NSW GOVERNMENT Education & Communities

ASSET MANAGEMENT DIRECTORATE

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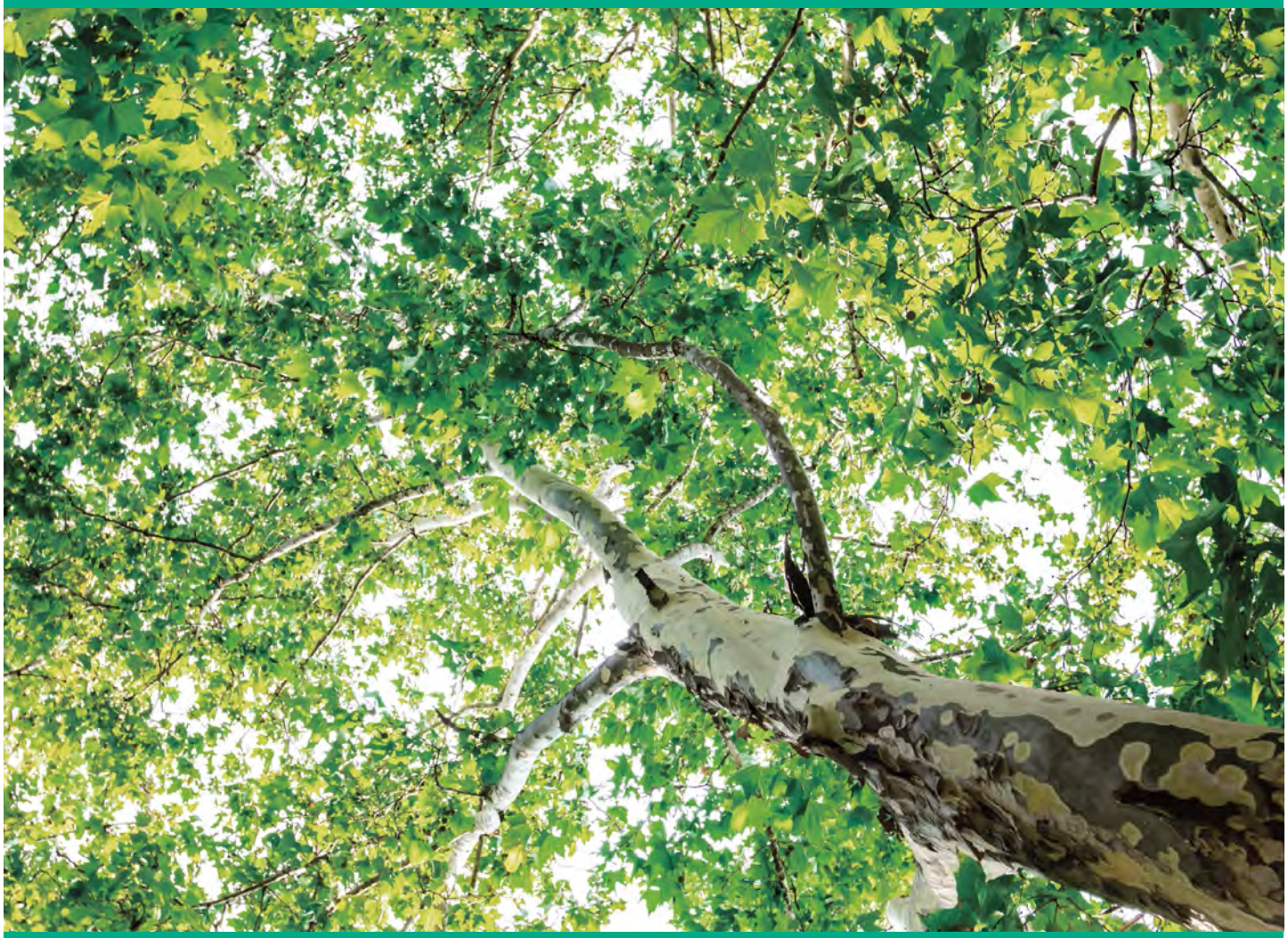

TREE MANAGEMENT GUIDELINES

A GUIDE TO ASSIST WITH THE MANAGEMENT OF TREES IN NSW GOVERNMENT SCHOOLS

DISTRIBUTED WITH: MEMORANDUM TO PRINCIPALS DN/15/00037

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Memorandum to principals

DN/15/00037

Tree Management in School.

Principals have been and will continue to be responsible for tree safety on school sites, using the annual global funding allocation for the school to fund any tree safety works. The Asset Management Directorate has recently completed the *Tree Management Guidelines*, to support principals in the management of trees on school sites. This document has been developed with input from other government agencies, professional arborists associations and both the Primary Principals Association and Secondary Principals Council.

Using the *Tree Management Guidelines*, principals are required to undertake at least an annual inspection of trees on school sites, particularly those in high use areas and in the vicinity of places where students and/or staff congregate, to determine any necessary maintenance works or the need to engage an AQF5 arborist to obtain expert advice. It should be noted that many of the 2014 arborist's reports provide details of ongoing maintenance works that would be sufficient to engage an AQF3 tree contractor. If in any doubt principals should contact their local Asset Management Unit for advice.

The *Tree Management Guidelines* will be provided as a hardcopy to schools and also available on the DEC Intranet at: https://detwww.det.nsw.edu.au/assetmanagement/safecomp/tree_management.htm with links to related advice and a Question/Answer forum to assist with enquiries in the first instance.

A Webinar will be available early in Term 2 2015 to support principals with the ongoing management of trees on school sites. Should principals have queries not addressed by the *Tree Management Guidelines*, the online Question/Answer forum or in the Webinar, they will be requested to send their queries to email address TreeSafety, Corporate and responses will be provided online via DEC Intranet. Please allow 48 hours for a response turnaround.

The Department is currently finalising an on-line HTML tool for schools to submit the tree checklists, thus schools should not submit scanned pdf of annotated printed checklists. Advice will be provided by email (school account) to principals as to when checklists may be processed. This email will provide a link to the HTML software and a password unique for each school.

The Department recently conducted a tree safety review on all school sites, undertaken by qualified consulting arborists. Inspections of all trees in areas where children and teachers congregate were completed in October 2014 and remedial work required by arborists has now been completed. This work was funded centrally.

All principals will have obtained an arborist report on the tree risk assessment for the school site they manage. These arborist reports will now form the basis of future tree management on all school sites and they have been placed on the DEC Asset Management System. Records of the tree works undertaken at each school site have also been uploaded onto the DEC Asset Management System.

Should you wish to discuss this matter further please contact: Paras Doshi / Peter Smith, Compliance and Safety Officers on Ph.: 9561 8969 / 9561 8224 or Alan Smith, Manager Compliance and Safety, on Ph.: 9561 8956.

Anthony Perrau
Executive Director, Asset Management Directorate
28 April 2015

Tree management in NSW schools

This Tree Management Guidelines is intended to assist NSW government school principals in making informed decisions in the management of trees in and around their schools.

These guidelines provide helpful information to school principals, asset managers and landscape maintenance staff and assists in identifying when more specialised assistance is required in the management of trees, particularly in respect to risk.

The overall aim is minimise the need for expensive actions or works on trees, whilst providing a safe and desirable landscape that sustains sound, healthy trees of educational, environmental, and ecological health and economic benefit to the school and their communities.

Introduction

In 2014, the Department of Education and Communities (DEC) directed all government school principals to engage consulting arboriculturists to undertake tree risk assessments at all DEC schools in NSW.

These tree risk assessment reports were used by the DEC to undertake necessary works on trees that posed an extreme or unacceptable safety risk due to their condition and location.

A review of a sample of the tree risk assessment reports and discussion with stakeholders (i.e. other government agencies, principals, arboriculturists and other interested parties) has identified a range of tree management practices which have been carried out in schools. These range from the active review of trees on site with works carried out when required to minimal oversight and action only being undertaken when needed.

The management of trees in and around the school site must consider the needs and safety of all who use the school and its facilities.

A balance between the abilities of the school to manage its tree assets (e.g. financial and botanical knowledge) and the well documented benefits that trees bring to the school environment should be considered when making decisions to plant, maintain, manage or remove trees.

As most schools do not have a tree management plan, tree works have traditionally been reactive and expensive. A proactive approach to the management of trees can avoid many unforeseen and predictable costs. Relatively simple and logical actions can be taken to reduce or avoid issues as trees grow, mature and become large structures in the school landscape.

Over time with sound management practices, tree risk and maintenance issues will likely decrease and will place fewer demands on school funds allocated to the management of the landscape.

Given the biological and dynamic nature of trees, the department accepts it is not possible to say there is nil risk posed by trees, even if they are very frequently inspected by arboriculturists, unless all trees were replaced by low shrubs. It is understood this extreme position would not be generally acceptable to the community.

These guidelines will promote the responsible and informed management of the tree assets in NSW government schools, which endorses the continued presence of trees on schools sites, but within a framework of regular oversight that principals are required to implement.

Legislative framework

Planning and environmental laws impact on the removal and maintenance of trees at schools. Laws commonly involved are summarised below:

The *Environmental Planning and Assessment Act 1979* (EPAA) and associated legislation[1] regulate the clearing of vegetation (including tree cutting, lopping, ringbarking or removal etc.):

- Consent from council is usually required – through a Development Application (DA). In certain circumstances removal or lopping of a tree which poses human health or safety risks may be done without council consent (known as 'exempt development'), however conditions apply.[2]

In addition, trees sometimes have extra protection because they are rare and/or of heritage significance:

- Trees which are threatened species, populations or ecological communities are protected under NSW and Commonwealth laws and require assessment to determine the significance of impacts.[3] This is sometimes done during the DA process.
- Trees with heritage value are protected under State and Commonwealth laws[4] and any impacts require appropriate assessment.

Planning, heritage and environmental professionals can assist in meeting these requirements and the DEC AMU may be contacted for support if needed.

At all times DEC and schools will comply with Commonwealth, NSW and council legislative requirements. In critical high risk issues (such as damaged trees after storms or where tree failure is imminent), contact the NSW State Emergency Service.

1 Such as the State Environmental Planning Policy (Infrastructure) 2007 (ISEPP), local environment plans and other environmental planning instruments.

2 See Clause 31 and Division 4 of the ISEPP.

3 See *Threatened Species Conservation Act 1995*, Section 5A of the EPAA and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

4 See EPBC Act, *Heritage Act 1977, National Parks and Wildlife Act 1974*, SEPP/LEP heritage lists.

1. The benefits of trees

Trees provide many environmental, community and personal benefits that have immediate and long term economic, social and ecological value.

Trees improve the air quality and environment around schools:

- Trees provide oxygen, filter harmful pollutants and particulates, and sequester (isolate and store) carbon.
- Trees cool air temperatures by blocking direct sun onto buildings and by transpiration (water vapour loss) from leaves.[5]
- Trees block, dissipate or reduce wind speed.[6]
- Trees reduce the impacts of rainfall and run-off, and reduce erosion.
- Trees can assist in reducing and softening the visual bulk of built elements.
- Trees can highlight positive features and screen unwanted views.
- Trees are essential to the positive perspective and vitality of open spaces for active and passive recreation.

Trees improve natural ecosystems:

- Trees are living systems that interact with other living things in sharing and recycling resources – as such, trees are living centres where living things congregate and are concentrated.
- Fallen tree leaves moderate soil temperature and soil moisture loss. Decaying leaves promote soil microorganisms and provide nutrients for plant growth.
- Trees are aerial highways for arboreal species, such as sugar gliders and possums.

Photograph C. Mackenzie

5 Coder, KD 1996, *Identified benefits of community trees and forests*, University Of Georgia Cooperative Extension Service, Forest Resources, Georgia.

6 Coder, *Identified benefits of community trees and forests*.

2. Tree risk management

2.1 Tree risk assessment

A review of several existing tree risk assessment reports undertaken at NSW Government schools in 2014 revealed a common misunderstanding of the terms 'hazard' and 'risk' by many arboriculturists. The terms are not synonymous, and when interchanged in a report can give the reader misleading information about the actual risk posed by a tree.

Hazard – in relation to trees, a 'hazard' is the tree part(s) that has an increased likelihood of failure, which is identified as a likely source of harm. The arboriculturist assessing a tree using Visual Tree Assessment (VTA)[7] techniques records the presence or likelihood of defects based on visible symptoms and signs and the 'body-language' of the tree.

- VTA identifies the hazard(s).

Risk – a risk arises when there is likelihood that an event (such as a tree or tree part failure) will *actually cause harm*. The level of risk will depend on factors such as whom or what could be harmed, how often the area near or under the tree is occupied by a target (e.g. people or structures), and how serious the injuries or damage that result from impact of the tree on the target could be. A Tree Risk Assessment (TRA) incorporates VTA observations and data but also includes the identification and categorising of targets, evaluation of the chance of an event occurring (i.e. failure and impact), the severity of potential consequences of failure and impact, and the subsequent determination of the risk level.

- TRA determines the level of risk.

For example, a tree may have a very serious structural defect (i.e. the hazard) yet, if it is growing in the midst of a group of trees and excluded from staff and children by fencing, the risk of harm is likely to be very low. If that same tree was growing next to the school canteen where many children and staff gather, the risk of harm may be significantly increased and the tree might possibly be assessed as posing a high or extreme level of risk.

The level of risk may be mitigated in many situations by undertaking works on the tree; e.g. by pruning, cabling or removal. The level of risk can also be mitigated by moving the target (e.g. park bench), or restricting or eliminating use of the area within proximity to the tree target zone.

It is worthwhile noting that the tree risk assessments undertaken in DEC schools during 2014 required the identification of High-use areas in schools. Trees in these areas identified with an elevated risk (i.e. extreme or unacceptable risk) commonly required removal.

7 VTA is a procedure of defect analysis developed by Mattheck and Breloer that uses the growth response and form of trees to detect defects. Mattheck, C & Breloer, H 1994, *Field guide for visual tree assessment (VTA).* Arboricultural Journal, 18(1), 1-23.

2. Tree risk management (continued)

2.2. Tree risk management and planning

As trees or parts of trees may fall and cause injury to people or damage to property, it is important to assess trees for defects and determine the risk they pose.

While every tree or tree part has the potential to fall, only a very small number actually fall or strike something or someone – the target. There is no such thing as a completely 'safe' tree,[8] there is nothing to say an apparently sound tree in a High-use area of a school will not fail a day or a week after an arboriculturist inspection.

Many of the defects identified in tree risk assessment reports during 2014 in NSW Government schools have arisen due to the lack of tree management and the oversight of trees in High-use areas.

The 2014 reports provided valuable data for developing realistic and useful tree management plans.

Each school's 2014 tree risk assessment report has baseline information on tree locations, species, size, class, tree health and condition, maintenance needs, and key information in regard to safety issues. The school should utilise their tree risk assessment reports for developing a framework for tree risk management that is tailored for the specific needs of their school. The tree numbering system used in these reports should be maintained and extended as needed, to ensure ongoing identification of trees. This can also support the school in estimating future costs and budget goals.

2.3 Assessing the tree resource

A complete tree inventory provides the most accurate data but can be costly where a school has large numbers of trees. A partial survey focused on high occupancy school areas (e.g. congregation areas and buildings) can be better accommodated within limited budgets. Where necessary, the tree inventory should also include trees on neighbouring properties, particularly where trees are large, structurally suspect and overhang the identified High-use areas of the school. Conversely, trees on DEC sites that overhang adjoining neighbours and public walkways also need to be included.

As of late 2014 each NSW government school has a tree inventory to work with. Some of these will include the school's entire tree population, and some reports may only include trees in and around High-use congregation areas and areas nominated by principals.

If the school has a reason to seek further advice or assessment of trees and intends to engage an arboriculturist, it is important for the school to provide the arboriculturist with earlier tree reports or tree inventory data. Chronological tree data and information often highlights tree issues that may be specific to that school only, therefore decisions relating to tree management are more reliably and cost-effectively made when a history of the trees and tree works is maintained by the school.

The arboriculturist can provide additional advice by annotation or comment on the original report thus reducing the time and cost associated with preparation of new tree inventories and reports.

Advice and templates for engaging an arboriculturist can be found in Section 3.1 and Appendices A and B.

The minimum requirement of what is to be provided by the arboriculturist can be found in Appendix C.

8 www.treesaregood.com/treecare/resources/TreeRisk.pdf. Viewed November, 2014.

2.4 Identify tree maintenance needs and costs

Compiling and analysing the tree inventory data for your school's trees should assist in identifying tree maintenance needs and help with budgeting for future tree works.

By reviewing the reports the school principal can identify high-risk or problematic trees and actively reduce future maintenance costs by avoiding the planting of troublesome species, which may be location specific within NSW.

Schools can reduce their maintenance costs/budgets by utilising the by-products generated from tree removal instead of paying to remove those by-products. The use of mulching to replenish gardens rather than purchasing, or the sale of fire wood could contribute towards future tree works.

Photograph C. Mackenzie

2.5 Recognising tree risk

There are two essential factors required to be considered to improve tree safety on DEC sites:

- **Utilisation of the site**, should a tree fail it has potential for a greater impact in proximity to persons or property.

High-use areas, (ISA – Frequent[9]) around buildings, pathways and where students and staff congregate e.g. games court, hall or canteen, **Moderate-use areas**, (ISA – Occasional) such as open play areas, generally where persons are moving, **Low-use areas**, (ISA – Rare) where access by staff and students is infrequent, such as 'out of bounds' or under-utilised areas of open space.

- **The hazard posed by individual trees**, relates to defects or tree structure.

High likelihood of failure – these trees have defects which make them likely or very likely to fail in a way that persons may be significantly injured or property damaged. When such trees are in proximity to persons or property such as a High-use area in a school, the extent of the risk is compounded by the size of the tree or tree part and categorised as high or extreme risk.
Moderate likelihood of failure – these trees are unlikely to pose a significant risk, except in High-use areas of schools, where mitigation rather than tree removal is undertaken.
Low likelihood of failure – these trees are generally of low/negligible risk in any areas of schools, and may require very minor work, if any, to reduce risk.

Most high and extreme risk trees on school grounds will have been identified during the tree risk assessments undertaken in all NSW Government Schools in 2014. The risk these trees presented to the school community will have been mitigated in some manner (e.g. tree removal or pruning).

Principals, staff and asset managers can readily identify common visual tree defects that are indicative of a potentially elevated hazard (i.e. a higher likelihood of failure) rating.

It is the school's responsibility to manage the remaining and future trees on and directly adjacent to their grounds. Understanding the basics of tree risk and addressing the risks associated with trees makes a school safer and prolongs the life of the tree.

9 Modified terms from the *Tree Risk Assessment Manual* published by the International Society of Arboriculture (ISA).

2. Tree risk management (continued)

2.6 Advice on identifying tree risk

Some guidance for identifying common tree defects (hazards) associated with tree risk are provided below, however, evaluating the seriousness of these defects is best done by an AQF5 qualified consulting arboriculturist.

Where a tree has had several failures from indeterminable causes, this may indicate that the tree may have some form of genetic weakness that could lead to further failures. Indeterminable failure is one where no significant defect can be found and failure did not occur during inclement weather.

The likelihood of tree or tree part failure can be categorised using the following guidelines:

- **Extreme or unacceptable (imminent)** – failure has started or is most likely to occur in the near future, even if there is no significant wind or increased load. This is a rare occurrence for a risk assessor to encounter, and it may require immediate action to protect people from harm. In a High-use area, the tree or tree part might be identified as an extreme or unacceptable risk.
- **High (probable)** – failure may be expected under normal weather conditions within the specified time frame (see Section 3.4). In a High-use area, the tree or tree part might be identified by a risk assessor as a high risk.
- **Moderate (improbable)** – the tree or branch is not likely to fail during normal weather conditions and may not fail in many severe weather conditions within the specified time frame. In a High-use area, the tree or tree part might be identified by a risk assessor as a moderate risk.
- **Low (possible)** – failure could occur, but it is unlikely during normal weather conditions within the specified time frame. In a High-use area, the tree or tree part might be identified by a risk assessor as a low risk.

2.6.1 Imminent failure

(e.g. major defects are about to fail or are already failing)

This group would include trees with defects that are failing or that are likely to fail in the immediate future. Many of these defects will only be apparent during times of strong and/or gusty winds. If these are noted in the course of inspection, the area around the tree must be immediately fenced off to exclude entry.

- Tree visibly rocking in the ground, indicating poor root anchorage.
- Leaning tree with recent evidence of root lifting, soil movement, soil mounding or subsidence.
- Active and/or partial failures (cracking noises are often heard prior to complete or partial failure).

2.6.2 Dead tree, dead top or dead branch

(i.e. 100mm or greater in diameter) (wood decomposition, structurally unsound and hangers)

High likelihood of failure

- Any lodged branch (*hanger).*
- Any dead tree, top or branch greater than 100mm diameters.

2.6.3 Cracks

(separation of wood, deep split in the wood)

- The majority of cracks are formed when the load exceeds the capacity of the stem or branch to withstand that load. Vertical or horizontal cracks may be observed. Horizontal cracks are generally rare and indicate likely imminent failure.
- Seams may be confused with cracks but are generally flush with the stem and are the final phase in the wound sealing process.

High likelihood of failure

- Stem is split in two by a crack.
- Stem segment has multiple cracks and decay.
- Horizontal stem cracks.
- Transverse cracked branch (across the grain).

Moderate likelihood of failure

- Stem has a single crack and decay.
- Branches with longitudinal cracks (with the grain).

2.6.4 Weak branch unions

(poorly formed branch to branch, or branch to stem)

- The incidence of failure of an included junction decreases as the diameter of the stem increases, and also decreases when the included junction is close to the ground i.e. less than twice the trunk diameter. The potential for failure increases when the size of the part increases and the distance of fall increases.

High likelihood of failure

- Weak union is also cracked, diseased or decayed.
- Large *epicormic* branch on decaying stem.

Moderate likelihood of failure

- When a co-dominant stem or branch has included bark.

2.6.5 Decay fungi

(e.g. cavities and large open-faced, decaying wounds)

- Decayed wood – decay equals loss of wood strength, although the process of degradation can take a long time from wood discolouration to decay to cavity.

High likelihood of failure

- Advanced decay affecting >40% of the circumference of any stem, branch or root collar.
- Note: you will need to probe and measure a cavity at ground level to gain some insight into the severity of the cavity.
- Any large branch with decay.
- Advanced tree decline associated with large areas of dying, discoloured and/or splitting bark, mushrooms and bracket fungi and other indicators of long-term and established fungal activity.

Moderate likelihood of failure

- Indicators of advanced decay found on 25% – 40% of the circumference of any stem, branch or root collar.

2.6.6 Root problems

(anchorage and stability of the tree compromised)

- The main function of the larger, woody roots of the tree is to anchor the tree in the ground. Extensive damage to these roots, whether by excavation, trenching, soil compaction, grading, paving, advanced root rot or environmental stresses can cause a tree to fail at the ground and fall over (i.e. whole tree failure).

High likelihood of failure

- More than 40% of the roots within the structural root zone (SRZ)[10] of the tree have been severed, damaged or are decayed or dead.
- Roots girdling and constricting more than 40% of the trees stem base.

Moderate likelihood of failure

- Less than 40% of the tree roots in the SRZ are severed, damaged decayed or dead.

2.6.7 Poor architecture

(structural imbalance and weakness in branch, stem or tree)

- Leaning trees are the most common examples of poor architecture. Some tree leans occur over a long time and may be considered normal (static), whereas others may develop a progressive lean accompanied by changes in the soil immediately around the base of the tree.

High likelihood of failure

- Signs of soil subsidence and/or lifting (heaving) ground and/or recently exposed roots; may indicate imminent failure – see section 2.6.1.
- Tree with excessive lean >40%.
- Leaning tree with crack in the stem.

10 The SRZ is the area required to maintain tree stability. The radius of the SRZ is determined using a formula based on the tree trunk diameter measured immediately above the tree root buttress. Australian Standard *Protection of trees on development sites* AS4970 2009, 12.

- Leaning tree with canker or decay on the lower stem.
- Leaning tree with horizontal crack on upper side of the stem, or buckling bark and wood on the lower side of the stem.

Moderate likelihood of failure

- Branch with a sharp bend or twist.
- Large, horizontal branch with several vertical branches on it.

2.6.8 Cankers

(areas where bark and/or cambium are dead)

- Each growing season where the tree forms a new ring of wood the canker area will not be able to do so. The larger the canker (over time) or a number of smaller ones predisposes failure as there is not enough sound wood to support the tree at the canker site.

High likelihood of failure

- Canker affects >40% of the circumference of any stem, branch or root collar.
- Canker plus decay affects >40% of the circumference of any stem, branch or root collar.

Moderate likelihood of failure

- Canker, or canker and decay, affect 25% – 40% of the circumference of any stem, branch or root collar.

2.6.9 Trees in decline

- All trees eventually die; some have relatively short lives depending on the species.
- The imminent death of a tree is a precursor to its failure, although failure may take a long time. Such trees once identified should have their removal programmed before degradation (e.g. rotting) and total failure of a dead limb or tree occurs.

Common signs of trees in decline include:

- Unexpected, sudden loss of leaves – not to be confused with seasonal changes of deciduous trees.
- Loss of support where a significant lean occurs over weeks or months.
- Such trees should be removed by an AQF3 arborist.

2.6.10 Storm damage

- When a school is subject to a severe storm, this is normally evidenced in the community by fallen trees and property damage. (See also Section 3.5).

School sites should be inspected after severe storms for trees with:

- Broken / hanging branches – these will die and fall.
- Splits in tree trunks – usually little can be done to save such trees.
- Lightning strikes resulting in physical damage to large branches and or the main stem. Usually evident by large shards of wood blown and scattered outwards from the tree.
- Such trees will have been inspected by the appropriate school staff and if necessary remediation works arranged to be carried out by an AQF3 arborist.
- Note: most tree-related failures occur during inclement weather. To reduce the risk of harm to the target, activities close to or under trees should be restricted or avoided for the duration of the storm or inclement weather. A post-storm inspection of trees in the High-use areas of the school should be conducted before allowing staff, students or school visitors to undertake activities under the trees.

Major defects

1. Imminent failure

Soil movement, root lifting leading to, or in the process of, failure.

Issue: Tree 'rocking' in the ground. Raised root-plate, apparently with freshly exposed root surface possibly indicating recent movement.

Cause: Various reasons e.g. root severance, root death (construction impacts), constrained root growth, prolonged heavy rain and strong winds.

Advice / actions: The tree appears to be actively failing and could fall at any time. The tree should be removed if it is located in any Low to High-Use school areas.

Source: Lonsdale, D 1999, *Principles of tree hazard assessment and management*, research for Amenity Trees No.7, The Stationary Office, London.

Issue: Leaning tree and soil lift due to root-plate movement, though long stabilised.

Cause: Possible partially blown over when young and/or during very wet, windy weather.

Advice / actions: The partial stem failure appears to be stabilised, although if this tree was in a High-use area on a DEC school site removal may be warranted.

Source: Lonsdale, D 1999, *Principles of tree hazard assessment and management*, research for Amenity Trees No.7, The Stationary Office, London.

Tree cut down after severe lifting of roots out of the shallow soil.

Source: http://hort.ufl.edu/woody/images/ficus-over-web.jpg. Viewed November, 2014.

Defects

2. Dead tree, top or branch

Parts greater than 100mm diameter.

Issue: Dead trees.

Cause: Various reasons e.g. drought, soil compaction or root severance to name a few.

Advice / actions: Any dead tree in a High-use area should be removed. A dead tree with cavities (hollows) may be a habitat tree and contain nesting or roosting fauna. Where possible, and prior to tree or branch removal, advice should be sought from NSW Wildlife Information Rescue and Education Service (WIRES).

Photograph: C. Mackenzie

Issue: Dieback of top of crown and large dead branches.

Cause: Various reasons, such as construction damage, heavy and/or repeated insect predation or disease, etc.

Advice / actions: Removal of all *deadwood* to reduce the risk of *branch failures*. Investigate cause of tree decline (as there may be implications for other trees), and improve growing conditions if possible.

Photograph: C. Mackenzie

Issue: High likelihood the detached, lodged branch will fall.

Cause: The top of the stem has failed and lodged between branch forks. The failure may have been caused by weakness and triggered by storms or wind, for example.

Advice / actions: The branch needs to be removed by an AQF3 arborist. When climbed, the remaining stems and branches should be inspected for signs of decay and other weaknesses.

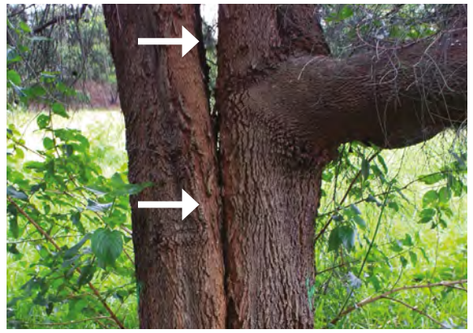
Note: In the example shown the supporting trees are deciduous and the broken branch is readily seen during winter.

Source: Urban Tree Risk Management USDA

Defects (continued)

3a. Cracks

Stems and branches.



Issue: *Co-dominant* stems are splitting apart. This is an inclusion of the two stems where inward growing bark forces the stems apart; creating what appears to be a crack between the two stems.

Cause: As the tree moves in the wind the force may assist in complete separation and failure of at least one of the stems.

Advice / actions: There is a high likelihood of failure, especially if the gap is widening. If the tree is in a DEC High-use area, removal of the tree is appropriate. If in doubt about tree risk, consult an AQF5 arboriculturist.

Issue: Hazard beam crack with impaired wound *occlusion* (sealing).

Cause: Longitudinal crack that cannot seal or form ribs due to width of split and continual wood movement.

Advice / actions: Hazard beams have a low likelihood of failure. If the tree is in a DEC High-use area , removal of the affected branch may be appropriate. If in doubt about tree risk, consult an AQF5 arboriculturist.

Photograph: C. Mackenzie

Issue: Horizontal crack forming – imminent risk of failure.

Cause: Cracks across the wood grain formed by poor graft connection or under high tree crown load that pulls wood fibres apart – this is a rare occurrence.

Advice / actions: As failure is imminent, this tree would be removed if located within DEC Medium or High-use areas.

Source: Urban Tree Risk Management USDA

Defects (continued)

3b. Cracks

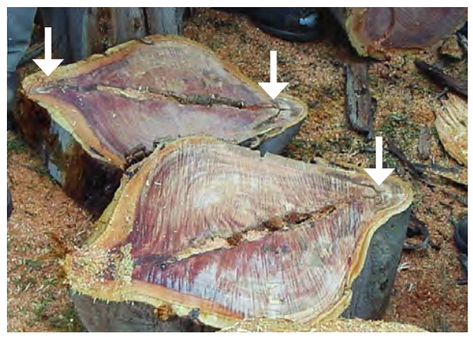
Internal cracks and pointy ribs.

Issue: Co-dominant stems with included bark will often develop a *compression fracture*, a 'big ears' defect.

Cause: The tree attempts to seal over a transverse crack but tree movement prevents it. The tree forms distinctive ribs. 'Pointy' ribs (arrowed) indicate an increasing crack, whereas 'snub-nosed' ribs are more indicative of an arrested crack.

Advice / actions: If the tree is in a High-use area, removal is appropriate. If in doubt about tree risk, consult an AQF5 arboriculturist.

Photograph: C. Mackenzie



Cross-section view of trunk with an internal crack. There was potential for this tree to fail. Although the ribs were more or less snub-nosed, there were indications the cracks were not arrested (arrows). Ribs on both sides of the stem indicate a higher likelihood of failure.

Photograph: C. Mackenzie

Defects (continued)

3c. Cracks

Pointy and snub-nosed ribs.

The diagrams below clearly illustrate the differences between co-dominant stems with included bark and high-risk, pointy ribs, and the stronger attachment of two included stems where growth has formed around and arrested the internal crack.

Source: Mattheck, C 1999 *Stupsi explains the tree*, 3rd edn, Karlsruhe Research Centre, Karlsruhe, Germany.

If such an acute fork has a lot of bark between the two stems together, the fork can easily break apart.

The bark between the stems acts like a crack, and therefore a pointy-nosed rib is formed on each side.

From the side the tree fork then looks as if it has big ears.

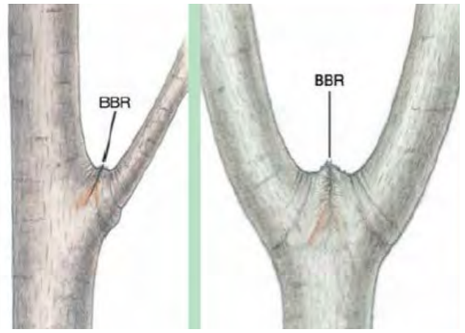
Here there is only a little bark enclosed between the stems and there are many annual rings binding the two stems of the fork together.

Therefore the ribs in front of the ends of the included bark, which is acting like a crack, are snub-nosed. The tree fork has only little ears and is much less dangerous than a fork with big ears.

The best tree forks do not have any included bark between the stems and therefore do not form any ears.

Defects (continued)

4a. Weak branch unions



Example of a strong branch to stem attachment (wood-to-wood) and strong co-dominant stems union. An upturned ridge of bark, known as the *Branch Bark Ridge* (BBR) is found on the upper part of the union.

Source: Urban Tree Risk Management USDA

Issue: Poor attachment of branch to stem. This bark-to-wood attachment is known as 'included bark'. As more and more bark is included inside the tree the weak union is more likely to fail.

Cause: Can be a species trait; storm damage, poor pruning and other factors can increase the occurrence of this defect in trees.

Advice / actions: Consider pruning out of smaller branches or stems. If in any doubt, consult with an AQF5 arboriculturist.

Photograph: D. Marsden

Far left – example of included bark and extending crack (arrowed) in long section.

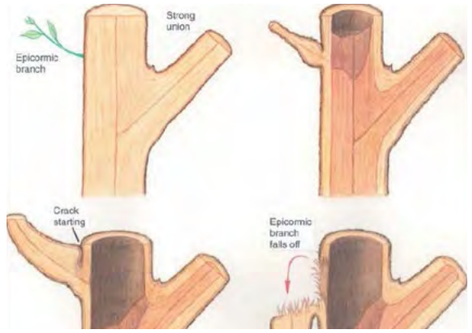
Left – strong wood-to-wood union (orange pencil) and weaker, included bark-to-wood branch (blue pencil on right).

Source: www.treedictionary.com/DICT2003/tree_pruning/codom_leaders/. Viewed November, 2014.

Defects (continued)

4b. Weak branch unions

Epicormic shoots.



Epicormic shoots generally form from latent buds on the stem or branch and are shallowly attached. They grow quickly and can become heavy. Underlying wood may be decayed, or the epicormic branch attachment may not be completely around the parent branch. This risk of the epicormic branch failing increases as the underlying wood fails to support their weight.

Source: Urban Tree Risk Management USDA

Issue: Epicormic shoots that are poorly attached to a lopped branch; a high likelihood of failure.

Cause: Often several branches result from the damaging practice of topping or lopping. Can also be a result of storm damage and other injuries.

Advice / actions: The branch attachments should be inspected by an AQF5 arboriculturist. If the tree is in a High-use area it may need to be removed or the offending branches pruned to reduce risk.

Photograph: D. Marsden

Issue: Epicormic shoot attached to decaying branch; a high likelihood of failure.

Cause: Possibly a result of storm damage.

Advice / actions: If the tree is in a High-use area it will need to be pruned to reduce risk.

Photograph: C. Mackenzie

Defects (continued)

4c. Weak branch unions

Inclusions and clusters.

Issue: Significant inclusion (bark-to-wood) of branch with stem.

Cause: Can be natural or occurred at nursery production stage and not pruned out. Can also be a result of storm damage and other injuries.

Advice / actions: If the tree is in a High-use area it could be removed or pruned to reduce risk.

Issue: Stems of branches arising from the same/ similar point on the stem. Weaker stems or branches may be forced out by the expansion of their neighbours and fall from the tree.

Cause: Often several branches result from the inappropriate practice of topping. Can also be a result of storm damage and other injuries.

Advice / actions: The branch attachments should be inspected by an AQF5 arboriculturist. If the tree is in a High-use area it may need to be removed or pruned to reduce risk.

Photographs: C. Mackenzie

Defects (continued)

5a. Decay

Cavities and openings.

Issue: Large stem cavities are sometimes clearly seen and evaluated from ground level.

Cause: Initial wounding creating conditions favourable to pathogen entry. Storms, branch failures or poor pruning practices could contribute to initial damage.

Advice / actions: If the tree with this degree of decay is in a DEC High-use area, removal is appropriate. If in doubt about tree risk, consult an AQF5 arboriculturist.

Photograph: D. Marsden

Issue: Numerous cavities suggesting possibility of a continuous column of stem decay in one or both stems. The extent of decay cannot be evaluated from the ground.

Cause: Cavities possibly formed from *cankers* and enlarged by parrots.

Advice / actions: If the tree is in a DEC High-use area, removal may be appropriate.

If in doubt about tree risk, consult an AQF5 arboriculturist.

The tree will need to be inspected from an elevated work platform or climbed to assist risk evaluation.

Photograph C. Mackenzie

Defects (continued)

5b. Decay

Bulges and other anomalies.

Issue: Basal cavity at ground level and extending up the trunk with notable thickening and in-rolling of wound edges.

Cause: Possibly initial wounding caused by impacts from machinery (e.g. lawn mowers, grass trimmers, etc).

Advice / actions: If the tree is in close proximity to buildings or gathering places, consider removal. If in doubt about tree risk, consult an AQF5 arboriculturist.

Photograph: D. Marsden

Issue: No external cavity opening present. A typical bulging of basal area of stem (bottle butt), could indicate serious loss of wood strength via decay and risk of stem breakage.

Cause: Often decay begins in the roots and can extend into the lower stem.

Advice / actions: This tree should initially be tapped with a nylon mallet to listen to the sounds produced. However, this basic testing should be undertaken by an AQF5 arboriculturist. Experience with wood resonance is required as wood densities vary over different tree species. If the tree is in close proximity to buildings or gathering places, consult an AQF5 arboriculturist.

Photograph: D. Marsden

Defects (continued)

5c. Decay

Fungi in roots and stems.

Issue: Mushrooms at base of tree may be *Armillaria* root rot. Advanced disease can be a precursor to failure at the roots (whole tree failure).

Cause: Natural causes (from other tree roots), root damage, etc.

Advice / actions: The fungus needs to be identified by an experienced arboriculturist or by pathology testing.

The upper fungus is *Armillaria* which can be a fast root-rotting agent. The fungus below is *Gymnopilus junonius*; a weak pathogen that is not a serious threat to trees. If *Armillaria* is suspected, consult an AQF5 arboriculturist.

Photographs: C. Mackenzie

Issue: The fungal bracket in the stem of this tree is *Laetiporus portentosus*, a common parasite (looks like polystyrene) of gum trees.

Cause: Usually secondary to injury.

Advice / actions: Generally one of the easier fungi to identify, the presence of several indicates substantial white rot along the stem. If the tree is in a DEC High-use area it should be removed.

Source: http://bie.ala.org.au/species/Laetiporus%20portentosus. Viewed December, 2014. Photograph: John Brigham

Defects (continued)

5d. Decay

Fungi in stems.

Issue: Fruiting fungal bodies from apex of old wound indicating some decay. Loss of approximately 30 – 40% circumference of live bark from the lower stem. Much of the exposed timber is solid.

Cause: Likely to be vehicle damage initially as the tree is immediately adjacent to a busy carparking area. Decay organisms colonised the exposed wood tissue.

Advice / actions: If the tree is in a DEC High-use area consult an AQF5 arboriculturist for advice.

Photograph: C. Mackenzie

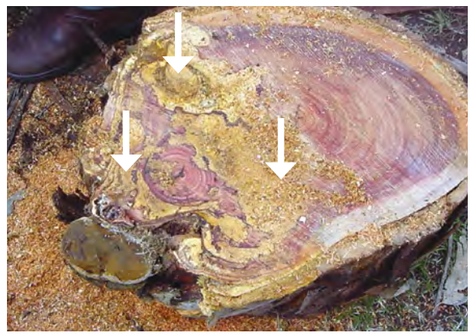
Issue: Fruiting fungal bodies indicating decay, some bulging around wounded area.

Cause: Wounding possibly from poor pruning, storm damage, etc.

Advice / actions: If the tree is in close proximity to buildings or gathering places, consider removal. If in doubt about tree risk, consult an AQF5 arboriculturist.

Cross-section view of a tree trunk at the point where the fungal bracket was located. Note the paler area of the timber (arrows) indicates the deterioration of wood (white rot disease in this case).

Photographs: C. Mackenzie



Defects (continued)

6a. Root problems

Girdling roots.

Issue: Poorly developed root system where roots have partially or fully encircled the base of the tree causing constriction of the stem, potentially leading to breaking at the stem base. Note flattening of the stem (arrows) where girdling roots prevent expansion at the stem and root interface.

Cause: Most often can be traced back to poor plant nursery practices (e.g. 'pot-bound'). Also can be caused by soil obstructions or other factors.

Advice / actions: If the tree is in close proximity to buildings or gathering places, and exposed to prevailing wind the risk of failure will increase over time. Some roots may be able to be cut without affecting tree health or stability. Always consult with an AQF5 arboriculturist if root cutting is considered.

Photographs: D. Marsden

Left – after removal of soil around the base of the tree, shows the constriction of the trees stem caused by girdling roots.

Source: http://cvarb.com/2014/01/01/girdling-roots/. Viewed December, 2014.

Defects (continued)

6b. Root problems

Construction impacts.

Issue: Lack of oxygen to tree roots causing dieback in tree crown. High risk of rotting of main anchor roots with potential collapse of tree.

Cause: Natural slope has been filled in many years ago and retained with a wall on one side, including burying of tree stem up to one metre above natural ground.

Advice / actions: The roots of the tree need to be exposed and inspected for decay. If the tree is in a High-use area it may need to be removed.

Issue: Works close to trees may result in unacceptable root cutting and other construction practices which may make trees unsafe. Approximately 40% of the trees root zone is damaged and its likelihood of failure is deemed as high.

Cause: Planning did not account for existing trees. Excavation machinery too close to tree.

Advice / actions: The tree needs to be removed. This issue can often be avoided by appropriate planning for works in proximity to existing trees.

Photographs: C. Mackenzie

Defects (continued)

6c. Root problems

Restricted root zones.

Issue: Tree has a concentration of roots in a small, elevated radius around it.

Cause: Planted into a confined space above natural ground.

Advice / actions: High likelihood of failure due to poor lateral root spread and exposure to wind. A tree such as this in a DEC High-use area would be removed.

If in any doubt, consult with an AQF5 arboriculturist.

Source: http://i.imgur.com/szJZqHI.jpg. Viewed December, 2014.

Issue: Root system unable to develop balanced, radial anchorage; decreased ability to resist overturning under wind load.

Cause: Walls on two sides of the tree and basement underneath obstructing the roots and forcing them to grow in a linear pattern alongside the structures.

Advice / actions: If the tree is in close proximity to buildings or gathering places, and exposed to prevailing wind the risk of failure will increase over time, as will potential for damage to structures. If in any doubt, consult with an AQF5 arboriculturist.

Photograph: C. Mackenzie

Defects (continued)

7. Poor architecture

Leaning trees.

Issue: Tree > 40–45 degree lean.

Cause: Proximity to buildings preventing overhead sunlight from reaching tree.

Advice / actions: The tree should be removed as it is in a High-use area.

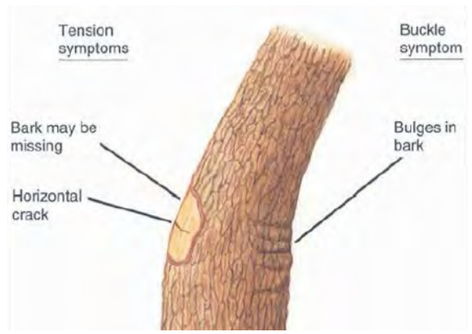
Photograph: C. Mackenzie

Issue: Tree > 40–45 degree lean.

Cause: Partial failure at the base when young, stabilised with self-corrected, but excessive, lean.

Advice / actions: The tree should be removed as it is in a High-use area.

Photograph: C. Mackenzie



Issue: Tree showing signs of failure.

Cause: Weight of the leaning tree is causing buckling of wood fibres under compression, popping off of bark on the upper (tension) side. The horizontal crack, formed as wood fibres are torn apart, indicated imminent failure.

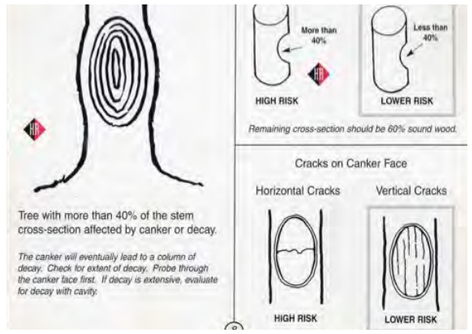
Advice / actions: The tree should be removed if it is in a High-use area.

Source: Urban Tree Risk Management USDA

Defects (continued)

8. Cankers

Target and diffuse.



Cankers are areas on the stem of a tree where disease kills the living bark tissues, preventing wound sealing; most commonly seen as bark discoloration, cracking and/or oozing of sap and can predispose the tree to secondary pathogen attack. Cankers are only serious risk issues where the affected area is large and/or girdling the tree part by 40% or more.

Source: Urban Tree Risk Management USDA

Issue: Stem has more than 40% affected by canker and secondary decay.

Cause: Commonly mechanical damage (pruning, storm or vehicles, etc), starts the process.

Advice / actions: If the main trunk of a High-use area tree is affected more than 40% of its circumference the tree should be removed. Branches, where the canker does not extend into the branch collar or parent stem, may pruned to reduce risk.

Source of images: Hayes, E (ed.) 2001, *Evaluating tree defects – a field guide*, 2nd edn, Safetrees, Wisconsin, USA.

An example of a 'target' canker on the stem of a young tree at far left; the tree develops a new wound edge each growth season, which is in turn affected by the disease, creating a target-like appearance.

Source: http://extension.umass.edu/landscape/sites/landscape/files/fact-sheets/images/image1_22.jpeg. Viewed November, 2014.

The tree at left has an advanced stem canker that creates severe bark splitting and stem deformation. The tree may fail at this location as the canker increases in area and severity.

Source: Keane P J, Kile G A, Podger F D & Brown, B N 2000, *Diseases and pathogens of eucalypts,* CSIRO, Victoria.

Defects (continued)

9. Trees in decline

Tree decline is a general term described as a gradual reduction of growth and vigour (reduction of energy levels) resulting from stress. Recovery from decline is difficult and slow, and is usually irreversible.

Decline is often a sign of over-maturity and natural senescence, but can also be triggered or by various biotic and abiotic factors.

Tree dieback is the progressive death of twigs and branches, generally starting at the tips.

This condition can change when environmental conditions improve; there may also be a cyclic pattern of defoliation and re-growth. This is often a common feature experienced by many eucalypt species (gum trees) in natural ecosystems disturbed by infestations of populations of psyllids and Bell Miners, and/or disease (e.g. Phytophthora).

Dieback usually begins in the top of a plant and progresses downward, but it may start on the lower branches, especially with conifers. In Australian forests, repeated and persistent causal factors may lead to loss of forest structure.

There are many causes of decline and dieback in trees. Natural senescence is one, but most often soil issues (e.g. poor structure and drainage, compacted, soil fill or removal), root issues (e.g. construction damage, disease, poorly formed, poorly planted, restricted growing space), significant damage to trunk or major limbs, repeated defoliation (e.g. insects or disease) and extended drought are primary causes.

General symptoms of decline and dieback may include pale green or yellow leaves, delayed spring flush of growth, scorching of the leaf margins, smaller (than normal) leaves, reduced twig and stem growth, early leaf drop, heavy seed production and, as the disease complex worsens, thinning of foliage in the crown, dieback of twigs and branches, and production of suckers on the branches and trunk.

If a tree shows symptoms that identify the tree is ailing or different from normal, there may be a need to engage an AQF5 consulting arboriculturist to determine why a mature tree is declining.

Defects (continued)

9. Trees in decline

Issue: True decline of a tree where loss of vigour is irreversible and death follows.

Cause: Cumulative impact of adverse changes to the tree's growing environment. Note: No regrowth or recovery has occurred.

Advice / actions: If the tree is in 'DEC High Use Area', removal is appropriate. If in doubt about tree risk, consult an AQF5 arboriculturist.

Photograph: C. Mackenzie

Issue: Dieback of Grey Box eucalypts.

Cause: Grey Box Psyllid outbreak.

Advice / actions: These trees may form part of an endangered ecological community and may require assessment by an ecologist and subsequent management advice in collaboration with an AQF5 arboriculturist.

Note: The typical re-growth along branches after defoliation by psyllids. Having regrown after defoliation by psyllids, these Cumberland Plain Grey Box eucalypts are making way for road widening in Western Sydney.

Photograph: David Thompson

Defects (continued)

10. Storm damage

Issue: Following a severe storm, trees have broken limbs, partially detached from the tree.

Cause: Usually very strong winds that may also be from directions to which the tree is unaccustomed.

Advice / actions: High likelihood of failure due to broken attachment to the parent branch or stem. Such limbs should be removed by at minimum an AQF3 arborist.

Source: http://i.imgur.com/szJZqHI.jpg. Viewed December, 2014.

Issue: Large damaged stem or branch with broken sections and large wood splinters.

Cause: Lightning strike.

Advice / actions: A very common physical indicator of a lightning event is vertical stripping where bark, and sometimes the wood underneath, is torn from the trunk or major scaffold limbs. This stripping may affect isolated sections of the stem or branch or it may be continuous most the way up the tree. As well, it may rise straight up vertically or it may spiral around the trunk.

The tree over time may die due to catastrophic internal damage, or survive but have structural damage that requires assessment by an AQF5 arboriculturist.

Photograph: M. Kokot

3. Tree management on DEC school sites

3.1 Choosing an arborist or arboriculturist

The growing trend in the arboricultural industry to define the difference between a consultant and a contractor is to use the term *arboriculturist* to identify a person who undertakes professional consulting work in relation to trees and tree risk, and the term *arborist* to identify those persons that carry out the works on the trees.

3.1.1 Consulting arboriculturist (consultant), AQF5

Consulting arboriculturists have the training and experience to provide expert assessments on the health, condition and risk of trees. The arboriculturist provides specialist advice and arboricultural reports on the health or risk status of your tree.

All tree reports prepared for NSW government schools shall be prepared by a consulting arboriculturist who holds a minimum Australian Qualification Framework Level 5 (AQF5) in Arboriculture or AQF5 Horticulture (Arboriculture).

Formal training and currency of qualification in Tree Risk Assessment is also desirable, e.g. TRAQ – International Society of Arboriculture Qualification and/or QTRA – Quantified Tree Risk Assessment.

When choosing an arboriculturist to undertake assessments at your school the arboriculturist must meet the minimum criteria for undertaking those works – these criteria are set out in:

Appendix A: Consulting Arboriculturist Criteria, Minimum Eligibility Criteria

3.1.2 Arborist (practicing/contractor), AQF3 qualified

Arborists are trade qualified to care for trees, and are generally hired to provide basic care, including pruning and/or removal. The practicing/contractor arborist is often engaged by the school to undertake the works recommended in a report prepared by a consulting arboriculturist. They may be contacted directly by schools to resolve issues arising from severe weather events.

To undertake tree works, the arborist should/shall hold a minimum AQF Level 3 (AQF3) qualification in Arboriculture. This ensures that pruning work is done in accordance with the Australian Standard AS4373–2007 *Pruning of amenity trees*, and all works are carried out in accordance with the NSW WorkCover Code of Practice for the Amenity tree industry.

AQF3 arborists must have a minimum 5 years industry experience and preferably be a licensed, current member of a professional body such as:

- The Tree Contractors Association of Australia
- Arboriculture Australia

All contractors are to provide their insurance details, Certificate of Currency, proof of memberships, eligibility to undertake works, etc.

3.2 Managing tree risk

A consulting arboriculturist may be retained to confirm risks and provide recommendations for managing the trees on your property. The arboriculturist can provide advice and/or treatments that may help reduce the risk associated with certain trees. An arboriculturist familiar with tree risk assessment may suggest one or more of the following:

- Remove the target. While a classroom or a nearby power line cannot be moved (in most cases), it is possible to move outdoor tables, play equipment, landscape features, or other possible targets to prevent them from being hit by a falling tree or tree part.
- Prune the tree. Remove the defective branches of the tree. Because inappropriate pruning may weaken a tree, pruning work is best done by at minimum an AQF3 contracting arborist.
- Cable and brace the tree. Provide physical support for weak branches and stems to increase their strength and stability. Such supports are not guarantees against failure.
- Provide routine care. Mature trees need routine care in the form of water, nutrients (in some cases), mulch, aeration, and pruning as dictated by the season and their structure.

- Remove the tree. Some trees with unacceptable levels of risk are best removed. If possible, plant a new tree in an appropriate place as a replacement.

Damage to the tree and its root system is a common problem, particularly as the tree's root system is not usually visible. The symptoms from root damage may not necessarily appear immediately. Prevention of root damage will go a long way in keeping the tree healthy and reducing problems such as the formation of dead wood. Depending on the extent of damage, it is rarely possible to repair or re-invigorate stressed and injured trees.

To help reduce root damage and potential secondary problems, a list of common causes and practices that should be avoided, is provided below:

- placing structures on the root zone or under trees,
- car parking under trees,
- running service trenches through the root system,
- building up the soil level around the trees root system,
- burying tree trunks with mulch piles or surrounding trunks with grass clippings,
- concreting/paving under trees,
- washing chemicals in the soil.

If work is required around trees then seek advice or other alternatives from an arboriculturist before proceeding.

As a guide to determining the extent of the Structural Root Zones and Tree Protection Zones, refer to Section 3 of AS 4970-2009 *Protection of trees on development sites*, Standards Australia.

If a tree is located near a power line, the contractor arborist engaged to undertake the works on the tree has a responsibility to contact your local electrical utility provider prior to commencing those works.

Placing advisory signs in parking areas under trees and in areas utilised by parties other than the general school community is a simple and low-cost method of managing risk in Low-use areas.

Recognising and reducing tree risk not only increases the safety within the school grounds and its users, but also improves the tree's health and may increase its longevity!

3.3 Tree risk assessment methodologies

It should be noted at the outset that professional consulting arboriculturists will have a range of risk assessment outcomes when looking at the same tree. The professional associations of arboriculture have only in recent years brought tree risk methodology in line with risk assessment theory used in other fields requiring risk assessments such as engineering and insurance.

The International Society of Arboriculture (ISA) has provided access to the Tree Risk Assessment Qualification (TRAQ) to local arboriculturists since the end of 2013. A TRAQ credential holder is required to take the two day course and pass the exam every five years in order to renew the credential.

The other peer-reviewed methodology, Quantified Tree Risk Assessment (QTRA), provided training and licensing in Australia since 2007 and has continually updated the practice notes with a significant revision occurring in 2013 accompanied by the introduction of assessment of licensed users.

Arboriculturist's decisions may become more aligned as the methodology becomes more established and understood.

Despite the pros and cons of the various tree risk methodologies it should be understood that all have a degree of inherent subjectivity arising from the skills, knowledge and experience of the tree risk assessor.

3.4 Monitoring of trees in and around DEC school grounds

The majority of schools do not have the resources to undertake annual inspections of all trees in and around their grounds. Annual inspections should only be required for large or mature trees, or those with identifiable defects, that are retained in the High-use areas of the school. Examples of trees with identifiable defects where retention of the tree is desirable, despite its location in a High-use area, might include trees of special significance to the school or local community.

It would be expected the issues relating to the tree and its issues would have been identified by the consulting arboriculturist. With subsequent discussion with the school in regard to the management of such a tree, to ensure appropriate management procedures are followed to reduce any risk associated with the tree.

Table 1: Suggested time frame for tree monitoring according to location and likelihood of failure of defect(s).

High-use = a constant (e.g. buildings) or frequent (people) use.

Moderate-use = infrequent or irregular occupation by people.

Minimal-use = rare occupation, such as out-of-bounds/remote areas rarely visited.

*Likelihood = used as qualitative description of probability and frequency.

NA – all identified extreme-risk trees have been removed from DEC schools during 2014.

More detail on risk categories can be found in the Glossary – Appendix F.

Principals are required to arrange annual inspections of trees in DEC High-use areas – this process is detailed in Section 4.

3.5 Storm damage and other weather events

It is important to be aware of a notable exception to the above monitoring time frames. The period immediately following a significant storm event is crucial for visual inspections of trees in High-use areas to determine whether there are any obvious changes in the tree, such as visible signs of broken tree tops, branches, increased leans (lifting soil/soil changes), new or enlarged stem or branch cracks and so on.

If there are trees down or building damage in the vicinity of the school, there should be an inspection of the school site for obvious storm damage. The principal, general assistant or other nominated person should inspect the school grounds starting with High-use areas and undertake the following as needed:

a. Report any damage to buildings using FM-Web, and contact the Asset Management Unit.

b. Where there is tree damage, and a risk is posed by a fallen or suspended tree/limb, immediately cordon off an area to isolate the hazard from staff and students.

c. Arrange for remediation works using FM-Web, or the engagement of an AQF3 Arborist.

d. The general assistant may be able to undertake minor cleanup works at ground level, and should only work from the ground to parts of a tree no more than head height.

e. Any damage that results in an electrical hazard such as fallen power lines, must be immediately reported to Emergency Services on Phone: 000.

f. Any disruption to electrical supply to the school should be advised to the Energy Supplier for DEC schools (ERM Ph: 1300 376 769).

g. Damage to electrical services within the school, must be immediately logged in FM-Web, to enable early rectification.

Table 1:

Likelihood of failure*	High-use area	Moderate-use area	Minimal-use area
Imminent	NA	NA	1–2 years
Probable	Annual	1–2 years	3–5 years
Possible	1–2 years	3–5 years	5–7 years
Improbable	3–5 years	5–7 years	>7–10 years

3. Tree management on DEC school sites (continued)

On average, the severe storm peak period in NSW and ACT occurs in the months November to February, between noon and 6pm.[11]

It is important to restrict activities under trees during severe weather events.

A significant or severe storm event is typically one where one of more of the following has occurred over a short period (usually one week, sometimes more):

- Prolonged heavy rain followed by strong winds, including gusts up to and over 90kph.
- Hailstones of diameters >2.5 centimetres.
- Severe wind storms, including tornadoes, with or without rain.
- Flash flooding.
- Severe electrical storms, as trees may be struck by lightning.

After surveying storm damage and trying to determine whether the tree or trees are safe there are questions that may need to be asked, such as 'will the tree still be healthy, attractive, and of value to the school after repairs'? If you are unsure, engage a consulting arboriculturist to inspect the trees of concern, but after the school is made safe.

Other weather events

There are other weather events, such as drought, snow and frost, which can stress, damage or place a tree in terminal decline. When such an event is identified, principals should complete a storm event tree assessment and checklist and annotate as needed.

Usually the effects of drought on trees will be identified during the annual inspection of trees, and to ensure the best decisions are made when a number of trees are affected, an AQF5 arboriculturist should be engaged to provide advice. Where multiple schools are affected the Asset Management Unit may be able to obtain generic AQF5 advice that is applicable for tree species on multiple sites.

3.6 Neighbour's trees

The issue of trees and adjoining neighbours can be problematic, and should the principal need support they should contact the Asset Management Unit.

A record of all discussions and written/email communications regarding trees affecting neighbours, should be retained by the school along with a record of annual inspections.

3.6.1. Trees on DEC sites that may affect neighbours

Principals should be in liaison with neighbours if there is a concern with trees on DEC sites. Trees on DEC sites that are in sound condition and do not warrant removal but have branches overhanging into neighbouring sites, are best managed with regular maintenance, which may include pruning of overhanging branches.

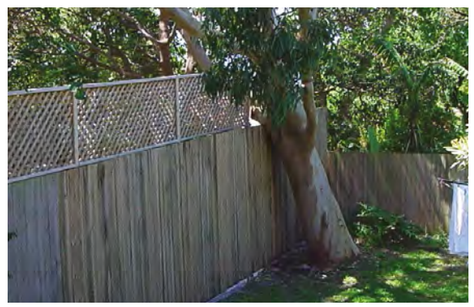
Should trees be in a DEC Minimal-use area, large trees that pose a risk to adjoining properties / fences should be regularly oversighted.

3.6.2.Trees on neighbouring sites that affect DEC sites

Principals should treat trees on neighbouring sites as they would in DEC High, Moderate and Minimal-use areas.

While DEC Minimal-use areas should not be a concern from an adjoining high risk tree, the same cannot be said for DEC High-use areas. Should trees on adjoining properties in close proximity to the boundary, have major defects (1-10, in Section 2.6), then the property owner should be requested to undertake action. If this action is not forthcoming then the local council and the Asset Management Unit should be contacted.

In Section 4, which details annual inspections, trees on neighbouring sites are specifically referenced.



Neighbours' overhanging trees must also be considered in the overall management of trees on DEC schools. Photograph: C. Mackenzie

11 Australian Government Bureau of Meteorology http://www.bom.gov.au/nsw/sevwx/about.shtml. Viewed November, 2014.

4. Oversight of trees on DEC school sites

4.1 Implement an annual inspection of trees

As ongoing follow-up to the tree risk assessments undertaken in schools during 2014, DEC requires principals to implement oversight of trees on school sites using advice provided in these guidelines.

Principals and staff in schools, while not trained arborists, are able to readily identify changes in trees and large scale defects that may be problematic. The conscientious application of a generic checklist, used in conjunction with any previous tree risk assessment advice is required. Where needed principals may seek additional AQF5 arboriculturist support, but this is not mandated.

When principals undertake the annual tree inspection, this is an ideal time to identify any maintenance issues, which may be appropriate for the general assistant to undertake, or an AQF3 arborist. Principals need not engage an AQF5 arboriculturist to scope tree maintenance works.

4.2 Implementation of an inspection of trees after any major storm

Section 3.5 provides information on storms and tasks that need to be undertaken, and there is a separate checklist that can be used for tree inspections after major storms.

4.3 Steps in completing DEC annual tree inspection and checklist

Step 1:
Determine the DEC Usage area of High, Moderate and Minimal-use areas for the school. These could be areas identified in a previous tree safety assessment report.

The benefit of using a previous plan is that the locations of trees are usually plotted.

Step 2:
The checklist is to be completed by the principal with support of the general assistant or members from the school WHS committee.

Step 3:
Using the three checklists, inspect trees for defects listed in Section 2.6 using pages 12-29 to identify the type of defects if present.

It is important that the principals ensure that:

- The numbering system for trees is maintained, if one exists in a previous report.
- The tree/s are located accurately on a plan, if one does not exist.

NOTE: principals are not required to assess likelihood of defects causing a failure, but are required to identify when a defect changes. As a defect change will impact on likelihood of failure, an arborist inspection will be required.

Step 4:
On completion of each checklist, determine whether there is a need to obtain additional AQF5 arboriculturist advice or whether action is required to maintain specific trees.

Step 5
The signed (by principal as the site manager) record of inspection, is to be retained with these guidelines.

NOTE: As the Department is currently finalising an on-line HTML tool for schools to submit the tree checklists, schools should not submit a scanned pdf of annotated printed checklists. Advice will be provided by email (school account) to principals as to when checklists may be processed. This email will provide a link to the HTML software and if needed, a password unique for each school.

4.4 Retention of records

The principal should ensure that records relating to tree safety are retained, with essential documentation being:

- Annual DEC Tree Inspection (checklist), signed.
- Arboriculturist AQF5 inspection reports.
- AQF3 arborist, works undertaken on site.
- Any communication with neighbours regarding tree safety issues, including actions taken by the school.
- Records of occasional maintenance works by the general assistant are not required.

DEC: Annual tree inspection and checklist: **High-use area**

School name _____ **School code** ☐☐☐☐

School usage area | **HIGH** | MODERATE | MINIMAL | STORM EVENT |

Using the schedule of defects (hazards) in Section 2 of Tree Management Guidelines, identify trees that have major defects

Defect No.	Defect	Are defects present?	List number of affected trees (attached marked up site plan)
Example		Yes ☑ No ☐	12 , 16
1	Soil movement-root lifting	Yes ☐ No ☐	
2	Dead branches / trees	Yes ☐ No ☐	
3 a,b,c	Cracks – stem, branches, internal	Yes ☐ No ☐	
4 a,b,c	Weak branch unions	Yes ☐ No ☐	
5 a,b	Decay – cavities and bulges	Yes ☐ No ☐	
5 c,d	Decay – fungi	Yes ☐ No ☐	
6 a,b,c	Root problems	Yes ☐ No ☐	
7	Poor architecture – leaning trees	Yes ☐ No ☐	
8	Cankers	Yes ☐ No ☐	
9	Trees in decline	Yes ☐ No ☐	
10	Storm damage	Yes ☐ No ☐	
11	Trees – neighbours	Yes ☐ No ☐	

For trees in the High-usage area of the school – showing defects 1-10

1 If nil trees identified with defects.....then..... **No AQF5 inspection is required**

2 If trees with defects have been identified.....then.....
Has there been a change in these trees in the past 12 months?

☐ **No** (if same defects present, no change in size) **No AQF5 inspection is required**

☐ **Yes** (if new defects identified, or defect is enlarged or amplified) **Engage AQF5 inspection for the necessary trees**

Action undertaken by school _____

Name (principal / site manager) _____

Signature _____ **Date** ☐☐/☐☐/☐☐☐☐

DEC: Annual tree inspection and checklist: **Moderate-use area**

School name _____ **School code** ☐☐☐☐

School usage area HIGH | **MODERATE** | MINIMAL | STORM EVENT

Using the schedule of defects (hazards) in Section 2 of Tree Management Guidelines, identify trees that have major defects

Defect No.	Defect	Are defects present?	List number of affected trees (attached marked up site plan)
Example		Yes ☑ No ☐	12 , 16
1	Soil movement-root lifting	Yes ☐ No ☐	
2	Dead branches / trees	Yes ☐ No ☐	
3 a,b,c	Cracks – stem, branches, internal	Yes ☐ No ☐	
4 a,b,c	Weak branch unions	Yes ☐ No ☐	
5 a,b	Decay – cavities and bulges	Yes ☐ No ☐	
5 c,d	Decay – fungi	Yes ☐ No ☐	
6 a,b,c	Root problems	Yes ☐ No ☐	
7	Poor architecture – leaning trees	Yes ☐ No ☐	
8	Cankers	Yes ☐ No ☐	
9	Trees in decline	Yes ☐ No ☐	
10	Storm damage	Yes ☐ No ☐	
11	Trees – neighbours	Yes ☐ No ☐	

For trees in the Moderate-usage area of the school – showing defects 1-10

1 If nil trees identified with defects.....then..... **No AQF5 inspection is required**

2 If trees with defects have been identified.....then.....

Has there been a change in these trees in the past 12 months?

☐ **No** (if same defects present, no change in size) **No AQF5 inspection is required**

☐ **Yes** (if new defects identified, or defect is enlarged or amplified) **Engage AQF5 inspection for the necessary trees**

Action undertaken by school _____

Name (principal / site manager) _____

Signature _____ **Date** ☐☐/☐☐/☐☐☐☐

DEC: Annual tree inspection and checklist: **Minimal-use area**

School name _____ **School code** ☐☐☐☐

School usage area HIGH | MODERATE | **MINIMAL** | STORM EVENT

Using the schedule of defects (hazards) in Section 2 of Tree Management Guidelines, identify trees that have major defects

Defect No.	Defect	Are defects present?	List number of affected trees (attached marked up site plan)
Example		Yes ☑ No ☐	12 , 16
1	Soil movement-root lifting	Yes ☐ No ☐	
2	Dead branches / trees	Yes ☐ No ☐	
3 a,b,c	Cracks – stem, branches, internal	Yes ☐ No ☐	
4 a,b,c	Weak branch unions	Yes ☐ No ☐	
5 a,b	Decay – cavities and bulges	Yes ☐ No ☐	
5 c,d	Decay – fungi	Yes ☐ No ☐	
6 a,b,c	Root problems	Yes ☐ No ☐	
7	Poor architecture – leaning trees	Yes ☐ No ☐	
8	Cankers	Yes ☐ No ☐	
9	Trees in decline	Yes ☐ No ☐	
10	Storm damage	Yes ☐ No ☐	
11	Trees – neighbours	Yes ☐ No ☐	

For trees in the Minimal-usage area of the school – showing defects 1-10

1 If nil trees identified with defects.....then..... **No AQF5 inspection is required**

2 If trees with defects have been identified.....then.....

Has there been a change in these trees in the past 12 months?

☐ **No** (if same defects present, no change in size) **No AQF5 inspection is required**

☐ **Yes** (if new defects identified, or defect is enlarged or amplified) **Engage AQF5 inspection for the necessary trees**

Action undertaken by school _____

Name (principal / site manager) _____

Signature _____ **Date** ☐☐/☐☐/☐☐☐☐

DEC: Annual tree inspection and checklist: **storm damage**

School name _____ **School code** ☐☐☐☐

School usage area | HIGH | MODERATE | MINIMAL | **STORM EVENT** |

Using the schedule of defects (hazards) in Section 2 of Tree Management Guidelines, identify trees that have major defects

Defect No.	Defect	Are defects present?	List number of affected trees (attached marked up site plan)
Example		Yes ☑ No ☐	12 , 16
1	Soil movement-root lifting	Yes ☐ No ☐	
2	Dead branches / trees	Yes ☐ No ☐	
3 a,b,c	Cracks – stem, branches, internal	Yes ☐ No ☐	
4 a,b,c	Weak branch unions	Yes ☐ No ☐	
5 a,b	Decay – cavities and bulges	Yes ☐ No ☐	
5 c,d	Decay – fungi	Yes ☐ No ☐	
6 a,b,c	Root problems	Yes ☐ No ☐	
7	Poor architecture – leaning trees	Yes ☐ No ☐	
8	Cankers	Yes ☐ No ☐	
9	Trees in decline	Yes ☐ No ☐	
10	Storm damage	Yes ☐ No ☐	
11	Trees – neighbours	Yes ☐ No ☐	

1 For trees in the **High-use areas**, with identified damage to be dealt with immediately using AQF5 arborist, or via FMC. (also see section 3.5)

2 For trees in the **Moderate-use areas**, with identified damage to be dealt with immediately using AQF3 arborist or via FMC or isolated from use until works can be programmed at a later date.

3 For trees in the **Minimal-use areas**, with identified damage, there is no immediate need for action unless there is a risk to an adjoining property owner or impact on DEC usage (e.g. mowing under trees).

4 After major damage to a site, it can be beneficial to obtain specialist AQF5 advice, to renew trees on site.

Action undertaken by school _____

Name (principal / site manager) _____

Signature _____ **Date** ☐☐/☐☐/☐☐☐☐

Appendices

Appendix A: consulting arboriculturist

DEC tree risk assessment – minimum eligibility criteria

NSW Department of Education and Communities

The information below outlines the criteria for the minimum requirements for tree risk assessors undertaking works at NSW Department of Education and Communities schools and education facilities. The requisite documentation supporting the consulting arboriculturist tendering, applying or quoting for works is to be attached to the Tree Risk Assessment Checklist (on the following page) and provided to the relevant authority (principal/ asset manager/or other approved party).

Who can undertake a Tree Risk Assessment (TRA) at a NSW Government school?

1. Proof of eligibilty

Tree risk assessors must provide proof of at least one (1) of the following minimum requirements from each of the three (3) groups below to be eligible to undertake Tree Risk Assessments (TRA) at NSW Government Schools.

Requisite qualification

- Australian Qualification Framework AHC50510 Diploma of Arboriculture (AQF Level 5) with a minimum 5 years post-graduate experience.
  - Colour copy of transcript of academic record and/or graduation certification.
- Australian Qualification Framework 5865 Diploma of Horticulture [Arboriculture] (AQF Level 5) with a minimum 5 years post-graduate experience.
  - Colour copy of transcript of academic record and/or graduation certification.
- Demonstrable proof of a minimum 5 years full-time professional occupation as a consulting arboriculturist.

It is preferable that a consulting arboriculturist be a member of a professional body such as:

- Accredited Member (AM) of the Institute of Australian Consulting Arboriculturists (IACA). Proof of current membership required.
- Registered Consulting Arborist™ (RCA) of Arboriculture Australia (AA). Proof of current membership required.

Note: principals to confirm via Internet.

Requisite tree risk assessment training

- Colour copy of current Quantified Tree Risk Assessment licence (QTRA).
- Colour copy of current ISA Tree Risk Assessment Qualification (TRAQ).

2. Insurances

Tree risk assessors must have the following insurances. A copy of each Certificate of Currency must be provided with the completed checklist.

- Public liability insurance – minimum $20 million.
- Professional indemnity insurance – minimum $5 million.

Proof of eligibility is to include a signed declaration of impartiality and of pecuniary affiliations with, or potential for beneficial gain derived from, any tree business whose primary income is derived from the cutting and removal of trees.

Note: all requisite documentation is to be provided for every job.

Unless all requisite documentation is provided to the principal, asset manager or approved authority acting on behalf of the school, the arboriculturist should not be retained to undertake tree risk assessments at NSW government schools.

Appendix B: consulting arboriculturist – checklist

NSW Department of Education and Communities

School name _____ **School code** _____

School contact (name) _____ **Phone no.** _____

Arborist details

Tree risk assessors name _____ **Phone no.** _____

Business name _____ **ABN** _____

Proof of eligibility provided (attach colour copies for each group below)

1. Qualification/s and minimum 5 years post-graduate experience Yes ☐ No ☐
2. Accredited/registered membership of peak arboricultural body Yes ☐ No ☐
3. Tree risk assessment qualifications – TRAQ or QTRA Yes ☐ No ☐
4. Signed declaration of impartiality and non-pecuniary interests Yes ☐ No ☐
5. Public liability of minimum $20 million Yes ☐ No ☐
6. Professional indemnity of minimum $5 million Yes ☐ No ☐

A school specific WHS plan will be produced and used to complete the tree risk assessment Yes ☐ No ☐

School has supplied an AMS site plan of the school Yes ☐ No ☐

Scope of inspection

The inspection is required on: **Selected trees** Yes ☐ No ☐ **Entire site** Yes ☐ No ☐

- on trees in and around buildings and in areas congregated in numbers by students and teachers before and after school, during recess/ lunch and during learning activities;
- to identify those trees that pose an unacceptable and extreme risk due to location and condition;
- to recommend immediate remedial action where required and prioritise ongoing remediation and maintenance works;
- to identify the tree species type, its significance (including heritage significance), and any listing on the *Threatened Species Conservation Act 1995*, *Environment Protection and Biodiversity Conservation Act 1999* and council's tree register.

Date of inspection ☐☐/☐☐/☐☐☐☐

Outcome of the inspection

From the inspection, any of the assessed trees that in the expert opinion of the tree risk assessor poses *an unacceptable or extreme risk to human health or safety* have been advised to the principal in writing so that the principal can take immediate action to address student, teacher and parent safety and to direct their asset maintenance contractor to remove or prune the tree(s).

The prepared tree risk assessment report includes the minimum requirements as outlined in the department's Tree Management Guidelines Appendix A.

Yes ☐ No ☐

Arboriculturist's signature _____ **Date** ☐☐/☐☐/☐☐☐☐

Principal's signature _____ **Date** ☐☐/☐☐/☐☐☐☐

Appendix C: tree risk assessment report

Minimum requirements

DEC requires that the following criteria are the minimum used by any person undertaking or requesting a tree risk assessment[12] to be undertaken at a NSW government school.

Tree risk assessments that do not meet these criteria should be rejected by the school principal or person acting on their behalf.

A tree risk assessment must:

1. Be performed by a person who has been formally trained in tree risk assessment.
2. State, in unambiguous terms, the method of tree risk assessment performed and any limitations of the tree inspection undertaken to arrive at the tree risk assessment.
3. State any diagnostic testing that was undertaken in assessing the tree.
4. Demonstrate that the tree risk assessment has followed a peer reviewed and published system designed for the purpose of assessing tree risk (and not tree hazards) and identify the system used, or alternatively provide a detailed documentation of the system used, and demonstrate the validity of the system against known benchmarks.
5. Clearly identify the tree(s) that were assessed, using an existing numbering system if one exists.
6. State the defect(s) or tree issue(s) that gives rise to the assessed risk(s).
7. Use photographs that illustrate the tree, its defect/s or issue/s, to clearly communicate the identified risk concerns.
8. Demonstrate that in determining the risk, the assessment has considered and provided;

   i. the likelihood of the said tree or tree part failing, and

   ii. the likelihood of the target being impacted by the said tree or the tree part, and

   iii. the probable consequences of injury or damage that would result from the failure, and

   iv. ensures that points are the typical or most likely outcome and not the worst case scenarios.

9. Where possible, the assumptions and end outcome of the risk assessment are checked with scientific rigour, using any available research papers, data, and benchmarks.
10. Where in writing, include the name of the client, the date of the assessment, the name of the assessor, and the qualification of the assessor.
11. The report must be provided as a single PDF file, and if not referencing a previous site plan, ensure an annotated electronic DEC AMS plan, or aerial photograph is used to identify trees.

In addition, a tree risk assessment should:

12. be in writing to ensure the information has been communicated clearly, to allow for independent review, and to provide a document trail in the event of an incident occurring.
13. provide benchmarks of common risks that allow the risk manager and other stakeholders to better understand the level of risk posed by the tree(s).
14. this assessment, *should not* focus on secondary WHS issues related to trees that will be readily apparent to the school, such as: trip hazards resulting from: low tree limbs and roots disturbance of paving.

Note: Where a school requests a small number of trees on site to be reinspected, a previous tree assessment report may be referenced for site specific details and the identification of particular trees.

A supplementary report for a small number of trees may only require a one page risk analysis (with photograph/s) per tree, with a clear recommendation of actions, if any, to be undertaken.

12 Modified from Arboriculture Australia publication July 29, 2014. V1.8.

Appendix D: tree pruning

This advice is provided to support schools managing trees effectively. Work at low level may be undertaken by the school general assistant or appropriately skilled / qualified contractors. Any implied high work listed is not proposed to be carried out by general assistants.

1. Why prune trees?

Pruning is the most common tree maintenance procedure. Landscape trees in our urban communities need a higher level of care to maintain their structural integrity, aesthetics and health.

It is essential that the reason for pruning a tree is established prior to works being undertaken otherwise unnecessary removal of living material may be removed and the health, structure and amenity value of the tree may be adversely affected as a result.

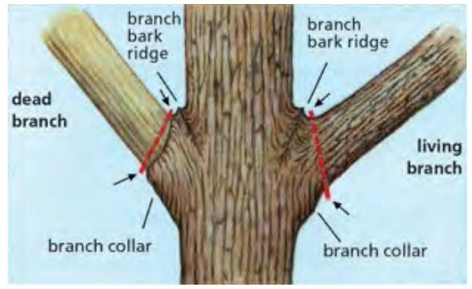
Correct pruning practices rely on a sound understanding of tree biology and in almost all cases, should only be undertaken by experienced and qualified arborists.

Proper pruning will reduce tree risk and safety concerns, assist in maintaining good tree health and structure, and enhance the aesthetic and economic value of the school landscape.

2. Good pruning practices

Proper pruning practices can be described as natural target pruning, where the removal of branches, stems and stubs is such that final cuts are achieved in accordance with the principles of branch attachment and compartmentalisation.[13]

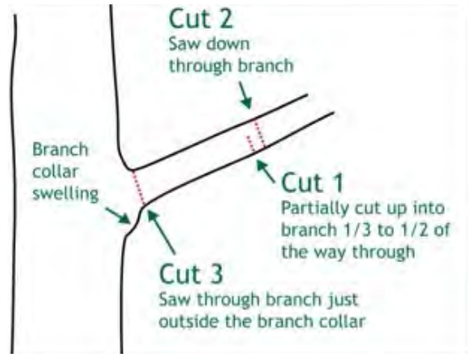
Pollarding and remedial pruning are the exceptions to the above – these methods do not adhere to natural target pruning but are specialised methods aimed at achieving specific results that may require intensive management. These methods would not normally be recommended for school trees unless those trees have special significance that warrant their retention and high level of management.



Natural target pruning

The branch collar is the base area of the branch where the tissues of the branch and main stem join. In some cases the 'swollen' collar is not readily identified. AS4373 provides further information in determining the correct location for cutting where the branch collar is not visible.

Source: http://fyi.uwex.edu/forestry/files/2013/02/BBR.jpg. Accessed 01.11.14



'Step' or 'pre' cutting

This method of cutting using below and above branch cuts is to prevent the weight of the branch causing splitting or tearing back towards and into the branch collar and stem. The remaining stub is removed with the third and final cut at the branch collar.

Source: http://fyi.uwex.edu/forestry/files/2013/02/Pruning-process-e1360943077718.jpg. Viewed November, 2014.

13 A dynamic tree defence process involving protection features that resist the spread of pathogens and decay causing organisms (AS4373).

Appendix D: tree pruning (continued)

3. Poor pruning practices

Improper timing and techniques for pruning of trees can cause lasting damage, shorten the useful life of a tree, create tree hazards and increase maintenance costs.

Examples of poor pruning practices include:

- Flush cutting – cutting that damages or removes the branch collar or removes branch and stem tissue and is inconsistent with branch attachment as indicated by the branch bark ridge.
- Lion's tailing – removing branches from the interior of the tree canopy, leaving most of the foliage at the ends of branches. Lions' tailing may lead to structural hazards and increase risk.
- Lopping – perhaps only second to topping as the most harmful pruning practice. Lopping is the cutting of branches or stems between branch unions or internodes.
- Topping – considered to be the most harmful tree pruning practice known. It is the indiscriminate cutting of the tree (usually the main stem or stems) to reduce the height of a tree. Topping a tree increases risk in the long term.

Photograph: C. Mackenzie

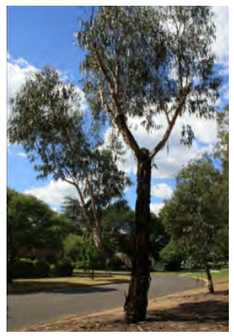
Lion's tailing (above left)

A tree that has undergone excessive removal of lower branches. The tree has a reduced ability to manufacture food and to dampen the oscillation of its branches and upper stem.

Flush cutting (above right)

The cutting of branches 'flush' with the parent branch or stem which removes the branch collar and damages stem and branch tissue.

Source: http://www.dirtdoctor.com/pics/content_img.9663.img.jpg. Viewed November, 2014.



Photograph: C. Mackenzie

Topping (above left)

A tree that has had its main (central) leading stem removed.

Lopping (above right)

A tree that has had its branches cut between internodes, and not at the branch collars.

Source: http://georgeweigel.net/wpcontent/uploads/2011/01/tree.topped.jpg. Viewed November, 2014.

Appendix D: tree pruning (continued)

4. Types of pruning

4.1 Pruning young trees – formative pruning

Directing plant growth and/or developing a sound structure by pruning of young and establishing trees is known as formative pruning. Trees that are correctly pruned when young will require less corrective pruning as they mature, thus reducing tree management costs in the long term.

Undercl. 7.2.5 of AS4373 the aims of formative pruning are described as:

a. To enhance form and improve structure, or to directionally shape the young tree;

b. To reduce the development of structural weaknesses;

c. As a precursor to more specialised pruning; and

d. To accommodate site constraints and reduce encroachment on utilities or buildings as the tree grows.

Formative pruning of young and developing trees. Congested growth is removed and the result is a balanced, well spaced branch architecture that is also aesthetically pleasing.

Branches that are rubbing, crossing, poorly formed or attached or growing in an undesired direction are also removed.

(Source AS4373, 15.)

4.2 Pruning mature trees – crown maintenance and crown modification

Crown maintenance general pruning

1. Deadwooding

Without a doubt the most common pruning undertaken in the school grounds will be the removal of dead branches – 'deadwooding'.

Some deadwood in a tree is perfectly normal. This may be the result of the growth of the canopy shading out lower branches so the tree withdraws nutrients and water from the branch (via the process of compartmentalisation) allowing it to naturally die. Some species of trees hold their deadwood for many years.

However, excessive or abnormal production of deadwood can be a sign that the tree is suffering from other health issues, such as shoot, foliage or vascular disease, root rot (often as a result of poor management and other external influences), and other problems that manifest themselves by crown dieback and branch death.

Wind is nature's way of assisting the shedding of old, dead limbs, however, in school grounds, the failure of dead branches poses a real risk. To manage risk, the trees in frequently occupied areas should be routinely inspected for deadwood and have the material removed as specified by the arboriculturist.

Vigorous trees are unlikely to require deadwooding more frequently than three to five years, or more.

2. Crown thinning

The aim of crown thinning is to reduce canopy density through the removal of lower order (those branches secondary and lesser to the main/scaffold branches) whilst maintaining the structural integrity of the tree.

This form of pruning may be used, for example, to increase light penetration, air movement, assist good form or to restore views.

Appendix D: tree pruning (continued)

3. Selective pruning

Selective pruning is the removal of identified branches that are causing a specific problem, such as contact with a building, poor attachment to the tree, contact with other trees, etc. This may also include formative pruning of specific branches of mature trees.

Crown modification – changing the form or habit of a tree

4. Reduction pruning

The ends of branches are removed to internal lateral branches or stems to reduce the height and/or spread of the tree. This pruning adheres to the principles of natural target pruning – it is not topping or lopping.

5. Crown lifting

This is the removal of the tree's lower branches for a specific purpose such as, access, to improve light penetration, clearance and safety.

6. Pollarding

Pollarding is a specialised pruning technique that establishes branches ending in a pollardhead of buds and vigourous shoots. Trees are cut back to just above the same point every one to three years resulting in the production of multiple shoots.

This pruning process is suited mostly to deciduous trees that have been formatively pruned at an early age and should not be carried out on mature trees that have not been previously pollarded. Trees pollarded initially and not regularly maintained can become hazardous.

7. Remedial (restorative) pruning

This type of pruning is normally reserved for those trees that have lost their natural form through damage, e.g. disease, poor pruning, dieback, storms, vehicles, etc.

The aim is to induce *epicormic shoots*, done in several pruning stages, to form a new crown. The branches formed from epicormic growth may be weakly attached, so risk is likely to increase. This pruning should only be considered for trees of special significance to the school, and where occupancy beneath the tree can be limited or excluded entirely.

8. Line clearance

Line clearance is pruning to maintain clearances around overhead services and is the application of reduction pruning. This is specialised work and must only be done by approved tree contractors on behalf of the local energy provider.

4.3 How much material can be removed?

When pruning, be sure not to remove too many branches. Leaves and their supporting branches are major sites of food production and storage. Eliminating too much of the canopy can 'starve' the tree, reduce growth, and increase stress. No more than 25 percent of the crown should be removed in one pruning, although in the case of mature trees this amount may even be excessive.

4.4 Treating pruning wounds

Research has shown that wound dressings and treatments do not reduce decay or speed up wound closure and rarely prevent insect or disease infestations. Wound dressings are not recommended.

4.5 Who can prune a tree?

Any pruning of branches in excess of two metres above ground must be undertaken by an arborist with a minimum AQF3 in arboriculture. It is recommended that the work of cutting arborists is specified and signed off by a consulting arboriculturist to ensure practices which may increase associated risk from trees in the long run are avoided.

Where school staff intend to prune branches up to two metres above ground, they will need to familiarise themselves with to the pruning advice of these Tree Risk Management Guidelines.

It is recommended that all pruning at schools, even when undertaken as a part of general grounds maintenance by school staff, adheres to the Australian Standard *Pruning of Amenity Trees (AS 4373–2007).*

Appendix E: new tree plantings

The Education Facilities Standards and Guidelines (ERSG), Landscape Guideline provides extensive guidance on plantings of trees in new schools. This advice has been developed after experience in the establishment of both passive and active environments in many new schools, to support the learning outcomes for students. The longevity of plantings and robustness of plantings are essential in providing surfaces that support a range of activities.

The Landscape Guideline should be consulted before any decision is made on the species of any plant / tree proposed to be installed. Too often, inappropriate plantings in existing schools can impact on building maintenance, damage to in-ground services, affect easy oversight of play areas and egress to buildings and the site.

Future tree planting should consider the species, its mature size and the negative and positive attributes of its surrounds and growing environment.

Appendix F: glossary

Abiotic components are non-living chemical and physical factors in the environment which affect ecosystems, such as, water, light, wind, soil, humidity, minerals, gases.

Aerial inspection Where the subject tree is climbed by a professional tree worker or arborist specifically to inspect and assess the upper stem and crown of the tree for signs or symptoms of defects, disease, etc.

Armillaria luteobubalina (Honey fungus, *Armillaria* Root Rot) is a soil borne fungus that causes root rot of a wide variety of plants including many native and introduced ornamental plants. The fungus is native to Australia and causes losses in natural ecosystems, forest plantations, fruit crops and ornamental plants.

Basal flare The rapid increase in diameter that occurs at the confluence of trunk and root crown, associated with both trunk (stem) and root tissue.

Biotic Describes a living component of an ecosystem; for example organisms, such as plants, animals, fungi and bacteria.

Bottle butt Uncharacteristic bulging stem growth at the base of the trunk due to altered stress in this region, often associated with decay.

Bracket fungus The rigid fruiting body of some fungus species, especially those associated with live trees or the *decay* of wood. The structure is often bracket shaped, usually protruding from the roots, trunk or branches of the host tree when the fungus matures. The fruiting body may be ephemeral or persist for many years, and may be solitary or gregarious.

Branch bark ridge The raised strip of bark at the top of a branch union, where the growth and expansion of the trunk or parent stem and adjoining branch push the bark into a ridge.

Branch collar The ring of wood tissue which forms around the base of a branch (near the branch attachment), frequently more pronounced below the branch.

Branch failure The structural collapse of a branch that is physically weakened by wounding or from the actions of pests, diseases, or overcome by loading forces in excess of its load-bearing capacity.

Branch tear out Dislodging of a branch from its point of attachment where it is torn away from the branch collar, snapping the branch tail causing a laceration usually to the underside of the branch union of the branch or trunk to which it was attached, forming a tear out wound.

Burl A woody protrusion found generally on the trunk, often rounded or hemispherical, and may reach substantial dimensions.

Buttress root A large woody root located at the base of the trunk (the root crown) which is important to the overall stability of the tree due to its contributions to basal flare.

Cambium (Vascular cambium) refers to the layer of cells between the exterior bark and the inner wood which primarily controls cell division, and hence radial expansion of the stem, branches and shoots.

Canker Cankers are fungal infections of the bark and cambium that can occur on all parts of the tree. In severe cases they cause twig and branch death, coppice death and stem distortion. The rate at which the tree responds to invasion by canker fungi can be modified by environmental conditions, so that stress, such as that caused by defoliation, can result in increased canker size. The wound, often marked by concentric disfiguration, is created by repeated localised killing of the vascular cambium and bark by wood decay fungi and bacteria. The wound may appear as a depression as each successive growth increment develops around the lesion forming a wound margin.

Cavity A void often localised, initiated by a wound and subsequent decay within the trunk, branches or roots, or beneath bark, and may be enclosed or have one or more openings. These voids are also referred to as hollows.

Chlorotic Result of a severe reduction in chlorophyll (which gives leaves their characteristic 'green' colour), evidenced by yellowing or lack of colour of photosynthetic tissue.

Cluster Describes a group of branches or stems arising from the same point on a larger branch or stem.

Co-dominant Refers to stems or branches equal in size and relative importance.

Appendix F: glossary (continued)

Compartmentalisation A dynamic defense and protection process in trees to resist the spread of pathogens and decay organisms using existing and new cells as physical and chemically enhanced barriers as a system of four walls.

Compression fork A fork formed where two stems or branches with an acute branch crotch grow pressing against each other with included bark. Eventually the bark becomes enclosed bark where the stems flatten at their interface under increasing compression from each successive growth increment, forming a weak graft as a welded fork, which remains susceptible to tensile stress.

Compression wood Type of reaction wood produced by conifers on the underside of branches and leaning trunks. Compression wood on broadleaved trees is an undesirable structural feature.

Condition Refers to the tree's form and growth habit, as modified by its environment (aspect, suppression by other trees, soils) and the state of the scaffold (i.e. trunk and major branches), including structural defects such as cavities, crooked trunks or weak trunk/branch junctions. These are not directly connected with health and it is possible for a tree to be healthy but in poor condition (or vice versa, i.e. a tree that is obviously in poor health and/ or dead but has little/no structural defects).

Consequences Are the effects or outcome of an event. In tree risk assessment, consequences include personal injury, property damage, or disruption of activities due to the event.

Crown All the parts of a tree arising above the trunk where it terminates by its division forming branches, e.g. the branches, leaves, flowers and fruit: or the total amount of foliage supported by branches.

Crown maintenance Pruning that preserves the size and structure of a tree while maintaining crown volume (Australian Standard 4373-2007 *Pruning of Amenity Trees*, page 6). Generally confined to deadwooding, selective pruning, formative pruning and crown thinning.

Damping Dissipation of wind energy by a tree through resistance of the surface area of its leaves; the swaying in complex looping movements of successively lower order branches; and movement of the reduced energy along the trunk to the root plate and into the soil. See also oscillation damping.

Deadwood Refers to any whole limb that no longer contains living tissues (e.g. live leaves and/or bark). Some dead wood is common in a number of tree species.

Decay Process of degradation of woody tissues by fungi or bacteria through decomposition of cellulose and lignin. There are numerous types of decay that affect different types of tissues, spread at different rates and have different effect on both the tree's health and structural integrity.

Deciduous Describes trees and bushes that shed their leaves in the autumn.

Decline The response of the tree to a reduction of energy levels resulting from stress. Recovery from a decline is difficult and slow, and is usually irreversible.

Defect Any structural weakness or deformity.

Dieback Death of growth tips/shoots and partial limbs, generally from tip to base. Dieback is often an indicator of stress and tree health.

End weight The excessive concentration of foliage at the distal ends of branches.

Epicormic Shoots which arise from adventitious or latent buds. These shoots often have a weak point of attachment. They are often a response to stress in the tree. Epicormic growth/shoots are generally a survival mechanism, often indicating the presence of a current, or past stress event such as fire, pruning, drought, etc.

Failure Tree failure is the breakage of a stem, branches, root, or loss of mechanical support in the root system.

Fall zone The distance away from a tree that may be physically influenced if it was cut down or subject to *collapse*.

Forest form Relates to a tree grown in a group with competition for light and space, protected from wind, often resulting in a taller tree with a narrow, spreading crown that is concentrated towards the top of the tree.

Formative pruning This consists of the selective removal of specific branches to enhance form or improve structure, or directionally shape the young tree.

Appendix F: glossary (continued)

Flight cuts A longitudinal slit in the trunk, cut by termite workers to allow the winged termites to leave the colony. In response the tree forms callus tissue to seal the wound, resulting in a characteristic thin scar on the face of the tree's trunk.

Flush cut A cut that damages or removes the branch collar, or removes branch and stem tissue, and is inconsistent with branch attachments as indicated by the branch bark ridge.

Gall abnormal Localised swelling or an outgrowth on a leaf, stem or root, caused by a parasite.

Ganodermabutt rot A significant wood decomposing fungus, generally found in the roots, butts and trunks of trees.

Girdling Usually used to describe a root that is not radial away from the trunk or root/s, and curves to encircle the trunk or root/s, constricting phloem or vascular cambium, causing dysfunction.

Growth crack/split Longitudinal crack/split that may develop as a rupture in the bark from normal growth. Longitudinal crack/split that may develop in the trunk of some fast growing palms.

Hanger Unattached, cut or broken branches that are caught in the canopy.

Harm Is the personal injury or death, property damage, and/or disruption of activities.

Hazard Refers to anything with the potential to harm health, life or property.

Hazard beam Occurs where a stem or branch that curves upward is bent in the opposite direction to the curve as a result of excessive loading forces causing a longitudinal split along the stem.

Hazard tree A tree that has structural defects in the roots, stems or branches that is likely to cause the tree or tree part to fail, where such failure is likely to cause an unacceptable degree of injury, damage or disruption. The tree poses a high or extreme risk, therefore the tree is hazardous.

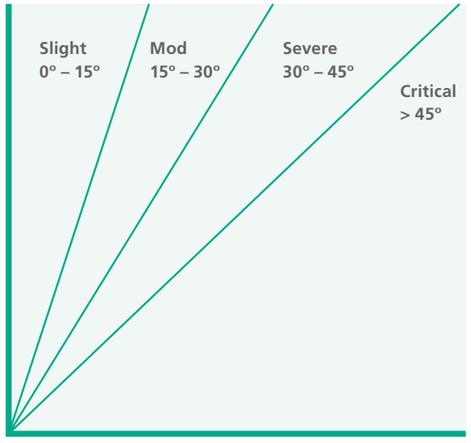
Health (Synonym – vigour) refers to the tree's vigour as exhibited by the crown density, leaf colour, presence of epicormic shoots, ability to withstand disease invasion, and the degree of dieback.

Hollow A void initiated by a wound forming a cavity in the trunk, branches or roots and usually increased over time by decay or other contributing factors, e.g. fire, or fauna such as birds or insects, e.g. ants, termites.

Inclusion The pattern of development at branch or stem junctions where bark is turned inward rather than pushed out. This fault is located at the point where the stems/branches meet. This is normally a genetic fault and potentially a weak point of attachment as the bark obstructs healthy tissue from joining together to strengthen the joint.

Kino The brown or red gum-like resinous accretion stored in veins, pockets and cells of bark and wood, particularly of *Eucalyptus, Corymbiaand Angophora* species.

Lean A tree where the trunk grows or moves away from upright. A lean may occur anywhere along the trunk influenced by a number of contributing factors. A leaning tree may maintain a static lean or display an increasing, progressive lean over time. Slight lean = 0° – 15°. Moderate lean = 15° – 30°. Severe lean = 30° – 45°. Critical lean = > 45°.



Appendix F: glossary (continued)

Likelihood The chance of an event occurring. In the context of tree failures, likelihood refers to (1) the chance of a tree or tree part failure, (2) the chance of that tree or tree part impacting a specific target, (3) the combined likelihood of a tree failing and the likelihood of impacting a specific target.

Lions tailing Refers to the excessive removal of branches, leaving only a small amount of foliage at the distal ends of remaining branches or stems. This is a highly undesirable practice as it contributes to tree instability, and branch failures.

Lopping cutting Between branch unions (not to branch collars), or at internodes on a tree, with the final cut leaving a stub. Lopping may result in dieback of the stub and can create infection courts for disease or pest attack.

Mallet test A nylon head hammer or mallet is used to tap a suspected defective area of the stem, buttress or branch. The resonance of the sound produced, i.e. dull for decayed areas, brighter for sound wood, help to identify whether the tree part requires further investigation.

Mature Refers to a full-sized tree with some capacity for further growth.

Necrosis Dead areas of tissue that may be localised, or spread over large areas of leaves, branches, bark or roots.

Non-woody roots Roots where the primary function is the absorption of water and nutrients in solution. Smallest non-woody roots also referred to as 'fibrous' or 'fine' roots. Protection and retention of these roots is important to tree viability. Some non-woody root loss is tolerable, depending on the tree's age, vigour, species tolerance, growing conditions, etc.

Occlusion Wound wood growth that encloses the wound face by the merging of wound margins concealing the wound and restoring the growing surface of the structure by growth increments re-aligning the wood fibres longitudinally along the stem to maximize uniform stress loading.

Oscillation damping Vital importance for trees to withstand strong gusty winds. Tree adaptation to wind loading takes place over a long time and during a storm only passive damping mechanisms can reduce the impact of the wind on trunk and roots. Structural damping, a phenomenon, which is associated with the conspicuous movements of the branches relative to the trunk is of particular importance. Primary and higher order branches can be seen as multiple-tuned mass dampers.

Moreover, as the frequency bands overlap within branches and between primary branches and the entire tree, resonance energy transfer can distribute mechanical energy over the entire tree, such that it is dissipated more effectively than in a tree with stiff branches and not so much focused on the tree trunk and the roots. If trees didn't undergo this multiple resonance damping they would oscillate wildly and dangerously.[14]

Over-mature Refers to a tree about to enter decline or already declining.

Phytophthora A microscopic soil borne fungus invisible to the naked eye, which lives in soil and plant roots and causes root rot of a wide variety of plant species including many native and introduced plants. *P.cinnamomi* is the species that is most destructive in Australian vegetation communities.

PiCUS sonic tomograph Used to investigate the internal condition of a tree using sound waves. A series of nails are installed around the tree at the measuring plane where visual inspections have identified weaknesses requiring further investigation. These nails become the measuring points and are used to send or receive sound waves. The distances between the measuring points are carefully measured and recorded by the field technician. The sound waves are generated by a hammer tapping on one of the nails. The PiCUS instrument measures the time of flight of sound waves between the sending point and the other receivers. The software calculates the apparent sonic velocities (distance/time) and draws a 'velocity' or 'density' map of the tree by combining the measured tree geometry with sonic data recorded during the assessment. The sonic velocity can be correlated with wood densities and therefore with the soundness of the wood.

14 Spatz, H C, Bruchert, F & Pfisterer, J 2007, *Multiple resonance damping or how trees escape dangerously large oscillations*, American Journal of Botany, 94(10), 1603-1611.
James, K 2010, *A dynamic analysis of trees subject to wind loading*, paper for Melbourne School of Land and Environments, The University of Melbourne.

Appendix F: glossary (continued)

Pollarding A pollarded tree has an established framework with a knob at each branch ending with numerous vigourous, upright, unbranched sprouts a year after being pruned. A pollarded tree requires two to three and a half times more labour than is needed to prune a mature, natural form tree of a comparable species and size.

Reaction wood Specialised secondary xylem which develops in response to a lean or similar mechanical stress, attempting to restore the stem to vertical.

In broad-leaved trees, reaction wood is termed *tension wood* and forms on the upper surfaces of branches and leaning trunks. It exerts an internal contraction that tends to pull the trunk to the vertical or a branch to its original angle of growth.

In conifers, *compression wood* develops on the underside of branches and leaning trunks. The compressive force tends to push the trunk upright, or the branch to its original angle of growth.

Residual risk Risk remaining after mitigation.

Resistograph® testing A Resistograph® is a specialised machine that measures timber density by drilling a 3mm diameter probe through the wood, simultaneously plotting the results on a graph at full scale.

Resonance test A nylon head hammer or mallet is used to tap a suspected defective area of the stem, buttress or branch. The resonance of the sounds produced, i.e. dull for decayed areas, brighter for sound wood, help to identify whether the tree part requires further investigation.

Rib Adaptive wood formed over a crack, included bark or enclosed bark and may be a sharp edged rib as an elongated protuberance where a crack continues to develop, or a round edged (snub-nosed) rib where a broad convex swelling is formed over the crack by the addition of new growth increments, and the cracking is slowed or prevented from developing further.

Risk The combination of the likelihood of an event and the severity of the potential consequences. Risk category terms (from the International Society of Arboriculture Tree Risk Assessment Module 2013) are low, moderate, high, and extreme.

Low – this category applies to those situations where:

- consequences are negligible and likelihood is unlikely, or
- consequences are minor and likelihood is somewhat likely.

Moderate – moderate risk situations are those where:

- consequences would be minor and the likelihood is very likely or likely, or
- consequences are significant or severe, and likelihood is somewhat likely.

High – the risk is high where:

- consequences are significant and likelihood is likely or very likely, or
- consequences are severe and likelihood is likely.

Extreme – this applies to situations in which:

- failure is imminent with a high likelihood of impacting the target, and the consequences of the failure are severe.

Root crown (synonym – root collar) Area at the base of the tree where the roots and stem merge.

Root crown inspection Extensive examination of the junction of root and stem, and the area immediately below, aimed at determining stability, presence of disease, decay, etc.

Root mapping The exploratory process of recording the location of roots usually in reference to a datum point where depth, root diameter, root orientation and distance from trunk to existing or proposed structures are measured. It may be slightly invasive (disturbs or displaces soil to locate but not damage roots, e.g. hand excavation, or use of air or water knife), or non-invasive (does not disturb soil, e.g. ground penetrating radar).

Scaffold branch/root A primary structural branch of the crown or primary structural root of the tree.

Self-corrected Lean which has naturally corrected to a vertical orientation by the development of reaction wood.

Appendix F: glossary (continued)

Shear failure A plane of weakness within a structure, e.g. a trunk, where sections slide against one another. Sometimes evident in a tree that is straight but leaning.[15]

Shear stress Loading force that promotes shear failure.

Structural root zone (SRZ) Refers to the radial distance in metres, measured from the centre of the tree stem, which defines the critical area required to maintain stability of the tree. Only thorough investigation into the location of structural roots within this area can identify whether any minor incursions into this protection zone are feasible.

Note: The SRZ is calculated on the diameter measured immediately above the root/stem buttress (DAB) and calculated using the formula provided in 3.3.5 of AS4970. Where this measurement is not taken in the field, it is calculated by adding 12.5% to the stem diameter at breast height (DBH). (Based on averages calculated from DBH and DAB measurements taken from 20 mature Brush Box and Camphor Laurel).

Note: The SRZ may not be symmetrical in shape/area where there is existing obstruction/ confinement to lateral root growth, e.g. structures such as walls, rocky outcrops, etc.

Sucker Epicormic shoots growing from latent buds in older wood. Such shoots are vigourous and usually upright, arising from below the graft union on the understock, or at or below ground from the trunk or roots.

Sudden branch drop The failure and collapse of live, usually horizontal branches, seemingly without any noticeable cause in calm, hot dry weather conditions, generally after rain. Such branch breakages usually occur at some distance from the branch collar, leaving a torn stub.

Support wood Only hardwood species produce this. If a branch or stem for whatever reason cannot properly support itself, it will produce both tension wood on the topside and support wood on the underside. One reason it's called 'support' wood is to distinguish it from 'compression' wood. Compression wood is found on softwoods and is a good thing; support wood is found on hardwoods and is usually a sign of branch subsidence, when it occurs in conjunction with other signs.

Suppressed In crown class, trees which have been overtopped and whose crown development is restricted from above.

Sweep A curve in the trunk, generally near the ground. This usually occurs when a tree is partially wind thrown when young, but then stabilises itself and straightens due to reaction wood. Stem sweep can also be a naturally developed feature of some tree species. e.g. *Araucaria columnaris* (Cook Pine), that has no relationship to a defect or partial windthrow.

Taper Relative change in diameter with length; reflects the ability of the stem or branch to evenly distribute stress along its length.

Target (risk targets) Are people, property, or activities that could be injured, damaged, or disrupted by a tree.

Target occupancy rates (adapted from the ISA Tree Risk Assessment Manual 2013)

1. Rare – used for sites that are not commonly used by people. Backcountry trails, fenced areas that are well away from more actively used parts of a site, remote parts of an estate, and gardens through which neither workers nor visitors would typically pass would all have rare occupancy. The client or site tree manager may decide, as a matter of policy, that the risk in these areas is so low that risk assessment is not justified.
2. Occasional – sites that are occupied be people or targets infrequently or irregularly. Examples include country roads, low-use footpaths, and low-use sections of parks or institutional grounds. In some instances, a seldom-used area may be heavily used for short periods of time (e.g. country fairs, cemeteries, special-event parking, etc). The client or site tree manager is to decide whether risk assessment is to consider low- or high-use times, or both.

15 Mattheck, C & Breloer, H 1994, *The body language of trees*, research for Amenity Trees No.4, The Stationary Office, London.

Appendix F: glossary (continued)

3. Frequent – this classification is used where the target zone is occupied for a large portion of the day or week, e.g. suburban streets with moderate volume of traffic, institutions (med-to High-use areas of universities, schools, etc) car parks for facilities that are open in the daytime only, footpaths in shopping centres and busy delivery areas.

4. Constant – indicates a target is present at nearly all times, 24 hours a day, 7 days a week. This is the case for static targets (e.g. buildings, utility facilities and other structures that cannot be moved). If there is a steady stream of mobile targets (i.e. people or vehicles) moving through the target zone (e.g. busy street or highway), this can be classified as constant occupancy.

Tension wood Type of reaction wood produced by broad-leaved tree species which forms on the upperside of branches, stems and leaning trunks or roots.

Topping tree Topping or heading back is cutting off the top of a tree, usually to shorten it or reduce its spread. The removal of terminal growth leaves a cut stub end. Topping causes serious damage to the tree.

Tree protection zone (TPZ) Refers to the radial distance in metres, measured from the centre of the tree stem which defines the *tree protection zone* for a tree to be retained. As defined under 3.2 of AS4970, the TPZ is calculated for a tree by multiplying its diameter at breast height x 12. The TPZ is a combination of the root area and crown area to be protected, which may be greater than the calculated radius under 3.2 of AS4970. This is generally the minimum distance from the centre of the tree trunk where protective fencing or barriers are to be installed to create an exclusion zone. The TPZ surrounding a tree aids the tree's ability to cope with disturbances associated with construction works. Tree protection involves minimising root damage that is caused by activities such as construction. Tree protection also reduces the chance of a tree's decline in health or death and the possibly damage to structural stability of the tree from root damage.

To limit damage to the tree, protection within a specified distance of the tree's trunk must be maintained throughout the proposed development works. No excavation (except where approved by an AQF5 arboriculturist or local authority), stockpiling of building materials or the use of machinery is permitted within the TPZ. Note: In many circumstances the tree root zone does not occupy a symmetrically radial area from the trunk, but may be an irregular area due to the presence of obstructions to root or branch spread or inhospitable growing conditions.

Tree risk management Is the application of policies, procedures, and practices to identify, evaluate, mitigate, monitor, and communicate tree risk.

Vigour (synonym – health) Refers to the tree's health as exhibited by the crown density, leaf colour, presence of epicormic shoots, ability to withstand disease invasion, and the degree of dieback.

Visual tree assessment (VTA) A procedure of defect analysis developed by Mattheck and Breloer (1994), that uses the growth response and form of trees to detect defects.

Whole tree failure Where a tree fails at the roots, or at the root crown (where the roots and stem of the tree meet).

Wind load All forces on a building or structure caused by or imputed due to wind pressure, which have to be taken into account in the design of the structure. Most wind loads on dwellings are uplift loads on roofs.

Wind throw Tree failure when a force exerted by wind against the foliage crown and trunk overcomes resistance to that force in the rootplate.

Woody roots Usually used in reference to the first order roots i.e. structural (anchor) roots and woody lateral roots within the structural root zone. Damage, disturbance to, or severing of these roots can compromise the stability of the tree.

Wound wood Refers to the tissue formed at the margins of a cavity or wound. The margins of this new tissue may eventually meet, closing off the face of the wound.

Appendix G: references/bibliography

AS4373-2007 Pruning of Amenity Trees, 2007, Standards Australia, Sydney.

AS4970-2009 Protection of Trees on Development Sites, 2009, Standards Australia, Sydney.

Urban Forest Technical Manual 2012, City of Ryde, Sydney, Australia.

Bagot, K 2014, *Nature play,* ABC, viewed 5 October 2014, <http://www.abc.net.au/catalyst/stories/4099330.htm>

Coder, K D 1996, *Identified benefits of community trees and forests,* University Of Georgia Cooperative Extension Service, Forest Resources, Georgia.

Costello, L R & Jones, K S 2003, *Reducing infrastructure damage by tree roots,* Western Chapter of the International Society of Arboriculture, California.

Draper, D & Richards, P 2009, *Dictionary for managing trees in urban environments*, Institute of Australian Consulting Arboriculturists (IACA), CSIRO Publishing, Victoria.

Dunster, J A, Smiley, E T, Matheny, N & Lilly, S 2013, *Tree risk assessment manual,* International Society of Arboriculture, Champaign, Illinois.

Harris, R W, Clark, J R & Matheny, N P 2004, *Arboriculture: integrated management of landscape trees, shrubs and vines,* 4th edn, Prentice-Hall, New Jersey.

Hayes, E (ed.) 2001, *Evaluating tree defects – a field guide*, 2nd edn, Safetrees, Wisconsin, USA.

Jacobs, S J, Vihma, T, Pezza, A B, 2014, 'Heat Stress During the Black Saturday Event in Melbourne, Australia' *International Journal of Biometeorology,* viewed November 2014, < http://link.springer.com/article/10.1007/s00484-014-0889-2>

James, K 2010, *A dynamic analysis of trees subject to wind loading,* paper for Melbourne School of Land and Environments, The University of Melbourne.

Jurkis, V 2005 *Eucalypt decline in Australia, and a general concept of tree decline and dieback*, Forest Ecology and Management, Australia.

Keane, P J, Kile, G A, Podger, F D & Brown, B N 2000, *Diseases and pathogens of eucalypts,* CSIRO, Victoria.

Lonsdale, D 1999, *Principles of tree hazard assessment and management,* Stationery Office Books, London.

Mattheck, C & Breloer, H 1994, *The body language of trees*, research for Amenity Trees No.4, The Stationary Office, London.

Mattheck, C & Breloer, H 1999, *The body language of trees: a handbook for failure analysis*, HMSO, London.

Mattheck, C 1999 *Stupsi explains the tree*, 3rd edn, Karlsruhe Research Centre, Karlsruhe, Germany.

Pokorny, J D (ed.) 2003, *Urban tree risk management: a community guide to program design and implementation,* USDA Forest Service, Saint Paul, Minnesota.

Shigo, A L 1986, *A new tree biology,* Shigo and Trees Associates, New Hampshire, USA.

Shigo, A L 1991, *Modern arboriculture,* Shigo and Trees Associates, New Hampshire, USA.

Spatz, H C, Bruchert, F & Pfisterer, J 2007, *Multiple resonance damping or how trees escape dangerously large oscillations,* American Journal of Botany, 94(10), 1603-1611.