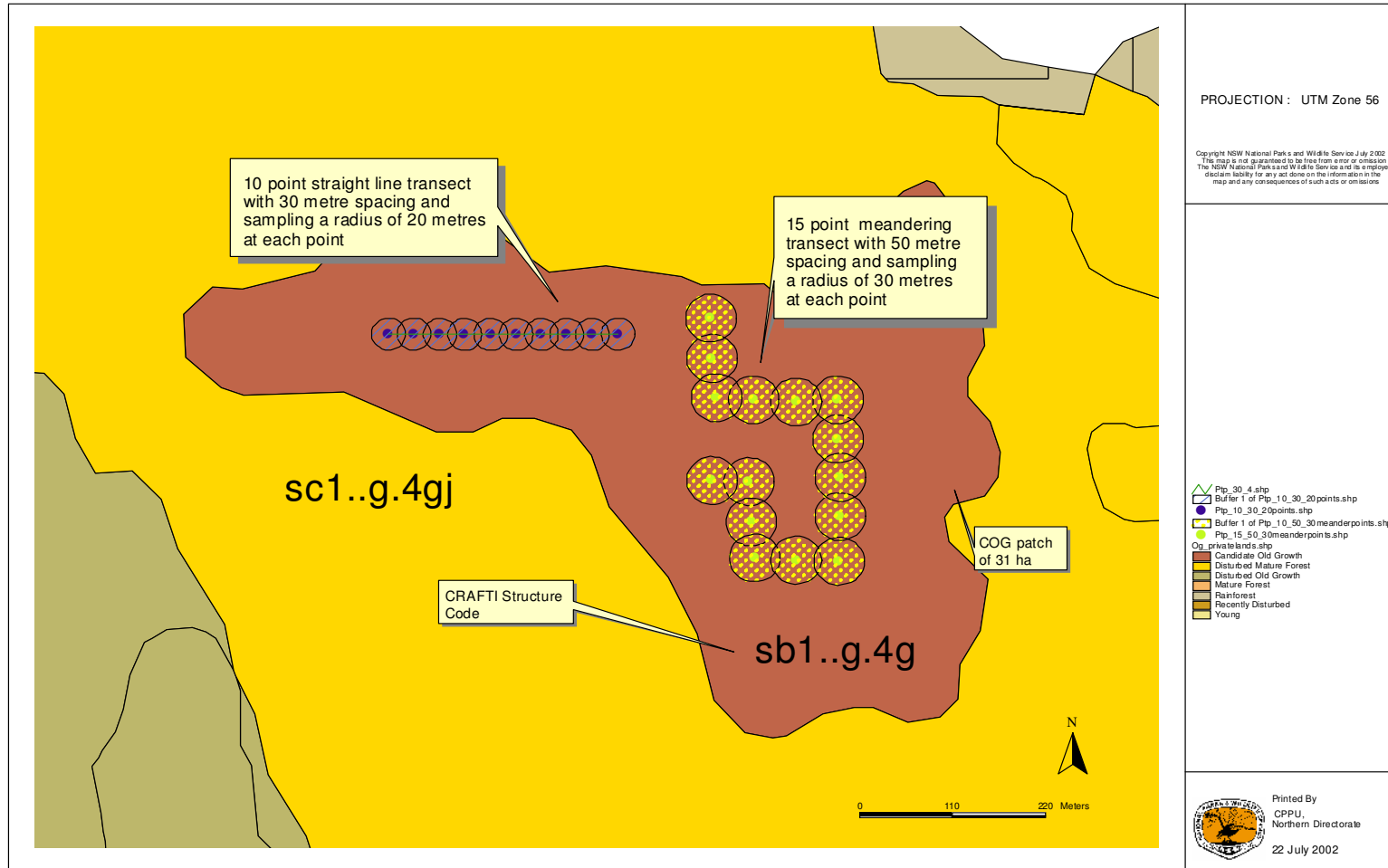
Code	Relative Crown Cover %	
	Regrowth Trees	Senescent Trees
<b>PNF codes</b>		
<b>tA</b>	<10%	>30%
<b>tB</b>	<10%	10-30%
<b>Non PNF codes</b>		
<b>tC</b>	<10%	<10%
<b>sA</b>	10-30%	>30%
<b>sB</b>	10-30%	10-30%
<b>sC</b>	10-30%	<10%
<b>eN</b>	>30%	no value recorded (as N)

**Table D : For deriving revised 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 or tB	Negligible	Candidate Old Growth
tA or tB	Significant	Disturbed Old 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 m spacing between points and sampling a radius of 20 m at each point.**

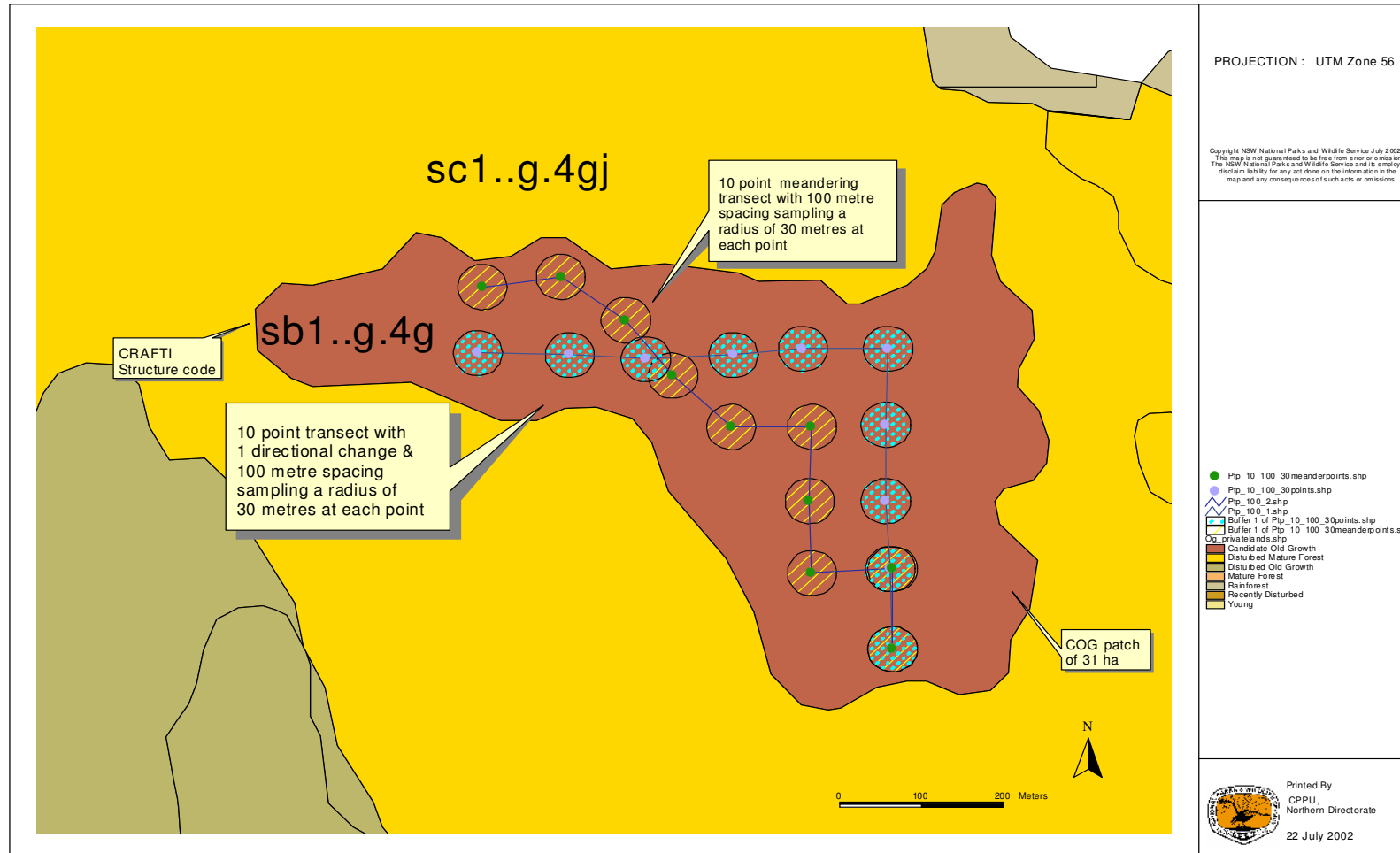
## Old-growth forest on Private lands Site Inspection





**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**

## Old-growth forest on Private lands Site Inspection



**Old Growth Private Property Site Inspection Proforma**

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

**Land holder**.....

**Photography/year**.....

**Location** .....

**Starting Point : EASTING** .....**Finishing Point :EASTING** .....

NORTHING .....

NORTHING.....

Note r = the average of the longest and shortest radius

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

**Recorders:** .....

**API code:**.....

**25k mapsheet:**.....

**Transect No:**.....

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												
<b>Total</b>												

**Disturbance indicator descriptions**

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 (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/ha = 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  $\pi$  (the formula being  $\pi r^2$  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/ha = 9 (denoted by N) x 307 (307 is calculated by squaring all radius measurements and multiplying by  $\pi$  for each transect point, and **THEN** averaging these answers)  
= 2158 m<sup>2</sup>/ha

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

Regrowth crown area = 117

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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 x 100 = 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			

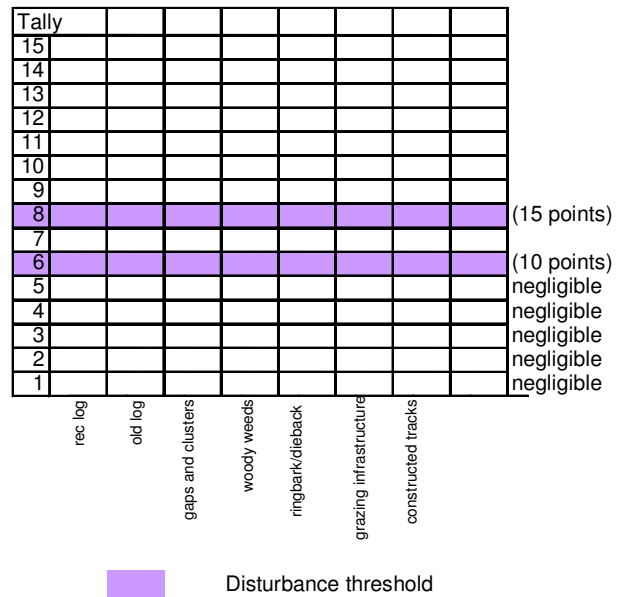
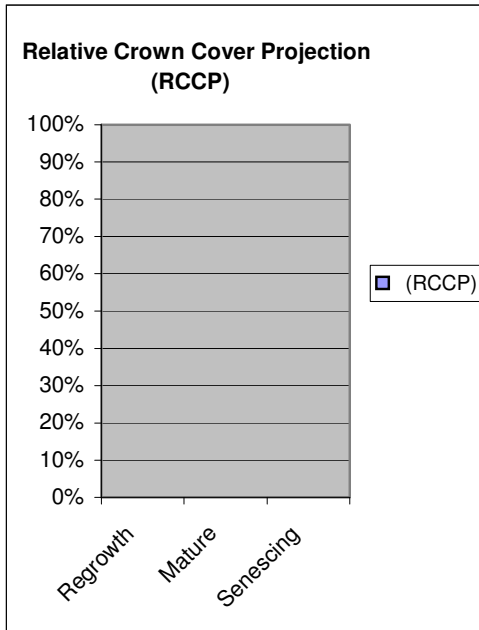
**Correction Factor (CF) Table for nil records (Point to Plant Surveys).**

**Site Survey Calculations and Results Proforma**

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

	Reg.	Sen	Mat.	Total
<b>N</b>				
<b>CA (ha)</b>				
<b>rCCP%</b>				
<b>Code</b>				

**Field Growth Stage**



**Field Survey**

Point to Plant transects.....

Other disturbance at site e.g Fire .....

**Calculated Site Details**

Growth stage	Disturbance Level	Growth Stage

## **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 Old-Growth status. 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 & 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 and / or the forest is not 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 Ha - 1 Point to Plant Transect of minimum 10 points

For areas 25 – 50 Ha - 2 Point to Plant Transects of minimum 10 points each

For area 50 – 100 Ha - 3 Point to Plant Transects of minimum 10 points each.

For areas > 100 Ha – An extra 3 sites / 100 ha 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 should 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 above are followed and the necessary data has been collected the results can be inserted into the spreadsheet (Excel spreadsheet which should be electronically provided on a PC computer) 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 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 old growth polygon be modified accordingly. The results of the transects should confirm or reject the coding and/or line placement. Revision of the line work 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 boundary should best reflect these differences.

It is acknowledged, however, that in areas up to 25 ha 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 line work are compatible, (ie 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 2<sup>nd</sup> property.

## **Description of Growth Stages**

### **Old Growth Forest**

These are forest stands where the senescing component (ie 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 (ie less than 10 % RCCP).

Depending on the forest ecosystem and site in question, the old growth forest may vary in its structural expression due to site quality considerations. Very productive sites (ie moist eucalypt forests) will usually attain high site heights > 40metres, be dominated by trees with a large girth (ie > 100cm dbhob) and extensive (& retracting) crowns and have a number of distinct sub canopy strata ( ie 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.

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 ie fire. In these stands trees will usually be less than 25 metres in height and not necessarily of a large diameter ie < 100cm dbhob. While these trees may bear hollows it may be generally more difficult to assess tree senescence from the ground. These stands are characterized by an open forest structure with a sclerophyllous, grassy or heathy understory 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 ha (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 old growth *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 characterized 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 (eg stumps, snag 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.