



## Karaka (*Corynocarpus laevigatus*): native taonga (treasure) or environmental weed?

Kate G. McAlpine, Sally Cory, Bart Te Manihera Cox, Terese McLeod (Taranaki Whānui), Gillian Rapson, Nick Rahiri Roskruge (Te Ātiawa, Ngāti Tama) & Lara D. Shepherd

To cite this article: Kate G. McAlpine, Sally Cory, Bart Te Manihera Cox, Terese McLeod (Taranaki Whānui), Gillian Rapson, Nick Rahiri Roskruge (Te Ātiawa, Ngāti Tama) & Lara D. Shepherd (05 Sep 2024): Karaka (*Corynocarpus laevigatus*): native taonga (treasure) or environmental weed?, New Zealand Journal of Botany, DOI: [10.1080/0028825X.2024.2388751](https://doi.org/10.1080/0028825X.2024.2388751)

To link to this article: <https://doi.org/10.1080/0028825X.2024.2388751>



© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 05 Sep 2024.



[Submit your article to this journal](#)



Article views: 1027










[View related articles](#)



[View Crossmark data](#)

## Karaka (*Corynocarpus laevigatus*): native taonga (treasure) or environmental weed?

Kate G. McAlpine <sup>a</sup>, Sally Cory <sup>b</sup>, Bart Te Manihera Cox <sup>c</sup>,  
Terese McLeod (Taranaki Whānui) <sup>d</sup>, Gillian Rapson <sup>e</sup>, Nick Rahiri Roskruge  
(Te Ātiawa, Ngāti Tama) <sup>f</sup> and Lara D. Shepherd <sup>g</sup>

<sup>a</sup>Department of Conservation, Wellington, New Zealand; <sup>b</sup>Wellington After Hours Veterinary Clinic, Wellington, New Zealand; <sup>c</sup>Urban Ecology Team, Wellington City Council, Wellington, New Zealand; <sup>d</sup>Zealandia Te Māra a Tāne, Wellington, New Zealand; <sup>e</sup>School of Food Technology and Natural Sciences, Massey University, Palmerston North, New Zealand; <sup>f</sup>School of Agriculture & Environment, Massey University, Palmerston North, New Zealand; <sup>g</sup>Natural History Team, Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand

### ABSTRACT

Karaka (*Corynocarpus laevigatus* J.R. Forst. & G. Forst.) is an endemic New Zealand tree species that attracts polarising views and controversy. Prior to the arrival of humans in New Zealand, karaka was probably restricted to warmer areas of the northern North Island, but it now occurs throughout much of New Zealand, including on Rēkohu/Chatham Island (where it is known as kōpi). Genetic analyses have shed light on the evolutionary origins of karaka and its translocation history. Karaka holds significant cultural and historical value for Māori and Moriori, but it is also viewed as an environmental weed outside its natural range due to its capacity to outcompete resident native vegetation and disrupt local ecosystems. Karaka fruit can be toxic to dogs and other animals, including humans, if not prepared correctly before consumption. The management of karaka in New Zealand presents a unique challenge that exemplifies the complexities inherent in balancing cultural values with ecological integrity. The aim of this paper is to bring together all these different perspectives and explore avenues for future management strategies that accommodate both the cultural significance and the ecological impact of karaka. An informed, culturally sensitive management strategy that involves mana whenua can pave the way for a future where both cultural and ecological aspects of the karaka tree are given due consideration where appropriate. Such an approach could also inform the management of other native plant species that become invasive outside their natural range both in New Zealand and internationally.

### WHAKARAPOTO

Ko te karaka he momo rākau māori nō Aotearoa e tauwehe ana i ngā whakaaro. I mua i te taenga mai o te tangata ki Aotearoa, i

### ARTICLE HISTORY

Received 23 March 2024  
Accepted 1 August 2024

### HANDLING EDITOR

Gary Houlston

### KEYWORDS

*Corynocarpus laevigatus*;  
cultural value; invasive plant;  
karaka; karakin; kōpi; native  
weed; New Zealand; taonga  
species; weed

**CONTACT** Kate G. McAlpine  kmcalpine@doc.govt.nz; Nick Rahiri Roskruge  N.Roskruge@massey.ac.nz

© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group  
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

tipu kōpīri kē pea te karaka ki ngā takutai o Te Ika-a-Māui, heoi, e tipu ana ināianeī puta noa i Aotearoa, tae atu ki Rēkohu, arā, ki Wharekauri (e mōhiotia ai ki reira ko te kōpi). Nā ngā mahi tātari iranga i mārama ake te kite i te pū o te kunenga mai o te karaka me ōna kōrero whakawhitinga pūira. He rākau whai tikanga nui te karaka ki te iwi Māori me te iwi Moriori, heoi, tērā anō te whakaaro he taru tawhiti ia kua horapa ki waho i tōna kāinga, nā te kaha whenumi anō ki ngā hautipu taketake me te whakararu i ngā pūnaha hauropi o te rohe. He kai tāoke te hua o te karaka ki te kuri me ētahi atu kararehe, hui tahi ki te tangata ki te hē te whakarite i mua i te kai. Ko tā te mahinga karaka ki Aotearoa he whakaatu i tētahi tukinga motuhake e whakatauiria nei i ngā uauatanga pūmau o te whakataurite tikanga i runga anō i te pono hauropi. Ko te whāinga o tēnei tuhinga he whakatōpū mai i ēnei tirohanga rerekē katoa, me te tūhura i ngā ara ki te whakahaere i ngā rautaki whakamua ki te āta whakarite tahi i te tikanga ake me te pānga o te karaka ki te hauropi. Mā tētahi rautaki whakahaere – e mārama aronui ana ki ngā tikanga me te whai wāhi mai o te mana whenua – e para ai tētahi ara whakamua e mātua whakaarohia ai ngā āhuatanga hauropi me ngā tikanga mō te karaka. Tērā pea mā tētahi ara pēnei e mārama ake ai te whakahaerenga mō ētahi atu momo tipu māori ka horapa ki waho i ō rātou kāinga.

## Introduction

Karaka (*Corynocarpus laevigatus* J.R. Forst. & G. Forst.; Corynocarpaceae) is a New Zealand endemic tree species with a rich history that is intertwined with humans. There has been much debate around its origins and whether it evolved in New Zealand or was brought here by early Polynesian explorers. For Māori and Moriori (who call the species kōpi), karaka is a taonga (treasured) species with significant spiritual and cultural importance – including being an important source of food, particularly in winter (Maxwell and Tromp 2016). On Rēkohu (Chatham Island), karaka trees were adorned with carvings known as rākau momori, which are unique to Moriori culture and globally significant (Maxwell 2017). Much of the current southern distribution of karaka is thought to originate from Māori translocation as part of its cultivation. Karaka groves were planted near pā (fortified village) sites and carefully tended (Leach and Stowe 2005).

On the other hand, karaka is sometimes considered an invasive weed where it occurs outside its natural range in New Zealand. In some regions, its propensity for what is sometimes called ‘aggressive regeneration’ can result in the exclusion of other native species (which may be locally endemic) and the transformation of existing native plant communities (Costall et al. 2006). This can pose a concern for environmental management, particularly in ecosystems that are already fragile or under stress.

Another negative aspect of karaka is that the seeds are toxic to dogs (and other animals) (Bullen 2015). Warning signs about the poisoning risk of karaka and the need for dogs to be kept on a lead are often erected in popular dog-walking areas where karaka trees are present. It is not clear how many dogs are poisoned by karaka in New Zealand each year, but it may be several hundred. It is not surprising therefore

that dog owners are extremely wary of karaka trees, some even going so far as to suggest that they be removed from all public areas.

Karaka's multifaceted identity as treasured native species with potential environmental and societal concerns exemplifies the complex and often nuanced relationship that humans have with the natural world. It challenges the straightforward classification of plants as simply 'good' or 'bad', highlighting the need for context-sensitive approaches to both cultural preservation and environmental conservation (Wehi and Lord 2017). The decision to retain or remove karaka is not black or white, given these diverse, often polarising viewpoints. Might it be possible to develop management solutions that are sensitive and respectful to all perspectives? What would those look like, and how and why might solutions differ according to location? In 2022, a wānanga (educational seminar and discussion) on karaka was hosted by the Wellington City Council and Zealandia Te Māra a Tāne (an ecosanctuary) in Wellington, New Zealand to consider these questions and plan the way forward. The aim of the wānanga was to bring together people representing these different perspectives to facilitate a mutual understanding and consideration of the bigger picture. This paper summarises these different perspectives and explores a way forward that respects them all.

## Ecology and distribution of karaka

Karaka is an evergreen tree up to 15–20 m tall, endemic to New Zealand. *Corynocarpus* means 'club fruit', and *laevigatus* means 'smooth', in reference either to the skin of the fruit (Molloy 1990) or the leaf (Poole and Adams 1994). *Corynocarpus* is the sole genus in the family Corynocarpaceae. *Corynocarpus* currently has five recognised species, of which only *C. laevigatus* occurs in New Zealand. The other four species are found in tropical to warm temperate areas in the southwest Pacific.

Karaka has large, 15(–30) cm long, untoothed, leathery, elliptic-oblong leaves which are dark green and glossy (Figure 1). Tiny green and white flowers (<0.5 cm) (Figure 1) appear in large clusters from August to November, depending on location. Karaka is gynodioecious, meaning female plants produce functionally female flowers while bisexual plants produce hermaphroditic flowers containing both sexes (Garnock-Jones et al. 2007). Female flowers (if pollinated) tend to set significantly more fruit than hermaphroditic flowers (Garnock-Jones et al. 2007). Pollination is probably by insects (Costall et al. 2006). Many large, yellow-orange fruits (Figure 1) are formed



**Figure 1.** Karaka bark (David Glenny/Landcare Research 2012, CC BY 4.0), foliage (Kate McAlpine), flowers (Michael Berardozzi), and ripening fruit (Robyn Simcock).

from January to April, with considerable regional and latitudinal variation in fruiting times (Dijkgraaf 2002; Stowe 2003). Each fruit is an ovoid, one-seeded drupe, which has a tough exocarp (outer flesh), a fleshy mesocarp (inner flesh) and a fibrous inner layer around the seed. Drupes (hereafter called fruits) are variable in size, from about 3 cm and up to 4.2 cm in length and 6(–13) g fresh weight (van Essen and Rapson 2005; Costall et al. 2006). Fruits have a distinctive sweet smell when ripe.

Karaka trees are usually single-stemmed, but readily resprout from epicormic buds, especially near the base if the main trunk is damaged (Figure 2). The species is relatively long-lived for an angiosperm, with Burstall and Sale (1984) and Stowe (2003) suggesting a maximum age of >500 years (Costall et al. 2006).

Karaka is capable of producing fruit from about ten years of age or earlier (Molloy 1990). Seeds tend to germinate rapidly after (ripe) fruits have been shed (Burrows



**Figure 2.** Karaka readily resprouts if the original trunk is damaged. Photo by Sandra Simpson.

1996; Stowe 2003), and seed viability can be as high as 90% (Burrows 1996; Wotton and Kelly 2011). Large seed size conveys an advantage for persistence in shade and for germination if seeds are deeply buried, but can be a disadvantage in exposed sites where seeds are vulnerable to drying out (Bannister et al. 1996). Karaka seeds are recalcitrant, meaning that they have a high water content, a well-developed embryo, no dormancy, and are sensitive to desiccation and intolerant of dry storage (Fountain and Outred 1991; Bannister et al. 1996). However, the fleshy mesocarp and husk (Figure 3) can buffer seeds from desiccation, which may allow seeds to persist on the soil for several months before germinating (Bannister et al. 1996). Burrows (1996) suggested that ideal conditions for karaka seedling establishment are if seeds are dispersed to moist, shaded sites, or are shallowly buried in the soil or beneath leaf litter.

The large size of karaka fruit means that kererū and parea (endemic wood pigeons of the genus *Hemiphaga*) are the only extant bird species with a gape large enough to consume and disperse karaka fruits (Wotton and Kelly 2011). The decline in kererū and parea populations has disrupted this dispersal mutualism (Kelly et al. 2010; Wotton and Kelly 2011). Dispersal failure, combined with seed and seedling predation by introduced mammals can lead to significantly lower recruitment of karaka (Wotton and Kelly 2011). Introduced mammals such as possums and ship rats do not appear to play a role in karaka seed dispersal (Costall et al. 2006), although they do consume karaka fruit flesh and old, presumably less toxic, kernels (Cowan 1992; Dijkgraaf 2002; Stowe 2003; Wotton 2007). This was apparent when possum and rat eradication on Kapiti Island led to a dramatic increase in karaka seedling recruitment (Sawyer et al. 2003). Centuries ago, karaka fruits may have been also dispersed by now-extinct species such as moa and other large birds (Clout et al. 1995).

Karaka is relatively frost-intolerant (Molloy 1990), and in northern New Zealand it generally occupies warm, moist sites close to the coast in mid-successional forests,



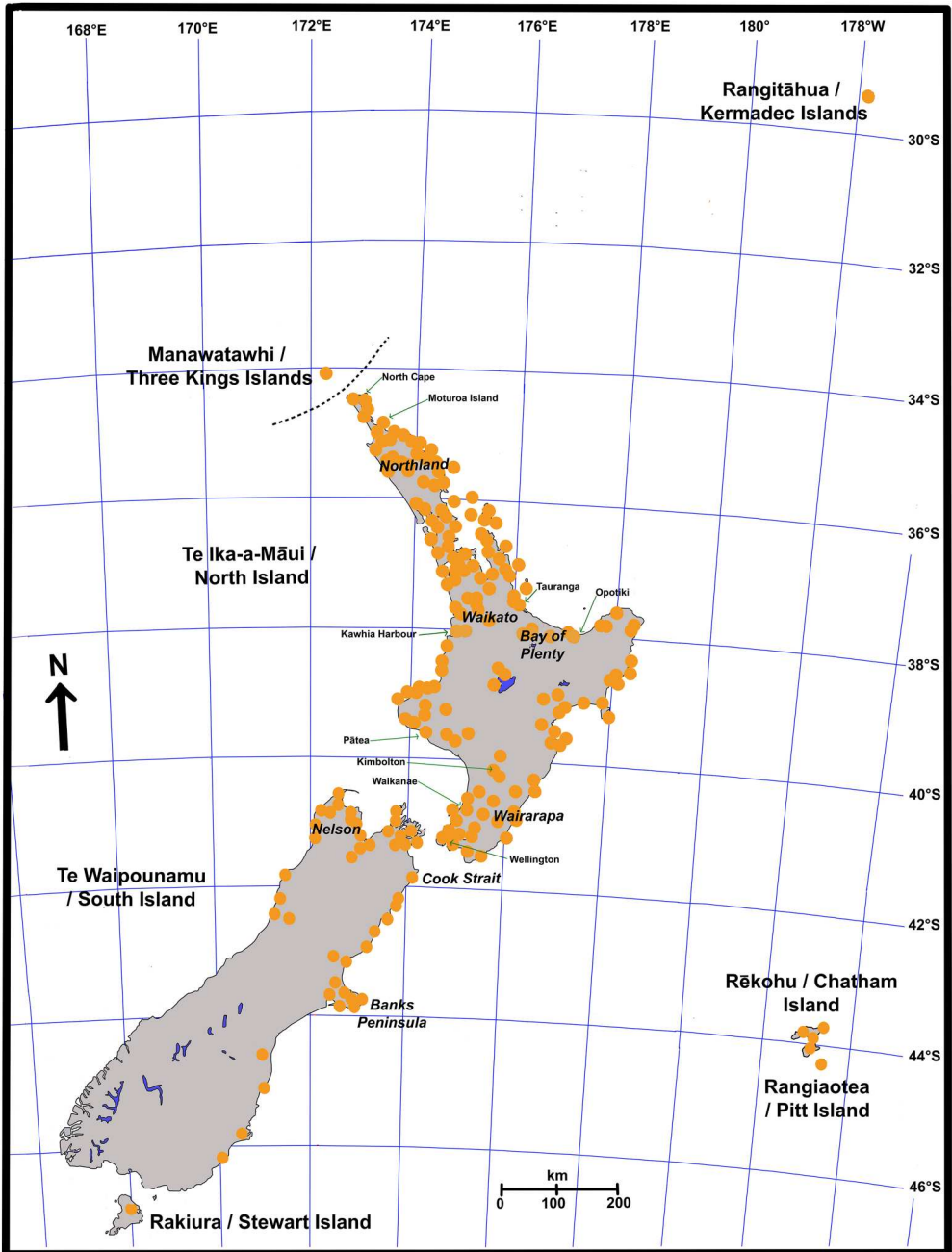
**Figure 3.** Karaka fruits, husks, and seeds/kernels. Photo by Murray Parsons/Landcare Research, CC BY 4.0.

where it co-occurs with a range of other tree and shrub species such as pūriri (*Vitex lucens*), taraire (*Beilschmiedia tarairi*), and kohekohe (*Didymocheton spectabilis*) (Wardle 1991; Platt 2003; Atherton 2014). On Great Mercury Island, Wright (1976) described karaka as forming part of the sub-canopy in pōhutukawa (*Metrosideros excelsa*) coastal forest, along with pūriri, tawāpou (*Planchonella costata*), kohekohe, lancewood (*Pseudopanax crassifolius*), māhoe (*Melicytus ramiflorus*), and a range of shrub species. Ogle (1997) described karaka occurring in mixed stands with tītoki (*Alectryon excelsus*) and māhoe on sand dunes of the Poutu Peninsula in Northland, sometimes with tōtara (*Podocarpus totara*) and kānuka (*Kunzea* spp.), but nowhere dominant.

Historically there has been considerable debate over the origin of karaka in New Zealand (Stowe 2003). Māori oral history includes many stories about the arrival and dispersal of karaka across Aotearoa and how local communities relied on it for sustenance. Early Polynesian explorers on the Aotea waka (canoe) (Ngā Rauru, south Taranaki) are credited with bringing karaka along on their journey, apparently having sourced the tree from Rangitāhua (Kermadec Islands; Figure 4), which they visited as they crossed Te Moana nui a Kiwa, the Pacific Ocean. The Aotea later made landfall in Kawhia harbour and the ancestors of Ngā Rauru then travelled overland following the coast until eventually arriving at Pātea. They planted karaka seed at a location called Pou-o-Turi where they settled and descendants remain today (Tautahi et al. 1900). Another story tells of karaka being introduced to the Eastern Bay of Plenty region by Roau of the Nukutere canoe and planted at Waioeke near Opotiki (Best 1925). According to Moriori tradition, karaka was introduced to the Chatham Islands by Maruroa and Kauanga who travelled in the waka Rangimata from Hawaiki (traditional Māori place of origin) and successfully planted karaka seed at several sites (Hamilton 1903; Roskrugge 2007).

There has also been uncertainty around the natural (pre-human arrival) range of karaka *within* New Zealand – in large part because it was so widely cultivated and translocated soon after humans did arrive (c. AD 1280; Wilmschurst et al. 2008). Specimens of karaka were collected in Queen Charlotte Sound during Captain Cook's second visit to New Zealand in 1773 (Molloy 1990). In 1889, karaka was reported to be present throughout the North Island from North Cape to Cook Strait and on nearly all outlying islands on the east and west coasts of the North Island, as well as many inland localities (Kirk 1889). Molloy (1990) suggested that Māori oral traditions that describe bringing karaka to New Zealand may actually relate to the translocation and cultivation of karaka within the New Zealand region, for which there is abundant anecdotal and botanical evidence. Records south of Banks Peninsula (mid-South Island; Figure 4) are likely to be recent horticultural introductions.

Although karaka is now found south to the northern half of the South Island, and on many offshore islands including the Kermadec and Chatham Islands, it is generally agreed that prior to the arrival of Polynesians in New Zealand, karaka was probably restricted in distribution to the northern North Island, where it was likely a remnant population that survived successive ice ages (Molloy 1990; Stowe 2003; Leach and Stowe 2005; Costall et al. 2006; Maxwell and Tromp 2016). The southern limit of many plant species is close to 38°S (see Figure 4) where the warmer northern climate gives way to a cooler southern climate (Garnier 1958; McGlone 1985). Northland has been a tectonically stable region of New Zealand and has acted as a refuge for some



**Figure 4.** Map of the distribution of karaka (orange dots) based on herbarium records (see Atherton et al. 2015) and iNaturalist observations (<https://inaturalist.nz/>). The dotted line indicates the main genetic split in the species based on Atherton et al. (2015). The 38°S latitude line is where the warmer northern climate gives way to a cooler southern climate and marks the natural southern limit of many New Zealand plant species. Records south of Banks Peninsula are likely to be recent horticultural introductions.

components of the flora during the Pleistocene (McGlone 1985; Atherton 2014). Karaka's association with other plant species in the Miocene, which are now confined to Northland, also supports the conclusion that the natural, post-glaciation range of karaka was Northland (Campbell 2002; Atherton 2014).

Stowe (2003) considered the issue from a different angle, classifying 805 existing karaka stands (not including the Kermadec or Chatham Islands) as either 'cultural' or 'unknown'. 'Cultural' stands were those growing within 500 m of a registered archaeological site (pā, storage pits, terraces, gardens, stone walls, middens, or cultivation areas) and 'unknown' stands were those that had no association with such archaeological sites. The greatest overlap between the two types of stand was in Northland and Auckland, although there was also significant overlap in Taranaki, Wellington/Kapiti and Nelson areas (Stowe 2003). These results add further weight to the conclusion that the northern North Island, to c. 38°S (Figure 4), was probably the natural, post-glaciation range for karaka.

## Genetics of karaka

Genetic analyses have shed light on the evolutionary origins of karaka and its translocation history. Several studies have examined the immediate relationships of karaka using DNA sequences (Wagstaff and Dawson 2000; Atherton et al. 2015). These have shown that *Corynocarpus* has a palaeotropical origin and that the closest relative of karaka is the New Caledonian species *Corynocarpus dissimilis*, confirming that karaka is endemic to (only naturally found in) New Zealand. Molecular dating indicated that the two species diverged around 5 million years ago (mya) (Atherton et al. 2015).

Genetic analyses have also helped to trace the origins and dispersal pathways of translocated karaka. Atherton et al. (2015) revealed that karaka from the Three Kings Islands was genetically distinct from other populations, likely diverging from the mainland karaka around 1 mya. Therefore, the Three Kings Islands are not the origin of translocated karaka. However, a lack of variation at the DNA markers examined prevented the determination of the genetic relationships between other karaka populations.

Atherton (2014) examined additional DNA markers, which provided further insight into the relationships of karaka populations but was also hindered by a lack of genetic variation. Six chloroplast variants were detected in karaka, all of which occurred within its putative natural range. Only two of these variants occurred in southern North Island and northern South Island and one of them was also found on Rēkohu (Chatham Island). The reduced genetic variation in these populations is consistent with a translocation origin. Unfortunately, the two DNA variants found in the translocated populations have widespread distributions within the natural range of karaka, so cannot be used to pinpoint their source population(s). This result contrasts with rengarenga (*Arthropodium cirratum*), where almost every population within its natural range exhibits a different DNA variant, thus allowing the precise source populations of translocated rengarenga to be determined (Shepherd et al. 2016).

Atherton (2014) detected only a single DNA variant in karaka that had been translocated from mainland New Zealand to the Kermadec Islands. This variant was much rarer on the mainland than the two variants in the translocated mainland populations and was

only recorded in the eastern Bay of Plenty, Tauranga and several sites in Northland. These sites are therefore potential sources of Kermadec Islands' karaka.

To date, determining the relationships of translocated karaka populations has been hampered by both insufficient genetic variation in the markers tested and a lack of genetic structuring (DNA variants have widespread distributions within the natural range). Developing and applying new genomic markers such as whole chloroplast genome sequences (Atherton et al. 2010) and ddRAD loci (Shepherd et al. unpublished data) may overcome the former problem but the lack of genetic structuring may be more difficult to circumvent.

## Significance of karaka to Māori and Moriori

Karaka was an important food crop for the ancestors of modern Māori and Moriori (Maxwell and Smith 2015). It replaced some of the Polynesian crops that were brought to New Zealand but failed to thrive in the colder climate (Barber et al. 2016; Maxwell 2017). Karaka fruits provided a good source of carbohydrates (58% per fruit) and protein (11% per fruit) (McCurdy 1947), especially in lean winter months when other foraged food options were scarce (Maxwell and Tromp 2016). The fleshy outer part of the ripe fruit is pungent and edible, but the kernel contains a poisonous alkaloid (karakin) and can cause paralysis. Māori and Moriori learned to process karaka kernels in a way that made them safe to eat, and this practice continues to this day in some parts of New Zealand. There were a number of processing methods used for karaka, usually including boiling or steaming for a prolonged period and then soaking in running water (for many days or even weeks), before being dried and roasted (Figure 5). These detoxified, dried kernels, known as 'Māori peanuts' and sometimes 'kōpia', were useful while travelling as they were light to carry and did not deteriorate easily. They were also important in traditional ceremonies and in formal exchanges between tribes. To make flour, the processed kernels were sundried until the outer husk came off, and the nut was then pounded into flour, mixed with water and cooked. The skill of knowing how to turn the toxic kernels into non-toxic food was hugely important in a society with limited food stores.

The significance of karaka to Māori and Moriori, particularly as a food source, is also reflected in the writings of early European historians in New Zealand. For example, Colenso (1880) wrote that the karaka was '*of inestimable value to the Maori as a common and useful article of vegetable food, second only in place to their prized kumara tuber*'. Skinner and Bauke (1928) reported that karaka was '*... most relied upon as food to be preserved for winter use ...*' on Rēkohu (Chatham Islands). Best and Andersen (1942) reported that

Horehore is a term applied to the covering of the kernel, which flesh is soft and mealy when the berry is ripe; the ripened berry is of an orange colour. When a native speaks of karaka horehore he means the berries of the karaka having this meal still adhering to the kernel. The prepared kernels used as a food-supply are called kopia, while kopi is another name for the tree.

Graham (1948) wrote of a Ngāti Awa informant by the name of Potene:

He had been applied to for some kope kotero (karaka berries) steeped in boiling water and in a state of fermentation (maaka). This concoction was esteemed as a highly delectable relish



**Figure 5.** Women roasting karaka kernels at Whakarongotai marae in Waikanae, 1908. Alexander Turnbull Library, Wellington, New Zealand. Photo by Harold Stevens Hislop.

(kinaki), eaten with or without other foods. Potene was a connoisseur in those matters, and an adept in the preparation of kope kotero. But a particular karaka tree produced in Potene's opinion, the only kakano (berries) amenable to the process of kotero. Hence his seasonal queue of clients applying for a supply of his kope kotero.

However, the evidence for karaka being a staple is limited, in particular when contrasted with the other starchy staples of kumara (*Ipomoea batatas*), bracken fern (*Pteridium esculentum*) root and the growing apices of tī (*Cordyline australis*). Early European visitors made little reference to karaka when describing the typical plants eaten by Māori, such as Angas (1847), who mentioned kumara, taro (*Colocasia esculenta*), fern root, tree fern (*Cyathea* and *Dicksonia* species), nīkau (*Rhopalostylis sapida*), tī and kiekie (*Freyinetia banksii*) but not karaka. Archaeological evidence is also limited, and it is not known where or how karaka fruits were stored by Māori and Moriori (Maxwell and Tromp 2016). Also, Best (1931) suggested that it was only used in appreciable quantities 'in some districts'. In summary, there is no doubt that karaka was a valued food item, but this was probably location specific.

In times past, many elements of the natural landscape contributed to food and rongoā (traditional medicines), which supported people's health and well-being. Karaka was not particularly renowned for its rongoā value other than in nutrition, but it did have some uses; the shiny, upper side of the leaf was applied fresh to heal broken or infected skin, whereas the dull underside of the leaf was used to draw an infection out (Riley 1994). A



**Figure 6.** Old karaka grove, likely planted by early Māori, at Mara in the Wairarapa. Photo by Leon Perrie.

body wash was also made from boiling leaves of both karaka and ngaio (*Myoporum laetum*) leaves and was used to relieve shallow pain such as in bruising (Riley 1994).

Karaka trees were also well recognised as landmarks or tohu to indicate camp sites, mahinga kai (food gathering) sites and bird snaring sites, and other tribal locations and boundaries. Karaka fruits were also used as attractants for bird snaring. Coastal iwi (tribes) were more familiar with the tree than inland tribes. Karaka was purposefully planted in groves (e.g. Figure 6) near settlements and managed from seedling to maturity for its food value (Molloy 1990; Park 1995; Wilmshurst et al. 2004; Barber et al. 2016). These trees were meticulously cared for and moss and mould was regularly cleaned off them to ensure a good fruiting season. Some of these groves were extensive, such as one that covered 6 ha on the south Wellington coast, and another that extended for ‘half a mile’ along a Wainuiomata valley (Sawyer et al. 2003).

Establishing new plantations of karaka outside its natural range may not have been easily achieved. Much speculation exists regarding the method of growing new plants either from seeds, clonal cuttings or as transplants (Leach and Stowe 2005), but it is generally thought that transplanting wild seedlings was the most common form of establishing new trees. In an effort to reduce the juvenile growth period, which can last up to 10 years, transplanted seedlings would be left to settle and in future seasons have strips of bark taken off them to encourage flowering and seed setting through stress (Klinac et al. 2009). There is also evidence that planted karaka trees had been especially selected

to bear larger fruits than those found elsewhere, both on mainland New Zealand and on the Chatham Islands (Platt 2003; Leach and Stowe 2005; van Essen and Rapson 2005).

Karaka trees were often named individually or as a grove to secure the role of the tree or grove in the whānau (extended family group), hapū (kinship group) and iwi (tribe) relationship with Papatūānuku (the Earth mother). Trees were named and revered for their reliable harvest each year. The whakapapa (lineage) of the trees was known and retained across the generations as old plantations were replaced with new ones. The kai-tiaki or guardians of these trees had the responsibility to observe and ensure their well-being throughout the year, not just at the seasonal harvest period. Laing and Blackwell (1940) suggested that karaka had ceremonial use but did not elaborate on which part of the tree or how it was utilised. Graham (1951) identified a karaka tree within the Waikato region known as Te Iringa o Okaroa, used for hanging the bodies of the deceased.

Karaka was also known for producing wood of suitable quality for making tools, and there are also anecdotes suggesting that the wood was used for construction purposes including waka building (Dieffenbach 1841; Graham 1951). On the other hand, Wardle and Platt (2011) report that karaka wood is easily split, of low durability and of little value other than for firewood. Similarly, in a study of the wood anatomy of karaka, Patel (1975) agreed with Kirk's (1889) assessment of karaka wood as non-durable, and suggested that this could be because "it consists of a large proportion of parenchymatous tissue whose carbohydrate contents would provide a readily available food source for the establishment of wood-destroying organisms". Thus, it is perhaps the tree, rather than the wood quality, that is reflected in the following whakatauki: *Anei ngā mea i whakataukitia ai e ngā tūpuna, ko te kaha, ko te uaua, ko te pakari, ko te kaha i te toki, ko te uaua i te pakake, ko te pakari i te karaka. Here are the things valued by the ancestors, it is the strength, the vigour, the sturdiness, it is the strength of the adze, the vigour of the whale and the sturdiness of the karaka tree.* Moriori also used karaka wood to smoke and preserve food (Kerridge 2018).

Karaka has additional emotional and spiritual significance for Moriori. Moriori inscribed ancestral figures and motifs on the bark of karaka trees, creating a unique, globally significant art form known as rākau momori (dendroglyphs; Figure 7). These carvings (which are actually created by bruising or etching, rather than carving the bark) are complex and diverse portrayals of ancestors and events – many of them memorials for departed loved ones (Solomon and Thorpe 2012). Rākau momori also feature stylised images of birds, fish, seaweed, trees, seals, and other objects (Jefferson 1955), and provide one of the few remaining links to Moriori culture and karapuna (ancestors) (Jopson and McKibbin 2000). Rākau momori were once found in the extensive karaka groves over much of Rēkohu (Chatham) and Rangiaotea/Rangiauria (Pitt) Islands. However, most of the karaka forests with rākau momori have been cleared for farming over the past 150 years, and the few remaining are under threat from grazing and browsing animals, wind exposure and storm events (Figure 8), vandalism, and from a plant pathogen that causes crown die-back, bark disintegration and root rot (Maxwell 2017). Many of the remaining rākau momori are barely visible to the naked eye because the markings slowly disappear as the trees grow, which sadly means the rākau momori will eventually be lost. In 2011 the difficult decision was made to remove eight of the trees (and another eleven in 2013) to preserve them (Figure 9). There is now a rāhui (restriction of access)



**Figure 7.** Rākau momori, a unique Moriori art form created on kōpi (karaka) trees. Photo by Nirmala Balram ©Te Papa.

on the groves because of their fragile state and urgent work is underway to protect the few remaining engraved trees, including restoring wind-resistant forest edges, building wind-breaks, excluding stock, and controlling pests (Maxwell 2017). Additional work to digitally scan the remaining rākau momori is also underway (Barber and Maxwell 2011; Solomon and Thorpe 2012; Barber et al. 2014).

Within te ao Māori (the Māori world), there is always an ecosystem that aligns to significant trees and that ecosystem would be read in relation to the health of the tree and surrounding resources. Different birds would feed from karaka trees at different times of the year. For example, tūi (*Prothemadera novaeseelandiae*) and korimako (bellbirds; *Anthornis melanura*) were known to visit during flowering to seek out nectar in the late spring (August in the north of the North Island through to around November in the top of the South Island). Karaka fruiting is a sign that kererū and kiore (*Rattus exulans*) will soon be at their best for harvesting, having fattened themselves up on karaka fruits (Kerridge 2018). During late summer kererū feast on the ripe fruits and disperse the seeds. Other smaller birds such as toutouwai (North Island robin; *Petroica longipes*), tauhou (silveryeye; *Zosterops lateralis*) and pōpokotea (whitehead; *Mohoua albicilla*) forage on and around karaka for insects. These floral and faunal life cycles around the dominant tree species such as karaka were always observed for their nuances in responding to environmental pressures; they were the tohu (signs) which informed the communities of old.

Historical karaka groves have also served as inspiration for modern day paintings, such as *The Karaka Grove*, by Michael Moore (Figure 10). The inspiration for this painting was a sacred grove of karaka near Te Wharau, Wairarapa, where members of the local iwi were said to camp and pray for a week every year (M. Moore, pers. comm.). The



**Figure 8.** Degraded and dying kōpi (karaka) grove on Rēkohu (Chatham Island). Photo by Jay Pruett.

planted karaka grove alongside Te Raukura (Te Wharewaka o Poneke) on Wellington's waterfront is another contemporary example that demonstrates the significance of karaka.

In another indication of the importance of karaka in New Zealand, an artistic rendition of the species was used for the one penny postage stamp in 1960 (Figure 11), replacing the traditional image of the sovereign. The same design was later used for the 1 cent stamp, issued on 10 July 1967 when New Zealand converted to decimal currency (collectables.nzpost.co.nz).

### **Poisoning risk to dogs and other animals**

Karaka poisoning is a serious and potentially fatal condition that can affect dogs and other animals when they eat karaka fruit. The fruits contain the alkaloid karakin, along with several other related compounds which together contribute to the plant's toxicity. Karakin is hydrolysed in the body to produce the toxic metabolite 3-nitropropionic acid (3NPA). 3NPA results in impaired ATP synthesis, oxidative damage of cells, and



**Figure 9.** Rākau momori kōpi (karaka) trunks ready for preservation processing on Rēkohu (Chatham Island). Photo by Jack Ward, reproduced with permission from the Wairoa Star.



**Figure 10.** 'The Karaka Grove—diptych', by Michael Moore, 2013. Acrylic on canvas. Private collection, reproduced with permission from Michael Moore.

neurodegenerative effects (Slaughter et al. 2012). Effectively, 3NPA halts cell energy production and leads to cell death (Slaughter et al. 2012).



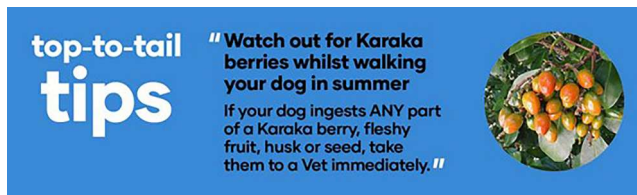
**Figure 11.** New Zealand one penny postage stamp 'Karaka (*Corynocarpus laevigatus*)' issued 1 September 1960. Design by G F Fuller.

The concentration of karakin in the fruit is highly variable and dependent on such things as the maturity of the plant, soil conditions, climate and season (MacAskill 2013). The kernels contain the greatest concentration of the alkaloid and may remain toxic in the soil well beyond the fruiting season of the plant, leading to possible poisoning outside of the fruiting 'window' (Dalefield 2017). There is some evidence that the toxicity of uncooked kernels diminishes with age, but even 20-year-old kernels have been found to have significant levels of toxicity (Connor 1977).

Karaka poisoning has been recorded in dogs, humans, rats, kiwi, chickens, rock pigeons, guinea pigs, sheep, cattle, and rabbits (Connor 1977; Dalefield 2017; Watson et al. 2022). Conversely, (Platt 2003) reported seeing sheep consuming entire crops of karaka fruit, with no ill effects. Kererū (and parea) regularly consume karaka fruits (Figure 12), and although they can appear drunk (due to fermentation of the mesocarp) and/or too full to fly after consuming them, they seem to be otherwise unaffected. Nectar



**Figure 12.** New Zealand pigeon kererū (*Hemiphaga novaeseelandiae*) eating a karaka fruit. This karaka fruit is likely about 3.2 cm long, typical of a wild type. Photo by Geoff de Lisle, New Zealand Birds Online.



**Figure 13.** Warning message for dog owners on a New Zealand pet shop website (<https://www.animates.co.nz/articles/summer-safety>).

from karaka flowers can also be highly toxic to honeybees, and beekeepers are advised not to plant karaka trees and/or to move hives away from karaka trees during the flowering season (Palmer-Jones and Line 1962).

Dogs are particularly prone to karaka poisoning, because they are very attracted to the sweet-smelling ripe karaka fruits and will rapidly consume large quantities of whole fruits. Clinical symptoms in dogs include vomiting, diarrhoea, reduced appetite, loss of balance and weakness. This can progress to a paresis or paralysis of the hind limbs. In severe acute poisoning, dogs develop seizures which then progress to coma, respiratory failure, and death (Bullen 2015). In non-acute cases it can take up to 24–48 hours after ingestion of karaka fruits for clinical signs to manifest (Bullen 2015). There are no recorded data on toxic levels in dogs, but anecdotally they appear to be acutely sensitive to the poison. Poisoning has been recorded with ingestion of a single fruit (Bullen 2015).

It is not known how many dogs are poisoned by karaka in New Zealand each year, but it may be as many as hundreds. One veterinary clinic in Wellington has recorded 258 cases relating to known or suspected ingestion of karaka fruit since 2015, some of which proved fatal. This equates to approximately 7–8 cases per month seen by one clinic over the fruiting period of karaka (January–April) each year. Most cases are managed pre-emptively by inducing vomiting and decontaminating dogs that are known or are suspected to have eaten karaka, so the number of dogs that develop clinical signs of poisoning is significantly lower than that.

There is no antidote for karakin or 3-NPA toxicity, and so treatment and support is based on symptoms (e.g. fluids are given if the dog is not eating or drinking or is vomiting). If the patient responds to early treatment, it may take up to 6 weeks for return to normal neurological function (Bullen 2015).

If recent (ideally less than 1 hour) known or suspected ingestion has occurred, then early decontamination is recommended (Bullen 2015). Veterinary advice should be sought, and dogs may be made to vomit followed by the administration of activated charcoal to reduce the absorption of any toxins that may remain in the gastrointestinal tract.

Public education and awareness regarding the risks of karaka fruit ingestion and potential toxicity in dogs has increased significantly over the last decade (e.g. Figure 13), and many dog owners are now proactive in contacting their veterinarian when they suspect their dog/s may have eaten karaka fruit.

### **Karaka as an environmental weed**

What defines an environmental weed? As Pa McGowan explained in his 2021 report for the Parliamentary Commissioner for the Environment,

‘a weed is a plant that upsets the balance that Papatūānuku needs to be well. That suggests that a weed is a plant that dominates an ecosystem to the extent that it is no longer able to function in a way that enables it to sustain the life that belongs there. A weed is a plant that disrupts that natural balance’ (McGowan 2021).

The term ‘weed’ is typically associated with non-native species, so the notion of a native plant species being invasive and ecologically damaging can be challenging. However, human-driven environmental changes frequently create conditions that allow native species to spread beyond their natural range, which can in turn have negative impacts on plant community structure and diversity (Carey et al. 2012). There are numerous examples of plant species that have become ‘native invaders’ (Simberloff 2011; Carey et al. 2012), including *Acacia longifolia* and *Leptospermum laevigatum* in Australia (Head and Muir 2004) and *Pseudotsuga menziesii* and *Pinus contorta* in North America (Kaye et al. 2005; Simberloff et al. 2012). As discussed above, it is clear that the range expansion of karaka in New Zealand has been largely human-mediated.

When karaka is planted outside its natural range it can become invasive, dominating areas and shading out other species both in New Zealand (Duguid 1990; Sawyer et al. 2003; Costall et al. 2006; Perrie et al. 2011) and in Hawai‘i, where it was deliberately introduced for reforestation purposes (Wagner et al. 1999; Dawson 2014). Traits that likely contribute to its invasive ability include periodically high seed production (Garnock-Jones et al. 2007), high seed viability (Burrows 1996), and large seeds that give rise to fast-establishing, sturdy, deep-rooted and highly shade-tolerant seedlings. Karaka grows well in a range of conditions and creates deep shade in the understory, which can reduce both the number and diversity of other native species’ seedlings (Costall et al. 2006). Karaka seedlings are relatively unpalatable to introduced browsing mammals, which likely gives karaka an additional advantage over more palatable native species when browsers are present. Trees readily resprout from cut stumps and from branches left on the ground (Figure 14).

Since most fruits fall off the tree and do not disperse further, the immediate vicinity of a tree typically contains a parent and a ‘carpet’ of young seedlings (Costall et al. 2006) (Figure 15). These seedlings can survive for many years – perhaps decades – under the parent tree and provide the capacity to replace the adult when it dies. In theory, this could eventually result in a self-replacing stand of karaka that has potential to persist indefinitely (McAlpine et al. 2021).

When karaka invades and naturalises outside its natural range it can have long-lasting impacts on other native plant species. In general, because kererū, the only species capable of dispersing karaka fruits, are scarce, seedlings are rarely found away from parent trees, so spread to new areas is slow and relatively unusual. However, infrequent long-range dispersal events can occur when kererū are present (Wotton 2007), which can lead to new populations establishing. This may become more common as New Zealand moves towards Predator Free 2050 (a nation-wide predator-control project), assuming that more effective predator control results in more kererū. In one example of long-range dispersal, Costall et al. (2006) reported recently arrived karaka seedlings in the isolated Kimbolton Reserve, 2.3 km from the nearest known karaka tree. Also, karaka was first recorded on Moturoa Island in 1968 (Wright 1977), c. 380 m from the nearest mainland coast. Wright (1977) noted that the few karaka plants present on Moturoa



**Figure 14.** Karaka regrowing from cut branches left on the ground. Photo by Colin Ogle.

Island were small (and therefore likely young), and present in only one valley. This suggests that these plants probably originated from kererū-dispersed seeds.

It is not known if early Māori and Moriori observed karaka becoming ‘weedy’. The effort and care that went into establishing and maintaining the precious karaka trees and groves suggests that if karaka was seen to be dominating a site as it does in some places today (e.g. [Figure 15](#)), and this was considered undesirable, it would likely have been managed in some way. Of course, this is a contemporary insight, rather than from a purely traditional view which would have been that of the kaitiaki (guardian). If a tree was important enough to be named, it would have had a close (specific) kaitiaki. Groves for food and other uses would have been more generically managed – but in all cases the whole ecosystem was their guide, so maintaining appropriate roles within the ecosystem was what they aimed for. There was always a need for timber for other uses (including firewood), so there would have been other types of management determined by kaitiaki. In traditional times, those kaitiaki would have been acutely aware of the relationships of trees and species to the tribal needs – and this is the whakapapa element, or the historical relationships of species, that would have been maintained regardless of anything else.

It should be noted that the above discussion about the weediness of karaka all pertains to studies outside of its presumed natural range; it is not clear why karaka does not appear to become overly dominant when growing within its natural range. Is it because of competitor species dropping out below latitude 38°S? Does karaka lose some of its insect herbivores or fungal pathogens below that latitude (Lakeman-Fraser and Ewers 2013)? Or does karaka actually perform better under cooler regimes provided it is sheltered from frost? Furthermore, what is happening at the southern edge of its natural range: is it expanding? Future research to resolve these questions would be



**Figure 15.** Typical ‘carpets’ of karaka seedlings in the forest understory. Photos by Kate McAlpine and Colin Ogle.

useful – and could help shape management policy and gain support from the public around mitigation and control activities.

### Prospective management approaches

In dealing with weediness or invasiveness, whether of non-natives or of natives within or outside their natural ranges, different situations need to be considered carefully to develop appropriate management strategies. In the case of karaka, the issues are location-specific, whether inside or outside its natural range, and cultural, whether planted or self-propagated.

No species should need management (anthropic intervention) in its natural range, where it is both normal and acceptable from a human viewpoint, for a species to occur in mono-dominant, or even mono-specific stands; e.g. in New Zealand, mountain beech (*Fuscospora cliffortioides*) forms huge mono-specific stands below the tree line on dry mountains. And, although how their dominance is achieved is usually not well understood, such species are not usually considered ‘weedy’. However, human-driven environmental changes or disturbances frequently create novel conditions that can have major impacts on community structure and plant diversity (Carey et al. 2012), including allowing native species to spread in ways or into habitats which they cannot achieve in undisturbed conditions. In southern North Island of New Zealand, the most common example is that of the native forest climber *Muehlenbeckia australis*, which can become overly-dominant in disturbed forest remnants and restoration plantings.

Anecdotally, some would argue that no native species should be considered a weed, but this question is perhaps best considered on a site-by-site basis and from the perspective of the endemic plant community where the new species has established. Should we not prioritise survival of the local endemic plant species (some of which may not occur

naturally anywhere else) over the ‘out-of-town’ invader that displaces them – even if it is a native species? What if we consider this kaupapa (topic) from a plant-centric rather than a people-centric position, and ask, what are the rights of the indigenous members (i.e. locally endemic species) of any given plant community? Do they have the right to be protected from the introduction of non-endemic native plant species that may outcompete them? This perspective implies that careful consideration should be given before karaka is proposed as a restoration species in areas outside its natural range.

Outside its natural range in lower North Island, where weediness of karaka is widely recognised, especially with respect to restoration plantings, there are two situations to consider: (1) karaka as an escapee from managed specimens, and (2) karaka as an historical feature in groves. Outside its natural range *and* outside groves karaka trees are probably (still) rare and scattered or in small, localised clumps, and possibly consist of just a parent tree and subsequent progeny (Costall et al. 2006). The trees are likely to be producing fruit at the smaller, more natural size, because many of these trees will have grown from bird-dispersed seed (van Essen and Rapson 2005; Figure 3), and kererū with full crops are likely to perch near their meals to digest them. Such plants may represent potential sources of invasion of karaka into natural, regenerating or restored vegetation within the immediate vicinity, and so elimination may be the best management strategy in this situation. Further, frost-prone areas where karaka does not currently pose a risk may become more suitable for karaka establishment as temperatures increase under climate change, so ongoing monitoring for occasional karaka seedlings would be prudent. Similar logic may also apply to the warmer northern reaches of South Island, where such issues remain unexplored.

What management is appropriate to karaka in groves in lower North Island? Where a grove has cultural significance, then regeneration of karaka within the grove should be encouraged, at least at a level sufficient to generate replacement canopy trees for the future. This could mean that some thinning of seedlings might be desirable. Because of the especially large size of fruit produced by trees selected for cultivation in such groves (van Essen and Rapson 2005), these fruit are unlikely to disperse far from their parent trees, as kererū with full crops are more likely to perch near their meals to digest them. Accordingly, the grove could be self-sustaining but unlikely to present an unmanageable threat to nearby natural vegetation, although on-going monitoring for the inevitable long-distance dispersal events would be prudent.

In northern South Island, karaka is almost always coastal. Such a distribution in New Zealand is generally associated with climatic alleviation from seasonal frosts, and so mimics the distribution of other more northerly species. Karaka typically occurs either in obvious groves or as occasional remnant trees, all of which are certain to have been planted. Management should consist chiefly of observation, and attention to range changes likely associated with climate change. The same applies to the most southerly portion of South Island, which is apparently karaka-free, at least outside horticultural gardens.

Of course these are potential management approaches only, needing refinement, with consideration given to special circumstances, the changing biota, impacts of ongoing climate change, and resourcing.

## The way forward

The contrasting views on karaka summarised here serve as a poignant example of how human values, cultural practices, and environmental concerns can sometimes be at odds. While karaka is an integral part of the cultural heritage of Māori and Moriori, its ecological impact in certain areas makes it a subject of concern for conservationists and land managers. This is not to say that these views and values are mutually exclusive, and we do not want to imply that Māori or Moriori are or were not aware of potential weed issues or that conservationists are or were ignorant of the fact that karaka is highly culturally significant to Māori and Moriori. However, it is certainly true that some groups have felt unheard, or that their views and values were perceived as being less important than others. This, in part, was one of the main drivers behind the Zealandia wānanga (and this paper); to bring the different factions together to discuss and better understand each other's position so that future consideration of karaka issues would be more sensitive and respectful to all perspectives. The wānanga certainly achieved these goals, but also highlighted the fact that finding a way forward that is acceptable to all parties under all circumstances is likely to be far from easy. Engaging mana whenua in co-management plans is a critical first step in ensuring that cultural practices are respected and preserved while also addressing ecological concerns. Intergenerational wisdom, knowledge and confidence is strengthened when access to a significant cultural resource such as karaka is maintained – particularly in this current age of the movement of tino rangatiratanga (self-determination) of kai (food). However, mana whenua are mostly not funded to any significant extent to engage in these matters, and if they are to be anything more than gate-keepers with the right to say no, this has to change. Also, mana whenua who are not actively involved in the care of ancestral karaka groves – or who come from areas where karaka is not present – may not have sufficient connections to and knowledge of the plant to be comfortable making decisions around karaka management, and so again, support may be needed.

Another critical problem is that it can be difficult to determine whether the threat of karaka to local native vegetation is severe enough to justify costly management. The evidence is far from complete, and the answer is likely to vary depending on site-specific environmental and climatic conditions. Further research to resolve these issues would inform cost–benefit analyses and management plans and could guide decisions like where karaka may be planted or how it might be managed in wild settings. For example, in ecologically sensitive areas outside the natural range of karaka, restrictions could be placed on planting karaka, focusing instead on promoting other native species that are indigenous to the area or site. In areas where karaka is already established, strategic removal or thinning may be an option, but only after consultation with mana whenua. Educational programs that highlight the cultural significance of karaka could foster greater respect and understanding among the general population.

Regardless of the complexities and uncertainties around where karaka is and is not appropriate, acknowledging and understanding the myriad of issues and perspectives at play is a crucial first step in determining the best solution for any given site. Bringing all sides to the table creates intellectual and social diversity and represents a valuable opportunity to engage and connect with different knowledge systems. Diversity signifies health and abundance – not just in the forest, but in broader society too.

Karaka is the kupu Māori (Māori word) for the colour orange. Aptly, it is also the colour in between red and green in signalling travelling directions; signalling time to slow down and stop for a while, before progressing again.

## Acknowledgements

Ōtari-Wilton's Bush, Wellington City Council, and Zealandia Te Māra a Tāne organised the Zealandia wānanga. Thanks to the many people who contributed to the wānanga and/or to this paper, including Illona Keenan, Justin Maxwell, Leon Perrie, Danielle Shanahan, Maui Solomon, and Jamie Watson. We also thank the photographers who provided images and Michael Moore who allowed us to include his painting. Ranea Aperahama and Tamahou McGarvey from Te Papa translated the abstract into te reo Māori. Cleland Wallace measured a kererū skull for Figure 12. Comments from Colin Miskelly, Carol West and an anonymous reviewer improved the manuscript.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## ORCID

Kate G. McAlpine  <http://orcid.org/0000-0001-6355-7445>

Gillian Rapson  <http://orcid.org/0000-0001-8108-9577>

Nick Rahiri Roskruge  <http://orcid.org/0000-0002-2914-6316>

Lara D. Shepherd  <http://orcid.org/0000-0002-7136-0017>

## References

- Angas GF. 1847. Savage life and scenes in Australia and New Zealand: being an artist's impressions of countries and people at the antipodes. London: Smith, Elder and Co.
- Atherton R, Lockhart P, McLenachan P, de Lange P, Wagstaff S, Shepherd L. 2015. A molecular investigation into the origin and relationships of karaka/kōpi (*Corynocarpus laevigatus*) in New Zealand. *Journal of the Royal Society of New Zealand*. 45:212–220. doi:10.1080/03036758.2015.1093006.
- Atherton RA. 2014. Ngā uri o karaka: a genetic study of the karaka/kōpi tree in Aotearoa/New Zealand [Unpublished PhD thesis]. Massey University, Palmerston North, New Zealand. 200 p.
- Atherton RA, McComish BJ, Shepherd LD, Berry LA, Albert NW, Lockhart PJ. 2010. Whole genome sequencing of enriched chloroplast DNA using the Illumina GAI platform. *Plant Methods*. 6:22–26. doi:10.1186/1746-4811-6-22.
- Bannister P, Bibby T, Jameson PE. 1996. An investigation of recalcitrance in seeds of three native New Zealand tree species. *New Zealand Journal of Botany*. 34:583–590. doi:10.1080/0028825X.1996.10410137.
- Barber I, Maxwell J. 2011. A collaborative archaeological research and conservation project for Moriori carved trees (rakau momori), Rekohu (Chatham Island). *Archaeology in New Zealand*. 54:62–75.
- Barber IG, Maxwell J, Hemi R. 2014. Growing images: generating 3D digital models to investigate archaeological Moriori carvings on live trees. *World Archaeology*. 46:63–77. doi:10.1080/00438243.2013.871947.
- Barber IG, Maxwell JJ, Petchey F. 2016. A radiocarbon investigation of Moriori forest use on Rēkohu (Chatham Island), southwestern Polynesia. *Journal of Archaeological Science: Reports*. 10:96–109. doi:10.1016/j.jasrep.2016.08.040.

- Best E. 1925. Tuhoe: The children of the mist; a sketch of the origin, history, myths and beliefs of the Tuhoe tribe of the Maori of New Zealand. Wellington: Board of Maori Ethnological Research; 1211 p.
- Best E. 1931. Maori agriculture. Cultivated food-plants of the Maori and native methods of agriculture. (Continued). *The Journal of the Polynesian Society*. 40:1–22.
- Best E, Andersen JC. 1942. Forest lore of the Maori. Memoir 18. Wellington: Polynesian Society.
- Bullen B. 2015. Karaka poisoning. *Vetscript*. Nov 21.
- Burrows CJ. 1996. Germination behaviour of seeds of the New Zealand woody species *Alectryon excelsus*, *Corynocarpus laevigatus*, and *Kunzea ericoides*. *New Zealand Journal of Botany*. 34:489–498. doi:10.1080/0028825X.1996.10410129.
- Burstall SW, Sale EV. 1984. Great trees of New Zealand. New Zealand: Reed; 288 p.
- Campbell J. 2002. Angiosperm fruit and leaf fossils from Miocene silcrete, Landslip Hill, northern Southland, New Zealand. *Journal of the Royal Society of New Zealand*. 32:149–154. doi:10.1080/03014223.2002.9517687.
- Carey MP, Sanderson BL, Barnas KA, Olden JD. 2012. Native invaders – challenges for science, management, policy, and society. *Frontiers in Ecology and the Environment*. 10:373–381. doi:10.1890/110060.
- Clout MN, Karl BJ, Pierce RJ, Robertson HA. 1995. Breeding and survival of New Zealand pigeons *Hemiphaga novaeseelandiae*. *Ibis*. 137:264–271. doi:10.1111/j.1474-919X.1995.tb03248.x.
- Colenso W. 1880. On the vegetable foods of the ancient New Zealanders before Cook's visit. *Transactions of the New Zealand Institute*. 13:3–38.
- Connor HE. 1977. The poisonous plants in New Zealand. Wellington: Government Printer; 247 p.
- Costall J, Carter R, Shimada Y, Anthony D, Rapson G. 2006. The endemic tree *Corynocarpus laevigatus* (karaka) as a weedy invader in forest remnants of southern North Island, New Zealand. *New Zealand Journal of Botany*. 44:5–22. doi:10.1080/0028825X.2006.9513002.
- Cowan P. 1992. Analysis of the characteristics of fruit eaten by possums, *Trichosurus vulpecula*, in New Zealand. *New Zealand Journal of Zoology*. 19:45–52. doi:10.1080/03014223.1992.10423250.
- Dalefield R. 2017. Veterinary toxicology for Australia and New Zealand. Amsterdam, Netherlands: Elsevier; 628 p.
- Dawson M. 2014. On distant shores: New Zealand's natives as weeds abroad. *New Zealand Garden Journal*. 17:10–24.
- Dieffenbach E. 1841. An account of the Chatham Islands. *Journal of the Royal Geographical Society of London*. 11:195–215. doi:10.2307/1797646.
- Dijkgraaf A. 2002. Phenology and frugivory of large-fruited species in northern New Zealand and the impacts of introduced mammals [Unpublished PhD thesis]. Auckland: Auckland University.
- Duguid PC. 1990. Botany of northern Horowhenua lowlands, North Island, New Zealand. *New Zealand Journal of Botany*. 28:381–437. doi:10.1080/0028825X.1990.10412326.
- Fountain DW, Outred HA. 1991. Germination requirements of New Zealand native plants: a review. *New Zealand Journal of Botany*. 29:311–316. doi:10.1080/0028825X.1991.10416609.
- Garnier BJ. 1958. The climate of New Zealand: a geographic survey. London: Edward Arnold.
- Garnock-Jones P, Brookie R, FitzJohn R. 2007. Gynodioecy, sexual dimorphism and erratic fruiting in *Corynocarpus laevigatus* (Corynocarpaceae). *Australian Journal of Botany*. 55:803–808. doi:10.1071/BT07054.
- Graham G. 1948. He kai, he kai: some food (for) some food! An example of ancient Maori form of barter (hoko). *The Journal of the Polynesian Society*. 57:64–67.
- Graham G. 1951. Tainui. *The Journal of the Polynesian Society*. 60:80–92.
- Hamilton A. 1903. Māori carving on the trunks of karaka trees. *Transactions of the New Zealand Institute*. 36:11–13.
- Head L, Muir P. 2004. Nativeness, invasiveness and nation in Australian plants. *Geographical Review*. 199–217.
- Jefferson C. 1955. Dendroglyphs of the Chatham Islands. *The Journal of the Polynesian Society*. 64:367–441.

- Jopson FW, McKibbin CR. 2000. Moriori tree carvings, Chatham Islands: close-range photogrammetric record and survey. In: Department of Conservation Technical Series 20. Wellington: Department of Conservation; 27 p.
- Kaye MW, Binkley D, Stohlgren TJ. 2005. Effects of conifers and elk browsing on quaking aspen forests in the central Rocky Mountains, USA. *Ecological Applications*. 15:1284–1295. doi:10.1890/03-5395.
- Kelly D, Ladley JJ, Robertson AW, Anderson SH, Wotton DM, Wisser SK. 2010. Mutualisms with the wreckage of an avifauna: the status of bird pollination and fruit-dispersal in New Zealand. *New Zealand Journal of Ecology*. 34:66–85.
- Kerridge D. 2018. How to prepare the delicious – but poisonous – karaka berry. The Spinoff, 14 February 2018. <https://thespinoff.co.nz>.
- Kirk T. 1889. The forest flora of New Zealand. Wellington: Government Printer; 345 p.
- Klinac D, Benton RA, Rentoul S. 2009. Karaka nuts: a “new” NZ nutcrop. MAF SFF Report.
- Laing RM, Blackwell EW. 1940. Plants of New Zealand. Christchurch: Whitcombe and Tombs Limited; 499 p.
- Lakeman-Fraser P, Ewers RM. 2013. Enemy release promotes range expansion in a host plant. *Oecologia*. 172:1203–1212. doi:10.1007/s00442-012-2555-x.
- Leach H, Stowe C. 2005. Oceanic arboriculture at the margins—the case of the karaka (*Corynocarpus laevigatus*) in Aotearoa. *The Journal of the Polynesian Society*. 114:7–27.
- MacAskill JJ. 2013. Quantification of nitro-toxins in karaka (*Corynocarpus laevigatus*) drupes [Unpublished master’s thesis]. Hamilton, New Zealand: University of Waikato. 123 p.
- Maxwell JJ. 2017. Conservation and restoration of a cultural forest landscape: protecting the forests created by Moriori on Chatham Island. *Conservation and Management of Archaeological Sites*. 19:197–209. doi:10.1080/13505033.2017.1342070.
- Maxwell JJ, Smith IW. 2015. A reassessment of settlement patterns and subsistence at Point Durham, Chatham Island. *Archaeology in Oceania*. 50:162–174. doi:10.1002/arco.5062.
- Maxwell JJ, Tromp M. 2016. *Corynocarpus laevigatus*: where art thou? Finding evidence of this elusive tree crop. *Review of Palaeobotany and Palynology*. 234:198–210. doi:10.1016/j.revpalbo.2016.09.009.
- McAlpine KG, Lamoureaux SL, Timmins SM. 2021. Understorey vegetation provides clues to succession in woody weed stands. *New Zealand Journal of Ecology*. 45:1–10.
- McCurdy BJ. 1947. A proximate analysis of a Maori food; the karaka berry [Unpublished master’s thesis]. Dunedin, New Zealand: University of Otago. 114 p.
- McGlone M. 1985. Plant biogeography and the late Cenozoic history of New Zealand. *New Zealand Journal of Botany*. 23:723–749. doi:10.1080/0028825X.1985.10434240.
- McGowan R. 2021. Mauri tū! Mauri ora! Māori perspectives on exotic plants in Aotearoa. Report prepared for the Parliamentary Commissioner for the Environment. Wellington. 19 p.
- Molloy B. 1990. The origin, relationships, and use of karaka or kopi (*Corynocarpus laevigatus*). In: Harris W, Kapoor P, editor. *Nga Mahi Maori o te Wao Nui a Tane*. Contributions to an International Workshop on Ethnobotany, Te Rehua Marae, Christchurch, New Zealand, 22–26 February 1988. Christchurch: Department of Scientific and Industrial Research (DSIR); p. 48–53.
- Ogle C. 1997. Sand movement and the protection of natural areas on Pouto Peninsula, Northland. Wellington, New Zealand: Department of Conservation; 24 p.
- Palmer-Jones T, Line L. 1962. Poisoning of honey bees by nectar from the karaka tree (*Corynocarpus laevigata* J. R. et G. Forst.). *New Zealand Journal of Agricultural Research*. 5:433–436. doi:10.1080/00288233.1962.10419940.
- Park G. 1995. *Ngā uruora, the groves of life: ecology and history in a New Zealand landscape*. Wellington, New Zealand: Victoria University Press; 376 p.
- Patel RN. 1975. Wood anatomy of the dicotyledons indigenous to New Zealand. *New Zealand Journal of Botany*. 13:19–29. doi:10.1080/0028825X.1975.10428880.
- Perrie L, Russell P, Ogle C, Mitcalfe B, Horne C, Burton E, Rolfe J, Elliot R. 2011. Non-local indigenous New Zealand vascular plants self-propagating in Wellington. *Wellington Botanical Society Bulletin*. 53:23–47.

- Platt G. 2003. Observations on karaka (*Corynocarpus laevigatus*) and its fruit. *Auckland Botanical Society Journal*. 58:29–31.
- Poole L, Adams N. 1994. *The trees and shrubs of New Zealand*. Lincoln, Canterbury, New Zealand: Manaaki Whenua Press; 256 p.
- Riley M. 1994. *Māori healing and herbal: New Zealand ethnobotanical sourcebook*. New Zealand: Viking Sevensseas Limited.
- Roskrige N. 2007. *Hokia ki te whenua* [Unpublished PhD thesis]. Palmerston North, New Zealand: Massey University. 263 p.
- Sawyer JWD, McFadgen BG, Hughes PM. 2003. Karaka (*Corynocarpus laevigatus* J.R. et G. Forst.) in Wellington Conservancy (excluding Chatham Islands). Wellington: Department of Conservation; 27 p.
- Shepherd LD, de Lange PJ, Cox S, McLenachan PA, Roskrige NR, Lockhart PJ. 2016. Evidence of a strong domestication bottleneck in the recently cultivated New Zealand endemic root crop, *Arthropodium cirratum* (Asparagaceae). *PLoS One*. 11:e0152455. doi:10.1371/journal.pone.0152455.
- Simberloff D. 2011. Native invaders. In: Simberloff D, Rejmánek M, editor. *Encyclopedia of biological invasions*. California: University of California Press; p. 472–475.
- Simberloff D, Souza L, Nuñez MA, Barrios-Garcia MN, Bunn W. 2012. The natives are restless, but not often and mostly when disturbed. *Ecology*. 93:598–607. doi:10.1890/11-1232.1.
- Skinner HD, Bauke W. 1928. *The Morioris*. Honolulu: Bishop Museum.
- Slaughter RJ, Beasley D, Lambie BS, Wilkins GT, Schep LJ. 2012. Poisonous plants in New Zealand: a review of those that are most commonly enquired about to the National Poisons Centre. *New Zealand Medical Journal*. 125:87–118.
- Solomon M, Thorpe S. 2012. Taonga Moriori: recording and revival. *Journal of Material Culture*. 17:245–263. doi:10.1177/1359183512453533.
- Stowe CJ. 2003. *The ecology and ethnobotany of karaka (Corynocarpus laevigatus)* [Unpublished MSc thesis]. University of Otago, Dunedin, New Zealand. 238 p.
- Tautahi H, Taipuhi W, Smith SP. 1900. The “Aotea” canoe: the migration of Turi to Aotea-roa (New Zealand). *The Journal of the Polynesian Society*. 9:211–233.
- van Essen R, Rapson G. 2005. Fruit size of karaka (*Corynocarpus laevigatus*) in relation to potential selection by Maori. *New Zealand Botanical Society Newsletter*. 81:13–16.
- Wagner WL, Herbst DR, Sohmer S. 1999. *Manual of the flowering plants of Hawai’i*, Revised Edition. Honolulu, Hawai’i: University of Hawai’i and Bishop Museum Press; 1952 p.
- Wagstaff SJ, Dawson MI. 2000. Classification, origin, and patterns of diversification of *Corynocarpus* (Corynocarpaceae) inferred from DNA sequences. *Systematic Botany*. 25:134–149. doi:10.2307/2666679.
- Wardle JA, Platt I. 2011. *Wardle’s native trees of New Zealand and their story*. New Zealand Farm Forestry Association.
- Wardle P. 1991. *Vegetation of New Zealand*. Cambridge: Cambridge University Press; 672 p.
- Watson D, Evans A, Blockman M, Wiesner L. 2022. Detection of karakin poisoning using a targeted mass spectrometric workflow. *South African Medical Journal*. 112:901–903.
- Wehi PM, Lord JM. 2017. Importance of including cultural practices in ecological restoration. *Conservation Biology*. 31:1109–1118. doi:10.1111/cobi.12915.
- Wilmshurst JM, Anderson AJ, Higham TF, Worthy TH. 2008. Dating the late prehistoric dispersal of Polynesians to New Zealand using the commensal Pacific rat. *Proceedings of the National Academy of Sciences*. 105:7676–7680. doi:10.1073/pnas.0801507105.
- Wilmshurst JM, Higham TF, Allen H, Johns D, Phillips C. 2004. Early Maori settlement impacts in northern coastal Taranaki, New Zealand. *New Zealand Journal of Ecology*. 28:167–179.
- Wotton DM. 2007. *Consequences of dispersal failure: kereru and large seeds* [Unpublished PhD thesis]. University of Canterbury, Christchurch, New Zealand. 159 p.
- Wotton DM, Kelly D. 2011. Frugivore loss limits recruitment of large-seeded trees. *Proceedings of the Royal Society B: Biological Sciences*. 278:3345–3354. doi:10.1098/rspb.2011.0185.
- Wright A. 1976. *The vegetation of Great Mercury Island*. *Tane*. 22:23–49.
- Wright A. 1977. *Vegetation and flora of the Moturoa Island group, Northland, New Zealand*. *Tane*. 23:11–29.