



Poplar windthrow following Cyclone Gabrielle

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Author: John Ballinger, Dean Satchell, Simon Webb

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Background

Cyclone Gabrielle was a severe tropical cyclone that devastated the North Island and affected parts of Vanuatu and Australia in February 2023. The cyclone hit New Zealand from 12 to 16 February, with a national state of emergency declared on 14 February 2023.

Extensive flooding and tree windthrow occurred across Northland, while multiple roads were closed including SH1 near the Brynderwyn Range. Many people lost electricity, phone service, and internet connections. Gabrielle followed a very wet winter, spring, and summer, so soil conditions were incredibly wet when it hit. Gabrielle contributed to the wettest start to the year since records began for Whangārei Airport, which had over five times more rain than average for the first 46 days of the year. Between 250-400 mm of rain was recorded across the region with the largest amount recorded at Glenbervie Forest (408.7mm), with Whangārei Airport receiving 320.4mm. Wind gusts over 130 km/h were recorded in the most exposed stations with 141 km/h recorded at Cape Reinga. Whangārei Airport recorded a gust of 102 km/h. This was an exceptionally damaging event due to the track Gabrielle took, along with warmer sea surface temperatures and an atmospheric environment that encouraged tropical cyclone growth.¹

Anecdotal reports of poplar toppling during the event were investigated on 30 March 2023 by Northland Regional Council's land management advisors John Ballinger and Simon Webb. Dean Satchell, Northland Senior Forestry Advisor for Te Uru Rakau was also in attendance. The purpose of the investigation was to try and determine:

- 1) The relative extent of the windthrow in poplar.
- 2) What environmental factors exacerbated windthrow vulnerability.
- 3) Were there differences in poplar age, clone, or planting regime that effected vulnerability.

The sites visited were located at:

- Mangakahia Rd, Maungatapere
- Tokiri Rd, Titoki
- Houto Rd, Tangiteroria
- Mangapai caves Rd, Mangapai
- Harris Rd, Glenbervie
- Milne Rd, Titoki

Mangakahia Rd, Maungatapere

This site consisted of 220 Kawa *P. deltoides* × *yunnanensis* planted as poles approximately 25 years ago. These trees were planted at 7m x 7m spacing and had been pruned to create a 6m butt log free of branches, with no thinning. The soil is Ohaeawai shallow bouldery silt loam, a young volcanic clay with good drainage but has large boulders near the surface, being on the edge of a lava flow. Observations of upturned root plates showed that the tree roots had some distortion having struggled to penetrate deeply into the soil due to the presence of the boulders near the surface.

This Kawa poplar plantation suffered extensive toppling with 180 of the 220 planted blowing over (82% loss). The initial SE wind toppled 12 trees, then when it switched to the SW the rest of the trees came down. Even though the soil type is well drained, it was saturated during the cyclone. It was noted that poplars with poor form and of unknown parentage growing on the same soil on a neighbouring property did not suffer from windthrow. However, this could be a result of variations in wind tumbling/turbulence rather than a difference between clones.

¹ Metservice NZ (2023): Tropical Cyclone Gabrielle – Event summary February 2023

<https://blog.metservice.com/TropicalCycloneGabrielleSummary#:~:text=Wind%20gusts%20of%20up%20to,airport%20recorded%2078%20km%2Fh>



Kawa logs from toppled trees.



Root plate showing no taproot and some root distortion due to large boulders.

Tokiri Rd, Titoki

A short drive down Tokiri road found little toppling. Some old Italian hybrids planted as a shelterbelt along a drain approximately 50 years ago had come down (approx. 2%). The high-water table and resulting low soil strength probably contributed to the toppling, along with the trees being immediately adjacent to a drain. It was noted that a Kawa shelterbelt nearby had suffered no windthrow.



Old Italian hybrid root plate with standing water underneath due to the presence of a drain.



Fallen tree with unaffected Kawa shelterbelt in the background.



Old shelterbelt made up of Italian hybrids with fallen tree in foreground.

Houto Rd, Tangiteroria

Soil type is Waioira clay loam which is a young sandstone soil prone to tunnel gullyng. Old tunnel gullies were planted with Italian hybrids, estimated to be 50+ years old. Approximately 15% have toppled. These were mature trees nearing the end of their useful life, with some having fallen prior to the cyclone. Despite the toppling, the trees have done their job very well, with no obvious signs of the tunnel gullies they were planted to treat.



Mature Italian hybrids planted some 50 years ago to treat tunnel gullies.



Most of the hybrids that toppled were more exposed near the top of the gully.

On the same farm but in a different location, more tunnel gullies planted with Kawa poplar, estimated to be 15 years old. Between 40-50% have toppled. The trees were pruned with epicormic growth and the root plates show more plunging roots compared to the Kawa planted at Maungatapere, but the root plate was still small. While the trees were planted on the mid-slope, they were very exposed to the extreme SW winds that did the most damage. A shelterbelt of older *p. radiata* adjacent to the poplars suffered no windthrow.



Some toppling of Kawa in active tunnel gullies. More plunging roots than Maungatapere but root plate quite small.



15-year-old Kawa still standing. The toppled Kawa was further downslope. Note the radiata shelterbelt in the background was unaffected by the cyclone.



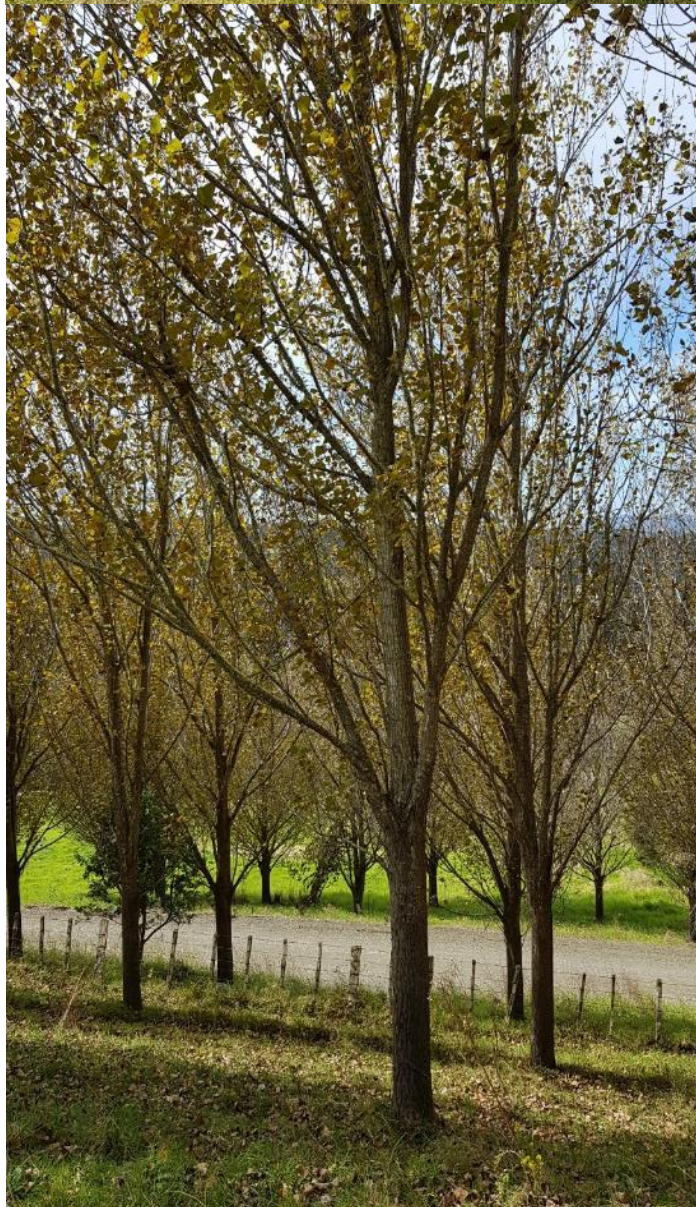
Root plates of older Kawa on a neighbouring farm. These trees were very exposed to the SW.

Mt Houto, Tangiteroria

Situated on the flanks of Mt Houto in an extremely exposed location. Soil type Takitu gravelly clay loam, a young semi volcanic soil that is naturally fertile, but particularly prone to shallow and deep-seated slipping. Two clones of poplar were planted on an active slip above the road. Kawa were planted at 7-8m spacing at the base of the slip and grew tall and toppled. Another clone, possibly Veronese *P. x euramericana* was planted at the top and adjacent to the slip and remarkably suffered little windthrow, although they were smaller than the Kawa. It's estimated the trees were planted 20 years ago.



Near complete loss of Kawa in foreground, with shorter more resilient clone in background.



Clone (possibly Veronese) planted above and adjacent to the slip. Note form and leaf shape.

Houto Rd, Tangiteroria

Kawa woodlot planted on the wet valley floor at 5m x 5m spacing and pruned. Radiata was planted on the hill. Sheltered from everywhere but the south. The soil is Mangakahia mottled clay loam, an alluvial soil that is poorly drained. There was quite a bit of toppling at the edge (30%), but less pronounced further into the forest (10%). The root plate was relatively shallow due to the high-water table.



Root plate quite shallow due to high water table.

Mangapai Caves Rd, Mangapai

On this farm there was a small amount of toppling along streambanks and drains. The soil type is Kara sandy loam with pan, a very old podzol known colloquially as gumland or pipe clay that is very prone to gullyng. Along a streambank a handful of mature Kawa (estimate 30 years old) were planted too close to the river edge on an eroding bend. A combination of stream bank undermining and extreme wind gusts pulled up the root plates, generating sediment. The big strong roots of these trees had been doing an excellent job of holding the steep bank together but ideally would have been shifted back beyond the bank full capacity.



A combination of streambank undermining and extreme wind gusts led to Kawa toppling.



Eroding bend with toppled trees.

Across the farm, Kawa shelterbelts had been planted alongside drains, with approximately 5% toppling. It appears the Kawa were planted too close to the edge of the drain, with roots plunging under the drain and up and out the other side. The roots on the drain side had low root strength and unfortunately this coincided with the direction of the strongest gusts, leading to toppling. The saturated soil conditions wouldn't have helped either. Once the toppled trees were cut, the root plate sprung back to position. The trees that toppled were wider spaced Kawa in low spots. While willow is well known for their fibrous root mat that protect against scour, it was observed that these poplars provided a similar service, albeit not as extensive as willow.



Toppled Kawa along drain. Note the root mass fell back in place once the trees were cut.



Kawa roots plunging underneath the drain. Set poplar back further to reduce risk of toppling.



Semi fibrous poplar roots are similar too, but less extensive than willow

Harris Rd, Glenbervie

This property had an 3ha Kawa poplar woodlot. This stand suffered extensive windthrow, with around 80% toppling. A few trees succumbed to the SE winds on the first night, but most of the damage was caused by the SW gusts. This damage was unusual in that the trees on the edge were still standing, whereas the middle of the forest was devastated. This suggests wind tumbling/turbulence may have knocked over a handful of trees in the middle of the forest, that then opened the forest up to more extreme gusts the second night.

The trees are growing on Waipu clay, a terrace soil classified as having no natural drainage. Water often pools in this area and the trees were notable for having more buttressing than normal for this clone. The trees are around 23 years old, planted at 5m x 5m spacing and have been pruned but not thinned. Consequently, the height to diameter ratio is high making the trees more vulnerable to windthrow, but even if the stand had been thinned it may not have saved the trees from toppling. It's clear the trees are healthy and have grown well, and examination of the root ball showed no obvious root decay with the root plate around 600mm in depth. The root mass appeared to be too low compared with the above ground biomass



Small root mass relative to height (left); buttressing due to consistently wet soil conditions (right).



Extensive toppling within the stand. Note edge trees still standing.

Milne Rd, Titoki

Northland Regional Council established an extensive poplar field trial on a Pamu/Landcorp Farm near Titoki in 2021. Poles, stakes, wands and rooted cuttings of various clones were planted, and a survival audit was carried out 3 days after the cyclone. This site was very exposed and a radiata plantation of similar age was completely flattened. Apart from leaf shredding, the entire site suffered very little toppling apart from one row of Kawa rooted cuttings that suffered socketing and wind throw. Adjacent Shinsei *P. nigra* LP 1'x *P. maximowiczii* rooted cuttings and Veronese poles coped better in the extreme wind.



Toppled Kawa rooted cutting row (left); Highly exposed site with Shinsei wands growing well (top right); evidence of wind shredding due to extreme winds (bottom right)



A poplar trial monitored 3 days after the cyclone had very little windthrow.



Radiata on the same farm and of the same age as the poplar trial above suffered extensive windthrow.

Key points

Cyclone Gabrielle was an extreme wind event and combined with prolonged saturated soil conditions resulted in localised windthrow of poplar. Because poplars grow fast, tend to be planted in wetter areas and were in full leaf at the time the cyclone hit, they appear to have suffered more windthrow than other tree species in Northland.

As Kawa has been the main clone planted in Northland since the 1980's, the majority of windthrow was Kawa. Levels of windthrow varied across the region, but we only visited locations that were extensively damaged. In many locations, Kawa was unaffected by the cyclone. Cyclones are unpredictable as to where they land and the direction of wind. While localised wind severity and turbulence can't be planned for, some broad-brush contingencies will increase windthrow resilience, including:

1. Poplar forest design should prioritise the main need e.g., erosion control, shade and shelter etc, with timber production secondary.
2. Avoid planting Kawa in poorly drained areas with weak soil strength, especially if a plantation crop.
3. Set poplar back from drain and stream edges (at least 3-5m from the top edge of the bank).
4. When growing poplar for timber, rooted cuttings are planted at up to 1,000 stems per hectare. However, at this stocking trees are tall and thin which increases their vulnerability to windthrow. To reduce the risk of this happening, thin poplar stands down to a final spacing of 250-300 sph, similar to a radiata regime.

Kawa has been a proven performer for Northland conditions. However, it appears Kawa is more vulnerable to cyclones than other clones such as Veronese. One reason for this may be smaller root plates compared to other poplar clones. Northland Regional Council is conducting field trials on a range of poplar clones to determine their suitability for Northland conditions. In addition to rust resistance, possum resistance, quality timber and good form, resistance to windthrow is an important selection criterion for future breeding and selection programmes.

Northland Regional Council

P 0800 002 004

E info@nrc.govt.nz

W www.nrc.govt.nz
