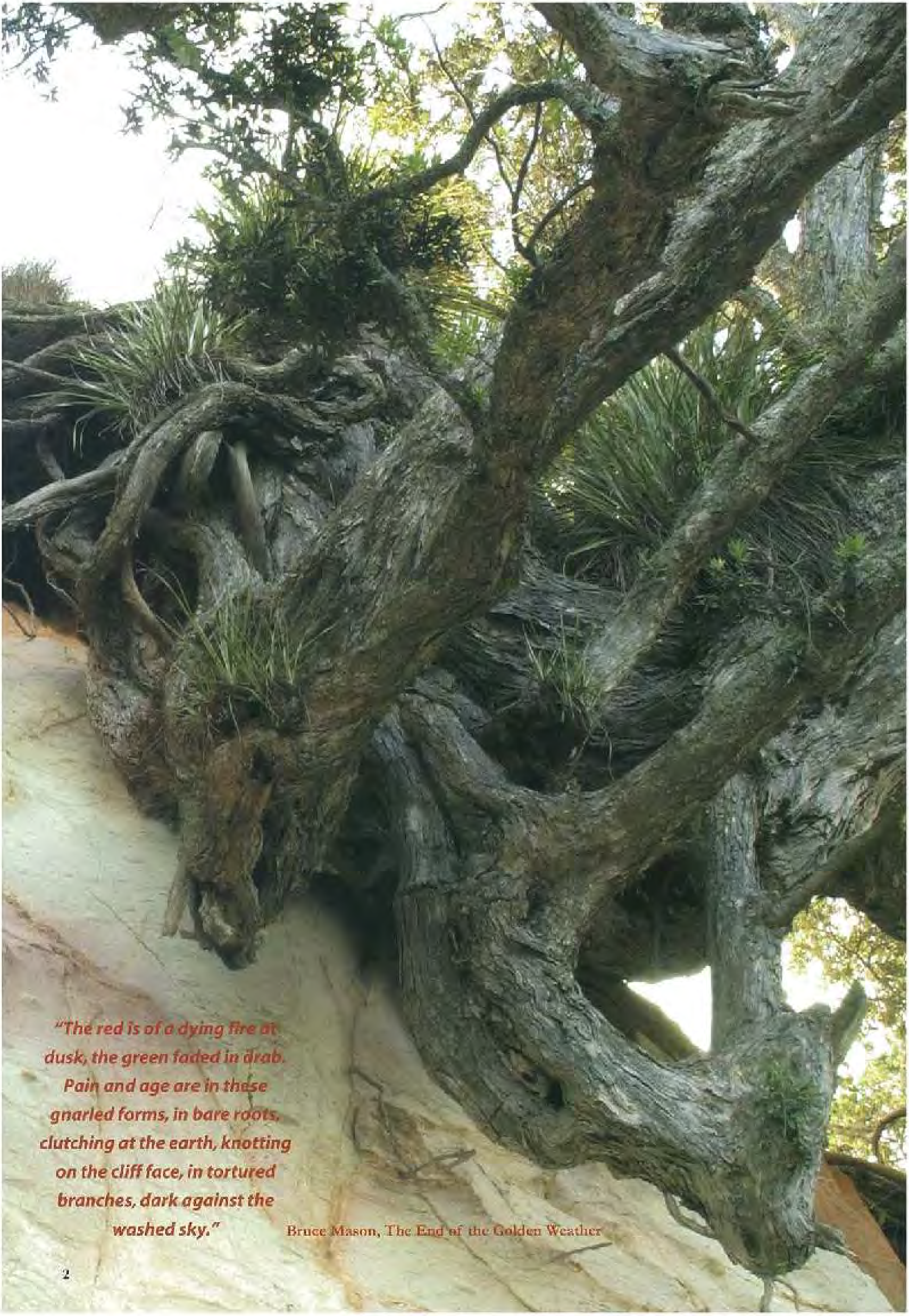
# POHUTUKAWA

## ECOLOGY, ESTABLISHMENT, GROWTH and MANAGEMENT

David Bergin
and Gordon Hosking



*"The red is of a dying fire at dusk, the green faded in drab. Pain and age are in these gnarled forms, in bare roots, clutching at the earth, knotting on the cliff face, in tortured branches, dark against the washed sky."*

Bruce Mason, The End of the Golden Weather

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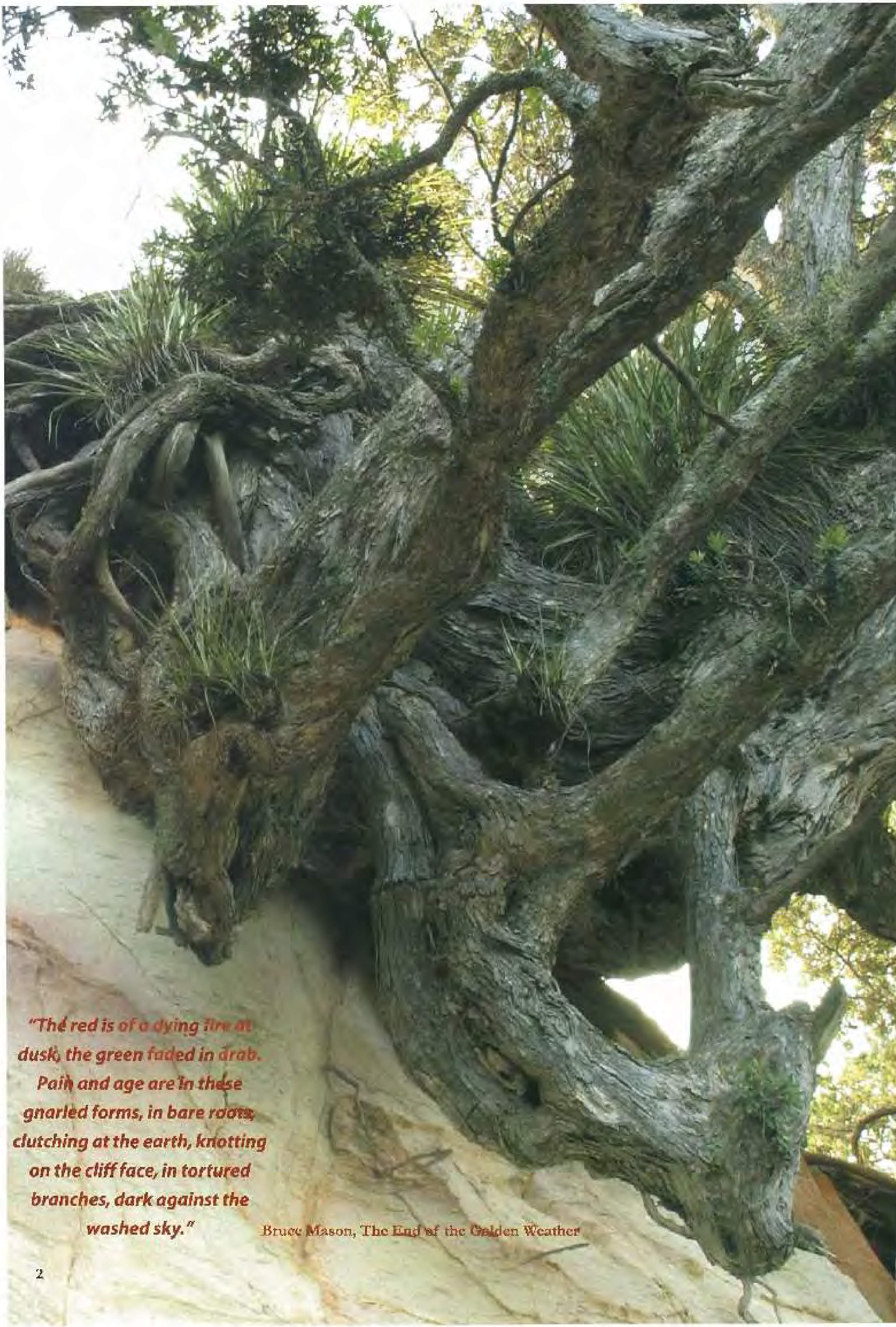

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# INTRODUCTION

Pohutukawa (*Metrosideros excelsa* Sol. ex Gaertn.) is one of the best-known and best-loved native trees in New Zealand. Endemic to this country, it is a distinctive multi-stemmed tree up to 25 m high, and is found mainly along the coastal fringe, often on rocky cliffs, throughout the northern half of the North Island. Pohutukawa once formed an almost continuous belt of forest around New Zealand's northern coasts. Its spectacular and profuse crimson flowers are formed during the summer in the period coinciding with Christmas holidays. The first European settlers used it to decorate their homes at Christmas time, the dark green leaves and red flowers forming a substitute for holly. It has since been accorded iconic status and is now regarded as New Zealand's Christmas tree.

Maori people regard pohutukawa as a sacred tree, one of the *rakau rangatira* (chiefly trees) that feature prominently in their history and legends. Many existing pohutukawa trees are *tapu* (sacred), some marking the burial sites of ancestors. A tree at Te Reinga, the northern tip of Cape Reinga, has great significance in Maori mythology. The spirits of the dead are said to descend through its branches and entwined roots as they begin their journey back to the homeland of Hawaiiki.

Pohutukawa had many uses for early Maori and European settlers. Leaves and bark were gathered for a variety of medicinal purposes, and the potential of its strong durable timber was soon realised. In the early days of colonisation, shiploads of pohutukawa timber were exported, and the magnificent coastal stands were severely depleted.

Fires and land clearing for settlement and pastoral farming along the coast contributed to the elimination of an estimated 90% of the original pohutukawa forest (Forest Research Institute 1989). The decline continues, largely due to browsing damage caused by the introduced brushtail possum.

Over the last decade widespread concern about continued losses has led to increased emphasis on the planting and management of pohutukawa, and greater interest in the protection of existing trees and stands. Much of the work has been inspired by the Project Crimson Trust, set up in 1990 to provide a focus for conservation of existing pohutukawa and restoration of the species as a characteristic of the northern coast. Project Crimson has promoted and assisted large-scale community-based pohutukawa planting and protection programmes.

The Project Crimson Trust recently commissioned the writing and publication of a book by Philip Simpson entitled *Pohutukawa & Rata: New Zealand's Iron-Hearted Trees* (Simpson 2005). This provides a detailed and scientifically comprehensive account of pohutukawa including its origins, ecology, historical and cultural significance, and a description of the decline and current conservation measures that are being undertaken. In addition, Smith (1999) has compiled a bibliography of pohutukawa and rata including annotated references to the many books on pohutukawa.

This Bulletin provides a "ready-reference" summary of some aspects of Simpson's work, specifically a description of pohutukawa and related species, its distribution, historical use, ecology, and habitat. In addition it describes current threats to the species from a number of injurious agencies. Parts 7–10 discuss methods for the management of pohutukawa including seed collection, propagation, planting, promotion of growth and wood quality, and management of existing trees. A picture of the status and special features of pohutukawa in four northern regions administered by local regional councils is presented in Part 11. Finally, a set of guidelines is provided for people who are enthusiastic about continued planting and management of pohutukawa.

# PART 1 - DESCRIPTION

Pohutukawa has many distinctive features that enable it to live and thrive in the seemingly inhospitable rocky sites and coastal cliffs of northern New Zealand. From seedling to mature tree, remarkable regeneration and survival strategies as well as specialised physical characteristics contribute to its tolerance of frequently extreme environmental conditions.

*Newly germinated pohutukawa seedling.*

## Seedlings

Pohutukawa seed germinates soon after it comes in contact with moisture. At first, energy is directed towards growth of the radicle or primary root, which has hairs that cling to moist surfaces such as rock or bark. The root is then able to penetrate cracks in the substrate. Very young seedlings have two leaves (cotyledons) which are only 1–2 mm long. Additional roots form at the base of the developing stem and these too become attached to damp surfaces. One or two shoots are formed from buds associated with the earliest leaves. After the first season of growth, a small cluster of roots and shoots is formed.

## Plant development

Often a number of shoots arise from a central base, and the young plant assumes a rounded, or slightly conical, form. Eventually, one or more of these shoots becomes dominant. If the plants are growing closely together, single stems will be more common. Widely spaced trees commonly have multiple trunks spreading from their base.

*Planted pohutukawa 6 years old, part of a Project Crimson community planting, East Cape. Pohutukawa established in the open typically form a rounded crown of foliage.*

## Epicormic shoots

A common characteristic of pohutukawa is the formation of epicormic shoots and coppice growth. The bright shiny green coppice shoots emerge from the base of a seedling, while epicormics arise from the stem and branches of older plants. Simpson (2005) suggests that epicormic shoot formation is related to the harshness of the open coastal environment. Dieback and breakage of the crown of pohutukawa caused by drought, frost, or animals may stimulate the development of buds buried in the bark, and the growth of epicormic shoots. Exposed stems and trunks, even of old trees, can develop epicormic shoots, particularly where significant pruning or thinning of crown foliage is carried out.

*Epicormic shoots occurring along an exposed branch of a stressed large pohutukawa tree.*

*Bright green coppice shoots from lower stems of a stressed container-grown seedling.*

Where pohutukawa seedlings have been planted on exposed open sites, crown dieback can sometimes occur and is often associated with coppicing from the base.

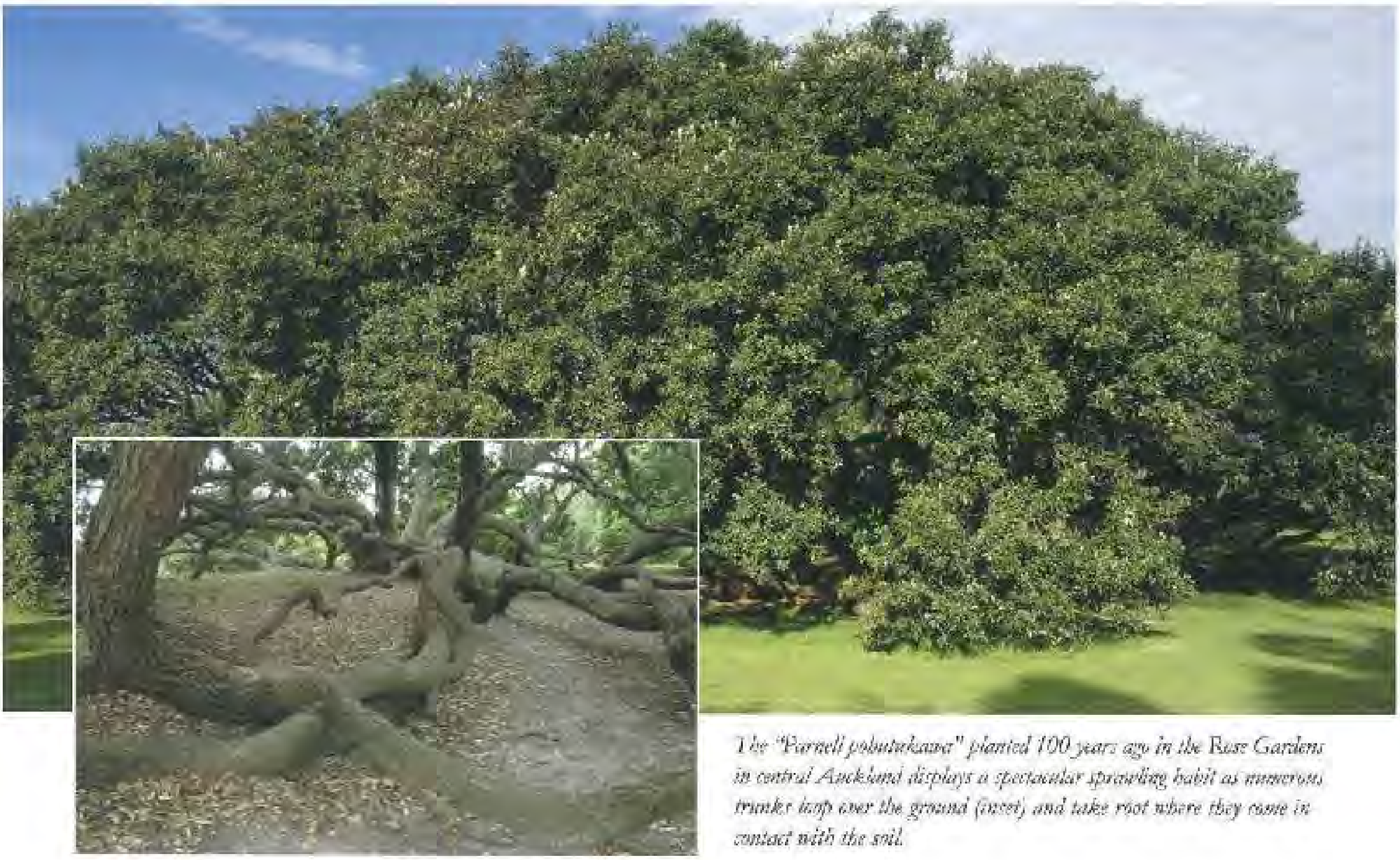
## Mature trees

Pohutukawa usually grow to 20 m in height with trunks 2 m in diameter (Allan 1961). Canopy spread is commonly around 20 m in diameter. The largest specimens, however, can have a crown diameter of over 50 m and can be up to 25 m tall, with trunk diameters exceeding 3 m (Gerald Collett, Treecare Services, pers. comm.).

Pohutukawa form is highly variable. Typically trees are multi-stemmed from the base and, with age, large trees often become sprawling with long branches that arch over the ground. Where stems touch the ground, roots are formed. Some trees have single trunks of various heights. Trunks and limbs can be entwined by one or

*The distinctive large crown of old pohutukawa, North Shore, Auckland, with Rangitoto Island in the distance.*

*Large mature pohutukawa hangs out over a beach where erosion from high seas has undermined part of the bank.*



*The "Parnell pohutukawa" planted 100 years ago in the Rose Gardens in central Auckland displays a spectacular sprawling habit as numerous trunks loop over the ground (inset) and take root where they come in contact with the soil.*

more roots or stems of various dimensions and sometimes a mass of aerial adventitious roots develops from the stem or branches.

Simpson (2005) lists several features that may account for the characteristic growth form:

- Pohutukawa shoots are strongly positively phototropic, i.e., they grow vigorously towards the light. The leaf canopy is dense and, as it develops, shaded portions are overtopped and leaves die and fall off.
- The stems contain bark-encased vegetative buds that grow into epicormic shoots after exposure to direct sunlight. In this way, young upright branches often develop from horizontal trunks. Aerial roots are also readily produced from stems and, once they come into contact with a suitable substrate, can develop very rapidly.
- Pohutukawa wood is dense and heavy. Laterally extensive branches often bend under their own weight and may snap or split at the junction with another branch or the central bole. They often collapse on to the ground while still partially attached, and form new roots. Once a branch touches the ground, it can form new roots by a process known as air-layering. These characteristics allow a fallen tree to re-establish itself and, in the process, act as a land stabiliser on eroding or unstable sites.

The spreading gnarled form of mature pohutukawa may develop in response to stimuli provided by strong winds and steep slopes, allowing the weight to be distributed over a large area. Loss of much of New Zealand's pohutukawa forest means that old, exceptionally large specimens are uncommon. A tree at Te Araroa, known as Te Waha O Rerekohu Te Araroa, has 22 trunks and is thought to be one of the largest in New Zealand. It is estimated to be at least 600 years old, and displays a spreading growth habit. A tree in the Parnell Rose Gardens, Auckland, planted over 100 years ago, is 15 m tall and has a canopy that is 50 m wide. Several spreading branches have touched the ground and taken root. Pohutukawa growing in dense stands can form single and occasionally upright stems with small crowns. In contrast, on open sites - such as isolated trees on coastal farmland - trees can have short single trunks that support spectacularly large rounded crowns.

Pohutukawa can also form one or more vine-like stems which hug the main trunks and large limbs, sometimes twisting around the trunk. Occasionally a mat of many smaller stems surrounds the main stem. It is not known what induces these extra vine-like stems to occur or whether they should be regarded as stems or roots.

*Pohutukawa grown in dense stands, can form single relatively straight stems as small crowns compete for light, Tarawera Falls, Bay of Plenty.*

*A large spreading tree, in a paddock, with a single short trunk forming a large rounded crown, typical of many pohutukawa on open farmland sites, Tapapakanga Regional Park, Firth of Thames.*

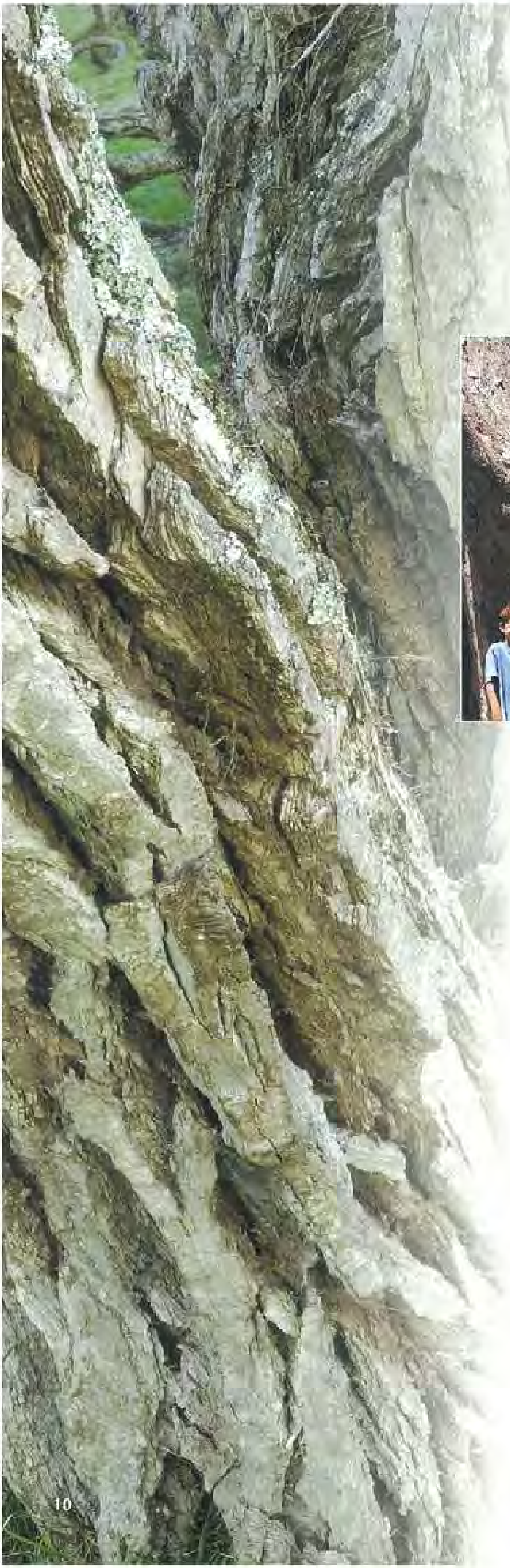
## Branching

Branchlets of pohutukawa are numerous and twiggy. The newly emerged branchlets are often covered in a white tomentum (mat of fine hairs), but this soon disappears. Two opposite branches grow from the tip of each shoot, resulting in a dichotomous pattern of diverging branches. Individual trees growing in the open are therefore almost perfectly dome-shaped. In a forest environment, shading often restricts the growth of some shoots. When only the upper bud of a pair develops, the tree will have a more upright form.

The entire branch structure of the tree crown is visible from below. This is because shaded leaves do not survive for long periods.

*Newly emerged branchlet covered in white tomentum.*

*Pohutukawa characteristically have a dense outer crown of foliage and twiggy, leafless lower crown.*



## Bark

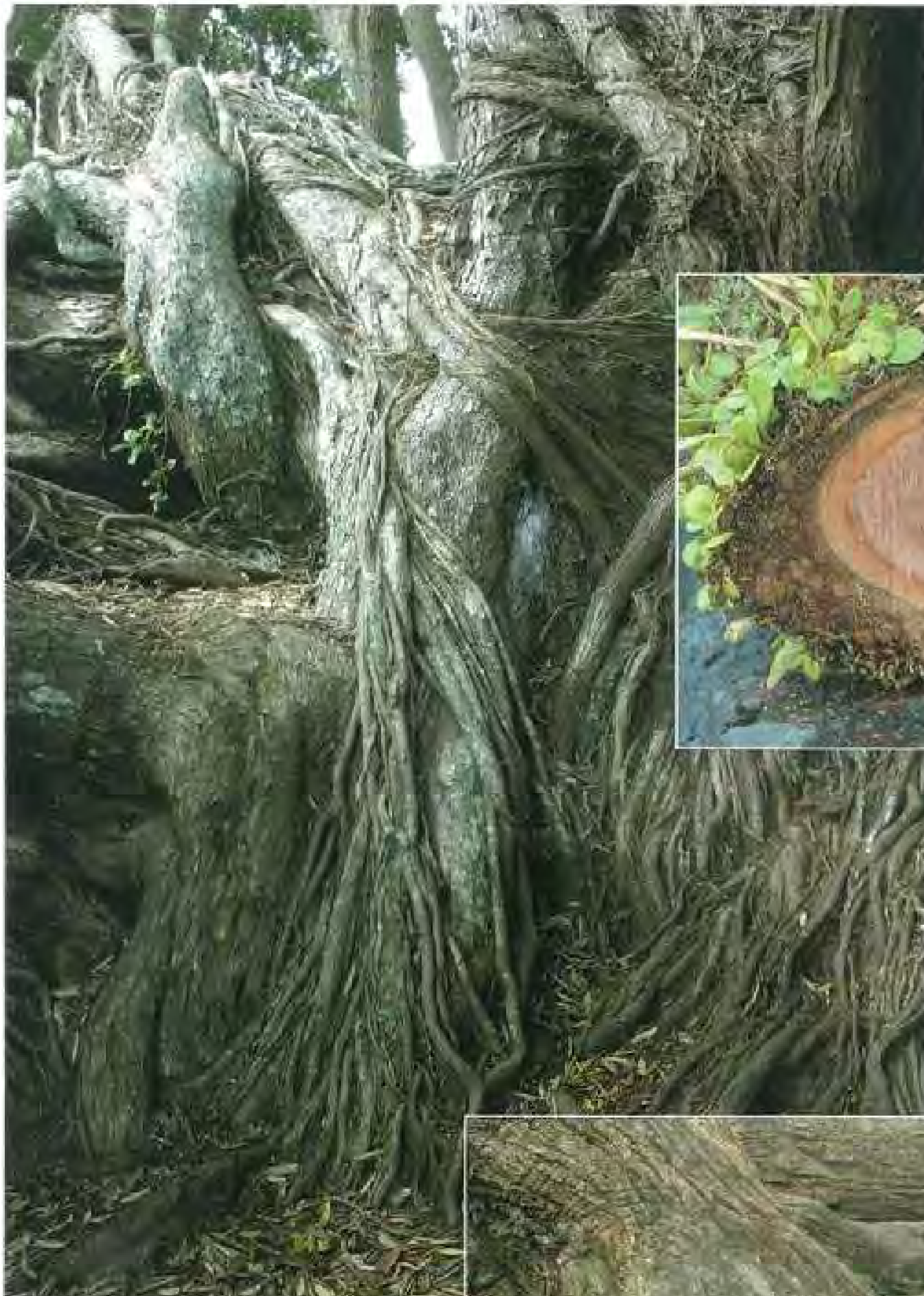
The bark on stems and branches is firm, often deeply furrowed, persistent, and difficult to detach. It is grey to grey-brown in colour and has a somewhat corky texture. Simpson (2005) suggests that the furrows in the bark help to channel rainwater to the base of the tree. However, occasional trees do have relatively smooth bark.

*The grey-brown bark is often furrowed; occasional trees (inset) can have smooth bark.*

## Roots

Pohutukawa roots can grow through the air as well as over and through solid substrates. The ability to penetrate crevices in rock is an important survival feature for colonisation of coastal cliffs and on volcanic rock. Even for relatively young trees, roots can extend many metres beyond the canopy. Mature trees form large, spreading, interlacing, woody root systems exploiting the available upper soil profile, including subsoil and rock substrates within reach. Root systems can extend far beyond the canopy or the main trunk and can be entirely lop-sided, a feature that helps to secure them to edges of cliffs and banks.

Pohutukawa readily form roots from the trunk and branches, known as adventitious roots. These can arise from almost any part of the tree and are easily induced where stems or branches come in contact with soil surfaces, forming a new anchor point and further source of nutrients and water. Tree survival on sand dunes may be dependent in part on adventitious root formation on upper stems and branches if these are partially buried by moving sand.



*Occasional pohutukawa trunks can be surrounded by a mass of fine stems (or roots) as shown in this cross-section of a limb sawn from the mid-crown of a tree.*

*Are these roots or stems? Pohutukawa can have vine-like stems trailing up and around main trunks and limbs.*

*Small red-coloured adventitious roots (right) arise from almost any part of the tree and are easily induced to grow when stems come in contact with the ground.*

*Pohutukawa that have been partially or wholly undermined by the sea or by erosion on a steep surface often reveal typically large spreading root systems.*

*Roots of a large pohutukawa tree traversing a rock face.*

Pohutukawa can also form roots which descend limbs or trunks; they have originated from the margins of an old pruning scar or a wound and can form large diameters of 10–20 cm and extend to the ground (Gerald Collett, pers. comm.). Simpson (2005) suggests that roots hugging trunks that are leaning or roots originating from damaged upper parts may be a response to an imbalance or reaction to a wound, and result in a strengthening of the trunk.

While vertical roots often form down the trunks of mature pohutukawa trees, some trees produce abundant adventitious roots which form large hanging beards of aerial roots from spreading trunks (Simpson 2005). Each aerial root develops for a limited time before its growing tip aborts. As new roots are formed and interlace, they provide mutual protection and continue to extend downwards. After many years, the beard may reach the ground where one or more of the centrally located roots may develop into a bark-covered prop root linking the stem with the soil.

*On some trees a conspicuous mass of aerial adventitious roots hangs from stems and branches.*

*These "beards" of hanging roots on pohutukawa on a Coromandel farm have been used by cattle for back-scratching.*

## Leaves

Newly formed leaves on established pohutukawa have a coating of soft white hairs (tomentum) which protects the transpiring surface from drought and wind. As the leaf ages, a tough shiny layer of wax develops on the upper surface as the hairs wear off. Hairs are retained on the underside where they form a thick felt that protects the breathing pores (stomata) from the effects of salt and wind, and hence unnecessary water loss.

Newly emergent leaves on seedling or juvenile pohutukawa are shiny green. Epicormic and coppice shoots on seedlings and established trees are also shiny, lacking tomentum. The mature leaves are elliptic in shape, 50–100 mm long and 25–30 mm wide, and have slightly rolled edges. However, significant variation in leaf size can be found beyond these limits. Mature leaves on the same tree can also exhibit a large variation in leaf size.

Most of the leaves fall within 3–5 years of formation, leaving dense bare twigs in the sub-canopy. Leaves often turn red before they fall.

*Once a hanging beard of aerial roots comes in contact with the ground, one or more of the roots develops into a prop root that provides not only support to the limb but also another source of nutrients and water.*

*Leaves turn red as they age.*

*This pohutukawa at Army Bay, Whangaparoa, is able to continue to survive on an eroding coastal site as a substantial portion of its root system trails back into the bank.*

## Development of a sprawling pohutukawa

The formation of the spreading form of pohutukawa is likely to follow a sequence that starts with the slow subsidence or splitting of trunks at or near ground level on a multi-stemmed tree. As stems in close proximity develop, the union is sometimes poor. With the growth in diameter of stems and increasing load on each stem from a developing crown, stems can break away either by sudden failure or by slowly bending until they meet the ground. In many cases part of the fallen stem remains partially attached to the tree. Often the twisting branches form loops over the ground and take root where the trunk comes in contact with soil.

*Sprawling pohutukawa begins as a multi-stemmed tree with trunks joined at or near the base.*

*The next stage where several trunks have splayed out, stems either suddenly fail, or slowly bend over due to increasing weight, and come in contact with the ground.*

*Failed trunks often remain partially attached to the main root system (inset).*

*The final stage in the development of a large sprawling pohutukawa tree where many of the originally upright stems are now lying on the ground. Where trunks come in contact with the ground surface, adventitious roots present as buds even in the largest stems begin to develop and form another root system and supply of nutrients and water for the tree.*

## Flowering

The spectacular dark-crimson flowers appear in abundance in December, just before Christmas. Flower-buds develop at the ends of branchlets where they protrude beyond the leaves, and hence heavy flowering can almost obscure the crown of leaves. The flowering period often extends well into January, but for individual trees it is relatively brief, lasting for about 2 weeks (Schmidt-Adam *et al.* 1999). Flowering in individuals of the same group may begin and end at slightly different times. Like many New Zealand trees, pohutukawa often flowers profusely in one year and less obviously in the next. This between-year variability is not well understood. Simpson (1994) has suggested that it promotes cross-pollination between different populations and helps to maintain the genetic diversity which is important in a species that colonises harsh and unstable sites.

*Right: Close-up of flower showing stamens and anthers. The yellow anthers at the tips of the red stamens are beginning to shed pollen.*

*Far right: A carpet of crimson stamens beneath flowering pohutukawa heralding the end of flowering.*

Flowering depends on the rate of crown development and may not commence for several years after establishment. The flowers usually develop on shoots that have been growing for 1 year. They are formed in broad clusters and each develops a single style (female part of the flower), followed by 20–30 crimson stamens (male part of the flower) that eventually assume a brush-like appearance. The many flowers together create a dense mass of red stamens. After pollination, the stamens wither and fall, forming a crimson carpet beneath the tree.

The flowers of pohutukawa vary widely in colour and, although shades of red from crimson to scarlet are most common, occasional trees can be seen with brownish, white, pale yellow, gold, or pink flowers (Simpson 2005).

*The occasional natural pohutukawa has flowers that are not the usual crimson colour such as this yellow-flowering pohutukawa tree at Ohiwa Harbour, Bay of Plenty.*

## Pollination

The yellow structure (anther) at the tip of each stamen holds the pollen. A shallow cup at the centre of each flower contains nectar. This attracts the birds and insects that transfer pollen from one flower to another. Pollinators include the tui and bellbird, a range of introduced birds, and native and introduced bees.

Some New Zealand lizards, particularly geckos of the genus *Hoplodactylus*, visit pohutukawa in large numbers throughout the season. They forage actively from flower to flower, and probably from one tree to the next, in their search for nectar (Whitaker 1987). Large amounts of pollen adhere to their bodies, mostly on their throats, where they can carry it for at least 12 hours and for up to 50 m from the source, transferring pollen between trees. Bats also feed from pohutukawa flowers and are likely to be involved in pollination. Short-tailed bats were found in larger numbers around flowering pohutukawa than non-flowering trees on Little Barrier Island (Arkins *et al.* 1999).

*Pohutukawa are pollinated by a range of animals including bees (left) and native and introduced birds such as the tui (right).*

Schmidt-Adam *et al.* (2000) maintained that the reproductive strategy of pohutukawa is "wasteful but sufficient". They found that the species has a mixed mating system with substantial levels of self-fertilisation, i.e., where seed has been pollinated by pollen originating from flowers on the same tree. Lower levels of seed were from cross-pollination, i.e., where seed has been pollinated from other trees. They indicated that the high proportion of self-pollinated seed found in pohutukawa (up to 60%) is unusually high for a long-lived tree species.

In a comparison between the relatively fragmented pohutukawa stands on the mainland and the larger intact pohutukawa forest on offshore islands, Schmidt-Adam *et al.* (2000) found similarly low cross-pollination rates. There was no significant difference between pollination rates brought about by native birds and insects that are found only on islands and those resulting from the activity of mainly exotic pollinating agents in mainland sites. The apparent ability of pohutukawa to use a wide range of pollinator species provides it with protection from dependence on one or two species that could be threatened by habitat degradation.

Schmidt-Adam *et al.* (2000) found that although the germination rate of self-pollinated seed (44%) was similar to that of cross-pollinated seed, early growth of seedlings from cross pollinated seed was significantly faster. Self-pollinated seedlings are therefore more likely to be suppressed than cross-pollinated seedlings. In spite of the high rates of self-pollination, the number of outcrossed seeds per tree is still high and will give rise to plants that are likely to predominate in developing populations.

## Seed formation

After pollination, the fruit containing developing seed starts to mature into a small broadly oblong capsule. Ripe seeds are shed in March and April as the capsules dry and split open. The 2-mm-long seeds are easily dislodged and are dispersed by wind, sometimes in large quantities.

Once seed has been released, most of the empty capsules fall to the ground.

Some studies suggest that a high proportion of formed seed is not viable. Sound seeds contain few nutrient reserves, but are able to withstand limited freezing, salt water, desiccation, and burial.

*The sequence from flowering to seed formation of pohutukawa.*

a) - *Unopened flower buds*

b) - *Partially opened flower buds*

c) - *Fully expanded flowers*

*d) - Flower cluster with partial loss of stamens*

*e) - Green seed capsules formed*

*f) - Mature seed capsule splitting exposing seed for wind dispersal*

## Natural range

Pohutukawa is native to the zone that lies between the Three King Islands and latitude 39°S (Wardle 1991). Other important indigenous trees, notably kauri and puriri, occur naturally in the same northen, warm temperate zone. From Northland to Coromandel, pohutukawa often forms an interface between mangroves and lowland forest around estuaries.

Pohutukawa occurs naturally along the coast, its range extending from North Cape to Tokomaru Bay on the east of the North Island and to Urenui, north of New Plymouth, on the west. It once formed an almost continuous band of forest along most of this coastline but logging and land clearing have reduced the population to isolated stands, single lines of trees and groves on cliff tops and coastal banks, or scattered individual trees. In terms of conservation status, the species is considered by de Lange and Norton (1998) to be "declining". Inland populations occur on the shores of the lakes of the Volcanic Plateau, specifically Lakes Rotorua, Rotoiti, and Taupo (Allan 1961)

The exact natural southern limit of pohutukawa is difficult to determine because the species has been so widely planted. There is evidence that Maori cultivated the tree in areas south of its natural range. Stands bordering the Rotorua lakes and Lake Taupo may originate from Maori plantings, although the presence of other coastal species in the same locations, particularly the Rotorua lakes (Clarkson 1991), suggests otherwise.

*Pohutukawa around the edge of Lake Rotoiti, where the species is found naturally established.*

*Pohutukawa has been popular for planting well south of its natural range. These include Christchurch (left), and Collingwood (right).*

## Planted trees

Pohutukawa grows well when planted in coastal and warmer lowland locations throughout New Zealand. It is found along the North Island coast from New Plymouth to the Kapiti Coast, the Wellington region, and Hawke's Bay. In the South Island it grows well in Nelson, the Marlborough Sounds, on the Kaikoura and Christchurch coasts, and on the west coast as far south as Hokitika. In many of these places regeneration from seed produced by planted trees has been observed. Burstall and Sale (1984) listed a number of notable pohutukawa trees that were planted south of the natural range. These include a New Plymouth specimen planted in 1874; a tree planted in Lower Hutt around the early 1840s; the Anzac Memorial tree planted in Eastbourne, Wellington, in 1915; a tree planted at Jacksons Bay, South Westland, in 1940; and a pohutukawa planted at Waitangi in the Chatham Islands.

*Tree planted in the grounds of Parliament, Wellington.*

# POHUTUKAWA PLANTED IN SPAIN SPARKS DEBATE ON DISCOVERY OF NEW ZEALAND

***"A pohutukawa tree at 'the end of the world' has stirred up debate on whether the Spanish were the first Europeans to reach New Zealand, ahead of the Dutch and British."***

Source: Manaaki Whenua Landcare Research

## El metrosidero coruñés abre una duda histórica en Nueva Zelanda

### Llegó en un barco que vino a abastecerse de jabón

### En la ciudad hay cinco ejemplares más

A giant pohutukawa is a big attraction in the Spanish north-west coastal city of La Coruña, capital of the province of Galicia. This province was thought until the time of Columbus to be the end of the world.

La Coruña's mayor has chosen the pohutukawa as the city's floral emblem, and many locals believe it to be 400 to 500 years old. However, because the tree is a New Zealand native, this could mean that the Spanish sailed to New Zealand before Captain James Cook in 1769, or Abel Tasman in 1642.

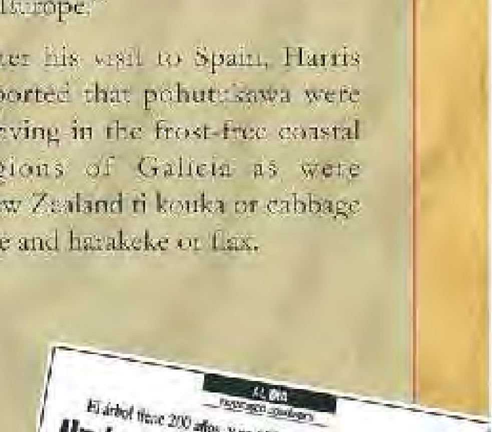
On a visit to Spain, Landcare Research botanist Dr Warwick Harris visited La Coruña in 2001 and caused a flurry of local media attention when he stated his belief that the tree could not be more than 200 years old. While no-one knows exactly how the tree got there, and it has not been aged, Harris wrote: "...I have this romantic idea that it was brought into Spain by the British during the Napoleonic wars and can be linked to the heroic story of Sir John Moore."

Moore took a small British army into Spain in 1808 to check the French invasion, but was forced by Bonaparte himself and a huge army to retreat over mountains. Nevertheless, the British mission saved Spain from full occupation by the French. Moore eventually led his men more than 400 km to La Coruña where British ships were waiting, but in the last phase of the evacuation his arm was blown off by a French cannon. He saw the end of the battle and died, and his hurried burial was immortalised in a famous poem by Sir Charles Wolfe.

Harris says that the history relating to Moore indicates the presence of a British garrison in La Coruña in the early 1800s. "At some stage, the British must have recovered Moore's body, and laid him in a tomb in what is now the Garden of San Carlos, created in 1834. Most likely there was a British involvement in the creation of the garden, and it is a romantic thought that the pohutukawa came to La Coruña at that time.

"We know that Captain Cook brought back plants from his first voyage to New Zealand, and within ten years there was commerce in those plants in England. We don't know about pohutukawa specifically, but we do know that the British were largely responsible for introducing New Zealand plants to Europe."

After his visit to Spain, Harris reported that pohutukawa were thriving in the frost-free coastal regions of Galicia as were New Zealand ti kouka or cabbage tree and harakeke or flax.



El árbol tiene 200 años, y no 500, dice el neozelandés Harris

## Un botánico diluye la leyenda del metrosidero gigante

# PART 3 - RELATIONSHIP WITH OTHER SPECIES

Pohutukawa is a member of the large myrtle family, which includes among its 3000 species worldwide eucalypts, guavas, feijoas, and bottlebrushes. New Zealand has several native myrtle species including manuka, kanuka, and swamp maire.

**Metrosideros tree species**

Within the Myrtaceae family, pohutukawa belongs to the genus *Metrosideros* which contains five New Zealand tree species.

**Metrosideros bartlettii (Bartlett's rata)**

Discovered in 1975 as a small isolated population of 30 individuals at the northern tip of the North Island. Trees are up to 20 m high and have bark similar to that of the paper-bark myrtles in Australia. They usually develop as perching plants in the canopy of a host tree. Roots are formed and eventually reach to the ground, coalescing into a single trunk which in due course replaces the host.

**Metrosideros kermadecensis (Kermadec pohutukawa)**

Naturally restricted to the Kermadec Islands about 900 km north-east of New Zealand. These usually smaller trees which are commonly planted on the mainland, are closely related to pohutukawa.

*Kermadec pohutukawa often has a more erect shrubby growth form than mainland pohutukawa.*

**Metrosideros robusta (northern rata)**

Large trees, widespread throughout the North Island, north-west Nelson, and northern Westland. Individuals often emerge above the general forest canopy and carry large numbers of epiphytes and lianes. Like Bartlett's rata, northern rata usually develops as a perching plant in the canopy of a host tree, and eventually replaces the host.

**Metrosideros umbellata (southern rata)**

A forest tree found on rocky slopes and in river gorges from coast to mountain in the south and west of the South Island. Restricted in the North Island to isolated stands or single trees on elevated cool damp sites. Considered to be an ancient species from which rata and pohutukawa evolved.

*Southern rata*

**Metrosideros excelsa (pohutukawa).**

*Metrosideros* is the Greek word for ironwood, which reflects the hard nature of the timber. The species name *excelsa* is derived from the Latin word meaning "raised" or "exalted". A former name, *Metrosideros tomentosa*, described the felt of white hairs (*tomentum* in Latin) which covers young stems, buds, and undersides of the leaves.

In addition to the tree species, there are seven *Metrosideros* in the *Mearnsia* subgenus, most of which are vines and known as climbing rata. These are *Metrosideros albiflora, M. carminea, M. colensoi, M. diffusa, M. fulgens,* and *M. perforata.* Parkinson's rata (*M.parkinsonii*) is the only shrub or small tree species in the subgenus in New Zealand.

## Distinguishing between species

Pohutukawa is frequently confused with the widely-planted *M. kermadecensis* which has smaller rounder leaves, much smaller flowers, and a tendency to flower sporadically throughout the year. On the New Zealand mainland, it grows with a more erect shrubby form, and rarely (if ever) develops into a large tree.

Care is required to distinguish the young leaf forms of pohutukawa from those of northern rata. The leaves from seedlings and epicormic shoots of pohutukawa are similar to the leaves of juvenile northern rata, but the juvenile pohutukawa leaf can sometimes lack the cover of felt underneath while the juvenile northern rata leaf lacks the notch of the adult leaf.

Pohutukawa can also be confused with another common coastal plant, the unrelated shrub karo. There are several easily recognised differences: karo has alternate leaves whereas pohutukawa has pairs of opposite leaves; karo has large round green seed pods which split revealing a sticky mass with relatively few seeds, compared to the smaller cup-shaped capsules of pohutukawa containing a mass of fine dry seed; unlike pohutukawa, karo does not form aerial roots, nor does it develop into a large tree.

*The leaf of Kermadec pohutukawa is smaller and rounder than that of pohutukawa although the upper leaf surface is similarly dark green and shiny (left) and the underside has tomentum (right)*

*Rounded leaves of Kermadec pohutukawa*

*The dark, upper shiny leaf surface (top) and lower leaf surface without tomentum (bottom) of northern rata. Note that northern rata leaves may have a notch at the tip (right).*

*Northern rata leaves are generally smaller than pohutukawa foliage and are glossy on both upper and lower surfaces*

*The dark green upper surface (top) and the distinctive white tomentum of the lower leaf surface (bottom) of pohutukawa.*

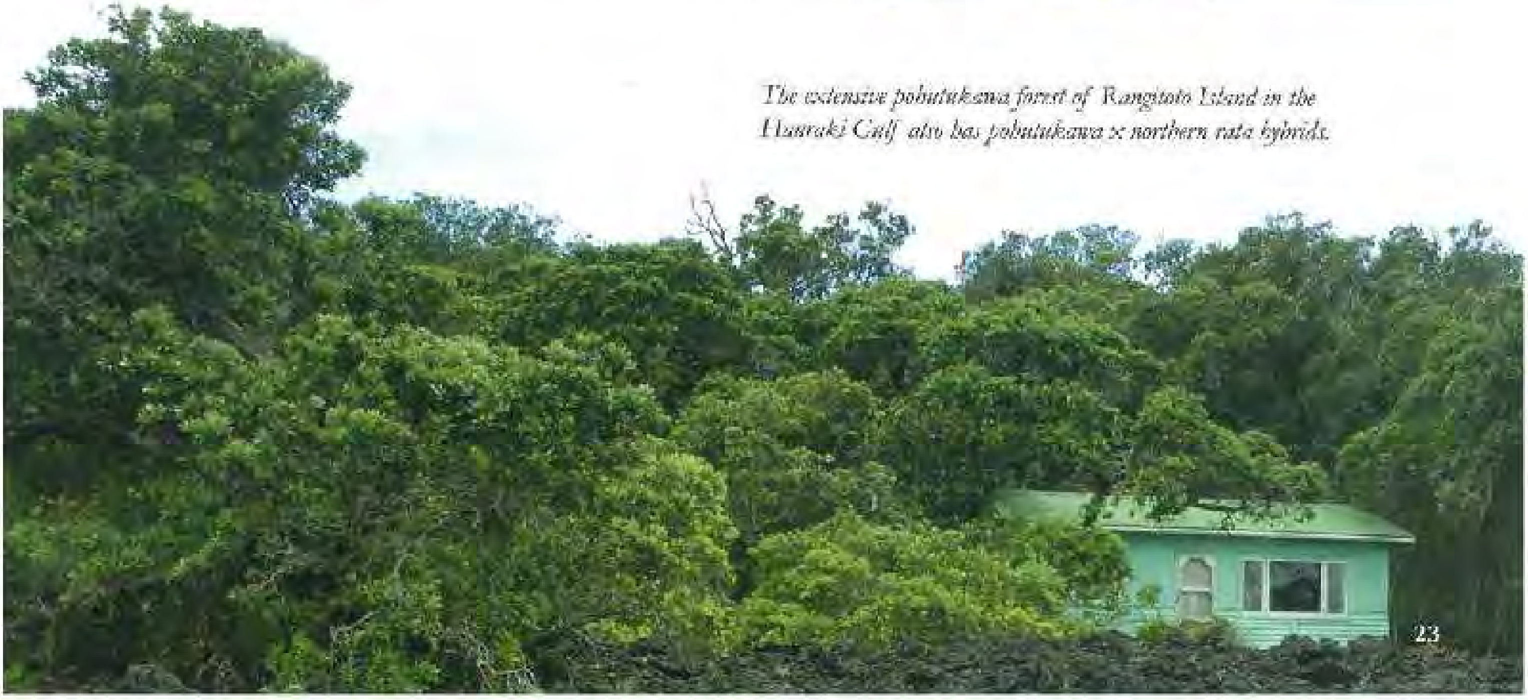
*Pohutukawa leaves are generally larger and darker green than northern rata and can have slightly rolled edges.*


*Pohutukawa is easily distinguished from karo: pohutukawa has opposite leaves and small capsules and karo has alternate leaves and larger capsules with shiny black seeds.*

## Hybridisation

Mainland and Kermadec pohutukawa hybridise readily wherever they occur together. Hybridisation between pohutukawa and northern rata is also common, with hybrid populations found on the shores of the Rotorua lakes and on Rangitoto Island. Early collections of specimens from Auckland and the shores of Lake Taupo were also described as hybrids (Allan 1961). Ogle and Bartlett (1980) considered that the distribution of pohutukawa x northern rata hybrids extends to Northland and Great Barrier Island. Many sites in which hybrids occur are previously logged areas surrounded by native forest in which northern rata is common. They are also close to coastal cliffs where pohutukawa is plentiful. Pohutukawa hybridises with southern rata and Bartlett's rata as well (Simpson 2005). Some hybrids or cultivars have been developed by the nursery industry, 'Mistral' (northern rata x pohutukawa) being a good example.

*Hybridisation between pohutukawa and northern rata can make identification difficult. This tree is a reputed hybrid tree from the Rotorua lakes region, possibly the only natural inland site of pohutukawa where northern rata also occurs.*



*The extensive pohutukawa forest of Rangitoto Island in the Hauraki Gulf also has pohutukawa x northern rata hybrids.*

## Is there a hybridisation risk attached to the planting of pohutukawa beyond its natural range?

Views are divided about the advisability of extending the distribution of pohutukawa beyond its natural range. In an article promoting the planting of pohutukawa, Duthie (1993) described it as a superb tree for exposed sites and "surely the best all round hardy tree for Wellington". He noted that pohutukawa trees can be seen growing beside some of Wellington's best known landmarks.

The Wellington Botanical Society regards pohutukawa as an invasive weed in the Wellington region because it occupies many of the sites in which northern rata would be expected to occur. Pohutukawa is thought to have been planted extensively by early settlers after large tracts of forest containing northern rata had been burnt. The result is that northern rata is now confined to small remnant populations. The Society maintains that pohutukawa is hybridising with local northern rata and that widespread planting of pohutukawa is therefore a threat to the survival of northern rata as a separate species.

Although Simpson (2005) acknowledged concern about genetic pollution of natural rata populations from the widespread plantings of pohutukawa in car parks and picnic areas adjacent to reserves, he could not find any evidence that hybridisation is taking place. He noted that pohutukawa and rata flower at slightly different times and suggested that natural hybridisation may have been an important feature of the evolution of pohutukawa and rata.

Jonathan Bussell, Manager of the Wellington City Council nursery, takes a pragmatic view of the use of pohutukawa in the city. The Council uses a wide range of local native plants in parks, gardens, and roadsides. Jonathan finds pohutukawa continues to be a popular choice for planting as a street tree and in city parks because it is attractive and easy to establish and manage. However, he is advocating the use of northern rata for larger-scale planting in parks and within the city's greenbelt on the many hillsides in and around the capital. This includes, for example, the removal of old pines along the town belt of Tinakori Hill and replacement with natives including the planting of locally sourced northern rata in collaboration with Project Crimson.

*Although outside its natural range, pohutukawa has long been planted in Wellington along streets and in parks where it thrives.*

In some instances, plants supplied by nurseries as pohutukawa have proved to be hybrids. Up to 90% of the seedlings obtained for a research trial at Whitianga were not true specimens of *M. excelsa* (Chris Ecroyd, National Forestry Herbarium, pers. comm.). Most of the plants that had the leaf characteristics of northern rata became unthrifty and died within a year of planting on an exposed coastal site. Plants with characteristic pohutukawa foliage survived (D.O.Bergin, unpubl. data).

## Genetic variability

Pohutukawa leaves vary in their shape and size and flowers can differ in colour. A high degree of diversity seems to be common in most stands of pohutukawa, and an assessment of 20 populations has shown that the levels of polymorphism are typical of long-lived species (Young *et al.* 2001). There is evidence of inbreeding, which is common in small populations and can result in reduced growth rates (Simpson 2005). The current distribution of pohutukawa is very different from its natural distribution before human settlement, and opportunities for gene flow that existed in the past have been reduced by isolation and the negative effects of possum browsing on residual stands. Thus, inbreeding in relict stands is likely to become more common in future (A. Shelbourne, Ensis Genetics, pers. comm.). While more research and debate on this topic are needed, self-crossed seeds may make up a significant proportion of the total seed crop produced by small populations. Young *et al.* (2001) suggested that while revegetation programmes should source seed locally, taking material from small populations should be avoided.

The Project Crimson Trust encourages the use of plants raised from seed that has been collected from naturally established stands located as near as possible to the planting site (sometimes referred to as "eco-sourcing"). Community-based and commercial nurseries are raising seedlings on behalf of the Trust, using known and approved seed sources. The number of parent trees and maximisation of their distance from each other are important factors to consider before seed is collected (Bergin and Gea 2005).

# PART 4 - HISTORY AND EARLY UTILISATION

## Significance of flowers to Maori

It is hardly surprising that a spectacular tree should figure prominently in Maori folklore. The colour red is considered a chiefly colour; it was worn only by people of high rank. It may have been one of the reasons why Maori transplanted seedlings to places well outside the trees' natural range – the Rotorua lakes, Motu Taiko, the island in Lake Taupo, and it seems also to Wellington and the Marbourough Sounds (Robert McGowan, Nga Whenua Rahui, pers. comm.).

One story relates how people on the Arawa canoe saw the pohutukawa in flower as they approached New Zealand near Cape Runaway. Nearing the shore, the rangatira (chief) said "The head-dresses of this land are better than those of Hawaiiki – I'll throw mine into the water." And he threw his own head-dress into the sea.

A similar story is associated with the arrival of the Tainui canoe at Kawhia (Schnackenberg 1935). On reaching the shore, the people noted the fragility and short-lived nature of the pohutukawa flowers, commemorated in the Tainui whakatauki (proverb):

***Kai mau Ki te Kura whero. He aha te Kura tawhiwhi. He amoruhoro.***

*(Hold fast to the permanent red! Of what use is the bright bloom which wilts away?)*

The flowering of the pohutakawa was one of the seasonal signs that is still used today. In many areas, when pohutakawa flowers the kina (sea eggs) are fat and ready for harvest.

## Maoridom and long-lived trees

As pohutukawa is a long-lived tree, it was often used as a marker on prominent sites. A good example of this is the tree Tangi Te Korowhiti at Kawhia. Tradition tells that this was the tree that the Tainui canoe was moored to when it arrived at Kawhia. The original trunk has long since disappeared but the tree keeps coppicing from the base and continues to grow on the site. When a large branch fell off many years ago, the Maori Queen Dame Te Atairangikahu (recently deceased) had tototoko (ceremonial walking sticks) carved from it. These she presented to kaumatua as part of the 1990 celebrations for the 150th Anniversary of the Treaty of Waitangi. These tototoko represent the connection to tupuna (ancestors) as well as the long history since the canoe first arrived, and the values and traditions that still live today.

There are many individual trees with long histories in Maoridom; their stories are often of great significance to the people of today who are part of those histories. They stand as a physical connection to tupuna long since departed, a source of mana, and a rallying point for those who seek to uphold the values and traditions. Such trees come to be considered tupuna (ancestors) themselves, not through physcial descent, but through direct ssociation with tupuns. Some were even the repositories for koiwi (bones of the deceased) and other taonga (Robert McGowan, pers. comm.).

## Maori medicinal uses

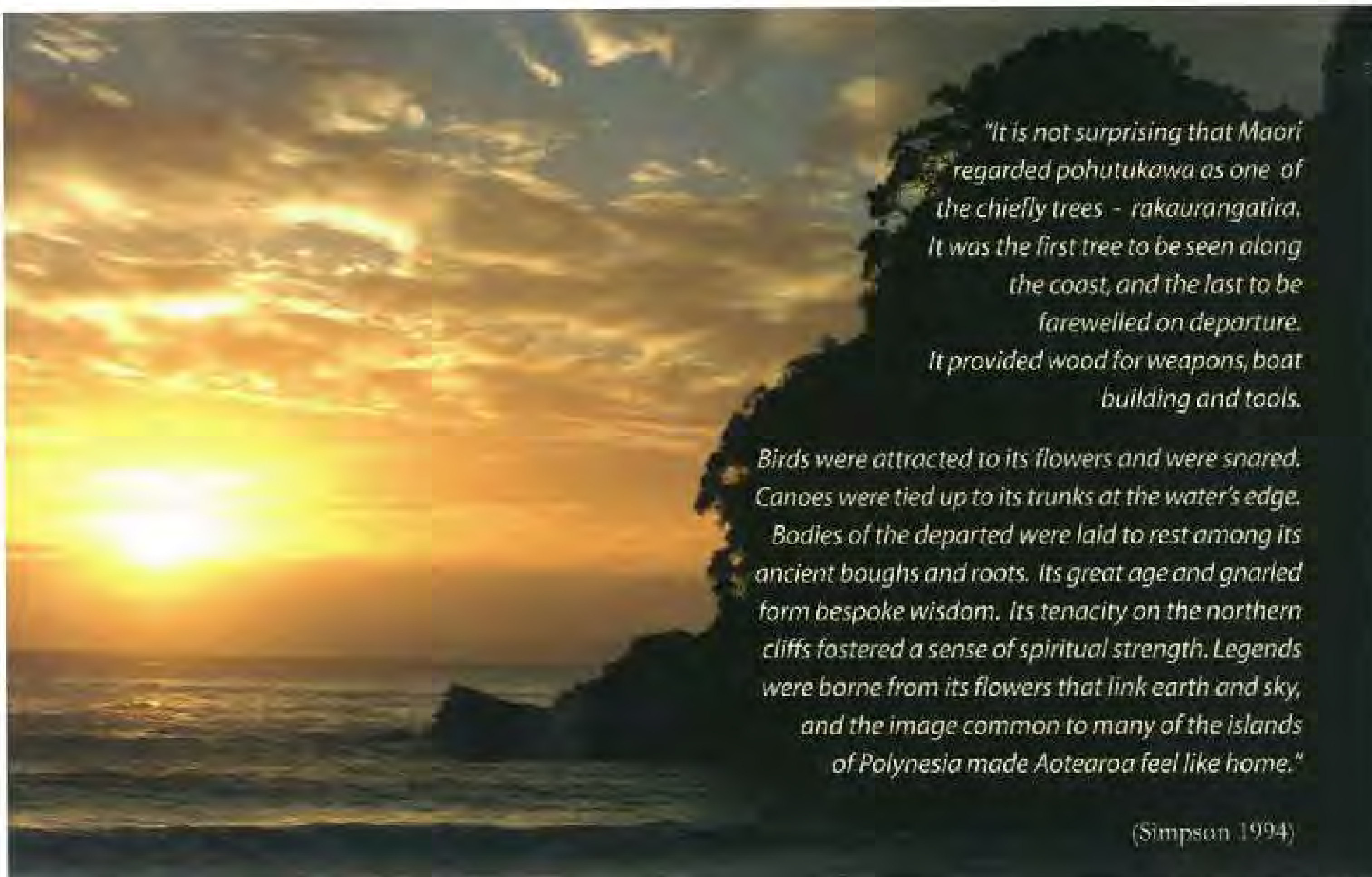
Pohutukawa was used medicinally by Maori. The tohunga (chief priest) would extract and make a rongoa (bark infusion), giving it tapu (sacred) status. Extracts of the inner bark (which contains ellagic acid) were used to treat dysentery and diarrhoea; it was also used to help stop bleeding. The inner bark was chewed to help alleviate toothache; sometimes it was boiled to soften it, but more often it was used raw as a convenient immediate treatment. The nectar was found to alleviate sore throats.

## Other Maori uses

The early Maori used pohutukawa wood to make small implements, paddles, weapons, eel clubs, and mauls. Because the wood is heavy, it was sometimes used in pounders for softening flax, or for preparing aruhe (bracken) rhizomes for eating. In colonial times, pohutukawa was much used by Maori for boat building

## Boat building

Early Europeans used pohutukawa extensively for boat building. The wood was resistant to the tunnelling of the teredo worm (a bivalve mollusc), and the natural curves from gnarled branches and roots, along with its inherent strength, made it attractive for fashioning ship members, with thousands of elbows being harvested for use in boat frames. Quoting from several early sources, Simpson (2005) described the popularity of pohutukawa for ship-building in the northern parts of the country. The evidence included a report to Parliament by Thomas Kirk in 1874, expounding on the wood quality of pohutukawa – "its peculiar habit, combined with its great durability, renders it especially adapted for the purposes of ship-building..."; Kirk considered that it was second only to puriri for resistance to the teredo worm. He also indicated that the best knees were made from the roots because they were more durable than the branches.



*"It is not surprising that Maori regarded pohutukawa as one of the chiefly trees - rakaurangatira. It was the first tree to be seen along the coast, and the last to be farewelled on departure. It provided wood for weapons, boat building and tools.*

*Birds were attracted to its flowers and were snared. Canoes were tied up to its trunks at the water's edge. Bodies of the departed were laid to rest among its ancient boughs and roots. Its great age and gnarled form bespoke wisdom. Its tenacity on the northern cliffs fostered a sense of spiritual strength. Legends were borne from its flowers that link earth and sky, and the image common to many of the islands of Polynesia made Aotearoa feel like home."*

(Simpson 1994)

Simpson (2005) describes how pohutukawa roots and branches were also used in many other parts of the boat frame and fixtures. A vast pool of knowledge was built up by early boat builders in carefully selecting curved wood to match the intended use, and in doing the shaping, seasoning, and sealing that were required. For instance, one source quoted indicated the time of the year at which pohutukawa was cut was important – frames cut in summer "…might tend to rot within six years or so but, cut in winter with the sap down and then properly seasoned, their life would be that of the ship".

Simpson (2005) noted that before the 1950s, when glue technology became sufficiently advanced to allow lamination, pohutukawa had been widely used in pleasure craft and work boats such as coasters and scows which required very strong hulls with many knees. Consequently, pohutukawa was greatly reduced in areas adjacent to boat-building yards. Even as far back as 1889, Thomas Kirk noted that pohutukawa had been destroyed in many areas and was becoming very scarce. This continued during the 1930s and 1940s when there was considerable public concern at the continuing loss of pohutukawa forest to boat building.

## Other early settler uses

Kirk (1889) described the suitability of pohutukawa timber "for planks for various special purposes, for trenails, for machine-beds and bearings." Because it is so hard, the wood was usually worked green, which often led to later problems, particularly shrinkage (Clifton 1990). When straight lengths could be obtained they were used for piles, stringers, bridge and wharf planking, mining timbers, and fence posts. Pohutukawa posts were used around the coast of Kawhia (Schnackenberg 1935), and probably in other northern coastal regions.

Kirk (1889) also noted pohutukawa as excellent firewood, although difficult to split. Like Maori, bushmen used a decoction of the inner layers of the bark as a remedy for dysentery. Simpson (2005) has described in some detail the early production and long recognised qualities of pohutukawa honey.

# PART 5 - ECOLOGY AND HABITAT

Pohutukawa can be described as an ecological opportunist. It flowers in profusion during a short time in early summer, and produces a mass of very small seeds in autumn. The seed is readily dispersed by wind to maximise spread to the most favourable sites for germination. While only a very small proportion of the seed germinates, once an individual is established, it can live for hundreds of years.

The longevity of pohutukawa is an unusual strategy for a colonising plant of bare surfaces including exposed coastal rock (Simpson 1994). Few tree species can tolerate frequent and violent storms, salt-laden winds, and a droughty, often unstable environment. Once established, pohutukawa provides shelter which eventually may allow other species to develop. Although the leaf litter does not decompose readily, and tends to inhibit the growth of plants immediately below the canopy, taller trees may eventually become established if conditions are suitable, and these in time will shade out the pohutukawa. However, because no other species is as successful at colonising bare rock and able to tolerate the strong salt-laden winds along the most exposed margins of the shoreline, pohutukawa maintains its dominance along much of the northern coast.

*A persistent litter layer under mature pohutukawa combined with low light levels can discourage regeneration of other species.*

## Ecological characteristics

Pohutukawa has a range of ecological characteristics that enable it to tolerate such exposed often-hostile sites and climatic conditions.

### *Temperature*

Restriction of the natural distribution of pohutukawa to the northern half of the North Island is largely related to temperature, particularly frostiness. In relation to the southern most latitude, winter freezing resistance, defined as the lowest temperature at which a plant shows little or no damage, is -3°C for pohutukawa (Sakai and Wardle 1978). Mature trees can tolerate light frosts, but seedlings do not survive low temperatures, especially if these persist for long periods. In the laboratory, leaf damage is observed below -8°C. Newly planted seedlings that may not have been hardened-off sufficiently can have leaves severely frosted after planting. Winter frosts can also occasionally cause severe damage to older trees. In July 1982 several northern coastal species, including pohutukawa and mangrove, were severely affected by low temperatures (Beever and Beever 1983). It may be the rare climatic event, possibly decades apart, such as a particularly heavy frost or an intense period of very cold weather, that determines the southern natural limit of many northern species including pohutukawa (Sakai and Wardle 1978).

*Seedlings of pohutukawa are susceptible to frosting especially if nursery raised seedlings are planted on frost-prone sites. If frosting is severe, plants may be killed outright or, if only tops are frosted, new shoots will coppice from the base.*

### *Light and moisture*

The seeds of pohutukawa are extremely small and contain little in the way of food reserves, so the seedlings do not have the ability to grow through dense ground vegetation. Natural establishment of pohutukawa is usually confined to open sites receiving full sunlight. Simpson (2005) considers that the nature of the substrate is important but that rainfall does not limit plant distribution. While moisture will be essential for germination and initial establishment, seedlings tolerate extremes of drought and high temperatures. On the other hand, pohutukawa are not found on wet sites where many other species thrive. Wotherspoon (1993) found in pot trials that pohutukawa did not grow in waterlogged soils.

*Considering that pohutukawa inhabit a generally windy coastal environment, it is only on the most exposed windy sites that crowns of established plants can be partially defoliated by extreme exposure to strong, usually cold winds.*

### *Salt and wind tolerance*

Despite constant exposure to salt-laden wind and to sea spray, pohutukawa trees located on headlands, cliffs, and other rocky outcrops are rarely damaged by salt deposition. Young trees may lose leaves on the seaward side of the developing crown if strong winds persist for long periods. While established trees typically retain a rounded crown on most coastal sites, on very exposed sites the crown can be sculptured by the wind.

## Habitat

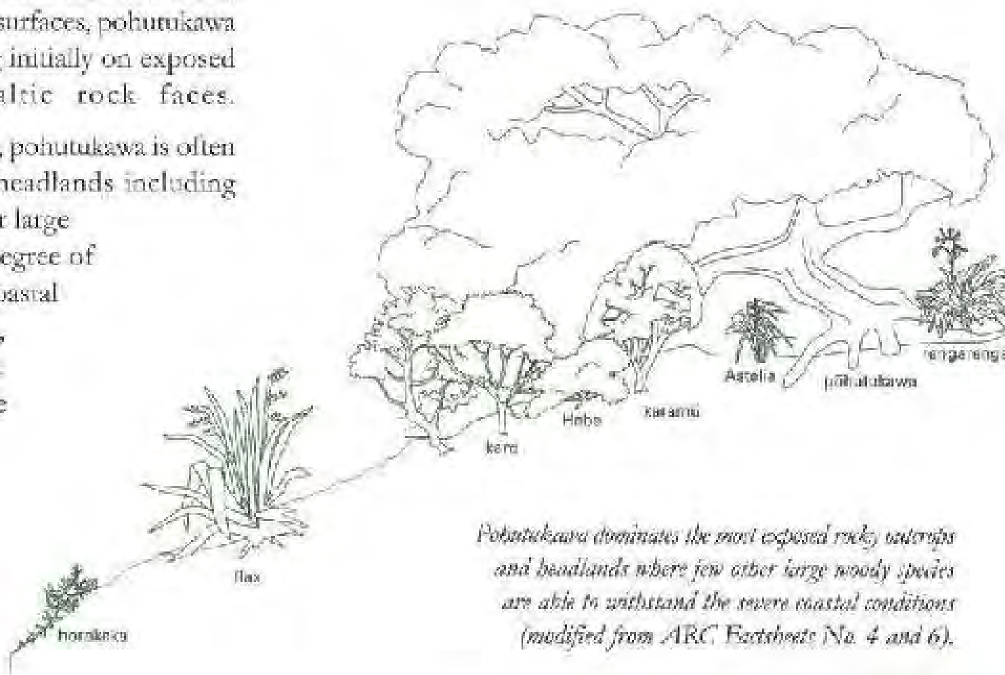
Pohutukawa grows on a wide range of site types. Coastal rocky cliffs, vertical mudstone and sandstone bluffs, banks of clay and volcanic ash deposits, sand dunes, and the leading edges of alluvium or estuarine mud are all colonised, as well as rocky open spaces along river banks and lake shores. Trees are also found in open grassland and fernland, and on volcanic and boulder fields where other pioneering species cannot survive. Pohutukawa forms an open understorey or continuous tall forest where tree crowns become moulded by the wind to the level of their associates (Wardle 1991).

*Pohutukawa is fundamentally a rock-loving plant with a particular affinity for colonising volcanic rock, such as the highly fissured bare lava on Rangitoto Island.*

### *Rocky sites*

Pohutukawa seems to have a particular affinity for colonising fissured rocky sites such as those which characterise Rangitoto Island in the Hauraki Gulf. Here, even on the seemingly most hostile surfaces, pohutukawa is the only tree species establishing initially on exposed coastal, dark-coloured, basaltic rock faces.

Around much of the northern coast, pohutukawa is often confined to rocky outcrops and headlands including off-shore islands. Virtually no other large woody trees can tolerate the high degree of exposure on these most exposed coastal margins. Around the Rotorua lakes, most pohutukawa are found on the steep well lit rock faces where there is less competition from other trees and shrubs.




*Pohutukawa dominates the most exposed rocky outcrops and headlands where few other large woody species are able to withstand the severe coastal conditions (modified from ARC Factsheets No. 4 and 6).*

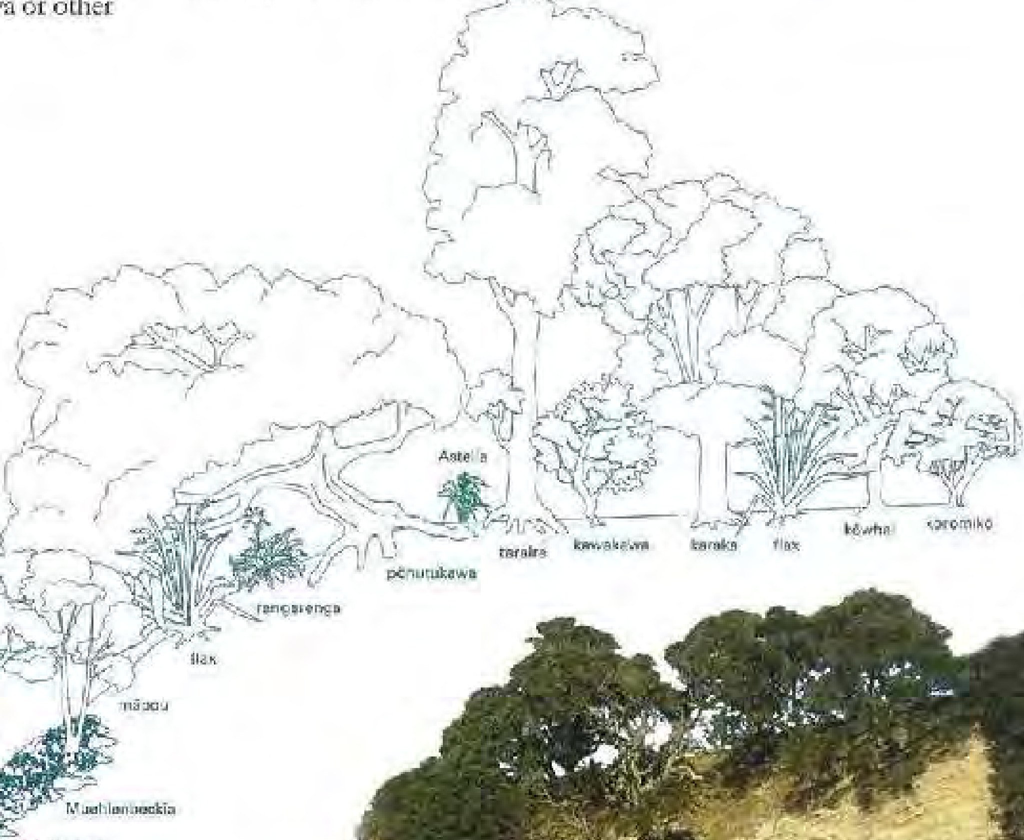
*Pohutukawa most often colonises rocky outcrops and headlands throughout its natural range.*

### *Banks*

Banks of clay or redistributed volcanic ash, sand, and silt bordering the harbours and estuaries of northern parts of the North Island would have naturally supported a land-to-sea sequence of coastal forest, with upper slopes often dominated by pohutukawa along with other species such as kanuka, puriri, and karaka. Towards the base of the bank, this would have graded into lower shrubs and flax with specialised plants completing the sequence forming low salt meadows and estuarine fringes. In many regions, only fragments of once-extensive coastal forests remain and the occasional large pohutukawa may be the only tree remaining. Continued grazing, browsing by pests, and development prevent regeneration of pohutukawa or other coastal species on these sites.

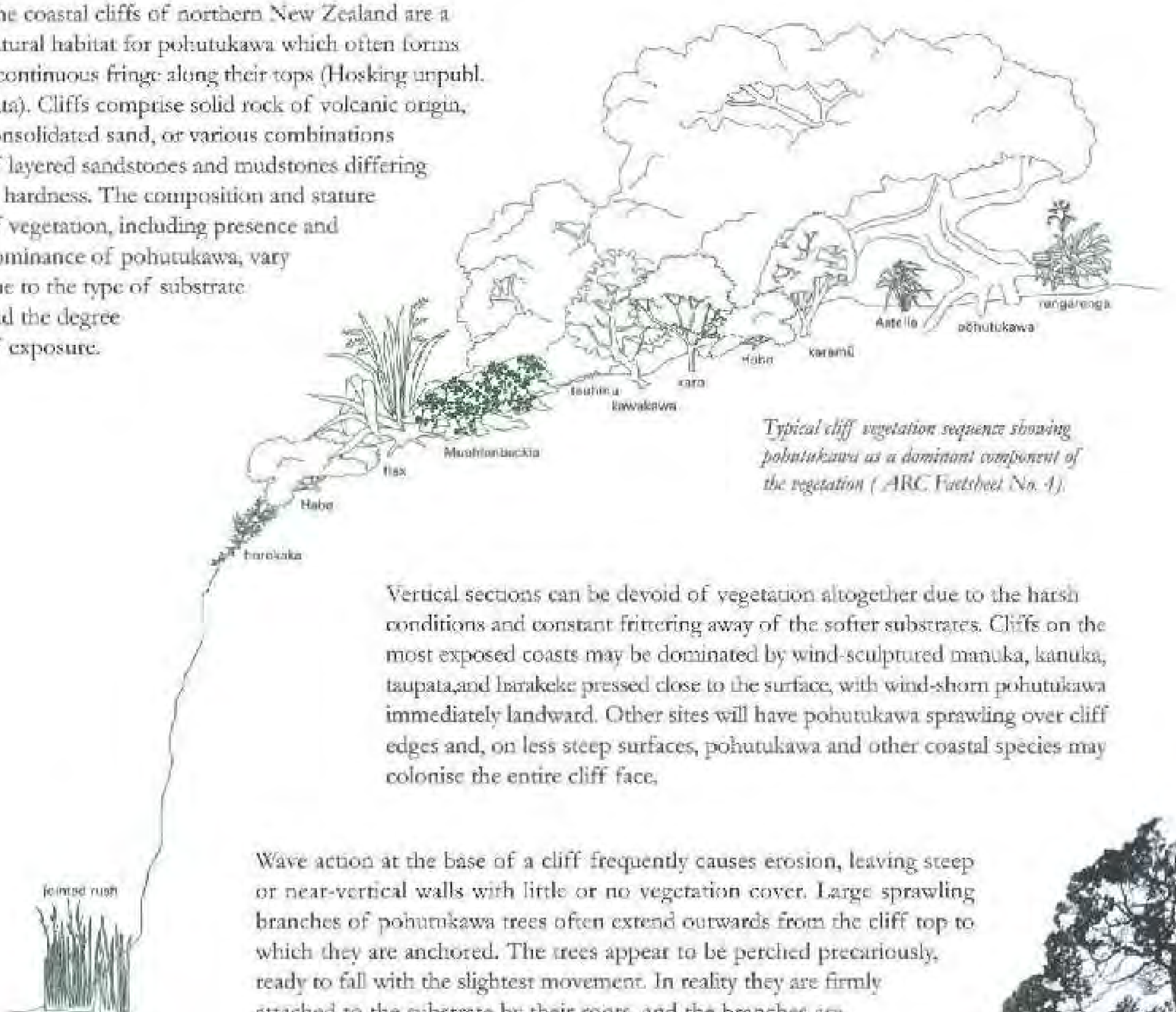
*Banks of clay or redistributed volcanic ash or sand and silt support remnant pohutukawa, evidence of once-extensive diverse coastal forest.*

*Vegetation sequence with pohutukawa across banks bordering an estuary or sheltered beach (ARC Factsheet No. 6).*




### *Cliffs*

The coastal cliffs of northern New Zealand are a natural habitat for pohutukawa which often forms a continuous fringe along their tops (Hosking unpubl. data). Cliffs comprise solid rock of volcanic origin, consolidated sand, or various combinations of layered sandstones and mudstones differing in hardness. The composition and stature of vegetation, including presence and dominance of pohutukawa, vary due to the type of substrate and the degree of exposure.

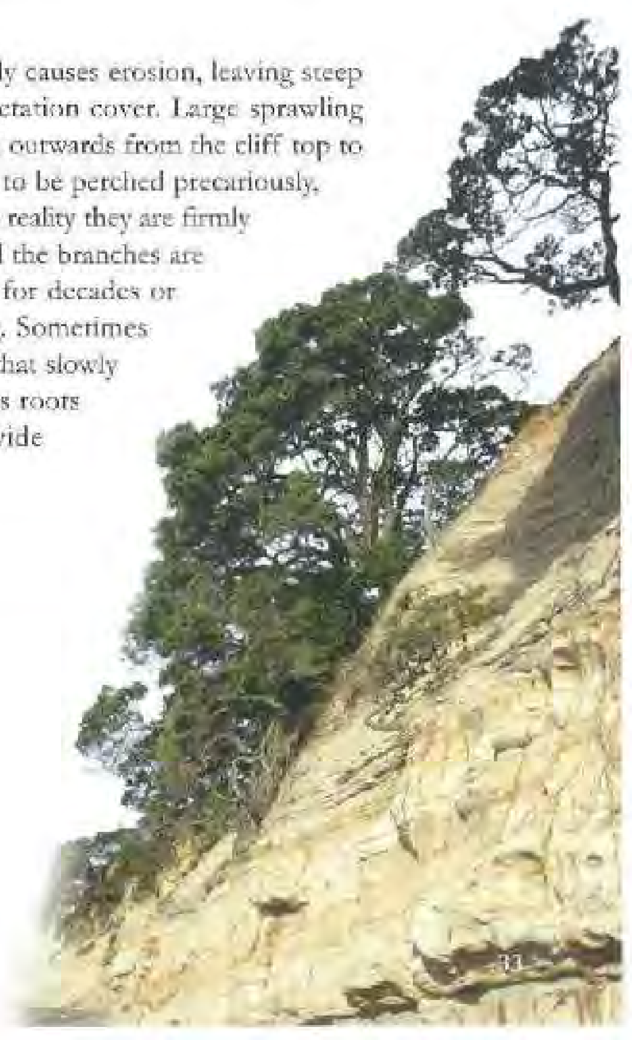



*Typical cliff vegetation sequence showing pohutukawa as a dominant component of the vegetation ( ARC Factsheet No. 4).*

Vertical sections can be devoid of vegetation altogether due to the harsh conditions and constant frittering away of the softer substrates. Cliffs on the most exposed coasts may be dominated by wind-sculptured manuka, kanuka, taupata,and harakeke pressed close to the surface, with wind-shorn pohutukawa immediately landward. Other sites will have pohutukawa sprawling over cliff edges and, on less steep surfaces, pohutukawa and other coastal species may colonise the entire cliff face.

Wave action at the base of a cliff frequently causes erosion, leaving steep or near-vertical walls with little or no vegetation cover. Large sprawling branches of pohutukawa trees often extend outwards from the cliff top to which they are anchored. The trees appear to be perched precariously, ready to fall with the slightest movement. In reality they are firmly attached to the substrate by their roots, and the branches are able to bend or rotate over the cliff edge for decades or even hundreds of years, without breaking. Sometimes caves develop beneath trunks or branches that slowly come to rest on the cliff face. Adventitious roots penetrate the substrate and rapidly provide additional support.

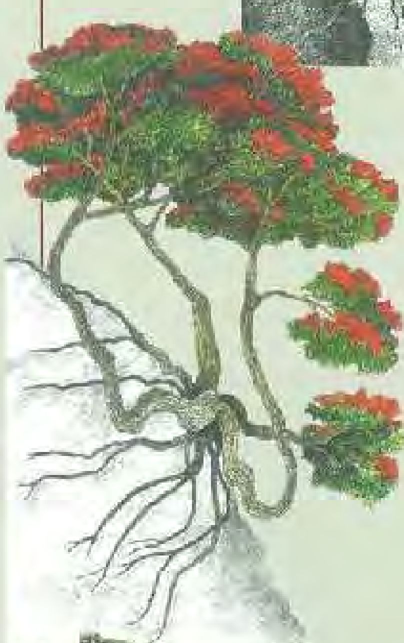
***"Pohutukawa is superbly adapted to northern coastal cliffs. It also ascends maritime gorges, often as hybrids with northern rata, and grows on lakeside cliffs on the Volcanic Plateau. The light seed can blow into any crevice, and the roots spread widely over rock faces, seeking fissures and pockets of soil. The canopy moulds to the wind and tolerates salt spray, and aerial roots descend from the trunks to provide further anchorage."*** *(Wardle 1991)*



## Pohutukawa rotating over the edge of cliffs and banks.

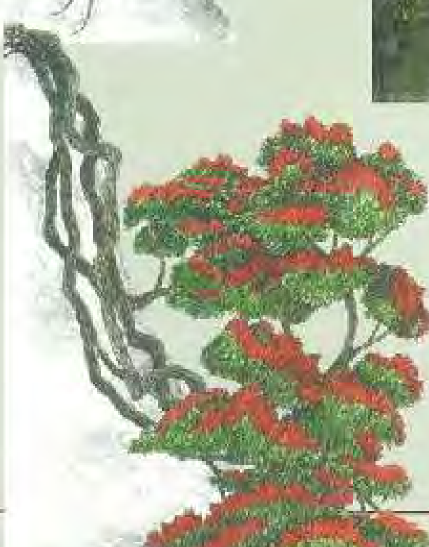
Over a period of decades or even hundreds of years, trees along cliff edges can bend or rotate over the cliff edge. Sometimes a cave develops beneath as large sprawling trunks slowly come to rest on the side of the cliff where adventitious roots take hold and begin to help support the tree. On less steep sections of coastal cliff, pohutukawa and other coastal species can occur from top to bottom. On lower cliffs where rock platforms have developed by wave action at near sea level, rotating pohutukawa can perch on the platform and with this additional support continue to thrive.

*Early stage of pohutukawa rotating over cliff.*



*Sometimes a cave may form under trees as the bank immediately beneath the root system erodes away.*

*Trees that rotate can sometimes come to rest on wave platforms which provide support and allow the tree to continue growing.*

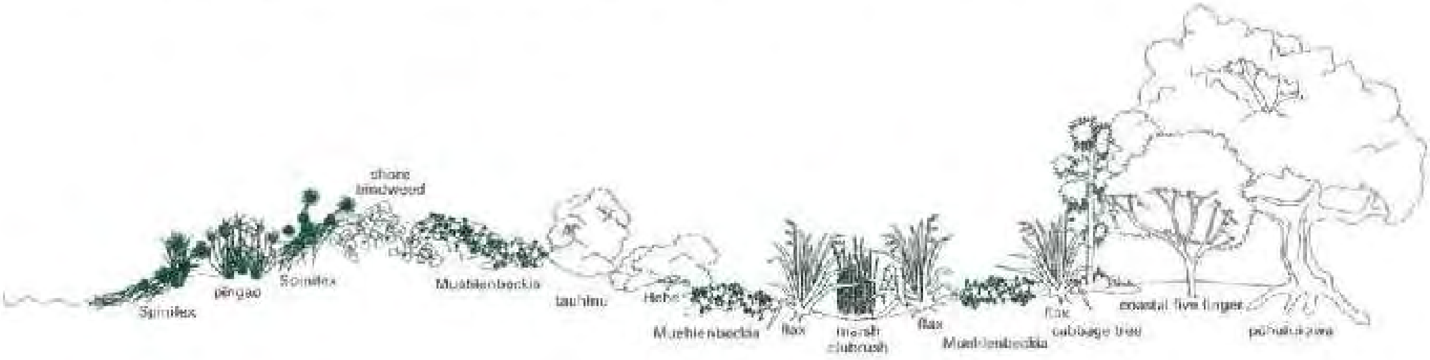


*Large roots that have been undermined and twisted and bent over the eroding cliff remain sufficiently anchored in the soil above to prevent this pohutukawa from falling down the cliff.*

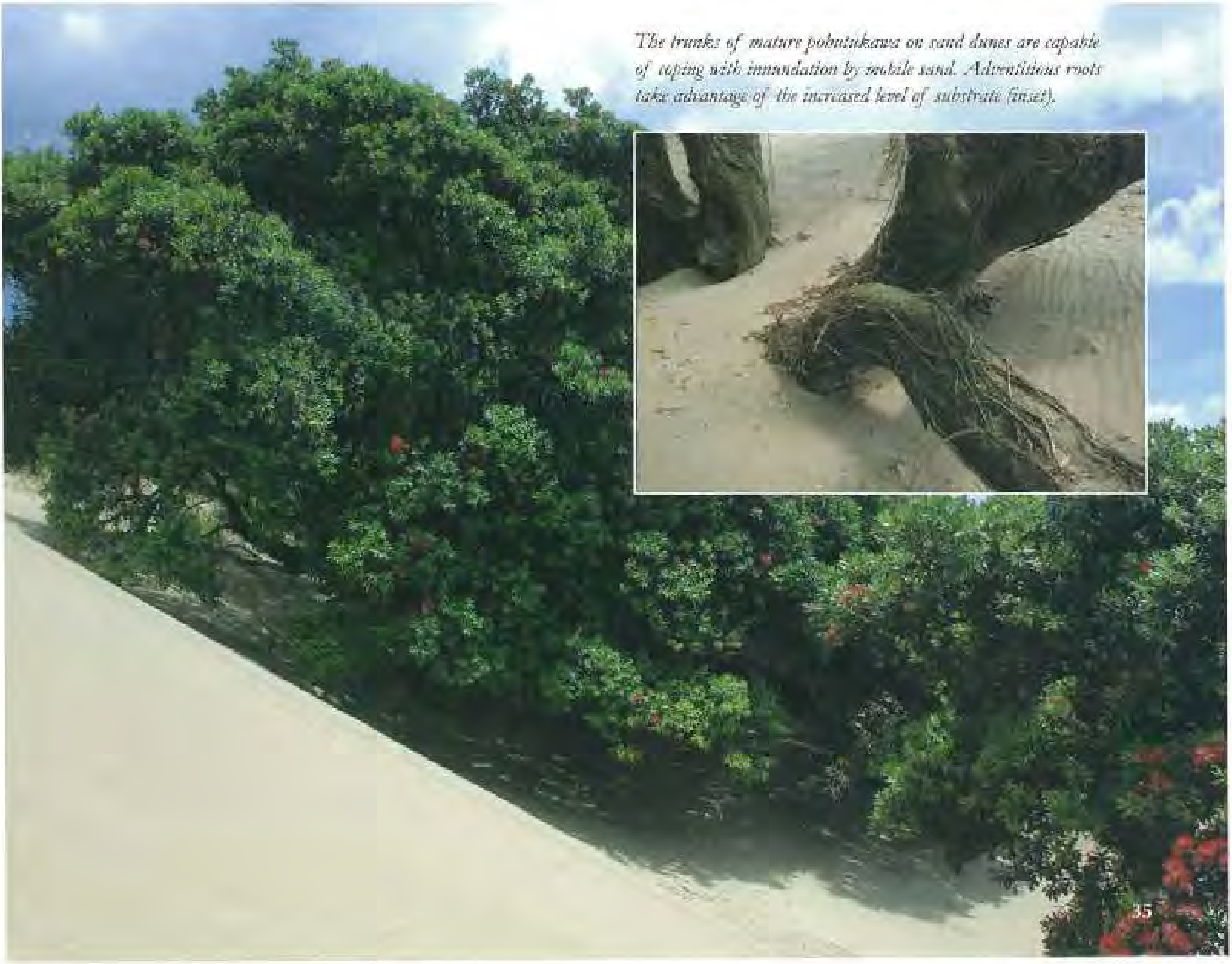
### *Sand dunes*

Pohutukawa are generally found growing on more inland parts of sand dunes where semi-stable sites and moist swales have allowed establishment of taller forest species. Once established, large pohutukawa can spread horizontally over the ground, and in some places their growth appears to have kept pace with sand accretion, their numerous branches merging to look like a group of trees rather than one individual.

In some instances, pohutukawa growing on sand dunes have initially established on driftwood, rock, or subsoil that was subsequently submerged by the moving dune to leave trees growing above raised sand levels. It has been occasionally observed regenerating on semi-stable dunes amongst spinifex, sometimes in association with driftwood. Similarly, since a reduction in grazing along East Coast beaches, pohutukawa is now found establishing amongst the masses of rotting driftwood found along these gravel beaches.




*Vegetation sequence for a sand dune with pohutukawa occurring on stabilised back dune sites (ARC Factsheet No. 2).*



*The trunks of mature pohutukawa on sand dunes are capable of coping with innundation by mobile sand. Adventitious roots take advantage of the increased level of substrate (inset).*

*Regeneration of pohutukawa on reshaped sand dune dominated by the native sand binding grass, spinifex, Wenderholm Regional Park, north of Auckland.*

*These extensive driftwood covered East Coast beaches can be havens for naturally regenerating pohutukawa seedlings*

### *Man-made structures and surfaces*

It is ironic that human activity, having been a major cause of the decline of the species, now provides some of the most suitable sites for establishment of pohutukawa seedlings. These include road cuttings associated with construction and re-alignment of coastal roads (Forest Research Institute 1989), exposed banks associated with tracks and other earthworks on farmland, as well as the many exposed high-light sites in urban areas dominated by paving.

There are many examples of pohutukawa establishing on a wide range of man-made surfaces such as rock walls, wooden piles and wharves, chimneys, and brick work of buildings and walls, and pavements. Seeds landing on rough surfaces germinate and roots of surviving plants exploit any crevices and cracks between bricks and stones where some moisture is present. Cracks in pavements made of stone, concrete, bitumen, or cobblestones are prime sites where pohutukawa seedlings can gain a foothold and, if left to develop, can distort and buckle roadways, footpaths, fences, and foundations of buildings.

*Mixed species coastal forest remnant on hill sides, East Coast, when pohutukawa is a significant component.*

## A diverse coastal forest

While there are many coastal plants with ecological characteristics to withstand strong winds, salt spray, and storms, on many sites it is the lone, sprawling, and twisting pohutukawa trees that may be all that remains of a once diverse coastal forest. However, there are some examples of remaining coastal forest that do exist on east and west coasts of northern New Zealand including off-shore islands, and occasionally some of these are extensive highly diverse stands.

The number of species associated with pohutukawa is often small because the sites on which it thrives are droughty, rocky, and exposed to salt-laden winds. However, pohutukawa frequently can dominate tall coastal bush containing kohekohe, taraire, karaka, tawapou, and puriri with ti kouka and titoki further inland. The trees form stands with an understorey of shrubs such as kawakawa, houpara, hangehange, and karo, and a ground cover of kakaha. On the borders of estuaries and inlets, pohutukawa merges with mangroves. On the shores of Rotorua lakes, the trees are associated with a wide variety of lowland broad-leaved species, especially tawa and rewarewa. In the Raukumara Range, hard beech descends some of the ridges and intermingles with pohutukawa.(Wardle 1991).

## Successional trends

The impact of pohutukawa on its environment can be observed on Rangitoto Island, where it becomes established in fissures in the black lava rock. The site is hot and dry and only drought-tolerant species can grow in the open. Pohutukawa forms low branches that spread from the central trunk. Shading by the extensive canopy of leaves reduces ground temperature. Fallen leaf litter decays forming humus that washes into rock crevices and absorbs and stores moisture. Birds, especially black-backed gulls, bring in seeds and plant nutrients. Soon other plants that would not otherwise survive can be seen to have become established beneath the pohutukawa.

From a long-running study of the major trends in forest successions in numerous northern offshore islands of New Zealand, Atkinson (2004) showed that pohutukawa not only colonises a wide range of sites after fires, but also can dominate forest succession for several centuries. He found that, compared with the other major seral species kanuka, pohutukawa retards the rate at which a diverse community can develop. The large size, long lifespan, and copious production of slowly decomposing litter of pohutukawa compared to other species have a strong influence on succession of other plants and animals.

Atkinson suggests this has implications for restoration programmes where most woody vegetation has been lost. Where pohutukawa is used as the major initial cover, plant and animal diversity will increase relatively slowly. Therefore, it is recommended that in addition to areas planted in pohutukawa, restoration goals should include establishment and maintenance of other habitats using a range of species.

## Associated animals

The abundant flowers attract a wide range of nectar-feeding birds, including tui and bellbird on parts of the mainland, and kaka and stitchbird on offshore islands. A large number of insects, most of them endemic, feed on the foliage, fruit, bark, and wood, as well as dead leaves and twigs in the litter layer beneath the tree canopy. These insects attract a range of insectivorous birds (J. Hutcheson and G. Hosking unpubl. data).

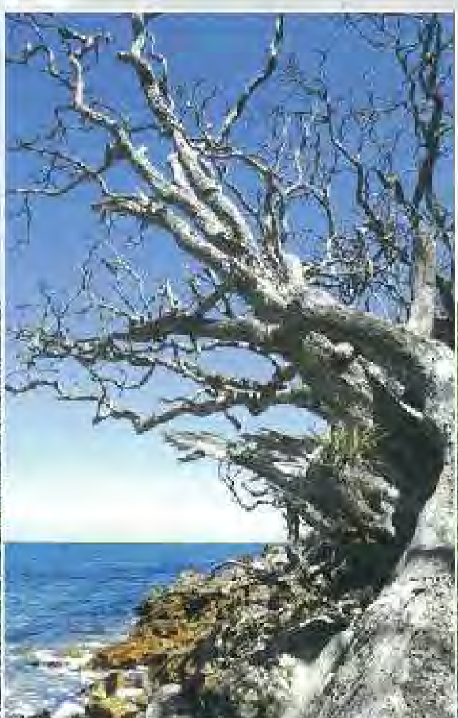
Geckos (common, Pacific, and Duvaucel's) visit pohutukawa flowers and were probably more common on the mainland before the introduction of predators. Shags and white herons roost and nest in pohutukawa lining the lakes, estuaries, and the coast close to their feeding grounds. Pollen present in short-tailed bat (pekapeka) guano provides evidence that pohutukawa may be a major source of nectar for this species even though feeding has not been observed (Simpson 1994).

**Possums**

Like all tree *Metrosideros* species in New Zealand, pohutukawa is at serious risk from the introduced brushtail possum. Pohutukawa damage by possums has been reported for several decades from many regions within its natural range (e.g., Forest and Bird 1969). Browsing of foliage by possums reduces tree growth, prevents flowering, and has been responsible for the death of large numbers of trees. Often where possum browsing occurs in tandem with unrestricted stock and vehicle access, pohutukawa forest is in danger of becoming locally extinct.

Possums not only consume large quantities of foliage but, more importantly, harvest the expanding buds in spring causing twig and branch dieback according to Hosking & Hutcheson (1993). They found that possums would consume all vegetative buds, although flower buds sustained only scattered damage. However, severely damaged trees seldom flowered. While newly flushed foliage is rarely browsed, possums return to the trees in winter, feed on mature foliage and appear to cause premature loss of damaged leaves.

Severe defoliation of mature pohutukawa can kill a tree in less than 2 years, and has led to the loss of thousands of trees of all ages along Northland's east coast over the past 20 years (Hosking & Hutcheson 1993). Pohutukawa is "possum ice cream" and in grassland, well-established runs can be seen linking individual trees. Trees in grassland or on the edge of pine plantations are particularly vulnerable, because of the lack of alternative food sources.



*Right: A recently dead pohutukawa which can result from just 2 years of intense possum browse.*

*Below: The grey skeletons of pohutukawa characteristic of trees killed by possums.*

*Foliage damage by possums is highly characteristic and easily separated from insect damage, primarily by the torn leaf blade and often protruding stripped midrib.*

*A distinctive growth form on the trunk of a pohutukawa that builds up as a result of persistent regrowth of epicormic shoots that are constantly being browsed by possums.*

## Tackling the pohutukawa health problem

By the late 1980s, an estimated 90% or more of pohutukawa stands had been eliminated by various agencies and the role of possums in the loss of pohutukawa had been highlighted for decades. Concern at the continuing dieback and loss of pohutukawa was gaining momentum with Government agencies and local communities and, in response, the Department of Conservation commissioned an assessment of the fragmented pohutukawa resource. An aerial survey of all coastal stands throughout the natural range of the species mapped and recorded canopy condition, and was followed by ground-based assessment of 190 key sites to determine the nature and cause of damage (Forest Research Institute 1989).

There were large differences in health between stands within a region, and even between adjacent trees in a stand. The typical symptoms of decline were foliage chewing by possums and insects, wilted new shoots and abscissed foliage, many bare twigs and branches, and a high proportion of dead twigs and fine branches. In the worst-affected areas, some trees were dead and many others appeared close to death, supporting virtually no foliage other than small epicormic shoots.

The study confirmed that remaining trees were under serious threat from a combination of animal browsing, human impact, and a shortage of suitable regeneration sites. This work led to the establishment of The Project Crimson Trust and a comprehensive research programme which included long-term monitoring of stand health, studies on the broad impact of possums on canopy damage and recovery, planting trials to revegetate slips and road cuttings, and replacement of damaged or lost trees.

*The exposed surfaces of cuttings and batters along coastal highways provide regeneration sites for pohutukawa where there is a local seed source.*

## Goats and domestic stock

Feral goats are the greatest impediment to the natural regeneration of pohutukawa in coastal reserves and shrublands. One study of pohutukawa health on the Coromandel Peninsula found that regeneration occurred only rarely, not only because of the presence of feral goats but also because of domestic cattle and sheep (Hosking & Hutcheson 1993). Fencing to exclude domestic stock is essential to allow establishment of planted seedlings or development of natural regeneration.

Uncontrolled movement of cattle and horses, including more than a century of cattle droving along coastal roads, has seen the large-scale removal of young pohutukawa plants from roadsides and the prevention of regeneration on the most accessible sites. The end of the major cattle drives around the North Island's East Coast as recently as the early 1990s has been associated with a dramatic re-establishment of pohutukawa along the coastal highway between East Cape and Opotiki (Hosking unpubl. data).

*Horses on a beach in the vicinity of pohutukawa. Grazing animals are still found roaming some of our beaches preventing regeneration.*

*Recovery of pohutukawa along the East Coast since cattle droving ceased.*

## Insects and disease

Like all trees, pohutukawa supports a community of insects and fungi, almost all indigenous to New Zealand, none of which cause any significant lasting impact on tree health. Young trees growing in rank grass may periodically be severely chewed by grass grubs but rapidly recover. Stick insects browse mature foliage. The tiny native weevil *Neomycta rubida* has an intimate relationship with its host. The larvae mine newly expanded leaves and the beetle browse on expanding buds, causing typical shot-hole damage once the leaves expand. Contrary to popular belief, *Neomycta* has no impact on tree health. Insect feeding on pohutukawa foliage is characterised by smooth edges, often not crossing the leaf midrib, compared with the tearing of possum feeding which leaves fibrous edges and often a protruding midrib.

Psyllids, which are sap-sucking insects, cause raised spots on leaves of young pohutukawa. Some nursery-raised seedlings and young plants can be heavily infected with these unsightly spots. Growth may be suppressed by severe infestation but plants seldom die.

A number of leaf fungi have been recorded from pohutukawa (Gadgil 2005) but the only fungus observed causing damage to pohutukawa foliage is an unidentified species of *Dothierella*, a wilt fungus that attacks newly flushed buds, particularly under warm wet conditions, but it has no significant impact on the host.

*Evidence of insect feeding on young foliage of pohutukawa (adult grassgrub pictured in inset).*

*Bud wilt and shoot dieback caused by a fungal infection on newly opened buds of pohutukawa.*

*Psyllids, which are sap-sucking insects, cause unattractive raised spots. While this blistering of leaves can be severe and may depress growth temporarily, it does not lead to mortality.*

## Insects get bad press!

Seasonal damage to foliage, particularly in young pohutukawa trees, can be spectacular. In certain seasons the wilting of newly flushed foliage is associated with an insect complex including a gall midge, caterpillar, and weevils. The native weevil *Neomycta rubida*, a close relative of the beech leaf-mining weevil, attacks and mines newly flushed leaves which are subsequently shed from the tree. Work on the decline of unthrifty pohutukawa has demonstrated the surge of insect activity associated with such change. With death and decay all around, it is therefore understandable that insects have such a miserable public image (Hosking 1993).

While insects feature strongly in the ecology of pohutukawa, from a tree health perspective, most damage is transient and seldom has a lasting impact on tree health. Insects are often restricted to narrow windows of opportunity where they have a temporary effect on a particular stage of foliage maturation. However, trees in decline can ill afford the cost of an insect and disease complex, particularly where most buds and much foliage are being lost to possums.

***"The threat to pohutukawa, far from originating from the highly visible insect fauna, has a more insidious character. It begins with the decimation of stands during the clearing of land for farming and proceeds by the prevention of regeneration by grazing of domestic and feral animals to direct damage, particularly during bud expansion, from uncontrolled possum populations. Despite our impassioned reply (to those suggesting insects cause as much damage as possums!) the visible damage creates the myth and generates an unnecessary broad spectrum chemical attack on the undeserving insect and its entire associated community, all to little effect."*** *(Hosking 1993).*

*Leaves showing characteristic* Neomycta *damage resulting from adult feeding on buds before opening. This tiny weevil is native to New Zealand and while severe damage might suppress growth, it alone does not lead to death of pohutukawa.*

### Internal decay fungi

The stem and branch rots of pohutukawa are not well documented, but as in most trees the dead heartwood is often attacked by wood-rotting fungi gaining entry through wounds, including those caused by pruning. A typical example is *Phellinus senex*, which causes white-pocket heart rot (Hood 1992; Gadgil 2005), the fruiting bodies of which are the large woody bracket fungi seen on logs and the dead parts of trees.

The relationship between heart rot and stem breakage is not well understood, but undoubtedly in advanced cases it does contribute to the collapse of major stems at stem unions as well as along limbs and trunks. In many trees, the collapsed stem will establish new roots and continue to grow as part of the spreading habit characteristic of aging pohutukawa.

*A number of decay fungi such as* Phellinus *sp. have been reported affecting mature pohutukawa and can result in collapse of a substantial cross-section of trunks that can lead to instability.*

### Cormorants (shags)

This group of native aquatic birds commonly utilises pohutukawa as roosting and nesting sites. Their gregarious nature leads to large colonies in individual trees on the coast and around the Rotorua lakes. Guano generated by these colonies coats branches and foliage of the affected trees, and leads to loss of foliage and occasional branch death. Although canopy thinning and the white guano coating can appear dramatic and threatening, most pohutukawa are relatively resistant and much of the outer canopy remains unaffected (Gillham 1960). Tree death is rare but it can occur where pohutukawa are heavily favoured as roosting sites. Occasionally herons also use pohutukawa for roosting but, unlike cormorants, generally in small numbers.

*Pohutukawa on the edge of estuaries or lakes can be favoured roosting sites for shags.*

### Rabbits

Esler (1978) found that rabbits have influenced vegetation succession on two of the highly modified small offshore islands off the west coast of Coromandel Peninsula. He observed that where selective browsing by rabbits has removed most of the competitors of pohutukawa, dense stands of young pohutukawa have developed.

### Exposure

Salt spray and wind have sometimes been invoked to explain widespread dieback of coastal pohutukawa. However, despite the severity of the coastal environment, damage to pohutukawa trees from storms is uncommon, even where trees are exposed to spray. Storms frequently cover these trees in salt but, even after the worst gales, breakage is rare (Forest Research Institute 1989). Rarely, prolonged severe onshore winds have been known to defoliate pohutukawa, and sculpturing of tree crowns can occur on exposed coastal sites (Gerald Collett, pers. comm.).

*Although pohutukawa are very tolerant of the coastal environment, dieback on extremely exposed sites or as a result of particularly severe gales can occur. Remnant trees, left after other forest vegetation has been removed, can be especially vulnerable.*

*Right: Mature pohutukawa trees killed by a grass fire which left scorched trunks.*

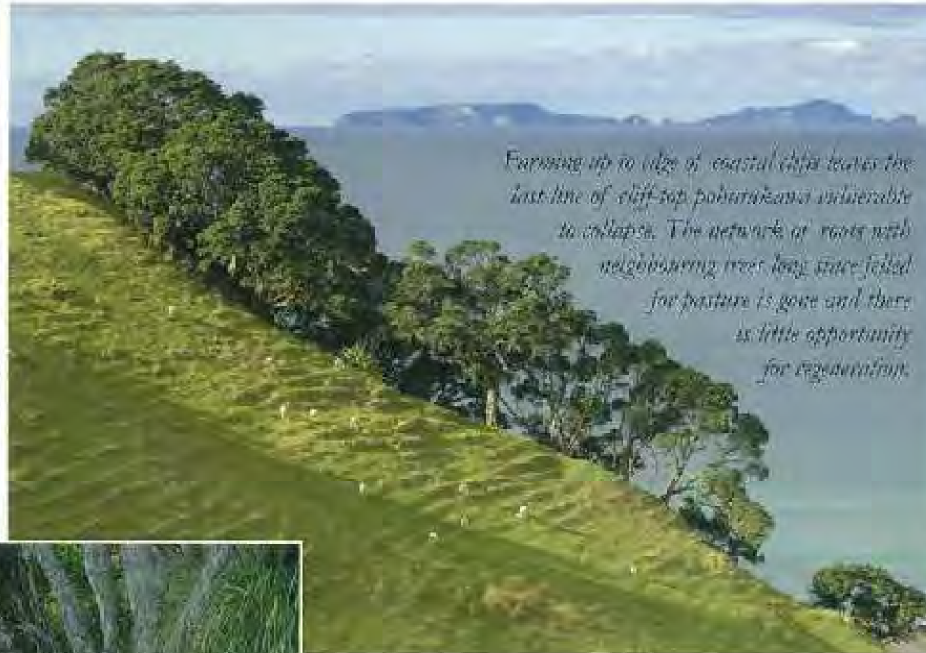
## Human impact

Human activity has historically had the greatest impact on pohutukawa. As settlement and development have concentrated along the coastal fringe and along lake edges, large-scale destruction of pohutukawa forest has occurred. Human population pressure on coastal sites with pohutukawa continues today, particularly in urban areas where growth has seen trees removed to make way for building and development.

The historical use of fire in land clearing was responsible for the loss of much of the coastal forest. Fire is anathema to mature pohutukawa; even a light grass fire escaped from a barbecue at the base of a tree can lead to death. Unfortunately, fire has always been the primary tool used by Maori and European settlers to clear land for farming. As a result, pohutukawa has been virtually eliminated from areas which lack refuges from burning, such as the sand dune areas of the west coast. In such areas, the seed needed for regeneration has disappeared with the last trees (Forest Research Institute 1989).

The dense wood of pohutukawa, which has a relatively low moisture content, burns readily – possibly aided by a high concentration of flammable chemicals (Simpson 2005). The bark of pohutukawa is dry and flaky and also burns readily. The leaves contain flammable essential oils and form a dry and brittle litter, tending to exclude more moist green plants from growing beneath it. These characteristics, and the fact that it inhabits an often windy coastal environment, leave pohutukawa vulnerable to fire despite its strong ability to coppice.

Loss of pohutukawa to development continues, with trees still being removed for new buildings, for improving views, for road widening, and for accommodating landscape designs that exclude pohutukawa. In high-use areas, the exposed tree roots designed for spreading over rock surfaces are easily damaged by trampling or by vehicle use, and unfenced pohutukawa are damaged by grazing stock.



*Farming up to edge of coastal cliffs leaves the last line of cliff-top pohutukawa vulnerable to collapse. The network of roots with neighbouring trees long since felled for pasture is gone and there is little opportunity for regeneration.*

*Above: The highly used Mount Maunganui reserve (Mauao) is subjected to occasional fire and many mature pohutukawa have been lost. Replanting with a range of natives including pohutukawa is being undertaken by the local councils and community groups.*

*Right: Even camp fires on beaches where live pohutukawa roots occur have been implicated in death of mature pohutukawa.*

*Houses are often built within a few metres of the edge of cliffs where only a single line of pohutukawa remain. In some instances, cracks in lawns open and close as trees are buffeted during high winds, indicating possible future failure.*

*While some pohutukawa inevitably will fall off cliffs, human modification such as inappropriate drainage is likely to be contributing to many failures during high intensity rain storms.*

*Collapse of cliff and loss of pohutukawa adjacent to cliff top development.*

*Realignment and widening of coastal roads can expose root systems and leave pohutukawa on edges of cuttings unstable.*

## Plant pests

A wide range of exotic plant weeds exists within the warm temperate zone of northern coastal New Zealand, coinciding with the natural range of pohutukawa. While few other tree species can inhabit the exposed rocky coasts where pohutukawa often maintains dominance, there are many less exposed coastal sites where vigorous herbaceous plants and grasses prevent establishment of pohutukawa. Dense vigorous kikuyu grass can prevent regeneration of pohutukawa on previously cleared sites.

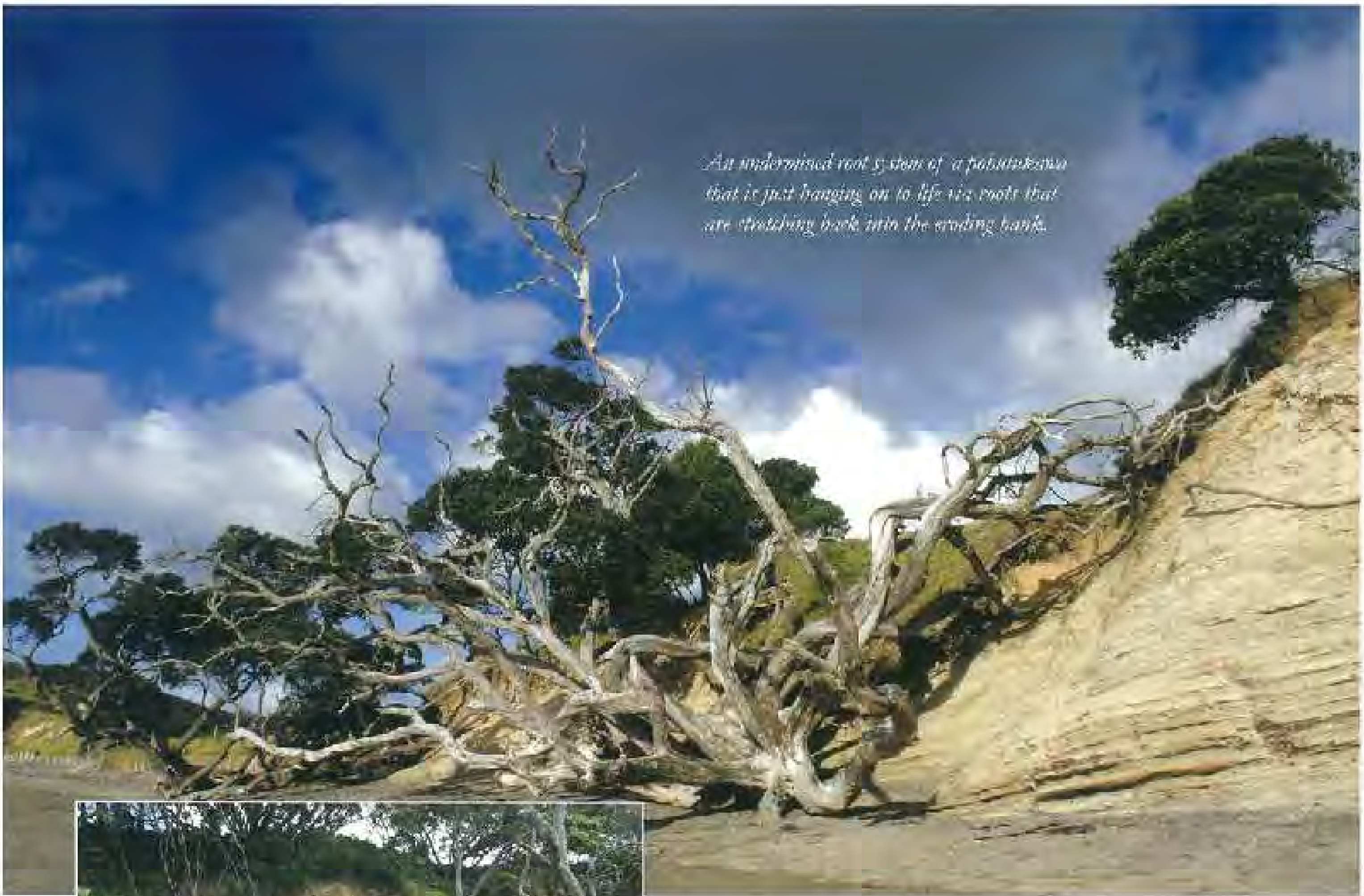
Similarly, woody or scrambling exotic plant species have the potential to compete with establishing pohutukawa. Many species such as eleagnus, Japanese honeysuckle, blue morning glory, German ivy, and jasmine, some of which can climb into the crown of established pohutukawa shrouding the canopy, have the potential to severely destabilise or even kill the tree.

Buckthorn and pampas are among exotic species that are threatening re-establishment of pohutukawa on off-shore islands (Mike Wilcox, pers. comm.). Various pine and wattle species can often come to dominate fresh slip faces near the coast that are key sites for natural establishment of pohutukawa.

## Volcanicity

Pohutukawa characteristically establishes well as a coloniser on primary surfaces such as recent volcanic ash and coastal cliffs prone to continual erosion, and it is not surprising that it is vulnerable to disturbance or destruction from time to time. Volcanic activity has damaged or destroyed at least 20 000 ha of indigenous vegetation in the North Island over the last 450 years (Clarkson 1991). Eruptions in the 1970s and 1980s saw the decline of more than two-thirds of the pohutukawa forest and scrub on White Island (Whakaari) (Clarkson and Clarkson 1994). The most probable causes of death of pohutukawa were toxic fumes, wet ash coating leaves, and "acid rain". This forest has almost certainly waxed and waned in response to many centuries of periodic volcanic disturbance, and typically the age of pohutukawa here rarely exceeds 70–100 years.

*Kikuyu grass can grow up to a metre high preventing regeneration of many coastal native species including pohutukawa. There is little chance that pohutukawa will naturally regenerate in the dense kikuyu grass that dominates this Northland coastal site despite the nearby source of seed.*



*An undermined root system of a pohutukawa that is just hanging on to life via roots that are stretching back into the eroding bank.*

*Pohutukawa-dominated bank undermined by high seas has collapsed on to the beach.*

## Coastal erosion

As a coloniser of coastal sites, it is not surprising that pohutukawa is subjected to the destructive forces of the sea and climate along the shoreline. Simpson (2005) argues that the southern limit of pohutukawa may have retreated northward on both the east and the west coasts due to erosion of mudstone bluffs. Near Wai-iti in the northern Taranaki, mudstone cliffs are collapsing piece by piece into the sea with loss of 200-year-old pohutukawa.

While pohutukawa are able to inhabit erosion-prone sites for centuries, there are inevitably examples of pohutukawa succumbing eventually to the erosive forces on coastal sites throughout its natural range. These include occasional spectacular collapses of banks and cliffs which have been slowly undermined by wave erosion and finally give way, resulting in large old pohutukawa falling into the sea. Often cliff collapse has been exacerbated by development landward of the coastal margin.

For large trees established just above sea level, landward movement of the shoreline can expose massive root systems of large pohutukawa which may hang on tenuously to life with roots clinging to eroding banks. Inevitably, shoreline retreat will see the death of large pohutukawa as the last of the roots are exposed by constant wave action, with trees often ending up as skeletons on the beach.

*When these pohutukawa undermined by the sea finally die, arborist Gerald Collett sometimes refers to these skeletons of large pohutukawa as "the walking dead".*

## Collection of seed

Collection of large quantities of pohutukawa seed is relatively easy. Use of trees along the coastal margin should lessen the risk of propagation of hybrids since northern rata usually grows further inland. In order to preserve local genetic integrity, seed should be collected from a minimum of 10 trees with a minimum distance of 100 m between individuals (Bergin and Gea 2005).

Seed is usually mature by March-April, and most of it is released over a period of 2–3 weeks. Collection can begin as soon as a major proportion of the capsules on lower branches are found to be open or partially open.

Seed should be collected when the weather is dry. A paper bag is held over a cluster of partially or fully open capsules while the branch is shaken vigorously. This dislodges thousands of seeds. Alternatively, ripe and partially open capsules can be gently removed and dropped directly into the bag. Dark brown capsules persisting from the previous year do not contain seed and should be rejected. Paper bags allow moisture to disperse whereas plastic bags accumulate moisture and should be avoided, unless they can be stored under cool conditions immediately after collection.

## Storage of seed

Mature capsules hold a mixture of filled seeds, each containing an embryo, and non-viable seeds. Schmidt-Adam *et al.* (2002) reported germination rates of 99% for filled seed immediately after harvesting and 90%+ after 1 year of storage at 1°C. Storage at room temperature resulted in rates lower than 60% after 6 months and 0% after 1 year.

Seeds of pohutukawa are very small and contain few nutrients. They should be sown as soon as possible after collection. Long-term storage should be avoided, but viability can be prolonged by using airtight containers kept in a refrigerator.

*Split seed capsules of pohutukawa and a mass of tiny seeds.*

*Large numbers of pohutukawa seed can be collected by shaking lower branches to dislodge seed into collection containers beneath or by carefully cutting clusters of capsules containing seed. Paper bags that keep seed dry are preferred to plastic bags.*

*These capsules are full of seed which is about to be released.*

*Do not collect the empty dark brown seed capsules that sometimes persist on trees from last year*

## Raising of seedlings

Only seed collected in the current year should be used. Large quantities of seedlings can be produced if standard nursery techniques are used. Some skill is needed to ensure that the plants will be robust and that root systems are not distorted.

Recently collected seed is scattered thinly and evenly over a standard seed-raising mix contained in a seed tray, covered with a thin layer of sieved seed-raising mix, and lightly watered. Humidity is maintained by placing elevated sheets of plastic and newspaper over the trays, which are kept in a greenhouse. Heating may be necessary in colder regions to encourage faster germination.

Under temperatures of approximately 20°C, germination begins after about 7 days. Paper and plastic covers are then removed, but the newly germinated seedlings must be kept moist and sheltered from wind, direct sun, and frost.

Size of seedlings is governed by many factors including the season in which germination takes place. Self-fertilised seed produces plants that grow more slowly in the early stages (Schmidt-Adam *et al.* 2000). Seedlings from cross-pollinated seed will be approximately 5 cm tall after 3 months, and will have two fully extended cotyledons. Once sufficient quantities of seedlings 5–10 cm tall have been transplanted, the remainder should be discarded in order to avoid propagation of weaker material.

Seedlings are transferred (pricked out) into small containers or propagation cells with a diameter of approximately 5 cm, filled with a standard potting mixture. It is essential that the dibble hole is deep enough to accommodate the relatively long root system. Firming with a sideways motion avoids forcing and bending of the roots. Subsequent growth in a shade house will be influenced by season, local climate, and the availability of artificial heating. Under sheltered warm conditions, plants will be 15–20 cm high within a year. They can then be transplanted into their final containers. Any distorted roots should be trimmed as the plants are repotted.

*Seed is broadcast sown over a seed tray.*

*Newly germinated seedlings of pohutukawa in a seed tray*

*Transplanting of seedlings from the seed tray to the first container*

Final containers are usually PB2 or PB3 polythene bags that are at least 10–15 cm diameter and 15 cm high. Small pots inhibit the expansion of plant tops and can cause spindly shoot growth. No special treatment is required at this stage apart from protection from frost. In colder areas, growth will be enhanced if plants are kept in greenhouses. They are hardened-off by being placed outside for several months before transfer to the planting site. In most nurseries a plant height of at least 40 cm is achieved within 2 years.

## Raising plants from cuttings

Plants can be grown from cuttings if specific attributes of a parent tree are to be retained. Raising plants from cuttings is a highly specialised and time-consuming process; it is not practical for large-scale plant production and not recommended for revegetation programmes where genetic variablity should be maintained. Specialist nurseries using bottom heat in glasshouses may grow pohutukawa from semi-hardwood cuttings taken in winter.

*Seedlings of pohutukawa and a range of other native trees and shrubs raised in containers in a community nursery at Kawhia.*

*Large-scale production of pohutukawa seedlings at the Naturally Native New Zealand Plants nursery, Whakatane, pictured above and the Horizons 2 nursery at Te Teko, pictured below. Most pohutukawa are raised in PB3 polythene planter bags for large-scale revegetation projects. Seedlings are raised for 2 years to a planting height of at least 40 cm.*

*Left: Large pohutukawa can be raised in bigger containers such as these in PB5 polythene planter bags at a community nursery in Kawhia*

# PART 8 – PLANTING OUT

Pohutukawa was one of a number of native tree species planted by early Maori within its natural range and also elsewhere in the country. Pohutukawa also appealed to early European settlers who planted it during the 1800s in many coastal regions throughout New Zealand (Burstall and Sale 1984). During the last two decades, encouraged by The Project Crimson Trust, local community groups, landowners, and land management agencies have been planting pohutukawa within the area of its natural range. Many thousands of nursery raised seedlings have been established successfully, but poor survival and growth have sometimes been observed.

General techniques for planting and early management of native trees and shrubs outlined by Bergin and Gea (2005) can for the most part be applied to pohutukawa. There has been only limited experimental work specifically on establishment of pohutukawa, but considerable experience has been gained from large-scale planting programmes, including information on selection of appropriate planting sites and substrate types, provision of shelter, and weed control.

## Planting sites

Although pohutukawa is a natural coloniser of cliffs and rocky areas, the planting of such sites is difficult. Natural regeneration from local seed sources is more likely to produce good results, provided that possums, fire, and other human-induced disturbances are eliminated. Planting will be more successful on banks, backdunes, and the edges of estuaries, and on modified coastal and lowland sites such as street borders, parks, and gardens.

Pohutukawa prefers a well-drained soil that does not dry out completely. It is a light-demanding species, and open sites encourage good growth. On the other hand, young plants are susceptible to desiccation and frost damage which may occur in exposed locations.

*Pohutukawa are being successfully established on a large scale around parts of the Whaingaroa Harbour (Raglan) and will form stands within only a few years. These extensive riparian sites have been retired from farmland to improve water quality in the harbour.*

*Planting rocky shores is not practical. Natural regeneration is likely to produce adequate numbers of pohutukawa on such sites provided there is a local seed source and the effects of human-induced factors such as possums and fire are minimised.*

## Beware that pohutukawa grow big!

As pohutukawa will eventually become large spreading trees, planting positions must be selected carefully, especially in developed areas. Loss of views and, in the long term, risk of failure of large stems near buildings and heavily used areas such as play grounds and carparks, are significant issues for town planners and arborists.

A pragmatic approach may be warranted in densely developed areas. Planting a suite of coastal native trees and shrubs including pohutukawa provides opportunities for revegetation of coastal sites. Smaller shrubs such as karo, harakeke, and taupata are often more suitably planted where lines of view are important and pohutukawa and other taller coastal trees are planted either side of view lines.

### Managing for views and shade

From an early age, planted pohutukawa can be trimmed and pruned carefully to maintain views and to avoid development of stems that may be at risk of sudden failure. Early planning and management will then allow for pohutukawa in densely built-up areas. Young planted trees on foreshores are successfully trimmed to allow views through lower limbs or provide windows of view through the canopy. Pohutukawa is amenable to pruning of lower branches to leave a high canopy of foliage. Trees planted along beaches are ideal for providing low maintenance shelter and shade for beach users while contributing to local biodiversity. Provision of shade is likely to become more important for beach goers with increasing concern about prolonged exposure to the sun and increasing levels of skin cancers.

*This tree has been pruned from an early age to allow a view of the seascape beyond.*

*As pohutukawa grow into large trees and live for several centuries, some forethought is required at planting time on the long-term consequences for the site.*

*This pohutukawa planted landward of a community planting of native sand binders has been pruned and provides beach users with shade.*

## Planting trials

The results of research trials are providing information that can assist in the selection of appropriate sites and methods for planting pohutukawa.

### *Whitianga*

Environment Waikato, the Whitianga Beach Care Group, and Forest Research scientists established a collaborative trial at Buffalo Beach on the Coromandel Peninsula. The site was a modified backdune area. Early survival and growth of pohutukawa were considered unsatisfactory (Bergin and Herbert 1997) but many of the plants that had been supplied as pohutukawa were found to be hybrids with northern rata. Unseasonal frosts and onshore winds contributed to establishment failure. Pohutukawa benefited from side shelter provided by shadecloth fences, particularly when planted on the most seaward zones tested. Provision of shelter to boost early growth and survival of pohutukawa planted on the less exposed, more inland sites was not as critical as on exposed seaward sites.

*Pohutukawa planted in this backdune trial at Whitianga, Coromandel Peninsula, are growing better on landward sites or with shelter on exposed seaward sites.*

### *Awhitu Peninsula*

A very exposed and elevated sand dune site on the Awhitu Peninsula was planted with a range of native coastal tree and shrub species, including pohutukawa. Existing vegetation consisted of dense kikuyu grass, recently planted marram grass, and older dense marram grass. The exotic marram grass had been planted as a sand binding species to increase the initial stability of mobile sand, especially landward of the foredune on exposed coastal sites (Gadgil 2002).

Performance of pohutukawa was best where dense marram grass, up to 1 m in height, provided shelter. All of the planted species grew poorly on exposed open sites. Growth was best where cleared planting spaces were small, but the grass had to be controlled to prevent overtopping of pohutukawa during the first 3–5 years. Six years after planting, survival of harakeke, karo, ngaio, and pohutukawa was 70–90% where surrounded by dense marram. Height of trees and shrubs was in excess of 2 m.

*David Craig of the Awhitu Peninsula Landcare Group planting a pohutukawa within dense marram grass. While the dense grass cover provides shelter for improved early growth, grass must be kept from overtopping them over the first few years after planting.*

*Left: This very exposed west coast site at Awhitu Peninsula near Auckland was planted with a range of native trees and shrubs including pohutukawa six years ago. Best initial growth was in small gaps within dense grass cover that provided some shelter. The group planting of a mixture of species is now providing mutual protection for continued growth.*

## *Eastern Bay of Plenty*

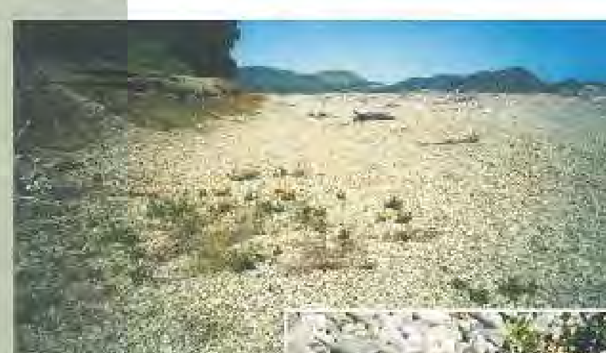
A survey of major plantings of pohutukawa along the eastern Bay of Plenty coast revealed that survival was poor and canopy cover growth was slow, particularly where seedlings had been planted on exposed sand or gravel beaches. First-year survival was best (80%) on ash-derived soils at Ohiwa; much poorer (less than 40%) on sand dunes at Snells Beach; and even more unsatisfactory (20%) on shingle at Torere. Application of slow release fertiliser at time of planting had no effect, but growth appeared to have been improved where compost or soil had been placed in the planting holes.



Survival (upper) and growth of foliage cover (lower) of pohutukawa within 12 months of planting at Ohiwa (ash-derived soil), Snells Beach (sand dunes), and Torere (shingle beach). Values with the same letter are not significantly different ($p>0.05$).

Results confirmed that high mortality and poor growth of planted pohutukawa were associated with sand dune and shingle sites. Drought and exposure were considered to be the main inhibitory factors.

*Trials on the East Coast comparing soil, sand, and shingle sites show that pohutukawa performance was best on soil. Addition of soil or compost at planting time improved growth and survival of pohutukawa on sand and shingle sites.*



## Driftwood

Substrate type is clearly an important factor in plant establishment. Of particular interest is the observation that pohutukawa seedlings develop naturally on rotting driftwood lying on sandy and shingle beaches along parts of the eastern Bay of Plenty. This has also been found on the eastern beaches of Auckland, although some regeneration of pohutukawa directly on sand has also been observed (Barry Green, Senior Park Ranger, ARC, pers. comm.).

On the East Coast, pohutukawa are growing well amongst piles of driftwood where cattle and horses do not have access to beaches. Planting nursery-raised pohutukawa as either small plugs of seedlings less than 10 cm tall or larger container-raised stock directly into rotting driftwood gave better early survival and growth than planting directly into sand or shingle. The rotting wood is likely to be a source of moisture and possibly of nutrients. The planting of pohutukawa within rotting driftwood or inclusion of rotting driftwood in planting pits may improve survival and growth in drought-prone areas.

*Plugs of tiny pohutukawa seedlings raised in the nursery and planted in rotting driftwood have high survivals 1 year after planting and are easier to find (left) than seedlings planted on adjacent shingle sites without any organic material (right).*

*Similarly, larger seedlings planted directly into rotting driftwood have established well compared to planting directly into shingle or sand.*

## Shelter

Side shelter assists the establishment of young plants which at this stage are vulnerable to wind damage and desiccation. Shadecloth screens can be provided for individuals or small groups of trees, but these are not practical or cost-effective in larger-scale planting programmes.

The Auckland Regional Council (ARC) has obtained good results on open sites by planting a range of native coastal species with pohutukawa (Barry Green, pers. comm.), sometimes referred to as nurse species or companion planting. Shrub and tree hardwoods such as taupata, houpara, karo, harakeke, ti kouka, ngaio, and tauhinu, which all occur throughout the natural range of pohutukawa, are planted at 1- to 2-m spacing in small groups or larger clusters. Where pohutukawa is interplanted within this nurse cover at a wider spacing of 5–10 m survival and growth are often improved, especially on exposed coastal sites.

*Pohutukawa within a cluster of other planted native coastal species at Wenderholm Regional Park north of Auckland are benefiting from the shelter.*

*Pohutukawa is a favourite tree for planting in streets and city parks and gardens. These specimen trees are raised for several years in nurseries in large containers and planted out up to 2 m tall, often with stakes or other support structures to provide initial support and protection*

## Plant size

The choice of seedling size is dependent on a range of factors including site characteristics such as degree of exposure, the weed species and animal pests present, the size of the planting programme, and the resources and commitment to after-planting care (Bergin and Gea 2005). In general, well-conditioned seedlings of pohutukawa that are at least 40 cm high are likely to give best results in large-scale planting programmes. Smaller plants will require more weed control and may be more vulnerable to browsing by rabbits and possums. Costs involved in raising plants from seed and in transporting them to the planting site are major considerations in any planting programme. Most of the larger revegetation programmes involve the planting of pohutukawa seedlings that are 40–50 cm high raised in PB2 or PB3 polythene planter bags (approximately 12–15 cm diameter and 15 cm high), container types that are commonly used in native plant nurseries.

For planting along urban roads, Auckland City Council (ACC) and North Shore City Council use tall trees, 1.8–2 m in height, raised in large containers such as PB60 up to PB95 polythene planter bags, container sizes equivalent to 10- to 20-litre buckets. These are planted by skilled Parks Unit staff or arboricultural contractors after careful site preparation. The trees are supported with stakes, and high survival rates and fast early growth are achieved (Howell Davies, Arborist, ACC, pers. comm.). Pohutukawa plants raised in larger numbers for city parks are grown in containers such as PB5 up to PB12 to a height of 1 m.

## Stable tree form

Pohutukawa can have significant differences in tree form and, in the longer term, differences in stem and branch stability. In particular, the union between stems can have an impact on whether they may be predisposed to failure in the long term. Stem unions most likely to fail can often be identified from an early age by an elongated split at the junction.

Where pohutukawa is to be planted in high-use areas or near buildings and roads, seedlings that are predisposed to forming a well-structured tree are more desirable. Alternatively, early intervention through form pruning can ensure the development of an appropriate tree form.

*Nursery stock showing single-stemmed vs multi-stemmed seedlings*

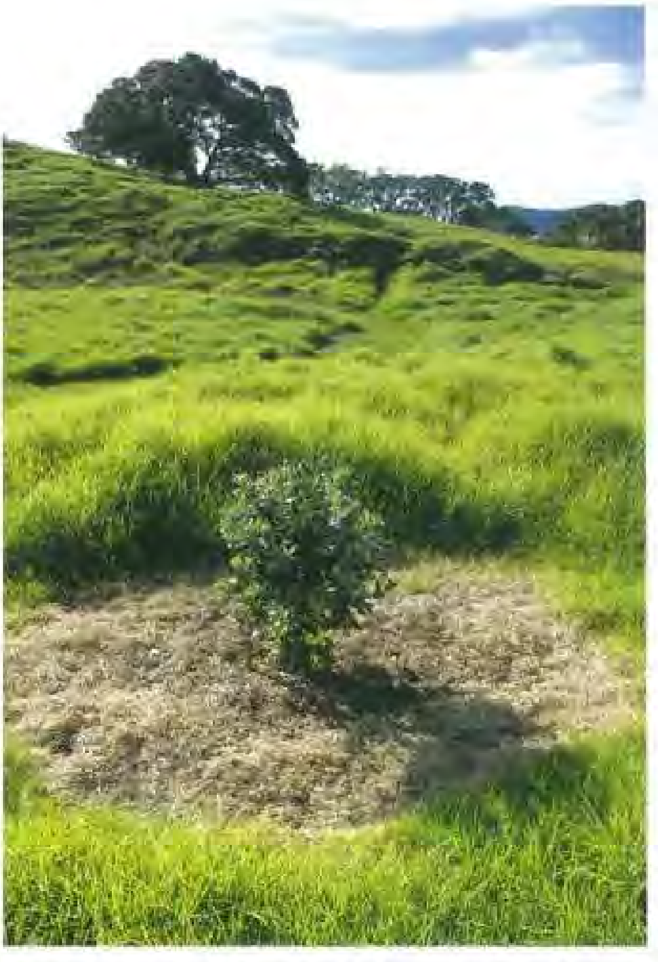
## Weed control

One of the biggest threats to newly planted pohutukawa is competition from faster-growing vegetation. Kikuyu, a dominant grass in many northern coastal sites, can overtop young pohutukawa plants within months. Site preparation by spot- or blanket-spraying with a herbicide such as glyphosate before planting is unlikely to give long-term control unless further spraying is carried out within 3 months of planting and repeated as necessary until the pohutukawa is more than 1 m high. Hand-clearing or mowing of competing grass, however, is practicable only in relatively small-scale planting programmes.

Small pohutukawa plants, especially if growing slowly on a difficult site or suppressed by surrounding weeds, will have numerous new shoots coppicing from the base and red-coloured aerial roots that may grow through surrounding grass. Care is therefore required in spraying around such plants to ensure that herbicide does not come in contact with lower shoots and aerial roots. Hand clearing of dense grass immediately around the base of seedlings is prudent before knapsack spraying of a wider circle around each seedling. Once trees are above grass competition, further herbicide spraying of surrounding vegetation is not necessary.

The light-demanding pohutukawa will not tolerate overtopping by adjacent competing trees and shrubs. Pohutukawa planted within dense woody vegetation will require hand clearing to maintain a "light well" above.

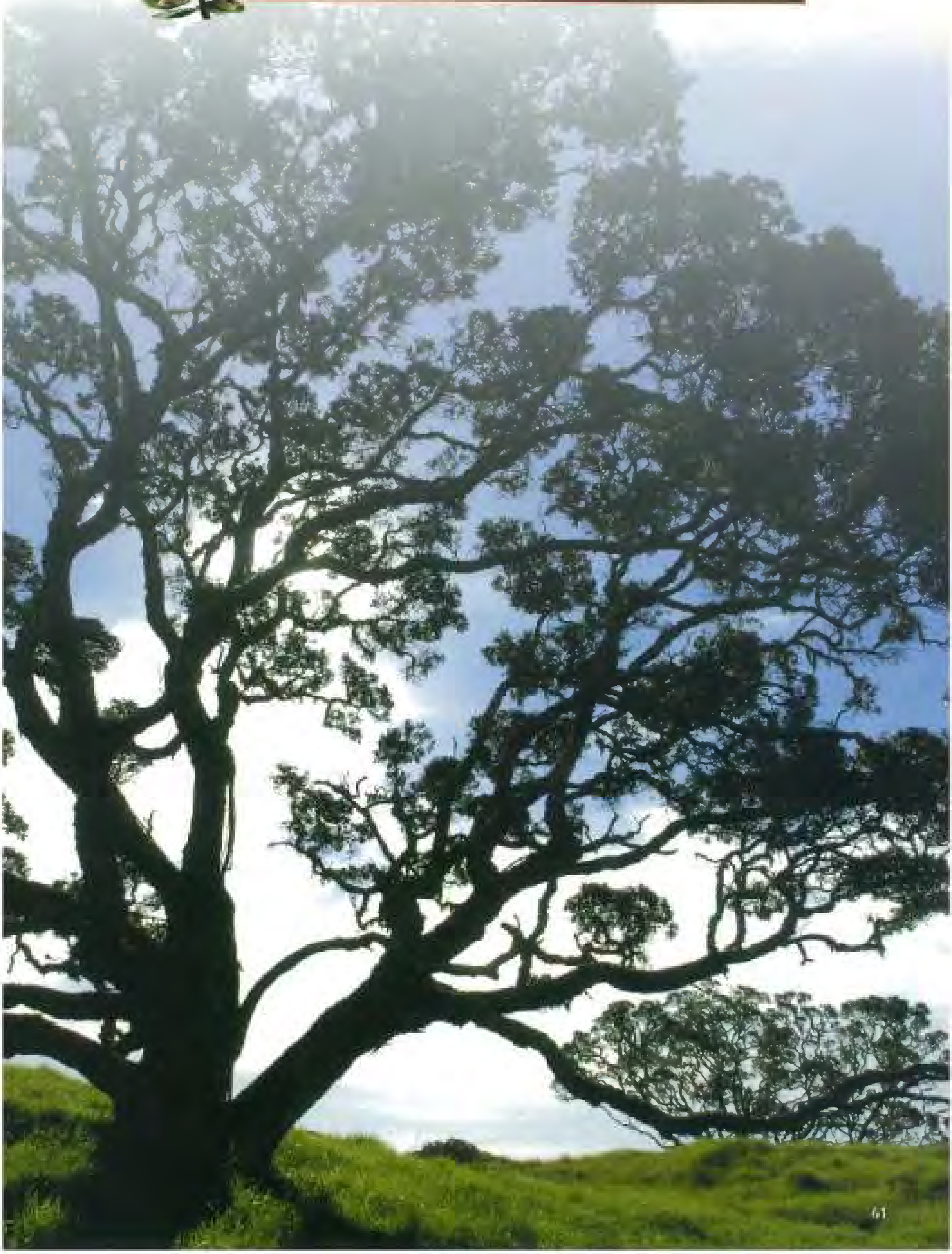
*Planting of pohutukawa in dense grass cover without using herbicides is practical on a small scale where the tall grass can give some degree of early shelter. Regular maintenance is essential to ensure that light demanding pohutukawa are not overtopped by surrounding grass.*



*Planted pohutukawa seedling where kikuyu grass has been kept clear by spraying with herbicide.*

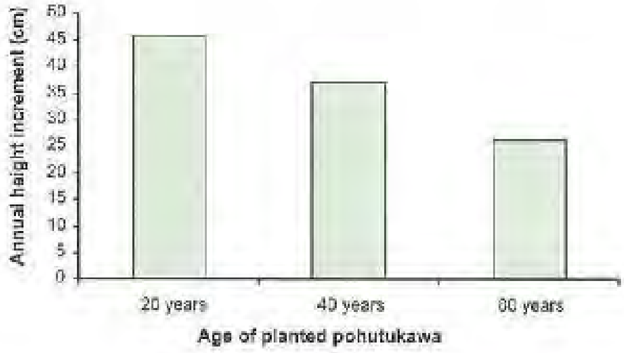
*Lack of weed control is one of biggest threats to successful establishment of pohutukawa on many coastal sites. Small planted pohutukawa can become overtopped in vigorous exotic grass growth within 3 months of planting. Good weed control shown here ensures high survival rates and good growth.*

# PART 9 – TREE GROWTH, WOOD QUALITY AND USE



## Growth rates

Development of 14 stands of pohutukawa planted in small groves or as individuals was assessed by Pardy *et al.* (1992) who reported that height growth rates decreased over time. Mean annual height increment was 45 cm at 20 years but slowed to only 25 cm annually by age 80 years.




In a survey of 14 planted pohutukawa stands throughout mostly the northern North Island, annual height growth rate was found to decrease as the stands became older.

Mean annual diameter increment (MAI) was 9.7 mm. Of 39 native species planted at 55 sites throughout the country, pohutukawa showed some of the fastest growth. On average, planted pohutukawa was found to take 50 years to reach a height of almost 20 m and a mean stem diameter approaching 50 cm. Many of these pohutukawa were planted on sheltered lowland sites in managed parks and gardens, providing ideal growing conditions.

Individually planted trees grow rapidly, even when they are some distance south of the natural range of the species. Their spreading habit often restricts height growth as arching multiple stems slowly subside with increasing weight. Quantification of diameter growth is difficult where there are multiple stems, some of which are very large. Approximate growth rates of a small selection of pohutukawa planted over 100 years ago indicate annual height increments of 13–18 cm and annual diameter increments of 1–2 cm.

| Location | Approximate age (years) | Height (m) | Height MAI (cm) | Diameter (cm) | Diameter MAI (cm) |
|---|---|---|---|---|---|
| Lower Hutt | 150 | 20 | 13 | 240 | 1.6 |
| New Plymouth | 110 | 20 | 18 | 200 | 1.8 |
| Thames | 135 | 18 | 13 | 181 | 1.3 |
| Thames | 135 | 18 | 13 | 120 | 0.9 |

Growth rates of individual planted pohutukawa in several districts.

Growth rates estimated for a limited number of natural pohutukawa appear to be somewhat slower. Longevity of natural pohutukawa varies with site. Along the north Taranaki coast it can be 200 years; observations on several islands off the Auckland and Northland coast indicate that individual pohutukawa can live for 300 years or more (Atkinson 2004), while on terraces slightly inland from the East Cape coast it may be more than 500 years (Simpson 2005). Growth rates of natural pohutukawa are generally in the range of 2–3 mm in diameter per year in the hostile volcanic conditions of White Island (Clarkson and Clarkson 1994), similar to average diameter growth rates for southern rata of 2 mm per year.

*The very large diameters of pohutukawa planted only a century ago indicate fast growth rates compared to most other native tree species.*

*Pohutukawa growing in a dense stand near Tarawera Falls, near the outlet of Lake Tarawera in the Rotorua lakes region, have straight trunks not typical of most pohutukawa. However, these may be hybrids with northern rata and that could be influencing straighter stem form.*

**"It is not impossible to imagine that dense groves of pohutukawa, managed to form straight trunks, could be grown to serve as a future timber resource"** (Simpson 1994).

The strength, density, and presumed durability of pohutukawa wood suggest that trees could be planted as a timber resource. Single-stemmed trees with straight trunks do exist, although some of these may be hybrids with northern rata. The small population of pohutukawa near the Tarawera Falls contains many individuals with an upright form, and many of these have single stems. It is not known whether this is the result of dense stand development or of hybridisation.

*Left: An unusually straight large pohutukawa growing on farmland on Awhitu Peninsula, west of Auckland. It is likely this tree would have been surrounded by dense coastal forest which may have influenced its form but has survived subsequent clearance and conversion to farmland. However, pohutukawa typically do not form single straight stems in coastal forest.*

*Right: Totara North pohutukawa plantation this plantation of pohutukawa was established at Whangaroa Harbour in the early 1900s by a boat builder concerned at the loss of pohutukawa forest and a sustainable resource of pohutukawa bends for his boats. The plantation up to 20 m high looks natural with sprawling trunks up to 30 cm in diameter.*

Pohutukawa has rarely been planted specifically as a timber crop. A small stand was established by a boat builder in Totara North on the Whangaroa Harbour, Northland, to supplement the dwindling local resource (Stephen Lane, Lane Bros. Mill, Totara North, pers. comm.). Trees were planted at a spacing of 4-5 m to encourage the development of large curved stems that could be used for boat frames. At 80 years of age, the plantation consisted of large, spreading, multi-stemmed trees with individual trunk diameters up to 30 cm. This plantation has the appearance of a natural pohutukawa stand estimated to be approaching 20 m in height, with multiple stems arching over a diverse understorey of northern hardwoods.

It is not yet known whether pohutukawa can be managed to produce single stems in plantations. The possibility of genetic selection for the required characteristics of stem straightness and upright growth, and the effects of stand density, pruning, and thinning, would all be interesting topics for a research programme. The use of nurse crops to encourage rapid vertical growth of pohutukawa planted within "light-wells" would also bear further investigation.

## Wood quality

Pohutukawa has very hard wood. This is due to the presence of thick-walled fibres and narrow elongated cells that have little or no conducting or storage function but contribute to overall strength and density (Simpson 2005).

Pohutukawa heartwood is usually a rich reddish brown in colour but can vary from soft pink to rich red with black streaks. The wood has a swirled grain and is very dense, heavy, and strong. Its reputation for durability, including resistance to the toredo or shipworm, led Clifton (1990) to suggest that it would also be resistant to decay fungi. However, the dead heartwood of established pohutukawa is often attacked by wood-rotting fungi (e.g., Gadgil 2005). It is not uncommon to see decayed centres of stems while trunks of older trees can be hollow. Although pohutukawa has been used for fence posts, some farmers believe that it lacks long term durability in the ground and needs to be replaced within a few years. No scientific testing of wood quality has yet been carried out.

The growth rings of pohutukawa are considered by Meylan and Butterfield (1978) to be "indistinct to slightly distinct" based on core samples of the outer-wood, presumably sapwood, from mature natural trees. While ring counting has been used to estimate age of pohutukawa, decayed centres of stems make a full sequence of rings from pith to bark often difficult to obtain. Other native tree species in warm districts (e.g., totara, Bergin 2003) can form more than one ring per year. Further investigation is required to determine if pohutukawa, which can have several growth spurts from spring to autumn, is forming more than one ring per year.

*It is difficult to determine what a stem of pohutukawa comprises. Large stems often have decay in the central pith or can even be hollow. Other stems comprise several small stems or masses of fibrous roots. A solid wood stem of a mature pohutukawa reveals a narrow band of light coloured outer sapwood and the deep reddish brown colour of the heartwood.*

*Left: Externally some trunks appear to be one stem but when cut comprise several stems. These may have initiated as a cluster of vine-like stems (below).*

*Multi stemmed trees, irregular shaped stem sections, and internal rot make ring counting impossible on many pohutukawa.*

## Current uses

At present, pohutukawa wood can be obtained only from fallen branches and stems, or occasionally from trees felled during rural or urban development. This timber supplies a small wood-turning and furniture craft industry, although most of it ends up as firewood.

Pohutukawa makes good firewood and even freshly felled and undried wood will burn, presumably because it contains a high concentration of flammable chemicals, and also because its high density prevents storage of a large quantity of moisture (Simpson 2005).

Pohutukawa wood chips are used for smoking fish, and are reputed to provide an excellent flavour.

*Pohutukawa driftwood carved into the form of a swimming dolphin. Carver Tony House, Bluestone Studio, Whangamata*

*The beautiful swirled grain of pohutukawa makes it a popular choice for wood turning and decorative items.*

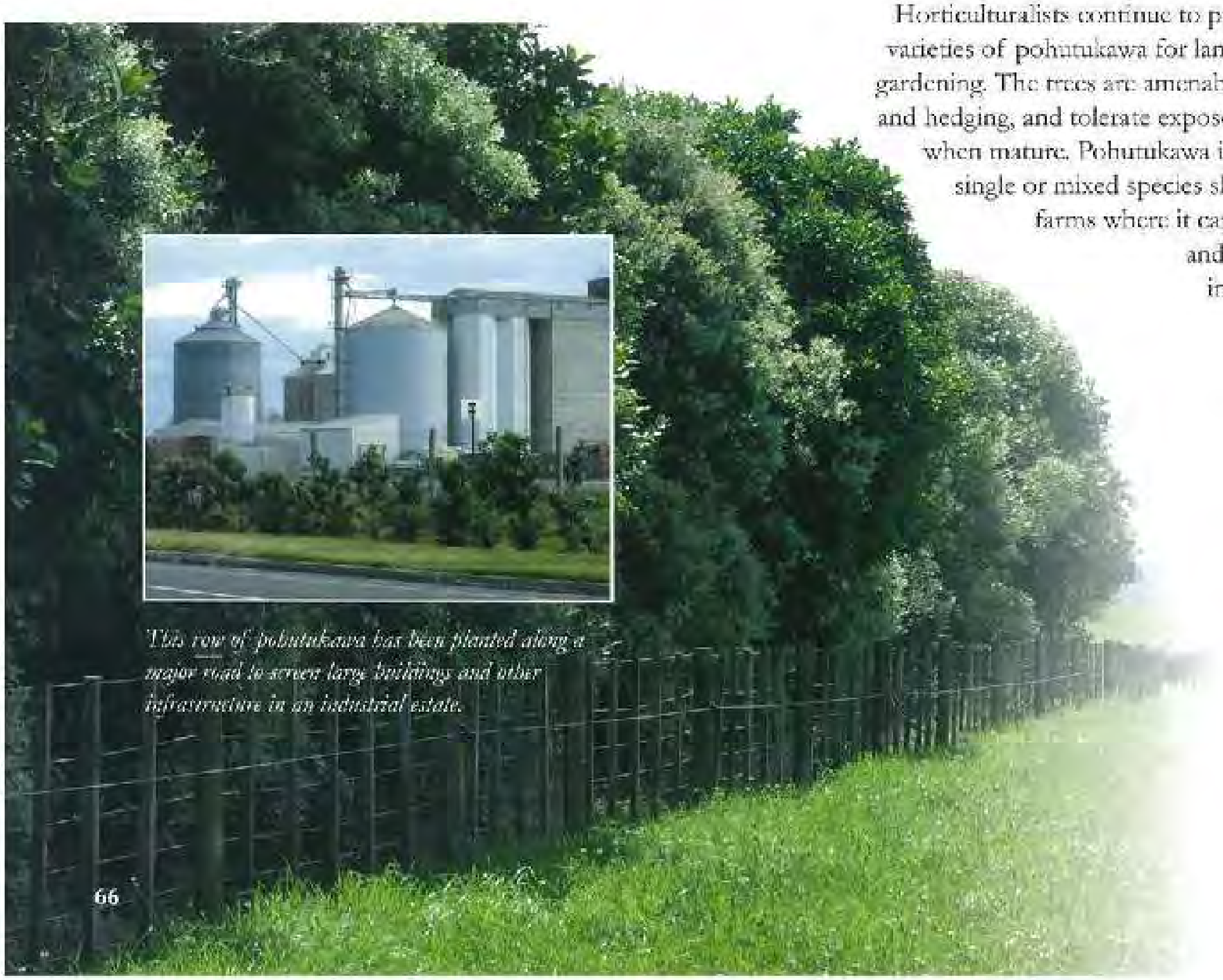
*This dresser is made entirely from pohutukawa. It was built by Mike Blackmore of Blackmore Design Ltd, Mt Maunganui.*


*Pohutukawa honey production is big business throughout the northern half of the North Island where hives are placed amongst remnants of coastal pohutukawa forest during the height of flowering.*

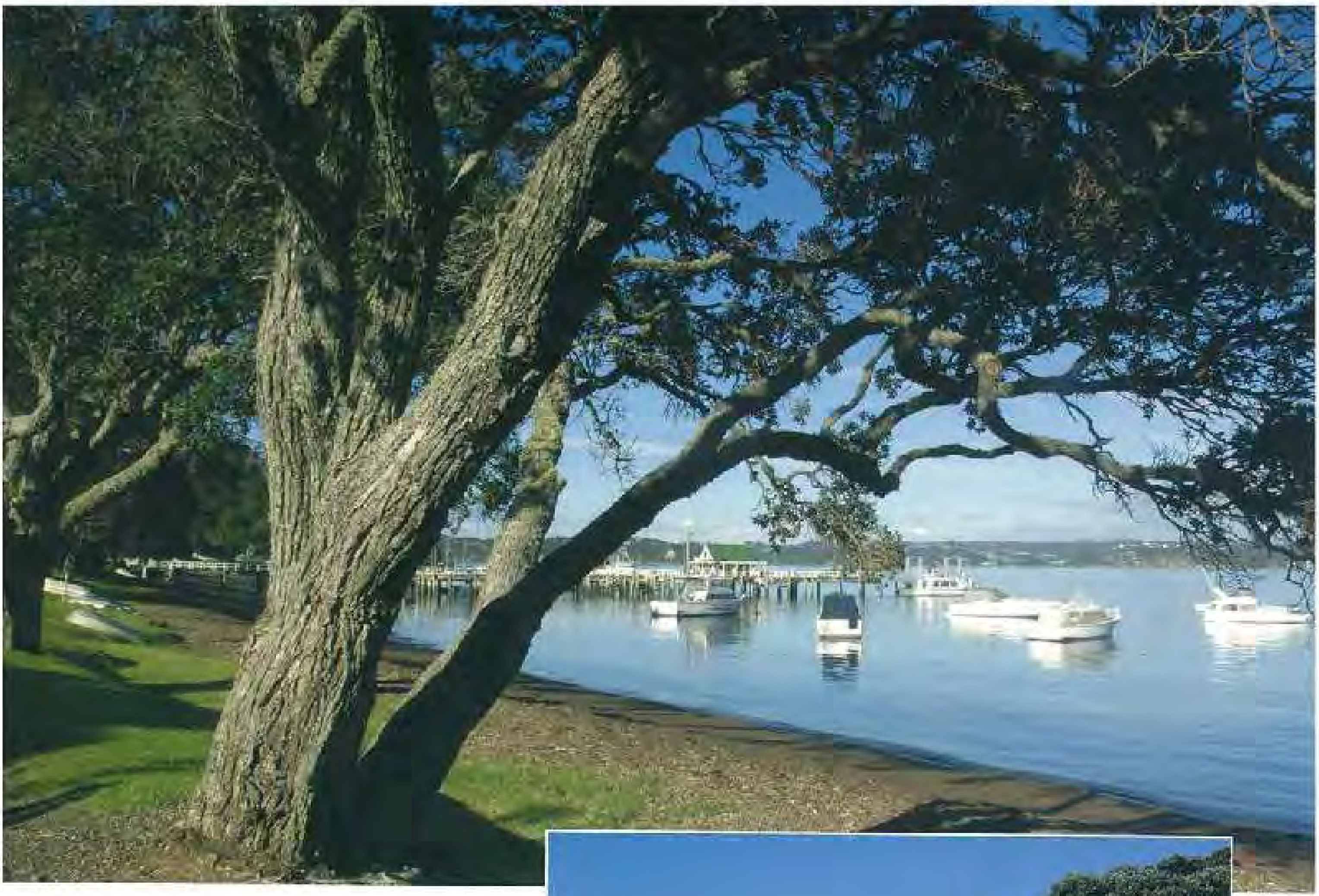
The pohutukawa honey industry is active in many coastal areas, including Rangitoto Island (Simpson 2005). Essential oils can be extracted from the inner bark. They are used for cosmetic and cleansing products such as honey soap, body wash and lotion, and hand and nail cream.

*The essential oils extracted from the inner bark of pohutukawa are used in a wide range of specialty cosmetic goods.*

Horticulturalists continue to promote many varieties of pohutukawa for landscaping and gardening. The trees are amenable to pruning and hedging, and tolerate exposed conditions when mature. Pohutukawa is also used in single or mixed species shelterbelts on farms where it can be trimmed, and as screens in industrial areas.



*This row of pohutukawa has been planted along a major road to screen large buildings and other infrastructure in an industrial estate.*



*Greater use is being made of pohutukawa as an amenity tree such as at Russell (above) and Mt Maunganui (right) on the coast where an increasingly uv-conscious public can benefit from the shade that it provides.*

*Some landowners are planting thousands of pohutukawa on seaside properties. Several hectares of this property on the Coromandel Peninsula have been retired from grazing and planted with pohutukawa, using tall nursery-raised seedlings.*

Pohutukawa plays a strong traditional and nostalgic role in the lives of many New Zealanders. Simpson (2005) describes it as one of New Zealand's best-known icons and demonstrates how the many images of pohutukawa continue to be popular for use in marketing and cultural endeavours. Images of pohutukawa are embossed on sides of concrete motorway ramps and bridges in central Auckland, and a sculpture symbolises the distinctive flower of pohutukawa; these are among the many instances where the species is profiled. Images of the tree, flower, and branching of pohutukawa appear in photographs, paintings, and Christmas cards. It is also used as a subject in plays, poems, and literature.


*A sculpture erected on a high-profile site in Auckland, with its illuminated red stamens and yellow anthers, is immediately recognisable as a pohutukawa flower, symbolising its iconic status in New Zealand.*

# PART 10 – MANAGEMENT OF EXISTING TREES

Pohutukawa could become one of the most endangered of New Zealand's native trees. Much of its habitat on the northern coastal fringe is considered desirable for residential development. Possum browsing continues to be a major cause of decline. To a lesser extent, natural losses due to wind damage and soil erosion also take a toll. Tendencies for communities and managing agencies to plant a range of exotic tree species such as Norfolk Island pines along the most modified sections of the coast are lost opportunities for the establishment and management of pohutukawa. If this species is to remain a prominent feature of our coastal environment, strategies for countering some of these negative effects on existing trees must be continued, attitudes modified, and, wherever possible, new management methods devised and put into practice.

*Norfolk Island pines are among several popular exotic trees planted on many northern beaches where pohutukawa would be more appropriate. Establishing and managing of pohutukawa instead of exotics along our northern coasts will enhance the natural character and help to increase local native biodiversity.*

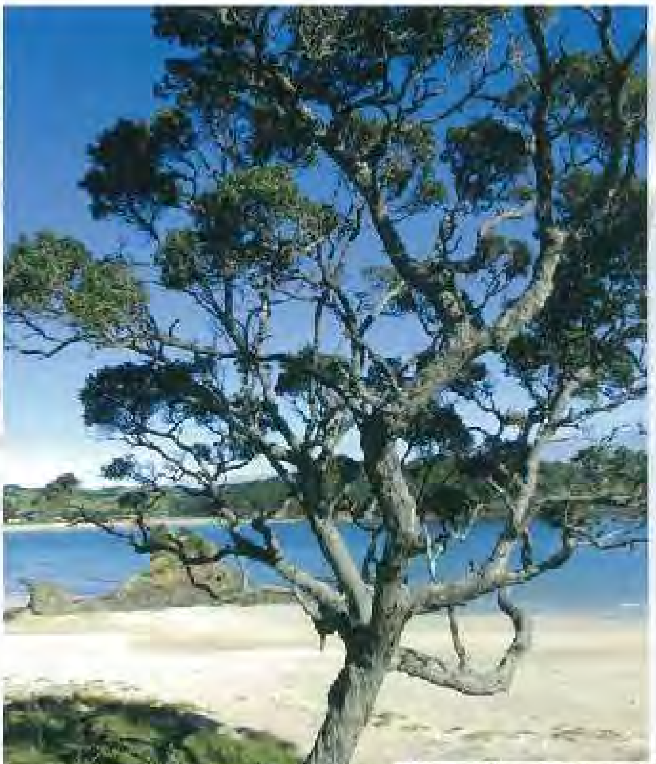
## Animal damage

### *Possums*

Pohutukawa trees that have been badly damaged by browsing of foliage and twigs will recover if possum populations are reduced or eliminated. Choice of control methods will depend on the resources available, the scale of the project, and proximity to high-use and urban centres. Aerial drops of poisoned carrots and trapping along transects can be effective over large areas. For isolated stands or individual trees, localised trapping, shooting, or poisoning operations can be successful. Care is required, and it is always wise to consult and involve local communities and landowners in advance. Some control methods may not be permitted near residential areas.

Hosking and Hutcheson (1993) recommended that targeted possum control should be carried out in late winter (August to early September) so that new foliage can develop naturally. Any interruption of possum activity over the period of bud extension allows more foliage to accumulate and this will improve tree vigour. Hosking and Hutcheson suggested that trees would regain the normal complement of foliage after 2 consecutive years of protection from possums.

*Possums cause considerable damage to emerging buds and foliage. A short-term possum control programme in late winter will allow the new foliage to develop.*



*A band of galvanised sheet metal around the trunk(s) will prevent possum access to foliage if the canopy is not in contact with other trees.*

*Bait stations containing poison in remnant pohutukawa forest. When regularly serviced these are very effective in reducing possum numbers.*

Large-scale possum control programmes provide greatest long-term benefits because reinvasion is slowed down. Where trees are scattered, or on land with different tenure, control of possums may be fragmented and therefore less effective. Project Crimson has helped local communities, agencies, and landowners to co-ordinate local possum control. Trapping and poisoning have been sustained by the enthusiasm of volunteers.

Provided that the tree canopy is isolated from the canopies of other trees, the placing of a smooth band (usually galvanised sheet metal) around each stem will prevent possum access to the crowns. The bands must be at least 60 cm long (longer if the stem is not vertical) to prevent the animals from jumping over the barrier. The bands appear to have no adverse effect on the trees, but small wooden battens used as spacers between the trunk and the band can be used to prevent possible overheating in direct sunlight (Gerald Collett, Treecare Services, Auckland, pers. comm.). The visual impact of the metal can be reduced by a coat of grey or dark green paint.

## Farm animals

Pohutukawa trees can be damaged by grazing animals if the foliage is within their reach. Nursery-raised plants are especially palatable. Recently planted pohutukawa and areas of natural regeneration need to be fenced off if they are to survive. Wire or plastic tree guards supported with stakes will protect individual trees from rabbits and hares as well as farm animals. Substantial post, rail, or wire fencing will exclude sheep and cattle from larger areas.

The placing of fences to exclude grazing stock near cliff edges will depend on the expected rate of erosion. A forested buffer zone at least 10 m wide is recommended. Ideally, 20–30 m should be allowed to maximise the development of an interlocking network of roots. This will have a "cargo net" effect, helping to bind edge trees and soil to trees further inland.

*Grazing under pohutukawa trees causes exposure of root systems and damage due to constant trampling. Lower foliage is stripped and eaten.*

*Robust wooden rails and electric wire on extensions prevent cattle from reaching the crown of this specimen tree.*

*A fence placed several metres from the cliff edge will prevent grazing and allow pohutukawa seedlings to establish. A forested zone along cliff tops will help to anchor cliff edge trees and soil by providing a network (a "cargo net") of strong roots.*

*Permanent fencing is essential to prevent browsing of pohutukawa by farm animals.*

## Control of weeds

The large number of plant species that inhabit the warm temperate zone of northern coastal New Zealand especially on less-exposed sites often prevent the establishment of pohutukawa. Garden escapes (including vines) frequently dominate the vegetation in coastal areas. Constant vigilance is required to ensure that existing and developing pohutukawa plants are not suppressed by less desirable species. Vigorous grass will require spraying with herbicide and woody weeds cleared by hand to ensure establishing pohutukawa are not overtopped. Exotic vines will require cutting and perhaps stumps swabbed with herbicide to prevent smothering of larger tress.

*Pines and other exotic plants can dominate fresh surfaces of slip faces normally key regeneration sites of pohutukawa. Such sites will require control of exotics if pohutukawa is to become established.*

## Development threats to pohutukawa

Examples of disturbance, destruction, and removal of pohutukawa during building and development projects are numerous and varied. Rising coastal real estate values continue to stimulate the modification of existing properties and the development of new subdivisions. Small lifestyle blocks and isolated holiday baches that were once visually integrated into a forested environment are being urbanised by the building of expensive dwellings, with consequent removal of large trees. Roading improvement can often result in destruction of established pohutukawa. Sites suitable for replanting or natural seedling establishment are becoming scarce.

Even in established coastal settlements, pohutukawa trees are often thoughtlessly removed by residents. Maintenance and

*Top: Foundations and pavements in the vicinity of pohutukawa trees can be distorted by growing roots. Remedial work often involves removal of the tree.*

*Centre: The root systems of these trees have been disturbed by construction of this house. There is no hope that the pohutukawa will be replaced when this last line of trees succumbs to cliff erosion.*

*Bottom: Roots (foreground), which are essential for the long-term survival of this large tree, are constantly disturbed by lawnmowing.*

*Coastal development, including infill housing, fencing, and paving, is a threat to old pohutukawa trees that can be damaged by disturbance and are often destroyed.*

enhancement of sea views frequently receive higher priority than the care of old and picturesque trees. The consequences for conservation and soil stability are rarely considered. In spite of local by-laws aimed at the protection of pohutukawa and other notable trees, illegal or insensitive felling, trimming, or poisoning is quite common. Few convictions result because proof of responsibility is difficult to establish, but damage to protected trees is becoming a more common matter for scrutiny by the Courts.

*These variegated pohutukawa trees planted on public land are constantly trimmed by local residents. They are a poor substitute for natural pohutukawa along this coastal cliff top site.*

*An attempt to kill the tree by poisoning has caused partial defoliation.*

*These pohutukawa trees had been growing for several decades in a public reserve. They were recently poisoned, probably to allow sea views.*

*This line of pohutukawa on a roadside bank was once trimmed regularly (dotted line) by the council. Cessation of trimming has seen the regrowth of healthy crowns.*

*Left: The top of this tree was removed to allow an unrestricted view of the beach in the distance.*

*The top of this young pohutukawa tree planted in a street has been cut back to prevent it from growing too high, probably to maintain views.*

## Challenges in tree management

There are inconsistencies in local by-laws set by adjacent council authorities. In some areas there are no general tree protection rules; in others the regulations are strict. Residents can be reluctant to plant pohutukawa, fearing that the authorities will not permit future pruning or thinning. Some landowners are planting non-protected species as an alternative (Gerald Collett, pers. comm.).

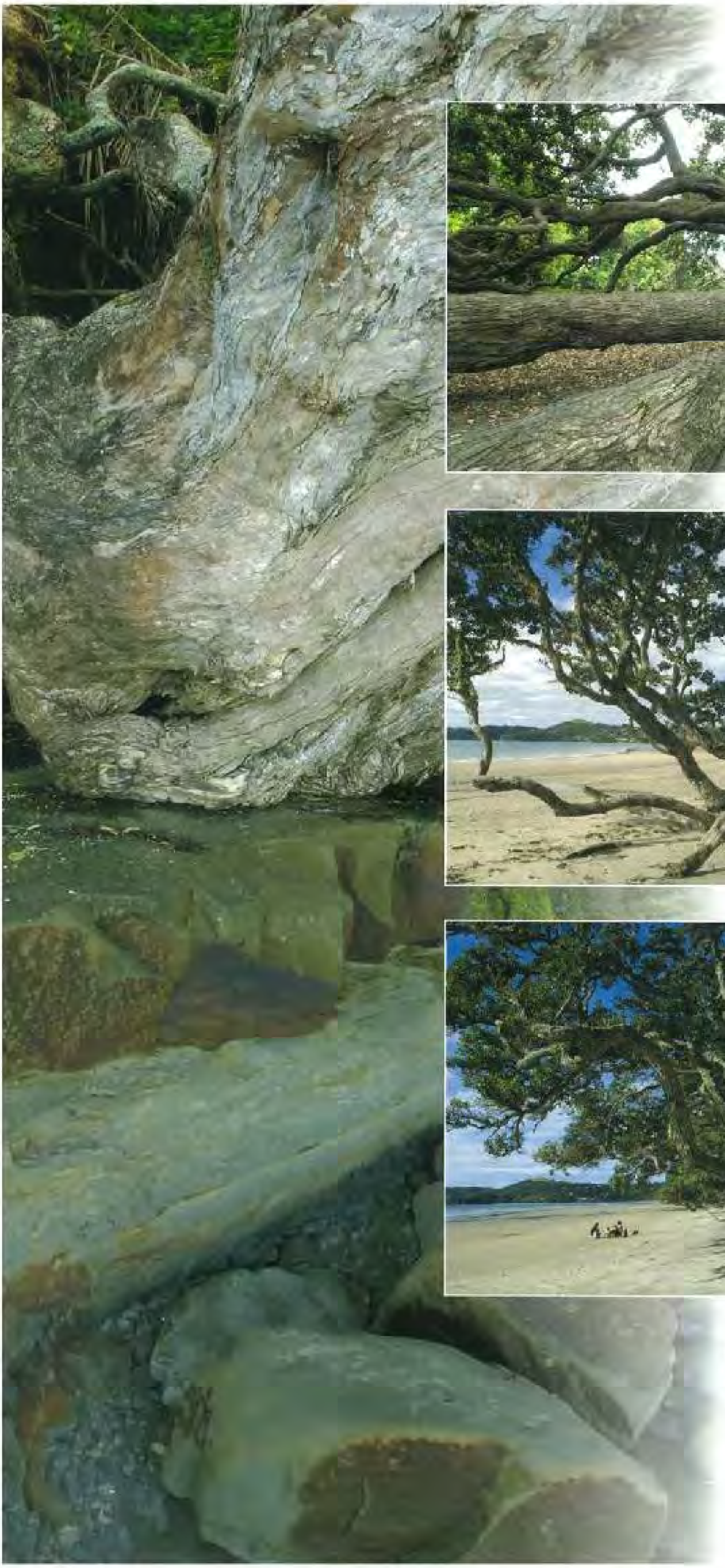
A number of creative options have been suggested by people wanting to modify or remove existing pohutukawa. Some of these suggestions that have not been examined carefully may increase rather than decrease the rate of disappearance of pohutukawa from the coastline. Local authorities are now implementing strategies that will reduce such destruction. Many councils consult local residents about the management of protected pohutukawa on private as well as public land. This has led to changes in attitude among council personnel as well as residents.

The importance of early consultation, and consideration of the value of pohutukawa in its natural habitat, cannot be over-emphasised. This approach allows for the canvassing and implementation of strategies for preserving existing trees. For example, residents along the western Coromandel coast recently raised concerns with roading authorities about plans for removal of a number of old pohutukawa trees along a section of highway that was due for road widening. Additional expert advice was sought and the plans were eventually revised so that the project could be completed without removal of mature trees. In some areas, council arborists offer advice about the management of existing trees although the cost of specialist advice and remedial work, even for protected trees, has to be met by the landowner.

## Tree stability

Pohutukawa trees are usually windfirm, even though they inhabit very exposed sites. Breakages are relatively uncommon, due to the strength of the wood and the ability of branches, roots, and canopy to grow in conformity with features of the environment. The trees often have horizontal limbs more than 20 m long which carry heavy canopy loads. Instead of breaking, these stems have the ability to bend slowly as their weight increases. Sometimes they settle on the ground and take root. Limbs of pohutukawa rotating over edges of banks and cliffs, gradually undermined by erosion, can come to rest on rock platforms or beaches.

*Pohutukawa inhabits exposed and windy sites, but branches and stems seldom break, reflecting the strength of the wood and the ability of the tree to mould to its environment.*



*Pohutukawa trees may have horizontal limbs at least 20 m long. These sometimes settle on to the beach or on to a rock platform or take root when the substrate is suitable. Others remain aloft over the beach. Such trees do not usually require management.*

## Safety issues

In spite of their relative stability, pohutukawa trees growing in urban areas must be assessed for their potential effect on human health and safety in the same way as other large trees. Older trees do develop stem rot, but it can be virtually impossible to predict the effect of this on stem failure. A long-term survey of stem failures of pohutukawa in urban areas is planned and this should identify factors likely to lead to instability. It is hoped this will lead to more information that will assist skilled arborists to assess risk factors of large pohutukawa.

Identification of poor unions between main branches or stems is often possible at the large seedling or sapling stage in the nursery, allowing opportunities for planting stock with good branch connections to be selected. Alternatively there is often scope for form or remedial pruning of affected plants, including early removal of poorly connected stems that will improve long-term tree structure and stability.

*Many older pohutukawa develop stem rot, but it can be virtually impossible to determine if or when failure of the branch or trunk will occur. Should every large tree with signs of stem rot be removed from public areas?*

*Above: A long split between two stems is a good indication that one of these stems, if not both, will eventually fail. Note development of adventitious roots from the junction.*

*Development of a split at the junction between stems indicates a poor structural union that may have been identified before planting.*

*A good connection between branch and stem, therefore little likelihood of failure at this junction in the long-term.*

Sometimes pohutukawa develop with stem unions that are inherently structurally flawed. Such unions are often characterised by tight forks between two or more competing stems, with the bark between the stems embedded within the crotch and preventing a secure connection between the stems. Here sudden failure is a possibility and a matter of concern in high-use amenity areas. Sometimes movement can be detected at the junction as large trees move in the wind, and occasionally adventitious roots may be found emerging from the join

## Management of individual trees

Depending on circumstances, there may be a number of management options for existing pohutukawa in high-use areas or near urban development and associated infrastructure. In some instances removal may be the most realistic course of action, but there are many alternatives that allow development around pohutukawa trees.

### *Felling of trees*

Felling eliminates any threat of stem breakage, but it will lead to the disappearance of beautiful old pohutukawa from our landscape and is not a satisfactory option for highly-valued heritage trees. High-use public land dominated by small young trees will have a visually monotonous appearance if all the older large trees are removed.

*Gradual loss of large pohutukawa trees from urban sites and along highways may be justified on the grounds of health and safety. However, removal of all large trees from high-use areas would reduce the amenity and aesthetic value of many of our landscapes.*

### *Form pruning and remedial pruning*

As trees develop, early removal of stems likely to compromise future safety, or to interfere with nearby structures, may be required. Structural or remedial pruning of established trees may be needed on occasion to reduce the risk of limb or trunk failures (G.J. Collett unpubl. data). Judicious pruning of interlacing branches can reduce overall crown density without spoiling the visual effect. Arborists experienced in the pruning of pohutukawa should be engaged for this work. Early management, sometimes requiring little more than the deft use of secateurs in the nursery, may allow the tree to be retained for 200 years or more.

*Early thinning of stems and branches of developing trees can reduce future concern about safety and proximity to buildings or other amenities.*

### *Reduction of weight*

Options for reducing crown weight include selective removal or shortening of the branches or stems. This can sometimes result in an ugly unnatural crown shape if the shape and stature of the tree do not allow alternative methods of pruning. It may be inevitable if old trees are to be retained, but should be avoided wherever possible.

*Stems of these trees were structurally unsound and considered to be unsafe in the vicinity of high-density housing. Topping of the crowns was done as a last resort as the trees have high amenity value and felling was the only alternative.*

*Pohutukawa such as these planted in an amenity area can be pruned to ensure long-term structural integrity while at the same time maintaining an attractive tree form.*

*Careful pruning of selected branches has allowed views of the sea through the canopy of a large pohutukawa. This practice is more acceptable than topping or removal of the tree.*

*Living with pohutukawa – trees within this dense coastal fringe of natural pohutukawa at Coopers Beach, Northland, have been topped and pruned to provide sea views for local residents. Uncontrolled pruning and tree removal have been avoided.*

## Transplanting large pohutukawa

Pohutukawa will tolerate transplanting to a new site. Many older trees have been repositioned with the aid of heavy earthmoving equipment and guidance from experienced arborists. Rapid development of adventitious roots probably assists re-establishment. In nature, large trees that fall from cliffs often continue to grow in their new position.

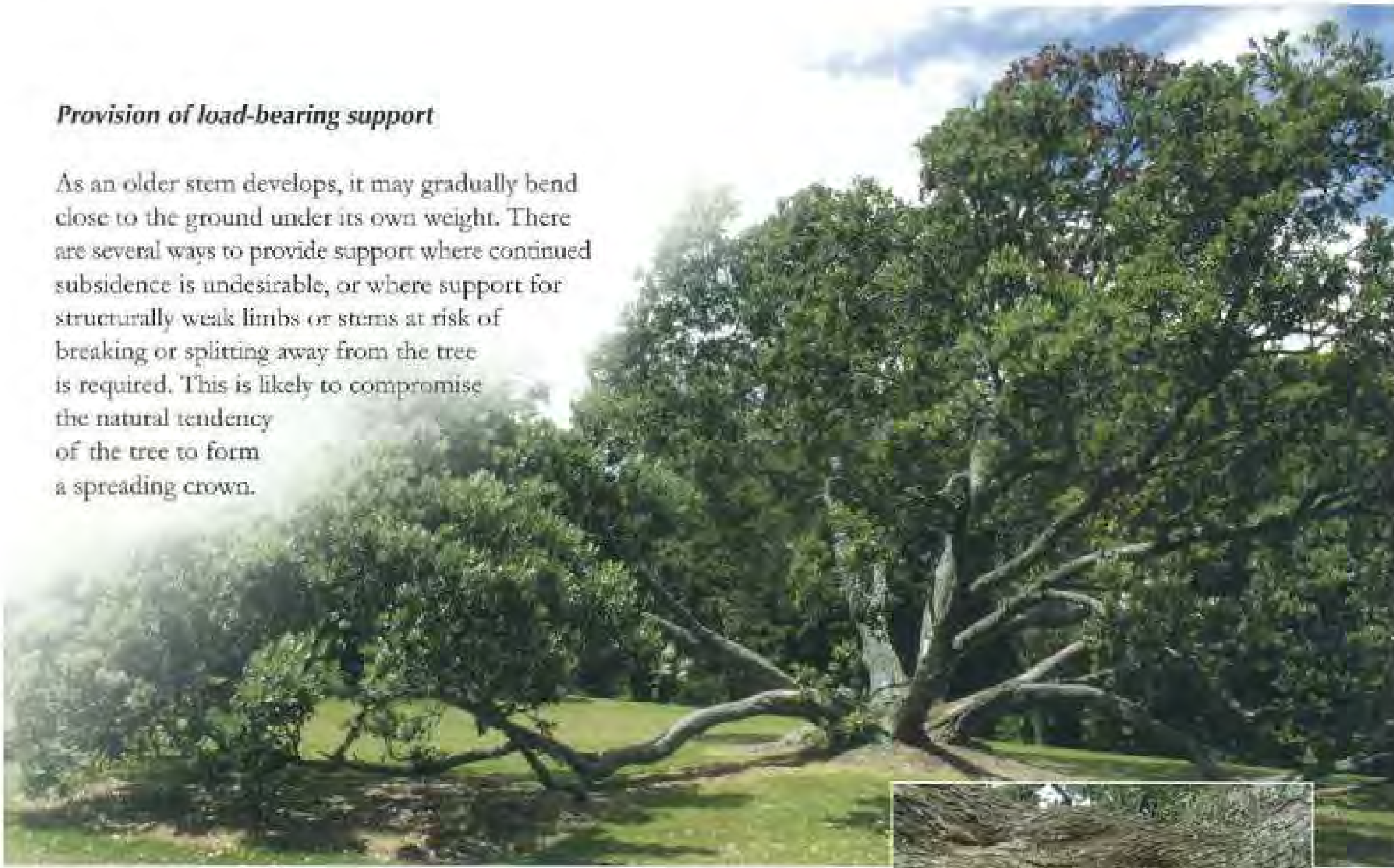
Relocation of trees is expensive and not often practical. Appropriate access must be available at the removal site and at the replanting site, which should be as close together as possible. Considerable financial resources will be needed for hire of the heavy equipment used for excavation and transport.

Trees to be transplanted do not require any pre-treatment. The excavated root ball can be quite small compared tocrown dimensions. Trees are normally watered for a short time after transfer, and they may require ties to give initial support until windfirm.

*Pohutukawa are easily transplanted as large trees. This flowering pohutukawa in a Takapuna street, Auckland, was successfully transplanted three years ago. The tree at the time of moving was 9 m high with a crown spread of 12 m.*

### *Provision of load-bearing support*

As an older stem develops, it may gradually bend close to the ground under its own weight. There are several ways to provide support where continued subsidence is undesirable, or where support for structurally weak limbs or stems at risk of breaking or splitting away from the tree is required. This is likely to compromise the natural tendency of the tree to form a spreading crown.



Support for subsiding limbs can be provided in one of the following ways:

- **Props** - Posts and cross-bars can be used to hold up leaning stems or large overhanging branches. Because the load is likely to increase with age, the possibility of eventual distortion and failure of the prop must be considered. Support structures therefore need to be designed to accommodate the increasing weight of heavy stems, or the stems periodically pruned to keep loadings at an acceptable limit. Gradual distortion and/or abrasion of the stem at the point of contact with the support structure may reduce long-term stability.
- **Cables** – Cables consisting of steel wire ropes and abrasion-resistant padding are used to support limbs at risk of failure. They are tied to more secure stems of the same tree or to adjacent trees. Sometimes the cables are kept loose to act as a backstop in the event of possible failure; other cables are designed specifically to hold the tree limbs together. It is important to make sure that neither the strop material nor the tree stem is likely to fail and cause damage or injury. Cables can be installed to limit on-going subsidence of leaning stems, but periodic inspection and adjustment may be required.
- **Anchors for cliff trees** – As a safety precaution, trees on cliff edges are sometimes cabled to buried anchors or piles on the cliff-top. Arborists and engineers are needed to supervise this work (Collett 2003). Such anchoring should typically be treated as a safety net whereby cables are kept loose so that normal strain is taken by the tree itself.

*Load-bearing structures may alleviate concerns about short-term stem failure, but long-term stability may be compromised and the tree may need regular trimming to prevent excessive weight on support structures.*

- **Soil mounds** – Mounds of soil can be built under leaning branches as they settle close to the ground. Roots will form and penetrate the soil and will increase the stability of the tree. Placement of soil mounds around trees is likely to be practical only on some sites.

### *Cordoning-off old trees*

Construction of fences around large trees that may threaten human safety could be a practical option in some situations. Sprawling pohutukawa trees invite sheltering and climbing, and fences may not be effective in preventing access. Encouragement of vegetation growth beneath the canopy may keep people away from trees identified as a possible hazard due to stem failure.

*Top right: As pohutukawa trees slowly develop a spreading crown, it may be better to allow long low stems to take root rather than to cut them off. Construction of a mound of soil under a leaning stem can prevent breakage and avoid safety issues.*

*Right: Cables can be used to hold limbs that may be at risk of sudden failure or to limit gradual subsidence of leaning stems.*

### *Promotion of natural forest succession*

In large parks and reserves it may be possible to encourage the establishment of other plant species under individual trees or groves of pohutukawa by not mowing or using herbicide spray for grass control. Natural succession of coastal species will depend on the proximity of local seed sources. Enrichment planting can be an option.

*Not mowing around trees, applying heavy mulching, or encouraging the natural accumulation of leaf litter around tree roots can discourage public access to trees that might present a risk due to stem failure.*

*Above and right: At Wenderholm Regional Park, north of Auckland, areas beneath some of the groves of large pohutukawa have been retired and native plants, including taraire, are regenerating in the unmown grass. Established pohutukawa can be underplanted with a range of tree and shrub species to increase local biodiversity; this may be a practical option for discouraging public access directly under selected trees identified as being at risk of stem failure.*

## Management of large trees near buildings

By careful planning of the construction, renovation, or extension of buildings, large trees in their vicinity can often be retained and may enhance the new built environment. The use of trenchless technology (drilling, thrusting or jacking) for underground services can minimise root disturbance and damage to the tree. In one example, a sewer pipe 2.5 m in diameter has been laid through a beachfront reserve in an Auckland suburb by tunnelling under large trees, including pohutukawa. The trees would have been destroyed by open excavation.

Many houses have been built under, and even around, large pohutukawa trees, considerable care being taken to ensure tree survival. While projects that accommodate trees are admirable in the short-term, problems may arise as trees grow larger.

*Housing development can be compatible with retention of large pohutukawa trees. The setting of houses well back from the cliff edge prevents damage to the root systems of trees that protect erosion-prone banks and cliffs.*

*This carpark in an industrial area has been constructed around an existing pohutukawa tree. Cobblestones were laid on a specially prepared porous concrete foundation that allows rainwater and air to reach the roots.*

Increasingly, plans for buildings, walkways, and roads now incorporate raised platforms to form bridges over tree root systems. Buildings in the vicinity of large trees are sometimes constructed to withstand possible future branch failure. Trees can also be propped in position as an alternative to removal to allow buildings to be erected among trees that are or may become structurally unsound over time.

*This roof was built around the limb of an existing pohutukawa tree. The limb is supported by a steel prop. If it becomes too big and unsafe for the space provided, it may have to be removed.*

## Management of pohutukawa on cliffs

Along many coastal cliffs under intense development, the future of a skyline dominated by pohutukawa is under threat. Development close to the cliff edge, lack of understanding by landowners and developers that pohutukawa do not exacerbate cliff erosion, and a desire by cliff top dwellers for uninterrupted sea views are all contributing to the loss of pohutukawa from these high-profile sites. Inappropriate siting of buildings close to cliff edges may accelerate soil erosion. Excavation disturbs soil and severs or damages tree roots that hold the soil in a strong network. Drainage water from roofs and paved areas that is channelled over or near cliffs is increasingly seen as a factor that can trigger slips and soil erosion during heavy rain storms.

While there are increasing numbers of engineering "solutions" to this gradual erosion in urban areas, they are usually at the expense of the natural character of the coastal landscape and eventually may lead to the degrading of the remaining fringe of pohutukawa. This fringe is the last row of trees of what used to be a coastal forest, often dominated by pohutukawa.

Pohutukawa are often singled out as the major cause of slips along coastal cliffs and banks after major storm events. Compared with other species, pohutukawa trees are in fact remarkably stable and long-lived, and are naturally adapted for survival on cliff edges. Extensive strong root systems anchor the tree to the cliff top. The ability of sprawling branches and stems to develop new roots as soon as they come in contact with the ground provides additional support and nutrition.

In rural areas, survival of pohutukawa on cliffs is enhanced by the existence of a belt of forest 10–30 m wide along the cliff top. Its network of roots, rather like a cargo net, holds the soil and slows erosion. The development of a wide belt of mature pohutukawa trees will help to ensure natural replacement of individuals that may be lost if the cliff face does collapse. This will require fencing in farming areas and restrictions on development in urban areas to reduce or prevent loss of vegetation cover along cliffs and banks.

*Although pohutukawa on cliffs and banks are often blamed for causing slips after heavy rain storms, they are usually very stable and long lived. Human-induced factors such as development along cliffs and banks are significant contributors to instability.*

*Generous set backs of housing and fencing from cliff edges will result in less disturbance to the pohutukawa fringe.*

# SAVING POHUTUKAWA ON AUCKLAND'S COASTAL CLIFFS – seawalls one possible solution

*Gerald Collett, arborist, Treecare Services Ltd, Auckland.*

Gerald Collett, a pohutukawa specialist with Treecare Services, Auckland, suggests that in some highly modified urban areas the building of seawalls may be an effective method for conservation of a pohutukawa-clad cliffline. Roads, driveways, and houses are often built on the inland side of the final remnants of pohutukawa forest, sometimes even on the cliff edge. They leave no opportunity for the establishment of replacement trees.

*Cliff-top residential housing built as close as possible to the cliff edge becomes vulnerable as cliffs either naturally retreat or are subject to occasional slips that may be exacerbated by disturbance from the development.*

Engineered structures are increasingly used to protect cliff-top residences and infrastructure. Engineering "solutions" to gradual soil erosion in urban areas do not usually complement the natural character of the coastal cliff landscape, and can result in disturbance and destruction of pohutukawa through excavation and the use of heavy machinery. Retaining walls constructed from concrete, rock, timber, or combinations of these are not uncommon along many eroding cliffs and banks in urban areas. There is an increasing trend towards use of palisade walls, based on a line of 60-cm-diameter reinforced concrete columnsinserted into holes drilled vertically into the cliff-top to depths of 20 m or more (ideally to below sea level). The line of columns lies several metres inland from the cliff edge, and the tops are joined by a concrete capping beam buried beneath the soil surface. All tree roots in the vicinity of the palisade are severed and the beam acts as a barrier, preventing secure root anchorage of pohutukawa located seaward of the beam.


*A reinforced concrete palisade wall is being constructed several metres inland of the cliff edge.*

*Engineering solutions to the problem of eroding cliffs in Auckland do little to enhance the natural character of the coastline.*

As a cliff face erodes, debris falls to the shore below and is washed out to sea. Occasionally a very large slip occurs, a huge volume of material slumping seaward to form a flatter profile. These slips offer more hope for survival of pohutukawa because they are a suitable habitat for establishment of this species.

Gerald Collett suggests that an artificial barrier or seawall erected at the base of vulnerable cliffs would trap fallen debris. In time, a new face would develop and this would be colonised and stabilised by trees and shrubs.

Collett draws attention to a large sewer pipe that runs along the foot of cliffs at Murrays Bay, one of Auckland's popular East Coast Bays beaches. The pipe was recently covered with a layer of concrete to protect it from wave action. The concrete armouring was designed to blend visually with the surrounding rock formation, where it has inadvertently become an example of a visually acceptable "seawall" projecting from the toe of the cliff. It is a popular walkway, and many people fail to realise that it is an artificial barrier Collett (2003).

*Debris at the base of a cliff with pohutukawa and other vegetation that has come down with a recent slip. The debris toe occupied by an interlacing mix of roots and branches is likely to be removed within months by high seas.*

*The sewer pipe running along the high tide line at Murrays Bay was covered with a layer of concrete to protect it from wave action. The structure is now acting like a low sea wall that could be reducing erosion at the base of the cliff. The concrete armouring of the sewer pipe was designed to look like the surrounding rock platforms and has become a popular walkway.*

Any plans to construct seawalls along the toe of coastal cliffs will require extensive community consultation and a rigorous resource consent process. Coastal dynamics are complex and the effects of any artificial structures built in the beach zone are notoriously difficult to predict. Sand deposition and littoral drift patterns could be altered. Potential risks associated with increased public use in the vicinity of eroding cliffs would require consideration and management. On the other hand, the seawall concept could prove an effective alternative to visually intrusive options such as sprayed concrete, wooden retaining walls, rock revetments, or palisade walls.

If these matters can be resolved, Gerald Collett envisages a series of seawalls flanked by pohutukawa, that could double as walkways. Slip debris accumulating at the toe of the cliff behind the wall will provide opportunities for natural regeneration or even planting of pohutukawa. The seawall concept would be more attractive and more functional than a coastline bereft of pohutukawa and characterised by massive vertical retaining structures. What will protect the palisade walls and retaining structures when they are eventually exposed by weathering and wave action?

## The Auckland Regional Council advocates planting rather than hard structures

The Auckland Regional Council (ARC) advocates planting of coastal areas rather than the creation of hard structures. A number of fact sheets have been produced and are available online at www.arc.govt.nz One of these deals specifically with planting on coastal cliff tops.

The Auckland Regional Coastal Plan and the Coastal Erosion Management Manual (ARC 2000) both include guidelines for the management of coastal erosion in the Auckland region. Policies generally advocate non-structural management where practical. Seawalls are not the preferred approach. Instead, alternatives are usually investigated to address the actual cause of the erosion.

Seawalls can affect natural character, amenity value, and public access. In some instances, seawalls can result in the protection of one aspect of the environment at the expense of broader environmental values.

## DO POHUTUKAWA CAUSE CLIFFS TO COLLAPSE?

Erosion of cliff edges is a natural and inevitable process. Soil type, weathering, wave action, and the amount and type of vegetation cover are factors that interact with each other and determine the rate at which land retreats away from the sea. There is a perception that pohutukawa trees, often containing many tonnes of timber extending well beyond the cliff edge, are a primary cause of cliff edge failure. This theory was examined carefully after an exceptional rain event in the eastern Bay of Plenty (Hosking unpubl. data). In July 2004, 400 mm of rain fell within 48 hours. The land was already sodden and numerous slips occurred throughout the region, some resulting in property damage and loss of life. Where mature pohutukawa trees were dislodged, the physical and visual impact was spectacular because of their size.

A systematic visual assessment along coastal and harbour cliffs identified 63 slips in 150 km of coastline between Otamarakau and Te Kaha (Hosking unpubl. data). Vegetation cover on disturbed soil was dominated by grass, gorse, pampas, and wattle. In adjacent undisturbed areas the vegetation cover was predominantly pohutukawa. Most of the slips originated in unconsolidated colluvial material at the base of cliffs. Water runoff from pasture or residential development landward of the cliff top was clearly a contributing factor. Areas with a wide continuous cover of pohutukawa forest stretching inland from the cliff top were least affected. Slips originating at the top of a cliff were invariably associated with modifications of land use, or interference with the vegetation cover.

The survey results indicated very strongly that pohutukawa trees do not contribute to cliff top erosion but on the contrary are likely to have a stabilising effect on the soil. Strong and deeply penetrating roots intertwine with the root systems of trees landward from the cliff edge and the tree is held in place even where soil erodes below. Extra anchorage is provided when stems bend over and develop additional anchoring roots. Sudden soil failure results often from human-induced changes to vegetation cover and water runoff, and is seldom caused by the existence of cliff-edge pohutukawa trees. Retirement from building development and restoration of coastal forest dominated by pohutukawa are recommended in order to reduce cliff failure in the Eastern Bay of Plenty Region (Hosking unpubl. data).

A graphic example of the relative stability of large pohutukawa on coastal cliffs is illustrated by an early photograph of a pohutukawa on a cliff at Whangaparaoa, north of Auckland, taken by John Kinder in 1868. Gerald Collett, an experienced arborist specialising in pohutukawa, immediately recognised this tree from his frequent visits along the Auckland cliffs. The latest photograph from almost the same angle 138 years later clearly shows virtually no change in the position of the tree.

*Pohutukawa on a cliff at Whangaparoa, 1868. (Auckland Art Gallery, Toi o Tamaki, purchased 1983). (Photo taken by John Kinder).*

*Gerald Collett, an experienced arborist recognised the tree, and this photograph taken 138 years later shows that its position has not changed.*

## Good practice guidelines

Realistic expectations must guide town and rural planning where development threatens the retention of large old pohutukawa trees. For example, the issuing of consents for infill housing where there are large old trees that are to be retained, may not always be practical. Good practice guidelines must be consistent across regions if pohutukawa trees are to remain features of our landscape.

Numerous issues need to be considered by everyone associated with each project. Farmers and other landowners, building and landscape architects, planning consultants, geologists, arborists, ecologists, iwi, engineers, archaeologists, and local authority staff can all contribute to assessments of the impact of a new development on pohutukawa.

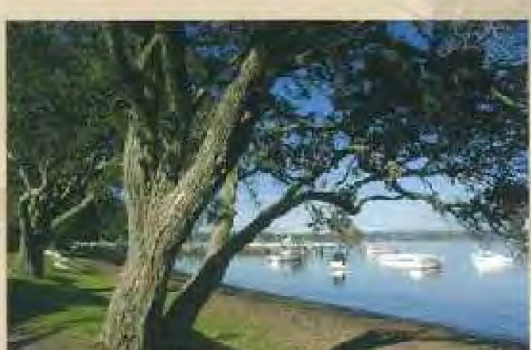
There are, of course, long-term issues with planning development near trees such as pohutukawa that are likely to live for hundreds of years. These include allowing realistic clearances to accommodate trees as they develop into their full potential size; these must take into account future risks associated with natural bending and settling of stems of sprawling trees, and possible sudden failure of stems. The management of pohutukawa on cliffs requires an understanding of the rate of cliff retreat, factors that can exacerbate or slow this retreat including the role of pohutukawa, and appropriate planning that allows continued and further development of such sites into the future.

Broad input to such assessments is relevant to both rural and urban areas from infill housing in cities, subdivision of the peri-urban fringe, road alignments, or to bulldozing tracks on farmland.

*Appropriate planning is required for development near trees like pohutukawa. This includes consideration of root systems and tree stability where foundations are to be excavated and allowing sufficient space for trunk and crown growth where buildings are erected next to or amongst pohutukawa.*

## Northland Region


Pohutukawa occurs naturally around the coast, for the most part, in four territorial regions - Northland, Auckland, Waikato, and Bay of Plenty. The southern limit of pohutukawa on the west coast falls just south of the Waikato Regional Council boundary in the northern part of the Taranaki Region, and on the east coast, in part of the Gisborne District Council. Individuals, agencies, regional and district councils, and community groups in each area are all involved in the restoration, protection, and management of pohutukawa. The following is an account of the distribution of pohutukawa in each area, together with a description of some of the local issues being tackled there.



### Northland's east coast

The main stands of pohutukawa in Northland occur along the east coast from north of Auckland to Cape Reinga. They consist of narrow strips of trees and occasional pockets of forest. Pohutukawa is less common along the larger sandy bays such as Doubtless Bay and parts of Bream Bay, but is found on the shores of Whangarei Harbour and outwards to Bream Head, often extending up hill slopes and into regenerating forest.

The rocky headlands and bays that are characteristic of the coastline north of Whangarei are dominated by large old pohutukawa. These trees are icons of the Northland coastal landscape. Extensive stands are found on isolated headlands, and occasionally these extend up valleys containing regenerating forest. Where farmland approaches the coast, pohutukawa is restricted to patches along cliff edges. Small stands and individual trees are found on inaccessible cliff faces. On islands in the Bay of Islands, pohutukawa often forms a continuous fringe around the shoreline ( Forest Research Institute 1989).

In the survey of pohutukawa health during the early 1990s, many of these stands were identified as heavily browsed by possums. The other major threat to pohutukawa is the widespread subdivision of farmland along much of this coast. Concern is increasing about the lack of tree protection policies and the fact that large trees are being felled to make way for building sites and sea views.

There are also stands on off-shore islands including the Cavalli, Three Kings, and Poor Knights.

### Northland's west coast

In contrast to the east coast, pohutukawa exists as scattered pockets between Ninety Mile Beach, where there are vast stretches of highly mobile, exposed, sand dunes, and the Kaipara Harbour. A significant population of pohutukawa is found at Maunganui Bluff. Further south, scattered stands and individual trees are found in valleys. There is one dense stand in a valley near Lake Tanaroa ( Forest Research Institute 1989).

Pohutukawa forest on fixed sand dunes is a distinctive and unique forest type containing rare associations of species (Lisa Forrester, DOC, pers. comm.). One of the finest stands of mature pohutukawa on sand occurs at Te Arai Sanctuary, half way along the Aupouri sand tombolo or Ninety Mile Beach. This Sanctuary was set up to protect one of the largest remaining stands of this forest type. The trees gather sand around their boles to give rise to a unique hill and bowl landscape with gigantic crowned pohutukawa and a diverse mixture of shrubs and ferns beneath.

### Bartlett's rata

Northland is the site of the most recent new tree species to be found in New Zealand, Bartlett's rata, a close relative of pohutukawa, the discovery of which is described by Simpson (2005) as a special event in modern New Zealand botany. John Bartlett, an Auckland schoolteacher, found this relative of pohutukawa in Radar Bush, south-east of Cape Reinga, where he was attracted to the white, soft, spongy bark that separates into thin flakes. Bartlett's rata has a white flower and occurs as an isolated population comprising around 30 trees, with seedlings found growing on tree ferns. The species has been brought into cultivation, has proved easy to propagate, is fast-growing, and it flowers at an early age.

### Te Reinga

The most famous of all the raakau rangatira ko te pohutukawa (venerable pohutukawa trees) is Te Reinga ("the place of leaping") from which the spirits of the dead are believed to depart for their homeland of Hawaiiki. This tree is located at the northernmost extremity of Te rerenga wairua (Cape Reinga). Traditions among the iwi of Aotearoa, recorded in the lament "Ki to kauwhau o te riri, ka rere koe" ("Far away you shall fly, to the north land's end") evoke this sense of journeying back to the point of origin in the islands of the Pacific further north. Pohutukawa was considered to be the first plant to greet the Polynesian settlers and the last to assist them on their homeward journey (Simpson 2005).

Manawa Tawhi, or Great Island in the Three Kings group is where the spirits stop to rest after their departure from Te Reinga. There are significant stands of pohutukawa on Manawa Tawhi.


# Auckland Region

## Auckland's east coast

The fringes of pohutukawa trees found along the coastal cliffs, bays, and harbours of the east coast of the Auckland region are present-day remnants of a formerly dense, diverse, coastal forest. Pohutukawa continues to dominate cliffs and rocky outcrops of the eastern coastline of greater Auckland, albeit as mostly scattered small groves. Large old pohutukawa trees exist as a coastal fringe and as isolated individuals along the Hauraki Gulf to the northern coast of the Firth of Thames. Many of these are under threat from development as urban and peri-urban sprawl of Auckland city continues.

## Auckland's west coast

Coastal forest on volcanic soils of the Waitakere Ranges contains substantial tracts of pohutukawa, often in mixture with other native tree species. Coastal forest with pohutukawa extends northward but there are few pohutukawa along the southern arm of the Kaipara Harbour. The Awhitu Peninsula south-west of Auckland supported significant pohutukawa forest at one time. Today remnants are found along the 60-m-high cliffs, and some scattered trees occur on farmland. The largest known pohutukawa tree in the Auckland area (crown diameter 52 m) is found on the Peninsula.

*One of the largest pohutukawa in the Auckland region is a sprawling multi-stemmed tree on Awhitu Peninsula with a crown diameter of 52 m.*

### Managing trees in the city

The majority of pohutukawa planted in the eastern bays part of Auckland city are eco-sourced from large trees within the local ecological area. The three most notable seed sources are the very large tree in the Parnell Rose Gardens, a tree near the lighthouse on Rangitoto Island, and a tree at Karaka Bay, St Heliers (Howell Davies, Auckland City Council Arborist, pers. comm.).

Howell encounters numerous instances of illegal poisoning, felling, or trimming of pohutukawa, usually carried out to improve sea views. "The loss of trees along cliff lines through development presents many problems with erosion and loss of habitat – and once trees are removed or poisoned, replanting is very difficult or near impossible". His approach is to focus on provision of information about the value of pohutukawa trees along the coastal frontage, including their ecological value as habitat and food sources for native birds and insects. Where possible he provides practical help to residents wishing to improve views by making suggestions about judicious pruning of tree crowns without compromising the long term health and stability of the trees.

### Rangitoto Island

Rangitoto has the country's largest remaining pohutukawa forest. Pohutukawa colonises the dark-coloured volcanic lava that has originated from relatively recent eruptions occurring mostly between AD 1200 and 1500, but some as recently as 1800. Although many other plant species grow in the shelter of the trees, the island is still not completely covered in vegetation. Growth rings show that none of the trees is more than 150–200 years old (Robertson 1986). Allan (1961) concluded from early descriptions by Thomas Kirk that some of the Rangitoto pohutukawa are natural hybrids between pohutukawa and northern rata. Latest studies indicate that the island is dominated by pohutukawa but northern rata and hybrids also occur (Mike Wilcox pers. comm).

The Department of Conservation has successfully completed a major project to eradicate possums and wallabies which were destroying the island's pohutukawa and a major weed eradication programme is under way.

### Islands of the Hauraki Gulf

Pohutukawa also occurs on other islands, including Little Barrier (Hauturu), Great Barrier (Aotea), Waiheke, Tiritiri Matangi, Motutapu, and Kawau. Great Barrier Island has dense, continuous stands of pohutukawa. One of New Zealand's most continuous and least-modified tracts of coastal forest, in which pohutukawa is a prominent component, is found on Little Barrier Island. This pohutukawa and pohutukawa/broadleaved forest occupies about 226 ha (Hamilton 1961).

Most of the Gulf islands are characterised by a discontinuous fringe of pohutukawa along the shore. Forests have been destroyed by land clearing and burning (Hosking unpubl. data). Esler (1978) described pohutukawa stands on Tiritiri Matangi, where there are no possums. Pohutukawa encircles the island on cliffs and coastal slopes, where there is little competition from other vegetation and some degree of protection from farm animals and fires. The few inland trees are likely to pre-date farming activity and have escaped fires. Pohutukawa began to spread naturally when farming ceased in the early 1970s. Despite predictions that vigorous grass growth would suppress regenerating seedlings, saplings more than 1 m high were observed in fernland and along stream banks within 3 years.

### Sacred Grove, Takapuna

Te Urutapu ("sacred grove") is the name given by Ngati Whatua to a stand of large pohutukawa on the coast at the northern end of Takapuna Beach. The reason for the name is not clear but is likely to collectively reflect a variety of values (Simpson 2005). A large multi storey residential block has been built immediately landward of the grove which occurs on both private land and a very popular public coastal reserve. A boarded walkway has been constructed through the grove as there is no beach access during high tide. The grove is an example of a difficult management issue which involves trying to balance the care of important heritage trees, some of which are structurally unsound, and the safety of residents and public. There has been considerable local council and other specialist input in the management of the trees, including topping of selected stems to reduce weight, removal of other stems considered unsafe, and use of strops to prevent sudden failure.


# Waikato Region

Environment Waikato
Regional Council

## The Thames coast

The rocky shores of the west coast of the Coromandel Peninsula are a stronghold of pohutukawa in the Waikato Region. A highway lying between the base of steep hills and the shoreline has probably been responsible for the preservation of an almost continuous fringe of pohutukawa because it has restricted grazing along the coast. Recent plans to remove up to 40 pohutukawa trees for road widening have met with resistance from visitors and from the local community because this coastline is regarded as one of the most scenic in the country. Eventual collaboration between engineers and forest ecology specialists has led to modification of the plans in order to save the trees.

Where farmland reaches the high tide line, and also along the edges of large shallow harbours, pohutukawa trees are few and scattered. Intensive grazing and lack of suitable sites for seedling development are likely to have been responsible for the population decline in these areas (Forest Reseach Institute 1989). One of the largest recorded single trunk diameters for pohutukawa occurs on a farm near Fantail Bay where a tree has a girth exceeding 11 m. There are also examples of trees that are composed entirely of vines compressed together to make what appears to be a single trunk. The series of small stems has not fused into a single stem but externally it looks like one trunk (Gerald Collett, pers. comm.).

## West coast

Much of the west coast of the Waikato Region lacks suitable sites for pohutukawa. The only significant stands are at Mokau, and around parts of the Whaingaroa (Raglan), Aotea, and Kawhia Harbours. Scattered trees, mainly in valleys and on isolated headlands, occur between Raglan and Kawhia (Hosking, Forest Research Institute 1989). South of Kawhia, scattered trees are present as far as Albatross Point and Marokopa.

Many of the pohutukawa around Kawhia Harbour are historically significant and have been given Maori names. Tainui, the ancestral canoe of Waikato and King Country Maori, is said to have been moored to a branch of a pohutukawa tree called Te Tangi-o-Korowhiti, standing on the harbour front at Kawhia (Burstall and Sale 1984). The historic canoe is supposedly buried on the shore of the harbour, its two ends marked by upright stones about 30 m apart. Other large pohutukawa trees on this coast are also famous for association with historical battles and traditional ceremonies and events (Simpson 2005).

## Southern limit on the west coast

Just south of the Waikato region, the southernmost naturally occurring pohutukawa trees on the west coast are located near to the Pukearuhe Scenic Reserve (Clarkson and Boase 1982). In a survey of the north Taranaki coast, Benson (1995) found four groups of trees that are likely to have developed naturally:

1. About 15 pohutukawa trees in eight locations on 30-m-high cliffs lying inland from the Paparoa Reef. Individual trees were 8–10 m high, and many developing saplings were growing in extremely exposed conditions. The trees had thick branchlets and narrow, short leaves. The cliffs are unstable and pohutukawa trees have been lost in several large slips. Land is farmed up to about 1 m from the cliff edge. The trees show evidence of possum damage.
2. One large pohutukawa tree growing behind the cliff edge near the Wai-iti Beach Camp had narrow short leaves which were similar to those of trees near Paparoa Reef. The area was the site of five pa (fortified villages) and a military redoubt in the 1860s, and the tree may have been planted.
3. A large tree growing approximately 10 m from the cliff edge at the top of Pukearuhe Pa. It was 10 m tall, with a girth of 5 m, and had narrow short leaves. The site contained a pa and a military camp up to the mid 1800s. It is not known whether the pohutukawa was planted.
4. About 15 trees growing on hills and sea cliffs near Rapanui. These were up to 8 m tall and were not planted. Their leaves were rounded in shape. They could be the progeny of taller trees planted nearby.

Benson (1995) concluded that pohutukawa on the cliff adjacent to Paparoa Reef were growing under natural conditions and least likely to have been planted or to be the progeny of planted trees. Because the site is so unstable, there is an urgent need for conservation. Simpson (2005) considered that mudstone is an unsuitable substrate for pohutukawa because the cliffs are gradually collapsing. In consequence, the limit of the natural distribution of pohutukawa may be shifting northwards.

## Offshore Islands

A survey of 28 small offshore islands off the west coast of the Coromandel Peninsula (Esler 1978) revealed that pohutukawa was one of the most conspicuous landscape features. Trees were present on most of the shores and coastal slopes, even in gullies susceptible to wind funnelling. Vegetation on most of the islands has been modified by land clearing, fire, and introduced animals. Where rabbits were present, pohutukawa has replaced manuka and has formed pure stands. On one island, healthy saplings were found among 2- to 3-m-tall manuka.

Along the eastern Coromandel there are numerous bare isolated rocks and offshore islands where pohutukawa are common. The largest islands have extensive fringes of pohutukawa despite a long history of Maori occupation and, over the last century, clearing for farming.

## Eastern Coromandel coast

The east coast of the Coromandel Peninsula consists of long stretches of vertical cliffs indented by numerous bays, wide coastal dune systems, and isolated pocket beaches (Environment Waikato 2001). Pohutukawa trees are plentiful, occupying some of the most inhospitable sites on the faces, bases, and tops of cliffs. Dense stands are found at the base of hills surrounding many of the narrow isolated beaches.

The coastal forest, which was once extensive, has been significantly reduced by fires, farming, and forestry, as well as the development of numerous seaside settlements. Pohutukawa populations have been reduced to a single line of trees or small groves along cliff tops. Fencing and land development reach as close to the cliff edge as possible. Despite the increasing pressure for residential subdivision and coastal resort development, pockets of pohutukawa-dominated forest remain on isolated cliffs and in the few coastal reserves. Examples can be seen on cliff tops and headlands between Waihi Beach, Whiritoa, Whangamata, and Tairua, and northward beyond Whitianga.

## Lake Taupo

The pohutukawa stand on Motutaiko Island on the eastern side of Lake Taupo is likely to have been planted by Maori (M. J. Johnston unpubl. data). Two other woody species that do not occur naturally in the area, kawakawa and titoki, are also present. Pohutukawa has probably survived here because the lake modifies winter temperatures in the area with the result that frosts are uncommon on the island.

## Bay of Plenty Region


### Eastern Bay of Plenty

Pohutukawa occurs in an almost continuous fringe along steep rocky cliffs and shores from Opotiki eastwards beyond Te Kaha. The only breaks in the fringe occur in the pocket gravel bays and occasional longer sandy beaches. Trees are never found more than a few hundred metres from the coast. The pohutukawa of Whangaparaoa are considered among the earliest seen by Maori, marking the summertime arrival of the Tainui, Arawa, and Aotea canoes.

Pohutukawa forest is still present on cliffs west of Opotiki, including parts of Ohiwa Harbour. It forms a prominent backdrop to the seaside resorts of Ohope and Whakatane. It is absent from river plains east of Whakatane. Continuous and extensive stands are found along coastal cliffs from Matata to Otamarakau and some stands extend inland to Awakaponga along the eastern flank of the Volcanic Plateau (Forest Research Institute 1989).

### The Waiotahi pohutukawa tunnel

A spectacular pohutukawa stand occurs at Waiotahi, immediately west of Opotiki, where large trees on either side of the main highway arch across to form a tunnel. Trimming of these trees to allow passage of large trucks is a recurring issue. A recent major trimming operation resulted in controversy. This has led to a more formal collaboration between community groups, local iwi, and the national roading authority in planning for the future management of the trees.

### Islands

Pohutukawa is found on numerous offshore islands. The forests of Whakaari (White Island) have survived in spite of the toxic fumes and showers of ash from frequent volcanic eruptions. There are many ancient pohutukawa on Tuhua (Mayor Island), including Nga-uri-apo, a tapu (sacred) burial tree (Simpson 1994).

Removal of goats from Moutuhora (Whale Island) in the late 1960s has allowed pohutukawa to regenerate in grassy areas from seed dispersing from surviving stands (M.C. Smale, pers. comm.).

### Tauranga and western Bay of Plenty

Pohutukawa is absent from the extensive sandy beaches of the western Bay of Plenty, but there are small stands near Pukehina and on headlands at Maketu. It dominates coastal vegetation around Mauao (Mount Maunganui), where deliberately lit fires are an occasional hazard. It occurs on numerous headlands around Tauranga Harbour, and those at either end of Waihi Beach. Many pohutukawa trees have been planted in Tauranga city.

### A century of cattle droving

For over a century until the mid-1990s, the East Coast highway was used regularly as a cattle-droving route between the Gisborne region and the Waikato. Many palatable plant species, including young pohutukawa, disappeared from accessible areas along the road and beaches. Since cattle droving ceased, and where coastal areas have been fenced to exclude grazing animals of local landowners, regeneration of pohutukawa is now occurring — including amongst the plentiful piles of rotting driftwood that accumulate on some beaches.

Over the last decade extensive planting of pohutukawa has been carried out by Opotiki District Council along the eastern Bay of Plenty coast in a collaborative project involving local communities and iwi. Tree survival on shingle and sandy beaches has been poor, but establishment on volcanic ash soil and roading fill has been more successful.

### Rotorua lakes

The only naturally occurring inland populations of pohutukawa are found around the lakes of the Rotorua district, in particular Lakes Okataina, Rotoiti, and Tarawera. Banks of the Tarawera River between the lake outlet and the Tarawera Falls are also fringed with pohutukawa with an understorey of small mangeao, titoki, and mamaku. A small stand on the south eastern shore of Lake Tarawera consists of regrowth that has developed since the last eruption of the mountain in 1886. Pole sized pohutukawa along with rewarewa, kamahi, and other young trees and shrubs, covered the cliffs along the shores of Lake Tarawera within 30 years of the eruption. A few pohutukawa are found on the northern shore of Lake Rotorua and a continuous fringe exists around the northern and western edges of Mokoia Island.

Many pohutukawa trees have been planted around Lake Rotorua, especially in reserves, with some replacing exotic trees, particularly willows. Trees spreading in the Whakarewarewa Thermal Reserve are the progeny of local plantings.

### Natural or cultivated

The Government Botanist Thomas Kirk was the first to note the presence of many "coastal species", including pohutukawa, in the Rotorua lakes district. Clarkson (Clarkson *et al.* 1991) suggested that these fell into one or more of three categories: those planted and cultivated by Maori; those associated with thermal activity; and those found on sites resembling the coastal habitat, i.e., rocky outcrops and cliff faces. He noted that the frequency of these features among the chain of lakes reaching to the coast would have facilitated natural spread inland. He also observed that overseas species closely related to pohutukawa are known as colonisers of volcanic material.

Pohutukawa does extend beyond the Bay of Plenty to the East Coast.

### Gisborne District
### Southern limit on the east coast

At one time pohutukawa may have grown naturally as far south as Gisborne, or even Young Nick's Head. Simpson (2005) considers there may be a northward retreat. Today the southernmost naturally occurring trees on this coast are found on a headland at Mawhai Point. Between this Point and East Cape several stands exist wherever the more stable types of mudstone occur. At East Cape pohutukawa is more common. It is found on coastal cliffs at Te Araroa and Lottin Point. It also forms overarching avenues along roads and along the sides of creeks.

### Te Waha o Rerekohu

At Te Araroa, the famous Te Waha o Rerekohu, with 22 sprawling trunks, is one of the largest existing pohutukawa trees. It has a canopy 40 m in diameter and many low spreading trunks that root wherever they touch the ground. The tree is near the site of a food store where local people left food for Rerekohu, a child destined to become an important Ngati Porou chief (Simpson 2005).

# PART 12 - GUIDELINES FOR PLANTING AND MANAGING POHUTUKAWA

The following recommendations for the planting and early management of pohutukawa are based on current knowledge of the ecology of the species, research trials, and field experience. They cover a range of scenarios, including planting on cleared sites, extension and management of existing stands, and amenity and urban planting. Additional information is available on the Project Crimson website: www.projectcrimson.org.nz

## Planning and resources

- Inspect the proposed site to determine factors that may affect the establishment of planted pohutukawa. Identify the causes of damage to any existing pohutukawa trees.
- Where appropriate, encourage landowners, iwi, and local community groups to collaborate with the local authority in the planning process; provide information, stressing the importance of pohutukawa in the landscape and its role in enhancing stability and biodiversity in coastal areas.
- Consider all options for improving the development of existing pohutukawa, e.g., reduction of possum populations, or fencing to exclude grazing animals.
- If the aim is to maintain or restore the natural integrity of the site, ensure that the proposed planting area lies within the natural geographic range of pohutukawa.
- Determine whether the planting site is appropriate for pohutukawa, taking into account the characteristics of its natural habitat and tree growth potential.
- In developed areas or in confined sites, consider the space required in the long term for the growth of large pohutukawa.
- For large-scale projects in particular, define realistic objectives and the resources needed in order to achieve them, including post-planting maintenance requirements; determine the scale of planting, and the source and quantity of seedlings required each year.
- Consider planting a range of native coastal trees and shrubs including pohutukawa to utilise a range of habitats.

## Preparation of the planting site

- Fence to exclude grazing stock.
- Control local animal pests such as possums and goats.
- Where necessary, provide barriers, signs, and alternative walkways.
- Spot spray grass on open sites; use natural gaps in any woody vegetation cover; remove exotic woody species to create planting sites (although retaining some as temporary shelter may be desirable on exposed sites).

## Seed collection

- Collect seed in dry weather by holding a paper bag over a cluster of capsules and shaking vigorously. Collect from at least 10 trees at least 100 m apart, in order to maintain genetic diversity in the planted stands.
- Use seed as soon as possible after collection.
- Where necessary, store seed temporarily in a refrigerator at 2–4°C.
- Discard seed that has been stored for 12 months or more.

## Raising plants from seed

Pohutukawa normally takes up to 2 years to grow from seed to plantable size (minimum height 40 cm) in the nursery. Large-scale propagation is carried out by commercial nurseries. Smaller numbers of plants can be raised in community-based nurseries.

### *Sowing and germination*

- Prepare a shallow seed tray by filling it to 50 mm with sterilised and moistened seed-raising mix or finely sieved loamy soil that contains no weed seeds.
- Scatter seed thinly. As a guide, allow about 10-20 seeds per square centimetre.
- Cover lightly with sand or finely sieved sterile potting mix or soil. Water with fine mist spray.
- Cover the seed tray with a sheet of plastic or glass to maintain high humidity, and layers of newspaper to reduce direct light.
- Keep trays in a sheltered, preferably warm, area out of wind and direct sun, and away from frost.
- Check for germination after 7 days. When seedlings emerge, remove the plastic or glass and paper coverings. Water daily with a fine mist spray. Over-watering increases the risk of fungal attack (damping off).

### *Plant growth*

- After about 2 months, seedlings should be about 1 cm high with 2-6 leaves.
- Transfer individual seedlings into small containers filled with standard potting mix or weed-free loamy soil to which slow-release NPK fertiliser has been added. For community projects, yoghurt containers, small milk cartons, or similar pots can be used. Commercial nurseries will use propagation cells and standard containers. Make sure that containers have drainage holes.
- Place potted seedlings in a warm sheltered location.
- Transfer seedlings to larger containers 1 year after sowing (autumn). Use polythene planter bags (PB2 or PB3), large milk cartons, or plastic bottles provided with drainage holes.
- After 1 more year, plants should be approximately 50 cm high with a root collar diameter of 8-10 mm. Foliage should be dark green and healthy.
- Insects such as scales or psyllids can be a problem and cause unattractive leaf distortion, but pohutukawa usually outgrows any attack. Control measures are generally unnecessary.

## Planting out

High-quality planting stock, adequate site preparation, good planting practices, and careful maintenance after planting all help to ensure the success of planting programmes.

### *Plant quality*

- Plants should be at least 40 cm high, with a root collar diameter of at least 6 mm, and a balanced root-to-shoot ratio.
- The root system should bind the potting mix so that the tree can be planted without disintegration of the root ball.
- Choose a structural form that is appropriate for the planting site – e.g., a sprawling multi-stemmed form might be unsuitable as a street tree.
- When ordering large numbers of plants from commercial nurseries, inspection for quality can be requested. A small random sample is selected. Plants are removed from containers, the potting mix shaken away, and the root systems checked for any distortion or pot-binding. The whole consignment can be rejected if plant quality is unsatisfactory. Where only a few plants are affected in a small-scale operation, distorted roots can be removed and root systems can be teased out before planting.
- Check planting stock for any undesirable inherent structural flaws such as poor unions between multiple stems. Form pruning using secateurs may be required to remove stems or large branches to reduce development of trees with limbs poorly attached to the main stem.

### *Time of planting*

- The best time to plant is autumn or early winter when the ground is wet and rainfall is likely to be frequent.
- Spring planting is preferable in frost-prone areas. Larger plants will be more tolerant of low temperatures.

### *Site preparation*

- On exposed sites plant establishment will be improved by provision of side shelter:
  - Hardy coastal species such as harakeke, ngaio, taupata, and karo can give lateral protection. On very exposed sites, they should be grown for up to 2 years before the pohutukawa is planted in sheltered gaps. On less exposed sites, pohutukawa can be planted at the same time.

  In small-scale plantings, shade cloth supported by stakes can be used to provide the side shelter.
- Grassy sites should be spot-sprayed with a herbicide such as glyphosate, using a knapsack sprayer. If the area is being retired from grazing, grass height should be reduced just before spot spraying.

### *Plant spacing*

- Spacing on open sites will depend on anticipated survival rates and the amount of weed growth that may be expected.
- Planting at 2 m will require around 5 years for canopy closure, depending on growth rate; wider spacings will require a longer period of grass and weed control.
- When interplanted with other species, spacing should be at 3-4 m. This will produce a dense stand of pohutukawa.
- Spacing in recreational areas or along streets for shelter, shade– or aesthetic purposes should be 10-20 m. The trees can be expected to develop crowns 15-20 m wide and 20 m high.

## *Planting technique*

- Prepare a planting hole at least as deep as the container, so that the root ball can be completely buried. If the site soil is heavy or compacted, loosen the soil around the planting hole to assist root penetration.
- On sandy or nutrient-poor sites, a slow-release NPK fertiliser in the form of pellets or granules can be incorporated at label rates into the soil in the planting hole. Use of fertiliser at time of planting is not essential on more fertile sites such as retired farmland.
- Compost or mulch can be beneficial but is practical only on a small scale. Even placing compost as a mulch can be beneficial.
- Do not plant seedlings that are severely root bound or have, poor root systems. Tease the outer roots and spread them radially within the planting pit. Remedial prune any girdling or deformed roots before planting.
- The soil around the planted tree should be gently firmed in to ensure good contact with the roots and to stabilise the tree.
- Staking should be necessary only if planting tall stock or if planting on particularly windy sites.
- Watering is practical only in small-scale projects but is likely to be beneficial if droughts occur within the first year. Large-scale plantings will benefit from shelter provided by established nurse plants.

## *Maintenance*

- Farm animals, possums and goats will kill newly-uplanted seedlings and must be controlled. Regular inspections are needed to ensure that control measures are adequate and timely.
- Maintenance of fences is essential.
- Vigorous vegetation can overtop newly planted pohutukawa during the first years of planting. Regular inspection of planting sites is essential to make sure that weeds are being suppressed.
  - Weeds must be sprayed *before* they overtop planted pohutukawa seedlings. Care is required to avoid spraying herbicide on foliage, stems or aerial roots. Additional hand releasing may be required.
  - Vigorous grasses must be controlled for 2 years after planting, or until pohutukawa tops are visible above grass height. Regular knapsack spraying with glyphosate (2-3 times annually) may be required.
  - Form pruning of planted pohutukawa from an early age will allow the development of a stem form and crown shape appropriate for the site.
- Continued monitoring of early growth will identify limbs that have poor unions to the main stem that may be best removed if in the long-term they are likely to become a safety concern for trees in high-use areas.

## Management of existing stands

- Established stands or individual pohutukawa trees will benefit from monitoring and timely management where necessary. Possums and grazing stock often remain as major threats to existing pohutukawa.
- Evidence of the presence of possum includes narrow flattened tracks in ground vegetation between trees; claw marks around the base of trunks; unevenly torn leaves in the tree crown or on the ground; knobbly growths on trunks or large branches due to repeated browsing of epicormic shoots; and small piles of droppings.
- Possum control is essential if damage is to be reduced. Tree recovery can be rapid.
- Large-scale trapping and poisoning lines that are maintained regularly are ideal for reducing possum populations over large areas. Local or regional councils can offer advice and sometimes practical assistance.
- Individual trees can be protected by placing at least a 60-cm-wide sheet metal band around the trunk. The tree canopy must not be in contact with that of any other tree.
- Permanently fence out grazing animals; control goats and other browsing feral animals.
- Pruning for tree health reasons is rarely necessary and is not recommended. Management of trees in relation to development and high-use areas is discussed in Part 10. If modification of pohutukawa is considered to be essential:
  - Consult the local council before any work commences as many provide advice and have bylaws restricting removal or modification of established trees.
  - Engage an experience arborist for advice and to undertake any major trimming.

## CONCLUSIONS

Summer, the coast, and pohutukawa, are inextricably linked in the psyche of New Zealanders. Yet farming, development, and introduced pests have taken a huge toll, reducing what was once the dominant species of a continuous coastal forest to a fractured fringe of stands and individual trees. Restoration efforts over the past 2 decades have done much to stem and then reverse the loss. This Bulletin provides further support to the individuals, communities, and local authorities involved in the battle.

In the past many restoration projects failed, or fell short of their potential, because of the lack of practical knowledge and readily available information. Use of eco-sourced seed that fairly represents local populations, grown to form robust well-developed seedlings which are then planted on appropriate sites with care and nurtured during their establishment, not only ensures survival but also rewards the efforts of the folk involved. Similarly, the protection and sympathetic management of existing trees ensures we retain the limited remaining resource.

The accumulated knowledge and experience to date presented in this Bulletin highlight the need for more research in several areas that will contribute to improved guidelines for those establishing and managing pohutukawa. Determining appropriate set backs for development along cliffs and other erosion-prone sites, selection of appropriate stock for planting on different sites including greater knowledge of genetic differences, investigating the role of stem decay in stability of old trees, and advising on their management in high-use areas, are among major issues requiring further research. Continued accumulation of knowledge through both formal research and practical management experience will ensure best practice is applied to the restoration and management of New Zealand's Christmas tree. Stability of our cliffs, shade for our beaches, succour for our birds and insects, and the return of a crimson summer - all of this is possible.

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## Common and scientific names for plant and animal species referred to in the bulletin.

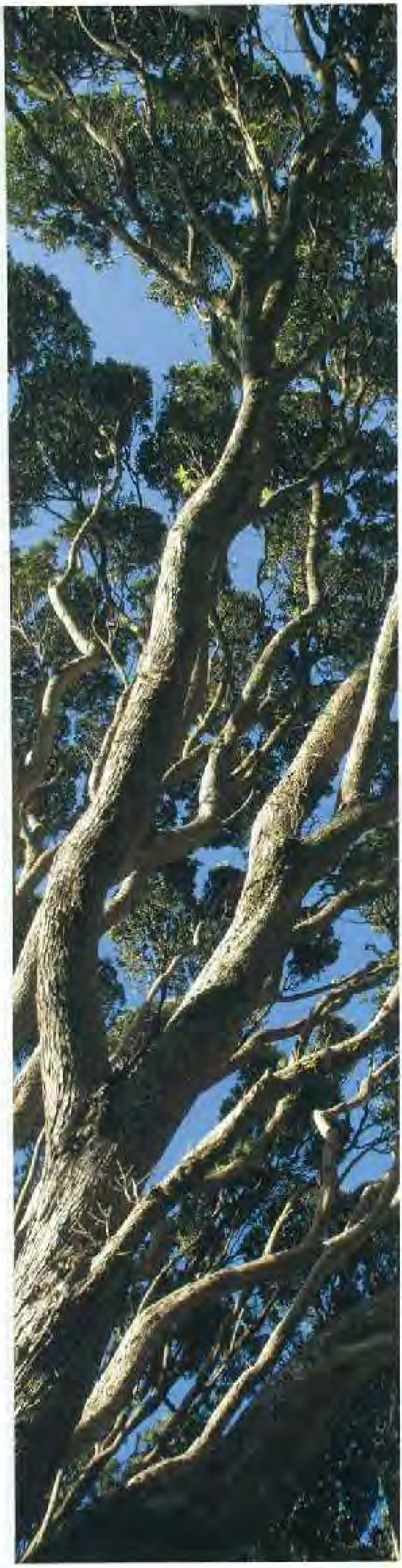
Asterisk indicates the plant or animal is introduced.

### Plants

| Maori or common name | Scientific name |
|---|---|
| Bartlett's rata | *Metrosideros bartlettii* |
| blue morning glory* | *Ipomoea congesta* |
| bracken | *Pteridium esculentum* |
| buckthorn* | *Rhamnus alaternus* |
| coastal astelia | *Astelia banksii* |
| coastal five finger | *Pseudopanax lessonii* |
| eleagnus* | *Elaeagnus pungens* |
| German ivy* | *Senecio mikanioides* |
| glasswort | *Sarcocornia quinqueflora* |
| gorse* | *Ulex europaeus* |
| hangehange | *Geniostoma rupestre* |
| harakeke/flax | *Phormium tenax* |
| hard beech | *Nothofagus truncata* |
| horokaka | *Disphyma australe* |
| houpara | *Pseudopanax lessonii* |
| Japanese honeysuckle* | *Lonicera japonica* |
| jasmine* | *Parsonsia capsularis* |
| jointed rush | *Apodasmia similis* |
| kakaha | *Astelia fragrans* |
| kamahi | *Weinmannia racemosa* |
| kanuka | *Kunzea ericoides* |
| karaka | *Corynocarpus laevigatus* |
| karamu | *Coprosma robusta* |
| karo | *Pittosporum crassifolium* |
| kauri | *Agathis australis* |
| kawakawa | *Macropiper excelsum* |
| Kermadec pohutukawa | *Metrosideros kermadecensis* |
| kikuyu* | *Pennisetum clandestinum* |
| kohekohe | *Dysoxylum spectabile* |
| koromiko | *Hebe stricta, H.macrocarpa* |
| kowhai | *Sophora microphylla* |
| mamaku | *Cyathea medullaris* |
| mangeao | *Litsea calicaris* |
| mangrove | *Avicennia marina* |
| manuka | *Leptospermum scoparium* |
| mapou | *Myrsine australis* |
| marram grass* | *Ammophila arenaria* |
| marsh clubrush | *Bolboschoenus fluviatilis* |
| ngaio | *Myoporum laetum* |
| Norfolk Island pine* | *Araucaria heterophylla* |
| northern rata | *Metrosideros robusta* |
| pampas* | *Cortaderia spp.* |
| Parkinson's rata | *Metrosideros parkinsonii* |
| phoenix palm* | *Phoenix canariensis* |
| pine* | *Pinus* spp. |
| pingao | *Desmoschoenus spiralis* |
| pohuehue | *Muehlenbeckia complexa* |
| pohutukawa | *Metrosideros excelsa* |
| puriri | *Vitex lucens* |
| rengarenga | *Arthropodium cirratum* |
| rewarewa | *Knightia excelsa* |
| sedge (salt marsh) | *Baumea juncea* |
| southern rata | *Metrosideros umbellata* |
| spinifex | *Spinifex sericeus* |
| swamp maire | *Syzygium maire* |
| taraire | *Beilschmiedia tarairi* |
| tauhinu | *Ozothamnus leptophyllus* |
| taupata | *Coprosma repens* |
| tawa | *Beilschmiedia tawa* |
| tawapou | *Pouteria costata* |
| ti kouka | *Cordyline australis* |
| titoki | *Alectryon excelsus* |
| wattle* | *Acacia* spp. |
| whau | *Entelea arborescens* |
| willows* | *Salix* spp. |

### Animals

| Maori or common name | Scientific name |
|---|---|
| bellbird | *Anthornis melanura* |
| brown beetle | *Costelytra zealandica* |
| brushtail possum* | *Trichosurus vulpecula* |
| cormorant, shag | *Phalacrocorax spp.* |
| gecko | *Hoplodactylus spp.* |
| goat* | *Capra hircus* |
| grass grub | *Costelytra, Odontria, Pyronota* |
| kaka | *Nestor meridionalis* |
| rabbit* | *Oryctolagus cuniculus* |
| short-tailed bat | *Mystacina tuberculata* |
| stick insect | *Phasmatidae* |
| stitchbird | *Notiomystis cincta* |
| toredo worm* | *Toredo sp.* |
| tui | *Prosthemadera novaeseelandiae* |
| white heron | *Egretta alba* |



PROJECT CRIMSON

renewing pohutukawa and rata

with Meridian Energy

The Project Crimson Trust was formed after a study (Forest Research Institute 1989) showed that 90% of New Zealand's original coastal pohutukawa stands had been lost to pastoral farming and development. Even more disturbing was the finding that remaining stands were being ravaged by possums and that regeneration from seed was inhibited in many areas.

New Zealand Forest Products (now Carter Holt Harvey), recognising that urgent action was needed to reverse the decline of one of New Zealand's most treasured trees, formed the Trust in partnership with the Department of Conservation. Project Crimson is a not-for-profit organisation dedicated to the protection and restoration of pohutukawa throughout its natural range. Its activities were recently extended to include tree rata. While much effort is focussed on projects that involve local communities, the Trust also provides advocacy, research funding, and support for education programmes.

### Protection

Fencing to exclude grazing animals is seen by the Trust to be essential for the protection of existing pohutukawa stands and the natural development of seedlings. Support for restoration plantings is often dependent on the sites being permanently fenced prior to any planting taking place. Possum control through trapping and poisoning is also funded by Project Crimson.

### Restoration

Many coastal communities are keen to re-establish pohutukawa by planting it on open sites or in areas where there are only scattered trees. Project Crimson supports these initiatives through direct funding and the provision of trees. Eco-sourced seed is grown under contract to the Trust by community and commercial nurseries.

### Research

The Trust has supported research on topics such as pollination and seed formation, evolution of the genus *Metrosideros*, and establishment of pohutukawa on Bay of Plenty beaches.

### Advocacy

Project Crimson promotes the preservation of threatened pohutukawa and rata trees by finding solutions that accommodate the needs of all parties and minimise impact on the trees. It works with local authorities to encourage the planting of pohutukawa and rata in parks and reserves and the appropriate management of trees in urban areas.

### Education

The Trust recognises that the education of children is the best way to ensure the future of pohutukawa and rata. Support for school-based projects, involvement of children in planting days, and production of educational material have always been high priorities for Project Crimson.

Find out more about Project Crimson by visiting our website www.projectcrimson.org.nz or writing to:

Project Crimson Trust, P.O. Box 10420, Wellington.

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Ensis is an unincorporated joint venture between Scion (a New Zealand Crown Research Institute) and CSIRO Forestry and Forest Products. Under its Native Species Research Programme, the planning and management of a range of native tree species is being evaluated from timber production as well as environmental and social standpoints.

For information on management of native species, contact Dr David Bergin, Ensis,
Private Bag 3020, Rotorua. Phone (07) 343 5899, Fax (07) 343 5332, email: david.bergin@ensisjv.com

Tane's Tree Trust was formed in 2002 to encourage New Zealand landowners to plant and sustainably manage native trees for multiple uses. The objectives of the Trust are: promotion of native forestry as an attractive land use option by consolidating and advancing the state of knowledge of native tree species; maximising economic incentives for establishing natives; resolving legal and political obstacles to the planting of natives; and encouragement of knowledge-sharing amongst stakeholders.

If you are interested in joining the network (subscriptions range from $30 for individual members to $110 for corporate members), or require further information, contact the Chairman: Ian Barton,
P. O. Box 1169, Pukekohe. Phone (09) 239 2049, email ibtrees@wc.net.nz .

## INDIGENOUS TREE BULLETIN SERIES

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