ARBORICULTURAL ASSESSMENT

For

FRIMLEY PARK

PREPARED BY

PAPER STREET TREE COMPANY

MANAGEMENT RECOMMENDATIONS

REPORT COMMISSIONED BY: Hastings District Council

REPORT DATED: 26.08.21

PROPOSAL: To provide arboricultural management recommendations

EST. PS 2013

ARBORICULTURE CONSULTANCY

Contents

Attachments

EXECUTIVE SUMMARY

The site survey recorded 123 items for management and monitoring purposes. The 123 trees recorded are estimated to have stored around 1,986 tonnes of carbon (which would be worth $74,582) and have intercepted (prevented runoff into streams and rivers) 536m^3 of stormwater annually.

Overall the trees recorded are in good condition and have been well maintained. The majority of works recommended from this assessment would be best described as typical maintenance with further suggestions to support management efficiencies.

Three trees are proposed for removal. Two are small and almost dead standing. The other is a mature tree standing in a state of irreversible decline.

Recommendations are made to support sustainable management practices to improve tree longevity and management efficiencies for a valuable tree resource.

Richie HIll

1 INTRODUCTION

1.1 I have been engaged by Hastings District Council to provide arboricultural management recommendations for Frimley Park and for the parcel of Council land that stands on the corner of Frimley Rd and Pakowhai Rd in Hastings.

1.2 The recommendations are based on; site observations and survey details carried out between April and May of 2021.

1.3 The purpose of this report is to summarise those findings, build on existing strategies and provide recommendations to support sustainable outcomes for the park.

1.4 ***Layout of the assessment***

The report is set out as follows:

2. Performance summaries of trees captured

Summarises the survey information.

3. Risks and management opportunities

Processes the site information and identifies risks and management opportunites.

4. Recommendations

Provide recommendation options based on the analysis.

5 Sustainable Development Goals (SDGs)

Assessing the recommendations against relevant SDGs.

1.5 *Assessing information to achieve objectives*

Street Tree Company Ltd (PS) supports the Sustainability Development Goals (SDGs). The Sustainable Development Goals provide a framework to build greener, stronger and more resilient societies.

1.5.1 There is a growing body of research documenting the benefits of the close integration of trees with society. These include buffering heat extremes, slowing rainwater runoff, reducing air pollution, sequestering carbon, and improving human health and wellbeing.

1.5.2 Competing land needs, management activities, development intensities, and climate change place increasing stresses on trees being able to deliver these benefits. This is at a time when there are growing public aspirations for more trees, not less. Therefore, adaptation, collaboration and partnerships across external and internal disciplines are essential to improve the sustainable management of the urban tree resource.

1.5.3 Therefore, the SDGs provide a measure to ensure recommendations allow pathways to meet that end, to build greater resilience within the urban ngahere

SUSTAINABLE DEVELOPMENT GOALS

"Sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The site is a premier park for the region and contains a number of large mature trees with notable and historical characteristics.

2.1 *Site survey methods*

The purpose of this assessment was to check all trees within the designated areas (section 1.1) and capture trees that require management action or discussion. Risk management (ISO31000) and asset management principles (ISO55002) underline PS management recommendations set against the SDGs. The site survey recorded 123 trees (shown below).

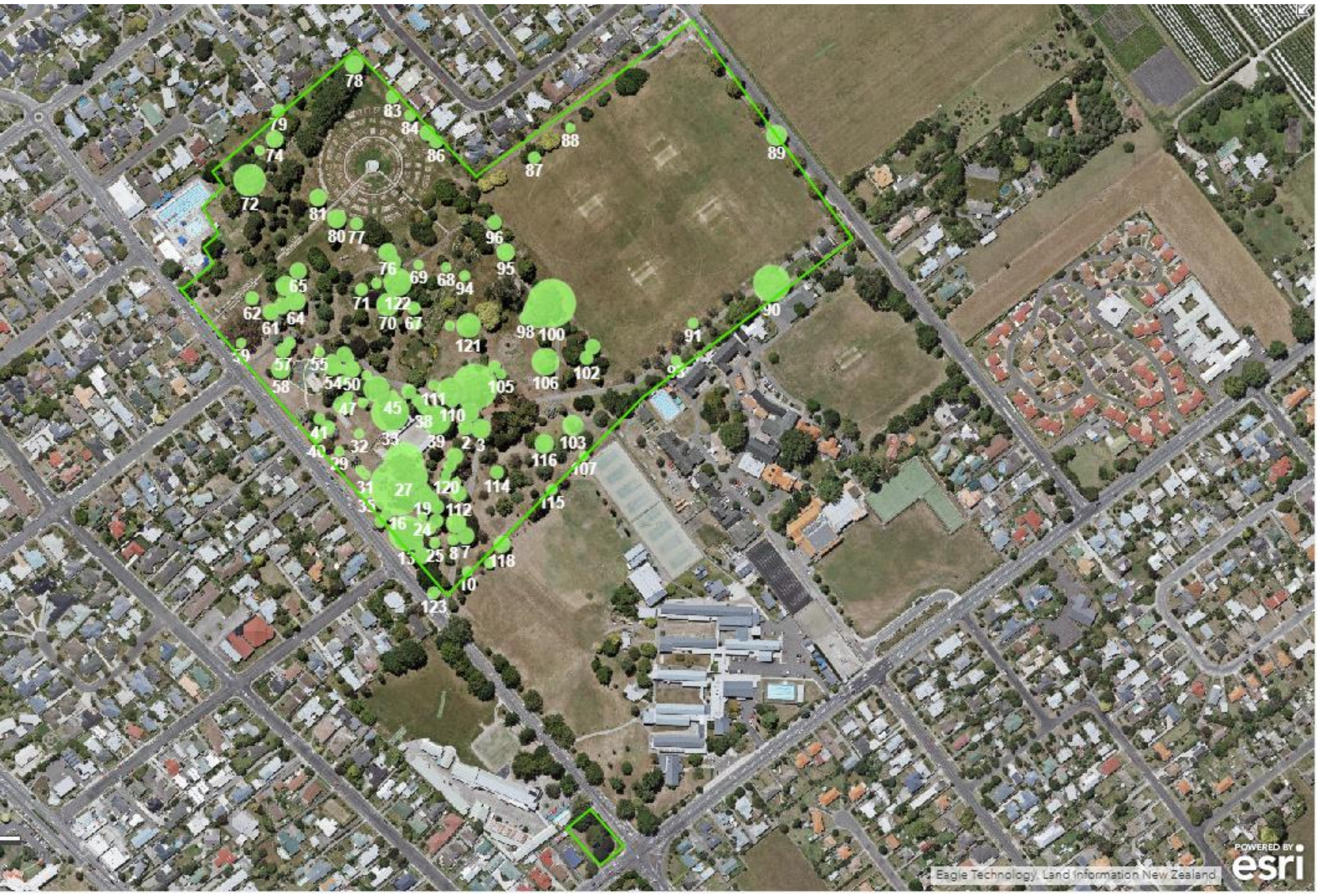


Fig.1 highlights trees captured. The size of dots reflects the ecosystem service value of the trees (Based on canopy and trunk volumes m^3). Green borders show areas where checks were carried out.

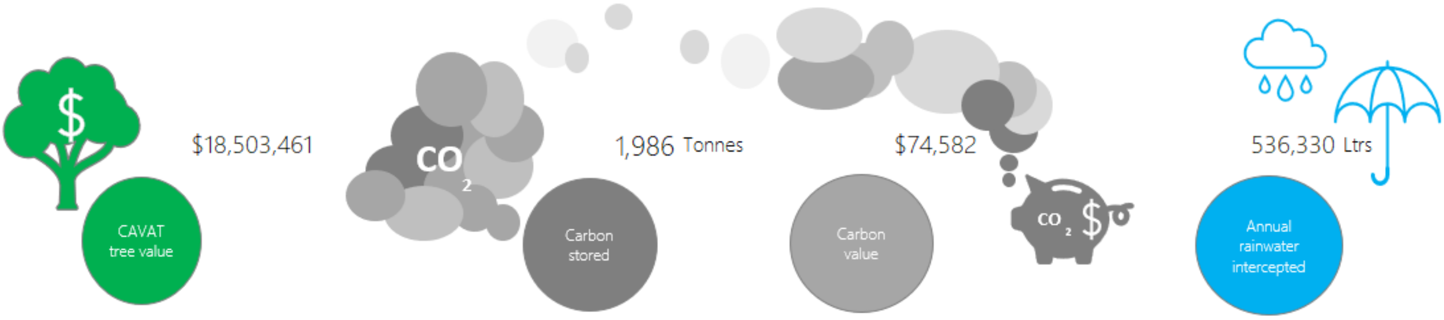
2.1.1 Specific site survey details can be viewed in the PS Excel spreadsheet titled:

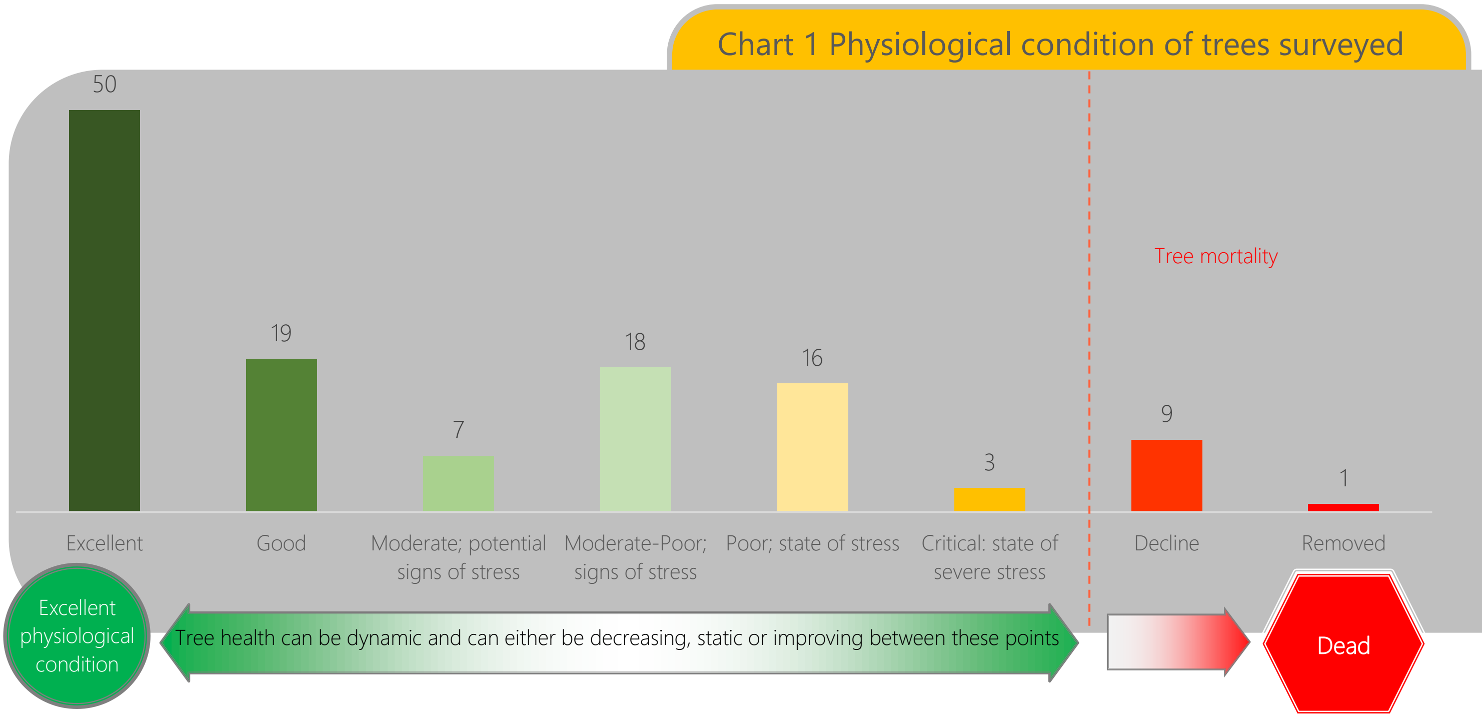
- PS Site Survey Frimley Park 2021

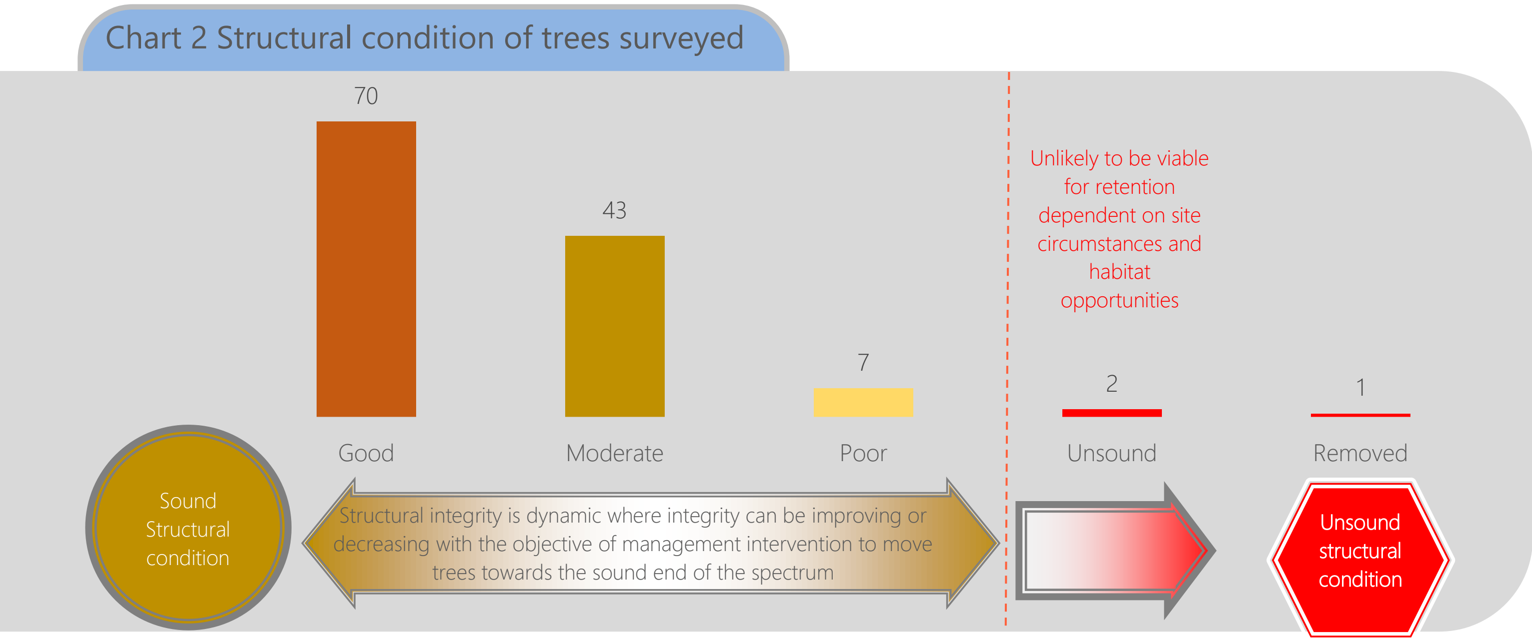
A tree location plan with management works overlaid is included within the spreadsheet.

2.2 *Overview of trees captured*

The current tree benefits, physiological and structural conditions are shown below.







This section summarises the management works and provides management options to reduce, control or remove the potential for an event to occur.

3.1 *Tree risk*

Reducing the risk of harm to people and property will always be a priority, but consideration is given to limit intervention works to allow the retention of trees with realistic potential to contribute to other important objectives such as enhancing ecological diversity, conserving heritage value sustainable management and optimising canopy cover. Further information on tree risk and how it is assessed is provided in Appendix 1.

3.1.1 For there to be a risk, there needs to be a target and a foreseeable likelihood of a failure to occur. The site generally has occupancy in the upper end of the occupancy spectrum; moderate to high (during the site inspections highest daily people count was 264 and the lowest 86). The main area of occupancy was the playground area. The other high public generators observed within site were the main paths, and due to proximity to the school, provide commuter routes (school pupils). Otherwise, people movement was unpredictable and fairly intermitted in other areas of the park.

3.2 *Management recommendations*

Management recommendations are set against six management principles for the 123 trees recorded:

- Risk of harm (18 work items)
- Risk of damage to structures (1 work item)
- Risk on asset performance (83 work items)
- General tree management (14 work items)
- Management discussion (3 items)
- No management works required (4 items)

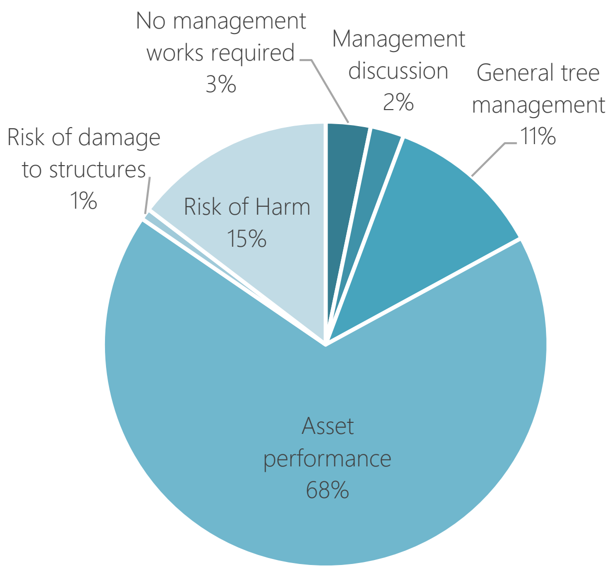


Chart 3. Allocation of works prescribed based on the management principle

3.3 *Nature of the management works*

In general, the extent of the management works is to remove hangers, deadwood and reduce limbs/trees to increase safety factors for trees/parts that show mechanical weakness. These works will not drastically alter amenity or environmental values and would be best described as works that the council carries out on a regular basis. Therefore, the spreadsheet should be referred to for further reading for specific management recommendations for these works.

The following section discusses the wider management issues, heritage trees and the impact on short-term and long-term landscape value.

Tree loss has the most significant impact in the short term, and three trees are proposed for removal highlighted in the map below

Fig.2 Aerial image of trees proposed for removal with average canopy spreads to indicate tree size

3.4 *Trees proposed for removal/future tree loss*

Three trees are proposed for removal (trees 31,77 and 107):

- **Tree 31**

  A Juvenile beech tree (*Fagus sylvatica)* (fig.3). The tree is in decline, and significant mechanical wounding is present at the base. The tree is located adjacent to Frimley Rd and is a good planting location for a feature tree. Remove and replant.

- **Tree 107**
- Almost dead standing Pseudopanax. The tree is located on the boundary of the school. Remove and replant (fig 4).

Fig. 3 Tree 31

Fig. 4 Tree 107

- **Tree 77**

  Tree 77 is a fully mature beech tree. Giant meripilus (*Meripilus giganteus*) at the base, a number of fruiting bodies have been removed or sprayed. Dieback throughout the canopy, the recent removal of adjacent beech has also occurred due to decline. *M. giganteus* has a common fungal association with beech. It can act as a parasite and, in most cases, likely signify root disturbance. Probing with the root spear found little to no root activity north of the tree's base and soft roots to the south.   Reduction in vitality indicates a significant reduction in tree function that would inhibit adaptation to loss of structural stability at the tree's root plate. However, the tree is of a large grith that has developed a broad buttress root system to provide a degree of stability, and the decreasing canopy would reduce loading at the base. But considering the fungus involved and the tree's condition, a reduction would be required, which would further deplete the tree's ability to react and likely accelerate the speed of deterioration (Figs. 5 & 6).

Fig.5 Note canopy decline in subject tree (pictured centrally) and the beech to the trees to the right

Fig.6 Giant meripilus highlighted in white. Chemical management has resulted in other fruit bodies being killed (highlighted in yellow). Giant meripilus, as its name suggests, has a sizeable fruiting body. If the area was not extensively sprayed, early identification of the fungus would have occurred. As the tree has a large root plate, the tree is fairly stable, but if the root plate was smaller, it would likely have failed.

Fig. 7 Area after spraying has occurred, all fruiting bodies killed hiding the significance of the structural loss.

3.4.1 Future likely tree removal (within 10yrs)

Three trees (Trees 80,81 and 96) are likely to be in a state of irreversible decline due to biotic agents (cypress canker (trees 80 and 81) and phytophthora (Tree 96)). It's likely that these trees will require removal within the next 10yrs years due to their conditions. See below for tree locations.

Fig.8 Location of trees 80, 81 and 96

3.4.2 Management opportunities for tree loss

Strategically replant and replace trees to ensure successive canopy coverage. Recommend that the beech tree is left as a high 2m stump for habit creation. Opportunities should be sought where possible to create habitat creation and allow natural processes to take place whilst providing a learning opportunity for members of the public:

- HDC demonstrating leadership in adopting advanced tree management action to support biodiversity
- Education opportunity in how natural processes occur and the importance of those connections – signs etc.

3.5 *Other management considerations*

3.5.1 Chemical damage

A number of trees within the site show symptoms and conditions likely to be attributed to chemical damage (e.g. dieback, burnt tips, defoliation and deformed leaves/needles). Certain trees are highly susceptible to particular chemical agents, causing reductions in health and can lead to irreversible decline if not controlled. In most cases, the declining condition can be reversed by changing the chemical agent used around these trees. It can take a number of seasons for a tree's physiological condition to improve, providing the damage has not exceeded the trees ability to overcome the stress.

The following figure provides some context in the value loss from such works to put it into context.

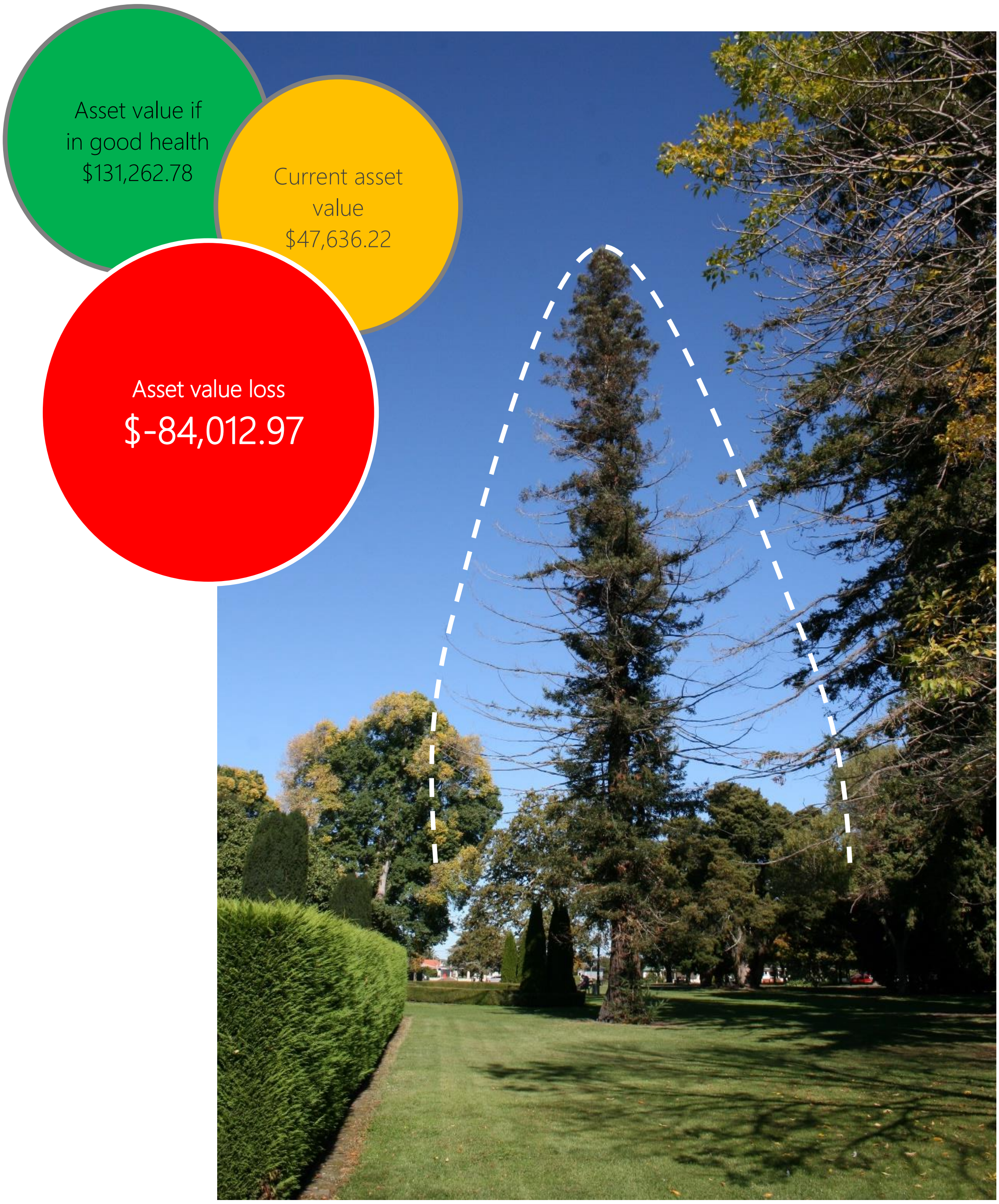


Fig. 9 Highlighting the loss of value from in Coastal redwood. Coastal redwood (Sequoia sempervirens) is a species that is sensitive to chemical damage

3.5.1.1 Management opportunities

- Establish and maintain a herbicide register for HDC parks to prevent further avoidable damage to important park assets.

- Increase and establish mulching schedules/specs for the site – this will facilitate natural processes improving soil quality, water holding capacity, and fungal activity.

3.5.2 Planting

A number of fairly recently planted trees have been planted too deep (see fig. 7)

Fig. 10 Illawarra flame tree (*Brachychiton acerifolius*) the root spear is beginning to detect roots at 20cm below ground level.

3.5.2.1 The tree in Fig. 7 has no future potential within the landscape. Aside from lack of water, planting too deep is the most common cause for unsuccessful tree establishment.

3.5.2.2 When looking at tree stability, broad buttressing, as seen in fig. 5, provides the tree with a stable base. Fig.8 shows no buttressing but a large root not attached to the stem, which will be girded around the root ball. Think of standing with a wide stance and being pushed (stable), then having your feet tied together and then being pushed (unstable). The same happens with trees. Often the defect is not recorded or reported when a tree is windthrown. The defect can take a number of years to occur after the planting event has taken place. See below.

Fig.11 Girdled root on maturing *idesia polycarpa*

3.5.2.3 Examples of girdled root effects

Fig. 12 Image of a girdled root system. These typically form from a tree being containerised to long. Container-grown trees, in most instances, will have gridled roots. But if these roots are not pruned, the above root structure can establish where windthrow is inevitable.

Fig.13 This is an example of how nature has evolved to do it. This is a self-seeded oak (*Quercus robur*). Typically a tree will send a tap root vertically down until it reaches an unfavourable medium, then it sends out horizontal roots primarily near the upper soil horizon as roots need oxygen to function. This creates a far more robust root system.

Fig 14, Effect of a girdled root on a mature Western red cedar (*Toona ciliate)* highlighted in green.

3.5.2.4 Formative pruning

Fig. 15 Tree 69; a young recently planted pin oak (*Quercus palustris)* note the dieback at its apical tip. Dieback is likely a response to transplant shock, but otherwise, the tree is in good health. Apical dominance gives trees their classic conical form; the top bud sends out chemicals to suppress the spread of the lateral limbs. As trees get older, or in certain species, they lose that dominance or have weak apical dominance, and many leaders will form. But when a tree loses its apical dominance during its juvenile stages, then there is nothing to suppress the lower limbs, and poor strucutrues forming. This can be addressed by a few snips of the secateurs and a formative pruning programme durin the juvenile stages.

Fig. 16 However, if left, this is a mature pin oak (Tree 90) that has historically lost its apical dominance at a young age, so it has a very broad canopy. The limb in the front spreads over the access road into the park, and as seen on the limb, there is canker and evidence of bulging and reactive growth, which shows there is likely an abated split in the limb forming a mechanical weak point. As the limb extends, the load at this point increases and failure is foreseeable. To remediate this will take three arborists, a truck and a chipper and around 5hrs to prune. Whereas in its juvenile stages, it would have taken one arborist 5mins to prune. This is to highlight that investing in pruning training and establishing formatively pruning specs will lead to greater long term savings and improved trees structures. Additionally, improved structures reduce the likelihood of limb failure.

3.5.2.5 Management opportunities

- Provide education and training for the staff who are responsible for pruning and planting.
- Continue to work and foster strong relationships with nursery providers. Consider developing growing specifications for the nursery and have trees preordered to ensure quality.
- Develop a formative pruning, planting and aftercare programme to improve return on tree investment.

3.6 *Development works*

Development works and disruption to roots has taken place within site for:

- Installation of the water and treatment plant
- A concrete footing for a fence
- Footpath renewals
- Storage of spoil

3.6.1 Tree protection is difficult to administer without an established set of rules, enforcement and competent arboricultural practitioners to provide appropriate guidance. But it needs to be acknowledged that damage as a result of lack of contractor care, leads to additional community costs and loss of amenity and environmental values whilst increasing carbon footprints.

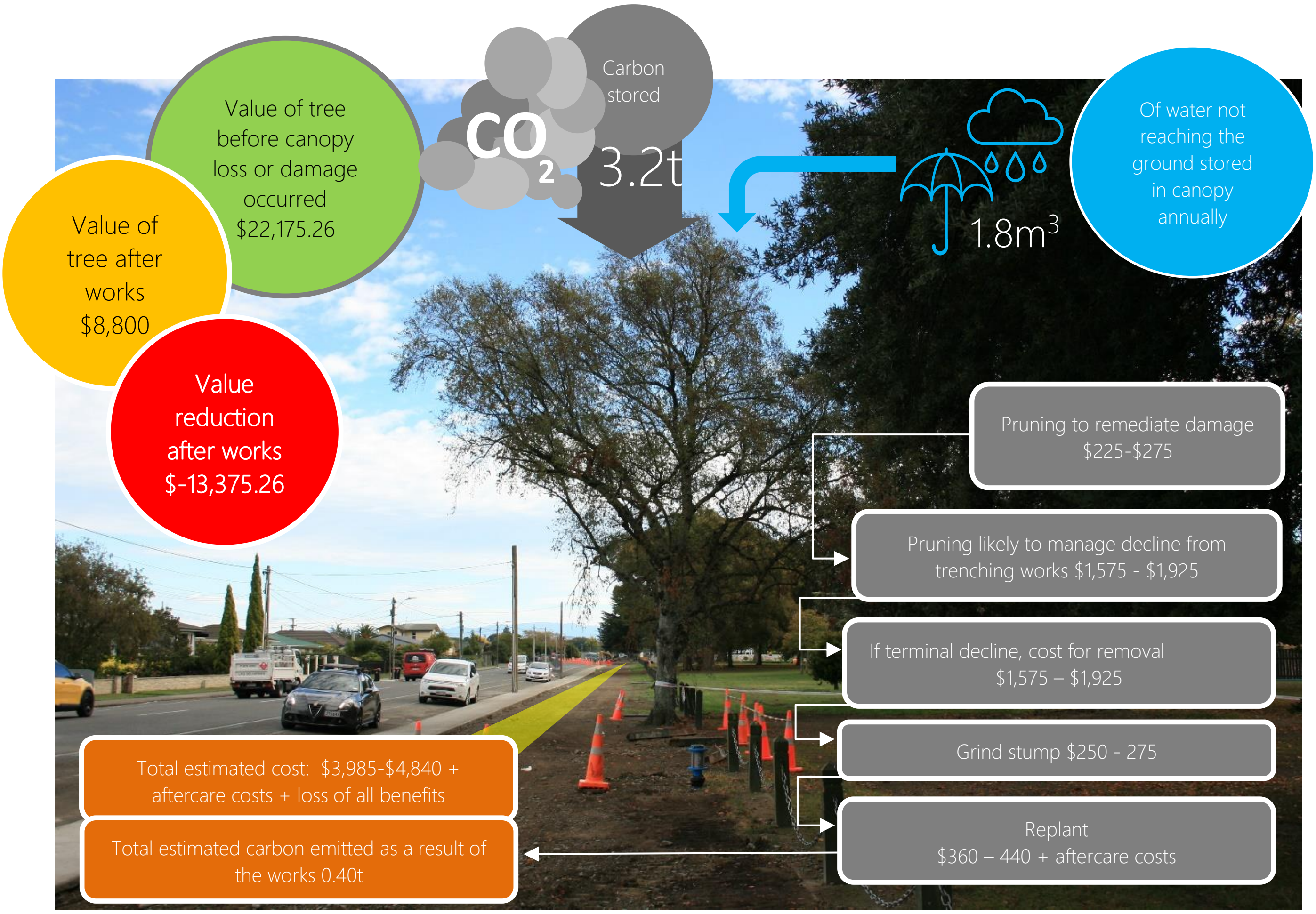


Fig. 17 Shows trenching works (highlighted in yellow) past a silver birch tree (*Betula pendula*).

3.6.2 Fig 13 is a good illustration of the likely creation of additional costs from lack of contractor care. HDC provided clearance for the works, but canopy damage is apparent. This is the visible part of the damage; the root system responsible for nutrient uptake and stability is also likely to have been damaged during the works, which could lead to irreversible effects.

3.6.3 Another example of damage is shown below of contractors working on behalf of the school installing a strip footing along the southern boundary for a fence. The lack of flexibility in design has resulted in damage and loss of roots at the structural root plate for a 30m Ponderosa pine (*Pinus ponderosa).* The pine currently stands in good health, but it is not fully clear the extent of the damage, but as with the example in Fig. 13 it’s almost impossible to reverse this sort of damage after the event.

Fig.18 Root damage by contractors installing concrete strip footing adjacent to base of 30m *P. ponderosa*

3.6.4 Below is the works to repair the pavement over a willow that stands adjacent to Lyndhurst road. Willow as a species are not effective compartmentalisers. Therefore, any disruption or debarking of its roots will allow entry points for decay and its spread. The tree is currently in good health and is likely to tolerate the disturbance, but solutions are needed to avoid unnecessary damage. Tree mortality for most species occurs due to the environmental stress to which a tree has been subjected. Increasing environmental benefits and often leads to more planting, but it can be more cost-effective to look at processes and solutions to safeguard existing assets, which also protects any new plantings to ensure net environmental gain is achieved for each tree asset.

Fig.19 New section of pavement within root zone of willow

3.6.5 A number of development works have been carried out within the site. Root disruption can lead to tree decline and death.

3.6.6 There is also evidence of root distruption from the scrapping and storing of soil within the immediate root zone of a mature totara (fig 16). Totara can be quite fickle in terms of the withstanding tolerances to root disruption. Often root damage can correspond to dieback above/adjacent to the area where root disruption has occurred, as can be seen in fig 16.

Fig.20 Build-up and scraping of soil at the base of totara, corresponding with canopy dieback

Fig.21 Close up of the damage. The extensive build-up, damage and debarking of a rare *Picconia excelsa* (left of image) by depot.

3.6.7 One of the survey outputs is for tree protection distances. This is an effective measure that highlights when careful consideration and care is needed if working within the vicinity of trees. If trees are considered at the initial design phase, this can lead to far improved long-term outcomes.

3.6.8 <u>Management opportunities</u>

- One of the barriers to tree protection being effective is the lack of education, and how certain works cultures view trees (e.g. contractors and engineers).

- Tree protection can be successfully administered if carefully considered. This can only be achieved through collaboration with all affected parties to create effective, pragmatic solutions. This has benefits that reach beyond Frimley Park, and can lead to improved cost savings and improved tree retention, environmental and wellbeing values.

3.7 *Heritage trees*

The following table provides comments and management recommendations for trees designated as notable heritage items. The Frimley poplar is not part of this review and is subsequently not included within the following table.

Notable tree reference	Species	Common name	Comments	Management recommendation
T44	Banksia integrifolia	Coast banksia	Planted by Mr Williams. The larger of two Banksias one on either side of the main entrance from Frimley Road'. The other tree has died; this is the remaining tree of the two.	
T45	Eucalyptus sideroxylon	Red iron bark	Planted by Mr Williams. Splayed form developed from historic failure	Reduce southern limb by 2m, reduce north-eastern limb by 2m and reduce northern limb by 3m
T46	Cinnamomum camphora	Camphor laurel	Multi-stemmed. Consisting of four stems. Dieback of bark on the upper side of stems from inclusion likely to be from historic separation from downward loading. Form suggests a possible transition to retrenchment life phase, or reaction to environmental stress. Dieback restricted to western canopy	Remove hanger from western canopy and deadwood above. Remove hanger in the lower eastern canopy and reduce western upper over-extended limb and deadwood. And top up mulch, and spread as far as practical from the tree's base.
T48	Casuarina cunninghamiana	She oak	Planted by Mr Williams. Bench beneath tree with dead hanger stuck above seat.	Remove deadwood over seating area
T49	Crataegus x lavalleei	Lavelle hawthorne	Planted by Mr Williams. This tree was badly affected when the homestead on the Williams farm burned down. There are still visible reminders of this damage. The Lime trees mentioned in Burstall's list have been removed, but the tree is still one sided'. Looij 1986. 'This cross was made in France in 1870 and therefore must be among the first of the species planted in New Zealand'. Duthie 1993. Support for upper north spreading limb historical removed limb partial failed supported by lower limb. Overextended limb north.	Establish a herbicide register and spread mulch to the extent of the dripline. Reduce northern spread between 1.5m and 2m.

Notable tree reference	Species	Common name	Comments	Management recommendation
T50	Quercus rubra	Red oak	Notable tree Planted by Mr Williams (Williams family gifted Frimley Park to Council). Currently the biggest red oak by girth recorded in NZ. Dieback in central stem. Not an uncommon characteristic for species	Change mapping location (to 176.831559, -39.624296) as tree has been incorrectly located. Preclude parking around tree base, spread mulch for as far as practicable. Tree is the largest of it's species recorded in NZ
T52	Photinia serrulata	Chinese photinia	Planted by Mr Williams. Deformed leaves and reduction in tree health likely to be a result of herbicide damage.	Establish a herbicide register and spread mulch as far as practicable around the base.
T53(a)	Ulmus procera	English elm	Planted by Mr Williams. Historic loss of north stem. Ground disruption near base from infrastructure works.	
T53(b)	Ulmus procera	English elm	Planted by Mr Williams. Historic loss of large limb spreading north. Ground disruption near base from infrastructure works.	
T53(c)	Ulmus procera	English elm	Planted by Mr Williams. Loss of significant limbs from southern canopy leaving a large overextended limb. Ground disruption near base from infrastructure works.	
T53(d)	Ulmus procera	English elm	Planted by Mr Williams. Overextended stems are spreading southwest. Ground disruption near base from infrastructure works.	
T53(e)	Ulmus procera	English elm	Planted by Mr Williams. The southern upper canopy exhibits five failures, all located adjacent to each other; loss of failures occurred mid-stem with no visible defects above attachment points likely related to overextended limbs. The tree is a double stem with a bifurcation at the base. Ground disruption near base from infrastructure works.	Management discussion to manage species characteristics in the long term
T53(f)	Ulmus procera	English elm	Planted by Mr Williams. Multi-stemmed specimen (3). Northern stem reduced over yard, and the eastern ascending stem has also had some reduction work carried out. Ground disruption near base from infrastructure works.	
T53(g)	Ulmus procera	English elm	Planted by Mr Williams. Heavily pruned western canopy over the yard. Significant limbs removed. Inclusion at base bifurcated union with bacterial wetwood oozing on the southern side form union. The stem has been reduced and defect managed. Ground disruption near base from infrastructure works.	

Notable tree reference	Species	Common name	Comments	Management recommendation
T55	Pinus coulteri	Big cone pine	Planted by Mr Williams. The tree has had a substantial amount of its lower canopy removed. Pruning wounds appear to be fresh and the tree exhibits a reduction in needle density. Removal of the lower canopy reduces the tree's ability to dissipate loads and increase loading at the lower part of the stem. Additional limb loss may occur, and given its current state and reduce leaf area further decline is likely. Quite often, old pines will shed large limbs and increase in vitality. But assessing the it's current state this may not be likely in this instance	Establish a herbicide register and spread mulch as far as practicably possible around the tree's base. And monitor to check for any further reduction in health and if any further intervention can be made.
T56	Cryptomeria Japonica	Japanese cedar	Planted by Mr Williams	Top up mulch around base
T58	Quercus ilex	Holm oak	Planted by Mr Williams. Eastern ascending stem separated from bifurcation and stabilised.	Reduce eastern limb by 2m, and reduce in any adjacent limbs so as not to leave any protruding limbs light canopy lift secateurs only
T59(a)	Brachychiton populneus	Kurrajong	Planted by Mr Williams. Rare tree for region	
T59(b)	Brachychiton populneus	Kurrajong	Planted by Mr Williams. Rare tree for region	
T60	Aesculus hippocastanum	Horse chestnut	Planted by Mr Williams. Decay cavity at the base. Rabbits, currently burrowing under, and into the cavity, are controlled, which is essential as rabbits are likely to be debarking woody material within the cavity. Ganoderma bracket present at buttress into the cavity. Tree in good health with good reactive growth.	Inspection of buttresses and if any decline is noted in next inspection.

3.7.1 Management opportunities

In addition to the above trees the following trees should also be considered due to their notable characteristics. Standard Tree Evaluation Method (STEM) score included within table, explanatory notes for STEM scores attached as Appendix 2.

PS tree id ref	Spieces	Common name	Comments	Management recommendation	STEM score
T33	Ulmus procera	English elm	Largest English elm recorded nationally and fourth largest recorded English elm in the world. Large historic failure of central stem. Failed bracing evident in eastern canopy (hanging in tree). Brace on western canopy still present, viewing from the ground appears to be tight.	Add tree to notable tree list	201
T100	Ulmus glabra	Wych elm	The tree would represent one of the first trees planted within site and is currently the largest recorded specimen nationally.	Remove/make safe any deadwood that poses a risk to path users.	219
T50	Acer buergerianum	Tridet maple	Largest recorded specimen nationally and possibly internationally. Minor deadwood overhanging toilet entrance	Remove deadwood from above toilet entrance	195
T5	Picconia excelsa	Canary Island laurel	Rare nationally and likely to represent the only group of trees within one site nationally. Decay column on eastern stem from a historical failure	Remove or make safe deadwood that poses a risk to public	171
T34	Picconia excelsa	Canary Island laurel	Rare nationally and likely to represent the only group of trees within one site nationally. Included union base not uncommon for species no separation of the canopy to indicate any foreseeable failure.	Remove deadwood and top up mulch in garden bed	177
T37	Picconia excelsa	Canary Island laurel	Rare nationally and likely to represent the only group of trees within one site nationally	Prevent stockpiling of spoil around the base. Spread mulch as far as practicably around the base.	153
T52	Picconia excelsa	Canary Island laurel	Rare nationally and likely to represent the only group of trees within one site nationally. Historic failure of central stem, pockets of dieback included unions large lateral spread southwest spread noticeable dieback. Ganoderma feeding off decay in failed stem	Overall reduction to manage high loading of lateral growth and exposed form from central stem failure	153

3.8 *Willow trees along Lyndhurst Rd*

All the trees are in good conditions with no obvious signs of defects where failure would be foreseeable. The trees appear to be once pollarded but appear to be well maintained. One tree is noted for works to remove deadwood over the path, but otherwise, it is recommended that current management controls are continued.

3.9 *Climate change*

Climate change predictions for the region suggest temperature increases and extended periods of prolonged dry weather and decreases in rainfall. These changes will, and can, impact tree health, especially for trees that sit at the edge of their climatic tolerances for drought conditions and seasonal rainfall requirements. Improving soils by mimicking natural processes over time will improve water holding capacity and improve species resilience.

3.9.1 Management opportunities

Looking to improve the longevity of the trees within the landscape is often difficult where space and practicalities restrict the spreading of mulch, but there are opportunities within the park to further increase the spreading of mulch, which to my knowledge HDC are already working towards. This practice will improve long-term tree health and resilience if carried out and maintained.

This section provides the final management recommendations based on the analysis of the tree data.

4.1 *Management works*

4.1.1 Carry out the management recommendations as prescribed in the works programme. All Management works are to be discussed with the operation manager to ensure all works details are understood in terms of works and risk requirements for the next 3yr period.

4.2 *Risk management*

4.2.1 HDC to maintain regular checks throughout the year and after storm events by employees and contractors. The type of check must be a walked visual check looking from accessible viewpoints for obvious defects from a distance and close-up. Should the visual check identify areas of concern, a detailed inspection should be carried out by competent personnel with enough training and experience working with trees to identify obvious and subtle defects and recommend how to manage them.

4.2.2 This regime should be supported by periodic inspection (as recommended in section 4.5) by a suitably qualified arborist with suitable training and experience in risk management. The arborist is to provide recommendations and critically analyse the advice and recommendations received from other tree contractors and arborists for any risks under current controls.

4.2.3 Failures that do not cause harm or damage provide a useful opportunity to identify opportunities to improve the management system and inform further recommendations based on intelligent analysis. Therefore its recommended that a system is established that records the following information:

- Trees that failed and types of failure.
- Date and time when the failure occurred.
- Weather event at the time of failure.
- Any notes images by the contractor on failure.
- Notes on what action was taken and any recommendations.

This information can then be used to inform current and future management decisions and provide a documented account of how the risks are being pragmatically managed

4.3 *Planting and aftercare*

4.3.1 Establish and maintain a public herbicide register. Check all current chemical controls with a specialist who has experience in this area (see section 4.4).

4.3.2 Establish a mulching schedule with clear specs, extending current mulch rings as far as practicable.

4.3.3 Continue to plant with a diverse mix of species to maintain the character of the park. Plant a successive canopy species for notable tree T55. Continue or engage with the community and schools to encourage planting days and connection to place.

4.3.4 Plant to current industry standards, provide training where necessary to ensure current practices are carried out (See section 4.4). Monitor and inspect new plants for successful establishment.

4.3.5 Ensure young trees are formative pruned to current standards, provide training where necessary (section 4.4).

4.4 *Other recommendations*

Run, or discuss with primary parks contractor to engage Cadwallader Tree Consultancy to carry out a herbicide, planting, formative and large tree pruning workshop. Brad is the only practitioner who runs workshops specifically in these areas. Feedback from practitioners who have gone to these workshops has all been very positive and has led to changes within organisations and practices in how these treatments are applied. Additionally, engage Mr Cadwallder to review current chemical controls so any learnings can be directly transferred to the personnel who carry out the works.

4.4.1 Change location of heritage red oak (T50) to 176.831559, -39.624296 on HDC asset register.

4.4.2 Add additional trees to HDC notable asset register.

4.4.3 Consider greater controls/guidance for working within the vicinity of trees during development works and collaboration with engineers and other disciplines internally and external to create practical solutions for infrastructure/development conflicts.

4.5 *Next arboricultural inspection*

Reinspect trees in 3 years.

5 SUSTAINABLE DEVELOPMENT GOALS

This section reviews the recommendations against relevant SDGs to ensure management action promotes sustainable action to protect and enhance the urban ngahere.

5.1 Sustainable development goals

5.1.1 The management recommendations aim to improve asset resilience through intervention recommendations, education opportunities and to support the council in its continual collaboration for management improvements.

5.1.2 If all recommendations are successfully implemented, it provides a basis to support sustainable management practices, which will improve asset resilience and benefit delivery for existing and new trees.

5.1.3 For the recommendations to be successful, it requires partnerships between internal and external members. Workshop recommendations provide an opportunity to upskill and support practitioners on modern practices. This also provides shared learning experiences to create sustainable solutions that can be transferred to other sites.

RICHIE HILL

EST. PS 2013

Attachments

APPENDIX 1 TREE RISK DETAILS

The following information sets out how Paper Street (PS) assesses risk and inspects the trees. The appendix has been divided into three sections so the reader can view the section relevant to their interest:

Part one

This section outlines the background and provides the basis of tree risk management. This is to provide some context to a subject that can create a lot of uncertainty and subjectivity. This section also contains current (at the time of the report) guidance. PS risk management recommendations and strategies are continually reviewed during each project, based on updated information and site specifics. To this end, PS does not use or subscribe to a "risk method" as such methods offer limitations in implementing improvements in assessment processes. It should be noted that risk methods can improve certainty for practitioners with inexperience, high uncertainty, or who are in general risk-averse by nature. Such tools can aid decision making for experienced practitioners for comparative analysis, should such analysis be required.

Part Two

Sets out PS inspection process

Part Three

Provides additional information on PS tools used to facilitate risk analysis.

Part one

P1.1 ***Introduction***

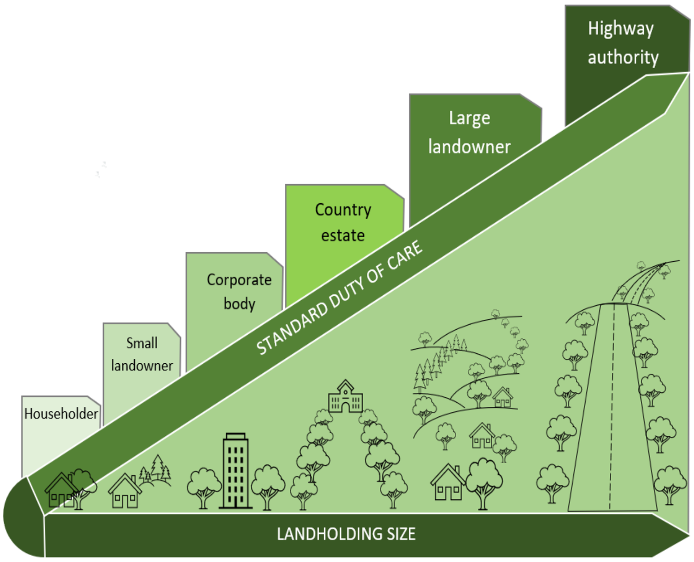
Although trees can be a liability, there is a growing research base documenting the benefits that arise from the close integration of trees with society. Those benefits are many, including buffering heat extremes, reducing heating and cooling costs, slowing rainwater runoff, ecological enhancement, air pollution reduction, carbon sequestration, increasing property values, conserving living cultural connections to the past and future, visual enhancement, and improving human health and wellbeing, to list the most obvious.

P1.2 For communities to make the most of these benefits, trees must be close to where people live and work, so spread evenly across the built environment. Urban trees are most useful when growing alongside roads and other transport routes, close to buildings, in gardens, and throughout urban recreational spaces. Unsurprisingly, there is a strong link between tree size and the number of benefits received. Although the precise relationship will vary from species to species, the amount of benefit is significantly influenced by the three-dimensional crown volume, which is a reliable proxy for leaf area, rather than the two-dimensional area projected beneath the branch spread. This results in an exponential relationship between tree size and benefit delivery, so big trees are significantly more useful than small trees.

P1.3 However, trees are natural shedding organisms. This natural process can lead to potential damage or harm to occur where trees are located adjacent to areas of high occupancy. Within this context, management recommendations need to manage those important community benefits whilst minimising the likelihood of harm or damage occurring.

P1.4 *Legal requirements*

In the civil context, a duty holder carrying out a business or undertaking has obligations under the HSWA, as far as reasonably practicable, to prevent and minimise foreseeable harm or damage occurring from trees that are under their ownership and control. A good way to visualise the level of care from a duty holder is on the adjacent graph (Graph 1)



Graph 1 Duty holder level of standard of care

P1.5 *Risk management*

In the broader management context, risk is defined as the:

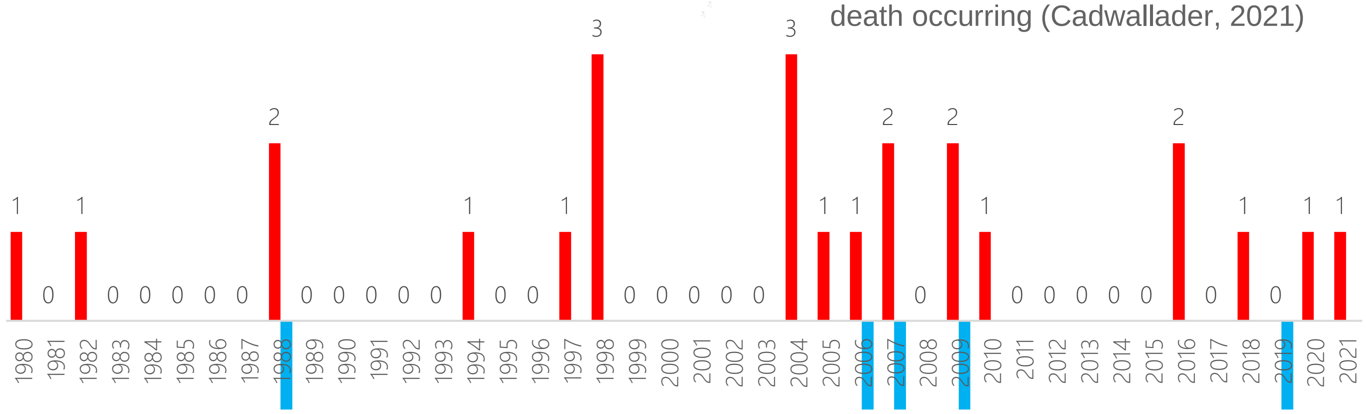
> *"effect of uncertainty on objectives"*
>
> (AS/NZS ISO 31000:2009 and ISO 31000:2018)

The effect is a deviation from the expected (positive and/or negative). As trees provide multiple benefits, action or management could control one risk but adversely affect another objective if the risks are not assessed in context (HSWA).

P1.6 *Perceptions of tree risk of harm occurring*

Before determining the risk of harm, it is important to establish the risks to ensure any guidance recommended is proportionate and reasonable.

Unpublished research currently identifies that over a 41yr period, 25 deaths have occurred in NZ due to a tree-related failure. This equates to around 1:7 million chance of a tree related death occurring (Cadwallader, 2021)



Graph 2: Number of fatalities in the 41yr period. Blue lines indicates when an inquest was carried out. Risk assessment methods introduced; Matheny & Clark (1993), QTRA (2005), TRAQ (2017) and VALID (2019)

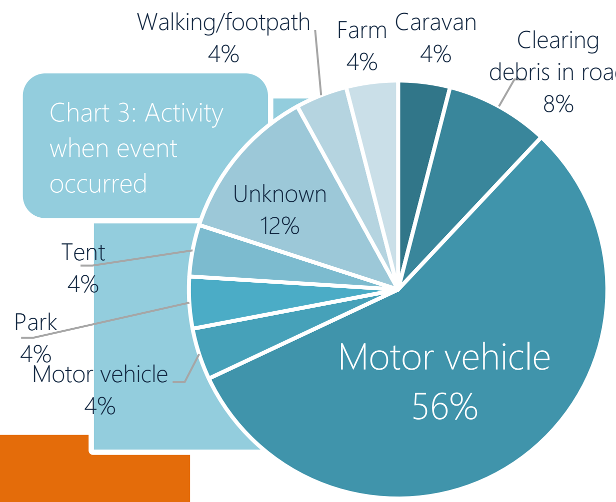


Chart 3: Activity when event occurred

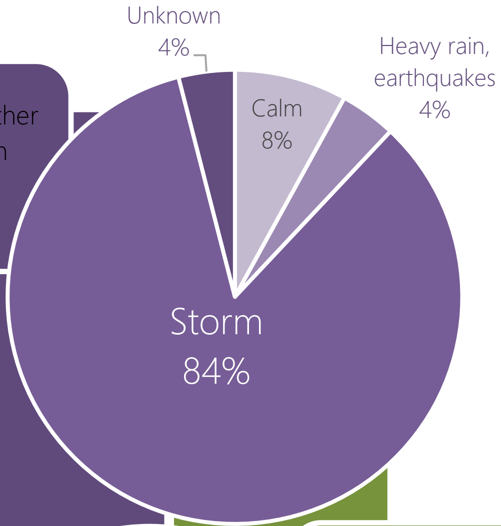


Chart 4: Weather event when incident occurred

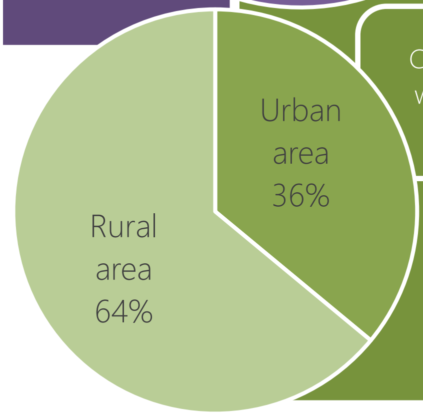


Chart 5: Area where event occurred

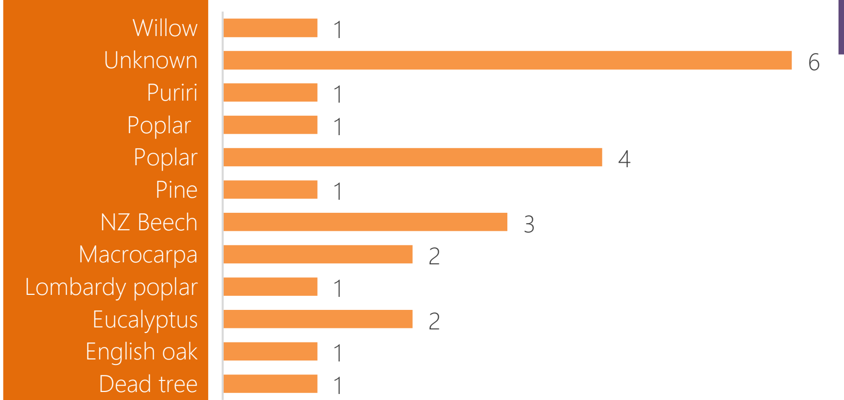


Chart 6: Species that failed

P1.5 ***International statistics***

In Australia, research works carried out found that over 168yr period 280 deaths occurred, equating to a 1:4million chance (Hartly 2019). In the UK, the research identified 64 deaths in a 10-year period equating to a 1:10million chance (NTSG, 2011). In the US, the research identified 407 deaths in a 13yr period, equating to a 1:11 million chance (Schmidlin, 2008). To put that into some form of context, fatalities resulting from driving in NZ over a 1yr period (2019-2020) equated to 1/14 thousand chance. In the absence of having national guidance on risk thresholds, the HSE (UK) classed any risk below 1:1 million as being broadly acceptable, in other words;

> *"the levels of risk characterising this region are comparable to those that people regard as insignificant or trivial in their daily lives" (HSE, 2001),*

This would, in the broadest context, define trees as being very low risk.

P1.6 ***Perception of risk and biases***

The overall risk from trees may be low, but our perception can be strongly influenced by media showing images of limb/tree failures after high wind events (NTSG, 2011).

Fig.2 Image from recent storm in Auckland (03.08.21) RickyWilsonStuff.co.nz

This can influence our perception and can create a strong bias towards risk aversion. Trees are complex, and there are many unknown variables in predicting when a failure event may occur. This can create a lot of uncertainty, even within a tree "risk assessment". The personal bias and experience of the assessor and decision-maker has a greater influence on a risk rating than the tree itself (Koeser,2017). However, it is very important to acknowledge the differences between the broad concept of risk, which as highlighted above is generally low, and the localised potential for risk which could be high. Taking a minimal invention approach, therefore, is highly unlikely to be defendable in the localised context, e.g., a dead tree overhanging a high occupancy area will always be a high risk, not a low one. This could be why we see that only 36% of fatalities happen in urban areas (which are of higher occupancy) as risks are more likely to be proactively managed there.

P1.7 *Calculating tree risk*

Determining failure of a living structure that is constructed of a dynamic material such as wood is an imprecise undertaking. Currently, there is not enough data to reliably calculate tree risk (Matheny, Clark, 2009). As previously mentioned, the perception of risk, acceptance of risk, and an arborist's professional bias and their experience have more influence over the final risk determination than the actual tree assessed (Norris 2007; Koeser and Smiley 2017). This can lead to a wide range of opinions and mixed "risk terminology" and risk methods from arborists;

> *"Unfortunately, consistency (while an important aspect of making risk assessment more reproducible) is not the same as accuracy. Variability in ratings means some portion of the assessments will be inaccurate. However, false precision in a risk assessment method could create a very consistent bias that pulls the perceived level of risk away from the actual level of risk for all who subscribe to the method."*
> (Koeser 2016)

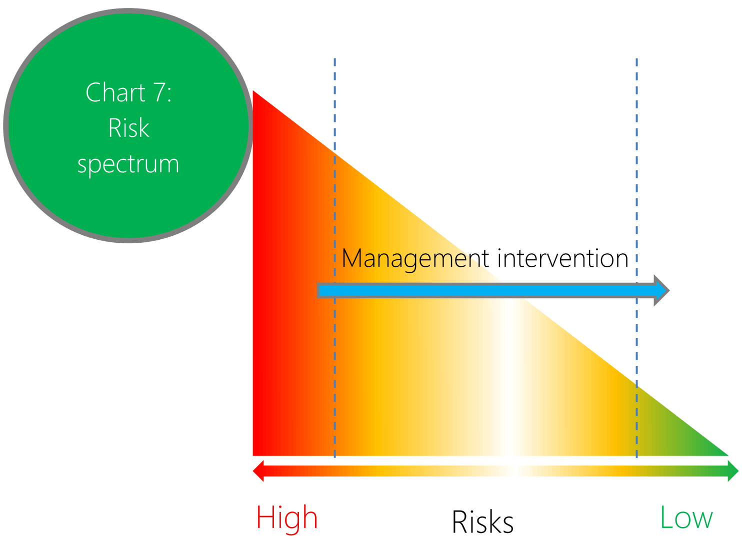
Therefore, the experience and objectivity of an assessor are critical if a proportionate management intervention is to take place.

P1.8 *Identifying a tree risk*

In risk identification risk can be simply expressed as risk = potential events, the consequences, and their likelihood (ISO 2009, 2018). Simply put for trees, for a tree to be considered a risk it would need to exhibit signs of foreseeable failure (Potential Event) standing in an area of sufficient occupancy (Likelihood) where a person is likely to be beneath the weak point when a failure occurs (Consequence). The likelihood of impact occurring strongly correlates to occupancy, and whether a tree exhibits a defect where failure is foreseeable within an inspection period. Therefore, a tree has to have a foreseeable failure within a high occupancy area for it to be a high risk. Conversely, a tree with foreseeable failure in an area with little occupancy would be of low risk.

P1.9 *Taking a tree-oriented approach*

For a decision-maker to understand tree risk is to conceptualise tree risk on a spectrum where risk is either increasing in one direction or the other. It is not possible to pinpoint the level of risk due to each site and a tree's condition being different, but it can be described as sitting on one end of the spectrum or the other. For example, a large tree with a significant defect in a high occupancy area could be described as sitting at the higher end of the risk spectrum and the intention of management interventions would be to shift it towards the lower end (Barrell, 2020).



Part two

P2.1 ***How PS inspects the trees***

Trees are inspected from ground level using binoculars where necessary. A visual criterion is used to assess the mechanical integrity of the trees[1,2]. If a defect is identified that has a foreseeable chance of harm or damage occurring, the tree and all necessary information is captured. Additionally, a sounding hammer is used to aid detection of any extensive decay within the stem buttress zone or bases of roots, should such an investigation be warranted. Trees are assessed in consideration to the weather events to which they would be typically subjected, and the environment in which they stand.

P2.2 All inspections are GPS tracked to provide a record of where the inspections were carried out.

P2.3 Reducing the risk of harm to people and property will always be a priority, but consideration will also be given to limit intervention works to allow the retention of trees with realistic potential to contribute to other important objectives such as enhancing ecological diversity, conserving heritage value, and optimising canopy cover.

P2.4 Intelligent tree management interventions are applied to the recommendations so not to just focus on managing the risk from tree failures, but also to be sensitive to the wider implications, so careful, considered and balanced outcomes can be reached.

P2.5 ***Inspection periods***

All assessments of risk are set against an inspection interval. Inspection intervals are determined during each assessment based on the condition of the tree being assessed. As tree condition is dynamic, so needs to be the inspection interval. Each inspection interval is based on trees being checked by contractors who can identify a significant defect that has the potential to cause harm after storm events. Additionally, works/inspections are carried out after a service request is raised by the public (e.g., a member of the public contacts the council to report a fallen tree).

Part three

P3.1 ***Additional details***

Additional analysis is carried out where necessary if risk falls outside of common-sense management (i.e. large hanging limb over a busy path) to support recommendations. Below are the methods PS used to assist in the analysis the risk where there are no measures to use:

P3.2 ***Occupancy***

To determine or measure the likelihood of impact as a consequence of a limb failure, a person or target needs to be beneath. Occupancy, or the duration in which something is underneath the tree or tree part assessed to fail, is a significant factor in determining the risk of harm occurring. Therefore, for it to be considered high risk, a tree needs to show foreseeable failure where failure would occur over a high enough occupancy area for the likelihood of a person to be beneath it when it fails.

P3.3 Occupancy could also be viewed on a spectrum, with high and low being at either end and the area between being harder to distinguish in terms of where one classification stops and another begins (e.g., low to moderate occupancy). Currently, there are no standards or classifications for how many people equal a low, moderate or high level for site occupancy. For this assessment, any defect that has around 3% of occupancy beneath it (45minutes a day of permanent occupancy) is used as a benchmark as the start of the higher occupancy end of the spectrum.

P3.4 ***Calculating occupancy***

People counts are factual measures and can assist as a base level for occupancy within site. During a PS survey, people counts are manually recorded where no people count data is available.

- **Frimley Park**

The maximum people count over an 8hr period (22.04.21): was 264 people (weekday)

P3.5 The time of year strongly influences people counts, especially for most park sites when inspecting trees in the winter months, as site use is generally at its lowest.

P3.6 People counts are becoming more common, and reviewing data for certain areas with annual counts can provide meaningful information on anticipated seasonal change and likely reductions during storm events. Chart 4 shows that 84% of all recorded fatalities in NZ have occurred during high wind events. Knowing that occupancy is much reduced in storm events is therefore important. Historic people counts show reductions in occupancy during those times, apart from CBD areas or commuter routes which show minimal reductions.

P3.7 I have not been able to source annual people counts information for parks in NZ yet. Therefore, data used from Central Park in New York City is used to provide an indication of anticipated human behavioural patterns for seasonal fluctuations for storm events. Below are the estimated data on people counts based on site recordings.

Estimation of occupancy Frimley Park					
Site description:	Public open space	Season decrease	% of total value remaining	Estimated weekend increase	Estimated weekend Occupancy
Season counted:	Autumn	32%	68%	84%	486
Max occupancy recorded	264		Estimated average week occupancy:		327
Seasons:	Summer	Autumn	Winter	Spring	
Est. seasonal decreases from high occupancy season (%)	0%	32%	65%	22%	
Estimated daily seasonal ave considering % seasonal changes:	481	264	168	206	
Est. annual daily occupancy mean:	235	Ave walking speed (m/s):	1.3		
Storm reduction:	46%				

P3.8 ***Putting occupancy into context***

Occupancy is considered over a 24hr period. Occupancy is difficult to determine with accuracy due to the unpredictability of public movement. Additionally, people often move in groups which can be influenced by peak flows and not equally spread out. Nonetheless, justification needs to be reached as to why a site is defined as low or high occupancy. To provide a base indication of occupancy, the size of each defect (estimated base dia, length and width) is recorded to estimate the duration in which a person may be beneath the part deemed to fail. The largest measurement is then used, and the average walking speed of 1.3 meters a second is used, to estimate the duration a person may be beneath the part. The weight of the defective part is also estimated based on cylinder and wood density to indicate force. Road volumes are also considered, with speed limits and annual average daily traffic counts based on road type, provided by NZ Transport Agency.

P3.9 Additional details are also considered where occupancy levels are reduced based on site usage e.g., a tree at the periphery edge of a park would have less of the site occupancy than the main path. Additionally, public generators are considered, such as seats with estimates of site duration.

P3.10 ***Storm events***

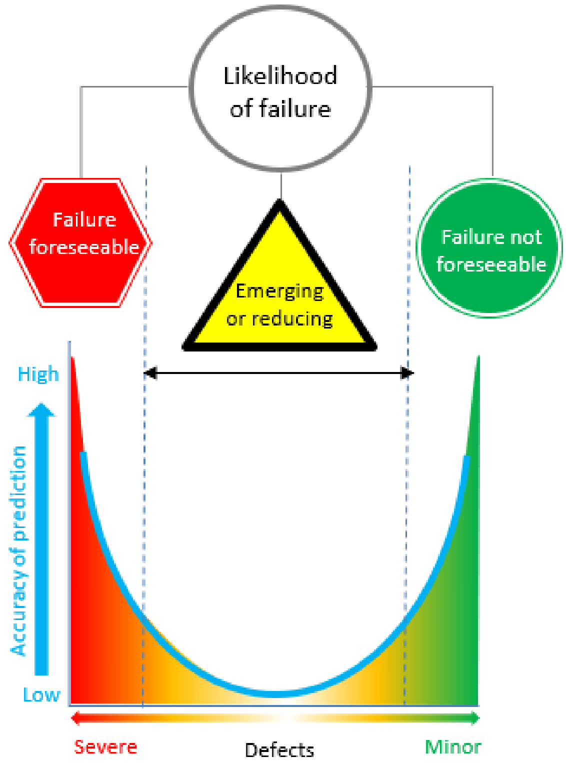
If a defect is identified, it is then assessed if the likelihood of failure will occur in a storm event or at any time. If a defect is considered to fail in a storm event, then the estimated occupancy is reduced by the estimated % taken from other site data of occupancy reductions during storm events.

P3.11 *Assessing the likelihood of failure*

Predicting the likelihood of failure is difficult to determine with a high level of accuracy. There is limited research to show the validity of arborists assessments for the likelihood of failure. What limited research there is suggests that unless a defect is severe, it is unlikely to increase the likelihood of a failure.

Research carried out during a high wind event used 673 trees, which were risk assessed by three experienced, trained practitioners and then revisited to assess storm damage. Trees were rated qualitatively where imminent was the highest likelihood of failure followed by probable, possible and improbable. The study found:

- 94.1% of trees that had an imminent rating failed
- 38.8% of trees failed that were rated as probable
- 15.3% of trees failed that were rated as possible.
- 0% of trees failed that were rated as failure being improbable.



The study highlights the less obvious a defect the greater the uncertainty of predicting the likelihood of failure. Therefore, unless a defect is obvious it is unlikely to be reliably assessed as foreseeable. The greater the uncertainty for failure the more inaccurate the determination, which has implications on management actions if wide ranges of terminologies are used.

Therefore, each defect is rated as:

- Imminent: an event that is predicted to occur at any moment
- Foreseeable: an event that a competent inspector would consider as likely to occur within a checked period.
- Emerging: an event which may take place within a checked period, but the significance of the defect is considered to increase over time
- Controlled: for defects being actively controlled where further controls may be necessary
- Further analysis: areas where further analysis is required to evaluate the risk.

References

Barrell, J. (2020). The implications of recent English legal judgments, inquest verdicts, and ash dieback disease for tree risk management regimes.

Cadwallader, B. (2020). Lists of deaths from accidental tree failures in New Zealand (unpublished research).

Hartley, M & Chalk, J. (2019). Australian Fatalities associated with Tree Failures, a Review of Deaths in Australia from Accidental Tree Failures

Health and safety executive (2001). Reducing risks, protecting people – HSE's decision-making process.

Koeser, A & Smiley, E. (2017). Impact of Assessor on Tree Risk Assessment Ratings and Prescribed Mitigation Measures. Urban Forestry & Urban Greening. 24. 109-115. 10.1016/j.ufug.2017.03.027.

National Tree Safety Group (2011). Common Sense Risk Management of Trees, guidance on trees and public safety in the UK for owners, managers and advisers. ISBN 978-0-85538-840-9

Norris, M.,2007. Tree Risk Assessments – What Works – What Does Not – Can We Tell? A review of a range of existing tree risk assessment methods.

Schmidlin, T.W. 2008. Human fatalities from wind-related tree failures in the United States, 1995-2007.