Tree Report

Site Address: Inverell NSW 2360

Prepared For: **Inverell Council**
PO Box 138
Inverell NSW 2360

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Prepared By: **Mark Hartley**
Dip Hort (Arboriculture) with Distinction
Diploma of Horticulture
Diploma of Arboriculture
LMAA; LMISA; LMIPS
ISA Certified Arborist WC-0624
AA Registered Consulting Arborist # 6222-01
Senior Consultant for

The Arborist Network
58 South Creek Road
Shanes Park NSW 2747
Phone (+612) 9834 1234
Email: *reports@arboristnetwork.com.au*

Table of Contents

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Executive Summary

There is a fairly limited pallet of trees species in Inverell, and this is understandable give the comparatively small size of the population. There are a number of London plane trees that have been planted in various locations around the town. This is a rapidly growing species of tree with some inherent problems including a recently introduced insect that is impacting upon the trees.

A number of the plane trees have been planted under wires, and these are now causing problems due to their size. Because of the rapid rate of growth, these trees would need to be gutter pruned. This can be quite problematic when trying to maintain clearances from unshielded overhead wires.

Plane trees have also been used in the commercial centre of town. These trees have been planted in a manner that limits the way in which root problems are managed and their size and rapid growth has already resulted in the trees having already been lopped once. Whilst the size and the canopy of these trees could be maintained by performing ongoing pruning, most likely pollarding, there is little that can be done to address the root problems.

When the problems and management costs associated with this species are weighed up it would seem appropriate to avoid the further use of this species in the landscape planting. Suitable alternate tree species should be selected for locations in the town, and as trees need to be removed or are progressively replaced they should be replaced with the appropriate replacement species.

Where plane trees are growing is suitable locations, pruning should be limited. Where pruning is required, it should ideally be performed correctly and should be timed during the period that the trees are dormant. It may be appropriate to consider treatment of significant London Plan trees that are retained as specimen trees, in order to manage the problems associated with the lace bugs.

These policies need to be incorporated into a Tree Management Plan for the town. This document should include other information related to the management of the trees in the town of Inverell and ideally should be developed in consultation with representatives of the community.

Brief

I have been asked to visit Inverell and to;

- Examine the trees in the urban area and in particular look at trees under the electrical wires and trees in the commercial area.
- Look at the overall effectiveness and longevity of the planting strategies
- Examine and consider the damage caused by trees .
- Make recommendations to provide an efficient and cost effective long term urban canopy.

Background

There has been a general absence of an overall Tree Management Plan for the town of Inverell. Planting, whilst in the main has been successful it has not been without problems.

- Large trees have been planted under wires.
- Planting, maintenance and cultural practices have resulted in the longer term complications.
- Trees have caused damage to the infrastructure, and on occasions, that damage has been quite extensive.

A recent attempt to remove a number of Plane trees from under the wires resulted in a community concern. This had led to discussions about what needs to be done to better manage the tree resources of the city.

Trees in the main streets (Otho Street and Byron Street) were planted in two stages over the last few decades. Planting in the main street included the use of a 1200mm long by 900mm diameter pipe as a form of a root barricade.

As a result, of problems associated with leaf drop and box gutters, the London Plane trees in the main street were lopped several years ago.

The lopping in recent years was also undertaken on the basis of controlling future growth, including slowing potential root expansion.

Method

A variety of locations and trees were inspected throughout the urban area of Inverell. The trees present were inspected for the problems typical for each species. Infrastructure damage and conflict was observed and photographed.

Climatic data for the city was obtained from the Bureau of Meteorology web site and accessed on the 5th April 2012.

Based on the growth rate and general performance of the trees it was assumed that the site soils were fertile and generally suitable for healthy tree growth and, as a result, no soil analysis was requested, recommended or undertaken at this stage.

Limits

This report is not intended to be a detailed account and assessment of the issues associated with individual trees or for that matter any species of tree in particular. The inspection of the trees must not be considered to be a Visual Tree Assessment (VTA), nor should the general inspection of the trees be construed to be or form part of a hazard or risk assessment.

This report must not be considered to be a tree management plan although the information contained in this report may be suitable as a starting point for the development of a Tree Management Plan.

Observations

Climactic details

The Bureau of Meteorology provides substantial data for Inverell at 3 different locations; Raglan Street, Inverell Research Station and Inverell Comparison, (which was made redundant, with the commencement of the collection of data at Raglan Street).

The annual rainfall for these 3 stations varies between 763.4mm and 804.5mm per annum and the decile 5 median rainfall varies between 750.8mm and 836.3mm with the peak in Raglan Street being for a substantially shorter recording period. Rainfall is highest during the warmer months with the wettest month being December and the driest month being April.

The temperature is cold temperate. The highest recorded summer maximum from the 3 locations referenced was 43.7OC, and the coldest winter minimum was -10.6OC. The Raglan Street maximum was 38.8OC, and the minimum was -9.5OC. Mean temperatures are between these ranges. Inverell regularly records sub zero temperatures over night and subsequent large frosts during the winter months.

Large trees under wires

There are a number of large trees planted under the wires most notably the London Plane trees. These trees have had a history of pruning, of various standards, in order to provide clearance from the wires. A number of the pruning wounds have resulted in decay, and several of the trees had obvious damage from decay or poinciana longicorn (Agrianome spinicollis).

The recent aborted tree removal resulted in lopping or non-nodal pruning as defined in the Australian Standard AS4373-2007 Pruning of amenity trees. (See Lopping pruning and pollarding below). This may not be the most ideal solution, however, in the short term, whilst the future of the trees is uncertain, there is no significant problem in leaving the lopping as it is rather than correcting the cuts

Trees in and near the town centre

There are a number of young trees planted in the commercial centre as well as in the adjacent areas. These tend to be the larger trees with some having trunk diameters in excess of 500mm in diameter. The two most common species used are Platanus X hybrida (some hybrid inconsistency or alternate species may have been present) and Pistacia chinensis.

There was some evidence of canopy chewing and highly deformed tips on several of the Pistachios that may be the result of a possum or some other larger animal regularly grazing, alternatively the dame may be from a smaller leaf chewing insect and mites (further examination and periodic inspection may be required in order to make a final determination).

The Plane trees, in the commercial centre, had all been lopped at some stage in the previous 5 years. This has left many of the trees with a poor form and making it difficult to undertake corrective pruning or even to establish a suitable base for a pollard.

Roots from a number of the more established trees had lifted the adjacent infrastructure, mostly kerbing and pavement. The trees that appeared to be causing the most damage were the London planes in confined planting spaces.

Heavy infestation of sycamore lace bugs were noted on a most of the London plane trees in the area and in some cases the damage was causing health issues for the trees.

Discussion

General Matters

There would appear to be an obvious and overall appreciation, by the community as a whole, of the value that trees provide to the urban area. This is of great benefit. Active community involvement is of great value to the process of urban greening, but it must be tempered with appropriate broader community consultation combined with a good understanding of the science of arboriculture.

The climactic conditions allow for a more diverse selection and with supplementary irrigation, particularly during the establishment period the potential range of suitable tree species is larger still. There is a fairly limited pallet of tree species currently being used in the area.

Larger cities and towns that will have plant material that is likely to be successful in Inverell include locations such as Canberra (and much of the ACT, Bathurst and Armidale. Locations such as these will serve as suitable testing grounds with trees that are very successful in those locations, generally also likely to be suitable in Inverell.

The soils of the area are generally black basalt soils suitable for agriculture, and it is assumed that these are generally present, along with some alluvial soils, throughout the town area. There were no obvious nutritional deficiencies apparent in the foliage of any of the trees inspected. Any common deficiency that may be present could be readily obtained from the local agronomist.

Plane Trees

This is a rapid and vigorous growing species that adapts well to urban stress. The plane trees appear to be relatively well adapted to the location. The growth rates are comparable to trees growing in areas with higher rainfall such as Sydney and trees growing on alluvial soils such as those growing in Richmond NSW.

This species produce huge numbers of trichomes (small cellular hairs) on their leaves that tend to be shed over time. In addition, the bristles from the fruit (an achene) are used in the distribution of the seeds and are shed as the fruit matures. These trichomes and bristles are often reported as causing irritation to the general public, particularly when conditions are winding. It is industry best practice to wear dust masks when chipping material from this genus because of the number of fibres that are released in the chipping process.

A number of the planes are planted under power lines and have been cut to provide clearance on a number of occasions. In the same way many of the planes in the main commercial area have also been cut back to provide clearance from the buildings. There was evidence of poinciana longicorn (*Agrianome spinicollis*) damage was apparent and this borer is well documented in planes particularly those within a kilometre or two from water.

A number of the planes have been planted in confined spaces and close to the adjacent infrastructure. Without exception these trees have been the source of the greatest proportion of the trees that have caused infrastructure damage. (See Root damage below)

Sycamore lace bug

The recent introduction of sycamore lace bug (Corythucha ciliata) to Australia sometime in 2006 has had a significant impact on this species. The first recorded outbreak by the arboricultural industry was in Hyde Park in Sydney City. This insect is a sap sucking insect (order Hemiptera) that has a limited rage of hosts (oligophagous). As such the insect is not a risk to trees other than Platanus. It is already present in high numbers on trees in Inverell.

The bug is large and tenacious and when on human skin it does on occasions “test” the surface which is more annoying than painful. Because of this, consideration needs to given to managing low foliage from this species in areas where people may regularly brush against it.

The insect causes stippling and gradual discolouration of the foliage. Leaf damage impacts on the trees ability to photosynthesise, reducing the growth rate and the carbohydrate reserves of the tree. The reduced carbohydrate reserves make the tree more susceptible to stress. Where the trees are already stressed the impact of the bug can be quite noticeable, such as the two planes in Captain Cook Drive outside Liquor Land.

Overseas, this bug has been reported as being responsible for the spreading of bacterial and viral infections. Such problems have not yet been recorded in Australia. The loss of vigour associated with this bug along with the loss of canopy associated with tree pruning has the potential to increase damage from other insects. In particular, damage by the poinciana longicorn is likely to increase.

In response to the health problems associated with the outbreak Sydney City Council has decided to undertake chemical treatment of a number of its plane trees in order to limit the impact. Whilst treatment is relatively simple, treatment may need to take place annually. Suitable chemicals can be injected into the stem and are expensive. Other chemicals can be injected into the soil but require an off label permit or need to be sprayed over the tree.

Decay longicorn

The larvae of decay or poinciana longicorn (Agrianome spinicollis) are finger sized, and unlike many other longicorns, this larvae feeds in the wood with the aid of a digestive yeast. The feeding process usually involves the spread of decay. Over time the combined galleries from the larvae feeding, along with the spread of the decay, weakens the stem of the tree.

The adult exits in late spring to early summer. The adult lives for only a few weeks with their primary focus being reproduction. They are generally attracted to trees that have been recently wounded or that have some level of decay. As a result, females are often prone to mate and lay eggs on the same tree. Population levels appear to be greatest within a few kilometre of continuous, flowing water (personal observations).

Other tree species

The comparative advantage of a suitable species can be seen by the use of the *Pistacia chinensis*. This slower growing tree when compared with the London plane tree has caused significantly fewer problems. The *Pistacia chinensis*, slower growth and smaller size mean fewer root problems than London plane trees. Its smaller leaves results in fewer blocked drains. Even so this tree can have problems with cockatoos if female plants are grown. As a result, wherever possible, male clones should always be used.

Other trees that can be observed growing well in the area include *Callistemon viminalis*, (weeping bottle brush) *Lagerstroemia indica* (crepe myrtle), *Ailanthus altissima* (tree of heaven - this appears to be weed-like in the area), *Albizia julibriss*in (Albizia), *Photinia serrata* (Photinia), and *Metrosideros glyptostroboides* (dawn redwood).

Planting and tree roots

Tree roots are responsive to their environment and grow most rapidly where conditions are ideal. As a result, where a tree is fast growing, and conditions for growth are ideal close to the surface roots will tend to grow close to the surface.

There are questions generally about the effectiveness of root barricades for young trees. For a barricade to be effective it should ideally penetrate above ground, and the deepest portion of the barricade should be sloped away from vertical by at least 15% to encourage deeper root penetration.

The use of pipes as a root barricade will have been largely ineffective and has limited remedial solutions that may have otherwise been available. The pipe has eliminated the lateral spread of any deeper roots, whilst roots close to the surface have grown over the upper rim of the pipe. Cutting surface roots is likely to cause problems with the health of the trees, and there is an increased likelihood of structural instability because the normal root morphology has been significantly altered.

Tree lopping, pruning and pollarding

As already mentioned, a number of trees have been lopped in the past. AS34373 defines lopping (3.31) as "*The practice of cutting branches or stems between branch unions or internodes.*" This sort of work has a number of secondary problems and is generally not an acceptable tree maintenance practice.

Image 1: Properly pollarded plane trees in Losone Switzerland

Reduction pruning, defined as (3.38) "*The removal of the ends of branches to lower internal lateral branches or stems in order to reduce the height and/or spread of the tree.*" Reduction pruning is a more appropriate option for managing trees under power lines or where a tree needs to be pruned away from some other structure.

Pollarding defined as (3.36) "*A specialized pruning technique that establishes branches ending in a pollard head of buds and vigorous shoots. Pollarding is not synonymous with lopping and topping.*" is an ideal pruning technique to keep trees small and at a fixed size. This type of pruning has been quite popular in formal European designs. Perhaps the best known avenue of pollarded trees is the Avenue des Champs-Élysées.

Image 2: Pollarded and clipped chestnuts growing along the Avenue des Champs-Élysées.

The trees in the Avenue des Champs-Élysées are pruned several times a year by hand, and this is very time consuming and costs several million dollars a year. Whilst this may be appropriate for a famous tourist attraction such costs may not be sustainable in the long term for a location such as Inverell.

Image 3: Pollarding is a labour intensive activity

Whilst pollarding is very effective at keeping trees small and very regular in shape and form, this sort of pruning is very time consuming and requires a high skill level in order to be performed properly.

To look their best and in order to avoid secondary problems from new growth, fast growing trees such as London planes should be pollarded annually. Because of their shape this can be often quite difficult, and such skilled work will prove to be expensive in the long term particularly when compared with using a tree species that has a form and size that is closer to the size of the pollard.

Tree selection

The palate of trees that has been selected for use has been somewhat limited. This is somewhat undesirable. Firstly it exposes a large portion of the tree population in the event of a significant disease outbreak, such as we have seen on numerous occasions in Australia over recent years and perhaps as may occur with sycamore lace bugs and the local London plane population.

The first consideration in selecting appropriate species is ensuring that they will tolerate the climate and soil type of the area. The climate and soils allow for a large range of tree species. The availability of a reliable irrigation supply increases the palate of suitable tree species even further.

The next most important consideration in selecting appropriate trees is the size (or rate of growth of the tree). It is important to understand that unlike animal trees do not have a ‘mature’ size; rather, they continue to grow in size until they reach over-maturity and start to decline. Where the height of the tree needs to be limited because of overhead structures such as wires or awnings trees that have a slower rate of growth are more appropriate.

The same is true for the size of trees that are to be planted in small confined planters. Planting trees that quickly develop trunks with diameter in excess of 500mm are probably not appropriate for planting within a few hundred millimetres from structures such as kerbs or light walls.

Almost equally important in the selection process is the form of the tree. Is a single or a multi-stemmed form desired? How high does the trunk need to be before the lowest branch? How wide or narrow does the canopy need to be in order to provide the desired benefits but not to cause unnecessary problems?

The final primary consideration in selecting suitable tree species is to determine shade issues. Should the canopy be evergreen or deciduous? Should the canopy be thick or sparse?

Only when the above factors are resolved should other more aesthetic issues be considered such as flowering characteristics, cultural benefits and so on.

Tree Management Plan / Policy

A Tree Management Plan is a simple document that details the overriding principles and policies that Council will use to guide decisions made relating to its trees and the trees under its control. An array of such documents can be found by performing a google search.

The Tree Management Plan should include reference to;

- guiding principles,
- the relevant legislation,
- associated policy documents including,
    - tree protection,
    - tree protection and development,
    - tree planting and development
- tree management options for various circumstances,
- tree inspection processes and frequency,
- tree risk management,
- lists of preferred species for various situations,
- a list of any undesirable species (for example, *Ailanthus altissima* appeared to behave in a weedlike fashion in several fields in the rural zones nearby.)

A tree management document is best prepared by those directly responsible for its implementation and oversight. This allows for the document to develop and evolve as required. In addition, community consultation should be given a high priority once an initial draft has been prepared. It is likely, however, that some outside resources and assistance may be required to provide guidance in some of the more complex areas.

Root Damage

Infrastructure damage

There has been some damage to pavement and kerb and guttering adjacent to a number of trees. In addition, there has been an invasion of pipes by tree roots. The damage is most significant on trees that are more vigorous in their rate of growth.

Macleod and Cram (1996) state that tree roots exert a pressure in the order of 800 - 900kPa, dependant on species. They also show calculations that show that roots can readily lift light structures such as retaining walls and pathways.

The turgid pressure applied by most cells, either plant or animal, is within the same order of magnitude. If the force, in the opposite direction, is too great, the cell will rupture or be unable to divide. As a result, there are upper end limits on the mass that can be lifted by roots. These pressures are not generally sufficient to lift heavier structures with most structures over several tonnes being relatively unlikely to be damaged by tree roots.

When it comes to larger heavier structures, such as buildings, tree roots are seldom ever large enough or present in such large quantities that they can lift a building. In addition, in the case of clay soils, the load bearing capacity of the clay (generally less than 500kPa) is not sufficient to bear the load exerted by the roots and the roots are forced into the clay.

It must be understood, however, that the vast portion of the surface area of roots is incapable of absorbing water. Water absorption is almost entirely limited to a small region behind the tip of newly formed roots. In many cases, these zones are only active for a few weeks, and as the root continues to elongate the absorptive zone continues to follow immediately behind. As a result, whilst trees can be responsible for differential drying they are only one of a large number of factors that are responsible.

Tree roots can influence the rate at which moisture is removed from the soil, and this can exacerbate the problems associated with reactive clays. Strangely enough, in some instances, turf grass can be equally capable of causing differential drying. The impact of trees on reactive clays and for that matter on clay soils in general should always be consider in the engineering of new buildings.

Tree roots do cause problems with pipes, and this is discussed at some length below. However, the tree roots have not cased the damage but rather are simply taking advantage of available water and nutrients.

Roots and plumbing

Roots from the trees have caused significant blockages to pipework. As will become apparent, this is more a function of faulty pipework that of the trees. All the same, the reality is that in many locations the pipework will be old and will predate PVC pipework with appropriate expansion joints and flexible joints where required. Regardless, the fact needs to be accepted that if the pipework is not repaired such problems will continue to occur.

It is important to understand that tree roots are biologically optimised organs that are responsible for the uptake of water along with dissolved elements and compounds. They have no perceptive or cognitive organs and so have no way of knowing where water is located until they are stimulated by physical contact with an appropriate amount of readily available water, sufficient enough to stimulate root growth.

Contrary to popular belief, tree roots do not go in search of water. Furthermore, because roots require available moisture to stimulate growth, at no stage do roots go searching for water when the soil is not appropriately moist. Rather the opposite is the case. Tree roots are opportunistic and they are stimulated, elongate and divide more rapidly as moisture levels and the surrounding temperature approaches optimal levels for the particular species. (It is this principle that drives the hydroponic industry)

An understanding of the mechanisms that drive root growth, namely soil moisture and temperature within the required range for the plant, and to a lesser extent available minerals, is vital in understanding that roots seldom break pipes and then enter them. In almost all circumstances roots enter through joins or cracks and breaks in the pipe work (see Forces applied by tree roots below).

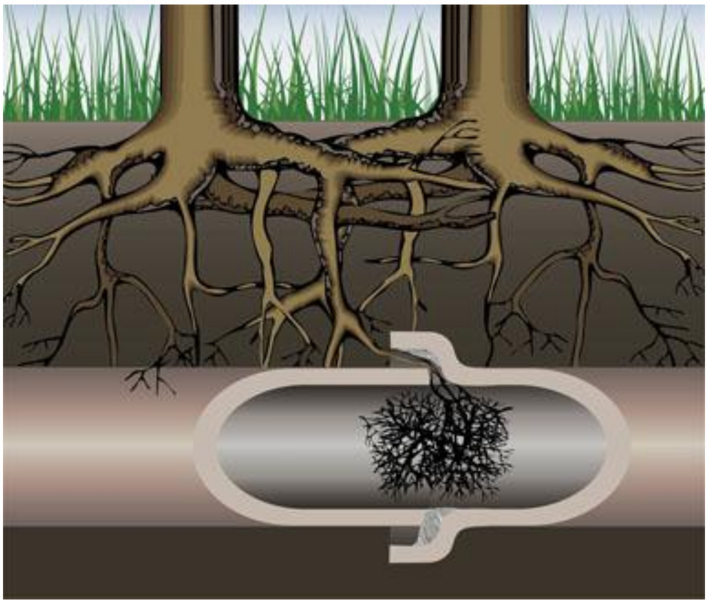

Diagram 1: Once roots enter faults in pipes, they divide rapidly.

Cracks in pipes often occur over time and the failure of cement joins and rubber seals are quite common. Once a pipe cracks or a joint fails, then pipes start to leak oxygenated and nutrient rich water through those faults into the surrounding soil. If a root comes into contact with this ideal growing environment it then starts to divide rapidly in order to take advantage of the available resources. In this situation it is generally only a question of time before roots come into contact with the fault and enter into the pipe where they divide even more rapidly

Forces applied by roots

In the past, it has sometimes been suggested that tree roots break or dislodge pipes and, whist this may occur in rare circumstances, the likelihood of it occurring are quite small.

On first appearance then, it may appear reasonable to conclude that tree roots can easily crush and certainly dislodge pipes. This, however, is simply not the case and the explanation can be readily provided with some basic physics.

A pipe is comparatively easy to crack when it is not supported by soil. In order to crush a pipe, where the sides of the pipe are supported by soil, a root needs to exert enough force to push the curved wall inwards. For the pipe to crack and fail a defect in the pipe needs to be present, otherwise outer portion of the pipe wall must be compressed. (See diagram) The load bearing capacity of baked clay is very high and this combined with the curvature of the pipe and the support of the surrounding soil means that the inward failure of a pipe due to forces from root growth is a rare occurrence. The impact of curvature on wall strength is well demonstrated by the childhood experiment of trying to crush an egg when pushing from either end.

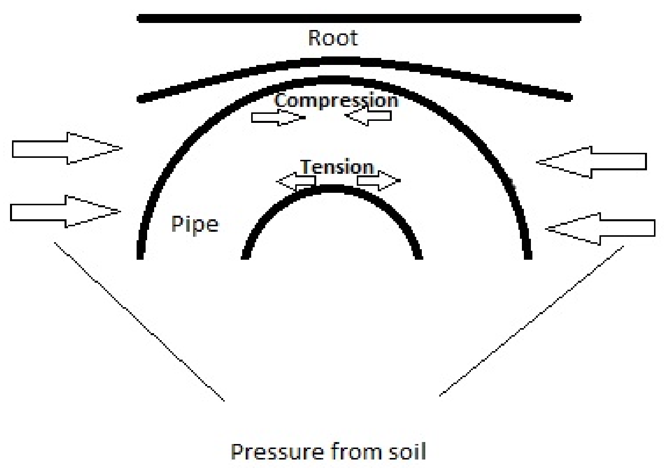

Diagram 2: When soil provide supporting pressure to stop flattening, a pipe becomes more resistant to breakage

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Roberts Jackson and Smith (2006, p 395) state that *'Cases where pipes have been broken as a result of root growth are reported to be rare.*' and again (page 398) *'Most authors concur that roots do not break pipes or force their way into pipes'*. In addition, it is possible to provide a good engineering rationale to support this position (available on request).

It appears highly unlikely that roots can ever crush or crack pipes simply as a result of their growth in girth unless the pipes is defective or significantly embrittled.

Image 4: There is little to no lateral movement that can be observed in this pipe even though there is no support from soil on the other side of the tree.

In soil that provides less support, such as clay, where it may be possible to push a pipe into the surrounding material, there is still an equal and opposite force being applied to the root of the tree. This, in my experience, is usually sufficient to inhibit root growth on the pipe side of the root and to result in more rapid growth on the opposite side of the pipe. This is because the root can more readily expand and push the soil away than it can push the pipe and compress all the soil that the back half of the pipe is touching.

Where roots can damage or dislodge pipes

To suggest that tree roots never damage pipes is not correct. Where roots have a diameter greater than the outside diameter of the pipe they may produce sufficient force to dislodge a pipe particularly if the soil is regularly approaching plasticity.

In addition, roots that enter through a join between pipes can conceivably develop sufficient surface area to move the pipe a few millimetres until it fully beds in at the next join. In the same situation, the volume of roots in the join could conceivably develop sufficient surface area that the outer collar of the pipe is broken, (the inner pipe being protected against breakage as described above)

The final way in which roots may damage pipes is raised and discussed in detail by Mattheck (1994). (The relevant pages are included in Appendix 2). Essentially this occurs where a root is curved around a pipe and that root is subjected to a tensile force in turn pulling on the pipe. Mattheck raises this issue based primarily from a theoretical perspective although Mattheck has actually observed such damage (personal communication). It is perhaps important to note that Mattheck does not make mention of root damage other than by this mode.

The tensile force that is applied to a root is a product of a number of factors including the force applied to the canopy of the tree above ground and the cohesive strength of the soil, the number of first order lateral roots, the rate at which root division and root taper has occurred, and so on. In most cases the amount of movement in roots is quite small and the extent of movement diminishes rapidly as the distance from the tree increases.

Suitable trees

This section is not intended to be complete or comprehensive, in fact the very opposite is the case. The trees listed here are simply intended to provide some inspiration as to what could be used. The major limiting factors for tree selection are the winter frosts and the peak summer temperature. Frost damage is a complex process based on a number of variables so as a result trees that are frost hardy will generally but not always be suitable.

There is some benefit in looking as a signature tree or signature palette of trees for the town. The use of a signature tree or trees that are largely unique or otherwise unclaimed by a city may be advantageous. Towns that have used a signature planting well include Grafton and Jacarandas and Roma and bottle trees.

The adoption of a single species or a primary species that comprises a high portion of a particular planting does add visual impact but comes with secondary problems. Most notably, is the risk of a disease outbreak, such has occurred with a number of species in Australia over recent times and is well illustrated, in this instance, with the sycamore lace bug. A diversity of species limits the risk associated with such species.

It is also important to understand that there is often a large degree of genetic variation in many species of trees. Cultivars are often selected to limit the variation or to capture a particularly desirable quality. For this reason, when choosing which species of trees will be included, it may be appropriate to consider or eliminate cultivars.

Signature plantings

The following are some ideas of possible signature plantings. As can be seen the link between the plants in the palette can be quite broad and doing this has the advantage of allowing the inclusion of adding further plants to the palettes.

a. *Cordyline australis* (cabbage tree) – structural form
b. *Jubaea chillanensis* (Chilean wine palm) structural form but a very long time frame
c. *Bismarckia nobilis* (Bismarck palm), *Brahea armata* (blue hesper palm), and *Nannorrhops ritchiana* (Mazari palm) - grey palm series
d. *Nyssa sylvatica* (tupelo) , *Acer palmatum* (Japanese maple) *Pistacia chinensis* (Chinese pistachio) - autumn colour
e. *Geijera parvifolia* (wilga), *Eucalyptus caleyi* (drooping ironbark), *Callistemon viminalis* (weeping bottlebrush) - spread weeping natives
f. *Corymbia ficifolia* (red flowering gum), *Eucalyptus sideroxylon "rosea*" (red ironbark) – red flowering natives
g. *Acer davidii* (snake mark maple), *Allocasuarina inophloia* (stringy-bark she oak), *Lagerstroemia indica* (crepe myrtle) - feature bark

Small trees

The following trees are slower growing specimens that are smaller trees that respond satisfactorily to pruning and may be suitable for use under wires.

- *Callistemon citrinus* (crimson bottle brush)
- *Lagerstroemia indica* (crepe myrtle)
- *Acer palmatum* (Japanese maple)
- *Malus spp.* (Crab apples)
- *Cercis chinensis* 'Avondale' (Chinese redbud)
- *Magnolia x soulangeana*' (saucer magnolia)
- *Magnolia grandifolia* "Little Gem" (dwarf Bull Bay magnolia)
- *Prumnopitys ladei* (Mt Spurgeon black pine)

Medium sized trees

The following trees are medium sized trees that tend to be slower growing and that would be more suitable for planting in the main commercial area. Whilst in time they may get quite large their growth rate is much slower and this allows for longer cycles between maintenance needs. It will also mean that impact on existing infrastructure will be less frequent.

- *Nyssa sylvatica* (tupelo)
- *Pistacia chinensis* (Chinese pistachio)
- *Liquidambar orientalis* (Turkish sweetgum)
- *Koelreuteria paniculata* (golden rain tree)
- *Acer rubrum* (Red maple)
- *Quercus virginiana* (live oak)
- *Ulmus parvifolia* (Chinese elm)

Conclusion

Despite the absence of a formalised Tree Management Plan, Inverell has been able to provide a reasonably successful urban tree canopy. The ongoing management of the plantings, in particular the London Plane trees is causing problems and decisions need to be made to ensure a sustainable outcome can be achieved in the future.

It would appear that the Inverell community has a growing appreciation of the value that trees provide in the urban area. As a result, community consultation needs to be an integral part of the management of urban trees; however, this community involvement must not override appropriate resource management or be at the expense of correct arboricultural standards and best management practices.

The main commercial precinct of Inverell has a limited palette of plantings. The dominant species, the London plane tree, is a rapid growing specimen and like many other towns has been at the centre of recent community debate.

The report highlights the problems that confront Council in regards to the plane trees such as

- their rapid growth rate,
- previous lopping and the high cost of appropriate management techniques such as pollarding,
- damage to or exacerbation of existing damage of infrastructure,
- impact of inappropriate root barriers installed at the time of planting on root morphology and the influence of this on current management options,
- impacts as trees mature and shed increasing quantities of hairs and fibre and
- the presence of the sycamore lace bug and other diseases.

It is recommended that Council develop a program for the staged removal of unsuitable species and select a palate of trees (including signature trees) for planting in a variety of different situations. The implementation of such, along with the overall management of the trees on public land, should be encapsulated in a Tree Management Plan.

Whilst the removal of tree species will often evoke an emotive response in some quarters, appropriate replanting’s now will ensure a vibrant and sustainable urban tree canopy for future generations.

The report provides and references some more technical information, and this needs to be considered and form the underpinning basis for any future decisions and documentation.

Finally a number of potentially suitable trees have been suggested to allow for a broadening of the planting palette of trees planted in Inverell. The list of trees is by no means exhaustive are not intended to be prescriptive; rather their purpose is to stimulate discussion and to broaden the scope of species used.

Recommendations

1. Develop an overall policy document and plan for trees in the council area.

2. Ensure that policies are consistent with the appropriate Australian Standards and relevant best management practices.

3. Engage community consultation in the development of the overriding documents and specific detailed documents where appropriate.

4. Develop a palate of trees for planting in a variety of different situations.

5. Consider the adoption of a signature tree or palate of trees.

6. Develop a plan for the maintenance of the existing urban treescape by planting new trees in available urban space, including planting small slower growing trees under wires combined with a staged removal of unsuitable trees.

7. Develop a plan for the staged removal of the London plane trees that have been planted in pipes in the main commercial area.

Should you require any further information, do not hesitate to call our office for assistance.

Arborist: **Mark Hartley**

Senior Consulting Arborist
Dip Hort (Arboriculture) with Distinction
Diploma of Horticulture
Diploma of Arboriculture
LMAA; LMISA; LMIPS
ISA Certified Arborist WC-0624
Registered Consulting Arborist™ #0001

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Appendix 1

7.0 WIND, ROOTS AND PIPELINES

7.1 INTRODUCTION

Some of the ways in which tree roots typically interact with soil need to be understood, with special reference to the *Axiom of uniform stress* and *Mohr-Coulomb's law* of soil mechanics. As pointed out throughout this book, the *Axiom of uniform stress* is a natural law of design that quite simply means that a tree, in common with all biological load bearers, always tries to distribute stresses evenly, thus avoiding local over-loading or under-loading of its structure. This principle also applies to engineering components; if they are optimised in this way, they can bear loads up to 100 times more load cycles than otherwise.

All of us, in our tender youth, have systematically employed *Mohr-Coulomb's law* – that is when we built sandcastles on the beach! If you want to build a particularly durable earthen wall, you tamp down the earth tightly, i.e., you compress it. Fig. 41 now shows the generalization of this childhood experience, still in a rather popular scientific presentation. If a sack of potatoes is stood on two planks placed one on top of the other, these slide less readily over each other. The friction is proportional to the 'normal pressure' that acts on the sliding planes perpendicular to the surface.

Similarly, a tree experiences downward pressure at the edge of the root-plate, i.e. from its own weight. The greater this so-called normal pressure σ_n is, the greater is the shearing strength of the soil and the smaller the risk of windthrow.

The shearing strength τ of the soil is proportional to the pressure σ_n on the shear faces:

$$\tau = \sigma_n \tan \phi + \tau_o$$

This equation expresses *Mohr-Coulomb's Law,* which we discussed in the last chapter. In it, ϕ is the so-called 'friction angle' and τ_o a measure of the adhesion between the soil particles. This natural adhesion gives some shearing strength to the soil, which can to some extent resist a slight tensile load caused by wind forces, even without the additional effect of the weight of the root-plate. However, Fig. 54 shows that in such cases the soil is less strong on the windward side and that soil cracks can eventually form here, as the process of windthrow is initiated. The tree counteracts this tendency, since it can respond to the mechanical stimulus of one-sided loading by forming thicker and longer roots on the windward side, on the uphill side of trees on slopes or on the upper side in the case of a strongly leaning tree. It is just that the roots are more heavily loaded and in accordance with the *Axiom of uniform stress*, more material is laid down at more heavily loaded sites, in order to equalize the load once more. It's perfectly easy to understand this effect by an analogy with reinforced concrete. If the concrete (soil) is poor, more steel (roots) is introduced in order to increase its tensile strength. In practice, this response has been recently demonstrated by biologists at the University of York and co-workers from the Forestry Commission's Research Station at Roslin (Scotland) who subjected young trees to one-sided wind loading. Thus, theory, experiment and field observation agree very well.

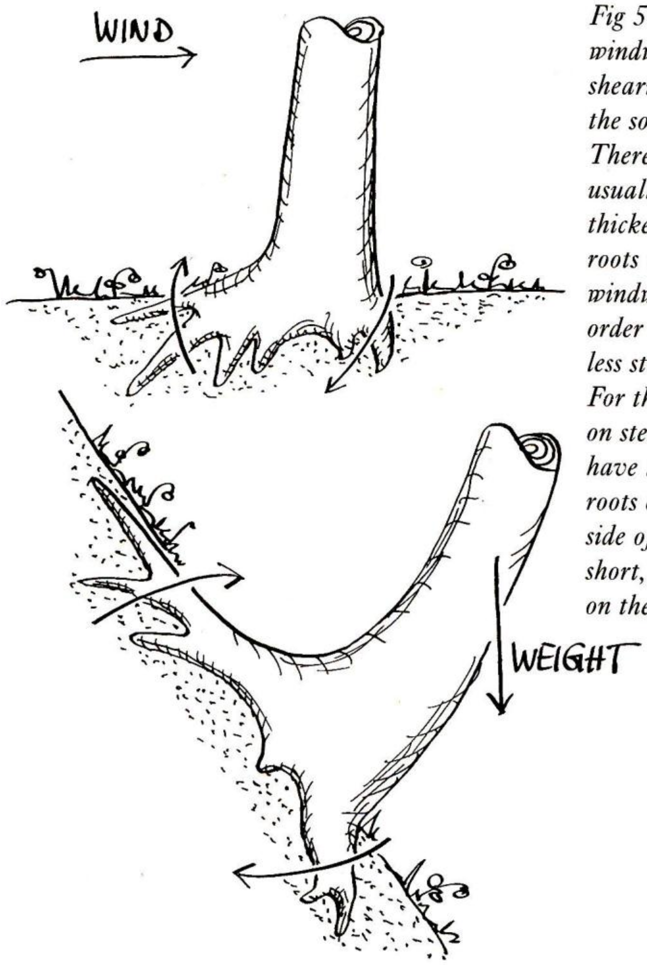


Fig 54. On the windward side the shearing strength of the soil is less. Therefore, the tree usually produces thicker and longer roots on the windward side in order to reinforce the less stable soil there. For this reason trees on steep slopes also have long, rope-like roots on the uphill side of the slope and short, strut-like roots on the downhill side.

As far as pipelines are concerned, it should be borne in mind that they are most likely to be affected by tree roots on the windward side of any trees that they pass, although this may not always apply if other factors affecting root growth (e.g. hydrotropic effects) are involved. With this prior knowledge, several mechanically determined root formations around pipelines can be readily explained.

7.2 THE MECHANICS OF ROOT-PIPELINE INTERACTIONS

7.2.1 The tensioning sling beneath a pipe on the windward side

Fig. 55 shows the principle. The length of root, mainly under tension, only yields a little when loaded and transfers the wide movement of the tree jerkily into the pipe. A plane tree root 10 cm in diameter has a mean breaking load of 42,000 kp. The working load is obtained by dividing this by the safety factor for trees S~4.5, giving about 9,000 kp. So under moderate wind loading there is roughly the weight of 2–3 elephants pulling sideways on the pipe. Not surprisingly, this can produce cracks on the pipe's upper side.

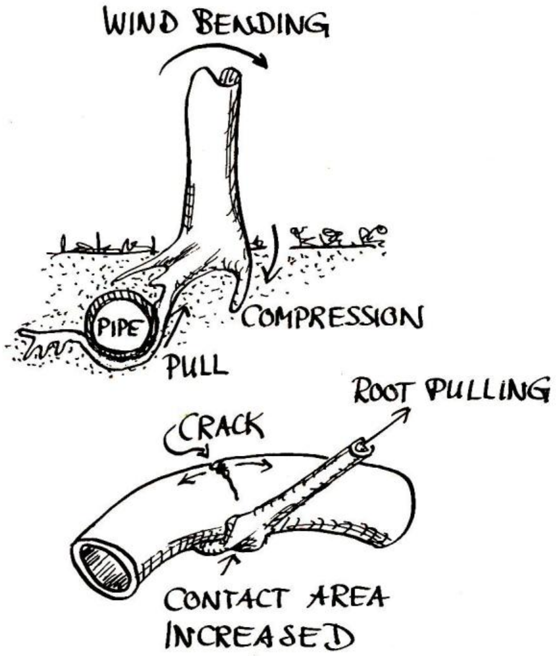


Fig 55. The tugging-cradling root passing under a pipe on the windward side represents, in the authors' opinion, the worst type of interaction between a tree and an underground service. Cracks appear in the upper side of the pipe.

7.2.2 The piston on the lee side pipe

It can be shown theoretically that a root lying on a pipe on the side away from the prevailing wind (lee side) at a distance of 1 m from the tree must be 5 times thicker than the tension sling in Fig. 55 if it is to be much of a danger to the pipe. As Fig. 56 shows, a plate-like root prop forms on the upper side of the pipe, helping to even out the contact stress. The load is not introduced into the pipe here in a jerky fashion but rather as a continuously increasing load with the tree's wind movement, because the partial slackening and jerky tightening of the tensioning sling do not operate here. The tree's movement is damped down more gently and more continuously.

7.2.3 Knot formation at contact points with pipes

The formation of 'knots' (Fig. 57) is probable, particularly where pipes lie side by side or one above another. These are the consequence of contact stresses in the same way as the piston in Fig. 56. The frictional forces which develop around the pipe resulting from the diversion of the

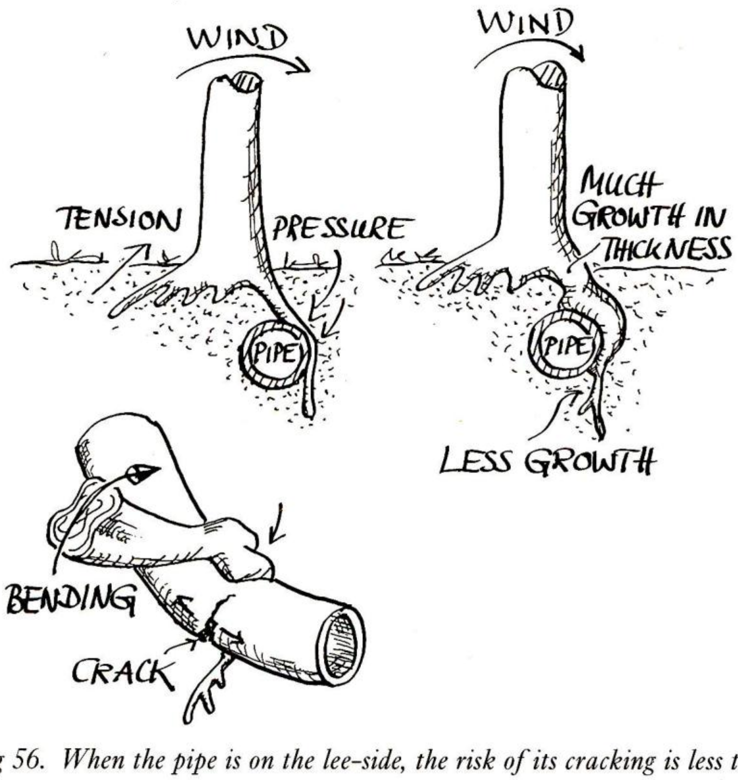


Fig 56. When the pipe is on the lee-side, the risk of its cracking is less than that of a windward-side pipe, unless the roots are considerably thicker than the tugging-cradling root depicted in Fig. 55

roots around it are a possible additional load. After a knot has formed successfully, wedge-type transverse forces develop and these add to the tensile load transmitted by the root.

7.2.4 Trees directly above a pipe

This arrangement is recommended in British Standard 5837, 'Trees in relation to construction' as an alternative to laying the pipes at a 'safe' distance from the tree. In fact, in a side wind the pipe then lies in the neutral pivot of the swaying motion where the soil is neither lifted up on the windward side nor pressed down on the lee side. If the pipe is laid very deep, there might be a moderate lateral pressure. This arrangement deserves sympathetic examination. Things are different where pipes pass under trees that are wind-loaded in the direction of the pipe (Fig. 58). In this case too, there is a risk, albeit a much smaller one, that tension slings may develop on the windward side and pistons on the leeward side. The danger of fracturing is not nil. However, as the trees standing above the pipe one behind the other shelter each other from the wind blowing in the direction of the pipeline, the risk is similarly small. This is another situation where 'knots' can form.

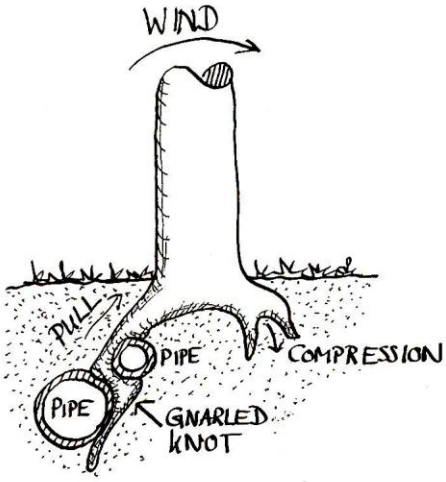


Fig 57. Knots of roots between pipelines can act like wedges, regardless of the way in which the pipes are placed in relation to the tree, though again the snatching load exerted by roots is the most dangerous effect.

7.2.5 Positioning of pipelines; options under current guidelines

In Britain, recommendations for minimum distances between trees and pipelines are mainly intended to avoid excessive damage to existing roots during construction work. We need to ask whether these recommendations, which are laid down in BS 5837, can also help to avoid damage to pipelines which might be caused by roots moving in strong winds. If such damage is to be avoided, the pipeline should preferably not pass within the area of the root-plate. As explained in the previous chapter, the root-plate is the central part of the root system which tilts over or rotates if the tree becomes windthrown.

We can get some idea of the size of root-plates for different sizes of tree by looking at the results of a field study carried out by the Karlsruhe Research Centre in co-operation with the Helge Breloer Bureau (Haren, Germany). In the study, which involved windthrown specimens of all the main native tree species, the radius R_R of the upturned root-plate and the stem radius R just above the root buttresses were measured for each tree. The resulting relationship, based on data from about 2,300 trees, is shown in Fig. 59. We have shown these data together with the minimum distances recommended in Britain and Germany for the separation of trees and pipelines. The German recommendation of a horizontal distance of 2.5 m for all trees – supposedly based on experience – falls well within the range of R_R values, and is therefore obviously too arbitrary to be applied irrespective of the size of the tree. On the other hand, the British recommendation, which varies according to the age and size of the tree, seems to allow an adequate clearance between the pipeline and the root-plate. However, it is worth remembering that R_R values measured after windthrown tend to be an under-estimate of root-plate radius, since some of the anchoring roots generally break off and remain in the surrounding soil.

Recommendations are all very well, but we know that in practice pipelines often pass very close to trees, either because site conditions do not allow sufficient clearance near existing trees, or because tree roots have grown close to existing pipelines. Countless trees would have to be removed if there were strict adherence to the recommendations; even in Germany, where the apparently inadequate distance of 2.5 m applies. In Britain, it is recognised that pipes or cables sometimes have to be laid within the root-plate area. In the case of new plantings, the current guideline of the National Joint Utilities Group is that pipes and cables should be laid within ducts, preferably at least 600 mm deep., which can resist root penetration and which will allow future replacement of the services with minimum soil disturbance. For exisiting trees, BS 5837 recommends the use of thrust-boring for the insertion of pipes and

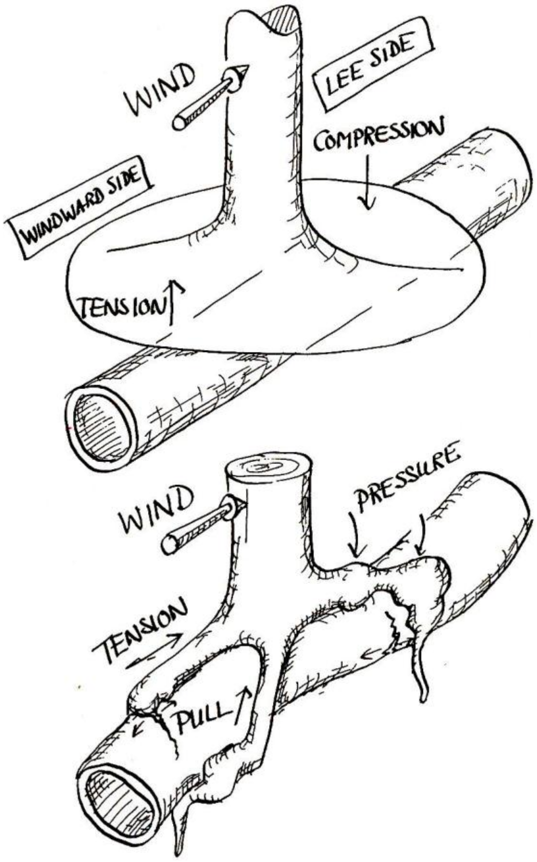
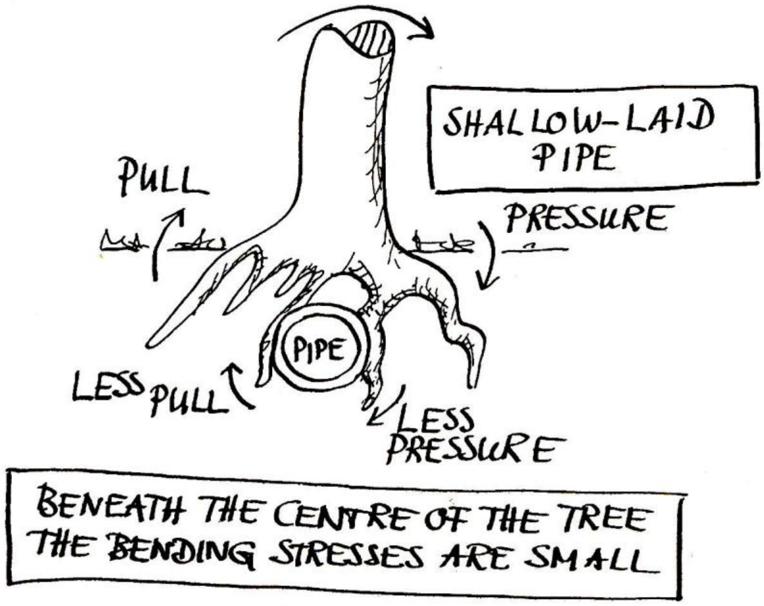


Fig 58. Pipes laid rather shallowly are moderately endangered by trees directly above them if these are subjected to a wind load in the direction of the pipeline.



cables which need to be laid within the protective distance. If this is impracticable, the next best option is to cut a narrow trench radially towards the stem base and to pass beneath the centre of the tree by undercutting a short distance.

As mentioned in section 7.2.4, the alternative recommendations under the British Standards, which allow a pipe to pass directly under a tree, might give such a pipe somewhat better protection from mechanical forces than one which passes a short distance away on the lee or windward side.

7.2.6 An example of damage

In the German town of Viersen, about 13 years ago, the roots of a plane tree began to grow under a gas pipeline which ran past the windward (west) side of the tree at right angles to the prevailing wind direction (Fig. 55). For a decade the tensioning sling formed by the roots subjected the pipe to increasingly strong transverse forces, at a point where there happened to be a welded joint, conceivably of poor quality. This led in stages to the development of fatigue cracks, which resulted in rupture. After this, a combination of many unfortunate coincidences led to an explosion. The accident might never have happened, and would

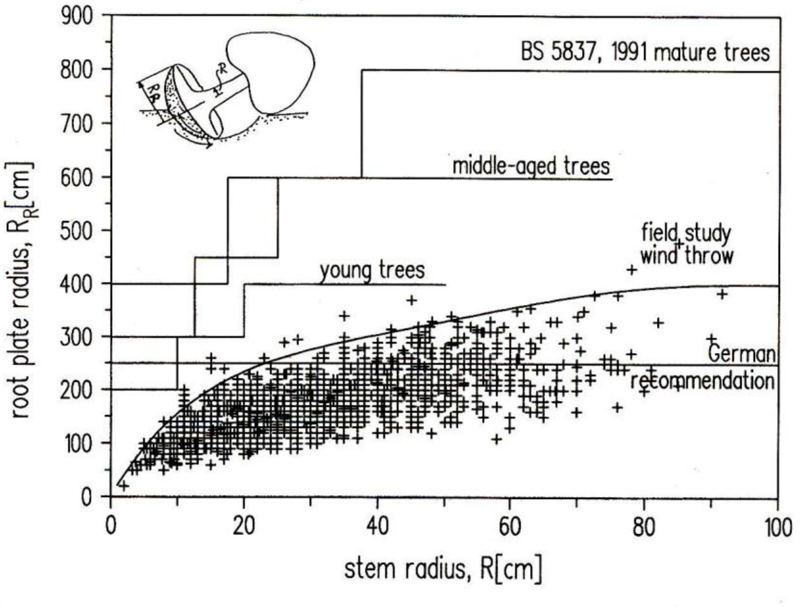


Fig 59. Root-plate radius R_R plotted against stem radius R, as measured above the buttress roots is shown here in relation to root spread values given in BS 5837. The values in BS 5837 include hydrotropic roots that have little or no mechanical role.

certainly not have occurred for many years if the weld had been properly made or/and not positioned above the root sling. Fig. 60 shows the sling of roots in which the pipe lay, a cross-section sawn through the root – from whose annual rings the load history can be read – , and a section through part of the weld in the pipe. The weld has two clear cracks running in the margin of the weld material, i.e. in the so-called heat-altered zone.

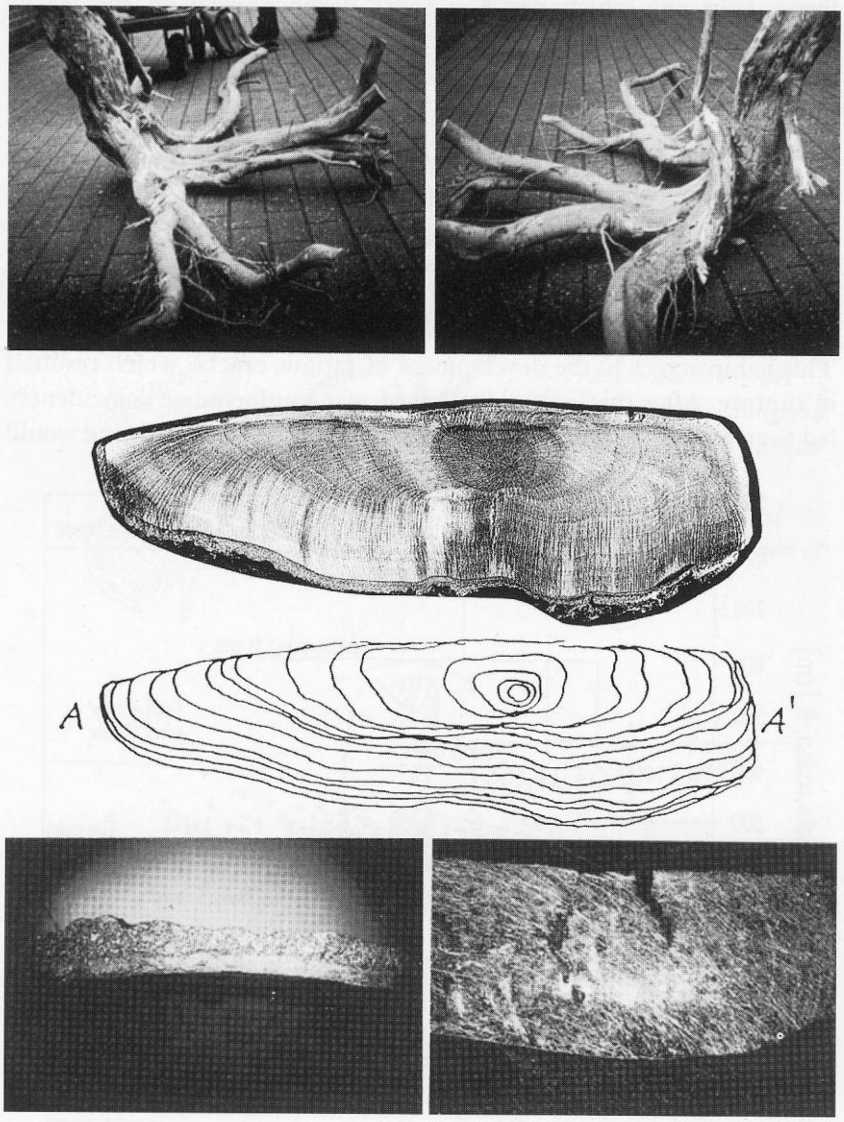


Fig 60. After more than 10 years, the cradling roots were enough to fracture a poorly made welded joint lying above them. The loading history can be read at the saw cut. The poor weld is clearly recognizable.

It was an unequal fight. The root continually improved the natural optimization of its configuration in accordance with the *Axiom of uniform stress* while the welded joint deteriorated as a result of material fatigue and the eventual formation of cracks. Similar growth responses were found in the roots of neighbouring trees.

The formation of tension slings or 'pistons', wherever roots meet obstructions like pipelines, is entirely predictable from the natural law that is represented by the *Axiom of uniform stress*. However, the above example, tragic as the consequences were, involved a series of coincidences (not all detailed here) which must be judged very exceptional. Even so, anyone who understands anything about probabilities knows that even the most improbable of events can occur at any time, however rare it might be.

Before this underground excursion amongst roots and pipelines, we examined the various types of mechanical damage that can affect trees above and below ground. This naturally raises questions about the possibilities of avoiding damage and of diagnosing and anticipating risks. In the next chapter we shall see that trees' body language often gives us clues that indicate the presence of internal mechanical defects.

Appendix 2

Curriculum Vitae - Mark Hartley

Education:

1979	UPCA Tree Care Certificate – Pass
1981	UPCA Tree Care Certificate – Credit
1986	Certificate in Continuing Studies Rivett Enterprises (Melbourne)
1987	Cert. Arboriculture AHCS (Melbourne)
1987	Cert. Continuing Education in Applied Arboriculture M.F.Blair Institute of Arboriculture (USA)
1988	Instructors Cert. Applied Arboriculture M.F.Blair Institute (USA)
1990	Certified Arborist Western Chapter - International Society of Arboriculture
1993	Train the Trainer TAFE articulated Advanced Certificate in Occupational Health Management 8627 Advanced Certificate in Training and Development 8628
1994	Palm Physiology Workshop Shigo Trees and Associates - Hawaii Botanic Gardens
1995	Certificate in Tree Biology - Appalachian State University (US)
1997	Certificate in New Tree Biology - Appalachian State University (US)
1999	Certificate III in Scientific Photography-TAFE (NSW)
2000	American Society of Consulting Arborists, Consulting Academy (Qualified to give evidence in the USA court system)
2006	QTRA licensed user
2008	QTRA licensed user update
2009	Diploma of Horticulture (Arboriculture) with Distinction - TAFE (NSW)
2009	TAA Certificate IV - Unity College ACT
2010	Diploma of Horticulture - Hortus (South Australia)
2011	Certificate of training in Advanced Tree Biology: Photosynthesis and Respiration Warnell School of Forestry and Natural Resources (University of Georgia)
2012	Diploma of Arboriculture – Agriplex Training (NSW)

Trade Affiliations:

- Life Member International Society of Arboriculture 1988 -
- Life Member International Palm Society 2000 -
- Life Member of International Society of Arboriculture Australian Chapter 2000-
- Member American Society of Consulting Arborists 2000 - 2005
- Life Member of National Arborist Association of Australia 2003 -
- President National Arborist Association of Australia 1988 – 1992
- Board member National Arborist Association of Australia, 1998-2001 and 2003-2011
- Education Chair Arboriculture Australia (formerly NAAA) 2003-
- Committee member ISA NEC and Awards committees 2009 -

Awards:

1995 Professional Consulting Arborists of America,
International Arborist of the Year

1996 Winner of the National Arborist Association's Grand Award for
Excellence in Arboriculture - Transplanting

1997 Winner of the National Arborist Association's Award of Distinction for
Excellence in Arboriculture - Transplanting

1997 Winner of the National Arborist Association's Award of Distinction for
Excellence in Arboriculture - Tree Pruning

1998 Winner of the National Arborist Association's Grand Award for
Excellence in Arboriculture - Transplanting

1999 Winner of the National Arborist Association's Award of Distinction for
Excellence in Arboriculture - Transplanting.

2003 Winner of the Tree Care Industry Association's Award for
Excellence in Arboriculture - Transplanting.

2009 South Western Sydney Institute of TAFE
Award for Academic Excellence- Diploma Horticulture (Arboriculture)

2009 TAFE New South Wales
State Medal - Diploma Horticulture (Arboriculture)

2011 **ISA Award of Merit -** This is the highest honour bestowed by ISA. It recognizes outstanding meritorious service in advancing the principles, ideals, and practice of arboriculture

Training Experience

1987- current. Presenter at various industry events including for Arbor Education Services, International Society of Arboriculture, and Arboriculture Australia

2003- current. Education Chair of National Arborist Association of Australia and the new merged body Arboriculture Australia.

2008- current. Part time TAFE teacher delivering Cert III, Cert IV and Cert V classes

2009- Chaired the committee for development and feedback to Agrifood on the arboricultural training Package including writing a number of new unit guides and reviewing many others

2010- Chaired the Arboriculture Australia Education Summit to facilitate the unpacking and roll out of the new arboricultural training package and to provide feedback and guidance to RTO's on the delivery of the new package

Work Background:

Mark is a second-generation arborist. He started working in the family business Arbor Tree Service in 1979. In 1986 he started a business in competition trading as The Tree Doctor. In 1990 he purchased the family business and amalgamated it into the general operations of The Tree Doctor.

Mark developed a passion for arboricultural study and was fascinated by tree roots and in particular their responses to construction injury and post-transplant response.

Mark undertook an ongoing program of education and research involving regular trips abroad as well as sponsoring international speakers to Australia.

His reputation as a palm expert resulted in him providing consultancy services in the UAE to the Royal Family. His reputation in tree transplanting has taken him to 7 countries in 3 different continents.

He has been involved with more than 45,000 transplants worldwide, each varying between several hundred kilograms to several hundred tonnes in weight. His reputation and expertise has seen him work on major projects such as San Diego Zoo; Disney Land - Hong Kong; Wynne Resorts, Las Vegas and the Olympic Stadium Sydney.

Mark has given evidence as an expert witness in the Local, District, Land and Environment, and Supreme courts of NSW and serves as a court appointed expert for the Land and Environment Court of NSW.