

# Forest Condition Monitoring (FCM) of *Pinus radiata* in New Zealand Field Data Collection Procedures

Prepared for **New Zealand Forest Owners Association**

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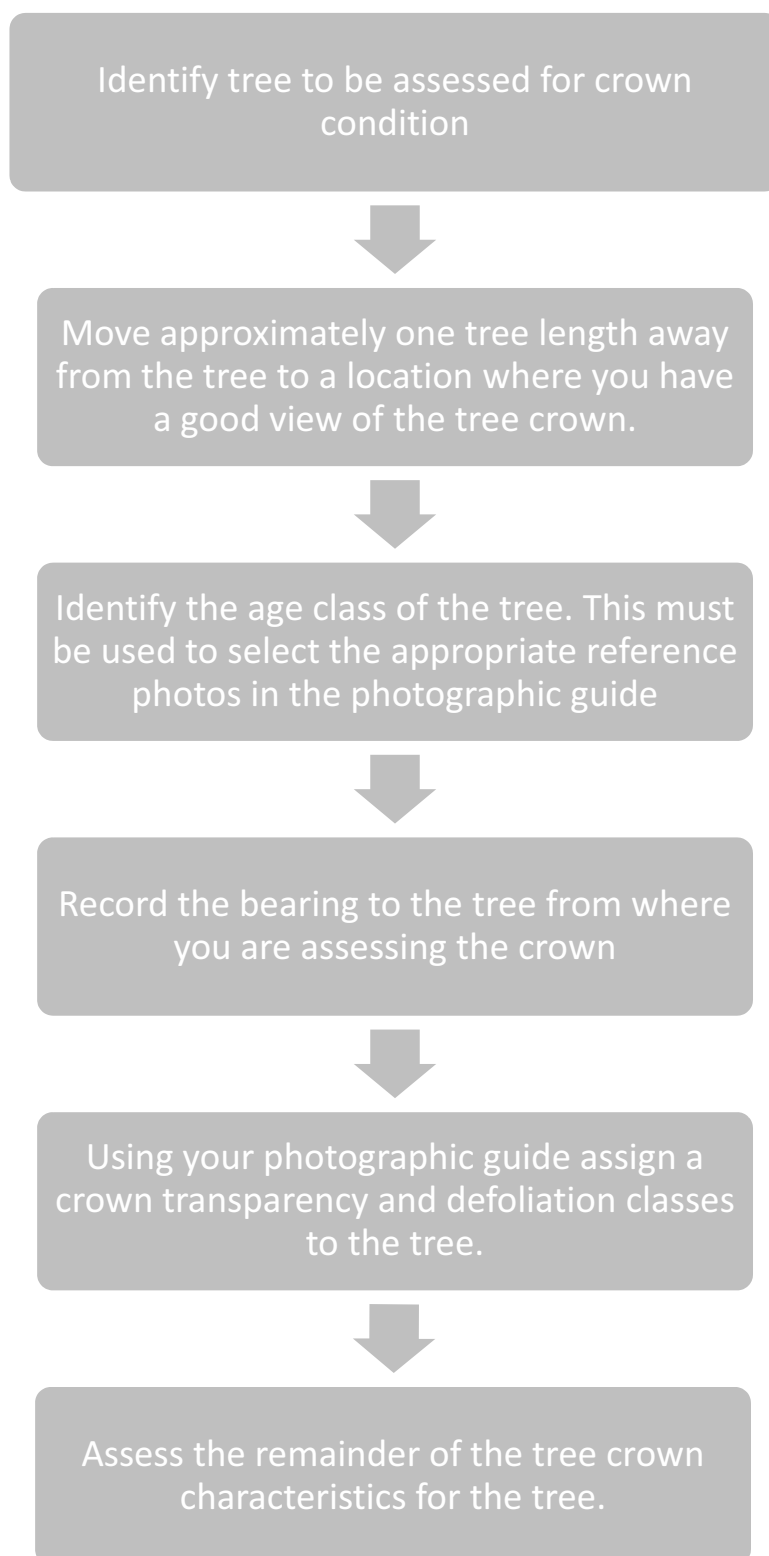
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## 1 SUMMARISED MEASUREMENT PROCEDURE

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Version	Description	Date
1.3.1	FCM field procedures manual prepared for the NZ Forest Owners Association for use in post 2010 measures of forest condition monitoring surveys	Jan 2011
1.2.1	FCM field procedures manual prepared for the NZ Forest Owners Association for use in the 2010 CMS Planted Forest survey	May 2010

Table 1. Quick guide to forest condition indicators.

Indicators: Description	Scale				
	0	1	2	3	4
<b>Crown Transparency:</b> The amount of skylight visible through the live, normally foliated portion of the crown	0-100% transparency (5% classes)				
<b>Crown Defoliation:</b> The amount of needle loss in the assessable crown as compared to a reference tree.	0-100% foliage lost (5% classes)				
<b>Stem Visibility:</b> The amount of stem visible through the foliage and branching		Less than 25% of the stem is visible	25-50% of the stem is visible	50-75% of the stem is visible	More than 75% of the stem is visible
<b>Needle Retention:</b> The number of needle age classes (to nearest year) present in lower third of the unsuppressed green crown	1yr old needles absent	1yr old needles present	2yr old needles present	3yr and older needles present	
<b>Crown Dieback:</b> The recent dieback of branches with fine twigs in the upper and outer portions of the tree	1-100% of crown is dieback (in 5% classes)				
<b>Crown Depth:</b> The depth of green foliage present in the crown		Green foliage in lower quarter of crown	Green foliage in lower-mid quarter of crown	Green foliage in upper-mid quarter of crown	Green foliage in upper quarter of crown
<b>Dothistroma:</b> <i>Dothistroma pini</i> causes needles to turn brown with red bands	1-100% of total crown foliage with infection (5% classes)				
<b>Resin Bleeding:</b> Resin on the outside of the tree stem	Not Assessed	Nil or light resin bleeding	Moderate resin bleeding	Severe resin bleeding	

## 2 ACKNOWLEDGMENTS

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## 3 INTRODUCTION

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### 3.1 PURPOSE OF THIS DOCUMENT

In response to a growing need for a health monitoring system for New Zealand forests, the NZ Forest Owner's Association (FOA) has commissioned (with the help of funding from the Sustainable Farm Fund) the development of a forest condition monitoring (FCM) system that will assist in the long term observation of forest health issues.

This document is a procedural manual that is designed to help conduct the field measurement techniques that underpin the FCM system. It has been written by Interpine Forestry Limited, in collaboration with industry experts in forest health issues. The techniques discussed in this manual have been drawn from years of research into long-term condition monitoring projects. It is intended that this document provides a standard procedure for field technicians so that forest condition attributes may be compared both spatially and throughout time with minimal user error variability.

### 3.2 FOREST HEALTH MONITORING SYSTEMS

Since the 1980's, in response to forest health concerns over the environmental impacts of issues such as air pollution and acid rain, forestry authorities in Europe and North America began to implement forest condition monitoring systems (Innes 1993). These monitoring techniques were based on the supposition that crown condition indicators like crown transparency and defoliation are an excellent indicator of overall tree and forest health.

In New Zealand however, there has been no concerted effort to monitor long-term forest health and all reports on the "supposed" decline of Radiata pine (*Pinus radiata* D. Don) health have been based on anecdotal evidence. Small scale research projects involved in FCM have been carried out in recent years (Bulman L. S., 1997), (Bulman L. S., 2003) yet no systematic wide-scale FCM project had been established. The FOA's intentions to implement an effective FCM system are driven by the need for quality information showing how the health of New Zealand's key production forests is changing over time. It is considered that this information will not only play a crucial role in understanding the long-term production trends of New Zealand forests, but also as an early warning system for large scale health issues that may not be explicitly apparent at the tree level.

### 3.3 CROWN CONDITION

Crown condition offers a useful, quick and scientifically valid method of forest health assessment. Despite this, crown condition measurement carries numerous dimensions of variability, namely spatial variability (from tree to tree and plot to plot), chronological variability (from year to year), and assessor variability (due to an element of subjectivity in measurement). The writers of this manual have been diligent in their attention to the sources of this variability, attempting to implement procedures that will improve crown condition assessment precision.

## 4 FIELD PROCEDURES

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### 4.1 SITE ACCESS

Field teams will be provided with aerial photographs, maps, owner contact details and plot locations loaded onto a handheld GPS device prior to going into the field. Ensure that you have all of this before going out to measure a plot. When inside a forest estate field teams must comply with all health and safety procedures of the forest managers.

### 4.2 LAND OWNER PERMISSION

Before establishing or re-measuring plots permission must be obtained from the land owner, the forest manager and from any persons whose property must be crossed to reach the plot. This information must be recorded for each plot measured as part of the FCM survey.

Check permission from the forest owner has been gained for the placement of a galvanised pipe into the ground at the site centre.

Also check whether landowner would like a copy of all data collected.

*Permission contacts:* Record the name and contact details (address, phone, fax, email) of the landowner, the method of contact (e.g. phone, letter) and the name of the person who made contact, for both the property on which the site is located and properties that need to be crossed to access the site. Include notes (e.g. requirement for gate keys) that may be useful for future field teams requiring access to the site.

### 4.3 SITE DESCRIPTION

For each site record the following information in your data capture application.

Altitude measured to the nearest 10m using one of the following methods:

- Barometric Altimeter. These should be corrected each morning, or more frequently during changeable weather, from points of known altitude on the topographical map.
- GPS fitted with a barometric altimeter. These should be corrected each morning, or more frequently during changeable weather, from points of known altitude on the topographical map.
- GPS not fitted with a barometric altimeter.
- Topographical derived estimate from contour lines.
- Estimate from map with no contour lines.

The preferred methods are either a normal calibrated barometric altimeter or a calibrated barometric altimeter within a GPS unit. Where an altimeter is not available, use one of the other three methods and in these cases plot elevation will be calculated from a digital terrain model (DTM) at a later date. Always note what method was used to calculate altitude.

*Site Marker:* Record whether the site has been marked with the 300-mm length of galvanised pipe into the ground.

*Hazards:* Provide a brief description of any hazards on site for purposes of warning any personnel involved in site re-measurement.

*Undergrowth:* Record the level of hindrance due to undergrowth. Undergrowth should be recorded as light, medium or heavy.

*Terrain:* Record the general terrain type of the plot. Terrain type should be recorded as flat, rolling or steep.

*Weather conditions:* Record the general weather conditions of the measurement day. Weather conditions should be recorded as one of bright, overcast, or raining.

## 4.4 SITE LAYOUT

To estimate forest condition data is collected from a single 0.06 hectare circular plot at each assessment site. The following sections outline the procedures which must be followed when establishing plots and are similar to those outlined in permanent sample plot manuals (Ellis and Heyes 2007, Herries et al 2010).

### 4.4.1 Using a GPS for navigation

The minimum standard of GPS unit suggested for location plot centres is the Garmin 60CXS device or better which has an accuracy of sub 15m and can be used to navigate to plot centres.

### 4.4.2 Navigating to a plot centre

It is unlikely that a standard handheld GPS unit will be able to locate the site centre point within accuracy of  $\pm 15\text{m}$  under a dense closed canopy. Therefore to locate a plot centre a GPS reading should be taken adjacent to the stand or in a gap (if possible) where the instrument accuracy should be greatest. Even when the centre of the plot is located on open ground, the GPS should only be used to navigate to within approximately 30m of the plot location. Then use a compass bearing and the horizontal distance reading displayed by the GPS unit to identify the location of the plot. When a GPS unit is being used to determine direction, ensure that the direction function is set to correct magnetic declination as defined for the site.

The above procedure is necessary because the GPS unit will display varying locations of a specified point in a random manner as that point is approached. It is important that the position of the sample point is determined objectively by strictly following the compass bearing and distance. Do not move the sample point from its pre-determined position. This applies even when the point is outside the area of planted forest, in a gap (e.g. old landing site), or on a track. Use the GPS unit in conjunction with topo maps and aerial photographs to best locate the plot on the ground.

### 4.4.3 Site Marking

It is beneficial for plots in planted forest plots need to remain as inconspicuous as possible to ensure they receive the same (i.e. neither more nor less) silvicultural treatment as the rest of the stand. Limited use of non-permanent aerosol paint is allowed. Please take the following precautions:

- Do NOT permanently mark the route to the plot.
- If owner permission has been granted, permanently mark the centre point of every plot by driving a 300mm length of galvanized pipe into the ground. Ensure the pipe is completely buried. These measures minimise the likelihood of other forest users inadvertently discovering the plot, and maximise the likelihood of field crews re-finding the plot centre with the aid of a metal detector.
- Using non-permanent aerosol paint, number every tree that lies within the slope-corrected radial distance of the plot centre (put numbers at stump level).
- If measuring dbh always mark the 1.4m dbh point with a dot. If diameter is shifted from 1.4m, put a short line where the diameter was taken.

- Mark all plot and subplot boundaries with hip-chain measurement cotton to ensure objects are not missed or double counted. After the measurement hip-chain cotton can easily be removed or broken down.

#### **4.4.4 Witness Trees**

Identify a prominent tree (or other permanent object if trees are not present, e.g. fence post or rock) that is 10–15 m outside of the plot and is clearly visible from the plot centre. Mark the stem with a paint band 2 m above the ground and clearly write the witness tree number (e.g. 1, 2 or 3) on the side of the tree facing the centre of the plot. Record the true bearing and horizontal distance from the centre of the plot to the witness tree. Repeat this process until 3 approximately equidistant trees around the circumference of the plot have been identified. These witness trees will aid in future site location.

#### **4.4.5 Plots that cannot be established**

Where a plot cannot be established at the specified grid coordinates because it is unsafe to do so (e.g. steep terrain prevents access to all or part of the plot area, logging operations taking place, the plots falls on a road, a residential area or cliff face) or the surrounding terrain makes it impossible to get to the exact location:

- Do not attempt to establish the affected plot at the specified point, or to relocate the plot.
- Record the site as abandoned.
- Take photographs of the site.

#### **4.4.6 Locating a pre-established plot centre**

When measuring a plot which has already been established as part of an earlier measurement programme a fixed GPS location for the plot centre and the distance and bearing from three witness trees will be provided to the field crew. Witness trees are prominent trees, or other permanent object, which are located 10 – 15m outside the plot boundary. Witness trees are clearly marked with a paint band 2m above the ground and have a number identifying the witness tree number (e.g. 1, 2, or 3) on the side of the tree facing the plot centre. The distance and bearings from the witness trees can then be used to locate the plot centre of the pre-existing plot which will be marked with a galvanised steel peg just below ground level. A metal detector should be used to assist with the location of peg marking the plot centre.

#### **4.4.7 Plot size**

The plot has a horizontal area of 0.06 ha and a horizontal radius of 13.82m (on flat ground). Where a plot is on sloping ground, measure the average slope of the plot and apply this to the slope correction table in Appendix 3 to obtain the corrected plot radius. When using a hypsometer to make these measurements it is important to check the calibration of the instrument.

The average slope of a plot is estimated by measuring the angle of maximum slope from the plot centre to the uncorrected plot radius, the angle is then measured 180° opposite the maximum slope. These two values are then summed and divided by two to give the average slope for the plot. The plot radius is only to be slope corrected if the average slope is  $\geq 5^\circ$ .

#### **4.4.8 Plot boundary definition (trees inside/outside plot)**

Trees are considered to be in the plot if the centre of the trunk at breast height (1.4 m) is within the slope-corrected distance from the plot centre. Where a tree is rooted outside the plot and is leaning into the plot to the degree that the centre of the trunk at breast height lies within the slope-corrected distance from the plot centre, the tree is considered to be in the plot. Conversely, where a tree is rooted inside the plot and is leaning out of the plot to the degree that the centre of the trunk at breast height lies outside the slope-corrected distance from the plot centre,

the tree is considered to be out of the plot. For trees where the centre of the trunk at breast height is located within 0.5m of the plot boundary, the distance to the plot centre must be checked with a tape (if using an electronic measurement device) to ensure the tree lies within the plot. Trees within 0.10m of the plot boundary must have their centre at breast height checked on both sides of the trunk.

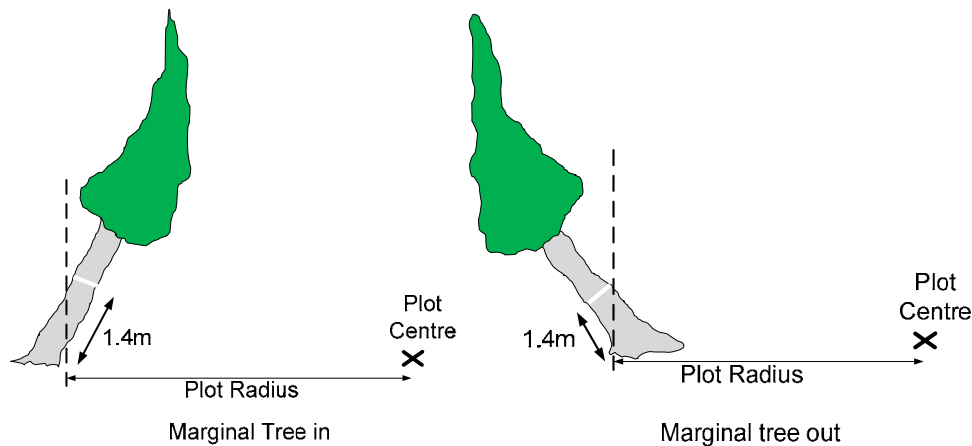


Figure 1. Examples of dealing with marginal plot trees

#### 4.4.9 Dealing with plots containing no *Radiata pine* trees

In some cases part or the entire plot may not contain any planted *Radiata pine* trees. This can arise for a number of reasons including:

- Non-planted areas (e.g. steep gullies, riparian areas, poor establishment, logging site or regenerating natural forest) within a planted forest stand
- Misclassification – an area mapped as planted forest is found to contain vegetation from another land use.
- Plot located partly outside the area mapped as planted forest.
- Plot has been determined in the absence of a mapped boundary and falls partially in a planted forest.
- Due to incorrect stand records plot has been located in a stand of a species other than *Radiata pine*.

When a plot with no *Radiata pine* stand is encountered the plot can be relocated using the methodology in 4.4.11 if there is a suitable stand *Radiata pine* within 100m of the original plot location. If not then the plot should be abandoned.

#### 4.4.10 Where a plot falls partly inside an area of a *Radiata pine* forest.

Where this occurs the plot should be established as normal; trees that are on forest edges should be assigned a descriptive code of “Edge”. Where a plot contains both *Radiata pine* and other tree species FCM assessments should only be made on *Radiata pine* trees.

#### 4.4.11 Moving a FCM plot

The following procedures should only be followed if collecting FCM data is the sole objective of the inventory. If FCM indicators are being recorded as part of a concurrent inventory then the plot relocation procedures of that inventory must be adhered to. When a plot containing no *Radiata pine* trees is located then the following methodology can be used to relocate the plot into a *Radiata pine* stand if there is a suitable stand within 100m of the intended FCM plot location. A point should be located 50m magnetic north of the original FCM plot centre, a

new plot can be located here if it this point is 10m inside the boundary of the Radiata pine stand. If this location is unsuitable for a new plot then proceed to a location 50m magnetic east of the original plot centre; a plot can be established here if this location is 10m inside the Radiata pine stand. If unsuccessful then repeat using the remaining two cardinal points to locate potential new plot locations if neither of these locations is suitable then repeat the process using locations 100m away from the original plot centre along the cardinal compass points. An example of the process for locating a new FCM plot is provided in Figure 2. If a plot is unable to be relocated in this manner into a Radiata pine stand then the plot must be abandoned.

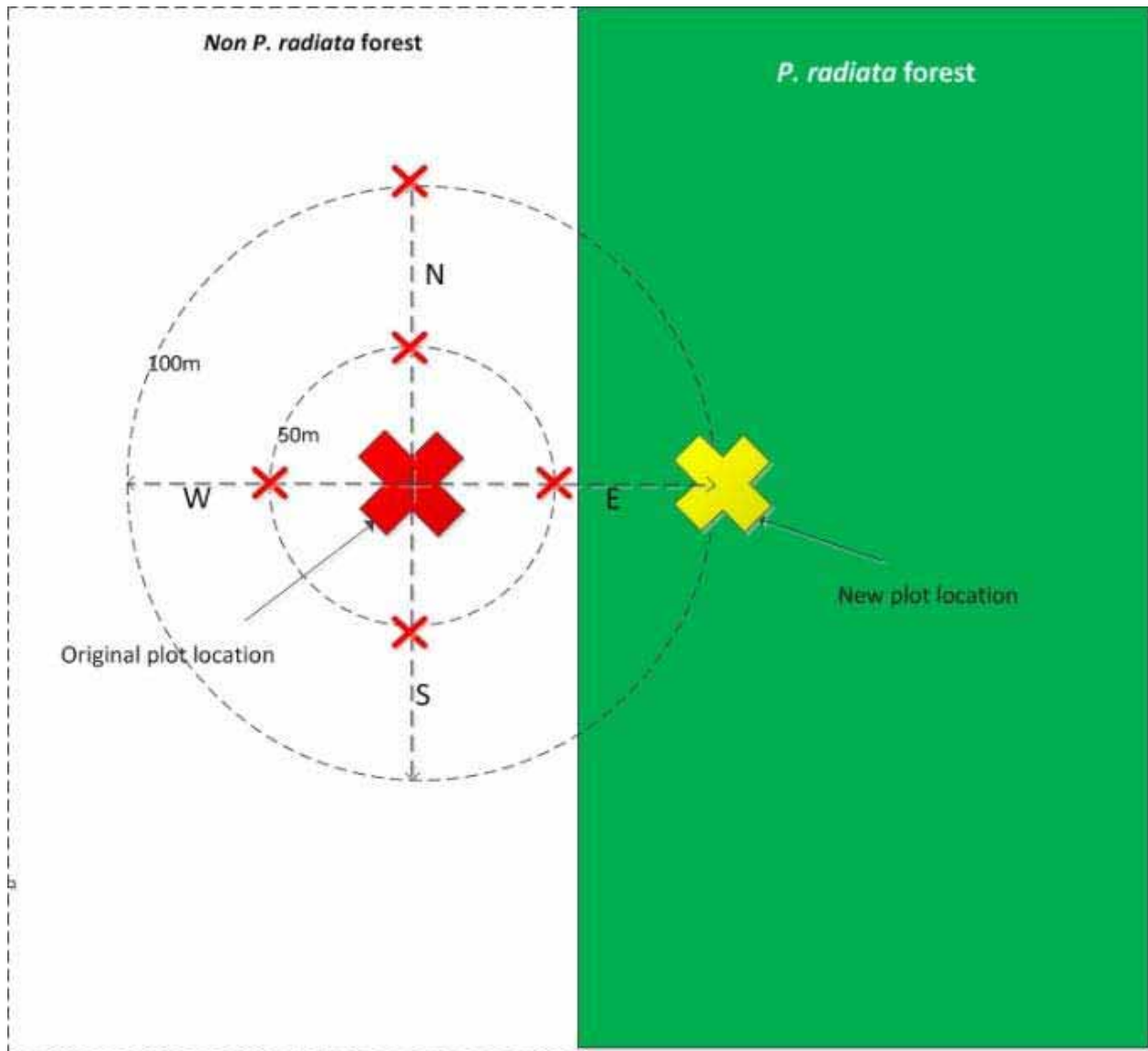


Figure 2. Relocation of a FCM plot when original plot location is outside of Radiata pine forest (red crosses indicate locations where new plots could not be established).

## 4.5 TREE MEASUREMENTS

The following sections outline the tree measurements which need to be recorded as part of the New Zealand FCM inventory. Additional measurements may be required as part of a concurrent inventory.

### 4.5.1 *Tree selection*

The crown condition measures outlined in this manual should be assessed on all live Radiata pine trees inside the plot boundary. A tree is defined as having a diameter at breast height (dbh) greater than 2.5cm.

### 4.5.2 *Tree dimensions*

Measurement of tree dimensions does not constitute part of the FCM inventory procedures. There are several good procedures manuals which outline measurement of tree dimensions and are suitable for measuring permanent sample plots such as those in the FCM inventory. Where a concurrent measurement programme requires you to measure tree dimensions an appropriate measurement procedure will be specified by the inventory manager.

### 4.5.3 *Crown Transparency and Defoliation*

Crown transparency and defoliation are the most important measures of crown condition in this forest condition monitoring surveys. Crown condition is strongly correlated with the health of a tree, therefore by observing changes in crown condition overtime we hope to track changes in tree health. The following sections contain information on the effective measurement of crown condition.

### 4.5.4 *Crown Defoliation Scale*

Crown defoliation is defined as the amount of needle loss in the assessable crown as compared to photograph of a fully foliated reference tree. The scoring system used in this field guide is based on crown defoliation indices used in European forest health surveys (UNECE 2006).

Crown defoliation is assessed in 5% intervals. The following provides a guide to measurement.

- 0% corresponds to a tree with full foliage;
- 5% indicates that >0-5% of the tree's potential foliage has been lost;
- 20% indicates that 16-20% of the tree's potential foliage has been lost;
- 55% indicates that 51-55% of the tree's potential foliage has been lost;
- 100% designates a tree with no foliage

**Note: when scoring defoliation assessors must estimate the amount of missing needles rather than noting the presence of dead foliage.**

### 4.5.5 *Crown Transparency Scale*

Crown transparency is defined as the amount of skylight visible through the normally foliated section of a tree crown. Crown transparency is assessed in 5% intervals. The following provides a guide to classification.

- 0% corresponds to a tree with full foliage allowing minimal skylight through its crown
- 5% indicates that 5% of the trees potential crown is transparent
- 50% indicates that half of the tree's potential crown is transparent

- 100% designates a tree where the crown is completely transparent i.e. it has no foliage.

The photographic guide provided in Section 5 shows a range of photos showing varying degrees of crown defoliation and transparency for three age classes. These photos should be used in the field to set a benchmark for assessment and reduce the variability that may arise between assessors. It is strongly recommended that field assessors undertake revision training prior to each assessment period. The intention of the training is to ensure that each assessor is able to calibrate their own measurement perception with the photographic benchmarks.

#### **4.5.6 Dealing with forked trees**

Trees with a fork below 1.4m are typically recorded as two separate trees for plot based forest measurements. For FCM surveys these trees should be counted as two individual trees and recorded twice in the data file, however, all assessments should be carried out as if the trees were a single tree and the same FCM scores should be applied to both trees.

#### **4.5.7 Assessable Crown**

There are numerous measures of assessable crown used throughout the world for assessing crown transparency and defoliation. The assessable crown includes recent dieback (i.e. branches which still have their side-shoots) but excludes the following:

- Natural gaps in the crown where it is assumed that no branches ever existed or where mechanical damage has occurred;
- Parts of the crown which are visibly or mechanically impaired by neighbouring trees;
- Snags that have been dead for many years; and
- Very large gaps between foliated branches.

Defining the assessable crown is difficult and can lead to variable results between assessors. In order to reduce this variability crown transparency is to be measured using two different measures of assessable crown, the entire crown method and the top 50% method. For the assessment of defoliation the assessment should be made for the section of green crown from the widest point of the crown up to the top of the tree.

The three methods for defining assessable crown to be used in this survey are:

1. The entire crown method - including all dead branches (***crown transparency***);
2. The top 50% of the tree crown (***crown transparency***);
3. The section of crown from the point where the green crown is widest up to the top of the tree (***defoliation***).

#### 4.5.8 Definition of Assessable Crown for Measuring Crown Transparency

The figures in this section provide a visual reference for field crews which indicate how the assessable crown is defined when measuring crown transparency. Two assessments of crown transparency should be made one including 100% of the unpruned crown and the other including the top 50% of the unpruned crown.

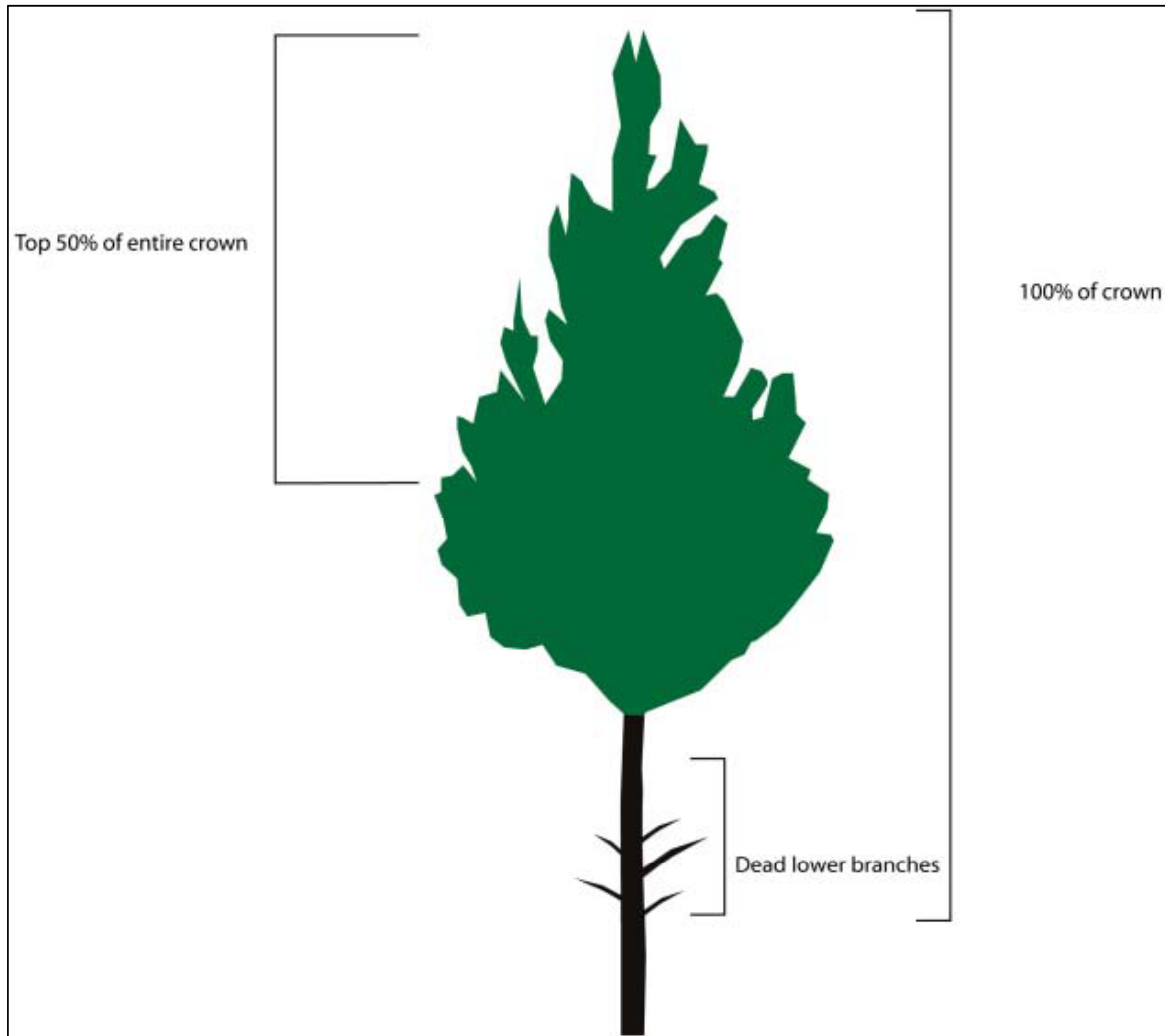


Figure 3. The 100% and 50% crown definitions

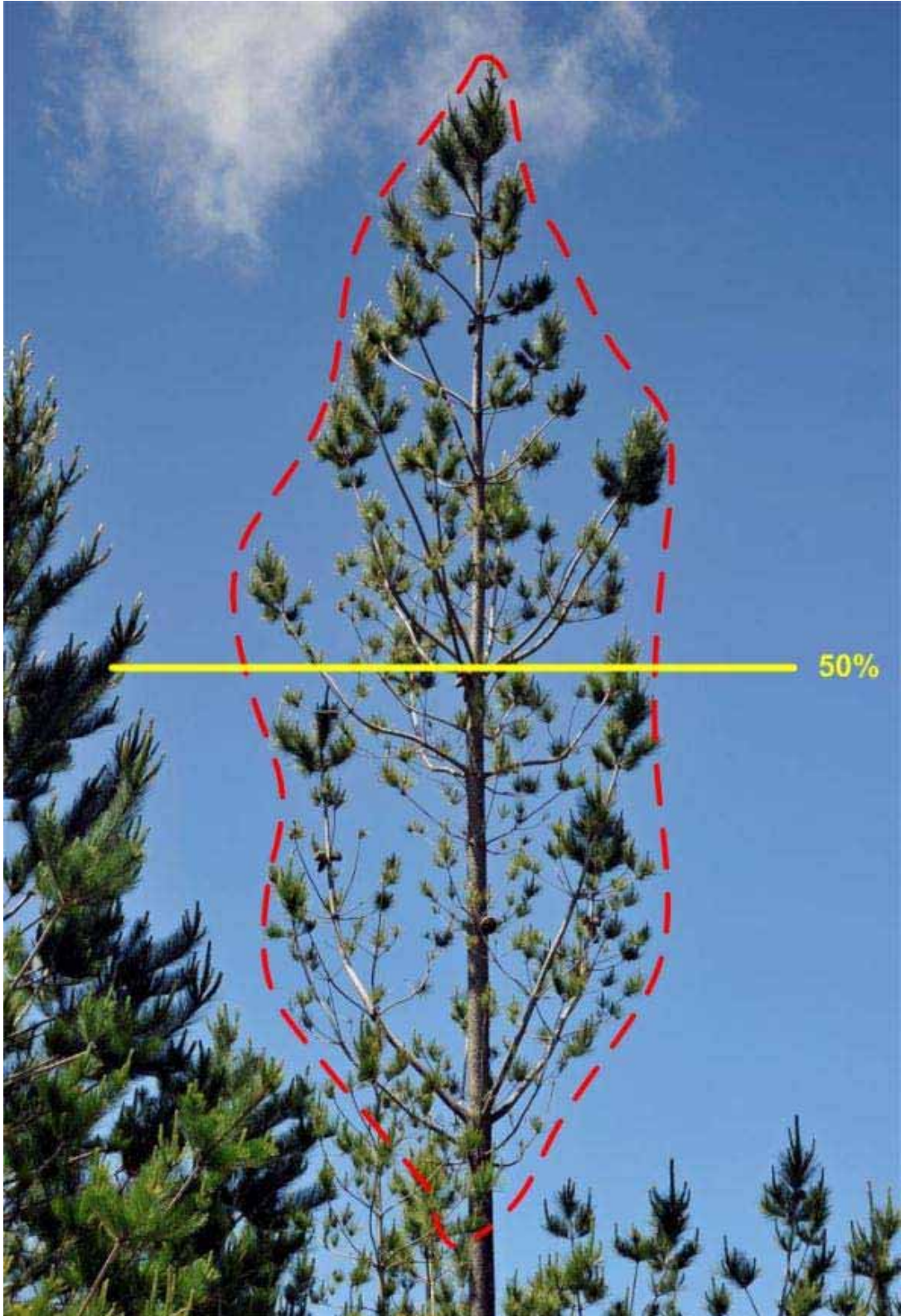


Figure 4. The assessable crown for measuring crown transparency in a mid rotation tree

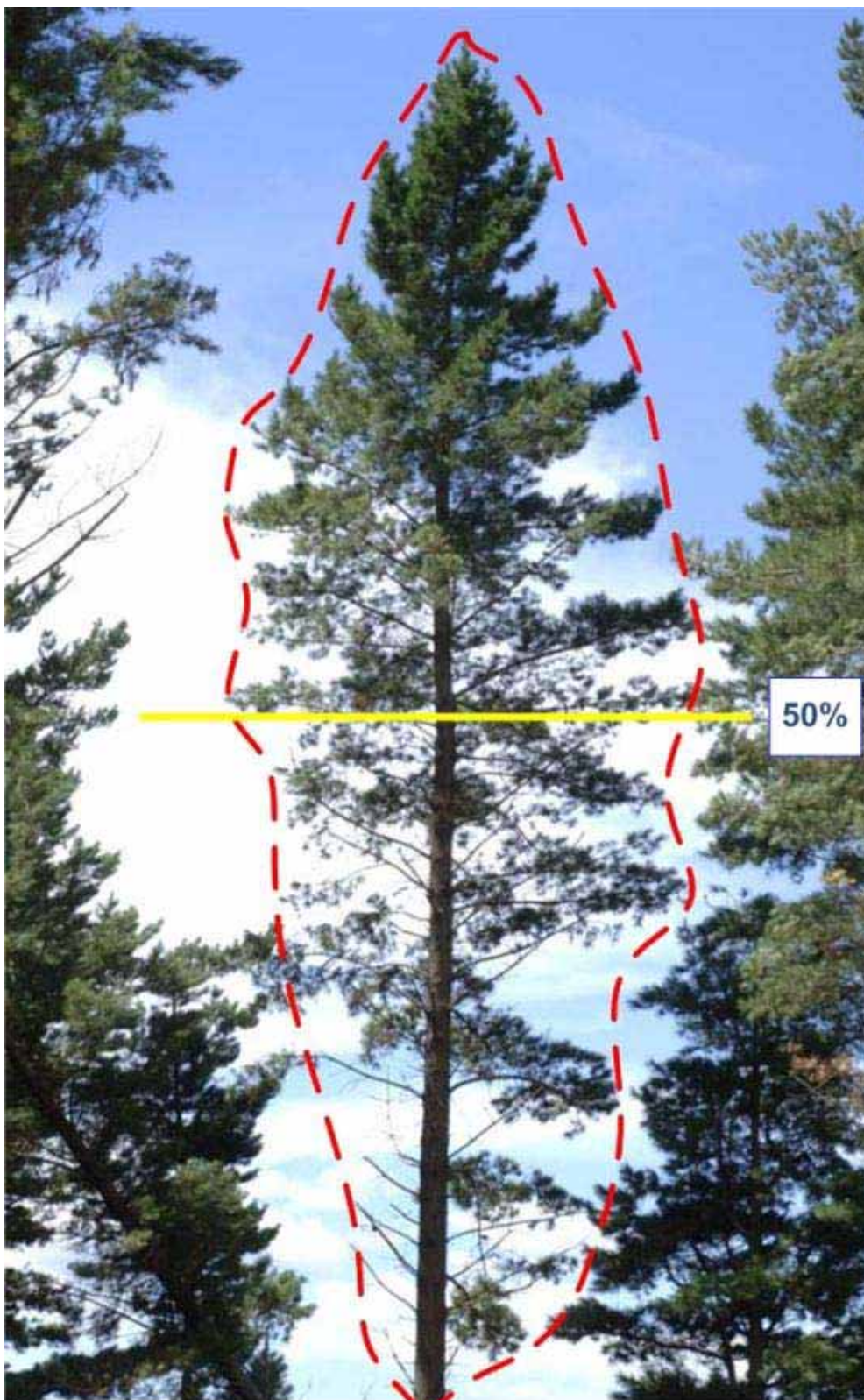


Figure 5. The assessable crown for measuring crown transparency in a mature crop tree

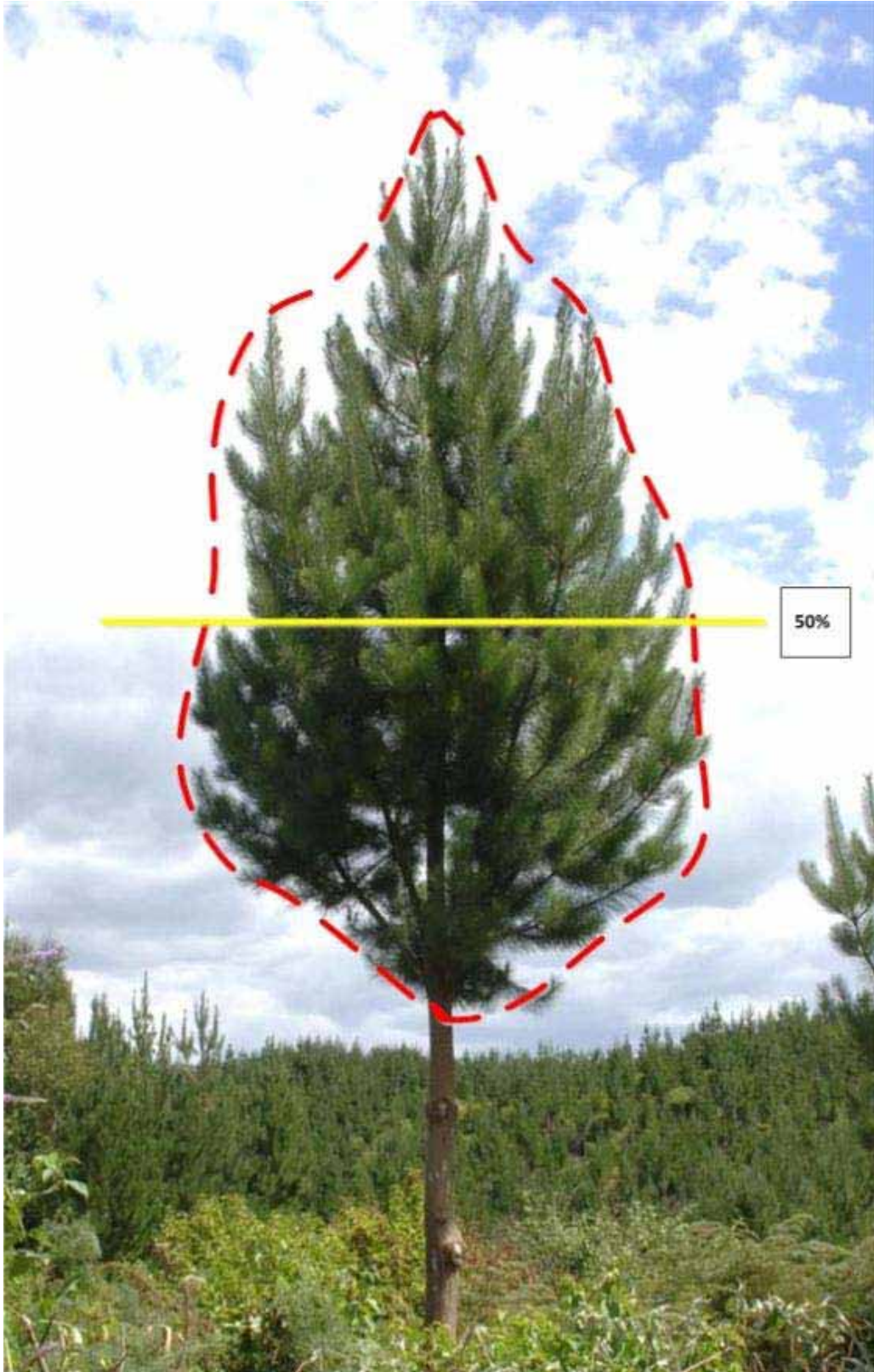


Figure 6. The assessable crown for measuring crown transparency in a young tree

Defoliation is assessed for the section of green crown from the widest point up to the top of the tree, in effect this is the section of crown which is free from shading by competitor trees; this ensures that the crown suppression caused by competition does not affect the assessment of defoliation. The figures in this section provide a visual guide to identifying the assessable crown when measuring defoliation.

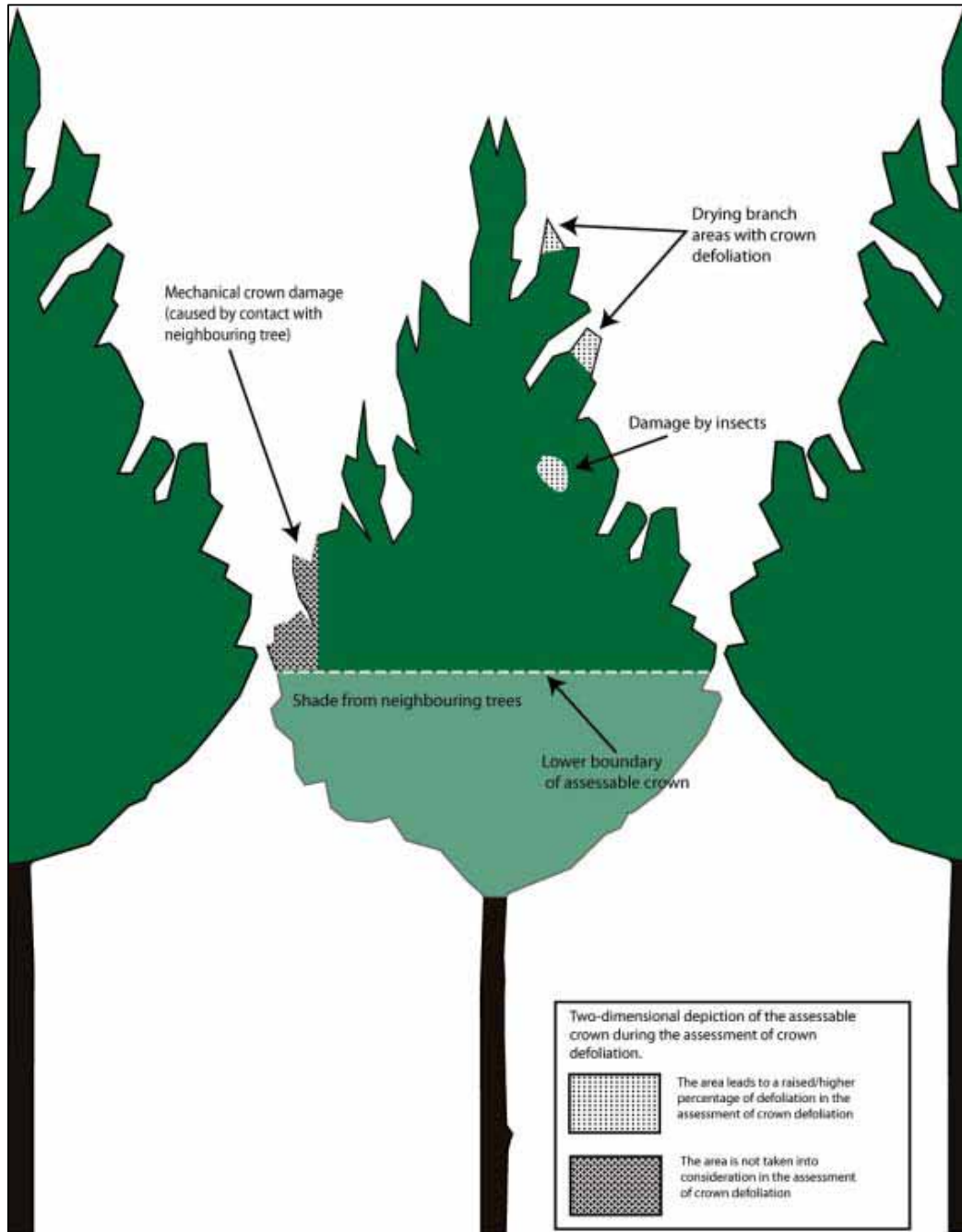


Figure 7. Outline of assessable crown to be used for assessing defoliation as defined by ICP Forests.

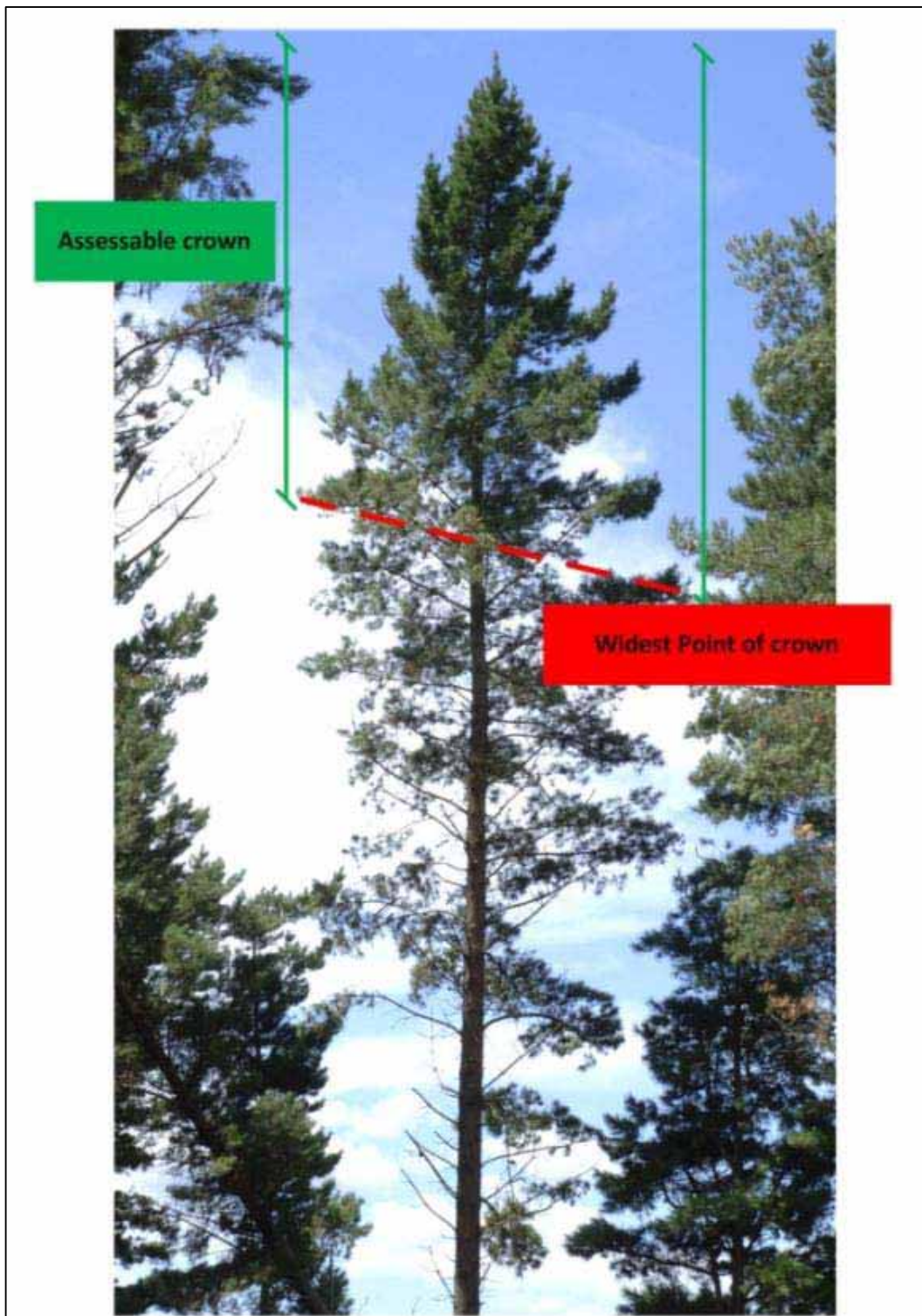


Figure 8. An example of the definition of assessable crown used for assessing defoliation

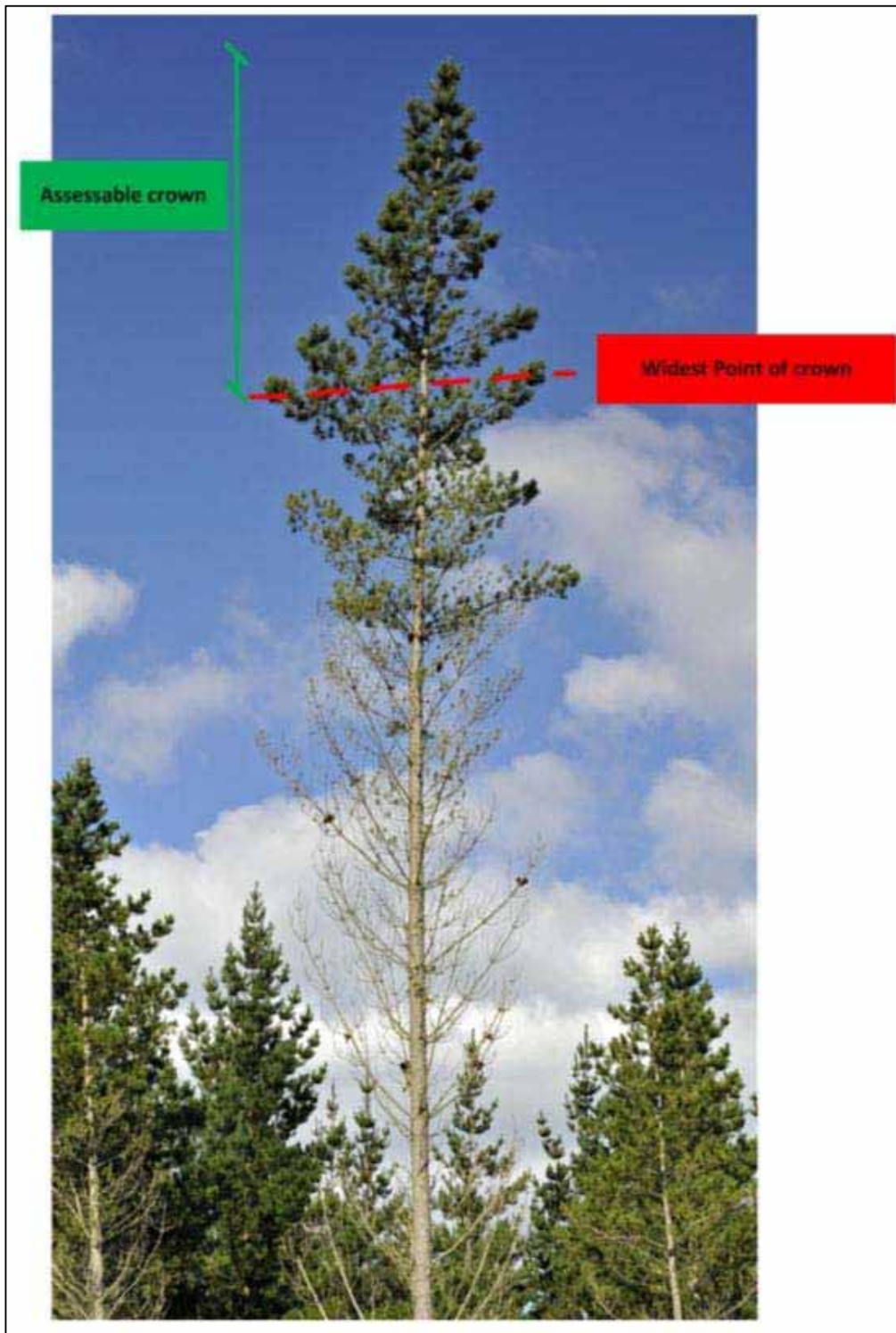


Figure 9. An example of the definition of assessable crown used for assessing defoliation

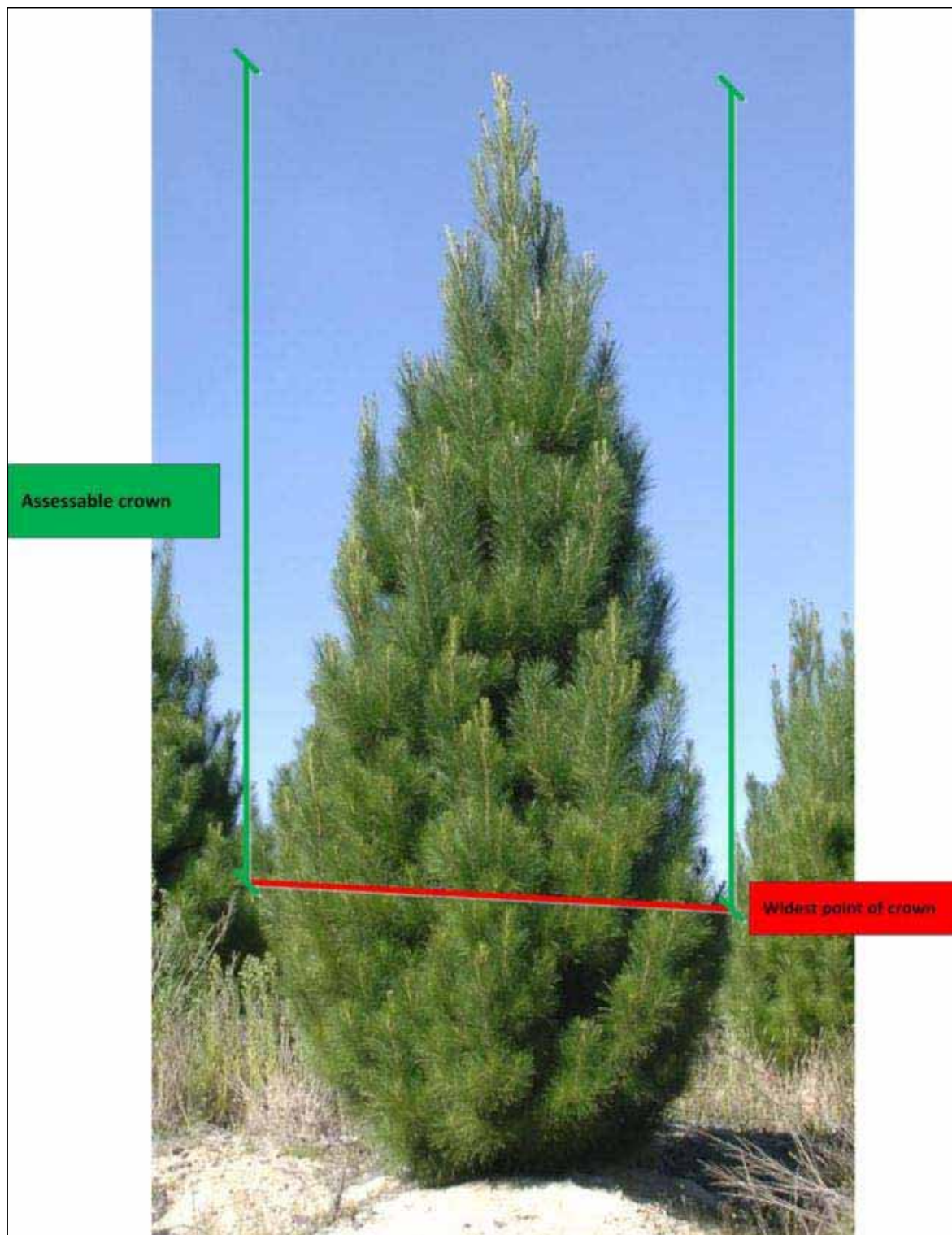


Figure 10. An example of the definition of assessable crown used for assessing defoliation

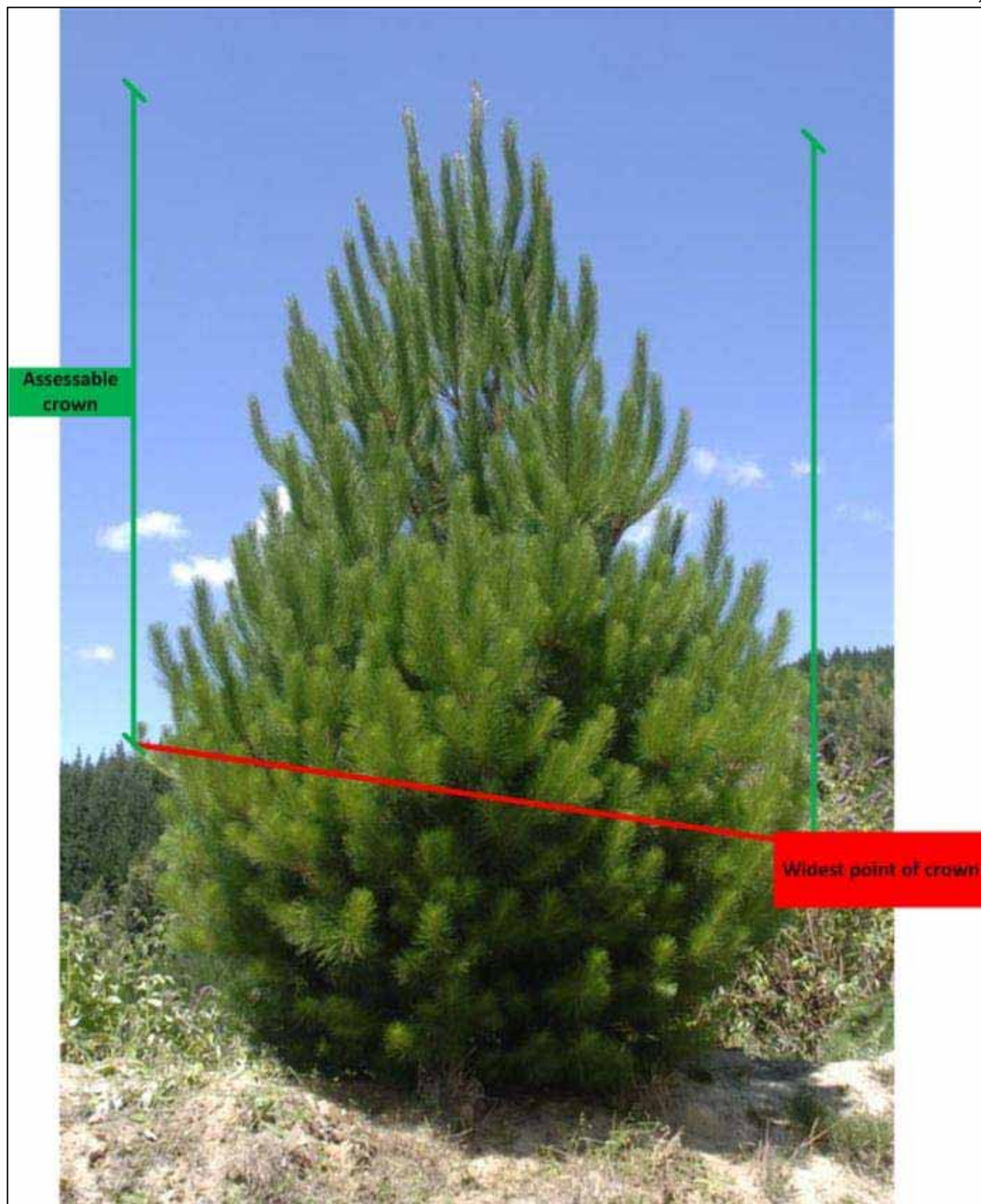


Figure 11. An example of the definition of assessable crown used for assessing defoliation in a young tree

## 4.6 STAND AGE

Crown characteristics (including crown shape), are influenced by many factors, one of the most prominent being age (Figure 12). When assessing crown condition using the scale and photographic guide provided in this document, it is important to know the age class of the tree being assessed as this will dictate which set of photographs should be used.



Figure 12. The shape of the crown can vary with the age of the tree. A young crop, B. mid rotation C. old crop (Photo source: L. Bulman).

## 4.7 POSITION OF ASSESSMENT

Crown condition indicators should be assessed from approximately one tree length away, upslope or to the sides of the tree if the ground is sloping. Binoculars should be used during the assessment of defoliation. Extra care must be taken if the observer is looking into the sun or if the weather is raining or foggy.

Re-measurement of crown condition parameters must be assessed from the same position as any previous measurements. The position of the assessor relative to the tree (distance and bearing to the tree) must be recorded so that effective re-measurement is possible.

### 4.7.1 Position of assessment during re-measurement

During re-measurement of a plot the distance and bearing to the tree from where the previous assessment was made will be provided to the assessor and should be used to select an assessment position. If it is not possible to assess the tree from this position then a new position should be selected and assessments made from the new position. The distance and bearing to the subject tree from the new assessment position should be recorded to facilitate future re-measurement from the new position.

## 4.9 ADDITIONAL INDICATORS OF TREE CONDITION

Crown transparency and defoliation are the key indicators that will be used to monitor the condition of New Zealand's forests and the maximum effort and care must be taken to ensure these are collected correctly. There are also a number of additional indicators which must be assessed for each tree where crown condition is assessed. These assessments will provide a quick and robust measure of tree condition and will contribute to the quality and reliability of the data set collected.

### 4.9.1 Stem Visibility

Stem visibility is defined as the amount of the unpruned stem visible through the tree's foliage and branches (Bulman L. S., 2008). A scale of between 1 and 4 (Figure 13) is used to assess stem visibility where:

- 1 = Dense branching, Less than 25% of the stem is visible through the unpruned crown;
- 2 = 25-50% of the stem is visible through the unpruned crown;
- 3 = 50-75% of the stem is visible through the unpruned crown;
- 4 = 75-100% of the stem is visible through the unpruned crown.

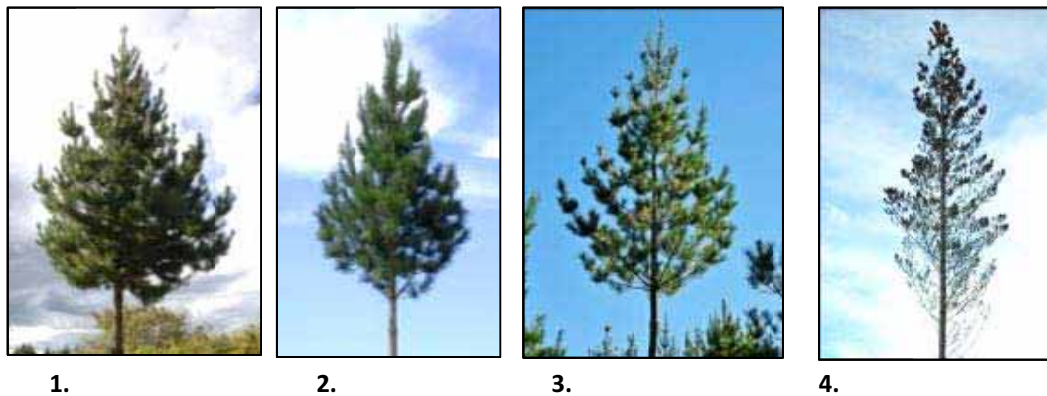
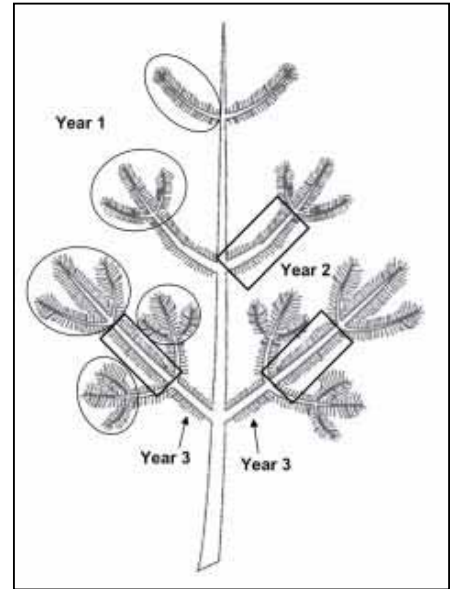


Figure 13. Stem visibility - . Less than 25% of the stem visible through the unpruned crown = 1, 25-50% of the stem visible through the unpruned crown= 2, 50-75% of the stem is visible through the unpruned crown = 3, and More than 75% of the stem is visible through the unpruned crown= 4.

Needle retention is defined as the number of needle age classes (to nearest year) present in the lower third of the unsuppressed green crown (Figure 14). The lower third of the unsuppressed crown typically correlates with the part of the green crown above the canopy closure point. Healthy radiata pines typically retain needles for at least three years. To assist with the assessment of needle retention the reference photographs in this manual have been assessed by expert assessors and these scores have been included in this manual for your reference.

Needle Retention Class	Class Description
0	1-year-old needle age-class absent. Exclude immature flushes of needles from your assessment
1	1-year-old needle age-class present
2	2-year old needle-age class present
3	3-year and older needle age-classes present



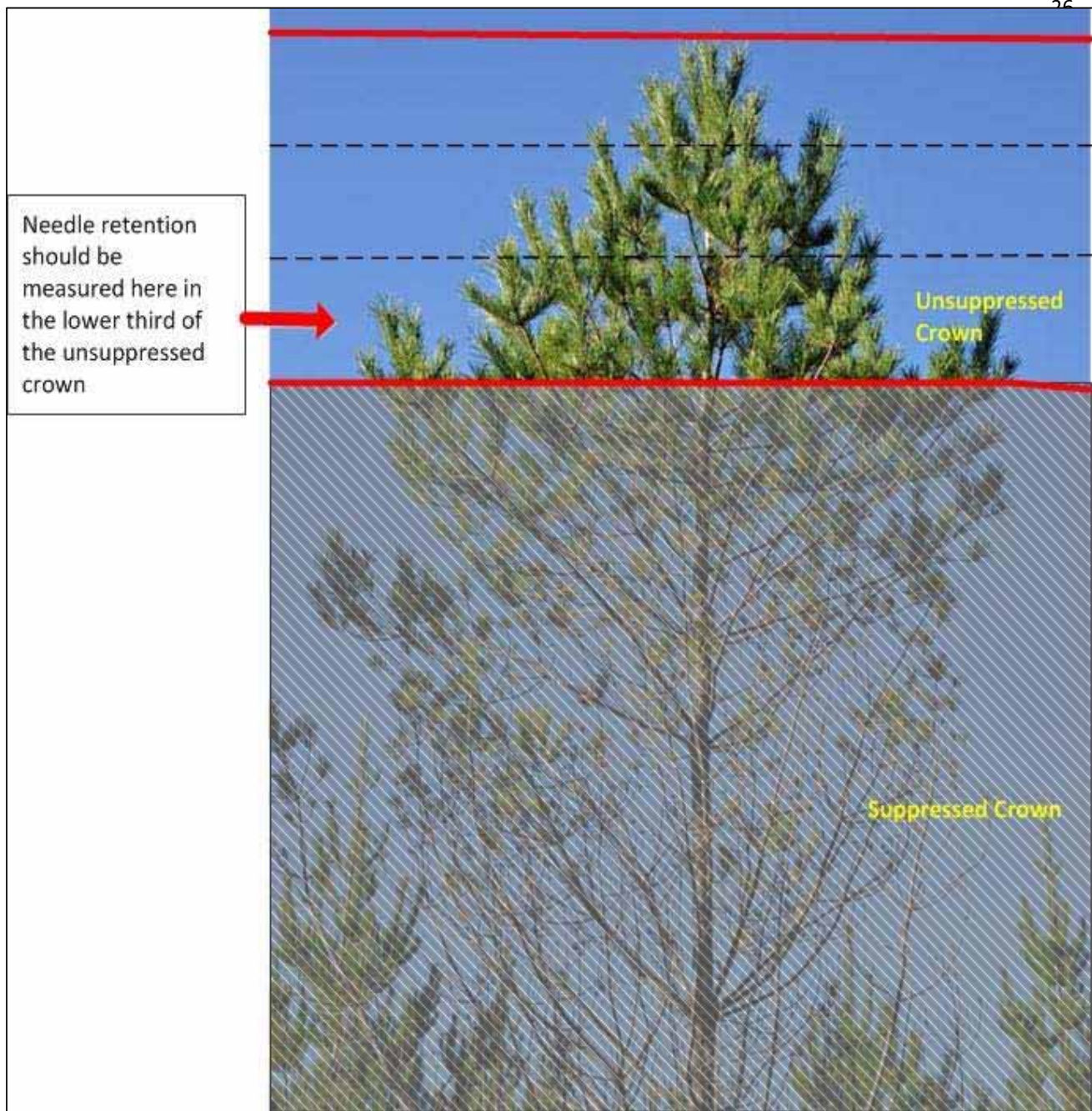


Figure 15. The needle retention assessment zone in a young tree

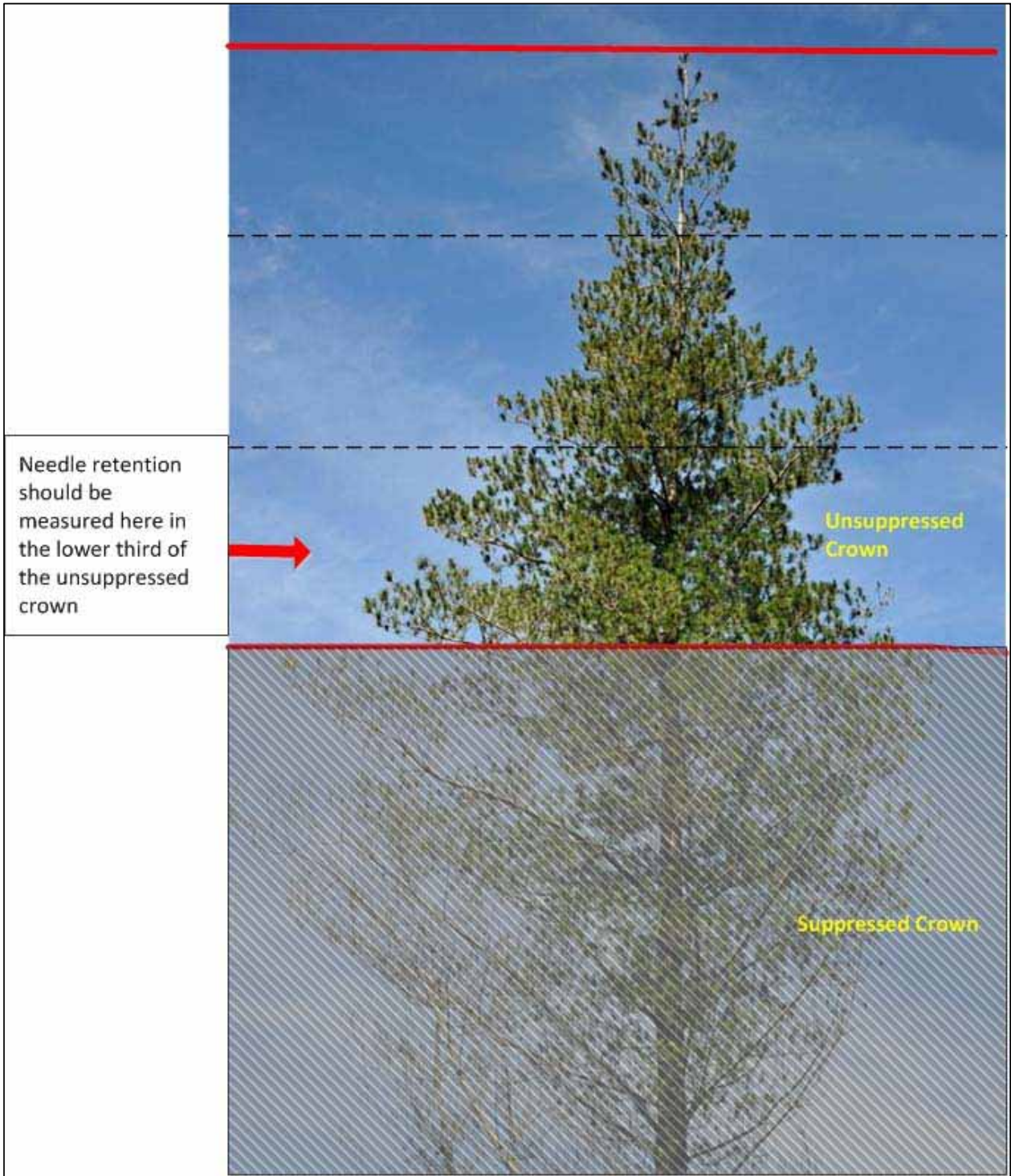


Figure 16. The needle retention assessment zone in a mature tree

Crown dieback refers specifically to the recent dieback of branches and fine twigs in the upper and outer portions of the tree crown (Schomaker et al., 2007). Crown dieback is measured as a proportion (in 5 percent classes) of the total live crown area, including the estimated dieback area. Assessments of crown dieback should only include recent die back in the live (green) crown and should not include any crown suppression which has been caused by competition (shading) by other trees. Crown dieback is defined as branch mortality that begins at the terminal end of the branch and extends towards the stem of the tree over time and is different from self-pruning that occurs when branches in the lower portion of the tree are shed due to shading. Dieback only occurs in the upper portions of the crown above any influence of shading (Reed and Mroz 1997).

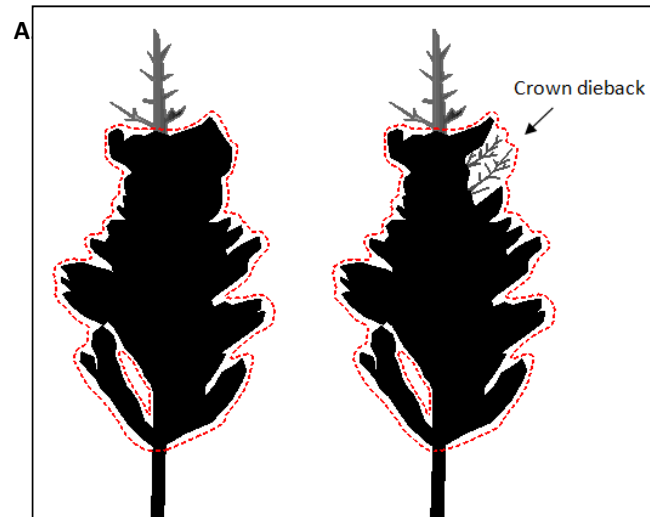


Figure 17. A. Crown with no dieback = 0%. B. Crown with some dieback = 10%.



Figure 18. An example of crown dieback

#### 4.9.4 Crown Depth

The depth of green foliage present in the crown can also be used as a measure of forest condition. Bulman L. S (2008), measured crown depth using a 1-4 scale where:

- 1 = green foliage present in the lowermost quarter of the unpruned crown;
- 2 = green foliage present in the second lower most quarter of the unpruned crown;
- 3 = green foliage present in the second upper most quarter of the unpruned crown;
- 4 = green foliage present in the uppermost quarter of the unpruned crown.

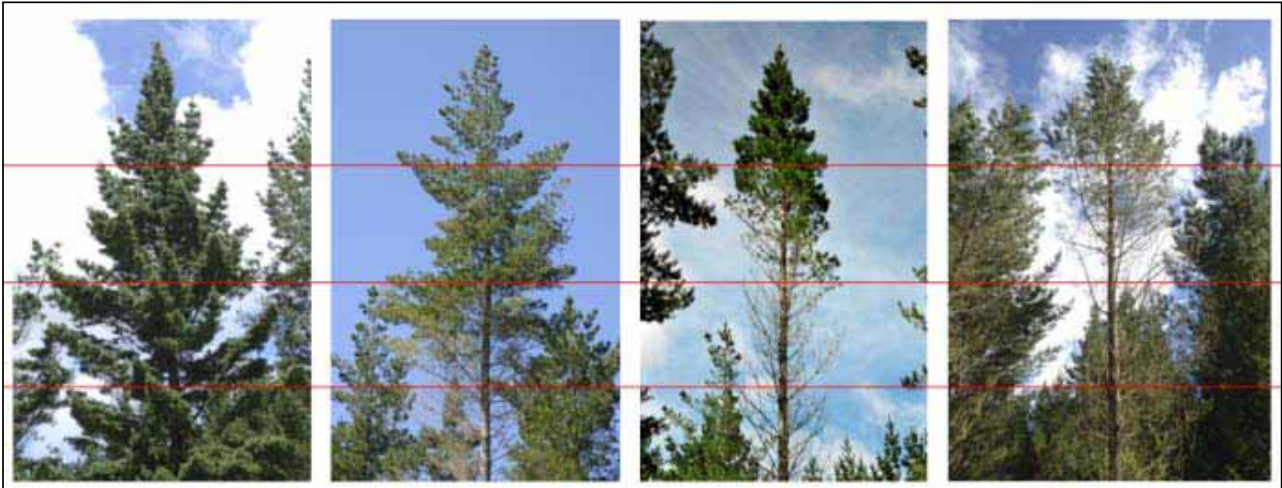


Figure 19. A visual guide to the assessment of crown depth

#### 4.9.5 Dothistroma

*Dothistroma septosporum* (dothistroma) causes needles to turn brown with red bands whilst remaining attached to the tree. Incidence is recorded in 5% classes up to 100% which would be used where a tree is completely diseased. For a more detailed description of the identification and assessment of *Dothistroma* see Bulman et. al. 2004 and Chapman 1999.

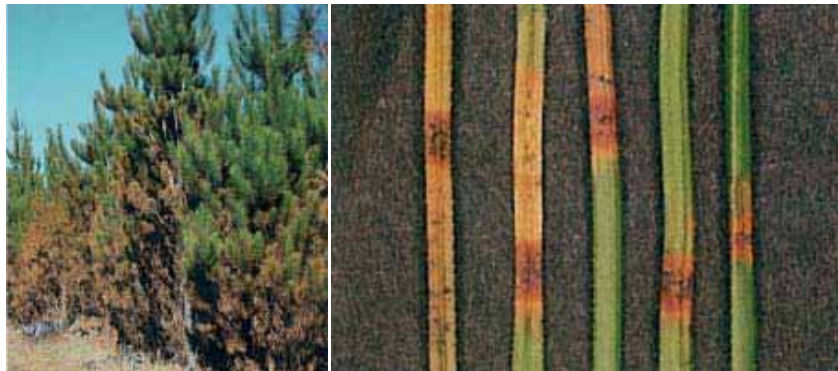


Figure 20. *Dothistroma septosporum* causes needles to turn red/brown (from Chapman, 1999)

*Cyclaneusma minus* (cyclaneusma) causes needles to turn completely yellow over the entire length, sometimes with green needles within the same fascicle. Incidence is recorded in 5% classes up to 100% which would be used where a tree is completely diseased.



Figure 21. *Cyclaneusma minus* causes needles to turn yellow-brown (from Chapman, 1999)

#### 4.9.7 Resin Bleeding

Resin on the outside of the stem can be assessed on all trees which have been pruned. Using the standard field guide for assessing resin bleeding in Radiata pine in New Zealand<sup>1</sup> the following codes should be applied:

- 0 - Not assessed;
- 1 – Nil / Light resin;
- 2 – Moderate resin;
- 3 – Severe resin.

A graphical representation of the resin bleeding classes is given below.

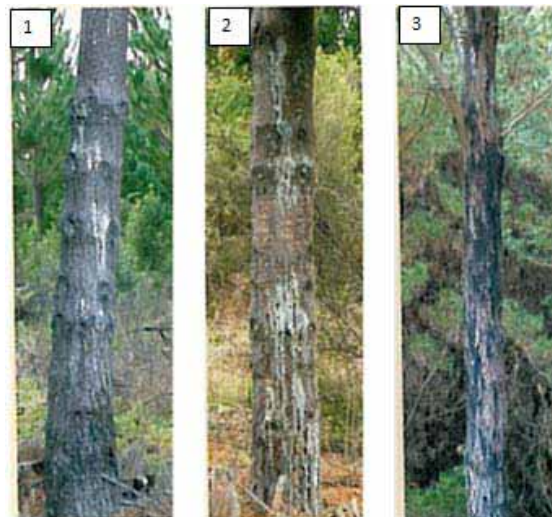


Figure 22. A photographic representation of the resin bleeding assessment scale.

<sup>1</sup> As prepared for the Wood Quality Initiative and Forest and Farm Plantation Management Cooperative, Don McConchie – Wood Quality Focus – WQI Report No. APP 12

## 5 PHOTOGRAPHIC GUIDE

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The following section contains a photographic guide for assigning defoliation and crown transparency for radiata pine in New Zealand. Each photograph has been assessed by leading experts who have assigned a score for defoliation and crown transparency of 100% of the crown and of the top 50%. The assessable crown definitions used are outlined in Section 4.5. The photographic reference trees have been segregated according to their age into:

- **Young crop** – age 0-9 years old;
- **Mid rotation** – age 10- 18 years old;
- **Old crop** – older than 18 years old.



Young crop



He rangahau tenei ra he hangarau apopo





He rangahau tenei ra he hangarau apopo





He rangahau tenei ra he hangarau apopo

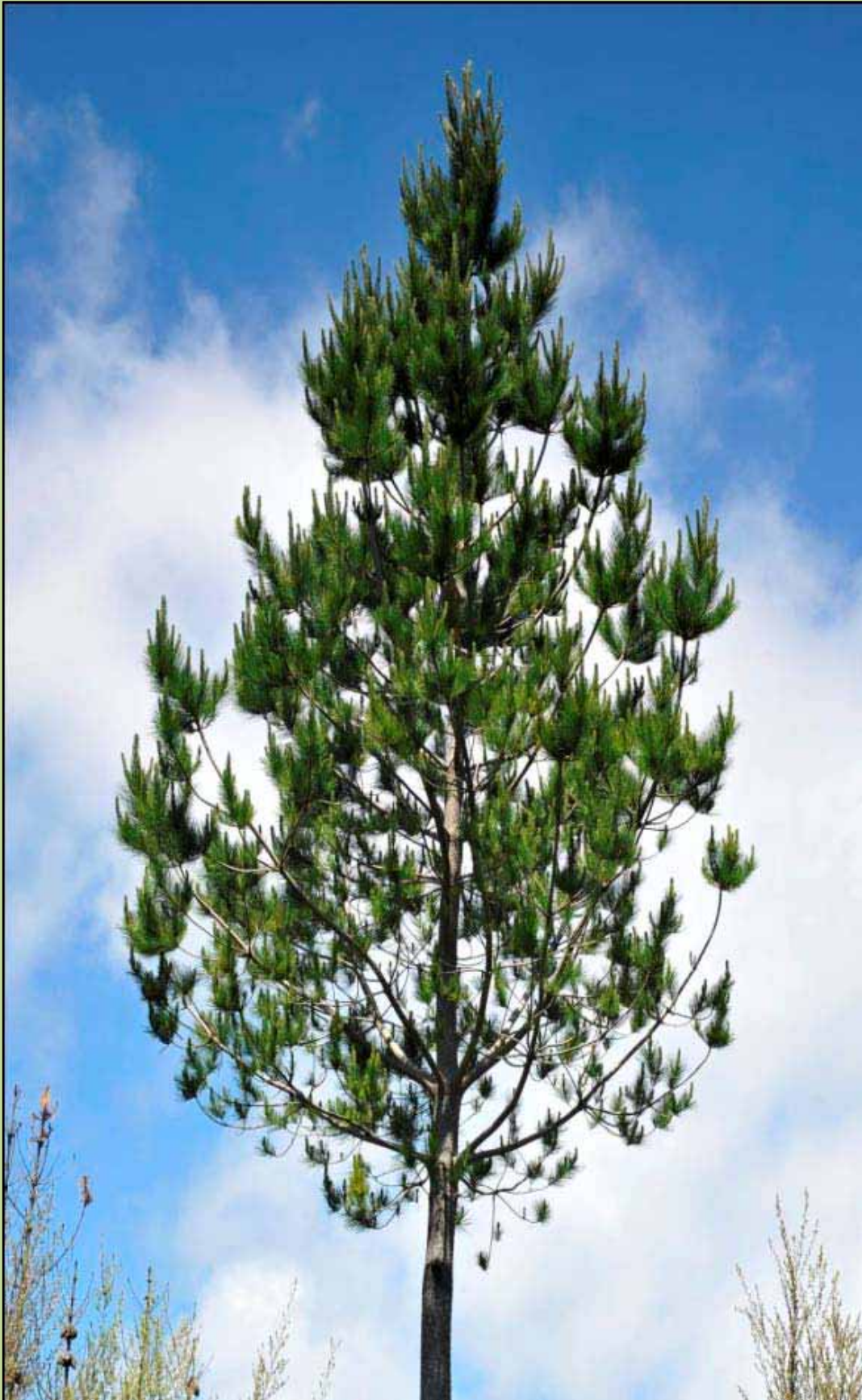


He rangahau tenei ra he hangarau apopo



He rangahau tenei ra he hangarau apopo





He rangahau tenei ra he hangarau apopo



He rangahau tenei ra he hangarau apopo



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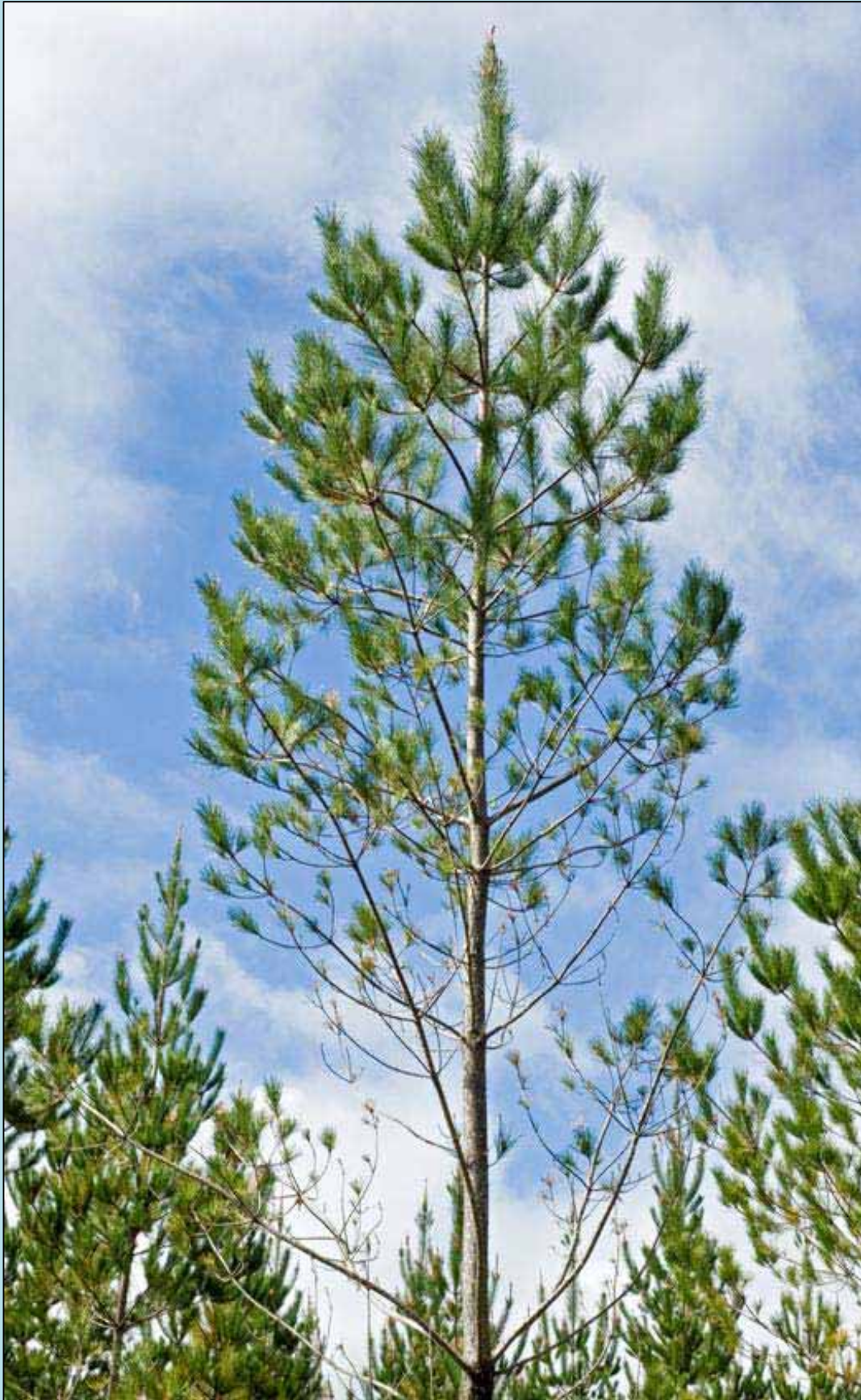
He rangahau tenei ra he hangarau apopo



He rangahau tenei ra he hangarau apopo



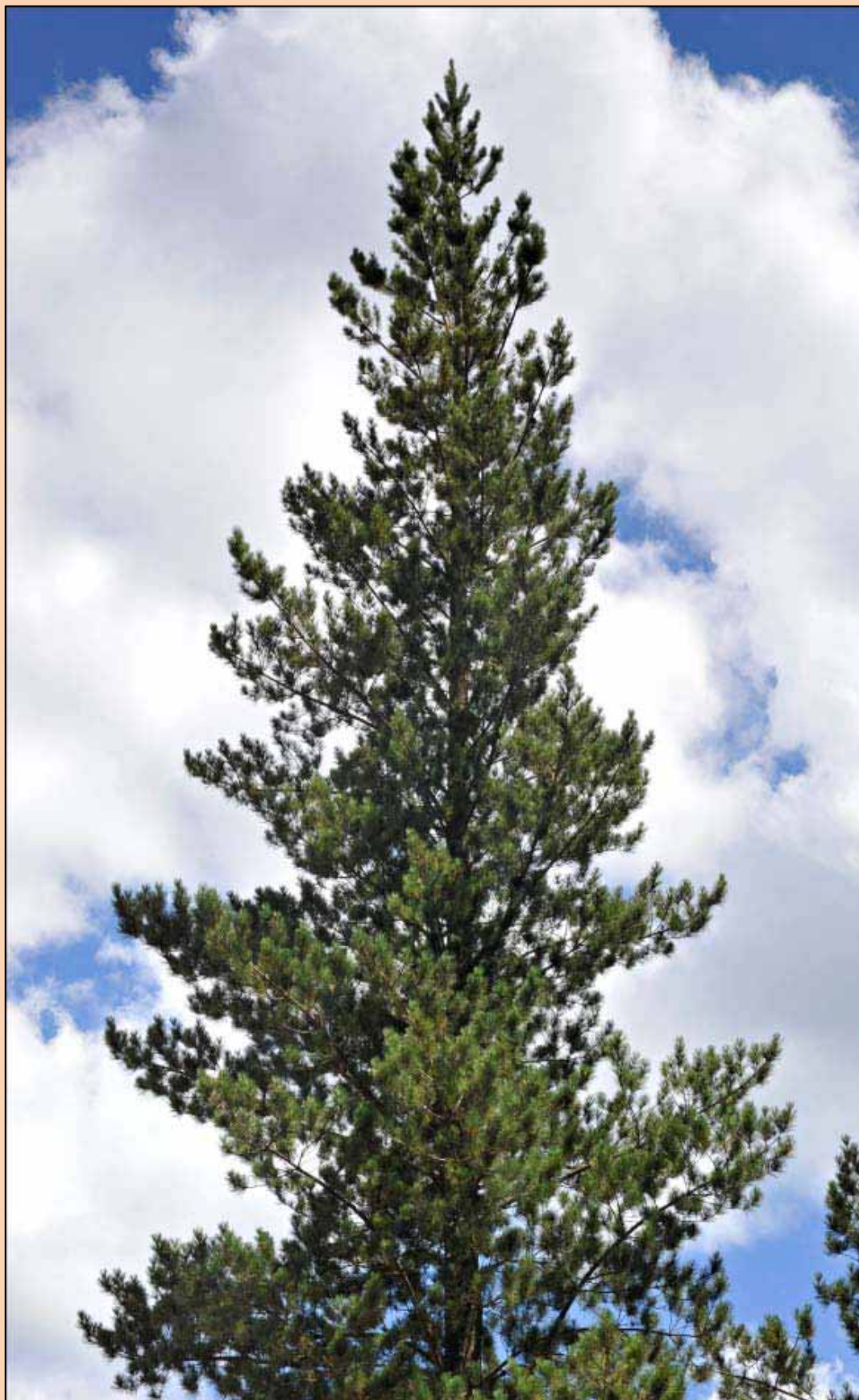
He rangahau tenei ra he hangarau apopo



He rangahau tenei ra he hangarau apopo



He rangahau tenei ra he hangarau apopo



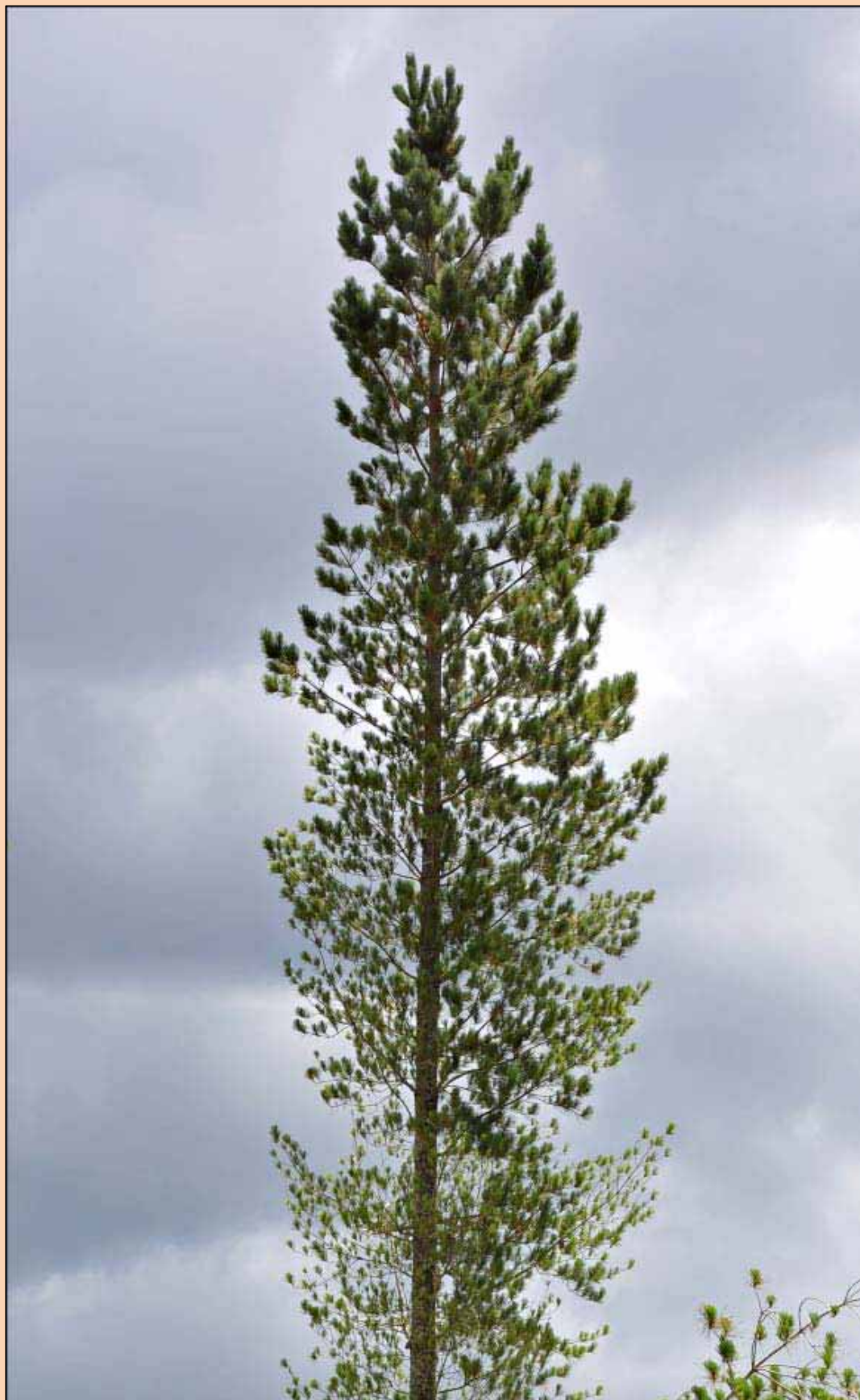
He rangahau tenei ra he hangarau apopo



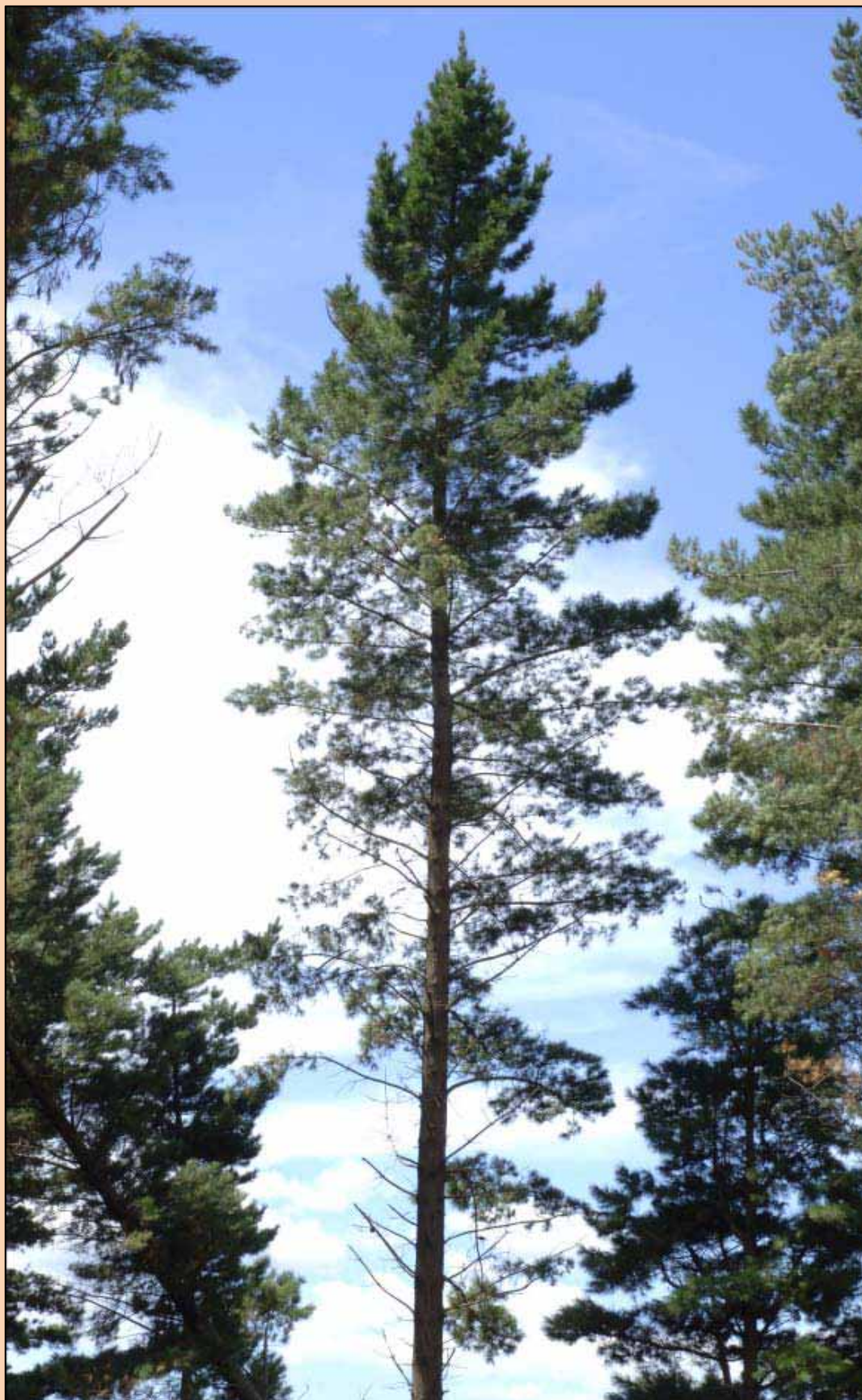
He rangahau tenei ra he hangarau apopo



He rangahau tenei ra he hangarau apopo



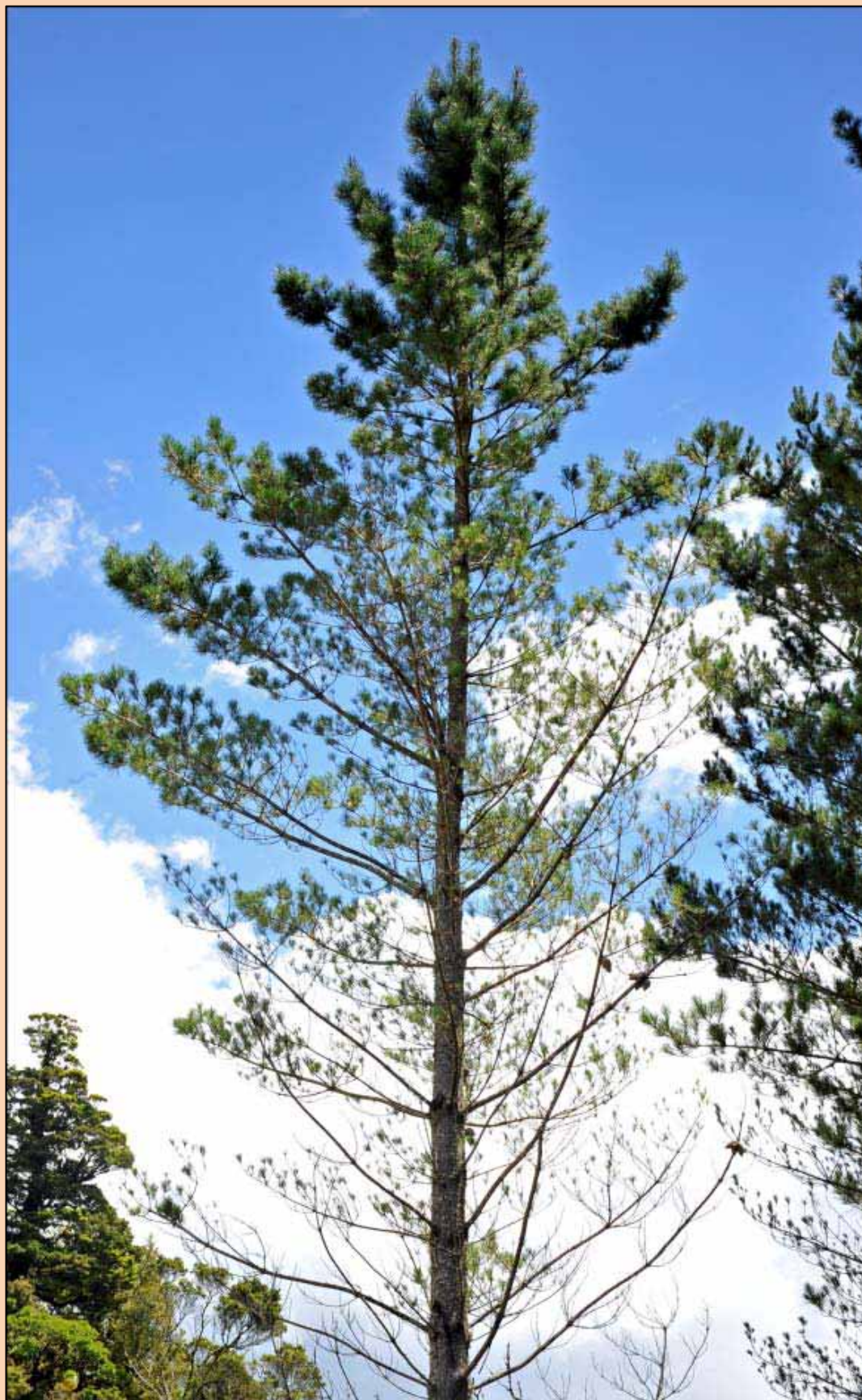
He rangahau tenei ra he hangarau apopo



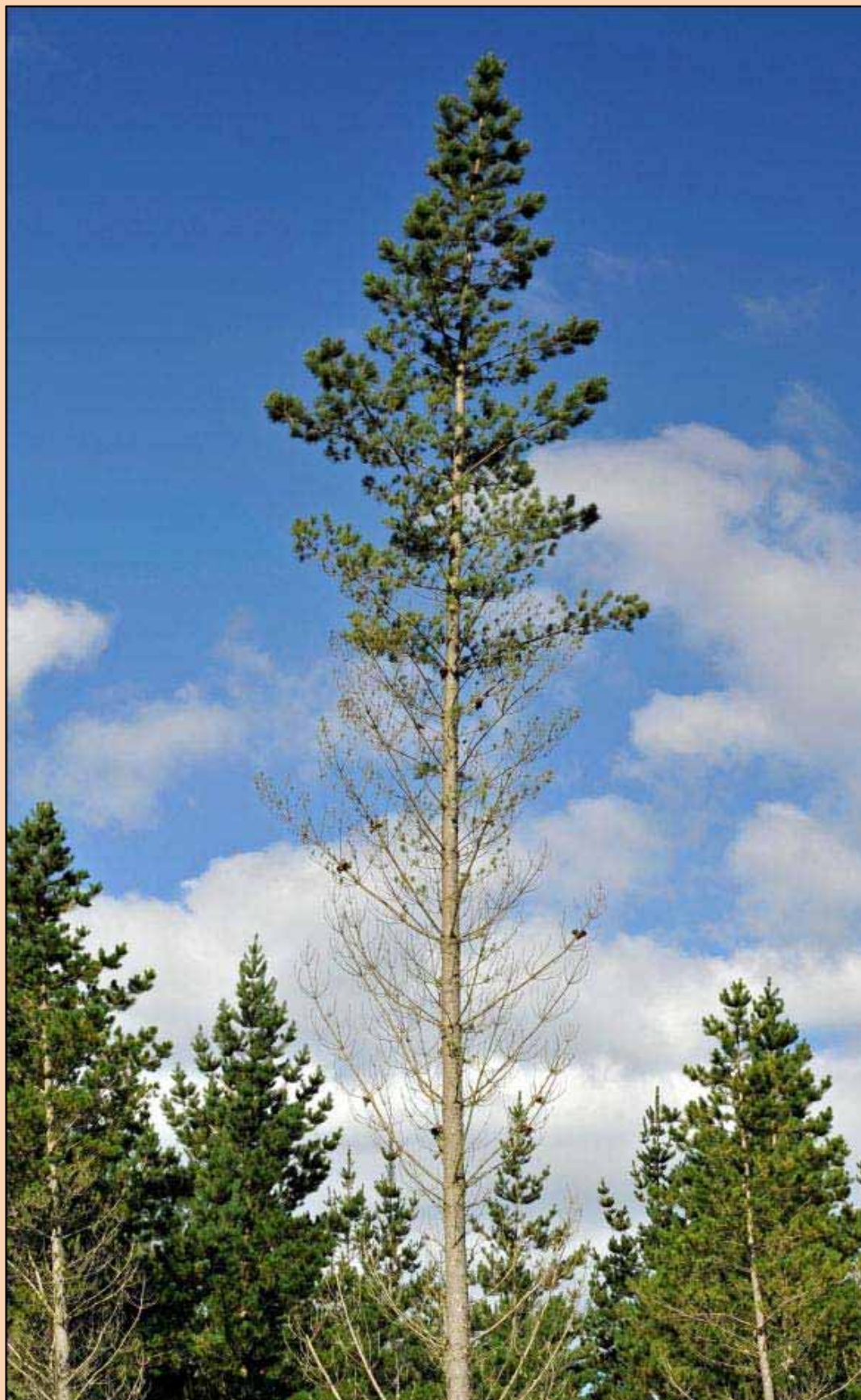
He rangahau tenei ra he hangarau apopo



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## 6 QUALITY CONTROL PROCEDURES

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Quality control (QC) is the system of routine technical activities that ensures the quality of the inventory that is being developed, in this case the provision of reliable datasets for the long term monitoring of forest condition. While it is intended that a proportion of the sites will be revisited and the accuracy of measurements blindly assessed, the main means of ensuring high quality data is the diligence of the field crews. The following procedures should be followed:

Prior to the commencement of fieldwork:

- Check that all equipment required is present and is in good working order.
- Ensure that adequate spare batteries are available for all electronic equipment.
- Ensure that crew members have the best available information to locate/re-locate the plot.
- Ensure that crew members are fully informed of all plot measurement methodologies.

Before all crew members leave the site, check that:

- Data sheets are completed legibly and that there are no obvious anomalies.
- The team leader has completed a count of all trees assessed for condition and equals the number of trees electronically captured.
- All equipment is accounted for.

En-route to home base, ensure:

- Secure storage of data sheets at the field base. If possible electronic data should be downloaded to a laptop computer and a back-up copy made.
- Where field crews are in the field for periods of more than 2 weeks, data should be returned to home base by tracked mail or equivalent courier service.

At home base, check that:

- Data sheets are updated
- Electronic data entry and checking routines have been completed and data sheets archived in the appropriate field data database.

## 7 DATA STORAGE

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Routine archiving of data is an essential part of any monitoring system. Field data are expensive to collect and because data from previous sampling periods form part of a time-series, it is not possible to recover data that have been lost. For these reasons it is important that all data and information collected (e.g. plot sheets, maps, aerial photographs, computer data files etc) are archived in designated facilities.

Daily backups take place in the field by creating a duplicate copy of the "DATA" folder within DataPlus and copying to an external memory card.

### 7.1 ELECTRONIC RECORD NAMING CONVENTIONS

All records are to be converted to electronic formats using the following naming and conversion guidelines.

- *Photos* – Named with Site ID and Photo ID suffix of “\_PhotoXXXXX” where XXXXX refers to the photo ID reference number. Preferred images formats are standard \*.jpg, \*.bmp or \*.gif files.  
e.g. AB123\_PhotoS2343001.jpg
- *Paper Forms* – Converted to PDF (Adobe Portable Document Format V.9), and combined into a single document including any relevant maps or aerials photos used.
  - File to be named with Site ID and Date  
e.g. AB123\_070101.pdf
- *GPS Co-ordinate files* – these are left in original file formats and provided with the following naming convention.
  - Site ID, date and GPS suffix  
e.g. AB123\_070101\_GPSXXXXX.XXX

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## 9.2 APPENDIX 3 SLOPE DISTANCE CORRECTION

Slope( $^{\circ}$ )	Radius of circular plot (m) <sup>1</sup>
0	13.82
1	13.82
2	13.82
3	13.83
4	13.84
5	13.85
6	13.86
7	13.87
8	13.89
9	13.91
10	13.93
11	13.95
12	13.97
13	14.00
14	14.03
15	14.06
16	14.10
17	14.13
18	14.17
19	14.21
20	14.26
21	14.30
22	14.35
23	14.40
24	14.46
25	14.52
26	14.58
27	14.64
28	14.71
29	14.78
30	14.85
31	14.93
32	15.01
33	15.09
34	15.18
35	15.27
36	15.36
37	15.46
38	15.57
39	15.68
40	15.79
41	15.91
42	16.03
43	16.16
44	16.29
45	16.43

<sup>1</sup>Slope adjusted radius =  $1/\sqrt{\cos \alpha}$