Before the Independent Hearing Panel appointed by the Christchurch City Council

In the matter of the Resource Management Act 1991 (**the Act**)

and

In the matter of Proposed Plan Change 14 Housing and Business Choice pursuant to Part 5, subpart 5A and Part 6 of Schedule 1 of the Act

Brief of evidence of Emeritus Professor David Andrew Norton on behalf of Riccarton Bush (Pūtaringamotu) Trust (as Submitter)

Dated: 20 September 2023

AJS-836740-4-59-V1-e

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Evidence of Professor David Andrew Norton:

Introduction

1. My name is David Andrew Norton.

2. I am an Emeritus Professor at Te Kura Ngahere (School of Forestry), University of Canterbury.

3. I have over 40-years' experience working on the ecology of native forests in Aotearoa as a researcher, a teacher and as an advocate for sustaining and enhancing our unique native biodiversity. I worked at Te Kura Ngahere (the University of Canterbury School of Forestry) for 37 years and have been closely involved with Pūtaringamotu throughout this time, having taken multiple student field trips there, had students undertake research there and most recently having been a member of the Riccarton Bush Trust Board from 2016-2023. I wrote the chapter on the dynamics of the kahikatea forest in Pūtaringamotu for the 1995 Riccarton Bush book edited by the late Dr Brian Molloy (Norton 1995). I have also authored or co-authored reports on the effects of adjacent dwellings on Pūtaringamotu (Chrystal & Norton 2001, Norton 2011).

4. As a result of my long term association with Pūtaringamotu, I believe that I am better placed than most to give this evidence.

Code of conduct]

5. In preparing my evidence I have reviewed and agree to comply with the Code of Conduct for Expert Witnesses contained in Part 9 of the Environment Court Practice Note 2023. This evidence has been prepared in compliance with the Practice note. I confirm that the issues addressed in this statement of evidence are within my area of expertise, except where relying on the opinion or evidence of other witnesses, which I will specify. I have not omitted to consider any material facts known to me that might alter or detract from the opinions expressed.

Executive summary of evidence

6. This evidence addresses the potential impacts of housing intensification on the health and integrity of Pūtaringamotu (Riccarton Bush) from an ecological perspective and provides support for the proposed qualifying matter in respect of Pūtaringamotu.

7. I suggest that ecologically the only logical definition of a 'Tree Protection Zone' for Pūtaringamotu is the predator-proof fence as Pūtaringamotu is a single ecological entity, rather than just individual kahikatea trees.

8. The international and New Zealand scientific literature on tree root systems clearly suggests that for mature trees (50 cm diameter or more), including kahikatea, these will extend at least 10-20 m from the base of the tree.

9. The literature shows that impacts of building construction including foundations and infrastructure will have a substantial impact on mature tree root systems, both structurally and in terms of the volume of soil they are able to absorb nutrients and water from, leading to tree ill-health and potentially dieback.

10. A reduction of green space around Pūtaringamotu as a result of housing intensification will also reduce the viability of populations of native birds such as korimako, kereru and tuī, while microclimate effects of high-density tall buildings will likely have adverse effects on the vegetation, especially through increased light pollution.

11. The probability of fire will also increase in proportion to the proximity and number of residential dwellings.

12. The presence of dwellings close to Pūtaringamotu may lead to reverse sensitivity effects where residents perceive the forest as having adverse effects on their quality of life resulting in them placing pressure on the Riccarton Bush Trust Board to trim and remove vegetation, adversely affecting the bush.

13. Pūtaringamotu is an urban forest remnant and it is not possible to remove all impacts of adjacent residential dwellings on the kahikatea forest and its flora and fauna, but through the use of appropriate set back distances for construction activities and buildings, it is possible to reduce these effects to manageable levels.

14. It is therefore my view that a minimum building setback of 22 m (the average height of kahikatea trees in Pūtaringamotu), with a minimum earthworks setback of 15 m to protect tree root systems, is appropriate. Both setbacks should be from the predator proof fence which marks the ecological boundary of Pūtaringamotu.

Introduction

15. This evidence addresses the potential impacts of housing intensification on the health and integrity of Pūtaringamotu (Riccarton Bush), a nationally significant alluvial kahikatea forest remnant. I do not address the ecological and cultural significance of Pūtaringamotu in any detail as, in my view, this is not under debate.

16. In this evidence I initially address the question of how the perimeter of Pūtaringamotu should be defined before focusing in detail on the effects of ground disturbance associated with erecting taller and more densely located buildings close to the bush. I finish by reviewing other potential effects of housing intensification on the bush. This evidence builds on previous submissions and reports referred to above.

Definition of the perimeter of Pūtaringamotu

17. I define "the bush" as the area that is enclosed by the perimeter predator-proof fence. The Christchurch City Council interpretation of tree protection zones based on individual trees does not recognise that Pūtaringamotu is more than just individual kahikatea trees. In a natural setting such as Pūtaringamotu, trees are transient as natural processes drive mortality and recruitment.

18. Furthermore, mature kahikatea trees do not occur universally along the boundary of Pūtaringamotu and it is to be expected that as a result of the restoration work that has been undertaken along both the south-eastern and north-western boundary of Pūtaringamotu (Molloy & Wildermoth 1995), as well as natural recruitment, that the density and size of large trees close to the predator proof fence will increase with time.

19. It therefore makes no sense ecologically to define the tree protection zone in Pūtaringamotu based on individual trees. Ecologically the only logical definition is the boundary of the bush itself which is defined by the predator-proof fence. All my discussion below is based on this definition.

Effects of Ground disturbance

The structure and function of tree root systems

20. Tree roots are essential to the growth and survival of trees for three fundamental reasons – they are conduits for water and nutrient uptake,

provide structural stability to the tree by physically anchoring it to the ground, and act as storage for carbohydrates (Kozlowski & Pallardy 1997). To perform these functions, roots grow both downwards and outwards from the tree exploring and utilising soil resources. While the fundamental role of roots is the same for all trees, the architecture of root systems varies widely among tree species and with different environmental conditions. Notwithstanding this, an intact and healthy root system is vital for any healthy tree (Day et al 2010).

21. Tree root systems comprise two main types of roots – woody and non-woody. Woody roots have undergone secondary growth in the same way that a stem has and are typically rigid and have a perennial lifespan. These roots are structural as they play a key role in anchoring the tree. Structural roots can be horizontal, descend obliquely into the ground, or descend vertically as tap roots or peg/sinker roots.

22. Although structural roots account for most of the root biomass, non-woody roots are far more extensive in terms of length (accounting for as much as 90% of total root length) and are the site for water and nutrient uptake. These roots extend out from the structural roots, are typically very small (<2 mm diameter) and have high turn-over (ie. have short lifespans). The tips of these roots are frequently the site of fungal symbionts (mycorrhiza) which are critical for nutrient uptake and plant defence against various soil pathogens. Non-woody roots are typically most abundant in the upper part of the soil profile (uppermost 10-20 cm), especially in forests, as it is in this zone that conditions are usually most conducive for nutrient uptake and where water logging is least frequent (Kozlowski & Pallardy 1997). These roots can occur very close to the surface in the soil humus layer of forest ecosystems.

23. The extent of tree root systems has been the subject of much research and debate, especially as it is difficult to directly measure root extent without considerable and often destructive sampling. Numerous studies have attempted to develop rules that enable the estimation of root system extent based on other tree attributes (e.g. tree height, canopy spread or trunk diameter), although it is important to recognise that there is considerable variation in the extent of lateral root spread within the same species at different sites and especially in different soil types.

24. In an international review of numerous studies measuring root spread, Day et al. (2010) suggested that tree height and canopy diameter were poor predictors of root spread because of marked difference between species and between different environments for the same species.

However, they showed that trunk diameter[1] was a good predictor of root spread for medium- to large-stature trees across a wide range of tree species and sites, although the relationship was non-linear. Rapid increases in root extent occurred for younger (smaller) trees (< 30 cm diameter) while slower increases in root extent occurred for older (larger) trees (> 30 cm diameter). For young trees, they showed that on average root system radius increases by 38 cm for every 1 cm of trunk diameter, but on older trees this increase is slower, although these values are averages from a large number of individual studies. Based on these data, it is therefore reasonable to expect that root systems in mature trees (50 cm diameter or more) to extend at least 10-20 m from the base of the tree.

Root systems in New Zealand native trees

25. There are few detailed studies of the root systems of mature native New Zealand trees, although there is more detailed information on root systems of young trees (typically <5 years old: Marden et al. 2018a, 2018b). Because of the challenges in sampling mature tree root systems, most observation are based on examination of tree roots in windthrown trees which do not show the full extent of the root system. Generic descriptions are provided for several species by Hinds & Reid (1958), but detailed information is only available for a handful of species, one of which is kahikatea. After providing a detailed discussion on kahikatea, I summarise below what is known about other native tree species from Aotearoa for context.

26. Kahikatea (*Dacrycarpus dacrydioides*) root systems are distinctive amongst New Zealand trees in having long surface lateral roots, often arching above ground level (Figure 1), and extending well beyond the canopy spread of the tree (Hinds & Reid 1957, Molloy 1995). These laterals can be very large and live for very long time-periods. Molloy (1995) found one lateral 36 cm in diameter to have 310 growth rings which he presumed to be annual. At intervals along these laterals, large peg roots descend into the soil, and it is from these that most of the smaller roots, especially the non-woody feeding roots arise (Figure 2). This root system does make kahikatea one of the most wind-firm native tree species.

[1] Usually measured at breast height which is typically 1.3 m above the ground.

Figure 1. *Surface lateral roots spreading out from the base of a mature kahikatea tree, Pūtaringamotu (photo by DA Norton).*

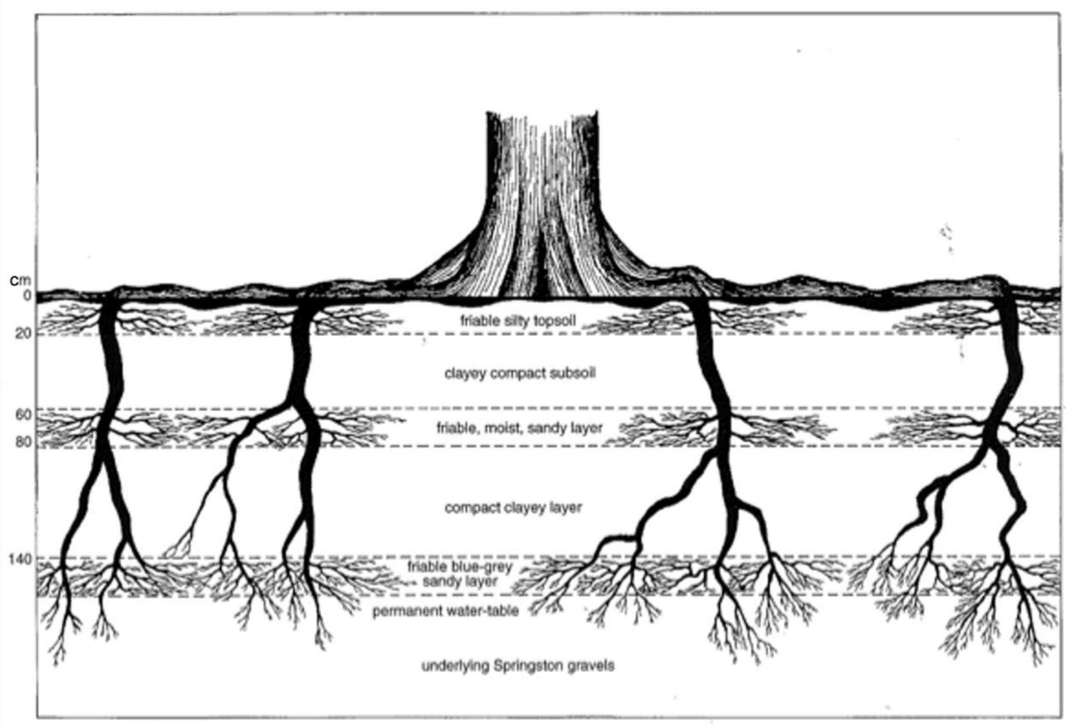

Figure 2. *Schematic diagram of the central horizontal and vertical roots of kahikatea in Pūtaringamotu. The tree the diagram is based on was 88 cm diameter, with an 8 m canopy spread. Surface roots extended 9 m to the right and 13 m to the left, while vertical roots were traced to 2.8 m depth (Molloy 1995).*

27. In an unpublished report I prepared for the Riccarton Bush Trust Board on the extent of surface kahikatea roots (Norton 2001), I showed, based on a sample of 29 randomly selected mature kahikatea trees (0.6–1.3 m diameter), that the longest surface root from each sampled tree extended for a distance of 3.6–11.1 m from the tree, and that the majority of tree roots were located on the southwest and west sides of trees (Figure 3).

28. There was, however, no significant relationship between trunk diameter and the length of the longest surface root (r^2 = 0.047). Molloy (1995) noted that lateral kahikatea roots in Pūtaringamotu extended for 15 m and sometimes more. However, these data are only for roots visible at the surface, and it is to be expected that subsurface structural roots would extend for a greater distance, with non-woody roots extending beyond these again. The greater extension of roots on the southwest and west sides of trees may reflect the prevailing wind in Christchurch being from the east-northeast. It has been suggested that coniferous trees develop greater root systems to the lee of the prevailing winds thus increasing tree stability (Nicoll & Ray 1996).

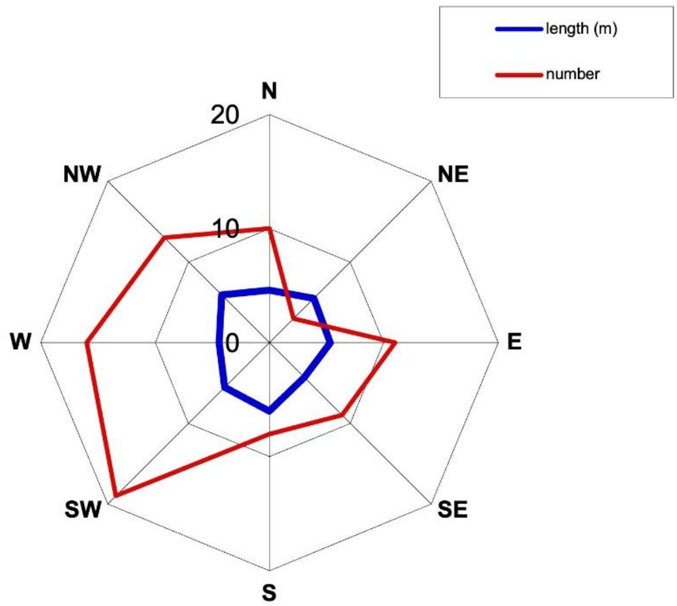

Figure 3. *Average root length (blue) and number of roots (red) from a sample of 29 kahikatea trees in Pūtaringamotu with respect to their orientation.*

29. The only other tree species present in Putaringamotu for which there is some information on the extent of tree root systems is tōtara (*Podocarpus totara*). In this species, the root system comprises a framework of large surface or subsurface laterals often extending well beyond the extent of the canopy, with obliquely descending peg roots

and nodulated feeding roots in humus near the surface, although tōtara root systems were often irregular and variable between soil types (Bergin 2000). The limited observational data on other mature forest tree root systems including for rimu (*Dacrydium cupressinum*), tawa (*Beilschmiedia tawa*), kauri (*Agathis australis*), miro (*Pectinopitys ferruginea*) and pūriri (*Vitex lucens*) show similar patterns (Hinds & Reid 1957, Cameron 1963, James 1980, Ecroyd 1982).

30. In summary, all the available information for mature forest tree species in Aotearoa suggests that while there is some variability between species and sites, root systems typically extend well beyond the extent of the canopy, especially in well drained soils. All species have abundant fine feeding roots in the uppermost soil and humus layers, while vertical (peg or sinker) roots can extend one or more metres into the soil.

Vulnerability of tree root systems to damage during construction.

31. Most of the research on the impacts of construction activities on trees have been in urban environments and include both planted and naturally growing trees. However, the likely impacts on trees will be similar between urban and natural environments such as in Pūtaringamotu. I now review some of this literature with reference to the potential impact of constructing buildings up to 8 m tall. Construction activities will include digging trenches for foundations and infrastructure (water, sewage etc), formation of compacted surfaces and deposition of fill.

32. Given the vital role of tree roots for tree health and the known substantial spatial extent of tree root systems, it is perhaps not surprising that many studies have documented the impacts of construction activities on tree health and survival (Hauer et al. 1994, Harris et al. 2004). Key construction impacts include (1) direct root disturbance through trenching (severance of roots), (2) burial of root systems by fill, (3) soil compaction and (4) changes in soil water properties through the construction of artificial surfaces (such as concrete pads).

33. Most of the research on construction impacts on trees has focused on the effects of trenching. While trenching and changes in soil water properties have direct and obvious impacts on tree health and survival (Miller & Neely 1993, Watson 1998, Morgenroth & Visser 2011, Benson et al. 2019a, 2019b), the underlying causes of tree decline and death because of compaction or root system burial are less well understood

(Day et al. 2001, Watson & Kelsey 2006). Notwithstanding this, the vulnerability of trees to all these factors is clear with dieback and death commonly observed because of construction activities.

33.1. Trenching: The construction of trenches and the associated root severance has a direct physical effect on tree growth as it reduces the root area that is available for nutrient and water uptake, and for stability, and hence the shoot area a tree can support. There is a substantial literature on this, and two examples below are representative:

- Miller & Neely (1993) documented the effects of linear trenching 0.5 – 3.3. m from trees on the mean annual diameter growth in four North American tree species (mean diameter across the species and treatments ranged from 23-48 cm). They found significant differences in tree diameter growth between trenched and control trees, with this effect strongly influenced by proximity of trenching to the tree. While only 7/98 trees surveyed died over the five-year study period, six of these trees (86%) had been trenched.

- Fini et al. (2020) in an Italian study found that trenching at 4.5x the tree diameter reduced stem diameter growth rate by 16−28% and shoot elongation by 30−41%, after 51-months. The authors suggested that root damage acts as a predisposing factor reducing the long term the capacity of trees to withstand co-occurring stresses by decreasing carbon availability for growth and defense. Similarly, the ability of trees to withstand uprooting was reduced by trenching, and no full recovery occurred in the following 44 months, when uprooting resistance was still 20%–66% lower.

33.2. Fill: The international literature is ambiguous regarding the effects of the deposition of new material (fill) over existing soil on tree growth and survival (Day et al. 2001). It is likely that the variability in effects on trees reflects species-level differences in response and differences in the properties of the fill material. For example, species-level differences have been documented for New Zealand where fresh silt deposits of *ca.* 0.6 m resulted in the death of kahikatea in Westland (Foweraker 1929), while silt deposition to depths of *ca.* 2 m had no effect on the health of Westland tōtara (*Podocarpus totara* var. *waihoensis*) which readily produced adventitious roots in the new silt material. Wardle (1974) described the death of mature kahikatea within four years of silt deposition >0.6 m, but with kahikatea surviving at deposition depths <0.6 m. Wardle also noted that miro can produce adventitious roots in a similar manner to tōtara after silting. Deposition of fill can also increase compaction of the underlying soil (see next paragraph).

33.3. Soil compaction: A common consequence of construction is compacted soils. These typically have a higher bulk density (Randrup 1997) which affects water infiltration and oxygen diffusion into the soil making soils less favourable for root growth or the activity of mycorrhizal fungi (Watson & Kelsey 2006). However, experimental studies have failed to clearly show the underlying causes of tree decline and death on sites with soil compaction perhaps because it is difficult to experimentally replicate real soil compaction conditions (Watson & Kelsey 2006) or because other factors such as root severance are also involved (Day et al. 2001). Negative effects of livestock induced soil compaction have been documented in natural eucalypt woodlands in Western Australian. Soil compaction resulted in reduced water infiltration into the soil which had flow on effects (moisture stress) that impacted the growth and reproduction of both the mature eucalypt trees and their parasitic mistletoes (Norton et al. 1995, Yates et al. 2000).

33.4. Artificial surfaces: The construction of artificial surfaces (e.g., concrete and tarmac) can also have adverse effects on trees through altering soil moisture properties, mainly through diverting water away from the soil (see also below under loss of greenspace), as well as impacts associated with soil compaction (see above), which together result in reduced growth rates and shorter lifespans for trees (Quigley 2004). However, some types of pavements (e.g., porous pavements) have been shown to be better for tree growth than other pavement types (Morgenroth & Visser 2011), although this is likely to be conditional on the soil beneath the pavement being conducive for root growth (e.g., not compacted).

Summary

34. Impacts of building construction including foundations and associated infrastructure will have a substantial impact on mature tree root systems, both structurally and in terms of the volume of soil they are able to absorb nutrients and water from, leading to tree ill-health and potentially dieback in Pūtaringamotu. This effect will extend at least 15 m and potentially further from the base of mature kahikatea trees. Construction activities such as trenching will also impact soil hydrology and particularly the lateral movement of water through the soil, which has the potential to lead to reduced water available for native vegetation within Pūtaringamotu (see next section on loss of green space).

Other effects of housing intensification

35. As well as the direct impacts of construction on tree root systems, a number of other effects of more intensive housing are likely to occur.

Loss of Green space

36. With intensification it is proposed to increase maximum site coverage from 35% to 50%, and to reduce minimum lots sizes from 450 m^2 to 400 m^2. In addition, the intensification rules suggest that the area of green space only needs to be 20% of the site. Pūtaringamotu does not occur as an island and is strongly influenced by what is happening in the surrounding environment, especially in terms of both individual native species and ecological processes that occur at larger spatial scales than the bush itself. Loss of greenspace will have adverse impacts on Pūtaringamotu in two main ways.

36.1. <u>Habitat connectivity for mobile species</u>: Pūtaringamotu is too small to provide habitat in of itself for some native birds (e.g., korimako, kereru and tuī). These species utilise the wider green space within Christchurch City including the Port Hills and rely on the presence of trees and greenspace both as food resources and to be able to move through this landscape. With sufficient suitable habitat, coupled with predator control, all the evidence suggests that these charismatic and unique native birds will persist and even expand within urban centres such as Christchurch (Heggie-Gracie et al. 2020, Noe et al. 2022). However, reducing the amount of greenspace around Pūtaringamotu will diminish the ability of these mobile species to be able to survive both in Pūtaringamotu itself and in Christchurch more generally, as Pūtaringamotu is such a key habitat for these species.

36.2. Hydrological processes: Reducing the amount of soft/green surfaces through which rainfall can percolate into the ground together with a much greater area of water being lost via hard surfaces (e.g., concrete and tarmac) into the storm water system will result in less water available for native vegetation within Pūtaringamotu (see also above under construction activities). This impact will exacerbate the existing effects of urban drainage systems around Pūtaringamotu which already necessitates the use of irrigation to maintain soil water status within the bush.

Effects on microclimates

37. The construction of tall buildings (to 8 m) on lots as small as 400 m^2 with a site coverage of up to 50% is likely to have direct impacts on Pūtaringamotu and hence habitat quality for native flora and fauna proportional to the height and density of structures by:

- Adjacent building will shade the vegetation with the effect being directly proportional to the height and density of buildings and their distance from the perimeter of Pūtaringamotu. Shading may reduce growth of restoration plantings on the boundary, and too much shading will result in an open understorey and a failure of plants to establish on the forest floor (as appears to be presently happening adjacent to a tall fence on the north-western boundary).

- Tall dense buildings will create strong wind funnelling effects that can increase transpiration from foliage and potentially cause physical damage to vegetation.

- Light pollution from buildings is known to have a direct impact on fauna (birds, lizards and insect) through modification of their behaviour (Rich & Longcore 2006, Rodrigo-Comino et al. 2023). Such effects are highly likely to occur in Pūtaringamotu as a result of the proposed intensification as there will be more buildings and hence more light adjacent to and shining on the bush.

38. A related consequence of housing intensification is an increased risk of fire (a risk that already exists). Fire in buildings immediately adjacent to Pūtaringamotu is more likely to spread into the forest than fire in buildings set further back from the perimeter. While buildings are replaceable in the short term, Pūtaringamotu is not. The threat of fire may be particularly marked for accessory buildings such as garages and sheds, which often contain flammable substances such as fuel and solvents. Little is known about the optimum distance to prevent fire spreading from buildings to adjacent forest. The irrigation system within Pūtaringamotu may reduce this risk to some extent as it is likely to maintain a more humid environment than would have been the case without it, especially during dry periods. However, with climate change resulting in overall drier conditions and higher wind speeds, the probability of fire is likely to be greater and more intensive housing will only exacerbate this effect.

Reverse sensitivity effects

39. Reverse sensitivity refers to the situation where people living close to Pūtaringamotu may perceive the forest as having adverse effects on their quality of life resulting in:

- Residents placing pressure on the Trust Board to have trees trimmed, thinned or even removed because they either cast shade on properties or are perceived as being a source of woody material potentially damaging properties.

- Residents placing pressure on the Trust Board to prune roots or have trees removed for their perceived or actual damage to infrastructure (belowground utilities, paved areas, building foundations).

40. Should residents place pressure on the Riccarton Bush Trust Board to do this, then this will diminish the values of Pūtaringamotu. This form of effect has been recognised by the Environment Court who defined it as:

> “the effects of the existence of sensitive activities on other activities in their vicinity, particularly by leading to restraints in the carrying on of those activities”

41. The potential for this reverse sensitivity effect to occur from a shade perspective is perhaps greatest along the south-eastern and southern boundaries where shading of properties will occur. The Riccarton Bush Trust Board has from time-to-time been approached by landowners

requesting vegetation to be trimmed back or lowered in height to reduce shading.

42. The Trust Board has been happy to work with landowners in trimming back overhanging vegetation, however the felling of trees entirely within Pūtaringamotu is a different matter and runs against the objectives of the Riccarton Bush Act (1914). Many of the trees around the boundary are well short of their mature heights and with the removal of exotic species during the 1970s and 1980s a significant amount of newly planted natives, including kahikatea, has been established around the boundary. The potential therefore is for the boundary canopy to be significantly higher in the future than is currently the case and buildings located close to the boundary will undoubtedly experience shading problems.

43. Increased development adjacent to Pūtaringamotu is also likely to result in an increased perception by residents that their dwellings are threatened by windthrow of trees or of tree branches from within Pūtaringamotu. While the number of tall trees along the boundary is presently small, this will increase as the boundary vegetation ages. Edge trees are more prone to windthrow (Chen et al. 1992, Esseen 1994) and the potential for windthrow may be enhanced by the presence of adjacent building (e.g., through damage to root systems or wind funnelling effects– see above). Windthrow *per se* does not directly threaten Pūtaringamotu, but pressure from adjacent residents may be sufficient to limit tree height along the edge of the bush thus directly impacting on the vegetation and the buffering effect of the boundary for the internal area of Pūtaringamotu.

Summary

44. Allowing more intensive and larger buildings close to Pūtaringamotu will have several other unintended consequences for the health and integrity of this nationally significant kahikatea forest remnant. In particular, a reduction of green space around Pūtaringamotu will reduce the viability of populations of native birds such as korimako, kereru and tuī, while microclimate effects of intensive tall buildings will likely have adverse effects on the vegetation, especially through increased light pollution. The probability of fire will also increase in proportion to the proximity and number of residential dwellings. Finally, the presence of Pūtaringamotu close to dwellings will likely result in reverse sensitivity where residents perceive the forest as having adverse effects on their

quality of life resulting in them placing pressure on the Riccarton Bush Trust Board to trim and remove vegetation, adversely affecting the bush.

Conclusions

45. Pūtaringamotu is a nationally significant remnant of alluvial kahikatea forest that has its own Act of Parliament (the Riccarton Bush Act 1914) in recognition of this.

46. Higher density taller housing on the margins of Pūtaringamotu will have a number of adverse impacts on the forest ecosystem and its species including through damage to tree root systems, loss of greenspace, microclimate effects, increased fire risk and reverse sensitivity effects.

47. Pūtaringamotu is an urban forest remnant, and it is not possible to remove all impacts of adjacent residential dwellings on the kahikatea forest and its flora and fauna, but through the use of appropriate set-back distances for construction activities and buildings, it is possible to reduce these effects to manageable levels.

48. The international scientific literature on the impacts of severance on tree root systems clearly suggests that it is reasonable to expect that root systems in mature trees (50 cm diameter or more) to extend at least 10-20 m from the base of the tree.

49. It is therefore my view that a minimum building setback of 22 m (the average height of kahikatea trees in Pūtaringamotu), with a minimum earthworks setback of 15 m to protect tree root systems, is appropriate. Both setbacks should be from the predator proof fence which marks the ecological boundary of Pūtaringamotu.

Date: 20 September 2023

Professor David Andrew Norton

Appendix 1:

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