Decay & Tree Risk Assessment

Site: **106 Great Russell Street, London. WC1B 3NB**

Client: **Mr Andrea Barbieri c/o Artemide**

Date: 5th June 2015

Reference: BA4904

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SUMMARY

The London Plane tree in the rear garden is a dominant large grown rounded tree, which is estimated at being roughly at its mature height. However, the canopy spread has the potential to increase due to the sheltered location and the stem is assumed to be less than half its potential stem diameter.

My assessment shows there are several features within the canopy including growth defects, areas of decay and the potential effects of fungal species, which could affect the trees stability and branches within the canopy.

Additionally, internal assessment indicates that decay within the central stem has occurred and advanced which has the potential to impact on the tree's stability.

Growth of the tree has resulted in damage to structures on site and neighbouring the site, additional growth is expected to compound the damage and potentially destabilise structures on and neighbouring the site and this is expected to worsen.

A requirement of a tree's growth is the biological necessity to develop a new tree on the outside of the original tree which exerts a load on structures which come into contact with the tree stem, buttress and main roots.

The short-term condition of the tree can be improved and the immediate risk reduced to acceptable limits, through canopy remodelling and ongoing remedial works. However, the principal issue is the tree's poor location, effectively the tree is an 'A shark in a goldfish bowl' and the current cracking and deflection of structures will only be compounded as the tree continues to grow, which is a biological necessity. This continued growth is expected to cause further management difficulties for both the site and third parties.

The tree offers a current and foreseeable nuisance and no management options to exacerbate or alleviate the problem of the trees poor location exists and based on this I recommend that the tree is removed and replaced, with a more appropriate species which is better suited to the site constraints and better located to avoid future management issues.

The relationship between the tree and the built form is not sustainable and further damage is expected. Management of this situation by severance of roots in this area is not a management option in light of both the volume of rooting required to maintain the tree's stability and accessibility to the roots, which is likely to be on neighbouring properties, therefore pruning of the root system and or severance cannot be considered.

Unfortunately, the tree is located closer to structures than the recommended distance within the current British Standard and whilst the tree is retained and is growing there is a need for the tree to increase in volume in response to secondary thickening, as a result whilst growing normally, the damage seen is expected to worsen.

Alternative methods of management are not available to enable the built element and the tree to co-exist. Although the tree has a high visual amenity and a high inferred financial worth to both the site and the locality the situation is unsustainable and as a result, I recommend to remove and replace the tree in a single event.

The tree is protected by a TPO, but is not visible from the public domain and has had previous approval to be removed under conservation area legislation.

1. INTRODUCTION

Objective: To assess the internal condition of a mature London Plane tree growing within the rear garden of the site and to provide sufficient information to enable a decision on the safe management of the tree to be made following the discovery of damage to nearby structures.

Surveyor: My name is Ian Barnes; I am an Arboricultural Association Registered Consultant, a Chartered Environmentalist, and Fellow of the Arboricultural Association.

Qualifications and experience: I have based this report on my site observations and the information; I have come to conclusions in the light of my experience, which I briefly outlined in Appendix 1.

Site Visit: 21st May 2015.

Weather Conditions: Bright & clear, visibility was good.

Brief site description: The tree is located at the northwestern corner of the rear yard and abuts the western and northern boundary walls.

I have shown the general position of the tree with a red circle on the adjoining Google Earth image, downloaded and used courtesy of ©Google and ©third-party supplying noted in the photograph.

The scope of this report: The statements made in this report do not take account of the effects of extremes of climate, vandalism or accident, whether physical, chemical or fire. Barnes & Associates cannot therefore accept any liability in connection with these factors, nor where prescribed work is not carried out in a correct and professional manner in accordance with current good practice. The authority of this report ceases at any stated time limit within it, or if none stated after two years from the date of the survey, or when any site conditions change, or pruning or other works unspecified in the report are carried out to, or affecting, the Subject Tree(s), whichever is the sooner.

2 TREE ASSESSMENT

The Terms of Reference: This report has been based upon a brief ground based Visual Tree Assessment (VTA) methodology, as devised by Mattheck (1993) in addition to Hazard Evaluation devised by Matheny & Clark (1993). Guidance is also taken from Lonsdale (1999) *Principles of Tree Hazard Assessment and Management*, Sterken (2005) A Guide for Tree-Stability Analysis, BS3998:2010 Recommendation for Tree works & Common Sense Risk Management of Trees National Tree Safety Group and Forestry Commission (2012) & construction - Recommendations' & The ISA Tree Risk Assessment Manual (2013) – Further details in appendix 2.

Assessment Methods: The assessment of the buttress and lower stem was undertaken from ground level, specific heights are provided in the individual assessments below. The height of the tree was measured using a clinometer. Where possible the canopy is measured using a measuring wheel or fabric tape from the centre of the stem, where access to the full canopy is not possible I estimate the dimensions.

Where internal assessment of stems was undertaken this aims to quantify the extent and quality of retained wood, which helps to identify regions that have a normal appearance versus areas that have structural defects such as cracking or hollow sections or areas that have been colonised and altered by fungal activity and to provide an insight into wood quality. The following appraisals include detailed assessment as necessary in light of the recorded defects and may be limited to single appraisal only.

Trees, unlike built structures are a dynamic self-optimizing structures that have distinct features in relation to the ways in which they develop and adapt to environmental and internal changes. These points are briefly discussed in Appendix 3 'Trees & Growth', Appendix 4, 'Rooting Patterns' and Appendix 5 'Tree Morphology'.

As trees develop, they can either develop defects as briefly discussed in Appendix 6 'Defects & Decay' and can be affected through the action of 'Fungi in Trees' discussed briefly in Appendix 7.

The ability of trees to accommodate their response to changes requires both interpretation and sometimes an adjustment in the perception of what can be considered safe, this aspect is briefly discussed in Appendix 8 'How Hollow is safe'.

To understand this we draw upon several methods in combination to provide an insight into safety. At the simplest level, we rely upon external visual assessments. To help extend our understanding we can then use a number of methods to help inform our management of trees which have questions against them, these include assessing the forces acting upon a tree as briefly discussed in Appendix 9 'Wind Loading', or through the use of detailed assessment techniques as outlined in Appendix 10 'Assessment Methods'.

Assessment of trees, particularly those with defects is far from a clear-cut subject and can be affected by many factors. Assessments need to be viewed in a similar light to those of the medical profession being an assessment of the potential rather than absolutes. Even with our best endeavours, arboricultural assessments, like medical assessments, can only offer a general overview; some processes naturally resist definition, and standardization, being more an art than science. Where internal assessment of stem was undertaken this aims to quantify the extent and quality of retained wood, which helps to identify regions that have a normal appearance versus areas that have structural defects such as cracking or hollow sections or have been colonised and altered by fungal activity and to provide an insight into wood quality.

Photograph taken in 2011

Species: London Plane

Mean Height: 22m

Height to underside of Canopy: 9m

Circumference at Breast Height: 3875mm

Diameter at Breast Height: 1230mm

Canopy radius: **North :** 4.5m **South :** 12.5m

East : 12m **West :** 12m

Distance to western boundary: 0mm buttress touching

200mm @1.3m

Cracking visible

Distance to western boundary: 0mm buttress touching

220mm @1.3m

Deflection in wall visible

Age Range: Early Over Mature

Growth Potential: Moderate to High

Legislative Protection: Conservation Area & Tree Preservation Order.

Key points noted during VTA:

- The tree is growing within a well-defined garden space close to the rear northern boundary wall and the western-shared party wall, which has signs of direct damage, visible.

- Cracking in the western boundary wall can be seen adjacent to the tree indicated by the red arrows on the photographs opposite and shown in detail in the photograph below.

Looking west along the rear boundary wall.

- In addition the northern boundary wall has a distinct bow when viewed from above, though this is difficult to show within a photograph. In addition to this there are signs of direct root damage in the neighbouring land (red arrows) which is 900mm below the garden of 106 Great Russell Street indicating that the tree has a mechanical advantage above the wall foundations which are assumed to be at or below the level of the ground on the neighbouring property.

Looking down and slightly east at either side of the Northern boundary wall

The northern canopy isabradingg with theneighbouring property to the north and signs of abrasion damage could be seen red arrow on the photograph opposite.

Looking upwards and north towards the canopy abrasion with the neighboring Flats.

- Within the canopy there are various defects and hollows. Principally the main canopy of the tree has been topped at some point in the past at roughly 9m above ground. This has resulted in the formation of a cavity on the northern face of the stem (red arrow) that extends both below the main canopy attachments and down the stem to some 1300mm when probed.

Looking down at the cavity entrance at 9m.

- Elsewhere in the canopy thereise a range of otherissues, includingg several tightly formed included and rubbing main leaders (red arrows) which are expected to become a pointofr weakness or pathogen entry.

Looking west and downwards at the main canopy attachment.

- In several areas leaf wilting and scorching (red arrows) indicate that the tree is suffering Plane Anthracnose (Apoignomonia veneta). This is not a significant issue at the current time, but will need to be reassessed periodically to ensure it does not impact of the tree's vitality.

Looking west within the canopy.

- Several areas of wounding on the upper surface of limbs could be seen as shown opposite (red arrows), which strongly suggests that the tree is affected with Massaria (*Splanchnonema platani*). This disease affects London Plane trees and it presents a real challenge for managers, in the built environment as the fungus appears to take advantage of branches predisposed by drought stress, leading to larger

Looking North West within the canopy.

branches being affected, that are then shed or predisposed to failure.

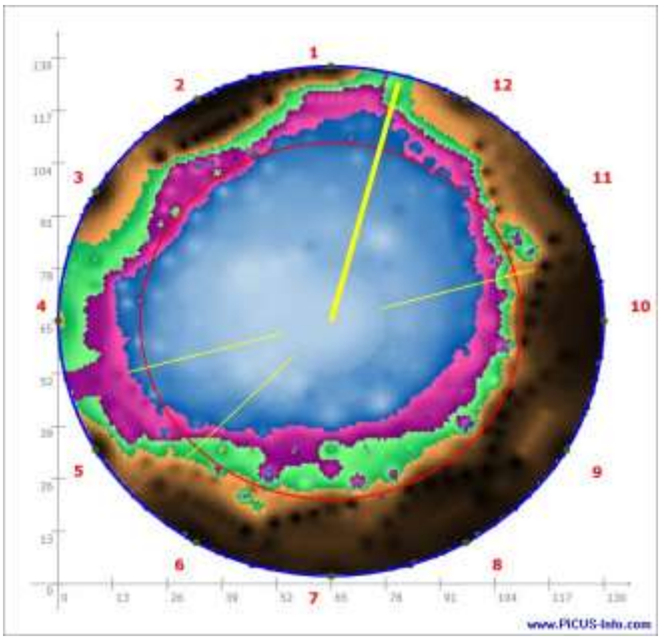
- Elsewhere the canopy displays the typical issues found within lapsed pollards of multiple attachments, where multiple ascending leaders originate from areas affected with decaying wood which increases the risk of main leader failure.
- The combined effect of the sheltered located and restricted light levels has led to the formation of long elongated leaders and branches within the canopy, which again become affected by gravity, increasing the risk of localized abrasion or branch failure.

Internal Assessment – This was undertaken using a sonic assessment of the stem at 800mm above ground level with the number 1 sensor orientated to the north.

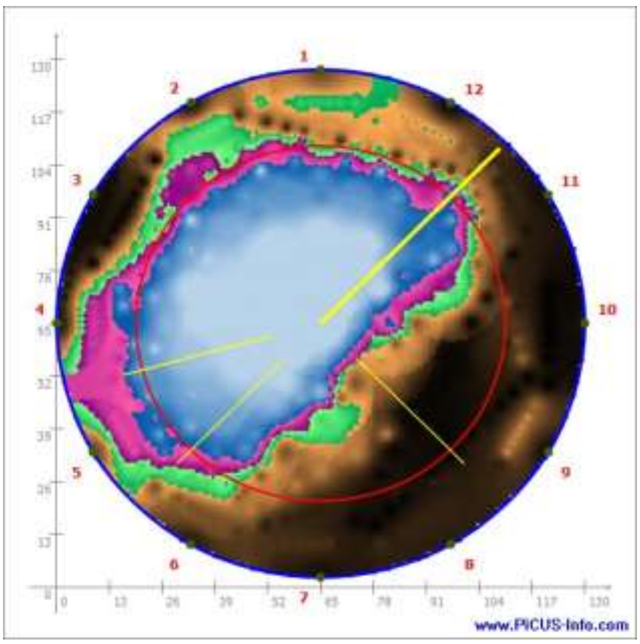
The assessment level is indicated by the blue dotted line on the photograph opposite. The blue arrow shows the position of Sensor 10 on the eastern face.

Due to the presence of the walls, I was unable to accurately measure the stem dimensions instead I used an ellipse based upon the north–south axis of 1270mm and the east-west axis of 1320mm this was used to create an ellipse and the sensor points were set at equal intervals. The results of the Sonic Tomograph at 800mm above ground is shown below. This assessment level was chosen to enable a comparison of the 2015 an earlier assessment undertaken in the 2011 at the same height, which I have included below:

2015 Results



2011 Results



This assessment shows that the central north western the stem has undergone significant decay, indicated by the blue and magenta sections.

The remaining green area of the stem is undergoing early stage alterations due to the effects of fungal colonisation.

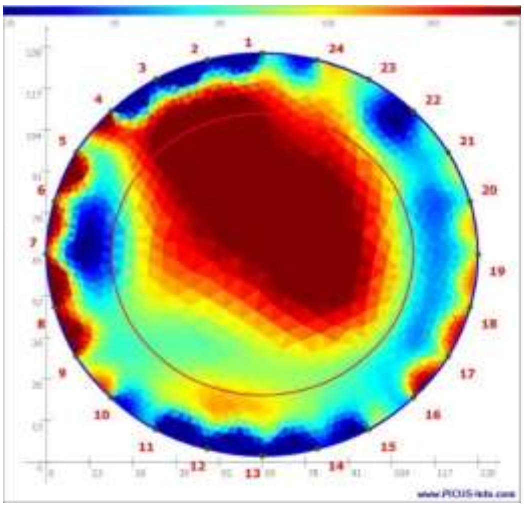
The better quality wood is represented by the brown colour.

The decayed section of the stem colonised and altered by fungal activity partially breaches the inner red line. This is shown on the image above, which is equivalent to the t/R ratio of 0.3, the normally regarded safe limit of decay in trees.

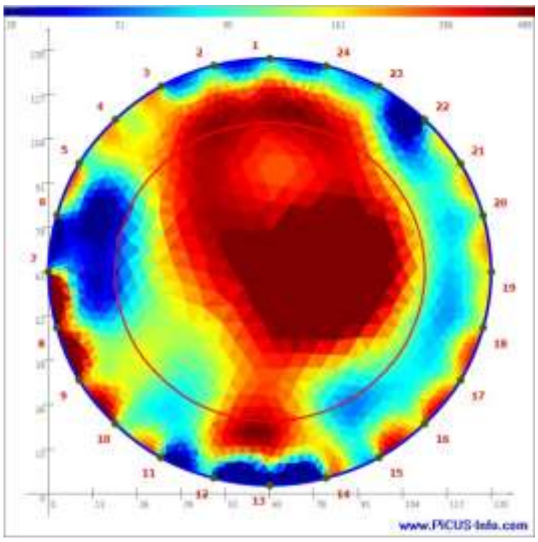
The results show that the significant portion of relatively sound wood to be present in the eastern and southern section of the stem. Typically trees are supported by the tension wood in the western canopy, which is the principal area of decay. Ideally, this stem decay or thinning of the stem would be assessed using either a Resistograph or borer. Unfortunately, in this case the present of the brick walls and limited separation distance prevented access.

To understand the situation further, a second assessment using ERT was undertaken at the same location as the sonic assessment; the results of the ERT from 800mm are shown in the tomogram below and again sensor 1 is orientated to the north. However, it should be remembered that this information is more general having some information both from above and below the assessment height.

2015 Results



2011 Results



The results show the tree to have an area of higher resistance – red areas within the central stem which is assumed to be the principal area of decay and internal drying.

The gradual movement of the central red area north and west is assumed to be in response to areas once colonised now being exhausted or area's within the central decay now having a build-up of damp organic matter and seasonal difference.

The key aspect is that the area of suspected decay extends beyond the inner one third line (Inner Red circle) just as the sonic results do. The red area on the outer stem around sensors 5 to 9 and the area's 16 to 19 are assumed to be high quality adaptive wood and the areas of greatest secondary thickening. Again, I would ideally, have assessed this area using either a Resistograph or borer. Unfortunately, in this case the presentance of the brick walls and limited separation distance prevented access.

Based upon the extent of retained wood in the outer shell the tree is expected to have sufficient wood to offer support to the tree in the short term at the level of assessment, based upon the relative strength of Plane wood and the very sheltered location. However, there is clearly a defect, which is expanding and compromises the tree's inherent stability.

An assessment of the rear and the western boundary wall, as forecasted, show that there has been a marked increase in the magnitude of cracking damage between the 2011 assessment and the 2015 assessment as shown below. The (red arrows) show the same position (based on the surface pattern) and assuming the nominal brick length of 230mm a comparison of the crack suggests that cracking has increased from 3mm to 5mm to around 25mm to 30mm. In addition cracking now extends higher up the western boundary wall, with cracking in excess of 40mm, which in addition is affecting the verticality of the rear northern boundary wall.

2015 Assessment

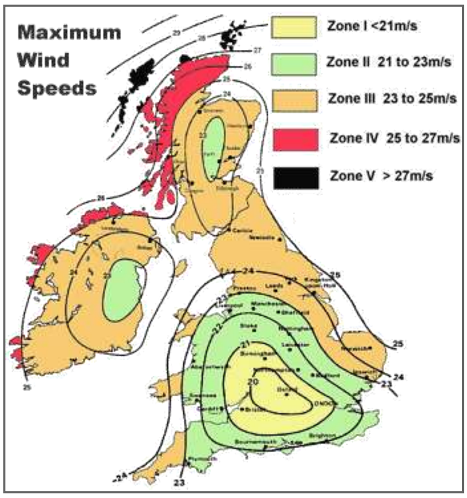
2011 Assessment

This situation will worsen as the tree has a biological requirement to increase in volume in response to aging. The tree normal growth requires the laying down of a new growth increment growth seasonally, effectly growing a new tree on the outside of the original tree which results in both an increase in volume and an applied lateral load, which is both well documented and as can be seen from the photographs above can displace and damage built structures.

4 RISK ASSESSMENT

Risk Assessment – Below is an assessment of the risk offered by the tree over the next year.

Potential Risk from Trees: Trees, unlike built structures are a dynamic structure and offer several specific management issues that need to be considered. Reasonable risk management generally aims to provide trees that can be regarded stable in a normal / foreseeable, storm event. In this area that would typically be a wind speed of 23 to 25 m/s based upon information published by the Building Research Establishment, copied opposite. This equates to a force 9 / 10, Gale / Severe Gale on the Beaufort Wind Scale. I have included further general information upon the Tree & Risk in Appendix 2.



Target evaluation. To enable a balanced approach to the site assessment I undertook an initial assessment of the associated risks on site to identify areas of high public access, areas where trees are within striking range of valuable or fragile structures or high human occupancy locations. Targets are broadly zoned in the 'Target' ranges based on the levels of occupation, population and value. These were assumed to be generally low target areas with the site having occasional to frequent occupation.

Risk Assessment. The assessment follows the general principles of Risk Assessment; Risk assessment is important to reduce the risk of injury to people, property damage or disruption of services. The International Society of Arboriculture (ISA) Tree Risk Assessment Methodology takes a qualitative rather than quantitative approach to risk assessment. The system uses the output of matrix 1 (copied below) to compare the likelihood of failure of a tree or tree part, the likelihood of impacting the target and the potential consequences of failure.

Matrix 1. Likelihood of failure

Likelihood of failure	Likelihood of Impacting Target			
	Very low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2. Risk Rating matrix

Likelihood of failure & impact	Consequences of Failure			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

The matrices generate an output in matrix 2, describing the risk offered by the trees in line with general risk assessment methodologies; these are arranged into bands differentiated by coloured text within the tree schedule. Highlighted above are the colours representing the following risk bands of indices.

Quantified Tree Risk Assessment (QTRA). Alternatively, the risk offered by a tree can be calculated to provide an annual Risk of Harm from a particular tree or part of a tree. To inform management decisions, the risks from different hazards can then be both ranked and compared, and considered against broadly acceptable and tolerable levels of risk. Which is directly related to the Value of Statistical Life (VOSL), a widely applied risk management device, which uses the value of a hypothetical life to guide the proportionate allocation of resources to risk reduction. In the UK, this value is currently in the region of £1 500 000, and this is the value adopted in the QTRA method.

Firstly, QTRA uses VOSL to enable damage to property to be compared with the loss of life, allowing the comparison of risks to people and property. Secondly, the proportionate allocation of financial resources to risk reduction can be informed by VOSL. The input values for the three components of the QTRA calculation are set out in broad ranges of Target, Size, and Probability of Failure. The assessor estimates values for these three components and to calculate the Risk of Harm. The UK Health and Safety Executive (Anon. 2001) suggests that "an individual risk of death of one in a thousand per annum should on its own represent the dividing line between what could be just tolerable for any substantial category of workers for any large part of a working life, and what is unacceptable for any but fairly exceptional groups.

The Tolerability of Risk framework (ToR) (HSE 2001) is a widely accepted approach to reaching decisions on whether risks are broadly acceptable, unacceptable, or tolerable. Graphically represented opposite, ToR can be summarised as having a **Broadly Acceptable Region** where the upper limit is an annual risk of death 1/1 000 000, an **Unacceptable Region** for which the lower limit is 1/1 000, and between these a **Tolerable Region** within which the tolerability of a risk will be dependent upon the costs and benefits of risk reduction.

In respect of trees, some risks cross the Broadly Acceptable 1/1 000 000 boundary, but remain tolerable. This is because any further reduction would involve a disproportionate cost in terms of the lost environmental, visual, and other benefits, in addition to the financial cost of controlling the risk.

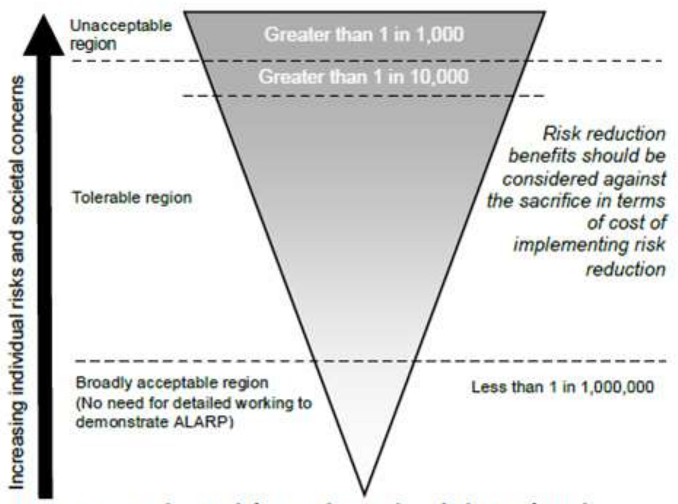


Figure 1. Adapted from the Tolerability of Risk framework (Anon. 2001)

For members of the public who have a risk imposed on them 'in the wider interest of society' this limit is judged to be an order of magnitude lower – at 1 in 10 000 per annum." Furthermore, "HSE believes that an individual risk of death of one in a million per annum for both workers and the public, corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions" as demonstrated in the figure opposite.

Advisory Risk Thresholds

Thresholds	Description	Action
	Unacceptable Risks will not ordinarily be tolerated	• Control the risk
1/1 000	**Unacceptable** (where imposed on others) Risks will not ordinarily be tolerated	• Control the risk • Review the risk
	Tolerable (by agreement) Risks may be tolerated if those exposed to the risk accept it, or the tree has exceptional value	• Control the risk unless there is broad stakeholder agreement to tolerate it, or the tree has exceptional value • Review the risk
1/10 000	**Tolerable** (where imposed on others) Risks are tolerable if ALARP	• Assess costs and benefits of risk control • Control the risk only where a significant benefit might be achieved at reasonable cost • Review the risk
1/1 000 000	**Broadly Acceptable** Risk is already ALARP	• No action currently required • Review the risk

This provides information upon priority with trees with the highest risk rating with the greatest target values requiring work urgently.

Where the priority of trees is recorded as being low and a low target value, works required to improve the trees risk of harm, are expected to be undertaken as part of the normal estate management.

Importantly, to enable tree assessors to provide appropriate management guidance, it is helpful for them to have some understanding of the tree owner's management preferences prior to assessing the trees.

Adopting the International Society of Arboriculture (ISA) **Tree Risk Assessment Methodology,** the assessed risk offered to the surrounding area by the tree is as follows:

Risk of whole Tree Failure	Risk of Primary Branch Failure	Risk of Secondary Branch Failure
Moderate	Moderate	High

Adopting the **Quantified Tree Risk Assessment (QTRA)** the assessed risk offered to the surrounding area by the tree is as follows:

Risk of whole Tree Failure	Risk of Primary Branch Failure	Risk of Secondary Branch Failure
1/300,000	1/ 30, 000	1/3,000

The above assessment is based upon a single target to provide an insight into the situation. However, it must be borne in mind that at points within the day, the risk is to multiple targets in light of the users of the garden space of 106 Russell Street. The potential users of the amenity space to the flats to the north of the site and in particular, clients of the restaurant to the west who are located below a glass atrium for long periods of time.

The risk offered by the tree is unacceptable region, particularly in light of the canopy spread and the likely effect upon neighbouring properties over a typical year. Such risks will not ordinarily be tolerated where they are imposed on others and will require management.

In this situation, much of the risk can be controlled through canopy remodelling or by limiting access. However, this is not thought to be acceptable and will not prevent further growth of the tree and risk from current and additional damage to nearby structures, which will continue, which in themselves will constitute a risk to site users and members of the public. Such branch failures are difficult to predict with any great level of detail and as such, I would recommend a defensive position is best adopted. In light of this, I suggest that changes to the opening arrangements are considered and incorporated into your **'Tree risk management policy & Procedure documentation'.** Ideally, access to the site should be restricted when the wind speeds approach 'Near Gale' or 'Moderate Gale' - Beaufort Force 7, 32-38 miles per hour or 30mph based upon normal broadcast weather forecasts or when gusting winds are forecast.

Conclusion: The assessment shows that there are several features within the canopy including growth defects, areas of decay and the potential effects of fungal species, which could affect the tree's stability, and that of branches within the canopy.

Internal assessment indicates that decay within the central stem has occurred and advanced and has the potential to impact on the trees stability.

Growth of the tree has resulted in additional damage to the built structures, both on and neighbouring the site and additional growth is expected to compound the damage and potentially destabilise structures.

In light of the above, the short term condition of the tree can be improved and the immediate risk reduced to acceptable limits, through canopy remodelling and ongoing remedial works. However, the principal issue is the tree's poor location, it is effectively 'A shark in a goldfish bowl' and the current cracking and deflection of structures will only be compounded as the tree continues to grow which is a biological necessity, resulting in management difficulties for third parties.

The tree offers a current and foreseeable nuisance and no management option to exacerbate or alleviate the problem of the trees poor location exist and based on this I recommend that the tree is removed and replaced, with a more appropriate species which is better suited to the site constraints and better located to avoid future management issues.

Further growth offers a foreseeable risk of further damage to nearby properties, the boundary wall and the paving, which constitutes a foreseeable nuisance. Within the current Planning Practice Guidance (http://planningguidance.planningportal.gov.uk/) Tree Preservation Orders and trees in conservation areas there is a clear reference to the works to abate a nuisance being classed as an exception to a Tree Preservation Order (copied below);

> ***What is the exception for work to prevent or abate a nuisance?***
>
> *The authority's consent is not required for carrying out the minimum of work on a tree protected by an Order that is necessary to prevent or abate a nuisance. Here 'nuisance' is used in its legal sense, not its general sense. The courts have held that this means the nuisance must be actionable in law – where it is causing, or there is an immediate risk of it causing, actual damage.*
>
> *When deciding what is necessary to prevent or abate a nuisance, tree owners and, where applicable, their neighbours and local authorities, should consider whether steps other than tree work might be taken. For example, there may be engineering solutions for structural damage to buildings.*
>
> *Revision date: 06 03 2014*
>
> *To prevent or abate a nuisance (http://planningguidance.planningportal.gov.uk/blog/guidance/tree-preservation-orders/making-applications-to-carry-out-work-on-trees-protected-by-a-tree-preservation-order/exceptions-relating-to-applications-to-carry-out-work-on-trees-subject-to-a-tree-preservation-order/#paragraph_082);*

The relationship between the tree and the built form is not sustainable and further damage is expected. Management of this situation by severance of roots in this area is not a management option in light of both the volume of rooting required to maintain the tree's stability and accessibility to the roots, which is likely to be on neighbouring properties, therefore pruning of the root system and or severance cannot be considered.

Unfortunately, the tree is located closer to structures than the recommended distance within the current British Standard and whilst the tree is retained and is growing there is a need for the tree to increase in volume in response to secondary thickening and as a result whilst growing normally the damage seen is expected to worsen.

Alternative methods of management are not available to enable the built element and the tree to co-exist. Although the tree has a high visual amenity and a high inferred financial worth to both to the site and the locality the situation is unsustainable and as a result, I confirm my original recommendation to remove and replace the tree in a single event.

Please feel free to contact me and discuss these findings, the wider site management and replacement tree planting and the wider implications and replacement tree options.

5 OTHER CONSIDERATIONS

It should be remembered that this assessment of the tree, provides an insight at a point in time, though in light of the characteristics of trees this situation will not remain static and could change markedly over a short period of time.

Legal Duty: Tree owners have a statutory duty of care under the Health and Safety at Work Act 1974 and the Occupiers Liability Acts of 1957 & 1984 to ensure that members of the public and staff are not to be put at risk because of any failure by the owner to take all reasonable precautions to ensure their safety. To avoid liability, a tree owner should take steps to ensure that they are aware of whether a tree is likely to cause problems and if it is, to take appropriate avoiding action as necessary. It is important for owners of trees growing close to people and property to have them regularly inspected and to act on recommendations.

A risk assessment is required under the Management of Health and Safety Regulations 1999. There is a need to inspect trees in or near public places, or adjacent to buildings or working areas to assess whether they represent a risk to life or property, and to take remedial action as appropriate.

To ensure a more robust stance with trees on site I suggest that changes to the opening arrangements are considered and incorporated into your **'Tree risk management policy or procedure documentation'** and that trees are periodically reassessed in line with current best practice.

Trees subject to statutory controls: If the trees are covered by TPO (Tree preservation order) or within a conservation area, it will be necessary to consult the local planning authority before any tree works other than certain exemptions are carried out.

Implementation of works: I would always suggest that you get at least three quotes for any such works. You must ensure that any contractor employed for the above works is suitably qualified and experienced, familiar with current best practice and covered by current, public, products and employee liability insurance, to an adequate level. I would advise that any arboricultural work is carried out by a reputable contractor from the local authority list if available or one approved by the Arboricultural Association (www.trees.org.uk) or Trustmark (www.treecareapproved.org). The contractor should carry out all tree works to BS 3998 (2010) Tree Work - Recommendations in strict accordance with the current arboricultural best practice ensuring that any pruning works accord with current target pruning methodology.

Contractors must be fully conversant with current arboricultural best practice and adhere to all relevant legislation including the New Road & Street Works Act 1991 for works in proximity of highways, and The Working at Heights Regulation 2004.

You should ensure that any contractor employed for the above works is suitably qualified and experienced, familiar with current best practice and covered by current, public, products, and employee liability insurance, to an adequate level. Contractors must also abide by all relevant legislation for health and safety including highway requirements.

Works should be planned to avoid times when birds are nesting, and be aware that a bat survey may be needed on significant tree hollows. There are thought to be 17 species of bat breeding in the UK and a number of additional species considered to be migrants, found in Britain, these are fully protected under Schedule 8 of the Wildlife and Countryside act (as amended) 1981 and the Conservation (Natural Habitats) Regulations 1994.

Ideally, the tree should be assessed periodically; ideally, during the dormant season to assess possible changes.In addition to this, the trees should also be visually checked following strong winds or adverse weather conditions.

Should you require any further assistance with this matter, please do not hesitate to contact me.

Yours Sincerely

Ian Barnes
Registered Consultant Arboricultural Association
Chartered Environmentalist
QTRA Licensed User
ISA (TRAQ) Tree Risk Assessment Qualified
F.Arbor.A, HND Arb, ND Ht/Arb, Tech.Cert (Arbor.A), MI Hort,, CEnv,

APPENDIX 1 – QUALIFICATIONS & EXPERIENCE

Qualifications:

Higher Diploma in Arboriculture (H.N.D Arb)
National Diploma in Horticulture & Arboriculture (N.D.Ht/Arb)
Arboricultural Association Technicians Certificate (Tech.Cert. (Arbor.A))
ISA Tree Risk Assessment Qualified (TRAQ)

Membership grades by peer review:

Chartered Environmentalist (CEnv)
Corporate Member Institute of Horticulture (MI Hort)
Fellow of the Arboricultural Association (F.Arbor.A)
Professional member Consulting Arborist Society UK.

Registration Schemes:

Arboricultural association Registered Consultant (49)

Practical experience:

I have worked in the Arboricultural Industry since 1987. Firstly as a climbing Arborist in both the public and private, sector, undertaking a wide range of practical operations on a variety of sites, before becoming a gang foreman. I set up and ran my own Arboricultural contracting business for 15 years, though this is now under new ownership. I have developed an arboricultural consultancy practice since 1993, working throughout Britain for both the public and private sector clients.

Continuing professional development:

As part of my ongoing education, I am a member of a range of related Arboricultural bodies. Including the Arboricultural Association (AA), International Society of Arboriculture (ISA), Royal Forestry Society (RFS), Forestry Contracting Association (FCA), and Arboricultural Mortgage & Insurance Users Group (AMUIG), which has been incorporated into the Consulting Arborist Society (CAS) of which I am a professional member. I am a corporate member of the Institute of Horticulture (MI Hort) and a Fellow of the Arboricultural Association (F.Arbor.A). An inclusive member of the British Mycology Society (BMS) in addition to being a Chartered Environmentalist (CEnv).
I am a registered consultant of the Arboricultural Association.

I regularly attend seminars and training events on issues relevant to Arboriculture these include events focusing on General Tree Management, Veteran Tree Management, Tree Health, Tree Pest management, Tree Diseases management, Trees Biology & Morphology, Tree Stability, Wind Loading of Trees, Tree Risk Assessment, in addition to keeping an upto date level of CPD.

I am a licensed user of the Quantified Tree Risk Assessment (QTRA) System and regularly attend updates.

I am a trained user of Picus 'Acoustic' Tomography and have attended training to extend my knowledge in this area.

I am trained in the use of thermal imaging as an aid to detecting defects in trees.

Relevant experience:

My career to date has involved me in a variety of tree care, dealing with trees in many different environments, and with differing management aims, these included: Tree planting schemes, including Woodland Design & Management, Detailed Health and Safety Appraisals, Tree inventories / population surveys, Management & selection on both proposed and active development sites, Advice upon trees in relation to structures, Additional areas of work such as Contract Specification & Management, Planning applications, Expert Witness.

This has provided me with a range of experience, enabling me to comment upon trees and their management, in line with current best practice. Full CPD and training record can be forwarded upon request.

APPENDIX 2 – RISK & TREES

Tree owners should take a balanced and proportionate approach to tree management

It is recognised that trees are managed for a variety of reasons and therefore that the expectation of a “suitable and sufficient risk assessment” referred to by the HSE varies with context. In general, the risk from trees has certainly reached the situation where residual risks (those that remain after management for safety) are sufficiently low that investment in additional measures is likely to be disproportionate to any safety benefit. As the HSE itself notes in *Reducing risks, protecting people*:

> *“Any informed discussion quickly raises ethical, social, economic and scientific considerations, for example: …how to achieve the necessary trade-offs between benefits to society and ensuring that individuals are adequately protected; the need to avoid the imposition of unnecessary restrictions on the freedom of the individual.”*

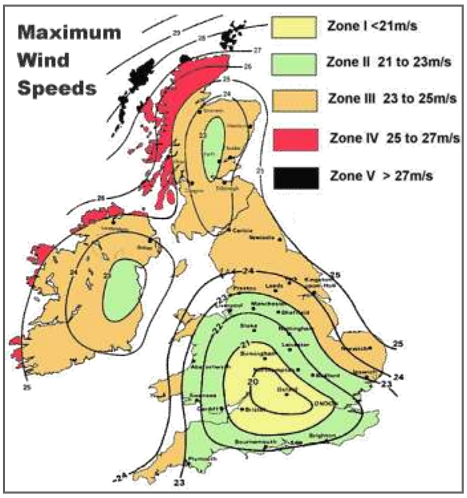
Extremely low risk of harm

HSE guidance for its inspectors and local authority enforcement officers on the standard of tree risk management and the DARM research commissioned by the NTSG on behalf of landowners confirm that the overall real risk of serious harm from trees in the UK is “extremely low”. Indeed, the levels of risk are so low that they are “comparable to those that people regard as insignificant or trivial in their daily lives”, near the bottom of the spectrum of what the HSE considers as an acceptable risk:

> *“Risks falling into this region are generally regarded as insignificant and adequately controlled. We, as regulators, would not usually require further action to reduce risks unless reasonable practicable measures are available. The levels of risk characterising this region are comparable to those that people regard as insignificant or trivial in their daily lives. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks.”*

Reasonable risk management generally aims to provide trees that can be regarded stable in a normal / foreseeable, regularly experienced storm event in relation to the situation / context of the tree. In this region, this is reasonable to assume a ‘Storm’ of force 10 using the Beaufort Scale (55 - 63 miles per hour) of wind speeds on land will occur annually.   It should be realised that all trees do pose a risk, recent work in Germany has shown even sound trees that would typically be regarded as safe can fail during high winds through various factors relating to wood physiology, dynamics and the relationship between the root system and the supporting soils. It should be remembered that for any given tree regardless of its stability, there will always be a wind load that has the potential to break or uproot a tree regardless of its condition.

Typically, trees have evolved to fail in part, i.e. twigs and branches are sacrificed / fail from a parent tree rather than the tree being lost entirely. Observations at various sites in this country have found that twigs and branches, can break from trees at wind speeds of as little as 31 miles per hour, the upper limit of a ‘strong breeze’ as detailed in Beaufort Scale 6 (25 - 31 miles per hour). This has led to a recommendation for certain sites with grounds open to the public, being closed when the wind speeds approaching 'Near Gale' or Force 7, as detailed by the Beaufort Scale (32-38 miles per hour). Such failures are difficult to predict with any great level of detail and a general position is best adopted. Typically the level of risk offered by trees will be significantly greater as the force of the wind increases, the threat from aerial parts i.e. deadwood, tight unions and elongated branches may remain even following remedial works. Typically branch failures are likely to be limited to small diameter branches and to periods of extreme weather, though as often seen in any natural model, exceptions to the rule can be expected. Therefore in managing trees we are aiming to limit or reduce the risk to nearby features, unfortunately it is not possible to remove the risk offered by a tree entirely.



As an arborist, I am a tree specialist and use my knowledge, education, training and experience to examine trees, to recommend measures to enhance their beauty and health, and attempt to reduce the risk of living near trees. As a client, you may choose to accept or disregard these recommendations, or seek additional advice. As an arborist, I cannot detect every condition that could possibly lead to a tree or limb failure. Trees are living organisms that may fail in many ways, some of which we do not fully understand.

Conditions are often hidden within the tree and below the ground. As arborists, we cannot guarantee that a tree will be healthy or safe under all circumstances, or for a specified period, of time. Sometimes trees may appear "healthy," but may be structurally unsound.

Likewise remedial treatment, like any medicine, cannot be guaranteed. Treatment, pruning and removal of trees may involve considerations beyond the arboricultural perspective, such as property boundaries and ownership, disputes between neighbours, planning issues, sight lines, landlord-tenant matters etc. Arborists cannot take such issues into account unless complete and accurate information is given to them. Likewise, as an arborist, I cannot accept any responsibility for the authorization or non-authorization of any recommended treatment or remedial measure. Furthermore, certain trees are borderline cases as to whether they should remain or be removed. Also, conditions change, and a tree may need further monitoring in the future to determine its health and structure.

Target evaluation. To enable a balanced approach to the site assessment I undertook an initial assessment of the associated risks on site to identify areas of high public access, areas where trees are within striking range of valuable or fragile structures or high human occupancy locations. Targets are broadly zoned in the 'Target' ranges based on the levels of occupation, population and value. These were assumed to be generally low target areas with the site having occasional to frequent occupation.

Risk Assessment. The assessment follows the general principles of Risk Assessment; Risk assessment is important to reduce the risk of injury to people, property damage or disruption of services. The International Society of Arboriculture (ISA) Tree Risk Assessment Methodology takes a qualitative rather than quantitative approach to risk assessment. The system uses the output of matrix 1 (copied below) to compare the likelihood of failure of a tree or tree part, the likelihood of impacting the target and the potential consequences of failure.

Matrix 1. Likelihood of failure

Likelihood of failure	Likelihood of Impacting Target			
	Very low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2. Risk Rating matrix

Likelihood of failure & impact	Consequences of Failure			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate.	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

The matrices generate an output in matrix 2 (above), describing the risk offered by the trees in line with general risk assessment methodologies; these are arranged into bands differentiated by coloured text within the tree schedule. Highlighted above are the colours representing the following risk bands of indices.

Alternatively, the risk offered by a tree can be calculated to provide an annual Risk of Harm from a particular tree or part of a tree. To inform management decisions, the risks from different hazards can then be both ranked and compared, and considered against broadly acceptable and tolerable levels of risk. Which is directly related to the Value of Statistical Life (VOSL), a widely applied risk management device, which uses the value of a hypothetical life to guide the proportionate allocation of resources to risk reduction. In the UK, this value is currently in the region of £1 500 000.

The UK Health and Safety Executive (Anon. 2001) suggests that "an individual risk of death of one in a thousand per annum should on its own represent the dividing line between what could be just tolerable for any substantial category of workers for any large part of a working life, and what is unacceptable for any but fairly exceptional groups. The Tolerability of Risk framework (ToR) (HSE 2001) is a widely accepted approach to reaching decisions on whether risks are broadly acceptable, unacceptable, or tolerable. Graphically represented opposite, ToR can be summarised as having a **Broadly Acceptable Region** where the upper limit is an annual risk of death 1/1 000 000, an **Unacceptable Region** for which the lower limit is 1/1 000, and between these a **Tolerable Region** within which the tolerability of a risk will be dependent upon the costs and benefits of risk reduction.

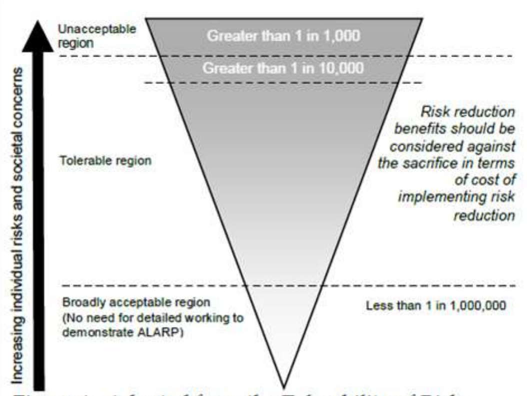


Figure 1. Adapted from the Tolerability of Risk framework (Anon. 2001)

In respect of trees, some risks cross the Broadly Acceptable 1/1 000 000 boundary, but remain tolerable. This is because any further reduction would involve a disproportionate cost in terms of the lost environmental, visual, and other benefits, in addition to the financial cost of controlling the risk. For members of the public who have a risk imposed on them 'in the wider interest of society' this limit is judged to be an order of magnitude lower – at 1 in 10, 000 per annum." Furthermore, "HSE believes that an individual risk of death of one in a million per annum for both workers and the public, corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions" as demonstrated in the table below.

The Advisory Risk Threshold provides information upon priority with trees with the highest risk rating with the greatest target values requiring work urgently. Where the priority of trees is recorded as being low and a low target value, works required to improve the trees risk of harm, are expected to be undertaken as part of the normal estate management.

Advisory Risk Thresholds		
Thresholds	Description	Action
	Unacceptable Risks will not ordinarily be tolerated	Control the risk
1/1 000	Unacceptable (where imposed on others) Risks will not ordinarily be tolerated	Control the risk Review the risk
	Tolerable (by agreement) Risks may be tolerated if those exposed to the risk accept it, or the tree has exceptional value	Control the risk unless there is broad stakeholder agreement to tolerate it, or the tree has exceptional value Review the risk
1/10 000	Tolerable (where imposed on others) Risks are tolerable if ALARP	Assess costs and benefits of risk control Control the risk only where a significant benefit might be achieved at reasonable cost Review the risk
1/1 000 000	Broadly Acceptable Risk is already ALARP	No action currently required Review the risk

Importantly, to enable tree assessors to provide appropriate management guidance, it is helpful to have some understanding of the tree owner's management preferences prior to assessing the trees.

Barnes & Associates can offer guidance on but cannot set the threshold of risk at which you manage your trees. We consider in line with normal health and safety guidelines that 1 in 10,000 an appropriate level and I have formulated management proposals on this basis. Please advise me if you consider it appropriate to manage the trees to a different level of risk and I will amend the management proposals to accord with your revised limit.

Target evaluation. To enable a balanced approach to the site assessment I undertook an initial assessment of the associated risks on site to identify areas of high public access, areas where trees are within striking range of valuable or fragile structures or high human occupancy locations. Targets are broadly zoned in the 'Target' ranges based on the levels of occupation, population and value. These were assumed to be generally low target areas with the site having occasional to frequent occupation.

APPENDIX 3 – TREES & GROWTH

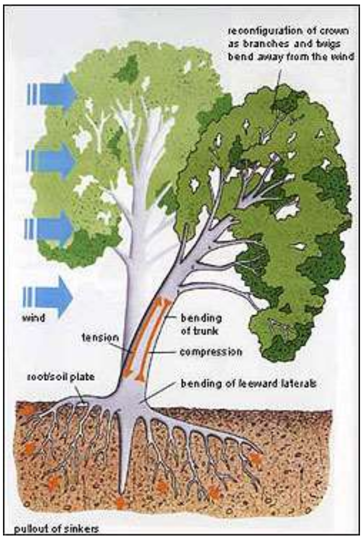
According to Wikipedia - A Tree is a perennial woody plant. It most often has many secondary branches supported clear of the ground on a single main stem or trunk with clear apical dominance. Some authors set a minimum of 10 cm trunk diameter (30 cm girth). Compared with most other plants, trees are long-lived, some reaching several thousand years old and growing to up to 115 m (379 ft) high.

Trees are an important component of the natural landscape because of their prevention of erosion and the provision of a weather-sheltered ecosystem in and under their foliage. They also play an important role in producing oxygen and reducing carbon dioxide in the atmosphere, as well as moderating ground temperatures. This is broadly true; however, trees are this and more.

In a sense, a tree is a multiple perennial plant, with every year grows a new growth ring is produced, which can be thought of as an individual tree, developing on the outside of the previous trees, which envelopes all the older trees that have gone before.

Trees as a life form have been in existence for at least 200 and possibly upto 400 million years; they have achieved this longevity through various adaptations to climate and environmental stress. However, the one constant is in their economy of material use. Trees have evolved to provide a compromise between their shape to achieve growth, the limits of material and the forces exerted on them as demonstrated in the diagram below.

"Mother nature knows no mercy! survive in the competition, will at least aside or even devoured. Hence, it's no shape-optimized and material mechanical resilience." Clause



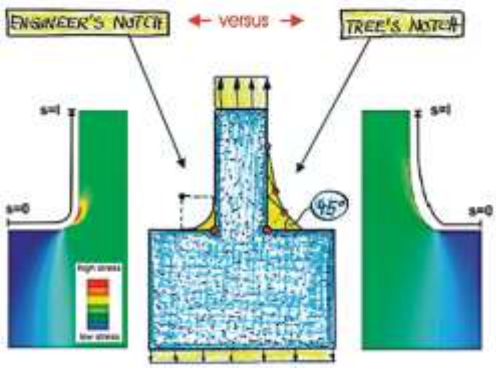
What does no work, what does not be chased away, overshadowed, push surprise that survivors of evolution are optimized with respect to their Mattheck

Trees are dynamic structures that and any additional forces such as wind and weather, through a network of root which intern transfers the force into the local supporting soils, through ever-within the wood of the tree, shown simplistically opposite.

economically transfer their own weight branches into the main stem to the changing Tension & Compression

This has following years of observation and assessment led to the development of defined in the Body Language of Trees by Claus Mattheck and Helge Breloer system commonly known as 'Visual Tree Assessment' (VTA)) as "the tendency for economic a use of their material as possible, and to become as strong as necessary to such mechanical systems as tusks of a warthog, a tree's root, a tiger's claw, a

the *'Axiom of uniform stress'.* Initially (which has now been refined into the all self optimizing structures to make as to perform their function". They allude chicken leg, the junctions of a branch.



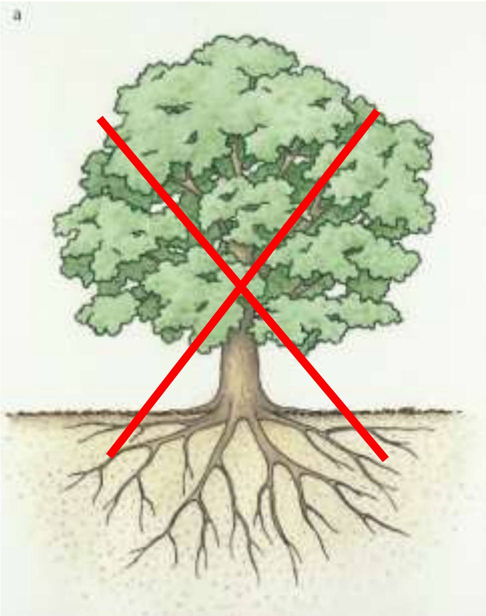
The authors apply the concept to every aspect of the parts of a tree, showing for example how geotropisms in trees are designed to fulfil a uniform stress load by bending the leaves and its crown in the direction of the wind: "This in turn reduces the whole area of its crown that is presented to the wind. Which in turn reduces the wind load and therefore ultimately also the wind bending moment of the stem". Which has led to the development of various design aids for engineering which outperform the accepted designs in engineering, as shown opposite where the tree 'Notch' or branch can transfer a load without a high stress zone (Shown in Red).

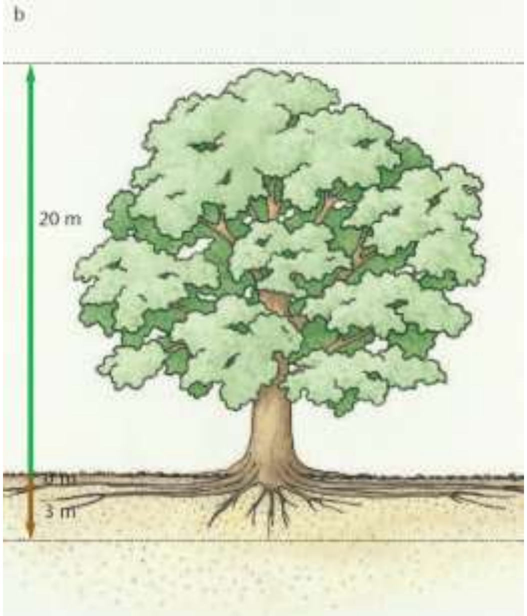
In addition to a good design principal, trees have the ability to sense potential weakness by detecting areas of high loading of force paths and strengthen these areas through a process known as adaptive growth, where new, typically high quality wood is deposited year after year, to strengthen the affected area. Such areas are shown in the photographs which show how trees can in extreme cases add additional wood to strengthen the connection between the stem and the roots to dissipate the load as shown to the left. Within the canopy a weak branch can be propped by the addition of wood annually to offer an additional strength where it's needed as shown in the cross section to the right, where support has been added below the original branch.

APPENDIX 4 – ROOTING PATTERNS

A common misconception regarding the tree root structure is that the volume and distribution of roots are thought to reflect that of the trunk and branches (see Figure a; Dobson, 1995), however through countless studies, this has been found to far from the truth.

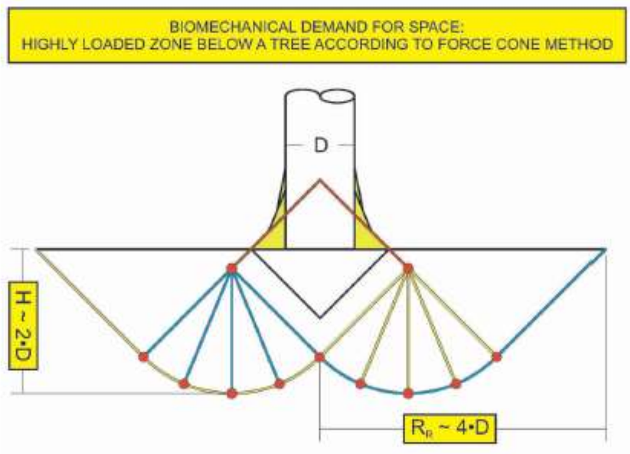
A more accurate representation of tree rooting pattern is shown in Figure b. Typically, trees have relatively shallow but widespread root systems. It is uncommon for roots to penetrate to a depth greater than 2 m, with 80–90% found within the top 60 cm of the soil profile. Many factors can influence the rooting habit of a tree; including soils structure, soil depth topography and exposure, though in general, rooting tends to be much shallower than most people imagine.





The tree stem is attached to the Root via a woody structure know as the Rootplate or the 'Zone of Rapid Taper' this is the primary structural roots extending out from the trunk. Roots branch readily, tapering in diameter. It is a continuation of the pipeline carrying water and nutrients from the absorbing and transport roots into the tree trunk. The root plate is the tree's primary support in winds up to 40 mph. Ideally, this area should be undisturbed and free of construction and hardscape features and should not be encroached into.

This area helps transfer the load of the tree into the soil whilst providing a connection between the tree and the absorptive section of the root system. Recent work has shown this highly loaded zone extends to a depth equivalent to 2 times the diameter of the trees , extending upto 4 times the diameter of the stem as shown below.



Mattheck

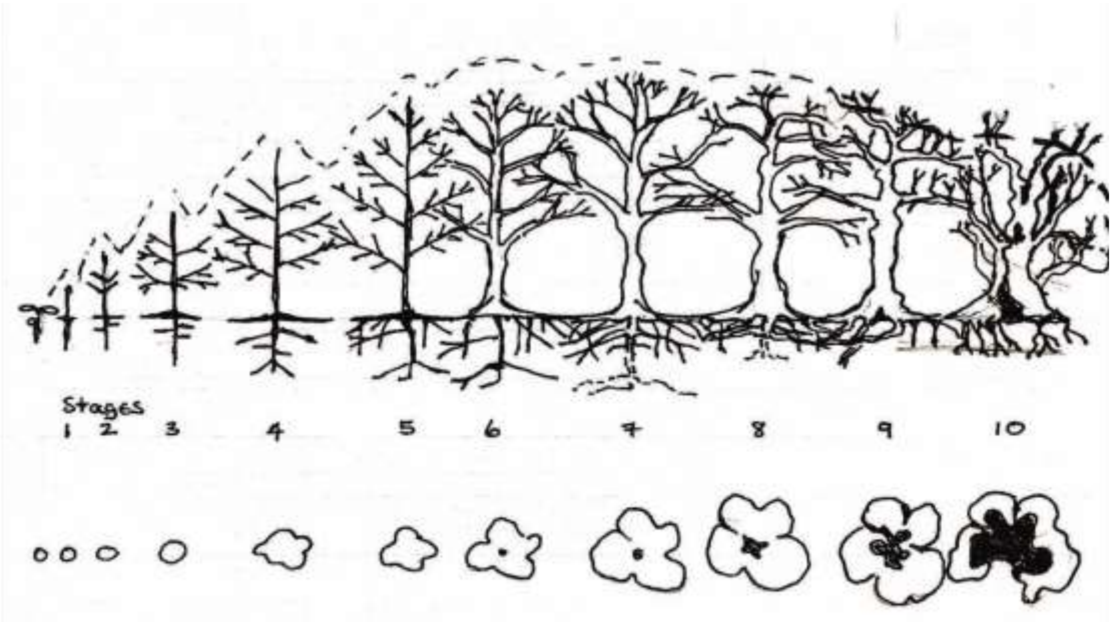
APPENDIX 5 – TREE MORPHOLOGY

When caring for trees its worth recognising that the life of a tree has ten stages. It is a general model that was presented by Dr. Raimbault.

Phase 1 is the *development phase*, which encompasses Stages 1-4. In the development phase most of the tree's energy is used for growth. This is the accumulation phase that begins with stage one. It starts with emergence from the earth and trunk development with no branches. The key to the stages is apical dominance where the leading shoot exerts dominance and subordinates other growth units. Apical dominance fades and exerts less influence in the later stages.

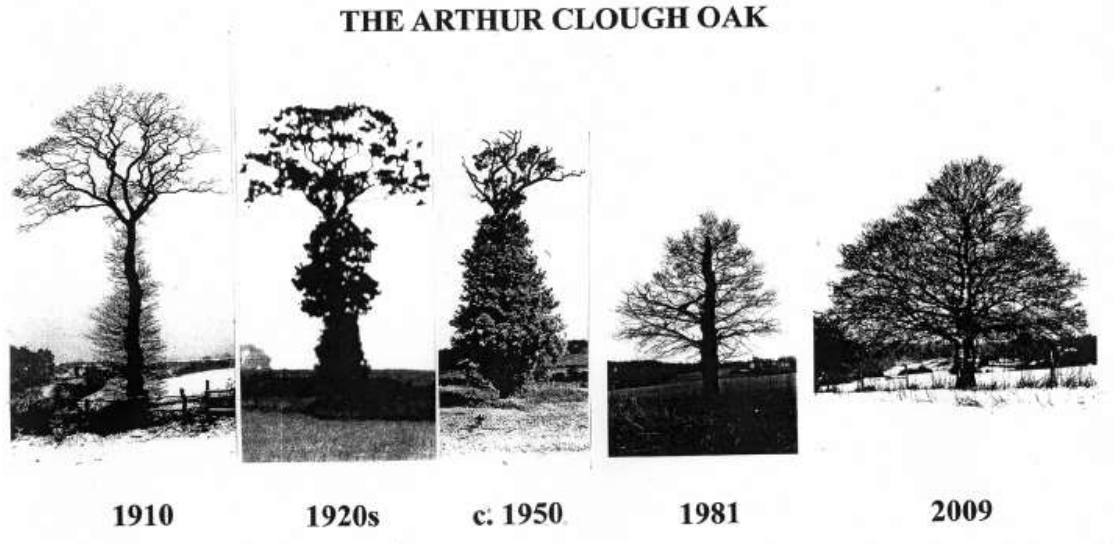
Phase 2 is the mature phase that encompasses Stages 5-7. In the mature phase. During this phase numerous repetitions of phase one development result in a superstructure. Optimum crown size is reached and food production becomes mostly constant.

Phase 3 is the decline phase, which encompasses Stages 8-10. During this phase the superstructure begins dismantling from the extremities inward. There is crown dieback and decreasing leaf area. Branches begin to sag under their own weight. New twigs and branches arise primarily along the upper faces. Strong shoots appear along the trunk. These shoots become progressively independent from the tree by initiating separate cambium columns in the trunk and generate their own root system in the soil.



Morphological Stages: Crown & Shoot Aging Processes – lead to a progression of basal decay / deadwood in balance with a reduction of the overall canopy volume and rooting area retraction. After Raimbault 1995, Lonsdale 1999 – Fay 2002

Unlike ourselves, the aging process of a tree is not a one-way street and given time and the right conditions a tree can rejuvenate its self as shown in the photograph below where the 'Arthur Clough Oak' can be seen to renew its self over time, and going from a derelict stage 8/9 tree to a vigorous stage 6 tree.



APPENDIX 6 – DEFECTS & DECAY

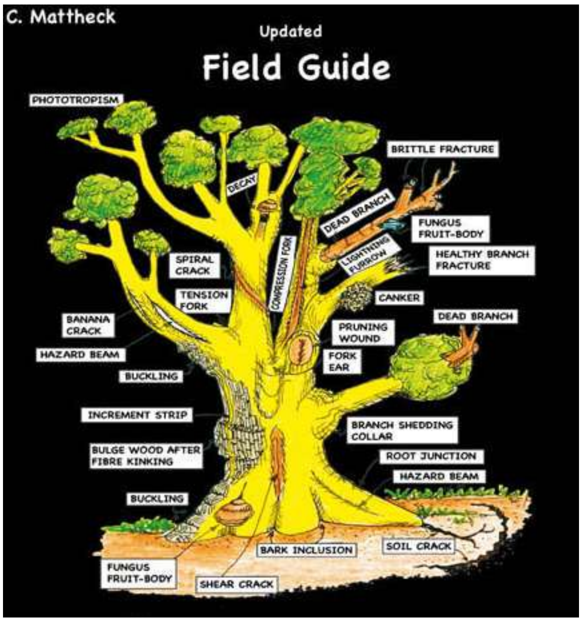
Defects can develop naturally, whether due to extreme weather events, because of pest, disease or through inappropriate management. Once present in a tree and because of the way in which trees grow defects can be accommodated for many years as outlined in the diagram opposite.

However the presence of a defect will typically result in an adaption in the form of the tree enabling the Arborist to identify the defect and offer a management solution

In addition to visible defects, trees can suffer from internal problems most typically brought about by internal decay due to colonisation by an array of fungal species. Many theories are in existence in relation between trees and fungi with several suggesting some trees intentionally become colonised to reduce their overall weight and recycle valuable recourses.

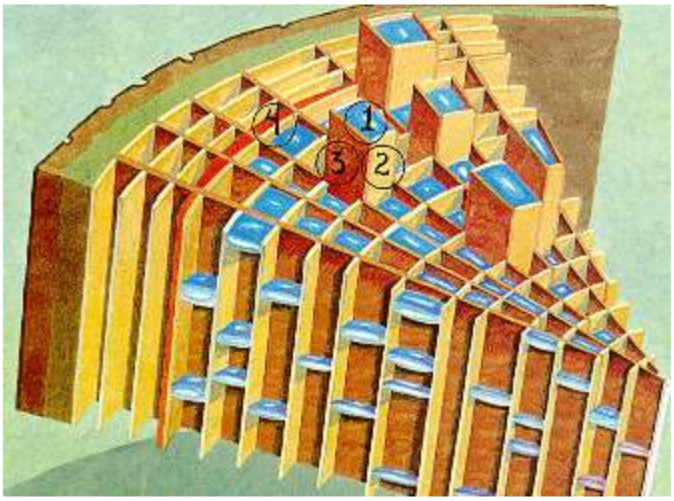
Trees are essentially a live outer shell growing around an inner deadwood core and with wood on the most part being a collection of relatively complicated sugars then over time fungal species have evolved to take advantage of this. Colonisation can occur in various ways, though typically begins with a wound, onto which microscopic spores of a fungi can land, develop and begin to colonise the parts of a tree cell by cell, using the gained reserves to feed yet more colonisation.

This is not a one sided battle and in tandem with the evolving fungi Trees have evolved various methods to survive Wounding, principally this is because a trees are Highly Compartmented Plants That Compartmentalize the Injured and Infected Tissues.



Trees have evolved so that even whilst under constant stress, they still have evolved to be the largest and longest lived organisms ever to inhabit the earth. Yet trees have NO WOUND HEALING PROCESS-healing in a sense of REPLACING or REPAIRING injured tissues. HEAL means to restore to a previous healthy state. It is impossible to HEAL injured and infected xylem. Trees have evolved as highly ordered, COMPARTMENTED plants that instead of healing, COMPARTMENTALIZE in an orderly way the injured and infected tissues. A coded MODEL System for explaining how a tree is compartmented and how it compartmentalizes infected and injured wood has been developed. It is called CODIT, an acronym for COMPARTMENTALIZATION OF DECAY IN TREES. Terms such as "walls" and "plugs" are used in the model only to help present a mental image of the compartments. These terms are not meant as technical terms.

CODIT – COMPARTMENTALIZATION OF DECAY IN TREES. According to CODIT, when a tree is wounded cells undergo changes to form "walls" around the wound, slowing or preventing the spread of disease and decay to the rest of the tree.



Wall 1. The first wall is formed by plugging up normally porous vascular tissue above and below the wound. This tissue runs up and down the length of the stem, so plugging it slows the vertical spread of decay. Tissues are plugged in various ways, this wall is the weakest.

Wall 2. The second wall is formed by the cells of the growth ring interior to the wound, thus slowing the inward spread of decay. This wall is the second weakest, and is continuous except where intersected by ray cells.

Wall 3. The third wall is formed by ray cells, which are groups of cells oriented perpendicularly to the stem axis, dividing the stem into sections not entirely unlike the slices of a pie. These groups of cells are not continuous and vary in length, height and thickness, forming a maze-like barrier to lateral growth of decay. After wounding, some ray cells are also altered chemically, becoming poisonous to some microorganisms. This is the strongest wall at the time of wounding.

Wall 4. The fourth wall is created by new growth on the exterior of the tree, isolating tissue present at the time of infection from that which will grow after. This is the strongest wall, and often the only one which will completely halt the spread of infection. When only the fourth wall remains intact, the result is something most people have seen walking through the woods or in a park: a living tree with a completely rotted-out interior. In such cases, all the tissue present at the time of injury has become infected, but new healthy tissue has been allowed to continue to grow outside of the fourth wall.

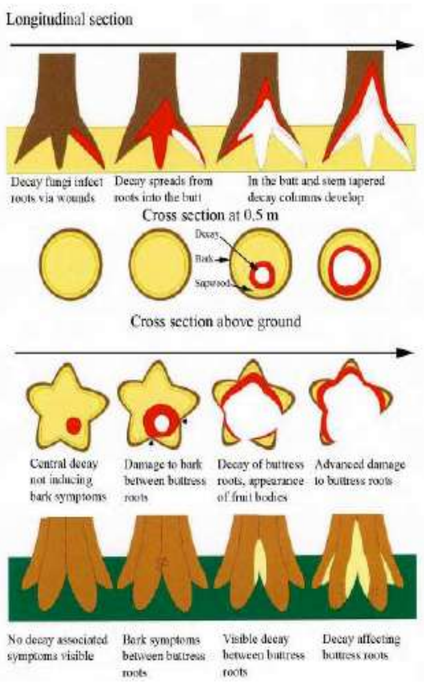
By increasing our understanding of how trees respond to decay, CODIT has had many applications. For example, arborists are frequently called upon to analyze the danger posed to people or property by a damaged or decaying tree. By knowing how decay is likely to spread, such hazard tree inspections may be more accurate, thereby preventing unnecessary tree removal, property damage, or injury.

APPENDIX 7 – FUNGI & TREES

Fungi play vital roles in many ecosystems and are crucial to the lifecycles of many plant species on this planet. Generally, fungi in association with trees, occur in three groups distinguished by how they feed. **Symbiotic or Mycorrhizal fungi** live in association with many vascular plants' root systems, and a beneficial exchange takes place between the two. **Saprophytic fungi** live on dead organic matter. This group of fungi will usually only take advantage of dieback caused by a separate factor. They may not kill trees but can ultimately cause mechanical failure. **Parasitic fungi** live off or at the expense of their live host plant, often resulting in the demise of this host. In general these fungi will only target already unhealthy or stressed plants but following colonisation they may kill trees by ultimately causing mechanical failure.

The decay process in wood is a complex subject and the details are only just starting to be fully understood. There are many different agents involved in the process. Recent studies have shown that if a tree has been damaged and is then cut some years later it can be seen to have dried out with a dysfunctional area of wood extending back from the wound. This area often has a sharp boundary wall between it and the rest of the tree as shown by a difference in the colour of the wood see figure left. This process of boundary setting is a demonstration of the trees defence system CODIT at work. The sharp boundary results from a response of living cells to the ingress of air and/or micro-organisms and may represent a barrier between healthy and damaged areas.

If a tree is badly damaged it spends energy in compartmentalising, leaving less for growth, which can result in a smaller annual rings and reduced extension growth. The more areas that are 'sealed off', the less tissue is available for the tree to distribute food and water to its various parts. Eventually, when there are too many dysfunctional compartments and the distribution of new sapwood becomes discontinuous, the tree is unable to maintain vital functions and death results.



Fungi tend to colonise living trees in two main ways:

From the outside. In the simplest scenario, physical damage to a tree weakens its physical defences and makes conditions suitable for the fungus to colonise and become established and grow, as shown opposite.

From the inside. The fungus makes use of the tree's own plumbing system (xylem and phloem) to reach different parts of the tree via the sap stream; this can occur at any stage in the life cycle. The fungi often remains in a latent (inactive) state without any noticeable impact on the tree until conditions within the wood change enough to activate them, e.g. drought, ageing.

Fungi growing within the heartwood Some fungal species are able to grow in the innermost part of the tree, which consists of dysfunctional wood. It is usually drier than the outer sapwood and so is more suitable for the growth of fungi if they are present. Species that rot the heartwood break down only the dead wood. This decays the centre of the tree but leaves the outer, living layers intact. While this may not be desirable from the point of view of a commercial forester, the tree is not harmed and this may actually benefit to the tree. Decay and hollowing are part of a nutrient recycling process. The tree can make use of the products of wood decay within the trunk by producing aerial roots from its above ground parts, which grow into the rotting stem. A hollow tube may respond differently from a solid trunk in high winds and is not necessarily more likely to snap, provided its walls are not so thin that buckling occurs.

Jahn 2005

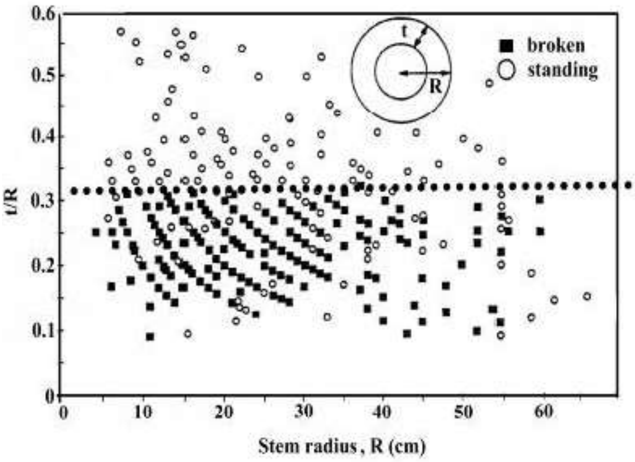
Types of decay depending on the species of fungi, decay tends to works in one of three main ways:

White Rot - When the lignin and cellulose are both broken down. In **simultaneous white** rot, the lignin and cellulose are broken down at approximately the same rate causing loss of both stiffness and strength, which, in the advanced stages of decay produces a thick porridge-like substance. In **selective delignification** (or **stringy white rot**) the lignin is broken down first and the cellulose degrades more slowly. White rot is more common is broadleaved than coniferous trees. The changes are subtle and may be detected by the tree and responded to.

Brown Rot - When the cellulose is degraded and the lignin is left behind. The initial results of the decay are brittle but rigid. The wood breaks into cubes known as cubical brown rot. Brown rot is more common in conifers than broadleaved trees and is difficult for the tree to respond to.

Soft Rot - This is when cellulose is degraded, as in brown rot, but the fungi invade the cell walls in a very different way. Many white rots and some brown rot fungi can behave like soft rot fungi in living trees. However 'classic' soft rots are caused mainly by specialised fungi ,which grow in the surface layers or very moist wood.

APPENDIX 8 – HOW HOLLOW IS SAFE

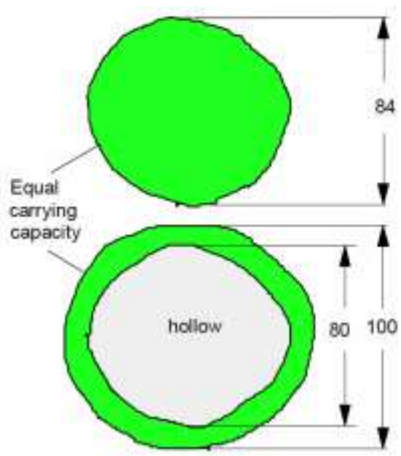


Trees plotted by t/R against radius. Mattheck and Breloer (1994).

What residual wall thickness is required by a tree?

The safety assessment of hollow trees has always fascinated arborists, and the criteria to be employed have led to severe public discussions in the profession. Based on Mattheck & Breloer (1995), many in the industry state that the required thickness of the residual wall should not be below a t/R ratio of 0.3 to prevent shell-buckling, cross-sectional flattening and hose pipe-kinking. Based upon a study of failed trees in a large population, extract shown to left. Although, the author has since gone on to qualify this stating this method is suitable for trees with a full canopy only.

Later research by Wessolly & Erb (1998) published an opposite theory by which often a *much* lower thickness are calculated and accepted. Their methods are based on the bending theory of the hollow beam and have been backed by extensive library of observation and load testing. The diagram to the right shows this theory - the carrying capacity of a stem cross-section. Both cross-sections are carrying the same amount.
The actual degree of hollowness is unimportant and is less important than the geometry of the stem and particularly as they are typically found one above the other in trees. The trees has made good its static deficit in the region of the cavity by increased diameter growth, the visible symptom is then a sign of successful stabilization and not of a weakness.

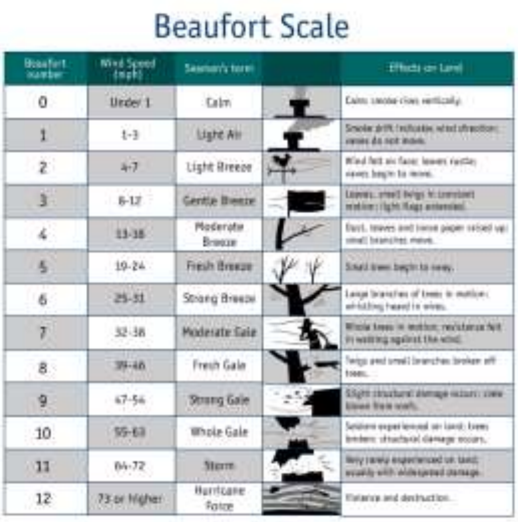


However it should be borne in mind these assessments are being approached for an engineering perspective and in some respects fail to include the dynamic nature of hollows in a trees or the trees which may in addition have an open section or be of a none uniform shape or not have a uniform shell thickness.

Further studies have shown trunk diameter and residual wall thickness for different tree-heights are variable and affect different criteria regarding torsion; shear, stress peaks, cross-sectional flattening and shell-buckling which can be affected differently. This and literature reviews suggests that the different types of failure of the residual wall depend mainly on parameters like stiffness and strength of the wood in different anatomical directions, geometry of the cross-section and different loads.

> *"Hence, fixed t/R assessment limits should be approached carefully. But, neither should the residual wall always be as thin in a real tree as predicted mathematically with the formula employed in accordance with the bending theory of the hollow beam."* Sterken (2005) suggests that the truth lies somewhat in the middle instead of in both extremes.

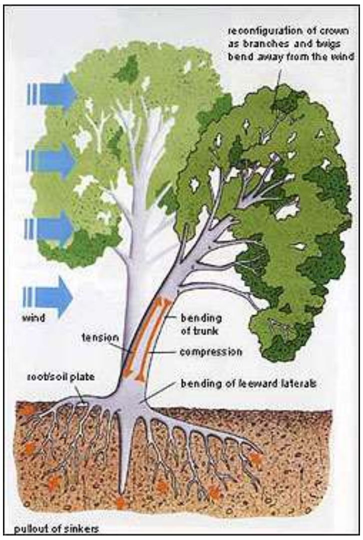
APPENDIX 9 – WINDLOADING



Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

The effects of wind on trees have been noted for many years as demonstrated by the inclusion of trees within the Beaufort Scale as shown opposite.

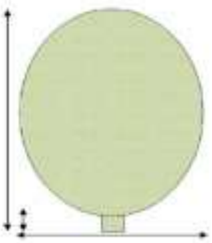
Tree stability in windstorms and tree failure are important issues in urban areas where there can be risks of damage to people and property and in forests where wind damage causes economic loss. Current methods of managing trees, including pruning and assessment of mechanical strength, are mainly based on a visual assessment or the experience of people such as trained arborists.



Only limited data is available to assess tree strength and stability in winds, and most recent methods have used a static approach to estimate loads. Recent research on the measurement of dynamic wind loads and the effect on tree stability is providing a better understanding of how different trees cope with winds. Dynamic loads have been measured on trees with different canopy shapes.

Results indicate that swaying motion is not a harmonic, but is very complex due to the dynamic interaction of branches. This dynamic structural property of the trunk and branches. The branch mass contributes to dynamic damping, termed mass damping, which acts to reduce dangerous harmonic sway motion of the trunk and so minimizes loads and increases the mechanical stability of the tree.

Models also attempt of incorporate the canopy changes that can be seen as the tree changes shape under the effect of wind loading, as at first the leaves fold or role back into the flow, followed by the twigs and then the flexible elements of the branches as shown above.

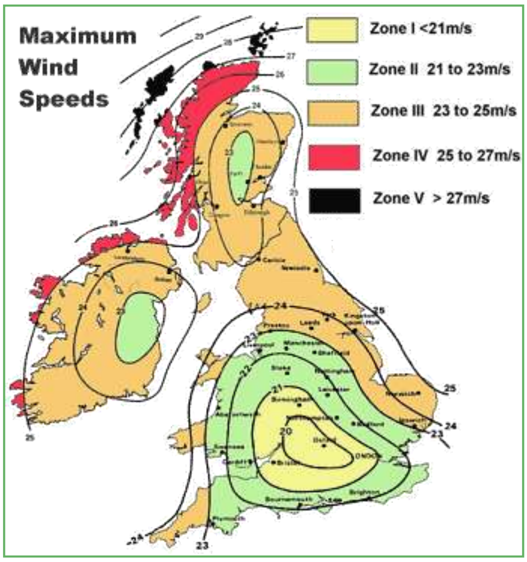


This information has led to the development of several methods incorporating the guidelines of Euro-code 1 Parts 1- 4. These help create a method of further understanding of the effects of wind on trees and help demonstrate the forces involved and show that the forces exerted by the wind from ground level to 10 metres can be very different from the forces at 10 to 20 metres and 20 to 50 metres above ground level. This information has been shown that a significant improvement in safety may be possible by relatively conservative canopy height reduction, although these works also need to consider the trees appearance and likely response.

In the UK studies have shown that a variation can be expected between the likely peak wind speeds that an area can expect to receive within the typical season. This helps the assessment criteria to be more regionally specific as shown by the information in the diagram below.

However, and as with many guides for natural systems these methods should be treated as general guide only, as significant changes can occur even over very short distances.

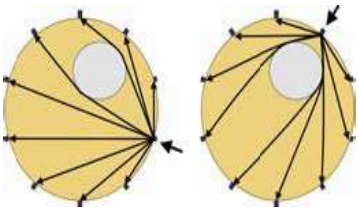
Even very complex models will struggle to predict with great detail the effects upon a tree by pruning, the loss of a neighbour, the changes following the removal of a woodland or the new wind flow patterns affecting a tree following construction of a building.



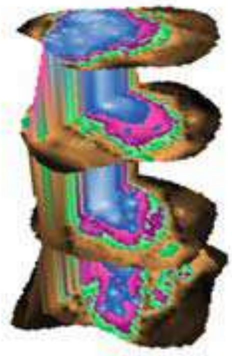
Map from the BRE.

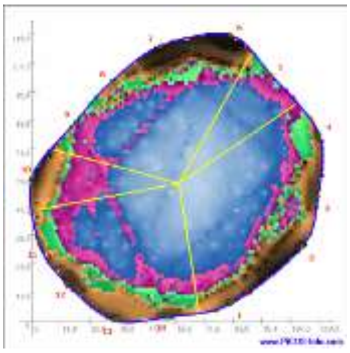
APPENDIX 10 – ASSESSMENT METHODS

SONIC TOMOGRAPHY



Sonic Tomography (SOT) : This is a non-invasive tool for assessing decay in trees – shown to the right. It works on the principle that sound waves passing through decay move more slowly than sound waves traversing solid wood. The Picus sends sound waves from a number of points around a tree trunk to the same number of receiving points, the relative speed of the sound can be calculated, and a two-dimensional image of the cross-section of the tree, 'a tomogram', can be generated. Using the differences in the transit times between each pair of sensors, the Picus analysis software constructs a two-dimensional picture (acoustic tomogram), which show zones of differing sound transmission properties within the stem.

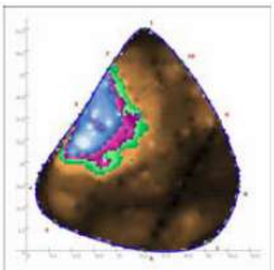




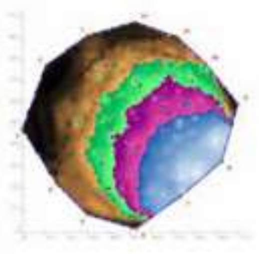
These zones are colour-coded, so that intact wood is shown as brown, slight degradation as green, moderate degradation as violet and advanced degradation / hollow as blue. The (Picus) Sonic Tomography gives valuable density information about the trees. The density strongly correlates with the soundness of the wood and can be combined to provide 3D Representation of the stem as shown left. This allows and assessment of the retained sound wood. In some situations, the sonic investigation may be affected by the internal structure of the wood. In particular, circular cracks and star shaped cracks, which can interfere with the sonic measurement, though these are highlighted within the results. There are three main colours to be taken into consideration:

1. **Black / brown** – Sound / Solid Wood.
2. **Green** – Partially changed wood.
3. **Violet / blue/ white** – Wood that has undergone advanced decay.

The colours violet blue and white need to be treated as one class only. For this reason the drawing of the blue and white colours can be suppressed on demand. In general the result of sonic based measurement cannot give information about the type of the structural loss in the tree directly. This means the tomogram does not tell us if a cavity, or a crack or a decay is causing a violet area in a tomogram. Nevertheless we can obtain additional information about the type of the damage by observing how the colours are spread (colour allotment) across the tomogram. In all cases a sound knowledge of trees and tree – diseases is needed to interpret the tomograms correctly. Experiences in operating the PiCUS and the experiences of other tomograms are very useful also.



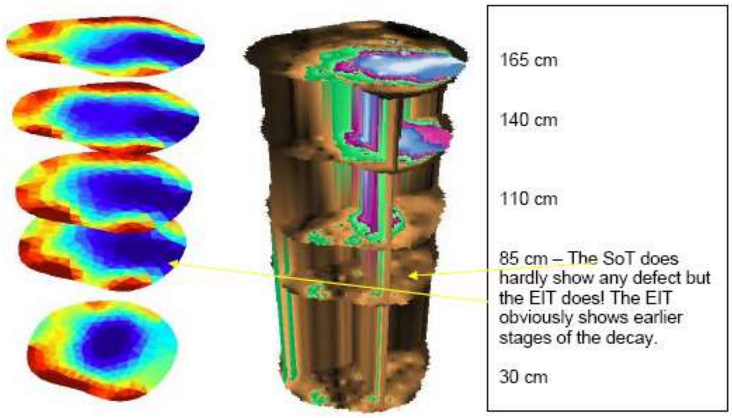
We can assume that the reaction zone (barrier zone) around a damaged area of the tree are well built if the main tomogram colours (brown, green, violet) lay very closed to each other. The left tomogram shows a typical case: the very small green area between the violet and brown area indicates a sudden increase of density.



In contrast to that, the right tomogram shows a wide green area and a relative long distance between the brown and the violet area. The tomogram was recorded on a tree with a Ganoderma infection. Having a tomogram like this the tree does most likely not have strong reaction walls. The fungus did probably break reaction walls frequently and is still very aggressive.

ELECTRICAL RESISTANCE TOMOGRAPHY

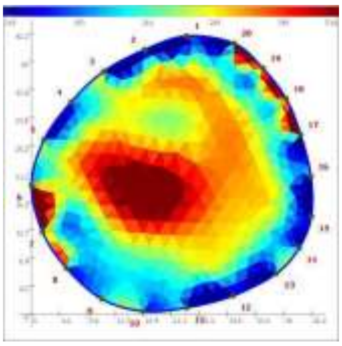
The example shows a 3D electric Impedance Tomogramm (EIT - left) and a 3D Sonic Tomogramm (SoT - right) of an apple tree with a decay. The source of the decay was an old branch that was cut off many years ago.



Picus Electrical Resistance Tomography (ERT), gathers chemical information about the wood such as water and/or ion concentration. The electrical resistivity or its reciprocal, the electrical conductivity, is a physical property that provides information about the internal condition of the stem. This determines the spatial resistivity distribution in a non-destructive way. Low resistivity can identify increased moisture content, whereas hollowed structures cause increases in observed resistivities. The measurement uses point-like electrodes (nails) that are attached to the tree just below the bark and a current is generated. The resulting electric field depends on the resistivity distribution and is measured using the other electrodes to obtain a potential difference (voltage). After collecting all the measurements the reconstruction of the resistivity distribution is carried out. The model can be displayed in the form of a coloured distribution plan for analysis as shown in figure above which shows typical output of ERT & SOT for a sound Oak stem. Again, these results can be combined within a 3D representation to provide a better understanding of the internal condition of the stem.

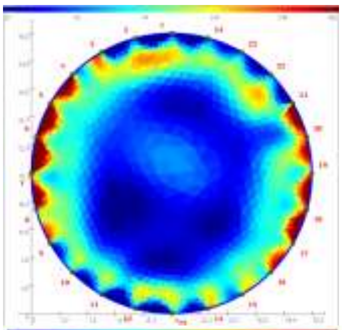
Interpretation How to read EI Tomograms The main aspect of interpreting ERTs is the distribution of high and low conductive areas. You are looking to see where high resistance is and where low resistance is. This information needs to be compared with the normal resistance distribution in sound trees of the particular species.

Typically the method produces **three types of typical resistivity distributions** in trees.

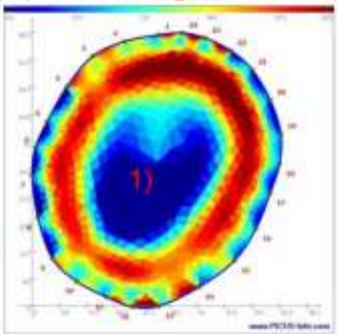


ERT Type 1 - Higher conductivity (low resistance – blue colours) on the outside and high resistance (low conductivity – red colours) towards the inside of the tree.

This ERT shows the normal resistance distribution of a sound beech tree. The heartwood of beech trees is less conductive (higher resistance) than the edge of the tree. The blue the ring on the outside shows the bark/sapwood for water transportation.



ERT Type 2 Low conductivity (higher resistance – red colours) on the outside and low resistance (high conductivity – blue colours) towards the inside of the tree.
The ERT of a sound Wellingtonia tree shows a high conductive centre (blue colours). The bark/sap-wood is less conductive (red colours). The absolute values of the sapwood indicate that the wood is conductive – because of the moisture content, it is not dry – but it is less conductive than the heartwood.

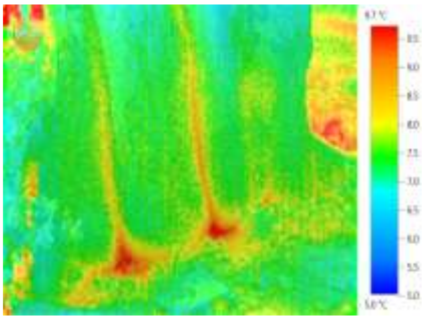


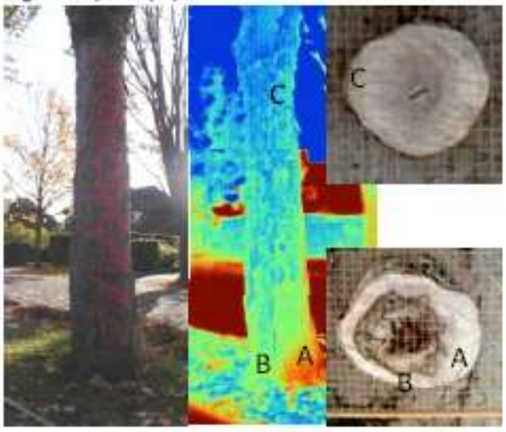
ERT Type 3
Ring-like resistance distribution This example shows the ERT of an Oak. In the ERT the blue ring (high conductivity) on the outside represents bark/sapwood. The blue high conductive centre (1) is caused by high concentration of ions. These tomograms are typical for sound Oak trees.

THERMAL IMAGING

Thermal Imaging Camera (TIC), produce Thermal Images, or **thermograms**, are actually visual displays of the amount of infrared energy emitted, transmitted, and reflected by an object. Because there are multiple sources of the infrared energy, it is difficult to get an accurate temperature of an object using this method. A thermal imaging camera is capable of performing algorithms to interpret that data and build an image.

Figure 2. *Thermal images indicating a central column of dysfunction and decay, the predominant decay at the base causes thinning of the functional wood from (A) to (B) this has led to desiccation of the stem higher up at (C).*





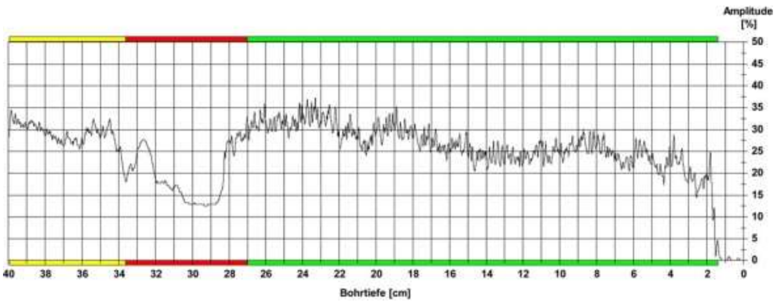
Although the image shows the viewer an approximation of the temperature at which the object is operating, the camera is actually using multiple sources of data based on the areas surrounding the object to determine that value rather than detecting the actual temperature. When the tissues of the wood or bark are altered or destroyed by physical actions or pathogens their heat holding properties are changed. This in turn alters the amount of heat that is emitted from the surface. As a result, cooler areas appear at the surface that is associated with the altered or destroyed tissues below the surface. Warmer areas can be interpreted as being associated with healthy tissues and cooler areas can be interpreted as being associated with altered or destroyed tissues. When dead tissues are close to the surface they become superheated (they retain heat above ambient air temperature) if they are heated directly by the sun (on the South side of the tree) or heat is trapped when a large area of dead wood is heated but covered by small amounts of living tissue. This can also lead to temperature inversion warmer areas indicate decay, cooler areas indicate small amounts of healthy tissues. This is common when over 80% of the wood is dead but is not fully decayed.

RESISTOGRAPH

The Resistograph is based on the principle of measuring the drilling resistance. A drilling needle is inserted into the wood under constant drive. While drilling, the needed energy is measured depending on the drilling depth of the needle.

That way, anywhere and with little effort it is possible to get information about structures, inner defects or residual walls of trees and wooden constructions. Depending on the instrument series, the obtained data can be recorded on a paper trace or electronically and then transmitted, evaluated and processed on your PC with specific software. This is a precision instrument that delivers significant results.

Depending on which instrument you use, the measurement data is printed simultaneously on a (wax) paper strip on a scale of 1:1. The measurement profile delivers information about the internal condition of the wood. It shows annual rings and density behaviour, as well as decayed zones in the wood.



AIR SPADE

An Air spade uses compressed air to remove soils from a given area whilst leaving none porous items such as roots in place and undamaged.

This enables a visual assessment of the buttress, main roots and even allows an assessment of the small diameter absorptive roots to be made.

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Tree Motion Sensors

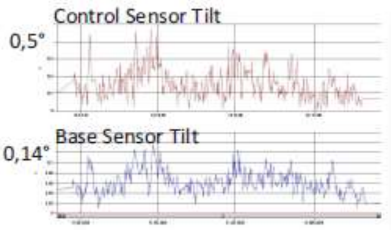
Safety of trees is an important factor in urban and other high risk areas. There are several methods to assess the condition & stability of trees and a thorough visual inspection (VTA) is always the most important step at the beginning of the assessment. Often there are trees in cities and parks that require further investigation and depending on the perceived defect different methods can be used.

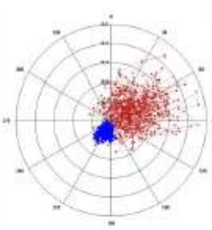
The **Tree Motion Sensors (TMS)** are used to test the root anchorage & stem stability of trees without the need to apply an external artificial deflection load. When wind blows trees start to sway and this load is transferred to the root plate. The TMS records the dynamic sway motion of trees in natural winds so what differences are there to the already established static tree pulling test technique?

The static pulling test, based on the findings of Wessolly (Wessolly & Erb, 1998), measures the root safety of trees. During the static pulling test the tree is exposed to a load which is usually created by a winch and a rope attached to the tree. The reaction of the tree - which is root plate tilt and compression of marginal wood fibres - to this load is measured. The artificial load is compared with a theoretical estimate of the load a typical wind would have caused to the tree. There is advanced software available to estimate the wind load on the tree (Arbostat & Detter). However, static pulling of trees can be difficult to implement & carry out, particularly in urban areas.

The TMS records the dynamic sway – or tilt - motion of trees in ***natural winds*** which is more realistic. However the wind blows and however the tree is sheltered by other trees / buildings, the sway motion recorded shows the real response of each tree to the natural conditions.







The graphs of the PC software show tilts of a birch tree at 50km/h wind gusts. Time domain of Control and Base sensor data on the left. Polar diagram on the right. Data is precisely synchronized through GPS.

The following are the most typical applications for the TMS system.

- **Confirmation of stability of trees.** Trees that show little to no root plate tilt in winds can be consider to be safe.
- **Identification of trees with root anchorage problems.** The most typical application is to equip several trees in the same area with TMS sensors. Comparison of the tilts recorded identifies trees with tilts larger than others. (James & Hallam, 2013)
- **Combination with static pull tests.** Once a tree with large tilt movement in natural wind has been identified, it can be useful to perform a static pull test to measure the reaction to a known force.
- **Supervision of trees near construction works.** The damage to major roots of trees caused during construction work can be detected.
- **Long term monitoring of a tree.** Trees which are suspected to have root problems may be monitored on a regular basis to see if:
  - the wind response gets better (ie. new roots grow)
  - gets worse (ie roots deteriorate or have been cut)
  - there is no measurable change

WINDLOAD ASSESSMENT

Wind load analysis in trees in accordance with Eurocode 1, part 2-4 - Enables an insight into the critical wind speeds using a mathematical model for the analysis of stability and breakage of trees.

This *model* allow tree specialists appreciate better the interaction between wind, tree stability, biology, wood-decaying fungi and mechanical behaviours and assist in the tree-diagnosis process. The Critical Wind Speed -"V" (Shown in RED) – can be predicted "V" is the wind velocity that would cause the stress in the outer fibres exceed the maximum compression strength and would hence produce failure of those fibres. This computerised model calculates the critical wind velocity "V" for several types of failures (uprooting, bending fractures of the sound or hollow trunk and torsion fractures of closed and concentric cavities). Safety factors obtained by analysis of the wind loads are incorporated as well, while the theoretical necessary residual wall thickness for each tree can be calculated.

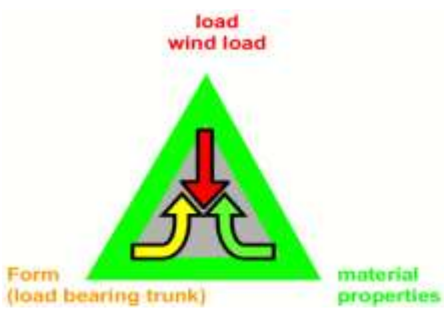
Data input=

Tree characteristics		
Species (see list of species)=	*Acer pseudoplatanus*	
Height tree=	19.00	m
Crown diameter=	14.00	m
Height trunk=	2.00	m
Circumference=	204.00	cm
Bark thickness=	2.00	cm
Residual wall thickness, t=	12.00	cm
Cw-value (see list of species)=	0.25	
Compression strength=	2.50	kN/cm*cm
(see list of species)		
Environment		
Altitude=	150.00	m
Minimum temperature=	-20.00	°C
Expected wind speed for the area=	90.00	km/h

Results=

Wind load analysis for trees		
Crown area=	186.92	m*m
Air density=	1.37	kg/m*m*m
Wind speed=	25.51	m/s
at height=	11.35	m
Wind load=	20.48	kN
	2088.73	kg
Wind induced bending moment=	232.49	kNm
Bending fracture of the sound stem=		
Critical wind speed=	39.43	m/s
Safety=	238.86	%
Required residual wall thickness=	5.04	cm
Torsion safety of the closed and concentric residual wall=		
Critical wind speed=	46.70	m/s
Safety=	335.02	%
Bending fracture of the residual wall=		
t/R measured=	0.39	
Critical wind speed=	34.76	m/s
Safety=	185.67	%
Dynamics=		
Natural frequency=	7.95	Hz
Vcrit_resonance=	24.22	m/s
Equivalent wind load=	18.47	kN

STATIC INTEGRATED ASSESSMENT



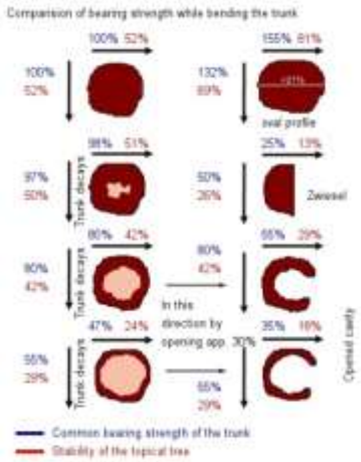
The Static Integrated Assessment (**SIA**) methods were first published by Sinn and Wessolly (1989) based on research carried out at Stuttgart University. It is acknowledged that there is no perfect method that covers all possible cases.

The approach published by Erb and Wessolly (1998), is based on a common understanding of the behaviour of mechanical testing in the construction industry. This approach may be simplified by representing the components of static forces, and is known as a model termed the "Triangle of Statics".

The results show that the requirements for the height, canopy form and location in relation to its which is good starting point for the basic safety of a

The consideration of load analysis is crucial example, a defect (such as a cavity) in a tree with structural failure, compared to the same defect in a

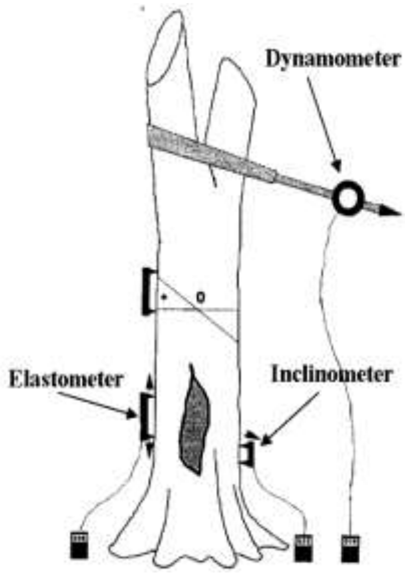
The system then goes on to generate an assessment localised stem damage as shown in the diagram



stability of a tree is based upon its species, stem diameter and outputs a basic safety figure, tree.

information for assessing tree safety; for height of 25m is far more likely contribute to tree only 10m high.

of the potential strength reduction as a result of opposite.



Static Integrated Method (SIM)

The Static Integrated Method (SIM) is a device-supported approach, which measures both the breaking resistance and the tipping resistance of trees. It was designed by Sinn and Wessolly (Sinn, Wessolly, 1989) to produce exact data about the reaction of a tree to an artificially imposed load. In practice this method has been used since 1995. This method applies a pulling test to a tree (involving the use of a hand-winch) to measure the response of the structure as a whole according to the following two parameters:

- The change of length of wood fibres in the outer parts of stem in the pulling direction (measured by an *elastometer* to a resolution of 0.001 mm over a 25 cm distance).
- The change of angle of the stem base. (The tipping procedure is measured by an *inclinometer* to a resolution of 0.01 degrees.)

This can produce a very detailed assessment of the trees stability

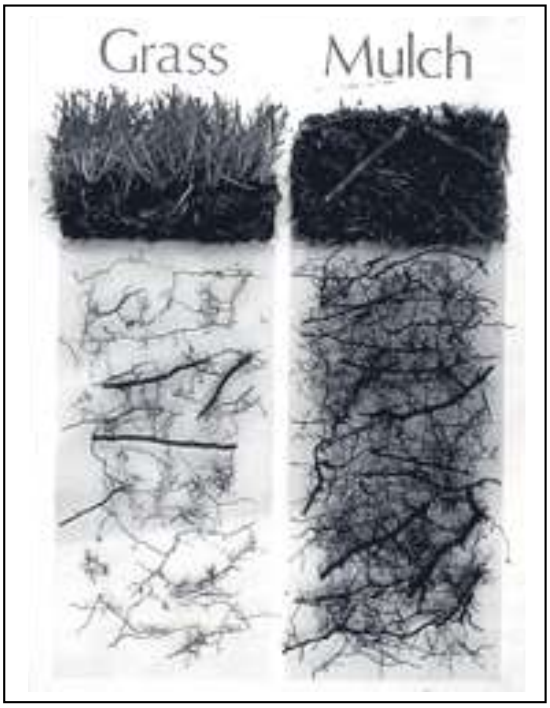
APPENDIX 11 –ROOTZONE IMPROVEMENT

Mulching is one of the easiest and most effective means of improving a trees health. It helps maintain soil moisture by slowing down evaporation from the soil, which saves water. It blocks sunlight to the soil, which helps control weeds. It serves as an insulating blanket that keeps the soils warmer in the winter and cooler in the summer. It can improve the fertility of the soil, improve soil aeration and drainage, encourage pedestrians to stay on lawns and paths and can inhibit certain plant diseases.

The idea of mulch is to mimic the soil in a forest. In a natural environment, a layer of loosely packed organic matter mixes with the top soil of the forest floor to form humus. This is nature's version of mulch. Mulch should also be kept natural, make sure it is composed of loosely shredded leaves, peat moss, composted organic material or composted bark or wood chips. Figure 1 shows the effects of mulch on root development of trees compared to those growing below mown grass.

Mulch should be 50mm to 100mm deep and ideally cover the entire root system, which may extend two to three times the diameter of the branch spread of the tree. But, while this may be the ideal, it's probably difficult to achieve on most sites. If space is restricted, you should mulch as much of the area under the drip line of the tree as possible. Where this is to be installed over turf ideally the grass should be removed first either by turf cutter or by treatment with an appropriate herbicide.

Figure 1



Tree Root Growth Under Grass vs. Mulched Surface.

Figure 2

A Mulch Volcano excavated to expose buried trunk. Some trees may develop girdling roots under the mulch pile. The trunk flare is not visible and note the discoloration on the stem just below the mulch line. This discoloration may encourage decay

Mulching too deep can be a problem.

Be careful not to cover the trunk of the tree with mulch; keeping mulch at least 50mm away from the base of the tree. This will prevent moist bark conditions and thus prevent damage to the stem. Mulch can cause problems if it is applied wrongly. Mulch can be piled against the stem to create a Mulch Volcano (Figure 2), where it is applied so deep that air cannot penetrate into the soil and roots will suffocate. It can also be so deep that water cannot penetrate and the roots may dry out. Either of these conditions is not healthy for the trees.

Additionally some tree species have shallow roots, especially maples. If mulch volcanoes are piled around the trunk, the roots will start to grow into it. These roots tend to stay in the mulch volcano and will then grow around the trunk in the mulch. As the root grows in diameter, it pushes against the trunk, which is also trying to grow bigger. These roots will eventually strangle the trunk.

Ideally plastic sheet mulches should not be used "because it interferes with the exchange of gases between soil and air, which inhibits root growth." 125mm to 150mm inches of organic mulch can also cause this, so don't apply too thick.

In situations where trees have suffered visible decline as a result of compaction or changes in soil level the beneficial effects of mulching can be accelerated. Following the removal of the surface covering a 25mm to 50mm layer of composted organic material can be incorporate into the upper 200mm of top soil by means of Air Cultivation prior to the area being mulched with your chosen organic mulch. This method allows the soil to be fully cultivated and organic material incorporated, whilst retaining but retains small diameter roots.

Barnes & Associates – Independent Arboricultural Consultants

Tree Surveys & Condition Reports	Development Site Tree Reports to BS5837
Tree Health & Safety Reports	Arboricultural Implication Assessments (AIA)
Tree Risk Assessments	Arboricultural Method Statements (AMS)
Tree Population Site Inventories	Construction Exclusion Zone Management
Estate Tree Management	Tree Protection Plan Design
Woodland Management	Tree Valuation & Replacement Costing
Tree Work Specification & Tenders	TPO Objections & Appeals
Insurance & Mortgage Reports	Tree planting Schemes & Landscape Design
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Professional
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