NOTE

TWO RECORDS OF KAURI REGENERATION FROM TREES PLANTED SOUTH OF THE SPECIES' NATURAL RANGE

G. A. STEWARD, D. O. BERGIN

New Zealand Forest Research Institute,
Private Bag 3020, Rotorua, New Zealand

and W. J. WINSTANLEY

168 Newlands Rd, Newlands, Wellington, New Zealand

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ABSTRACT

Agathis australis (D.Don) Lindl. (kauri) seedlings considered to originate from planted trees have been found in New Plymouth (latitude 39°05´S) and in Wellington (latitude 41°16´S). These sites are 120 and 365 km south of the area reported to be the natural range of the species in New Zealand. This is the first record of persistent reproduction of kauri from trees planted outside the currently accepted natural range.

Keywords: planting; seed dispersal; natural distribution; regeneration; *Agathis australis*.

INTRODUCTION

The natural range of kauri is regarded as the warm, temperate, northern part of New Zealand bounded by the latitudes 34° to 38°S (Sando 1936) (Fig. 1). Before European settlement, pure stands, groves, and scattered individual trees occurred within a matrix of podocarps and broadleaved species over an area of approximately 1 000 000 ha (Halkett 1983). Kauri is now most abundant on the peninsulas of Northland and Coromandel (Ecroyd 1982). It was present well south of its current distribution as late as 300 000 years BP (Mildenhall 1986). Although it was uncommon in its present habitat during the mild moist conditions of early postglacial periods, it became prominent during 7000–3000 BP in the southernmost part of its range (Ogden *et al.* 1993).

It is well-known that planted kauri can grow well in specific areas beyond its natural southern limit (Hutchins 1919). Pardy *et al.* (1992) reported on the performance of a range of indigenous plantations containing kauri throughout New Zealand. They found that kauri growth rates on good quality sites (lowland; moist, fertile, and free-draining soils) were

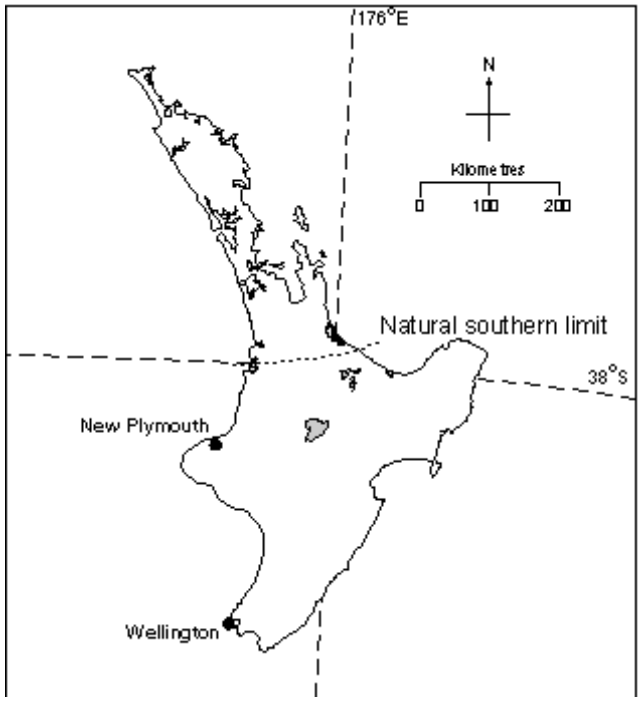

FIG. 1–Location of sites where kauri seedlings were found beneath planted kauri trees. Both sites are well south of the accepted natural southern limit of the species.

almost twice as great as those in natural stands, even in plantations outside the accepted natural range of the species.

Kauri produces wind-dispersed, small-winged seeds (Hutchins 1919). These germinate in autumn soon after dispersal and lose viability after only a few months on the forest floor (Whitmore 1977). Dispersal is usually limited to distances up to 150 m from the parent tree, but instances up to 1.5 km have been recorded (Mirams 1957). Bieleski (1959) and Barton (1982) described small seedlings as shade tolerant, but saplings and young trees require full overhead light for vigorous growth. Although tolerant of a wide range of soils (old sand dunes to heavy clays), kauri appears to compete best with broadleaved species on infertile sites and ridges (Silvester 2000). Natural stands tend to establish beneath shrub cover such as manuka (*Leptospermum scoparium* J.R. et G.Forst.) and kanuka (*Kunzea ericoides* (A.Rich.) J.Thompson) on previously disturbed sites (Beveridge 1975). Natural regeneration has been observed near the southern limit on disturbed sites (Beveridge *et al*. in press).

Female cones develop on planted trees as young as 6 years old (G.A.Steward unpubl. data). Within and outside the natural limit, trees produce viable seed at between 25 and 40 years of age (Halkett 1983). Ecroyd (1982) reported seed on 15-year-old trees. In spite of many years of kauri planting, no instance of persistent regeneration arising from trees planted outside the natural distribution area has previously been recorded. However, this note describes two instances of kauri regeneration occurring to the south of the natural limit.

OBSERVATIONS

Fred Cowling Reserve, New Plymouth

New Plymouth, on the west coast of the North Island of New Zealand, lies approximately 120 km south of the area described by Sando (1936) as the natural range of kauri (Fig. 1). The Fred Cowling Reserve, administered by the New Plymouth District Council, contains a 2.4-ha kauri stand planted in 1935. In 2001 the sparse understorey of this stand consisted of a range of indigenous hardwood species up to 30 cm tall. The most common were hangehange (*Geniostoma rupestre* A.Rich.), mahoe (*Melicytus ramiflorus* J.R. et G.Forst.), kawakawa (*Macropiper excelsum* (Forst.f.) Miq.), pukatea (*Laurelia novae-zelandiae* A.Cunn.), pigeonwood (*Hedycarya arborea* J.R. et G.Forst.), kamahi (*Weinmannia racemosa* R.Br.), tawa (*Beilschmiedia tawa* (A.Cunn.) Benth. et Hook.), and rewarewa (*Knightia excelsa* R.Br.). The margin of the kauri stand was dominated by tall (>7 m) planted heketara (*Olearia rani* (A.Cunn.) Druce) and varying amounts of regenerated kahikatea (*Dacrycarpus dacrydioides* (A.Rich.) de Laub.), totara (*Podocarpus totara* D.Don), and matai (*Prumnopitys taxifolia* (D.Don) de Laub.). In 1998 the 62-year-old kauri stand had a high stocking rate (1463 stems/ha); mean diameter at breast height 1.4 m (dbh) was 33.2 cm and mean height 18.7 m (Steward & Kimberley 2002). In November 2001 a single kauri seedling was observed on the southern margin of the stand. A subsequent intensive search located four more seedlings, all on the stand margin beneath the heketara/kauri canopy. Two sample seedlings were collected as herbarium specimens in January 2002 (Fig. 2A).

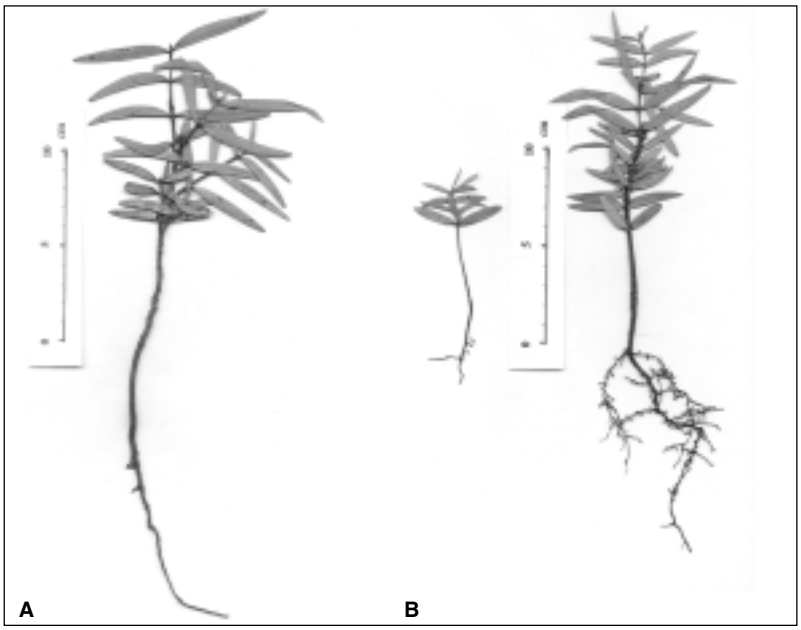

FIG. 2–Kauri seedlings found (A) in the Fred Cowling Reserve, New Plymouth, and (B) at Wilton, Wellington.
A. Herbarium specimen NZFRI 24421
B. Herbarium specimen NZFRI 24468

Wilton, Wellington

The suburb of Wilton lies to the north-west of the Wellington city centre and is approximately 365 km south of the area described by Sando (1936) as the natural range of kauri (Fig. 1). Approximately 200 kauri were planted in the Otari Native Botanic Garden (now Otari-Wilton's Bush) from 1929 (Cockayne 1932). During the same period, individual specimen trees were also planted in nearby private properties. In 2002, regeneration in the Otari-Wilton's Bush was reported in the local press (The Dominion 2002). Inspection by two of the authors (GAS and WJW) in May 2002 revealed many newly germinated (cotyledonary) seedlings beneath planted kauri. No well-established seedlings were found. A number of other reports of regeneration from planted kauri on private property were investigated at the same time. Four well-established seedlings were observed in a cultivated garden in Wilton Rd on the southern boundary of Otari-Wilton's Bush. These were growing immediately beneath a semi-mature open-grown kauri tree. Two sample seedlings were collected as herbarium specimens in May 2002 (Fig. 2B).

Seedling Description

Seedlings found at New Plymouth and Wellington were all growing within 1–5 m of semi-mature kauri trees. The habit of the root systems of the seedlings collected for herbarium specimens matched descriptions of natural seedling roots (Ecroyd 1982). There was no sign of distortion or taproot pruning, which is a feature of nursery-grown stock (D.O.Bergin & J.C.Van Dorsser unpubl. data) (Fig. 3), even some considerable time after planting (Steward pers. obs.). The range of root collar diameters was 2.8–3.5 mm in New Plymouth seedlings and 1.0–3.0 mm in the Wellington seedlings. Seedling age was

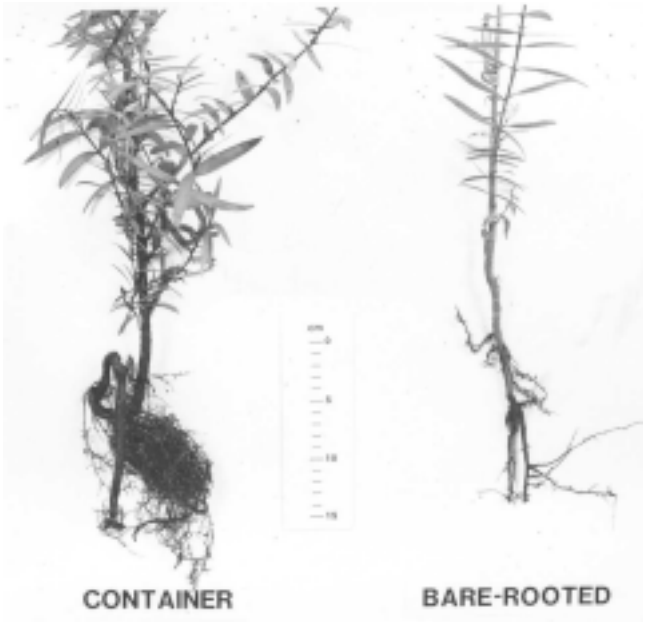

FIG. 3–Three-year-old nursery-raised kauri seedlings showing typical root system distortion and taproot termination and callusing.

estimated to be 5–7 years (New Plymouth) and 1–3 years (Wellington). At both sites the largest seedlings were considered to be well-established since the taproots had penetrated more than 10 cm into the mineral soil below the litter layers.

Site descriptions for Fred Cowling Reserve and Wilton are given in Table 1.

TABLE 1–Site descriptions.

	Fred Cowling Reserve*	Otari/Wilton's Bush†
Altitude (m)	60–80	70–280
Climate		
Mean annual rainfall (mm)	1540	1240
Mean No. of rain days per year	146	125
No. of ground frosts per year	6.6	15
Daily mean temperature (°C)	13.5	8.2–20.0
Soil	New Plymouth Brown Loam. Fine soft, non-cohesive yellow brown pumice.	Korokoro Soil. Shallow (less than 1 m deep); stony colluvium on ridges and slopes; silt loam over colluvium in valleys and hollows.

Sources:
* G.F.Pardy & D.S.Williams (unpubl. data)
† Wellington City Council (1996)

Climate Considerations

Lowlands within the natural range of kauri generally have warm summers and mild winters with well-distributed rainfall and a mean annual temperature of 13°–16°C. Frosts are rare. Meteorological conditions at the New Plymouth and Wellington sites are within the limits observed for the area occupied by natural stands and individuals (Table 2) and there is thus no obvious climatic barrier to kauri regeneration if a seed source is present. Conditions that allow or support kauri regeneration (Bieleski 1959; Barton 1982) clearly exist locally in regions outside the area regarded as the natural range.

TABLE 2–Meteorological data.

	Natural kauri habitat range	New Plymouth	Wellington
Mean annual rainfall (mm)	1000–2500*	1540‡	1240¶
Mean maximum temperature of hottest month (°C)	27–28*	29.1–30.0†	28.3–31.1†
Mean minimum temperature of coldest month (°C)	–2 to –3*	6.3–6.9†	5.4–6.0†
Absolute minimum temperature (°C)	–3*	–1.6†	–1.9†
Sunshine hours	1692–2297†	2114†	2020†

Sources:
* Beveridge *et al*. (in press)
† New Zealand Meteorological Service (1973)
‡ G.F.Pardy & D.S.Williams (unpubl. data)
¶ Wellington City Council (1996).

DISCUSSION

Viable kauri seed has probably been produced at both the New Plymouth and the Wellington sites for at least 28 years, and possibly for as long as 43 years. While there have been a considerable number of anecdotal reports from these sites of prior germination beneath planted kauri, high seedling mortality rates can be expected. McKinnon (1945) reported mortality in excess of 93% in a natural stand where there was a deep kauri litter layer penetrated by mature root systems. Here competition for moisture or other resources may have limited seedling survival.

An explanation for the recent appearance of these seedlings in these stands may be found in an analysis of climate data for New Plymouth and Wellington (NIWA 1994–2000) which shows a moderate increment in mean annual temperature at each site for the years presumed to cover the period of seed initiation, seedfall, germination, and early seedling development. At New Plymouth during the period 1994–96 the mean annual temperature rose by 0.14°C to 13.64°C. At Wellington during the period 1996–2000 the mean annual temperature rose by 0.54°C to 13.14°C. While a number of factors are likely to influence the successful germination and development of kauri seedlings, if the suggested trend towards global warming is real the extent of the area in which this species will reproduce is likely to increase.

After the initial finds of kauri regeneration from planted stands in New Plymouth and Wellington a number of other anecdotal reports were investigated in Wellington and Rotorua. The report of regeneration at Rotorua was the only incident where the seedling remained *in situ*. As the finds in New Plymouth and Wellington had been verified, and are south of Rotorua, no attempt was made to disturb the Rotorua seedling to verify its authenticity; the anecdotal evidence (Roger Crabtree and Margaret Dick pers. comm.) is reliable and accepted.

Currently there is enthusiastic support for planting kauri and other native trees for cultural, environmental, and heritage reasons, as well as for potential timber production (Herbert *et al*. 1996). The existence of seedlings originating from kauri planted outside the natural range of the species, as reported in this Note, extends the potential for managing kauri regeneration for a range of outcomes in the future.

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