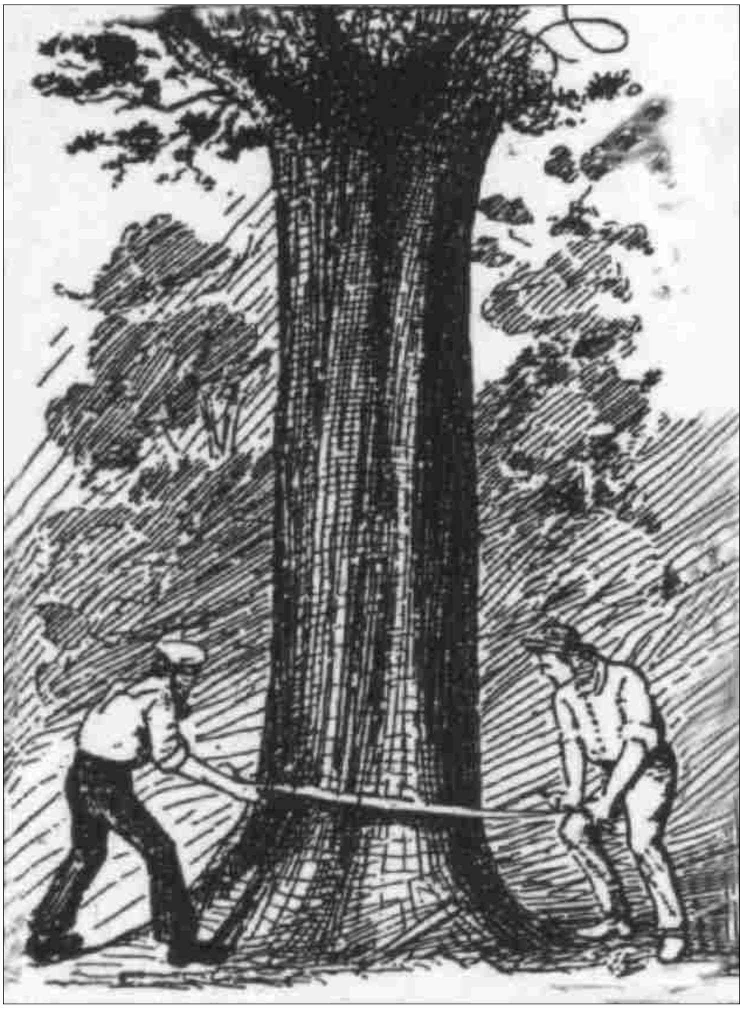
Australia and New Zealand Forest Histories



Araucarian Forests

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'Tree fellers' felling a kauri tree. From R. Sherrin and J. Wallace 1890. *Early History of New Zealand*, Auckland: Brett.

Contents

Preface

The Australian Forest History aims to advance the understanding of the interactions between people and Australia's forests and woodlands through the research that our members undertake and by making the results widely available. To this end we have added this series of Occasional Papers to the series conference proceedings that we have put out every three years or so since 1988. The Occasional Papers enable us to make material available outside that timetable and format. The papers are being made available to members and libraries in conventional 'hard copy', and also made available in an electronic version on the Internet.

This publication results from our continuing collaboration with the Forest History Group 6.07.01 of the International Union of Forest Research Organisations (IUFRO). The papers were presented at a Symposium on 'The History of the Araucarian Forests' that was held in the Queensland Museum on 9 August 2005 in association with the XXII IUFRO World Congress that was being held in Brisbane at that time. We were pleased to welcome many delegates from that Congress to the Symposium.

The topic was chosen because the wide distribution of the Araucariaceae family across the Southern Hemisphere makes it of interest to an international meeting, because it is particularly important in Queensland where the Symposium was held, and because of the recent discovery of the rare wollemi pine in New South Wales. The papers in this publication span the range of interests and disciplines that are needed to engage forest history.

The Society greatly appreciated the welcome that Dr R. Anderson OAM, Vice-Chairman of the Board of the Queensland Museum, gave to those attending the Symposium, and the Society is most grateful to Dr Margaret Kowald who facilitated holding the Symposium in the Museum.

Brett Stubbs
President
Australian Forest History Society Inc.

Biogeography of Araucariaceae

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Queensland Museum, South Brisbane

Key words: *Agathis, Araucaria, Wollemia, classification, evolution, fossils*

Introduction

The Araucariacae, with an extensive fossil record dating to the Mesozoic, has long been of interest to palaeobotanists and plant geographers. Extant members of the family (*Araucaria* Juss., *Agathis* Salisbury, and *Wollemia* WG Jones, KD Hill & JM Allen) are confined predominantly to southern regions but as first recognised nearly a century ago (Seward and Ford 1906), the family was formerly distributed over wide areas of both hemispheres. At that time, the family comprised two extant genera—*Araucaria* and *Agathis*—and was considered to occupy an isolated position amongst the conifers. Following the discovery of living *Wollemia* (Jones et al. 1995), molecular sequence data of extant members have provided some understanding of the inter-relationships within the family and of its relationships with the other 'southern' conifer family, Podocarpaceae (Setoguchi et al. 1998).

The incorporation of whole plant data, including morphological and anatomical characters of living and fossil members, may be expected to provide a robust basis for plotting the distribution of the family in time and space thereby yielding meaningful insights into its evolution. In this context morphological and anatomical analyses of recently discovered fossil araucarians have provided further insights into the past diversity and distribution of the family (Stockey 1982, 1994).

The most recent catalogue of extant Araucariaceae (Farjon 1998) lists 41 species grouped into three genera. Although no modern detailed taxonomic treatment of the Araucariaceae is available, several general works (Silba 1986, Page 1990) provide useful accounts of the family, notwithstanding that all predate the discovery of *Wollemia.* An extensive literature is available for fossil taxa assigned to the family, but many of the specimens are impressions or poorly preserved compressions lacking diagnostic characters and so must be treated with caution. In what follows, only reliably identified material is considered unless otherwise specified.

Extant representatives

Agathis *Salisbury*

Agathis, usually a forest emergent, extends from New Zealand and eastern Australia along the frontal arc to Malesia and Fiji. Species number from at least 13 (Page 1990) to 21 (Laubenfels 1988, Farjon 1998), depending on criteria used to delimit species. Sectional classifications based on external cuticle characters (Page 1980) or on the shapes of microsporophylls, cone scale tips, and seeds (Laubenfels 1988) are not confirmed by cuticle micromorphology (Stockey & Atkinson 1993). Moreover, neither classification is supported by clades generated from cladistic analyses of the plastid gene, rbcL, sequence data (Setogouchi et al. 1998, Stöckler et al. 2002).

Araucaria *Juss.*

Araucaria is the most geographically widespread genus of the Araucariaceae, with a range from South America to eastern Australia and islands in the southwest Pacific. It contains 18-20 extant species, most of which are forest emergents, grouped into four sections as outlined in Table 1.

Table 1: The sections of extant *Araucaria*, their defining characters, and geographic distribution

Section	Characters	Distribution
Eutacta Endlicher	Adult leaves small, awl-like, often keeled, imbricate, erect; juvenile leaves acicular; stomatal orientation oblique or horizontal; seed cone scales thinly winged and shed with seed; vascular trace to bract-scale single; germination epigeal.	New Caledonia, New Guinea, Norfolk Island, Australia
Araucaria Juss. (= *Columbea* Salisb.)	Adult leaves large, flat, generally thin; juvenile leaves not acicular; stomatal orientation vertical; seed cone-scales nut-like, wings absent, seed retained on scale at shedding; vascular trace to bract-scale single; germination hypogeal.	South America
Intermedia White	Adult leaves large, flat, generally thin; juvenile leaves not acicular; stomatal orientation vertical; seed cone-scales with broad wings; seed retained on scale at shedding; germination epigeal.	New Guinea
Bunya Wilde & Eames	Adult leaves large flat, spreading, imbricate; juvenile leaves not acicular; stomatal orientation vertical seed cone-scales large, woody' wingless; seed shed from scale at maturity; trace to bract-scale double; germination hypogeal	Australia

Note: Adapted from Stockey 1982, Stockey & Ko 1986. The sectional name *Araucaria* replaces *Columbea* to satisfy nomenclatural requirements.

Wollemia *WG Jones, KD Hill & JM Allen*

Wollemia is a monotypic genus (Jones et al. 1995) with little morphological or genetic variation observable between the less than 100 known trees that grow in three stands along the floor of a gorge in the Wollemi National Park, New South Wales (Royal Botanic Gardens Sydney 2005).

Relationships between and within extant genera of Araucariaceae

Taxa can be classified into hierarchical groups by 'cladistical analysis' on the basis of shared characters. Relationships between the three extant genera of the Araucariaceae and the Podocarpaceae, as suggested by four cladistic analyses, confirm the two families to be sister groups (Stefanović et al. 1998, Fig. 1). However, interrelationships of the three genera of the Araucariaceae are ambiguous. Three cladistic analyses based on gene sequences (Gilmour & Hill 1997, Stefanović et al. 1998, Wagstaff 2004) and one based on morphological/anatomical data place *Wollemia* and *Agathis* in the same 'clade', showing them to be descended from a common ancestor (Figure 2B). A fourth family tree, or 'cladogram' based on gene sequences (Setoguchi et al. 1998) has *Araucaria* and *Agathis* as sister taxa (Figure 2A).

Support for the presently recognized Sections within *Araucaria* is afforded by the analyses that include at least one species from each Section in the sampling protocol (Setoguchi *et al.* 1998, Stöckler *et al.* 2002). However, in each instance the resulting cladogram suggests there are three, not four, groupings in the genus. This reduction in grouping number results from Sections *Intermedia* and *Bunya* being treated as sister groups—i.e. derived from an immediate common ancestor—in the gene sequence analyses (Gilmour & Hill 1997, Setoguchi *et al.* 1998) and *Araucaria* and *Bunya* being sister groups in the morphological based analyses presented herein.

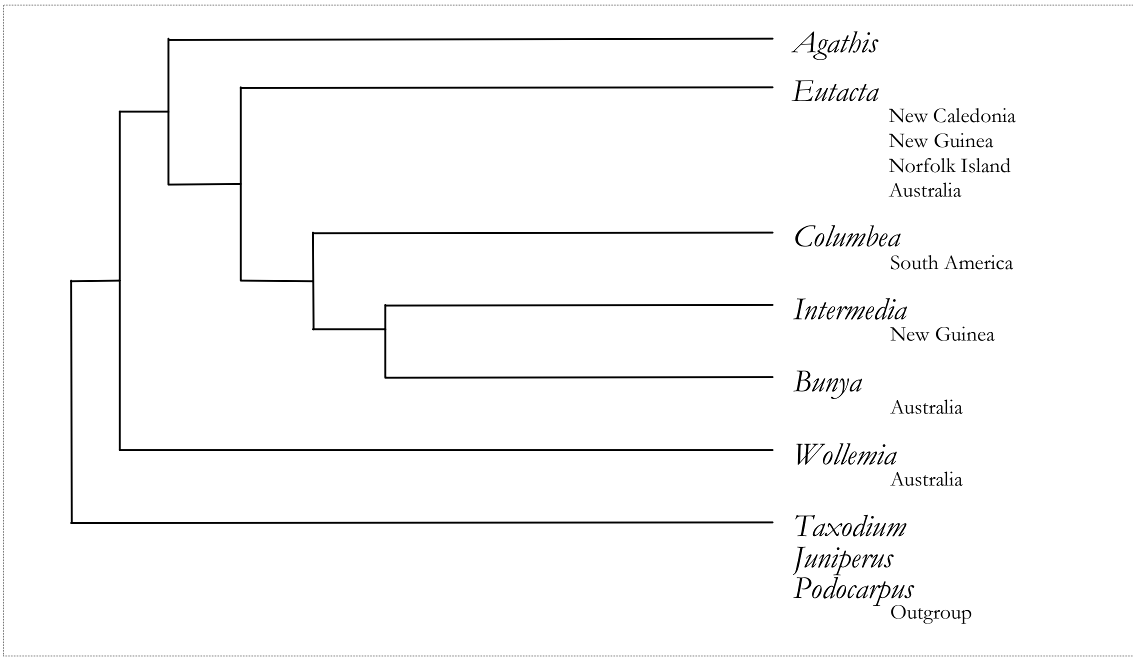

Figure 1: Consensus tree showing the relationships of the genera of Araucariaceae, based on rbcL sequences, with the geographical distributions of each Section of *Araucaria* superimposed. Adapted from Setoguchi et al. (1998).

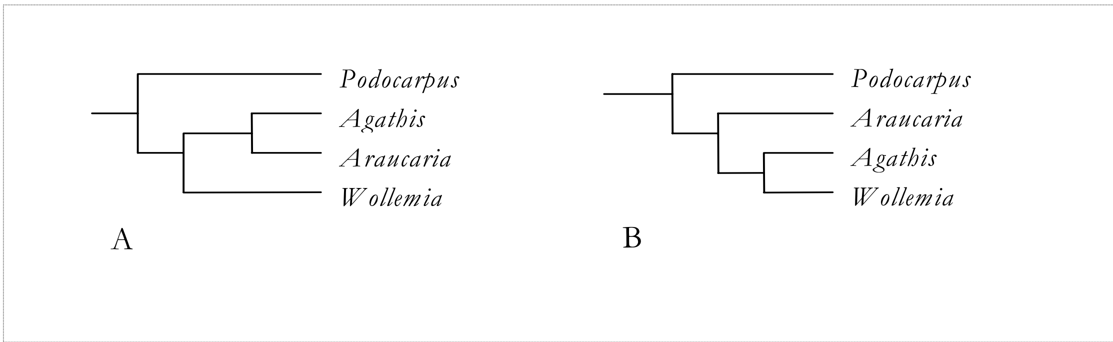

Figure 2. Cladograms, based on molecular sequences, expressing relationships between the genera of Araucariaceae. A. Cladogram resolved by Setoguchi et al.(1998); B. Cladogram resolved by Gilmour and Hill (1997), Stefanović et al. (1998), and Wagstaff (2004).

Formal taxonomic groupings based on morphological criteria have not been upheld for *Agathis*. However, cladistic analysis of rbcL sequences (Stöckler et al. 2002) segregate the genus into two, with the New Zealand endemic, *A. australis*, as sister taxon to the remainder. This, in turn, resolves into three clades, one of which is restricted to New Caledonia, one with species in Australia and one in Borneo, and the other with one species in each of Australia, Fiji, and Vanuatu (Fig.3).

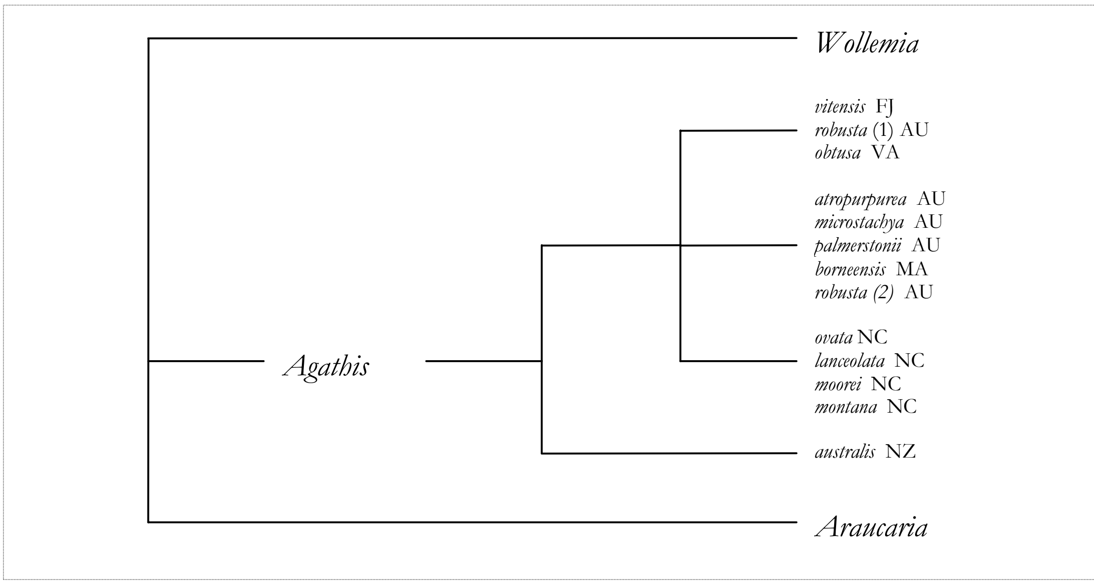

Figure 3: The relationships between the species of *Agathis* along with their geographical distributions. Adapted from Stöckler et al. (2002). AU, Australia; FJ, Fiji; MA, Malesia and Philippines; NC, New Cledonia; NZ, New Zealand; VA, Vanuatu.

Fossil representatives

The fossil record confirms a rich history of the Araucariaceae dating to the Mesozoic when the family was represented in both the Northern and Southern Hemispheres. Well-preserved reproductive structures and foliage date to the Jurassic in England, the United States, India and South America and to the Cretaceous of Japan and Saghalien (an adjacent Russian island), New Zealand, South Africa, Antarctica, and Australia (Stockey 1990, 1994; Hernandez-Castillo & Stockey 2002). Less certainly of araucarian affinities are many of the pre-Jurassic fossils of 'araucarian' foliage and wood (Stockey 1982). For instance, although leaf form of *Brachyphyllum* Lindley & Hutton resembles that of *Araucaria*, only a few of the fossils referred to that category have cuticle diagnostic of the family, while others have been shown to be consistent with the extinct conifer family Cheirolepidaceae (Stockey 1982). *Araucarioxylon* Kraus accommodates fossil wood consistent with the Araucariaceae and also of other disparate groups including that of cordaites (Stockey 1982).

Jurassic and younger reproductive and foliage fossils unquestionably of araucarian affinities include representatives of all extant as well as extinct sections of *Araucaria* (Stockey et al. 1992, Ohsawa et al. 1995, Pole 1995, Hill & Brodribb 1999). *Agathis* has been reliably traced to the Early Cretaceous (Albian), based on organically preserved foliage, but lacking cuticle (Cantrill 1992), and *Wollemia* to the Turonian on the basis of *Dilwynites*, a fossil pollen taxon that replicates pollen of extant *Wollemia* (Chambers et al. 1998, Dettmann & Jarzen 2000). There are foliage fossils of Late Mesozoic and Tertiary of undoubted araucarian affinity, but distinct from *Araucaria, Agathis,* and *Wollemia* and believed to represent extinct members of the family. In this category are several species of *Araucarioides* Hill & Bigwood. The pollen taxon, *Araucariacites* Cookson, which is widespread in Mesozoic and Tertiary sediments, accommodates pollen of the *Agathis*- and *Araucaria*-type; pollen of *Agathis* and *Araucaria* are morphologically similar and difficult to discriminate between in the fossil pollen record.

Fossil *Araucaria*

As noted above there is a fossil record of all four sections of extant *Araucaria*; selected fossil taxa representing each of the sections are mentioned and/or discussed below. Also represented in the fossil record are taxa that have been allocated to two extinct sections that combine characters of several extant sections or have features not known in living members of the genus. Additionally there are several taxa that include fossils possessing features of *Araucaria*, but whose sectional affinities are indeterminate.

Section *Eutacta*

The section, which today is widespread in the southwest Pacific, is known as fossil in Mesozoic sediments from both hemispheres. Northern Hemisphere representatives include the Jurassic cones and cone scales of *Araucaricites phillipsi* Kendall as well as leaves and pollen cones referred to *Brachyphyllum mamillare* Lindley & Hutton from England (Stockey 1994), and the Early Cretaceous cones of *Araucaria cutchensis* (Feistmantel) from the Early Cretaceous of India (Stockey 1994). Foliage with preserved cuticle has been confirmed from the Early Cretaceous of Victoria, Australia (Cantrill 1992) and there are numerous records of foliage and cuticle from the Tertiary of Australia and New Zealand (Hill and Brodribb 1999).

Section *Araucaria* (= *Columbea*)

Foliage remains from the Tertiary of Rio Negro, Argentina and Victoria, Australia assigned to *Araucaria nathorstii* Dusén and to *A. balcombensis* (Selling) respectively are considered representatives of this section (Stockey 1994, Hill & Brodribb 1999). The cone taxon, *A. nipponensis* Stockey, Nishida & Nishida reported from the Upper Cretaceous of Hokkaido, Japan and nearby Saghalien, Russia, is similar to those of Section *Araucaria*, but also possesses characters of Sections *Eutacta* and *Intermedia* (Stockey et al.1994).

Section *Intermedia*

Fossil leaves of *Araucaria haastii* Ettingshausen and cone scales from the Late Cretaceous of New Zealand conform with this section (Stockey 1994, Pole 1995).

Section *Bunya*

Araucaria mirabilis (Spegazzini), based on permineralised cones from the Jurassic Petrified Forest at Cerro Cuadrado, Argentina, conforms with Section *Bunya*, which today is represented by a single species, *A. bidwillii*, in eastern Queensland. Exceptionally preserved anatomical detail of the fossil cones reveals that two vascular strands lead from the axis to the cone scale complexes, which have winged bracts and vascularized ovuliferous scale tips free from the bract for about half their length. Embryos are similar to those of *A. bidwillii*. 'Seedlings' with swollen hypocotyls were described, but these woody corm-like structures have been reinterpreted as lignotubers and similar to the burls that develop under the bark on living Bunya pines (Stockey 1994, Hernandez-Castillo & Stockey 2002, Stockey 2002). Cones included in *A. sphaerocarpa* Carruthers, from the Middle Jurassic of England, have seeds borne on ovuliferous scales that are anatomically similar to the seeds of living Bunyas (Hernandez-Castillo & Stockey 2002).

There are no reliable fossil records of the section from Australian sediments, and thus far, no record from the Tertiary worldwide.

Section *Perpendiculares* Pole

Pole (1995, p. 1074) proposed the section on the basis of fossil leaves 'having stomate orientation predominantly transverse to the long axis'. The section is represented by a single foliage taxon, *Araucaria desmondii* Pole, from the early Late Cretaceous of New Zealand.

Section *Yezonia* Ohsawa, Nishida & Nishida

This section was proposed for araucarian plants that bore *Brachyphyllum*-like foliage and *Eutacta*-like seed cones, and is based on permineralised vegetative and reproductive fossils of *Araucaria vulgaris*

(Stopes & Fuji) from the Late Cretaceous of Japan (Ohsawa et al. 1995). The single taxon includes foliage originally described as *Yezonia vulgaris* Stopes & Fuji and cones allocated to *A. nihongii* Stockey, Nishida & Nishida. The helically arranged leaves are imbricate with stomates in discontinuous rows restricted to the abaxial surface. Cones are spherical with winged bracts and thin ovuliferous scales. The cones combine features of those of Section *Eutacta* (scales with thin wings) and of Section *Araucaria* (cone-scale complexes with vasculature in a single arched row) and Section *Bunya* (double vasculature to the scales at axis).

Araucaria Section unknown

Cones similar to, but larger than, those of *Araucaria mirabilis* have been collected recently from the Lower Cretaceous of Chubut, Argentina. These, which are referred to *A. 'alvarezii'*, have ligulate scales typical of the genus but await systematic documentation (Dernbach & Jung 2002). Foliage fossils referred to *Araucaria*, many with preserved cuticle, but of indeterminate sectional affiliation, occur frequently in Cretaceous and Tertiary sediments of Australia, New Zealand, and Antarctica (Hill & Brodribb 1999, Pole 2000, Cantrill & Falcon-Lang 2001). From the same region, cone scales and impressions of pollen cones occur at some localities, and some of the Australian foliage and cone fossils were considered to compare favourably with *Wollemia* (Chambers et al. 1998). However, arguments against identifying these fossils with *Wollemia* have been outlined by Hill & Brodribb (1999) and Pole (2000).

Fossil *Agathis*

In their review of fossil Araucariaceae, Hill and Brodribb (1999) consider the oldest reliably identified remains to be those from the Middle Eocene of Australia. Thus, they question the generic placement of *A. jurassica* White, a foliage taxon associated with seed cone scales, but without organic preservation, from the Jurassic Fish Beds, Talbragar, New South Wales; this taxon has also been compared with *Wollemia*, but detailed analysis has not yet been undertaken. Also without cuticle preservation is *Agathis victoriensis* Cantrill (1992) from the Albian of Victoria, a record accepted by Stockey (1994). Mid-Cretaceous foliage from New Zealand has been identified as *Agathis*, but this awaits systematic documentation (Daniel et al. 1989). According to Stöckler et al. (2002) the fossil foliage closely resembles that of extant *A. australis*, which they argue evolved from a New Zealand ancestor rather than from a migrant Australian taxon.

Securely identified compression fossils of *Agathis* are all from Middle Eocene and later sediments of southern Australia. Most are of foliage, but ovulate cone scales have been reported from the Oligocene of Tasmania (Carpenter 1991).

Fossil *Wollemia*

No macrofossils have been reliably identified as representing *Wollemia*, but *Agathis jurassica* (noted above), leaf fossils included in *Araucarioides* Bigwood & Hill, and various Cretaceous leaves, ovuliferous cone scales and pollen cones from Australia have been nominated as potential candidates (Chambers et al. 1998, Hill & Brodribb 1999). The latter authors note important differences between Tertiary *Araucarioides* and *Wollemia*, and Pole (2000, p.156) considers that Queensland Winton Formation impression fossils assigned to *Araucaria* are 'unlikely to represent *Wollemia*'. Nevertheless, reassessment of araucarian macrofossils may provide evidence of *Wollemia* foliage/reproductive structures in the fossil record.

Pollen evidence provides a fossil record of *Wollemia*. The distinctive pollen of *Wollemia* replicates the fossil pollen taxon, *Dilwynites* Harris, which has oldest occurrences in the Late Cretaceous (Turonian) of Australia and Antarctica and a Late Cretaceous-Early Tertiary distribution range that encompasses Australia, New Zealand and Antarctica. Youngest recorded records of *Dilwynites* are in the Miocene of New Zealand and late Pliocene of Australia (Macphail *et al* 1995, Dettmann & Jarzen 2000).

Extinct and indeterminate Araucariaceae

Araucarioides Bigwood & R.Hill

The genus was proposed for Araucariaceae leaf fossils that cannot be unequivocally be placed in an extant genus (Bigwood & Hill 1985). Although instituted without knowledge of leaf form/anatomy of *Wollemia*, the fossil genus is considered distinct from *Wollemia, Agathis*, and *Araucaria* (Hill & Brodribb 1999, Pole 2000). Described species of *Araucarioides* are from Albian and Eocene sediments of southeastern Australia and the Campanian of New Zealand (Hill & Brodribb 1999).

Araucarites Presl

Araucarites is a fossil genus with araucarian-like cones and cone scales which cannot be assigned with certainty to extant members of the family. Thus, *Araucarites* has been the repository of Mesozoic and Tertiary araucarian cones (and cone scales) lacking diagnostic characters or requiring further detailed investigation. These have been reported from Mesozoic sediments in both hemispheres and are common in Jurassic-Tertiary sediments of austral areas.

Biogeographic implications

Records of reliably identified araucarian fossils demonstrate that the family has a history extending to at least the Early Jurassic. Of extant taxa, *Araucaria* has the longest history dating to the Early Jurassic, and the genus persisted and diversified in both hemispheres during the Late Mesozoic. By latest Cretaceous-earliest Tertiary times all extant sections of *Araucaria* had differentiated, and in addition there were representatives of groups that are now extinct. Tertiary fossil occurrences imply restriction of the distribution range of the genus to the Southern Hemisphere encompassing the southern Gondwanan region of South America, Antarctica, New Zealand, and Australia. By latest Tertiary times, *Araucaria* was extinct on Antarctica and New Zealand, and in Australia was represented only along the continent's northeastern coastal margin having contracted from Western and southern Australia during sustained periods of climatic drying and increased seasonality (Kershaw & Wagstaff 2001). Today, the genus occupies cloud forests in South America and 'drier' rainforests of northeastern Australia and New Guinea. The area to the east, encompassing New Caledonia and subjacent islands, is the present centre of diversity of the genus.

Within *Araucaria*, Sections *Bunya* and *Eutacta* have the longest histories, both dating to the Jurassic and both occurring in the two hemispheres during the Mesozoic. Mesozoic records of *Bunya* include beautifully preserved cones, *A. mirabilis*, from the Jurassic of Patagonia, but there are scant records of its Tertiary history. Today the section is represented by a single species, *A. bidwillii*, in eastern Queensland. Section *Eutacta*, which today contains the most species, is concentrated in the southwest Pacific region. It is known from diverse Mesozoic fossils in both hemispheres, but Tertiary macrofossils are known only from Australia and New Zealand. These include numerous foliage taxa that are common at some localities in southern Australia and New Zealand.

Section *Araucaria*, which is represented by two living species in South America, has a history extending to the Early Tertiary in South America and southern Australia, and may have differentiated earlier if the cone taxon, *A. nipponensis*, proves to be an early member (Late Cretaceous) of this section. As mentioned above, the cone taxon is not entirely conformable with cones of present day members of the section. The fossil record of Section *Intermedia* is limited, being known only from foliage and cone scales from the Late Cretaceous of New Zealand. Extant members are restricted to Papua New Guinea.

Amongst the fossils allocated to *Araucaria* are foliage and cone taxa that possess character combinations not known in living members of the genus. These fossils are believed to have expressed higher diversity levels in the past than at present, and have provided the basis for adding extinct sections to the genus. On macrofossil evidence presently accrued, it would appear that diversification of *Araucaria* accelerated during Cretaceous-Early Tertiary times, a time period during which the other two extant araucarian genera, *Wollemia* and *Agathis*, enter the fossil record.

Undisputed fossils of *Agathis* occur in Middle Eocene and later sediments of southern Australia, but, if records of Victorian *Agathis victoriensis* are confirmed as belonging to the genus, then its history dates to the Early Cretaceous (Albian). Contraction of the genus to northeastern Queensland, where five species survive today, occurred in latest Tertiary-Quaternary times (Kershaw & Wagstaff 2001). Fossil occurrences of *Agathis* in New Zealand have yet to be confirmed, but Stöckler *et al.* (2002) accept a record for undescribed mid-Cretaceous foliage. Today there is one species in New Zealand, and the remainder of non-Australian taxa occur in New Caledonia, Vanuata, Fiji, and Malesia with the most northern occurrence in the Philippines.

The known fossil distribution of *Wollemia* is based on fossil pollen, which resolves first appearances of the genus in the Late Cretaceous (Turonian) and a Late Cretaceous-Early Tertiary distribution in Antarctica, New Zealand and Australia. By the latest Tertiary, *Wollemia* was confined to Australia and New Zealand, and today is relict at one locality in New South Wales. Older (Early Jurassic, Early Cretaceous) macrofossil taxa nominated as potentially representing *Wollemia* are all preserved as impressions lacking cuticular and anatomical detail, and should not be accepted as unambiguous evidence of the genus.

The Araucariaceae has a long and complex history, some understanding of which is revealed by the fossil record. This underscores the antiquity of *Araucaria*, and expresses the higher diversity levels and more widespread geographical distribution of the genus in the past than at present. It also emphasises earlier appearances of *Araucaria* (Early Jurassic) than either *Agathis* (late Early Cretaceous) or *Wollemia* (early Late Cretaceous). In this context the fossil record lends more support to phylogenies that resolve *Araucaria* occupying a more basal position in the family than *Agathis* and *Wollemia*.

Acknowledgements

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A history of kauri

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Keywords: *Agathis australis, dendrochronology, kauri, New Zealand, palynology, tree-ring analysis*

Introduction

The New Zealand kauri (*Agathis australis*) is a species notable for the height, bulk and longevity of the trees, and the good quality of its timber. Kauri towers above the canopy of the surrounding lowland forest (Figure 1), often occurring in stands of trees which are usually of a similar age. There are records of kauri attaining heights over 50 metres, girths greater than ten metres, and of trees which are estimated to be well over 1000 years old. These attributes of kauri—size, age, as well as timber quantity and quality—combine to make it an iconic tree which holds a special place in New Zealand landscape and culture. This is despite (or rather enhanced by) the natural distribution of kauri being restricted to the warm temperate forests of the upper North Island (Figure 2). Ferdinand Hochstetter, an Austrian scientist who visited New Zealand in the 1850s wrote that 'Three degrees of longitude [173°–176° long] and three degrees of latitude [34½° - 37½° lat]…encompasses the entire and the only range of this remarkable tree' (Hochstetter 1867: 141), although in the modern day, planted specimens can be found throughout the country.

Kauri features in the Maori creation myth. When Tane, god and father of the forests and its creatures, separated his parents Rangi nui (Sky Father) and Papa-tu-a-nuku (Earth mother) to bring light and beauty into a dark world, he grew like a kauri. The tall, solid and strong looking trees are often described as seeming to hold the earth and sky apart, and the kauri groves as cathedral-like. During the late 19th and early 20th centuries, kauri was used widely in the built environment of cities and towns throughout the country, and appears in New Zealand literature and art. Jane Mander's 1920 classic tale, *The Story of a New Zealand River*, is set at a kauri mill in the remote Kaipara region. The cover of the 2001 Vintage edition of this book is graced by Charles Heaphy's 1839 painting of a kauri logging camp on the Wairoa River, Kaipara. Today, the kauri forests are notable tourist attractions, and kauri recovered from peat bogs and swamps is transformed into furniture, bowls, boxes, and other items, prized for both the beauty and antiquity of the wood.

The economic and social history of kauri, from the late 1700s when Europeans arrived in New Zealand and the kauri forests began to be exploited for timber, is well documented. Reed (1953, 1964), Sale (1978), Halkett and Sale (1986) and most recently, Orwin (2004) variously write about: Maori use of kauri; the development of the kauri logging industry; bush life and the kauri mill towns; the efforts of conservationists to preserve what was left of the kauri forests from further logging; and where to find notable trees. These books are often illustrated by pictures from the archives of bush photographers such as the Burton Brothers and Tudor Collins. Their photographs clearly show the scale of land clearance, the size of the trees and the quantity of timber felled during the heydey of the kauri industry.

Figure 1: Mature kauri, Waipoua Forest, Northland, New Zealand

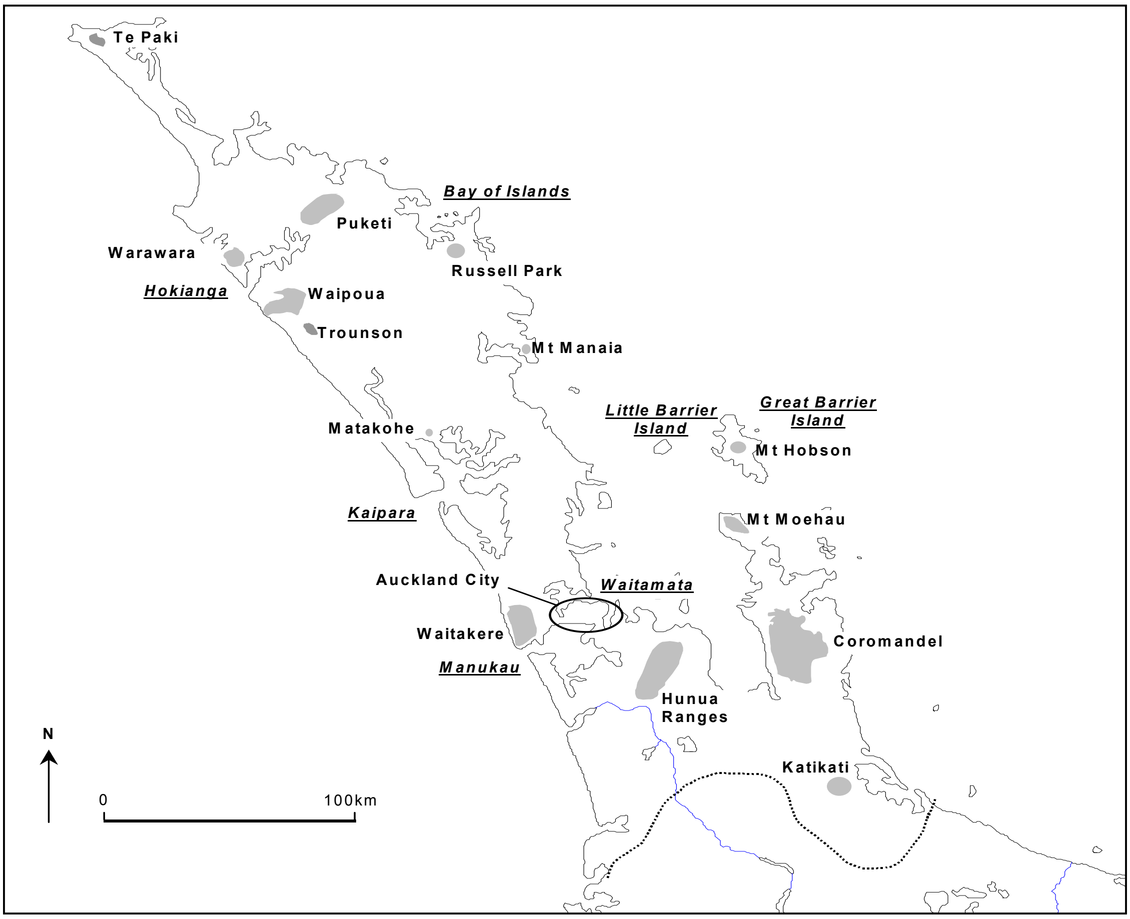

Figure 2: Region of kauri growth, upper North Island, New Zealand. The location of forest parks, reserves and harbours is shown. The dotted line marks the southern limit of kauri.

Reconstructing the natural history of kauri back beyond the historic period falls in the domain of scientists such as palaeoecologists, and is dependant on studying living stands of trees and the traces of trees—in the form of pollen, preserved leaves, cones and gum, wood, and podzolised soils—that remain in the landscape. Kauri is of particular significance because large quantities of wood have been preserved in peat swamps at different times in the past c. 50,000 years (50 ka). Therefore, there is potential to develop long records of tree growth (referred to as tree-ring chronologies) from sub-fossil (or swamp) kauri dating to different time periods. These tree-ring records not only provide information regarding the growth characteristics of the trees, but are also high-resolution, annual records of environmental change. Such a resource spanning such a long time period is unique in the western Pacific, and globally very rare.

This paper presents an overview of the natural history of kauri in the past c. 50 ka in chronological order from the distant past to the present, as it is currently known on palaeoecological and dendrochronological evidence. This overview is intended only as an introduction to the topic, and is by no means an exhaustive account. It should be noted that research on kauri is advancing quickly, particularly with regard to the dating of sub-fossil kauri, and paleoenvironmental story recorded in kauri tree-rings. A list of cited and recommended texts for further reading is presented at the end of the paper.

Reconstructing the natural history of kauri

The types of evidence used by palaeoecologists to elucidate the history of kauri include analysis of pollen, macrofossils and wood which have been preserved in peat deposits or in lake and pond sediments. At its simplest, pollen provides evidence of a species, such as kauri (Figure 3), in the local and/or regional landscape. Pollen records from a site often span many millennia, and the changes in species composition over time are used to infer changes in the environment. Macrofossils, such as leaves, seeds, and cones are also preserved in peat deposits or in discrete litter layers in waterlogged, anaerobic conditions. Such material is usually from the immediate environment. Therefore, species identification of leaves or seeds provides information on the local vegetation. In addition to pollen and plant litter, wood is also preserved in peat bogs or swamps. This may be the remains of stumps which have been slowly buried by peat, or tree trunks which have fallen into bogs or swamps. These tree remains provide direct evidence of tree growth and mortality at a site. Analysis of the kauri growth rings (Figure 4) provides information on the age of trees, and tree growth rates. Dendrochronological techniques can also be applied to determine if trees were contemporaneous, by comparing the pattern of wide and narrow rings on samples (crossmatching). Trees that have grown at the same time will have very similar ring patterns. This can determine if the trees died and were preserved at about the same time, or if tree-preservation occurred over a much longer timespan.

Figure 3: kauri pollen grain (photo: Yan Ben Deng)

Setting such data in a chronological framework requires the application of different dating techniques. The most commonly used method for material from the last c. 50 ka is radiocarbon dating. This technique measures the activity of carbon-14, an unstable isotope, in organic matter. Carbon-14 is taken up and constantly replenished in all living organic material, but when an organism, such as a tree, dies, the amount of carbon-14 begins to decay. Because the half-life of carbon-14 is known, it is possible to work out when the tree was alive by measuring the amount of residual activity in a sample of wood from that tree. For the recent past, dendrochronology (or tree-ring dating) can also be used to provide accurate and precise calendar dates for wood, through the construction of tree-ring chronologies. By starting with living trees where the calendar date of the last annual ring is known, and overlapping the growth patterns of successively older wood, it is possible to build long, continuous, calendar dated records of tree growth. Tree-ring samples of unknown date can then be compared to these records, to establish exactly when the growth rings were laid down. In New Zealand, one such record has been built from kauri which extends for over 3.7 ka from the present.

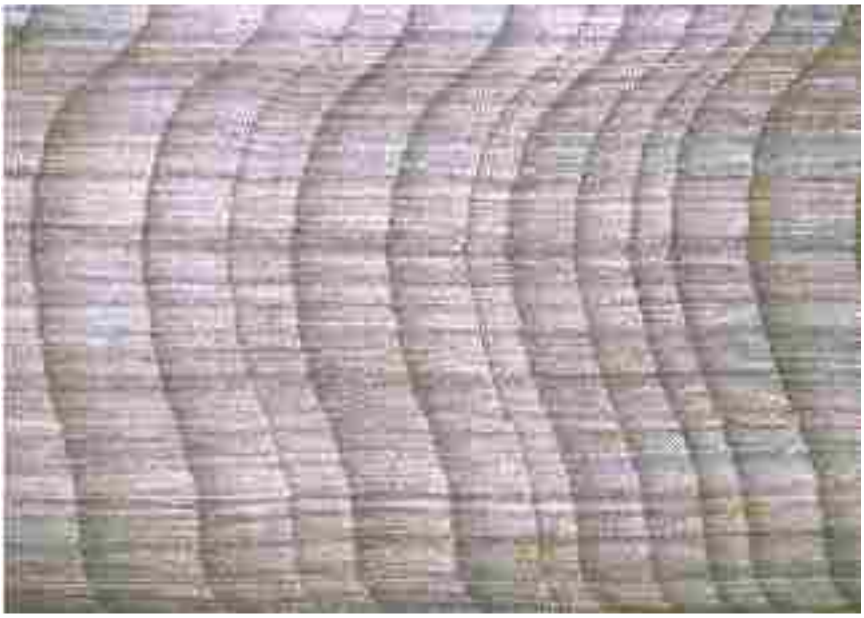

Figure 4: Kauri growth rings. Direction of growth is right to left.

Historical record

The history of kauri during the late Pleistocene and early Holocene (c. 50 ka to 7.5 ka ago) is based largely on palynological records, and is considered by palaeoecologists such as Ogden et al. (1992) and Newnham (1999) to be patchy with respect to the distribution of sites and temporal coverage. There are a limited number of sites, located mainly in Northland and the Far North, that have produced long sediment records. The authors also identify difficulties with the records associated with variable sedimentation rates, possible breaks at the time of the Last Glacial Maximum (c. 24–18 ka before present), and insecure radiocarbon chronologies. Despite these problems, they both draw broad outlines of vegetation changes in which it can be seen that kauri forest was probably more prominent in the landscape during the last warm interstadial (referred to as Marine Oxygen Isotope Stage 3 – MOIS3), and became less important during the colder Last Glacial Maximum (MOIS2).

The presence of kauri during MOIS3 as indicated by pollen is borne out by the large quantities of kauri wood preserved in peat swamps or bogs, which have been radiocarbon dated to between c. 20 ka and 50+ ka before present. This 'ancient' kauri is recovered commercially for its high quality timber, providing opportunities for scientists to collect samples of wood and peat for analysis. For example, the removal of logs from one particular site, Trig Road, located on the Aupori Peninsula, Far North of New Zealand, provided paleoecologists with an opportunity to study a kauri forest and peat swamp, radiocarbon dated to approximately 41–34 ka before present. Ogden et al. (1993) describe the composition of the former forest at this site, based on palynology, macrofossil and tree-ring data. There, it appears that a peat swamp had formed between dunes, surrounded by forest dominated by kauri. Flooding or waterlogging of the swamp killed many trees in marginal locations, and created suitable conditions for preservation of a leaf litter layer and the trees when they subsequently fell in. They observed that the kauri recovered from the site were large (approx. 2.5 metres in diameter), tall (approx. 20 metres to the first branch) and long-lived (average ring count of 665 years). Ogden et al. (1993: 115) write that: '[the kauri's] great size and age implies a natural forest structure equal to the most impressive extant kauri stands'. The continued recovery of such ‘ancient’ kauri logs from different sites in Northland has provided further opportunities for collection of wood and peat samples for dendroclimatology and palaeoenvironmental studies by researchers such as Andrew Lorrey, John Ogden, and in particular, Jonathan Palmer.

The mid to late Holocene history of kauri (from 7.5 ka to present) is better understood. There are a greater number of palynological records from locations in Northland and Waikato, which indicate expansion of kauri in the landscape particularly after 7.5 ka before present. By around 3 ka ago, kauri had become abundant in the upper North Island, as far south as the Waikato district and the current southern limit (38°S), and remained abundant until changes in forest cover occurred associated with the Polynesian settlement of New Zealand c. 700 years ago.

The palynological record is fleshed out by new dendrochronological data derived from kauri collected from swamps in Northland and the Waikato Lowlands. Holocene age sub-fossil (or swamp) kauri has been collected from such sites since the early 1980s (Figure 5), primarily to develop tree-ring chronologies for climate reconstruction and to extend knowledge of kauri ecology. To date, kauri has been collected from 14 peat swamps, and over the past four years, ten tree-ring chronologies (each comprising more than three samples) and 11 single tree-sequences have been developed. Significantly, these data have been linked with a calendar dated chronology constructed from living and recently dead trees, creating a single, continuous record of kauri growth that spans 3722 years, from 1724 BC to AD 1998. Therefore, the actual calendar date span for each kauri sample included in the record is known.

Figure 5: Freshly cut kauri sample collected for tree-ring analysis, sourced from the Okapakapa Swamp, near Dargaville, Northland in 2002. The sample was cut by Nelson Parker at his timber mill, Nelson’s Kaihu Kauri.

The tree-ring chronologies provide glimpses into the history of kauri at particular sites with regard to recruitment, age and mortality trends. Because of the spatial distribution of sites, the records also enable exploration of similarities and differences in such trends between sites. Already broad similarities are emerging. For example, in the Waikato Lowlands, south of Auckland, two generations of kauri were buried in a peat swamp near the town of Huntly, between 1223 BC and AD 992. At about the same time period, at least two generations of kauri grew on or near peat swamps adjacent to the Kaihu and Wairoa rivers, near the town of Dargaville, in Northland, with the most recent kauri being preserved in the swamps less than 700 years ago. Radiocarbon dates from single unmatched kauri samples indicate that at least two sites near Dargaville have a histories of preservation extending back over 7000 years.

The end of the swamp kauri record, in the 13th century AD, overlaps with the oldest sections of modern tree-ring chronologies constructed from living and recently dead trees, and newly developed tree-ring chronologies derived from kauri timbers. During the 19th and early 20th centuries, vast quantities of kauri were logged, milled and exported offshore, to destinations as diverse as Australia, the USA, Great Britain and China, for ship and building construction, furniture, street paving and a multitude of other uses. Kauri was also heavily used in New Zealand, most notably for buildings and boats. In the past three years, kauri timbers, including beams, joists, sarking and weatherboard, have been collected from houses which were being demolished in the Auckland and Northland regions, to determine whether such material could be useful for environmental and archaeological research. Tree-ring chronologies from such timbers which have recently been made by researchers at the Tree-Ring Laboratory at the University of Auckland span the period from AD 940 to 1908.

In addition to logging, large areas of kauri forest were also lost through fire, either lit accidentally or deliberately for land clearance. For example, the Puhipuhi forest near Whangarei, described in Haigh (1991) as containing 'possibly the finest stands of kauri in the country' was partially burnt in 1881, and then largely destroyed by fire in the summer of 1887-1889. What remained of the standing timber, charred and green, was subsequently logged by contractors of the Kauri Timber Company, a Melbourne based timber syndicate, between 1896 and 1911. As early as 1859, Hochstetter voiced concern at the rapid rate at which kauri forest was disappearing, but it was not until the mid 20th century that logging ceased in kauri forests, and places where old growth stands survived, such as Manaia Sanctury in the Coromandel Peninsula and Waipoua Forest in Northland, became protected areas. Today, only approximately 5 per cent of the kauri forest existing when Europeans arrived survives, but there are large areas of regenerating kauri.

In 1907 the eminent botanist Dr Leonard Cockayne undertook an ecological survey of the Waipoua Kauri Forest, providing the first detailed account of what he describes as 'one of the most rare, beautiful and … scientifically interesting' plant formations in New Zealand (Cockayne, 1908: 14). Until then, and despite the economic significance of the kauri industry, little was known about the ecology of the kauri dominated forests. Since Cockayne's early work, ecological research on kauri forests has continued, in particular since the early 1980s when ecologists such as John Ogden and his students sought to redress large gaps in knowledge about kauri-forest communities. Their research focused on, for example, elucidating the species composition and spatial distribution of kauri forest; population structures and tree growth rates derived from analyses of tree-cores; recruitment processes; and the significance of major disturbance events to regeneration of kauri. The results of these projects have extended understanding of kauri forests and provide analogues for interpretation of the palaeoecological and dendrochronological records of this species.

The modern kauri chronologies mentioned above were developed in conjunction with the ecological studies. These tree-ring records were (and are still being) used to identify the climatic conditions which favour kauri growth. The key findings of Ogden and Ahmed (1989) are that kauri tends to grow better under dry, perhaps sunny, conditions, particularly in spring whilst wet, cloudy, conditions are less favourable. More recently, a statistical relationship between kauri growth and the El Nino – Southern Oscillation (ENSO) phenomenon was identified by Fowler et al. (2001). Current dendroclimatological research by Anthony Fowler and his team is focused on refining understanding of the kauri-climate-ENSO growth relationship. They aim to develop proxy climate records from kauri from the modern kauri tree-ring record, ideally from the 3700 year Holocene chronology, and potentially from floating 'ancient' kauri records. These would be valuable contributions to wider research on environmental and climatic change in New Zealand, and global climate change, over the last c. 50 ka.

Summary

Kauri, as an iconic tree and as part of a major industry, is recognised as having an important place in the economic, social and cultural development of New Zealand. Today, kauri has great value as part of the natural forested landscape, but also retains status as a beautiful timber, through the recovery and milling of swamp kauri. As the natural history of kauri is slowly being pieced together by various scientists, kauri can also be seen as having an increasing role in the reconstruction of past environmental change in this country. This is particularly so with regard to the development of long tree-ring chronologies from swamp kauri, dating to the past 4000 years, and to before the Last Glacial Maximum. Such a role is perhaps fitting for a tree of such great physical stature.

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Assimilating the bunya forests

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Key words: *bunya pine, bunay nuts, Aboriginal culture, art, botany, conservation, landscape, nursery, gardens, dispersal, food, custodial rights*

The fate of the bunya forests is a compelling story of assimilation and survival. The forests' significance for local Aboriginal people stretches back over the millennia but with colonisation they were assimilated into European systems of scientific, economic, environmental and horticultural knowledge and practices. The forests have survived into the present although their range is greatly diminished. Aboriginal people today continue to revere the bunya tree and it remains one of an elite group of trees admired and studied around the world.

The bunya pine is endemic to the South-East of Queensland with small, related stands in the north of the state. During the bunya season from January to March the trees produce vast numbers of cones bearing edible nuts, with bumper crops occurring on a roughly three year cycle. The forests were imbedded in Aboriginal systems of environmental knowledge and classification of the natural world and efficient management of their resources. Local groups were bound to them through custodial obligations and rights. Early colonists recorded their profound cultural and spiritual significance for Aboriginal people as expressed in mythology and religious practices centred on large seasonal ceremonial gatherings. The bunya nuts provided a food resource sufficient to support gatherings of hundreds, some say thousands of Aboriginal people over a period of months to harvest the nuts and feast together. As the harvest time approached messengers were sent out by the forest custodians to announce the coming festival and some people travelled hundreds of kilometres to congregate at specific sites in today's Blackall Ranges and the Bunya Mountains. There they joined in ceremonies, settled disputes, held fights, arranged marriages and traded goods until the season drew to a close and they returned to their home territories.

With the advent of British colonisation in the Moreton Bay area in the 1820s, colonists also staked a claim to the forests. The bunya pine's majestic height, unique silhouette, dark foliage that was so different to the dull green of the eucalypt bush, unusual botanical features, Indigenous associations and potential as commercial timber drew the interest of a wide range of colonists including artists, natural scientists, entrepreneurs and gardeners. First reports of the tree came from escaped convicts and then free colonists such as Andrew Petrie who collected samples on a trip north with Aboriginal people to the Glass House Mountains. Explorer Ludwig Leichhardt who visited the Blackall Ranges in 1843 enthused in his journals over the 'remarkable mountain brushes, out of which the bunya-bunyas lift their majestic heads, like pillars of the blue vault of heaven' (McKay and Buckridge 2002: 66). Accounts of Aborigines' fierce protection of the trees led to an official proclamation in 1842 prohibiting settlers from cutting the trees. However the bunya forests were progressively felled for timber and cleared to make way for cultivation.

Despite their 'fierce and actively hostile tribal resistance' Aboriginal groups were gradually driven out of the forests and by the end of the nineteenth century their spectacular festivals had become a thing of the past. (Evans 2002, 59). However, their importance was kept alive through Aboriginal oral tradition and continued practices of harvesting the nuts. At the same time in colonial folklore, and in writings such as Cornelius Moynihan's ballad *Feast of the Bunya*, the great ceremonies were reduced to events of primeval barbarism and the facts of Aboriginal resistance were erased by prevailing Social Darwinian beliefs of Aborigines' inevitable demise.

Empty landscapes left by the retreating forests came to symbolise the vanishing ceremonies and dwindling Aboriginal populations of South-East Queensland. While surviving Aboriginal groups were swept into centralised reserves and settlements from the late nineteenth century, so too the bunya trees were cordoned off in 1908 for their own protection in Queensland's second national park at the Bunya Mountains. A visiting ornithologist observed in 1920 that the remaining trees appeared as if 'in mourning over their vanished kin-spirits, the original Queenslanders who held high revel at the Feast of the Bunyas' (Chisholm 1920, 208).

Ironically, at the same time as the bunya was disappearing from its natural habitat, it was making its way along the networks of empire into the centres of nineteenth century botanical research and into public and private gardens around the world. In the process it became assimilated into European systems of environmental knowledge and horticultural practices and scientists and gardeners assumed custodianship of the tree.

In 1843, after a brief visit to Moreton Bay to investigate the bunya pine, botanist John Carne Bidwill returned to England with dried and living bunya specimens, which he presented to Sir William Jackson Hooker at the Royal Botanical Gardens at Kew. Later that year in the London Journal of Botany Hooker announced the tree's scientific classification and nomenclature as *Araucaria bidwillii*. In this way the tree was incorporated into the grand system of botanical classification and nomenclature invented by Swedish botanist Carl Linnaeus in the early eighteenth century, which was based on particulars of plant morphology and sexual distinctions. In keeping with botanical nomenclature Hooker honoured Bidwill in naming the tree, despite its various recorded Aboriginal names and the colonists' naming of the tree in honour of Andrew Petrie.

The bunya was cast into a vast network of new relationships spanning time, space and cultures which provided new explanations of its origins and nature and new human connections. The bunya now belonged to the primeval class of gymnosperms—plants without flowers—and the order of coniferates—woody cone bearing plants—the forests of which had covered the ancient continent of Gondwana in Jurassic times when dinosaurs roamed the earth. The tree belonged to the family of Araucariaceae and the genus *Araucaria* whose 18 member species are found in parts of South America, islands of the South Pacific and the east coast of Australia. The family and genus names were derived from Indigenous terms for a tribal group and region of Southern Chile where Europeans first observed the monkey-puzzle tree, *A. Aruaucana*, whose edible nuts are still harvested as a food staple by local Pehuenche Indians.

Knowledge about the tree spread out through the empire along the conventional scientific pathways of publications, exchange of specimens, and botanical representations of the tree. During the late 1850s from his base at the Melbourne Botanical Gardens, Baron Sir Ferdinand von Mueller forwarded seeds to the Kew Gardens in England and to botanical gardens in Australia and New Zealand. Bunyas grown from these seeds were listed at the Royal Tasmanian Botanical Gardens in 1857, and in 1876 Walter Hill, Director of the Brisbane Botanical Gardens, sent in a further specimen. In 1863 Kew Gardens boasted a bunya tree of four metres that, ten years later, was reported to be bearing massive cones. Botanical artist Marianne North's drawings and paintings recorded during a visit to Queensland in 1880 and 1881 still hang in the Marianne North Gallery at Kew Gardens.

Scientific interest in the tree spilled over into the worlds of commercial nurseries and public and private gardens. Like many other botanists, John Bidwill combined his scientific interests with entrepreneurial activities seeking out exotic plant species in the colonies for the firm of Luscombe, Pince and Co. in his hometown of St Thomas in Exeter, which had plant collectors operating in Mexico, Brazil, West Africa and Australia during the 1840s. The bunya pine's symmetrical shape, domed crown, straight trunk, height, and exotic origins fitted well with fashions of nineteenth century landscape gardening, making the bunya and its close relative the monkey puzzle tree ready favourites with the gardening public of Victorian England. In particular, the Gardenesque style, promoted by John Claudius Loudon (1873-43), which dominated garden fashions from the early nineteenth century, 'emphasised the use of exotic plants, which were placed in specific settings in the landscape so that the individual colour and form of the tree could best be appreciated' (Cooke 2002: 85).

These fashions were also evident in the Australian colonies. By the early 1860s bunya plants could be purchased in Melbourne nurseries, while circulating nursery catalogues offered gardeners a variety of Araucarian species. The bunya's design qualities of good definition with height and dark green foliage rendered it highly suitable for large open expanses and the trees were used extensively for landscaping in public gardens and on country estates in Victoria where they stood as testimony to the status and wealth of their owners. Arranged in groups or as feature trees they were also used to adorn large public institutions such as the St Vincent Orphanage at Nudgee in Brisbane and the Goodna Mental Asylum (now Wolston Park) on the outskirts of the city.

With the development of nursery plantations in Queensland from the early twentieth century large quantities of cheap plants became available for civic plantings around Australia. In Perth bunya trees were planted at Raphael Park, Queens Park, Beattie Park, Hyde Park, Kings Park, Perth Zoo, Karrakatta Cemetery and in the grounds of the University of Western Australia. The bunya's presence in such civic settings also reflected its emerging symbolic meanings in settler culture of commemoration and the expression of Australian nationhood. This was evident in plantings to mark out cemeteries, as in the Toowong Cemetery in Brisbane, and war memorials erected in many country towns after the First World War. In 1927 the tree represented Australian nationhood at a ceremonial tree planting by the Duke of York to commemorate the opening of Parliament House.

The bunya forests were also of interest to the timber industry. Despite controls lasting into the 1860s and preference for other local timbers such as kauri, hoop and red cedar, cutters, sawyers and bullock drivers were already cutting a swathe through the forests when the Bunya Mountains were thrown open for selection in 1878. This unleashed a tide of destructive felling of stands of bunya and hoop pine to provide soft wood timber for commercial use in furniture, floor boards, fences and so on. In 1890 a government report recommended preservation of the forests through reservation and controlled management and ten years later a forestry branch was set up in the Department of Public Lands manned by an Inspector of Forests and two rangers required to control forests throughout the state. In the 1920s the government turned to the development of silviculture with the establishment of commercial hoop and bunya plantations. Meanwhile reduced saw-milling persisted in the Bunya Mountains into the mid-1940s and cutting down on private land continued on an unrestricted basis.

Bunya plantings for civic and private purposes declined dramatically from the 1930s. However, many trees are still standing in such far-flung places as the botanical gardens in Trinidad, Singapore and Naples, in the grounds of the University of California, the Sarasota Jungle Gardens in Florida, and at numerous sites in New Zealand. Bunyas still found in Australian cities now constitute an aging population of trees. Often perched precariously close to busy thoroughfares their continued existence is subject to the economies of local council budgets. Some have become the subject of bunya paranoia—the fear of bunya cones (which can weigh as much as ten kilograms) crashing from a great height onto pedestrians in public parks and other open spaces. This fear has posed a new threat with frequent demands for the trees to be chopped down. Less radical solutions include programs to cull the cones during the fruiting season, safety nets to catch the cones, and prominently displayed warning notices.

Meanwhile the bunya forests and plantations are becoming an increasingly valued resource, not for their timber but for the tourist and native food industries. The Bunya Mountains is now the centre of a thriving tourist industry and elsewhere ecotours take visitors to view remaining stands of the tree. Recipes using bunya nuts are offered on restaurant menus and the nuts are also commercially available. In 2005 the bunya nut was added to the Slow Food movement's Ark of Taste and the bunya nut was included in a session, 'Taste of Slow', at the 2005 Melbourne Food and Wine Festival. Alternative food sites on the web encourage cultivation of the tree for personal use. A new interest in the monumental amongst landscape gardeners has rekindled interest in ornamental use of the tree in Australia and overseas. Conservationists are propagating the tree to ensure its preservation and some gardeners continue to plant the tree for sentimental reasons. The Queensland Government is now supporting a move to add the Bunya Mountains to the World Heritage list.

Until recently Aboriginal voices have been largely absent from public discussion of the forests and their management. This does not signify a lack of interest on the part of Aboriginal custodians; rather, as Marcia Langton reminds us, the general absence of Indigenous people from environmental planning and debates represents 'not just a lacuna, but a comprehensive flaw in understanding the role of human presence in Australian landscapes' (Langton 1998, 72). Over the many decades of colonisation Aboriginal people retained their devotion to the tree and attempted to maintain their obligations of custodianship. A large tree still standing at the site of the former Deebing Creek Mission on the outskirts of Ipswich is believed to have been planted by Aboriginal families removed there from the Bunya Mountains in the early twentieth century. In 1931 Jenny Lynn, an elderly Aboriginal resident of Barambah (later Cherbourg) reserve near Murgon, protested to J. W. Bleakley, the Chief Protector of Aboriginals, at the cutting down of 'the best part of the Bunya trees', which she and other residents continued to harvest for their nuts. A note from the reserve superintendent on her letter indicated the futility of her quest:

> Old Jeannie [*sic*] spoke to me about this. I told her not to be silly. Of course it is serious in the Natives eyes. The Forestry dept, are cutting down the trees (Evans 2002, 59).

To this day throughout South-East Queensland during the bunya season Aboriginal families join together in harvesting and eating the nuts. Recently groups have adopted the settler practice of commemorative plantings as a way of formally honouring their people and cultures. In Canberra in 2001 Aboriginal people joined others at the Peace Park adjacent to the National Library in planting the bunya pine as the 'International Tree of Peace', reflecting the significance of the bunya ceremonies in creating peaceful relations between local groups. In the same year the Purga community near Ipswich began planting a commemorative avenue of bunya pines on their property to honour their elders.

Aboriginal people are now beginning to publicly assert their custodianship of the bunya forests through public meetings with environmental and other planning authorities, native title claims and plans to revive the bunya festivals and to establish related economic enterprises. The reopening by Aboriginal custodians of channels of sharing and exchange remains a guarded process given continued appropriation of resources and knowledge by non-Indigenous groups. This story of the survival of the bunya forests ends with the reclaiming of Aboriginal custodial rights. This was the powerful message delivered by Paddy Jerome, Jarowair elder and custodian of the Bunya Mountains, to a symposium on the bunya pine held in Brisbane in 2002:

> Now we are trying to keep all of our ways alive. It is very important that we revive the bunya festivals and our people are talking about this. We are already reviving the initiations. … But first we need to reconcile with our Aboriginal ancestors. …My people believe that every living thing on this earth was linked spirituality and each and every one of us must respect the earth and each other as equal. …My ancestors walked through this land, the land speaking to them ... We belong to this land, the land is our Mother. We are part of a spiritual structure. That's Aboriginal culture. That is Boobarran Ngummin, the Bunya Mountains, our Mother (Jerome 2002: 4-5).

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Sir David Hutchins and kauri in New Zealand

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Key words*: kauri, Sir David Hutchins, New Zealand*

Introduction

The kauri (*Agathis australis*), found only in New Zealand, is one of 21 species comprising the genus *Agathis* that along with *Araucaria* and *Wollemia* make up the Araucariaceae family. Mature kauri is notable for its massive almost cylindrical branchless trunk reaching over 13 metres. Tane Mahuta in Waipoua forest estimated at 1500 years old, is the largest living kauri. It has a girth of 13.77 metres, a trunk height of 17.68 metres, a total height of 51.5 metres and a volume of 244.5 cubic metres (Halkett and Sale 1986, p.173). The species is currently found in the North Island of New Zealand as far as 38ºS or approximately a line drawn from Kawhia to Maketu.

Kauri formed the basis of a spar trade from the 1820s to 1850s and efforts were made to reserve kauri forests for Royal Navy purposes when New Zealand was colonised by the British in 1840. A Conservator of Kauri Forests was appointed as early as 1841 but he was accidentally drowned and no replacement was ever made. Kauri sawmilling was an important 19th century industry. The timber was highly valued and was the one species to command colony wide sales. It was also exported in quantity particularly to Australia. The Kauri Timber Company established in 1888 which became the dominant player in the industry was Melbourne based. In 1885 Thomas Kirk the Chief Conservator of Forests estimated that kauri would be exhausted in 26 years. By 1908 the 12000 hectares Waipoua State Forest remained as the single largest area of kauri. Although heavily forested Waipoua had been purchased by the Crown from Maori in 1876 for conversion to farmland, but its relative isolation had meant that it had remained unsettled. In 1906 it had been gazetted as a state forest. Leonard Cockayne, the eminent ecologist, prepared a botanical report on the forest in 1908 in which he drew attention to its scientific and scenic value and argued for its preservation.

Existing forests legislation and other provisions in the Land Act were limited to the gazetting of forests and granting of timber licenses. There were no trained foresters, a timber famine was predicted by mid 20th century, and the solution was believed to lie in exotic afforestation. A Forests Branch of the Lands Department had been set up in 1897 but had concentrated on afforestation activity. To this might be added the growth of a forest preservation movement as witnessed by the establishment of several national parks from 1894 and the passage of a Scenery Preservation Act in 1903. The 1913 Royal Commission on Forestry recommended that 200 acres [81ha] of Waipoua forest be set aside as a 'national kauri park' and the remainder milled and the land thrown open to settlement. By 1915 the government had decided to preserve 2000 to 2500 acres [809 to 1012ha] of it as a national park and to allow the rest to be felled. Around this same time the agricultural scientist Alfred Cockayne, son of Leonard Cockayne, had published an article lauding *Pinus radiata* as 'the great timber tree of the future' (Cockayne 1914, 1). This was the situation that confronted the experienced colonial forester David Hutchins when in 1915 he accepted a brief to report on the forests of New Zealand for the Minister of Lands.

Sir David Hutchins: colonial forester

A graduate of the famous École Nationale de Eaux et Forêts at Nancy in France, Hutchins spent the early part of his career in India before transferring to South Africa in 1884 where he was involved in forest demarcation work, silviculture, and afforestation efforts particularly with eucalypts. In 1909 he prepared a report on forestry in British East Africa and subsequently was invited to inspect the forests of Cyprus for the Colonial Office. In 1914 Hutchins was part of the British Association for the Advancement of Science tour of Australia and produced a lengthy book entitled *A Discussion on Australian Forestry* that was both controversial and influential. It was, however, on the basis of his East African report that Hutchins was invited to inspect forests in New Zealand, albeit that the government was mainly interested in his reactions to their afforestation efforts. Hutchins arrived in Auckland in October 1915 and to the surprise of officials delayed his journey south to the plantations at Whakarewarewa in favour of a tour of Waipoua kauri forest. This was a harbinger of both Hutchins' growing fascination with kauri and his desire to make the case for the sustainable management of indigenous forests in New Zealand. The New Zealand 1913 Royal Commission on Forestry had also taken the view that exotic afforestation was the way forward for forestry in New Zealand. This was a position that Hutchins, as a professional forester, found astounding.

Hutchins and kauri forests

Hutchins knew of kauri before he arrived in New Zealand. He noted that his superior in South Africa, Comte Vasselot de Regné, the Superintendent of Woods and Forests had always hoped to visit the kauri forests. He also quoted a line of doggerel verse which he ascribed to forestry students in South Africa to the effect that:

> One thousand acres yearly and three million doubtful trees,
> Cost some eight thousand yearly to the wild New Zeas.
> And they don't care a tinker's d--- for the grand Kauri trees.
> (Hutchins 1916, p. 395).

In addition he had compared the qualities of kauri with the Yellow Wood (Hutchins described them as *Podocarpus thunbergii* and *Podocarpus gracilior*) of Kenya in his East Africa Report. In his report on Australian forestry he further compared the loss of red cedar (*Toonia ciliata*) in Queensland to 'the destruction of kauri in New Zealand, a national scandal, and a blot on the civilization of the 19th century' (Hutchins 1916, p. 291). Hutchins prepared a commentary on the Royal Commission on Forestry and this was published as an appendix in *A Discussion on Australian Forestry*. In this he expressed grave doubts about the official policy of meeting future timber needs from exotic plantations particularly in the absence of any professionally trained forestry advice.

> The story of the destruction of the Kauri forest is one of the saddest features in the history of this fair earth. There is nothing in this report to show that it is necessary or sound economically, or that it will not go down to history as a dark blot in the story of Anglo-Saxon colonisation (Hutchins 1916, p. 395).

That kauri should attract his attention once he arrived in New Zealand is hardly surprising.

Hutchins on kauri management

Hutchins spent from 23 October to 27 November 1916 in Waipoua forest largely engaged in forest demarcation work. This involved establishing the forest margin marked by some 25 permanent beacons enclosing a forest area of 29,830 acres (12,072 ha), including some cleared land, where the soil was poor but the forest was deemed capable of regeneration. In addition, he identified location for permanent forest stations (Figure 1). Hutchins with his Australian experience of recent European settlement fresh in his mind regarded forest demarcation as the essential first step towards the establishment of scientific forestry in New Zealand. Shrewdly he also used the discussion about demarcation as a springboard to discuss the subsequent management of the trees in Waipoua kauri forest. His focus on Waipoua was strategic; not only were kauri an iconic species, but they were regarded as likely to be felled to exhaustion within 20 years. The remainder of the report discussed the stock of trees and Waipoua as a stand of trees, milling, natural regeneration, fire, forest organisation, working plans and concluded with recommendations for other kauri forests.

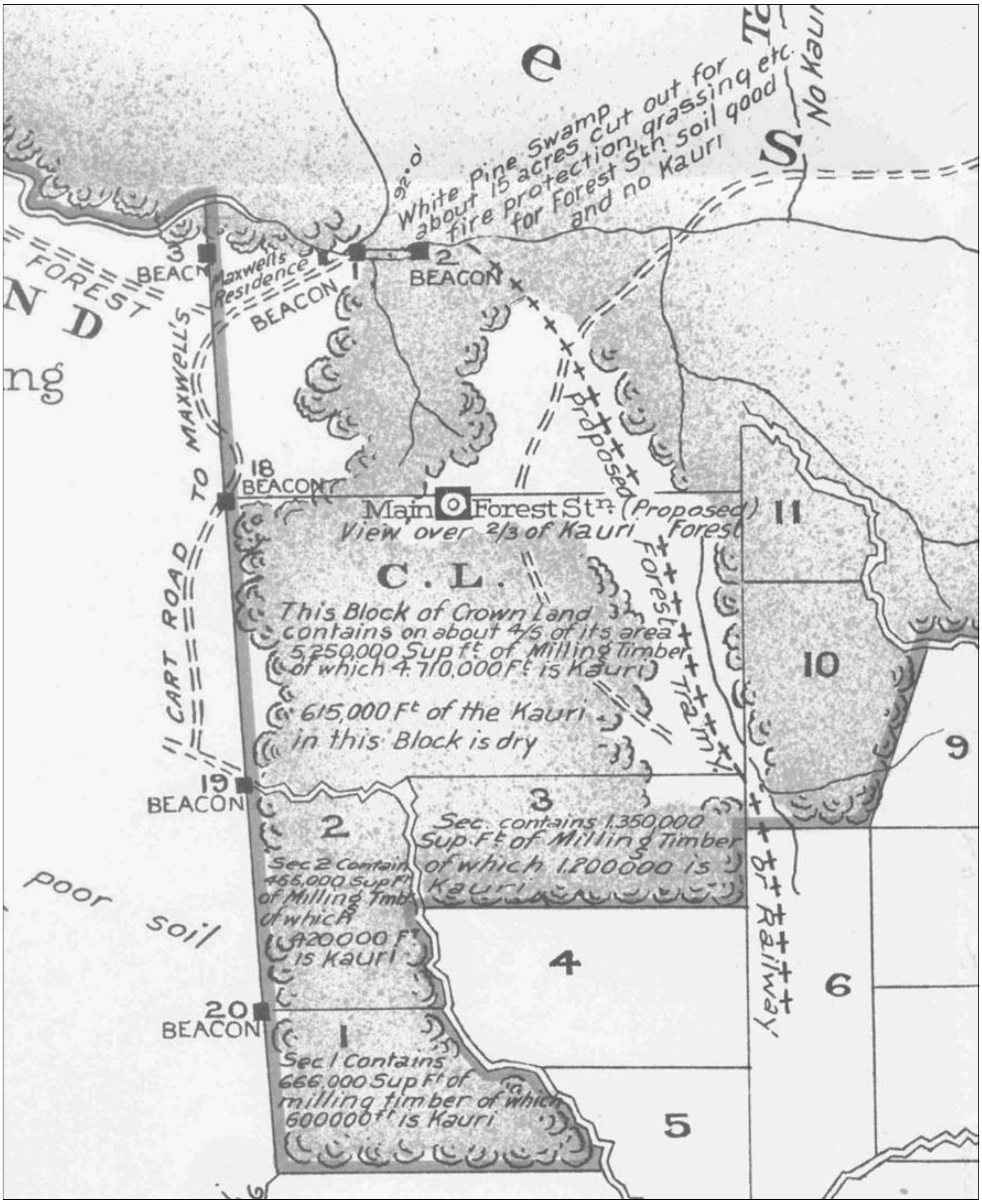

Figure 1: Part of Hutchins' 1916 map showing the demarcation line around a portion of Waipoua Kauri forest. This part shows how he proposed extending the demarcated boundary to include some Kauri forest on adjacent Crown Land. The site of his main forest station where it could overlook most of the forest is also shown on this portion of the map.

Kauri he lauded as the 'biggest timber tree in the world' (Hutchins 1918, 17) but most of the Waipoua kauri he estimated at 5000 to 6000 cubic feet [141 to 170 cu m] and at a royalty of 6/8d per 100 super feet believed they were worth about £200 each. Kauri did not grow in pure stands and Hutchins spent considerable time discussing the potential of other timber species, such as taraire (*Beilschmiedia tarairi*) and kamahi (*Weinmannia racemosa*). Milling he considered ought to be carried out by the government rather than private millers, the latter following old habits would he believed create a fire hazard. Hutchins also asserted that Waipoua was a virgin forest and that 'it is a forestry axiom that a virgin forest represents a capital earning nothing. It is in a state of nature wherein growth balances decay' (Hutchins 1918, 27). He had previously made this same point in his Australian report (Hutchins 1916, 109). The idle capital Hutchins calculated at a not inconsiderable £500,000. Natural regeneration was at the heart of his vision the scientific forestry. He acknowledged that natural kauri regeneration in Waipoua was 'not superabundant as in some forests, but it is suitable for nature's purposes' (Hutchins 1918, 28). Astutely he recognised that kauri was a light-demanding species and identified abundant natural regrowth on areas previously felled and cultivated by Maori as well as on burnt areas especially where manuka (*Leptospermum scoparium*) acted as a nurse plant. Other less valuable species such as tawa (*Beilschmiedia tawa*) were he believed regenerating abundantly. But he firmly believed that human intervention made it possible to greatly increase the number of merchantable species.

Hutchins observed that the wet kauri forests reminded him of areas of South African forest where elephants were still used for log hauling. He recommended letting them run wild in the Waipoua forest so putting 'the surplus animals to work, as is done in India. The old ones would be useful in forming costless paths and in keeping down the undergrowth' (Hutchins 1918, 42-43). This comment attracted attention away from his observations about more modern logging methods.

Hutchins' Waipoua report was to be read in conjunction with his more expansive *New Zealand forestry. Part 1, Kauri forests and forests of the north and forest management* (Hutchins 1919). Here he reiterated some of the points made in the Waipoua report as well as outlining more comprehensive proposals for forest management. The focus is however very much on kauri. The report was written in his characteristically discursive style drawing on classical forestry practice from Germany (via Schlich and India) and France and making a number of off hand comments about everything from the benefits to New Zealand if it had been colonized by the French to quoting Tennyson. His African and more recent Australian experiences also informed his views. Hutchins devoted some space to discussing kauri growth rates, to kauri gum and to the lessons to be learned from the felling and later burning of the Puhipuhi kauri forest.

Given the prevailing view that the indigenous forest trees of New Zealand were exceedingly slow growing this was a logical point at which to begin especially as Hutchins emphasised that the kauri still grew quicker than many of the forest trees that were being successfully managed in Europe. He also challenged the prevailing view that kauri was doomed to disappear, instead he compared them favourably with forests that were being managed in South Africa and declared that kauri with its 'robust growth and fair regeneration' was a 'tree in its prime' (Hutchins 1919, 29). The report reveals that he had made a comprehensive study of all the existing published work to that point as well as discussions with local experts and even spent some of his own time counting growth rings. He subsequently published a separate paper taking to task a local afforestation enthusiast for marshalling evidence for fast growth of exotics in order to argue that indigenous regeneration was a lost cause, when the real problem, in Hutchins' view, was the failure to distinguish between arboriculture (individual trees) and forestry (mass trees) (Hutchins 1920). Hutchins then devoted a chapter to the kauri gum trade, pointing out that it was strictly speaking a resin and a not gum, but making the case against the practice of bleeding trees because of the damage it caused. The cut out and fire swept Puhipuhi forest he considered in some detail in order to make a point about how much revenue and employment a managed kauri forest would generate and to compare the returns from forestry with those from dairying. This provided the platform for him to outline his kauri management plan. He described three different silvicultural systems: jardinage or selection felling, group felling (which he advocated) and strip felling (Table 1).

Table 1: Silvicultural systems compared

Type	Felling system	Suitability to New Zealand
Jardinage	Thinning of the mature forest as wanted	
Group felling	Felling of trees in irregular groups	Particularly suitable for mixed stands in New Zealand
Strip felling	Felling of trees in long strips as an aid to regeneration	

Hutchins envisaged the kauri forest of the future being managed on a 100 year rotation to produce trees of about 2 feet [60cm] in diameter with a 60 foot [18.28 m] bole stocked at some 150 trees to the acre [370 to the ha] along with about 150 secondary species. This would, he calculated, amount to 1700 cubic feet per acre [151 cu m per ha]. A notable feature of Hutchins' plan was that the conversion from overmature to a fully stocked 'normal' forest would be made in a single transition phase of 100 years (Table 2). By the time the normal kauri forest had been produced—that as Hutchins noted, it was remarkable the way the figures worked out—the average age of the main crops would be 100 year, the average number of tree per acre in the main timber crop would total 100, and the average cubic content of the bole of each tree and the average production of timber per acre per year would both be 100 cubic feet quarter girth measure [8.9 cu m per ha] (Hutchins 1919, 180).

Table 2: Hutchins' proposal for forest transition in kauri forests

Period	Duration	Forest structure	Stocking
First	8-12 years	Virgin overmature forest	
Second, 'Transition' Period	100 years		Becoming fully stocked
Third	100 year rotation	Normal forest	Fully stocked

Hutchins died in late 1920 and did not see the arrival of L. M. Ellis a Toronto graduate who was appointed as New Zealand's first Director of Forests. Ellis affirmed that indigenous forest management was a corner stone of the forest policy he intended to implement. He contracted William McGregor from Auckland University College to investigate kauri regeneration in 1921. Financial and other difficulties caused the work to lapse by 1925. By the late 1920s, however, New Zealand foresters encountered problems with regenerating forests which they explained at the Empire Forestry Conference of 1928 in terms of succession theory where other forest species replaced harvested kauri. Nevertheless, kauri remained, they believed, their brightest hope for successful sustained yield management.

A Kauri Working Circle was put in place in 1942. The irascible McGregor had, however, quickly become involved in arguments with the Forest Service over the research and eventually became a leading figure in a campaign for the preservation of Waipoua kauri forest. After a sustained campaign the area was gazetted as a forest sanctuary under an amendment to the *Forests Act 19 49* in 1952. Thus Waipoua remained under Forest Service control but its sanctuary status meant that it was to be absolutely preserved because this designation could only be lifted by Parliament. The episode left a bitter taste to the Forest Service where it was noted that Waipoua 'had been permanently sterilised and proclaimed a forest sanctuary' (Allsop 1973, 37).

By 1973 kauri policy restricted harvesting to a small annual cut of 870 cu m from Puketi forest, and this ceased once a threatened bird population of Kokako (*Callaeas cinerea*) were discovered in the forest. Kauri management research continued into the 1980s with later research tending to confirm Hutchins' original management proposals (Table 3).

Table 3 Proposed rotation periods for kauri,1923-1980

Year	Authority	Rotation (years)		Diameter	
1919	Hutchins	100		2 ft	60 cm
1923	McGregor	135-150	(7 ft girth)	2 ft 3 in	68 cm
1942	NZFS	150-200			
1980	Barton & Horgan	80			50 cm

By the end of the 1970s the environmental movement had won the political contest for indigenous forest preservation as opposed to sustained yield management (Halkett and Sale 1986). From the mid 1970s however the thrust of kauri policy turned towards the perpetuation of remaining areas where timber production was only an incidental aim (Halkett and Sale 1986). Environmentalist opposition to any form of harvesting from state indigenous forests intensified during the 1970s until in a series of staged retreats from the forest accord of 1987 to the decision to end Timberlands West Coast Beech management scheme in 2000 the government exited indigenous production forestry. This played out slightly differently for kauri. With most of Northland kauri under the stewardship of the Department of Conservation, environmental group Forest and Bird mounted a campaign for the creation of a kauri national park (Orwin, 2004). Local Maori were unenthusiastic as land claims in the area had not been resolved by the Waitangi Tribunal. In 1998 the Forest Restoration Trust in conjunction with Te Roroa purchased land at Waipoua and began planting kauri. The Department of Conservation in its Conservation Management Strategy for Northland meanwhile has continued to identify the Waipoua-Waima-Matrua forests as a 'priority' area as part in the proposed the Northland Kauri National Park in Northland.

David Hutchins was buried in Karori cemetery in Wellington, New Zealand. The headstone inscription in part reads 'An acknowledgement of the important services by him to Empire Forestry by members of New Zealand & Australian Forestry Leagues, Relatives and Friends who mourn his death'. The Headstone which stands a metre high features in relief a stylised kauri tree (p. 52).

Conclusion

Hutchins left a complex legacy both as a promoter of scientific forestry in New Zealand and as a forester who undertook the first professional forest demarcation at Waipoua and sketched out the rudiments of a management plan for kauri. He raised the profile of scientific forestry at a crucial time when moves were afoot to create a separate Forests Department and employ professionally qualified staff. But he also divided some of the forestry enthusiasts by making bold claims and being critical of local scientists, officials and politicians, not to mention by actually taking several years to complete a task that officials, admittedly overly ambitiously, expected him to complete in a month. Hutchins did, however, recognise the strategic importance of developing scientific state forestry around kauri. Not only was it the premier New Zealand timber tree but it was considered that supplies would soon be exhausted. In addition the kauri had iconic status at a time when tourism was growing. To show how kauri might be perpetuated through the application of scientific forestry would have made it much easier to implement similar schemes for the Podocarps where the rotation times would have been much longer.

Hutchins' reports had a strong utilitarian undertone that was rather lost sight of in his forceful advocacy of scientific forestry. He went to considerable lengths to make the case that on some land forests were the best crop that could be grown and that with careful management they could be made to yield a considerable amount of timber in perpetuity, amounting to more than competing agricultural uses would produce. He also paid attention to the cost of continuing to neglect forests in terms of the losses to the local economy. Yet his views were not entirely utilitarian for with an eye to tourism, he would have protected some of the mature kauri forest for scenic purposes. He was a keen observer and his views about the importance of light and the role of nurse plants in regeneration were borne out by a later generation of kauri researchers.

Hutchins' plans to manage kauri sustainably on a 100 year rotation were never implemented. Subsequent work always pointed to possibilities for kauri management. The Forest Service was too stretched financially and in terms of personnel to give a high priority to sustained research into kauri regeneration, and from the late 1940s the debate about the future of the kauri forests had been won by forest preservationists, though this was not clear until the 1970s.

If Hutchins' kauri management plans had been implemented in 1920 the transition phase would now be about three quarters complete. The success or failure of his scheme by now would be easier to assess but in either case the kauri forest would be much different with the old growth trees having been converted to 'rickers' of about 30 centimetres diameter. A period of 100 years is little in the life span of a kauri tree, and well within the rotation period of the European and colonial forestry traditions in which Hutchins was trained. However, in 1919 it was a mere 79 years since New Zealand had become a British colony. The environmental and social transformations that and taken place in this relatively short period of time had been great and to ask New Zealand politicians to think in terms of a 100 year transition rotation and then another hundred years for a rotation of the fully stocked kauri forest was too much of a challenge of faith.

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Araucariaceae in Queensland

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Key words*: hoop pine, bunya pine, kauri pine, Wollemi pine, plantations, native forest.*

Introduction

The first export from the colony of Moreton Bay (now Queensland) was hoop pine (*Araucaria cunninghamii*). It is a major source of high quality softwood, both as natural pine and as a plantation resource. Kauri pine (*Agathis robusta*) was widely used in the timber industry and initially was a promising timber species until insect damage stopped the planting program. William Pettigrew built the first large sawmill specifically for the processing of kauri pine (*Agathis robusta*) in 1863. Bunya pine (*Araucaria bidwillii*), with its characteristic crown shape, is an icon of the natural and cultural heritage of Queensland, it was a secondary source of natural and plantation softwood, and it was a major food supplier in early times for many indigenous groups of south-east Queensland. The newest member of the *Araucariaceae* family, Wollemi pine (*Wollemi nobilis)*, although not a native of Queensland, is being propagated in the state with the royalty from the sale of plants used to conserve the Wollemi and other threatened Australian plant species. This paper discusses the role played by these trees in the history of forestry in Queensland, and briefly mentions Norfolk Island pine (*Araucaria heterophylla*), klinkii pine (*Araucaria hunsteinii)* and Paraná pine (*Araucaria augustifolia*).

Hoop pine: 'the monarch of these woods'

> Hitherto in our examination of this River, we have been only gratified with the distant view of the Pine; immediately we approached one of the magnificent stature, the Monarch of these woods (A. Cunningham, 1824).

Nomenclature, location and properties

Hoop pine (*Araucaria cunninghamii*) lies within the genus *Araucaria*, the name of which is taken from the word Arauco, a province of southern Chile. It is the only major plantation-grown native conifer in Australia. The specific name honours Allan Cunningham, the King's botanist of the day and explorer of eastern Australia. Hoop pine is an impressive tree, growing up to a height of nearly 60 metres with a diameter (at 1.3 metres) of 60 to 190 centimetres.

It occurs primarily in Queensland but is also native to New South Wales, Papua New Guinea and Irian Jaya. In Queensland hoop pine is found as major and minor disjunctions within 150 km of the coast (and on many islands) from the New South Wales boarder to Captain Billy Creek, approximately 11°40'S, on Shelburne Bay. The majority of the great stands of maiden hoop pine were clustered in an area from the New South Wales border north to about Gladstone and west to Monto and the Bunya Mountains. In some districts the pines in the scrubs were so numerous that the panorama of the ridges and ranges from a distance was often described as being 'black with pine', and within the scrub the pines were so close that the vegetation was said to be 'choked with pine'. It is generally regarded as drought-tolerant and wind-firm but it is susceptible to damage from fire and frost.

It has long been grown in plantations in the Crown estate, as street trees, and in school plots (the first of these was planted in 1928); it has also been planted as windbreaks, and in land rehabilitation and private plantings. The timber is white to pale brown, fine-textured, carrying little figure, and light in weight (air-dried density of 560 kilograms per cubic metre).

Early exploitation of hoop pine

In 1823 the explorer John Oxley sailed up the Brisbane River and found 'timber of great magnitude [including] a magnificent species of pine … in great abundance.' The 'magnificent species' was hoop pine. In the next year botanist and explorer Allan Cunningham travelled with Oxley up the Brisbane River and described the hoop pine as 'monarchs' of the woods. The 'monarchs' were heavily cut and utilised in the 1800s leading to concerns for the future availability of the species. Accordingly, in 1901 a Forestry Branch of the Department of Public Lands was formed to provide government control of cutting.

Timber-getting methods

Initially axes were used in scrub (rainforest) felling and general timber-getting. Some popular brand names were Kelly, Plumb, and the Black Diamond. The Kelly was an Australian-designed axe made in the USA and sold in Australia from about the turn of the last century. Crosscut saws were popular, as two men working in tandem could use them, and were preferred to axes in the pine because they created less waste. After the Second World War, chainsaws became the main mode of tree felling, and productivity in the bush skyrocketed. In very steep areas, felled pine trees were often 'shot' or 'chuted' down the slope to the road or snig track. Shooting involved spearing the logs down the slope along a brushed path or track. The front ends of the logs were pointed to make their travel easier. 'Chuting' involved the sending of logs in a specially made chute constructed out of timber or bark; in some cases a trench was simply dug into the soil. In both methods the logs travelled with great speed. Often the logs would split into many pieces when they hit obstacles while being shot or when they landed at the bottom.

Both horses and bullocks were used to snig logs in the early days of timber-getting. In some places horses were used along narrow tracks to snig logs from the stump to a wider, main snig track where they were then snigged by bullocks to a loading ramp. As horses are surer-footed than bullocks, they were prefered for snigging in steep country. Nevertheless, as bullocks were stronger than horses, they were the favoured beasts for pulling loaded wagons from the loading ramp to the mill or railway yard. Overall, bullocks were favoured over horses because they could live more easily on feed in paddocks, were cheaper to buy and to maintain and were less susceptible to 'spooking' than horses. In 1920 and later years, cable devices and winches were used in conjunction with bullocks to move logs. By 1934 motor lorries were able to haul more cheaply than bullock teams and the days of the teamsters were coming to an end.

Hoop plantations

The harvesting of hoop pine in Queensland was unsustainable and by 1917 the need for plantation hoop pine to supplement the depleted natural stands had long been apparent. Following early growth trials, the first commercial plantations—48 hectares of mostly hoop and bunya pine—were established during the period 1917 to 1920 in southern and northern Queensland. So began the successful hoop pine plantation program in the state. Despite many early establishment problems by the early 1930s the total area of plantation was 1250 hectares.

The native conifer program that began as such a modest endeavour a few decades earlier was by 1940 a healthy and steadily growing enterprise showing promise of contributing to the economy of Queensland. Except for four years (1942–1946) during and just after the Second World War due to lack of labour, plantings have been made every year since 1920. The last of the first-rotation plantations of hoop pine on cleared-forested land was planted in the 1990–91 financial year;

second-rotation plantings were begun in the early 1980s. The size of the hoop pine plantation estate, located mainly in south-east Queensland, is now about 44,100 hectares (approximately 23% of the total Queensland plantation estate). About 50% of the current hoop pine estate was established between 1960 and 1980 and 27% of the plantations are second rotations. These plantations are widely acclaimed not only for their timber productivity but also for their aesthetic value.

Planting 1946.
Photo: Queensland, Department of Primary Industry, Forestry

Due to limitations on clearing native vegetation for first-rotation establishment and restrictions on what can be clearfalled (e.g. in areas prone to land slip), the size of the harvestable hoop pine plantation estate on land currently owned by the state will slightly decrease over time without the purchase of additional land. As hoop pine is very sensitive to fire damage, strips of scrub (dry rainforests) that will only burn during times of extreme fire weather were retained as a necessary safeguard against fire. Generally the dense scrubs provide a shaded forest floor and cooler conditions than the adjacent eucalypt forests. These green scrub firebreaks are supported by strategically placed fire towers and lookouts to aid in fire detection.

From 1920 to about 1988 establishment entailed logging rainforests, then clearfalling the remaining original vegetation (initially by hand, later by machine) and burning the debris. Since then, especially in the second rotation areas, a litter retention system has been used. Seedlings were initially planted at 1500 stems per hectare on a grid pattern of 2.7 × 2.4 metres. From 1980, when seed orchard quality seed became available, a planting spacing of 3.0 × 3.0 metres (1111 stems per hectare) was adopted. Currently planting spacing is 6.0 × 2.4 metres (694 stems per hectare).

A standard nursery production system was implemented in 1924. This involved growing seedlings in nursery beds under shade for about 12–14 months then transferring them to metal tubes, each 20 centimetres long, with a diameter of about 4 centimetres. After tubing, the seedlings were kept in the full sun for up to several months before they were planted. As facilities did not permit the transport of large numbers of tubed seedlings, nurseries were established close to the areas that were set aside for hoop pine plantations. This nursery production method was in place until 1998 when a new fully containerised nursery was built to supply all hoop pine seedlings for Queensland.

For the first plantings, seed was collected from well-formed high-quality trees in the native stands. In the late 1950s seed was collected from plantation-grown trees selected for good form, vigour and branching. In addition, small areas of hoop were heavily thinned to leave groups of well-formed stems as seed production areas. Since 1980 all planting stock has been derived from seed orchard quality seed.

In the early years a range of pest plants and animals were a problem in the young plantations. Wallabies and rats damaged young stock and reduced survival figures. Weeds and grass also invaded the new plantations. Erecting wire netting fences excluded the wallabies, and the weeds and grass were controlled by manual cultivation using hoes and grubbers. The main pests today are rats, turkeys and feral deer. Grass and weeds are now controlled by the use of chemicals and a range of mechanical operations.

In 1941, Australia was at war and forest workers and mill hands enlisted in large numbers. The demand for hoop pine and other timbers for defence and essential uses was heavy. During and immediately after the Second World War, much work was necessary to support a forestry reconstruction program but labour was scarce. The government made available northern European migrants (many were called 'Balts' as they came from the Baltic countries) to assist. By 1949 some 400 of them were working in the forests.

Removing the lower limbs (pruning) by handsaws to ensure knot-free timber for an expected future plywood market began in 1935. Pruning commenced at about age six when 600 stems per hectare were pruned to 2.4 metres. This was followed by three subsequent stages or 'lifts' using ladders when the best 300 stems per hectare were pruned to a final height of 6.8 metres. Today, pruning is undertaken in two to four variable height 'lifts' over a period of 4–5 years, commencing at about age five aiming at a final pruned stocking of about 350–400 stems per hectare and a pruned height of 5.4 metres. Pruning operations are confined to winter to reduce the risk of infestation of freshly cut pruning wounds by the pine bark weevil (*Aesiotes notabilis*).

First thinning in a hoop pine plantation, date unknown
Photo: Queensland Department of Primary Industry, Forestry

The first thinning operations began in the mid-1930s. Thinning has aimed to reduce the competition around the pruned stems and maintain the stand at close to the optimal basal area for growth. To ensure that the basal area was maintained within the prescribed range, thinning was done on a regular basis with some stands receiving up to five thinnings. Today thinning of first-rotation stands is limited to stands less than 35 years old with each stand being thinned at least once between the ages of 25 and 30 years. Thinning is based on a reduction in stocking levels and still aims to reduce the competition around the pruned stems.

In 1963–64 the cut of hoop pine grown in plantations exceeded the cut of natural hoop pine for the first time.

Up until 1965, horses were used to snig plantation thinnings because they caused little damage to the retained trees. In the same year the first crawler tractor with a specially designed winch was used. Horses continued to be used for the extraction of thinnings from steep areas up until the late 1970s. Depending on the terrain, wheeled tractors, crawlers, and cables were common in the mid-1970s; forwarders, skidders and the like are now used. By the 1980s there was a growing awareness of the importance of soil conservation to preserve the productive capacity of the forest sites. One outcome of this was a shift from downhill logging using the natural topography to assist snigging, to uphill extraction which requires more specialised harvesting equipment.

Clearfalling of first rotations commenced in 1982–83. By 1985–86 about 50 per cent of the volume of timber harvested was from clearfalled stands. Currently about one-third of the volume harvested is from thinning material. Second rotation plantations are now established under a stocking regime aimed at maximising clearfall volume and quality and with a single commercial thin on sites that will economically support it based on terrain. The current average clearfall age for the first rotation is around 55 years, whilst the envisaged length of the second rotation is around 40–45 years.

Forestry workers and supervisory staff lived on forest stations that were established on the reserves. By 1930 twelve forest stations were established in hoop pine plantation districts; by the 1960s–1970s the number had risen to about 20. Some stations were small and located in isolated areas. Others were larger, being located close to small sawmill towns with perhaps a community hall and a school. A typical small forestry station comprised one or two houses, a number of married quarters (small three-roomed houses with a detached kitchen) and single-man quarters (usually three-roomed buildings with a kitchen and an open fireplace on one end). The stations also had an office, truck shed and a storeroom. Larger stations often had a ranch or mess hall. Small forest stations employed 8–20 men while larger ones employed up to 80 men. Today, most small forest stations have disappeared or have been converted to other uses, for example as education centres owned by state and private educators.

Uses of hoop pine

As hoop pine has an even texture it has always been favoured for plywood. The plywood industry was established in Queensland during the First World War and was a big success. In 1918 plywood sold for six shillings a sheet. The logs were rotary peeled. Hoop pine has also been used extensively in the construction industry for framing and boards; internal flooring; protected lining; panelling; tongue-and-groove boards for walls and ceilings; protected structural joinery; protected non-structural joining; mouldings; weatherboards (painted); and building railway carriages. Today it is still favoured for plywood, mouldings, furniture componentry, panelling and joinery with a significant volume exported to Asia for reprocessing into products for the United States of Americia and European markets.

As hoop pine is one of only a few timbers in the world that does not have an aroma, it was used in the manufacture of meat cases, butter boxes and pine casts. During the early part of the 20th century the majority of the butter boxes manufactured in Australia were from Queensland hoop pine. The timber's lack of aroma is still an important trait with, for example, a local

Queensland company (only one in Australia) manufacturing approximately 1.5 billion taint-free paddle-pop sticks and coffee stirrers for the domestic and export market.

Research

The story of the development of hoop pine plantations has been not without its problems. It is a story of trial, determination and hard work. The development of techniques that has resulted in the successful establishment of the only native conifer in Australia to have been used as a plantation species has, since the early 1920s, been underpinned by a vigorous research effort. This research has involved technological advances in nursery systems, plantation silviculture and tree breeding. This research effort includes a new nursery system that has resulted in the production of more robust planting stock; the use of herbicides that has boosted the early growth rates; tree spacing trials and work on optimal pre-commercial thinning and pruning levels that have led to increases in the productive capacity of the forests; the use of better seed sources based on genetic research that has improved stock quality and growth rates; and the establishment of environmental assessment methods that ensure that all plantation establishment and harvesting operations adhere to strict codes of operations. This continuing research effort and the input from plantation managers will ensure that hoop pine plantations will continue to be established and managed on a sustainable basis.

Bunya pine: a noble denizen of the scrub

> This noble tree I purpose to dedicate to its discoverer, who is not only a successful cultivator of plants in his garden at Sydney, but who has been the means of making known to us many novel plants of Australia, and more especially of New Zealand (W.J. Hooker, 1843).

Nomenclature and location

Bunya pine (*Araucaria bidwillii*) lies in the genus *Araucaria*. The specific name honours John Bidwill (1815–1853) an early explorer, botanist and the first Land Commissioner for Crown Lands, Wide Bay District of Queensland (then New South Wales). The species is endemic to Queensland with a disjunct distribution in the state, with one large but fragmented area in the south-east and two smaller but adjacent areas in the north. In one small mountainous area in south-eastern Queensland—the Bunya Mountains (approximately 160 kilometres west of Brisbane)—this tree occurs in abundance. It was because of the bunya pine that this area was set aside as Queensland's second national park in 1908; the area occupied by the species in the Bunya Mountains National Park (19,490 hectares) is now less than 100 hectares.

Tree and timber properties

The bunya pine has many features that set it apart from most other Australian trees. It is a towering, majestic tree growing from 30 to 45 metres in height with a diameter (at 1.3 m) of up to 1.5 metres. It has 'a certain nobility of habit', with a single, straight, unbuttressed trunk and a very distinctive symmetrical, dome-shaped (parabolic) upper crown. Its branches often occur in whorls (15–75 centimetres apart) and are horizontal, evenly spaced and generally unbranched. In old trees the branches are 12–15 centimetres in diameter. In addition, the large female cones are unlike those of other aracaurias. There can be 20–50 pineapple- or football-shaped cones on one tree, each being very large (20 × 30 centimetres) and weighing up to 10 kilograms. They are found in the top one-third of the tree and are dark green in colour and often camouflaged by branches and leaves. Each cone can contain 50–100 seeds. These heavy cones can cause serious damage when they fall and indeed in recent times, because of the litigious nature of modern society, a number of bunya pine trees have been removed from parks and gardens for fear of accidents.

Bunya pine is classified as a cabinet wood, its timber being pale yellow and slightly pink with an even texture, faint growth rings, and light weight (air-dried density of 460–530 kilograms per cubic metre). Bunya pine has historically been used for the same purposes as hoop pine and in the 1920s hoop and bunya timber was collectively known as 'Queensland pine'. Today bunya pine wood is not readily available as the only trees cut are those removed for safety reasons or which are in poor health.

Bunya plantations

Although early timber-getters harvested the bunya pine because of its good wood qualities, it has not been planted extensively in plantations. The reasons for this lie in the persistent, sclerophyllous pointed leaves; the very thick prickly bark, especially in the butt; the presence of large-sized knots at close intervals that significantly affects the strength properties and the ability to take stains etc, and the inherently slow growth rates. During the 1960s a number of low-lying areas in south-east Queensland were planted with bunya pine as it is more frost-tolerant than hoop pine. Also as its thick bark affords some protection from fire, bunya pine has in a few cases been planted as a firebreak around hoop pine plantations. Although there were 510 hectares of bunya pine in plantations on state-owned land in Queensland in 1980, today there are only 368 hectares extant.

Aboriginal use and spiritual values

The indigenous people of southern Queensland (and northern New South Wales) have always had special affinities with the bunya pine. The trees were considered to be sacred and their edible seeds (or nuts) were, and still are, a ceremonial food of great significance. They were the focal point of major seasonal ceremonial gatherings that brought together thousands of people from a wide area, usually at the time of the bumper season every third year. Special envoys carrying message sticks from custodians of the trees travelled through surrounding districts to invite selected groups to attend the ceremonial feasts. Although the bunya pine is found in several areas in south-east Queensland, the bunya feasts were traditionally held in two main areas, the Blackall Ranges (in the Sunshine Coast hinterland 100 kilometres north-west of Brisbane) and in the Bunya Mountains. These feasts were times of great spiritual significance. It was a time when Indigenous people gathered to receive strength from Mother Earth. They were also times for arranging marriages, settling disputes, trading goods and sharing dances and songs. There is evidence, although scant, that they used parts of the tree other than the edible nuts. The headman of the Kaiabara tribe wore an armband made of bunya fibre as a mark of office and the bark of dead trees was used as fuel. Also, the gum and roots were a food source, with the roots being peeled before being roasted.

Bunya cones were collected by climbing the trees and knocking the cones off with a stick or stone tomahawk. There is some debate on how the trees were climbed. One tradition is that toe holes were cut into the bark using stone axes. However, some early observers recorded and present-day elders state that Aborigines would not damage the bunya trees for they were considered sacred and that climbing was done with the aid of vines that encircled the tree and the climber. The nuts were eaten raw, roasted in the ashes or on coals, or ground into flour.

The bunya pine is one of the few trees (perhaps the only tree) to have been protected by government legislation. In 1842, the governor of the day, aware of the importance of the bunya pine to the Aborigines and to lessen conflict between them and the white settlers who saw the bunya pine as a source of timber, proclaimed that Aborigines were to have sole use of bunya trees wherever they occurred.

Bunya pine today is mainly planted for ornamental purposes. Because of its unique branching feature this tree was very popular in the nineteenth century as in garden situations and was planted in cemeteries, around homesteads and churches, in streets, and around city memorials.

Kauri pine: gun-barrelled sentinels of the forest

> Here tower majestic Araucarias,
> Gun-barrelled Kauris in lead armour
> Thunder-browed Satinays from Fraser Island,

With their ladies, the comely Crow's Ash,
And crinolined and carmined Lillipillies,
And ti-trees wrapped in tissue paper (E.H.F. Swain 1966).

Nomenclature, location and properties

Kauri pine (*Agathis robusta*) lies within the genus *Agathis*, from the Greek 'agathis' meaning a ball of thread, referring to the resemblance of the cone to a ball of thread. The specific epithet is Latin for 'strong', an allusion to the vigorous growth of the species.

In Australia this species only occurs in Queensland. It has a disjunct distribution, being found in two locations. In south-east Queensland it is found in the Gympie, Maryborough and Fraser Island regions and in north Queensland it is found in rainforests between Ingham and the Big Tableland near Cooktown. Two closely related *Agathis* species are bull kauri (*Agathis microstachya*) and blue (or black) kauri (*Agathis atropurpurea*). They are both restricted to north Queensland and are not included in the descriptions of kauri below.

Kauri is a very tall tree between 36 and 42 metres in height with the occasional specimen nearing 50 metres. Mature trees can have diameters (at 1.3 metres) of 90–120 centimetres, sometimes up to 300 centimetres. Large kauri trees are quite imposing and majestic. Tree boles are usually straight with little taper and are branch-free in the lower sections (*Agathis* species are self-pruning). Trees grow on a variety of well-drained soils in the 1000–1500 millimetres rainfall belt.

The wood of kauri is creamy-white, of plain appearance, even-textured and fine-grained. It is easy to work and can be stained and glued readily, being relatively light with an air-dried weight of 324 to 450 kilograms per cubic metre. The timber is ideal for cabinetwork, joinery, panelling, framing, sheeting and plywood. Much has been exported to southern Australian states.

Kauri harvesting on Crown lands

William Pettigrew was the first sawmiller who recognised the potential of kauri pine. In 1863 he built the first sawmill specifically for the milling of kauri pine calling it 'Dundathu' after the indigenous word for kauri pine. The mill was on the banks of the Mary River downstream of Maryborough.

The relatively small natural distribution on Crown and private lands in south-eastern Queensland did not sustain the intensive logging of kauri for long and by 1912 southern kauri pine stands were described by the Forestry Branch of the Department of Public Lands as 'almost trees of the past'. Nevertheless, there were still considerable forests of the species on Fraser Island. By 1922, however, the Forestry Branch reported: 'Of kauri pine the southern resource is utterly gone.'

Natural kauri pine had been logged in north Queensland since the 19th century. In the 20th century, the total amount of Crown mill logs of northern natural kauri harvested was well over half a million cubic metres, mostly from state-owned lands. Logging in the north continued until the forests in that area were World Heritage listed in 1987. In regard to plantation pine, thinning of kauri in Queensland began in 1947–48 with a small quantity of 29 cubic metres being harvested.

Kauri plantations

In north Queensland a nursery was established near Atherton at the end of 1912 and sown with kauri seed and other potentially commercial rainforest species. The fledgling Forestry Branch of the Department of Public Lands decided in 1913 to trial kauri for survival rate and growth performance. The potential of future plantations of kauri pine in north Queensland looked promising according to the trial results. It was not until 1935, however, that 13 hectares were established as a plantation. Experiments in the early 1950s revealed that the kauri pine of north Queensland, under favourable conditions, showed growth comparable with the best hoop pine stands in the state. By 1952, 115 hectares of kauri had been planted in the north. No further plantings of note were carried out in this region. Enrichment planting of kauri was beginning to look promising in the 1960s. This practice entailed the planting of kauri seedlings in the more open sections of natural rainforest in north Queensland, either in naturally sparse areas or in pockets arising as a result of logging. The practice operated until the mid-1970s.

In southern Queensland kauri was first planted on Fraser Island in 1876 in gaps and large strips cleared in the forest. However, these plantings failed presumably from competition from the surrounding vegetation and competition from weeds. Despite these failures, kauri was re-established in plantations during the period 1916–1920. Growth in these was better, with some trees planted in 1918 being 12 metres tall at age four years. Effective plantations on the mainland in south-eastern Queensland were established in the 1930s. Then in 1935, an insect pest, thrip, was noticed on kauri seedlings in the Imbil Nursery. It was an ominous portent! The area of kauri plantation in Queensland in 1958 was 716 hectares and the maximum area established to kauri pine in Queensland by 1964 was 780 hectares. The future of kauri as a plantation species looked assured. But disaster struck in 1959 because of attacks in the Mary Valley of the coccid scale insect *Conifericoccus agathidis*. This native insect caused widespread defoliation of plantation kauri. Then in 1963–64, kauri thrips (*Oxythrips agathidis*) continued to increase the overall level of damage to southern kauri. The coccid also attacked kauri in north Queensland but the problem was not major. By 1967, the coccid attack in south Queensland was still serious and salvage logging of the affected plantation trees was carried out. The kauri plantation program in the south quickly came to a halt. Today there are only 129 hectares of kauri plantations on state-owned land.

Kauri gum

Mention is made in the late 1920s of commercial quantities of *Agathis Palmerstonii* (now *A. robusta*) fossil gum. The Technical Museum of the Forestry Branch reported that the product was 'valuable for the manufacture of spirit varnishes and that the product had a good commercial future provided that regular supplies could be obtained.' In 1946–47, 125 tonnes of kauri gum was harvested from Crown forests. In the following financial year the figure dropped to 45 tonnes and in 1948–49 the amount was only a little over 9 tonnes. As there are no further entries in Forestry Department annual reports it is assumed that the resource was exhausted.

Wollemi pine: the tree that time forgot

Wollemi pine (*Wollemia nobilis*) is one of the world's rarest tree species. It is the only member of the genus *Wollemia* and takes its generic name from the national park in which it was found. Its specific name *nobilis* honours its discoverer, David Noble, a New South Wales National Parks and Wildlife Officer who found it in 1994 in the Wollemi National Park, 150 kilometres west of Sydney. It has been called the 'dinosaur tree', for it has been suggested that the leaves of the tree were a food source for herbivorous dinosaurs, and as a 'living fossil' as its heritage can be traced back through the fossil record of Australia, New Zealand and Antarctica to the early days of the conifers. In 1999 it was known to occur at two sites (about 40 adult trees and 200 juveniles); in 2000 it was found at a third site (less than 100 adult trees). A tree with very distinct knobbly bark, it grows to a height of 40 metres with a diameter of over a metre. Its growth rate in the wild is very slow.

Although Wollemi pine produces viable seed, the species appears to possess little genetic variation. This is to be expected in a geographically isolated relict population. It has been exacerbated by the fact that many trees in the extant population have been reproduced vegetatively. Vegetative reproduction can occur through rudimentary buds in the axils of leading vertical shoots and by buds at the base of and along the trunk. This ability to readily coppice has resulted in trees with multiple trunks of different ages. However, this feature has been used to ensure that this rare and endangered species survives. In 2001 a joint venture company (Wollemi Australia Pty Ltd) was set up between Queensland's Department of Primary Industries and Fisheries and a private nursery to propagate, market, distribute and sell the Wollemi pine to the domestic and international market under licence from the Royal Botanic Gardens (Sydney). Propagation of the species is being undertaken by cuttings and tissue culture. Plants are due for public release in late 2005 and each plant sold will return a royalty to conserve the Wollemi and other threatened Australian plant species.

Other species

Three other species planted in Queensland are klinki pine (*Araucaria hunsteinii*), Norfolk Island pine (*Araucaria heterophylla*) and Paraná pine (*Araucaria angustifolia*). Klinki pine has been planted in trial plots in north Queensland. Although growth rates and tree form have been good, this species does suffer from top breakage caused by wind, and because of this there are no plans to plant this species commercially in Queensland. Norfolk Island pine has been planted extensively as an ornamental, especially at seaside locations in the 1920s and 1930s. Today these trees still survive. It continues to be planted in parks and roadside verges in new residential and industrial areas in coastal Queensland. The planting of the Paraná pine has been limited to several trial plot plantings.

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'Splendid spars': a Norfolk Island forest history

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Norfolk Island bubbled up out of the sea three million years ago as a result of volcanic activity. It was eroded by the sea to its current size of 35 square kilometres (3529 ha) and was colonised by organisms that could fly, swim or float to it. The flora and fauna evolved sufficiently distinct characteristics to be considered as separate species endemic to Norfolk Island. There are 178 plants indigenous to the island, 42 of which are regarded as endangered (Environment Australia 2000, 4). Some are like the Norfolk Island pine (*Araucaria heterophylla*) which has Gondwanic relatives to the north *(A. columnaris)* and on the Australian mainland—hoop pine (*A. cunninghamii*) and bunya pine (*A. bidwillii*). The latter are features of outstanding universal value in the Central Eastern Rainforests Reserves of Australia World Heritage property.

The island's ecosystems are highly vulnerable as a result of disturbance and 6 out of 15 bird species have become extinct since European settlement. This colonisation of Norfolk Island by flora and fauna is paralleled by its human occupation. During the early 13th century A.D. there was a little known occupation of Emily Bay by Polynesian people, who presumably moved on to the land of the long white cloud, New Zealand (Anderson and White 2001). Five centuries later, following enthusiastic reports about the island's resources from mariners, British colonial outposts and penal settlements were established in 1788 and again in 1825. Then in 1856 the Pitcairn Islanders were transferred to Norfolk Island forming the modern community which was much increased after the Second World War II (Lennon 2003).

The human population is less diverse than the plants which make up the current vegetation of the island and whose exotic names give evidence of their origins: African olive and box thorn; Chinese wood-oil tree; English oak; Hawaiian holly; Illawarra flame tree; Japanese honeysuckle; Jersey cud weed; Lombardy poplar; Lord Howe Island blackbutt; Madeira vine; Mexican poppy; Moreton Bay fig; New Zealand Christmas bush and pittosporum; Queensland black bean and umbrella tree. They vary from sturdy tree invaders to shrubs, flowers, grasses and creepers.

Norfolk Island was brought to the attention of Europeans when Captain James Cook RN in command of HMS *Resolution* sighted it on his second world voyage on 10 October 1774. Next day he and a party landed, claiming the island for the British Crown:

> …the chief produce of the isle is Spruce Pines which grow here in vast abundance and to a vast size, from two to three feet in diameter and upwards, it is of a different sort to those in New Caledonia and also to those in New Zealand and for Masts, Yards & Ct superior to both…My carpenter tells me that the wood is exactly of the same nature as the Quebeck Pines. Here is another Isle where Masts for the largest Ships may be had (Beaglehole 1961, 565-6).

Cook's report to the Admiralty and publication of his book *A Voyage to the South Pole* in London in 1777 gave Norfolk its first publicity (Hoare 1999, 5).

Lt Philip Gidley King established the first convict settlement on Norfolk Island on 6 March 1788, one month after Governor Phillip had established Sydney Cove (Hoare 1999, 10-12). By October 1796, 619 hectares of land had been cleared of timber which was used by sawyers for construction purposes, and in 1798 the 25 tonne decked boat *Norfolk* was built of local pine; this boat was sailed by Matthew Flinders in his circumnavigation of Van Diemen's Land in 1799. However, the planned widespread use by the Admiralty of Norfolk Island pine did not eventuate and the cleared land was given over to agriculture. Maize, wheat, potatoes, sugar cane, bananas, guava, lemons, apples and coffee were all successfully grown. The settlement was abandoned in 1814 (Hoare 1999, 25-7).

The second convict settlement occurred in 1825 and the sawpits were re-opened and a lumber yard was established in Kingston by 1831. The peak convict population of 1,872 occurred in 1840. By 1856 when the last convicts had sailed for Hobart, the island had been cleared of 40 per cent of its vegetation, and woody weeds were already a problem—limes, lemons and apple-fruited guavas had already over-run much of the formerly cultivated land and the native forest (Nobbs 1991, 161).

The Pitcairn Island community was relocated to Norfolk Island in June 1856. Shore based whaling and subsistence agriculture remained the main activities during the nineteenth century, although there are references to constructing small boats from pine logs (Hoare 1999, 97). In 1895 the New South Wales government took over the responsibility for Norfolk Island and in 1896 the population was over 800 of whom about one-third belonged to the Melanesian Mission (Hoare 1999, 107). From about 1910 Burns Philp commenced their Norfolk Island trade as part of their Pacific Trading enterprise.

Norfolk Island was 'placed under the authority of the Commonwealth of Australia' under the terms of Act No.15 of 1913 of the Parliament of Australia; a resident Administrator was appointed who, among other duties, regulated the disposal of Crown land. The main exports were lemon juice, passion fruit pulp, coffee, lemon seeds, potatoes, onions, wool, arrowroot, and frozen and smoked fish (Hoare 1999, 122). There was a 'banana boom' in the late 1920s due to the demand for disease-free fruit in Australia and New Zealand. New settlers arrived to grow bananas, causing the population to peak at 1231 in 1933 (Hoare 1999, 126-7).

Tourism was seen as a possible means of developing the local economy as early as 1919 and in 1926 the golf course was developed, foreshadowing the importance of recreational facilities in supplementing the island's natural beauty. In 1927 preservation of the historic buildings and repair of the ruins was mooted. In 1933 a tourist brochure referred to Norfolk as 'The Madeira of the Pacific'. The guest house *Dewville* at the eastern end of Quality Row developed in the 1930s but after the Second World War II, the Paradise Hotel was developed on this site, and tourism increased again by 1949 (OC 2002, 80-1).

Utilisation of local timber had been for domestic purposes aside from the construction during 1923-5 of the schooner *Resolution* which was to trade between Norfolk and New Zealand, but her first cargo of fresh fruit spoilt and in 1927 Burns Philp purchased her for the New Hebridean, Fijian and Tongan trade (Hoare 1999, 124-5).

Interest in forest conservation increased with the intervention of the new Commonwealth authorities, in the person of the Inspector General of Forests, C.E. Lane Poole. He first visited in 1925 and made recommendations regarding timber reserves, training, timber royalties, reforestation etc. However, by 1931 the Administrator, Colonel Bennett, merely sought his advice on technical matters. On 16 June 1931, he asked for advice on transplanting seedlings from the forest. Lane Poole replied to the Secretary of the Department of Home Affairs:

> I do not recommend the transplanting of seedlings from the forest to new country on account of the difficulty which exists in distinguishing between seedlings suitable for planting out and those which to all outward appearance are of seedling growth but which are dominated trees and not suitable for transplanting. If planting on a large scale is contemplated, more satisfactory results will follow if trees are raised in a nursery, and on reaching the age of two years, transplanted into their permanent sites… With regard to the spacing of trees I should advise planting in rows about eight feet apart, and the same distance between the plants, if planting for commercial purposes is carried out. This spacing gives 680 trees to the acre.

He elaborated on 23 June 1931:

> The transplanting of seedlings from the forest is usually attended by serious risk of failure, the reasons being that the seedlings, though quite small, may be many years old and be suppressed by the canopy and the roots of old trees of the forest. It has been demonstrated with trees whose annual growth rings are discernible with a microscope, that apparent seedlings 1-3 feet high were in reality 20-50 years old. It was customary in Queensland some 15 years ago to attempt planting by transplanting seedlings of hoop pine (this is a sister of the Norfolk Island pine), and the failures, which reached 85%, caused the department to resort to the sounder practice of raising the seedlings in a nursery.

He further gave instructions for nursery practice, tilth, weeding and shading. The Administrator ignored his earlier advice and, not one to be ignored, Lane Poole persisted with his attempts to have sound forest policy adopted on Norfolk Island. When the Administrator objected to his interference in setting the royalty for cutting pine on leasehold land, Lane Poole wrote a long reply to the Secretary of the Department of Home Affairs on the need for a forest policy for Norfolk Island, dated 24 June 1931:

> I am prepared to admit that the Administrator is in a better position than I to gauge the price the agriculturalist can afford to pay for the pine trees he cuts down. My fear is that in his desire to cultivate as much land as possible, trees may be felled on sites which will not be retained permanently for agriculture. This is what has occurred in all the States of Australia and in most other lands. I should like to see the price of the timber –the Crown's property – raised to something approaching what it will cost to grow it, so that instead of making it very easy for settlers to destroy an asset they will be forced to consider very carefully the relative value of land and timber before applying for a permit…
>
> The policy of planting three trees to replace one cut down is a very interesting revival of a law which has been tried in many lands, both old and new, and which has had to be abandoned for certain reasons, the most cogent of which are as follows:
>
> 1. It takes a number of trees, usually more than three, to supply one sound mature mill tree.
> 2. The trees must be correctly placed apart when planted.
> 3. They must be in sufficient numbers to form a little wood otherwise the necessary 'forest condition' will not become established.
> 4. They must be thinned at intervals so as to assure the maximum development of timber of the right size and form.
> 5. The area on which they are growing must be reserved or otherwise set aside for the production of timber and this reservation must be maintained for at any rate the duration of the life of the species making up the wood, which may be as long as 60 or 100 years.
> 6. The wood must be protected from small and great stock, from vermin, from fire, and from man during the whole period of its life.

The practical impossibility of securing such a continuity of policy as is required for forestry from private owners soon rendered the laws regarding replacement of trees inoperative and they became a dead letter or were repealed.

> …Norfolk Island held under lease hold tenure…select on each lease, an area which in the opinion of all, is less valuable for agriculture, fence it, and reserve it definitely for forestry purposes for all time. In this 'wood lot' to use the American farmer's term, the trees to replace those cut would be planted. Here again, I would rather if it is possible, get the lessee to plant a definite area annually than the number three per tree felled. Were he to plant a square chain annually with trees 6 feet apart, or 144 a year, he would in the course of 30 years have a valuable little wood of 3 acres. A reserve of 3 acres on each lease may be too small or too great, and 144 may not be an appropriate number; these matters would be decided by the Administrator. The principle should hold good, viz., the dedication of a definite percentage of land on each lease to forestry and a continuity of planting annual and equal areas, till the wood lot is complete. The final result will be the establishment by the

efforts of the lessees of a number of forestry reserves which in the aggregate would make up a satisfactory percentage of the total area of the island. The objections still remain, and only by including in the lease documents stringent conditions will it be possible to maintain a continuity of planting and of protection, and to enforce the [silvi]cultural operations which from time to time are necessary.

Even with these aids I am not very sanguine that the object desired will be attained and I certainly consider a better and a less expensive way in the end to all concerned would be achieved by concentrating on the existing Government Forestry Reserves and applying sound forestry practice to them…If the whole of the policy is not translated into action by the lessee, at any rate a number will it is hoped see the value of the proposal, and there may also develop in the minds of the inhabitants in general that somewhat rare civic attribute—a 'forest conscience.'…

I am sorry that the term 'neglect' used by me in connection with Mt Pitt timber reserve is resented. I submit, however, that the fact that the reserve is not enclosed is sufficient evidence of neglect. So long as stock can enter the reserve its improvement is not possible and it can only be labeled 'neglected.'...

In the matter of the comparison with Phillip Island, there is certainly one other destructive agent necessary to reduce Norfolk Island to the same barren condition, and that is the rabbit…The stages on the road to desolation are so gradual as to be hard to distinguish but they are always progressive. Many an ancient civilisation has boasted that the immutable laws regarding denudation might hold good for other lands, but not for them; and those civilisations and their cities have become deserts and wildernesses.

In conclusion, I must say that the Forestry Bureau is most desirous of assisting the Administrator to establish a forest policy that will be enduring…. (NAA, A2430 1931 POL13, pp.11-15).

The major effort at this time was directed at collecting seed for distribution elsewhere in Australia. In October 1931 Lane Poole advised that the request from the Western Australian Conservator of Forests for 2 cwt of seed of Norfolk Island pine could not be filled as the 'seed ripens in June and rapidly deteriorates in quality after maturing.' The prospects for next year were good as the Administrator had reported that 'the number of cones now forming would indicate a good seed crop.'

However, in July 1932 the Queensland Forestry Board was informed that supplies of fertile Norfolk Island pine seed were unavailable. There was also a request from the South Australia Forests Department for seed. On 5 July 1932, John R. Logan of *Edrom*, Eden, NSW wrote to Lane Poole regarding collecting seed from his Norfolk Island pine: '1 cwt gathered after a gale and more to come; tree planted by B. Boyd in 1847 and is 85 feet 5 inches high and nine feet around the butt.' He queried obtaining 20 shillings per pound for the seed. Lane Poole replied on 13 July that twenty shillings was possible from nurserymen and seed merchants with direct supplies to other States.

In July 1932 Captain Charles Pinney was appointed as the new Administrator of Norfolk Island, and on 22 August 1932 he reported on forest condition:

…inspection of the Mt Pitt Forest Reserve…deplorable condition. Apparently hardwood can be obtained only in the most inaccessible corners. The northern slopes of Mt Pitt are almost bare of marketable pine and the tracks cut through the undergrowth by various logging parties only serve as tracks for straying cattle who devour every young pine in sight …difficulty in obtaining hardwood fence posts…one settler has utilized concrete posts… (NAA, A2430 1932 POL13, p.34).

Pinney wanted to plant 100 acres of hardwoods and requested seed. In October funds were granted to complete the fencing of Mt Pitt reserve and the Administrator was advised on 29 October 1932 that Lane Poole had sent 3 parcels (each about ½ pound) of seed for planting in Mt Pitt Timber Reserve: tallowwood (*Eucalyptus microcorys*), (requested from L.Hudson, Forest office, Taree –'same gathering as we sowed at Coopernook'), turpentine (*Syncarpia laurifolia*), and grey ironbark (*E. paniculata*); the latter was collected in November 1930 by Andrew Murphy ('botanical seed collector of Australia', Woy Woy, NSW) at a cost of 25 shillings per pound. (NAA, A2430 1932 POL13, pp. 21-33).

Lane Poole also advised the Secretary of the Department of the Interior, on the training (wages, board, fares, conditions) of Master E.V. Stephenson, the local lad selected to be a forester:

> ...1½-2 years…under my direction as Acting Principal of the Australian Forestry School…training in nursery, clearing and planting…Yarralumla nursery…some two months at a Queensland nursery tending and raising hoop pine…5 year bond… 'because this country would have its attractions for a young islander' (NAA, A2430 1932 POL13, pp.11-12).

The new Administrator requested a visit from the Inspector General of Forests to advise on afforestation matters. He sailed on SS *Morinda* from Sydney on 19 January 1933 and later reported:

> Apart from Rocky Point Reserve which was already fenced in 1925, I can report no improvement in the conditions. On the contrary, thanks to the rapid commercial development of the island, the number of pine trees on the island has been greatly reduced and no steps taken to replace them. Standing on Mt Pitt and overlooking the whole island, I was astounded at the change. While much of the timber has been sawn up and utilized…a good number of trees have been destroyed in the process of cultivating the land for bananas and other crops…in 1925, 'there were two mills…combined out put of 12,500 cubic feet (150,000 super ft) a year-just enough to supply the little needs of the population in case wood and building timber, and to provide a tiny export to Vila and Lord Howe of second class case wood', today there are five mills and the export of fruit alone takes 84, 000 cases a year. In addition there has been a large increase in buildings. Now settlers have erected homes and out-houses, and boarding houses and cottages to let by the sea have sprung up…major part of mill logs have come from private property…it is clear that the trees on private property will not be replaced and the same applies to leasehold, so that as time goes on such lands will become treeless.
>
> …gratifying to know that the period of forest apathy is past and that the present Administrator has taken the first steps towards establishing a forest policy for the island. Headstone Reserve is now enclosed and the closing of the Mt Pitt Reserve will be effected very shortly.
>
> The very satisfactory growth of the self-sown pines on Rocky Point Reserve shows what would have occurred on the other reserves had they been also closed against stock…
>
> Mt Pitt…further areas without any old pines to act as seed trees. The planting up of these blanks with nursery raised stock is the most certain solution, though the Administrator's proposal to 'spot sow' them with the aid of the boy scouts and girl guides is an interesting one and may prove economical if successful.
>
> …grey ironbark and tallowwood seeds …raising them in tubes…nursery site chosen…old bowling green, surrounded by tall pines…fair soils…As an experiment I recommend that the whole of the old bowling green be fenced in and the ground cultivated. This will show the possibilities of raising pine trees naturally around the old trees in Kingston which must be replaced as they die out. It is important that the cultivation be deep so as to sever the tree roots or the young pines will die during summer drought through root competition.
>
> In my 1925 report I recommended an increase of 485 acres in the area of forest reserves…adjoining Mt Pitt Reserve. In 1927 the Minister approved 400 acres …being set aside for reforestation, but in September 1927 Col. Bennett recommended leasing for agricultural purposes of 263 acres…a serious blunder…now Capt Pinney has re-reserved 172 acres.
>
> Chopping and changing in any government policy leads to dissatisfaction. In forestry, changes of policy result as a rule in alienation of forest land and destruction of a government asset.

It is to be hoped…that the boundaries of forest reserves in Norfolk Island will not again be interfered with but will remain intact as an area dedicated to the growing of the Island's future requirements in timber…Unfortunately there is no change for the better and all but Rocky Point Reserve may be said to be growing a minimum of timber in a maximum of time.

I wish to emphasise…that Norfolk Island has definitely progressed along the lines of commercialization…The subdivision of the Melanesian Mission lands has resulted in the advent of settlers from the mainland who have initiated progressive methods of farming and have built up a fine export trade in bananas, potatoes, beans and passion fruit. There are 100 cars on the Island including heavy lorries. There has been a general rise in the standard of living, and the descendants of the Pitcairn settlers, known locally as 'Islanders' have been forced to follow the lead of the 'Mainlanders', as both Australian and New Zealand settlers are called…

At present the upward tendency of the curve of progress is flattened by economic forces beyond the control of the population; I feel sure, however, that with the restoration of stable economic world conditions the advance of the Island will continue.

…the need of a sound forest policy, important as it was in the old lotus-eating days, is now a fundamental necessity if the Island is to be a self-supporting unit of the Empire. There are many things which the Island must import and these will increase in kind and in number as the Island progresses. It should be able to attain a sound balance of trade; the possibility of this objective being frustrated by its having to import timber must be avoided. Again, a people who have progressed to the point now reached, can no longer be regarded as a primitive race but should be subject to laws differing in no essential from to those in force in Australia. The cutting of timber must be carefully regulated and the inhabitants must submit to laws and regulations which will minimise waste in utilization on one hand and on the other prevent forest destruction by stock of young trees growing up in forest reserves. They must be prepared to pay a fair price for the trees, that is a price that will pay the cost of growing the forest again. (Lane Poole, 21.February 1933, A2430 1933 POL13 Pt 2).

During the remainder of the year, correspondence shows that pine seed was dispatched from the Island to the Trade Agency section, Department of Treasury, in Sydney via SS *Mataram* for distribution and rendering of accounts and Mt Pitt was finally enclosed. In August 1933 Lane Poole argued for the reservation of Phillip Island as a forest reserve with a photograph which illustrates 'worst case of erosion that has come to my notice in the three continents where I have worked as a forester' (Lane Poole, 4 August 1933 to Prime Minister's Department, A2430 1933 POL13 Pt 2, p. 74-5). It was to be another 50 years until this erosion was seriously tackled.

Th Second World War had a major impact on island conditions and construction of the airstrip in 1942 entailed cutting down the convict planted landmark, the Avenue of Pines (Hoare 1999, 130). The demand for timber exploded during the war years and production increased to 65,000 super feet per month causing severe depletion of the Island's timber reserves—cutting out all accessible hardwoods and making heavy inroads into stocks of local pine (Norfolk Island Parks and Forestry Service 2003, 21). In 1943 Lane Poole reported again on Norfolk Island forestry and he retired in 1945.

An influx of settlers especially from New Zealand occurred in the mid-1960s and led to locals forming the Norfolk Island flora and fauna society in 1967 due to their concerns about destruction of native trees. In 1968 the Australian Conservation Foundation published Professor John Turner's report on *The Conservation of Norfolk Island* in which reservation of Mt Pitt as a national park was recommended as well as flora reserves along the cliffs and islets, reservation of Philip Island as a bird sanctuary, and conservation of the historic Kingston landscape.

In 1975 the local council chose the name 'Norfolk Island Nature Reserve' for the Mt Pitt area which had been re-fenced at the Australian government's expense again at this time and the national park and botanic garden were finally gazetted in 1985. Prior to this, both areas had been public reserves declared under the *Commons and Public Reserves Ordinance 1936*. The Kingston and

Arthurs Vale Historic Area was designated in 1981 and development was restricted there (Hoare 1999, 146-7). These areas were subsequently also proclaimed as Commonwealth reserves on 30 January 1986 under the *National Parks and Wildlife Conservation Act 1975* following a request from the Norfolk Island Legislative Assembly.

Norfolk Island National Park currently forms 14 per cent of the total land area of Norfolk Island. Prior to the Second World War, the Old Mountain track was the main access to Mount Pitt. The track is now used by walkers as a direct route from the park entrance to the summit. Much of the area was infested with introduced trees and shrubs which eventually became unwelcome weeds. These are gradually being removed and replaced with native species as part of a rehabilitation program.

The area comprising the Forestry Zone was cleared for banana plantations during the 1930s but after the collapse of the banana industry developed into a dense thicket of African Olive. This area was included in the Mt Pitt Reserve as an area reserved for forestry purposes in 1955 although it includes several small areas of remnant native vegetation.

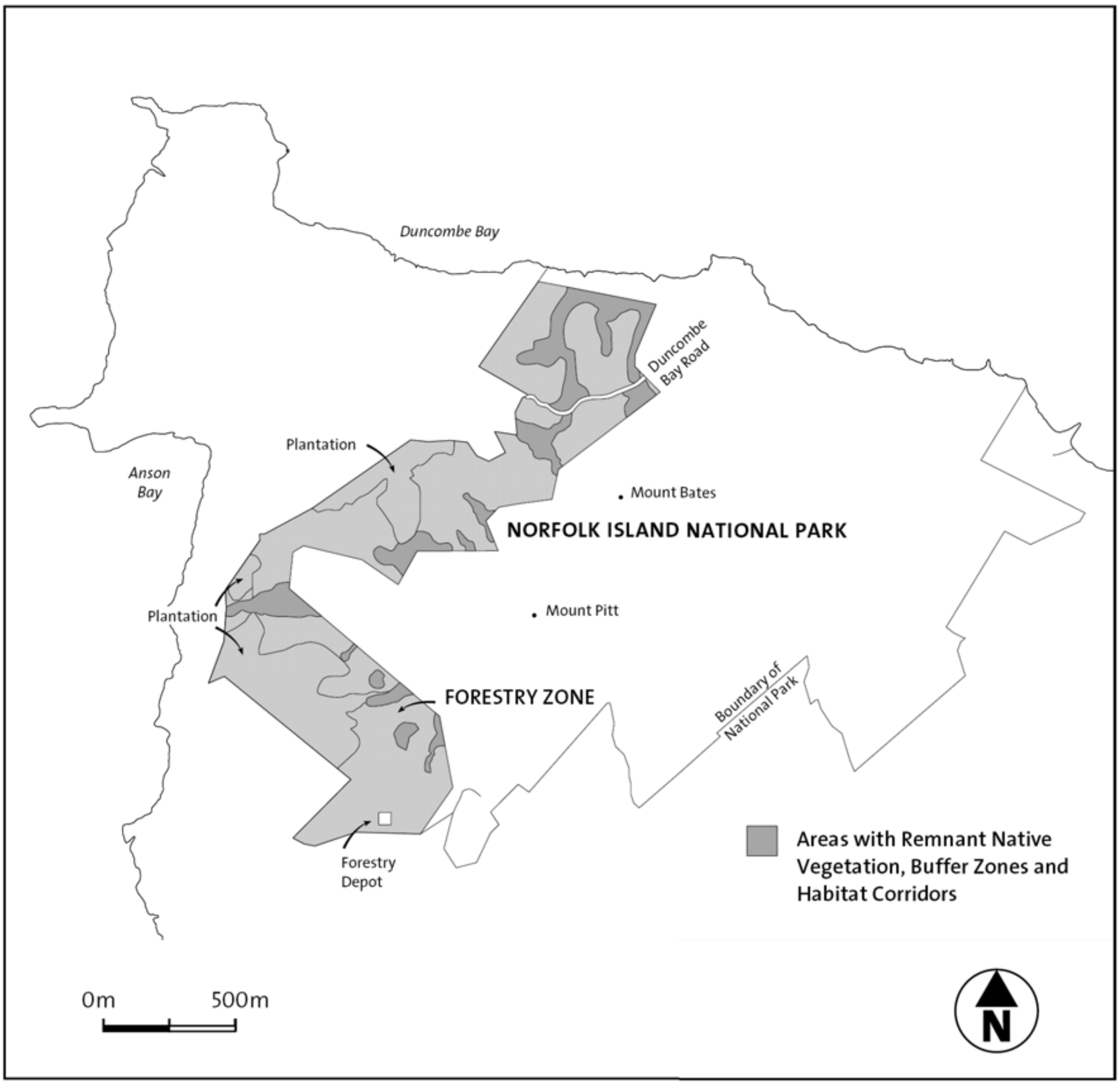

Figure 1: Norfolk Island Forestry Zone

Source: Environment Australia 2000. *Norfolk Island National Park and Norfolk Island Botanic Garden: Plans of Management*. http://www.deh.gov.au/parks/publications/pubs/norfolk_plan.pdf

Some sections adjacent to the western boundary were cleared of olives, and eucalypt plantations were established. Management of the plantations within the zone is the responsibility of the Norfolk Island Parks and Forestry Service and is based on the Forestry Working Plan (Benson 1985). Planting of approximately 4 hectares per year of Norfolk Island pine has continued. The small areas of remnant native vegetation in the Forestry Zone have been surveyed and recommended for preservation due to their high nature conservation values. No non-native species will be planted in the Forestry Zone with the exception of eucalypts which may be planted for a second rotation as existing eucalypts are harvested for local use.

A reliable source of seedlings for forestry operations within the Forestry Zone and for rehabilitation and endangered flora recovery programs in other areas of the National Park was required. This led to a nursery being jointly established within the Forestry Zone of the Park, staffed and maintained by the Island's Parks and Forestry Service (Environment Australia 2000, 69-70).

The Norfolk Island government passed the *Trees Act 1997,* to preserve and manage the taking (i.e, felling, ring barking, removing, destroying, etc.) of protected trees and to control the exploitation of the forestry resources of Norfolk Island. All 36 tree species native to Norfolk are protected under this Act, and permits are required to take any of them. Some are not protected, however, until they reach a specified height (e.g. *Araucaria heterophylla* at 4.5 metres in height); this takes account of the abundance and vulnerability of each species (pers. comm., P. Davidson). Trees Act permits apply equally to Crown or lease, but not to public reserves or national park, where other legislation protects all plants. Trees may be taken from public reserves for timber, by the Administration, provided to do so is within the Plan of Management and has the approval of the Conservator. Royalty now only applies to trees on unleased Crown land (Norfolk Island Parks and Forestry Service 2005). In addition, the *Trees Act* aims to promote and protect the conservation of the natural environment and landscape beauty of the island; and to encourage the cultivation of plantation timbers as a renewable resource. There has been significant planting of pines and other native trees and shrubs on the Island during the past 15 - 20 years.

Table 1: Norfolk Island, recent forestry activity

Year	Volume of timber treated by tanalith plant (cubic metres)	No. of tree permits issued
2000/01		136
2001/02	836	110
2002/03	610	125
2003/04	267	163

Source: Conservator of Forests, Norfolk Island, July 2005.

There are three mills operating on Island: Howard Christian's Mill, Rocky Point Mill, and a bush (mobile or Canadian) mill operated by the Norfolk Island Parks and Forestry Service. Most structural timber is imported, despite Lane Poole's policy of sustainable consumption, the reason for establishing Eucalypt plantations. However, Norfolk Pine is susceptible to borer and most pine is treated at the tanalith plant. Some eucalypt is cut annually by Parks and Forestry Service, mainly for posts and rails, also some flooring orders and large beams. There are several cabinet makers on the Island and some souvenir makers. The timber for the museum's new whaleboat came from two pines cut down near the Anson Bay lookout.

The utility of *Araucaria heterophylla* has spread far and wide across the Pacific. It has been widely planted in Hawaii with positive impacts (Hawaii Forestry Trees 2005) and studied at the Institute of

Tropical Forestry, Puerto Rico (Walters and Francis n.d.). However, in some parts of coastal New South Wales it is now regarded as a weed because of its landscape impact (Indigenous Landscape Design Australia 2005) and its 'splendid spars' are no longer valued. But on Norfolk, Lane Poole's hope of developing a 'forest conscience' has occurred with reservation of the national park and public reserves, extensive replanting, and a sustainable annual cut of timber from freehold land.

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