

The Wollemi pine (*Wollemia nobilis*) a hidden Gondwanan relic with a modern story

Lucy Cranwell Lecture, 3 Oct 2001

Ken Hill, Royal Botanic Gardens, Sydney, Australia

The connection that the subject tonight may have with the renowned New Zealand botanist Lucy Cranwell may not be immediately clear. There are however at least two links - firstly, the role that the palynology has played in placing this new discovery in context follows on from Lucy Cranwell's landmark palynological studies, and secondly, Lucy was a field botanist and I am sure understood the crucial role of field botany. Without the field botanist, this discovery and many similar both before and after may have never been made before the plants became extinct. Lucy was also vitally concerned with conservation of natural areas, and this discovery carries with it a strong conservation message.

While Australia is the second driest continent on earth, it supports a rich plant species diversity - perhaps 25 000 vascular plants and many thousands of non-vascular plants. These occur in a wide range of habitats: from seashore to mountain summit, alpine herbfield to tropical rainforest to desert.

Within this wide diversity, the so-called Gymnosperms are disproportionately poorly represented. There are only 41 species of conifers (Pinophyta) in Australia distributed among 14 genera in three families (Araucariaceae, Cupressiaceae and Podocarpiaceae). In contrast, 43 species of conifer are endemic in New Caledonia off the northeast coast of Australia, and 20 species occur in New Zealand. Many of the Australian conifers are relictual in distribution.

In 1994 a new genus in the family Araucariaceae was discovered in a sandstone gorge in a remote part of a wilderness national park 150 km west of Sydney - Australia's largest city. This discovery hit the front pages of many of the world's leading newspapers and was compared by some to discovering a "living dinosaur". Immediately after its discovery there was a public rush to view the species and a scientific push to study it. Over the last 6 years there has been a great deal of in-situ and ex-situ research on *Wollemia* and a commercial program is underway to grow it for public release. This commercial program is specifically aimed at protecting in-situ trees from exploitation. The story of the discovery, the research and the personalities involved has also become the subject of a best-selling book

Wollemia is a very rare plant, with less than 70 adult plants known, in four small groves. It is a member of the conifer family Araucariaceae, until now thought to include only two living genera, *Araucaria* and *Agathis*. The conifers are an ancient group of seed-bearing plants, dating back to the Carboniferous age, over 300

million years ago. Evolution has substantially changed the conifers since that time, although all modern conifer families are clearly known from the Triassic period, over 250 million years ago.

Araucariaceae is an ancient group, with fossil representation as old as the Triassic (over 250 million years ago). The family takes its name from the first member discovered, *Araucaria araucana* (the monkey puzzle tree from the Andes of Chile and Argentina); the family, genus and species being named from the Arauco region in which this tree occurs. The Araucariaceae reached maximum diversity during the Jurassic and Cretaceous periods, between 200 and 65 million years ago, when it had a worldwide distribution. Range and diversity was greatly reduced at the end of the Cretaceous, at the time of the extinction of the dinosaurs, when the Araucariaceae became extinct in the northern hemisphere. The remaining genera were an important component of the forests of the southern supercontinent of Gondwana in the early Tertiary period, but have slowly declined in numbers and diversity since, to be replaced by the more successful flowering plants.

The Wollemi National Park occupies an area of almost 500,000 ha. The extremely rugged nature of the terrain coupled with the low fertility of the soils has discouraged exploitation, and the area remains undisturbed. This sandstone massif is criss-crossed with many hundreds of narrow canyons, some only a few meters wide and hundreds of meters deep. The ridges and canyon walls carry a light cover of dry sclerophyll woodland and shrubland dominated by *Eucalyptus* species. The floors of these canyons frequently carry quite different vegetation, with a gallery of warm temperate rainforest dominated by coachwood (*Ceratopetalum apetalum*) and sassafras (*Doryphora sassafras*). It is in such a site that the Wollemi pine occurs, as a slender emergent above the rainforest canopy.

Female cone structure of *Wollemia* has many similarities to that of *Agathis*, whereas leaf form has similarities with that of *Araucaria*. Pollen, bark, seed shape, cone position (terminal on first-order branches), 4-ranked adult leaf form and dimorphism between adult and juvenile leaves are features not shared with either. Distinct features of morphology and wood anatomy (warts on border pits and arrangement of rays), together with DNA studies, clearly place *Wollemia* as a distinct genus in the family Araucariaceae.

Wollemia shares with the genus *Araucaria* an unusual feature in that leaves are broad-based and have no

mechanism for being shed from the tree when they have passed their useful lifespan. The related genus *Agathis* and most flowering plants develop a specialised layer of cells at the leaf base that facilitate the shed of senescent leaves. The Wollemi pine still faces leaf senescence, but manages this by shedding the entire branches. This gives the litter on the forest floor a very distinctive nature, and it was this litter in the stream that first alerted discoverer David Noble to the presence of the trees.

The Wollemi pine has a unique pattern of branching, resulting in a double crown effect. Successive whorls of primary branches arise from the vertical leading shoot. The lateral branches grow for between 3 and 8 years, but do not branch further. They are then terminated by a male or female cone. Female cones always develop on branches above branches bearing male cones. After bearing cones, branches stop growing and are eventually shed from the tree at a basal abscission zone.

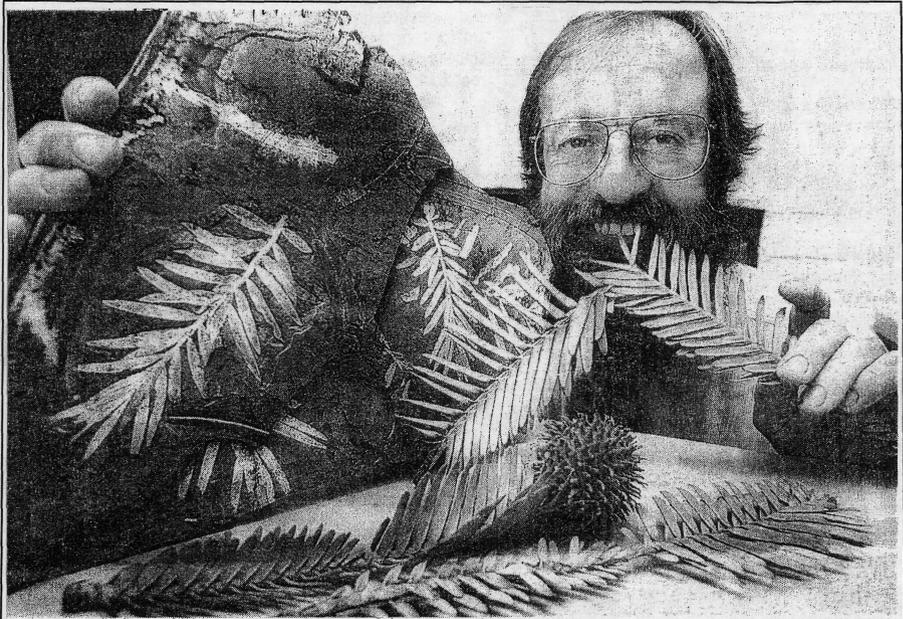
Older trees develop a branched crown, but the older branches, however, do not arise from the primary lateral branches. After the primary branches have fallen, the bare trunk below the primary crown produces a cloak of epicormic shoots with juvenile leaves, creating a second crown. These shoots

eventually become mature branches with foliage and branching structure resembling the initial leading shoot, so that older trees have a branched crown.

The fine scale-leaves on the leading vertical shoots all carry rudimentary buds in their axils. These replace the leading shoot if the latter is damaged. If not, they become buried beneath the developing and gradually thickening bark. A number later become active and form the 'second canopy' and ultimately the lateral branches of larger trees. Others remain dormant for longer periods, and may sprout from older trunks or from the base of the trunk.

This capacity, 'Coppicing', eventually leads to large old plants with multiple trunks of different ages. This is another defence against damage, as are the epicormic shoots. Old Wollemi pines have as many as 60 separate stems developed through coppicing, and the original trunk is long gone. Epicormic shoots and the coppice habit are characteristic strategies for surviving environmental pressures such as droughts and fire.

Genetic fingerprinting techniques reveal the remarkable fact that there is very small genetic variation between all individuals from the several known stands (that are within a few kilometres from each other in the same catchment). This suggests a



Mr Hill shows the fossil and the real thing at the Royal Botanic Gardens in Sydney.

PICTURE: SYDNEY MORNING HERALD

Fig.1 Ken Hill with Wollemi pine: the image that traveled the world. *NZ Herald* 22 Dec 1994: p.9.



Fig 2. Caged Wollemi pine at Canberra Botanic Gardens. Apr 2001. Photo: E K Cameron.

gradual loss of genetic diversity over millions of years as the species declined due to changes in climate and or fire regimes. This low level of variation has implications for genetic research and plant conservation generally. A reason suggested for the rarity of the Wollemi pine is depression of fertility due to inbreeding with the small population, and consequent accumulation of harmful recessive genes. However, numerous seedlings of varying ages are present at the site, and fertility is probably not the main reason for rarity.

The Wollemi pine has become the focus for research at the Royal Botanic Gardens Sydney and around the world. Comparison of DNA sequences of the Wollemi pine and related groups show that, of the living members of the Araucariaceae, *Wollemia* is closest to *Agathis*. Other research has shown that the Wollemi pine is host to the endophytic fungus *Pestalotiopsis guepinii* that can produce the potent anticancer drug taxol, a substance originally discovered from this genus growing on the Pacific yew (*Taxus brevifolia*).

Wollemi pine pollen has been matched with fossil *Dilwynites* pollen. This pollen first appeared early in the Late Cretaceous period, about 94 million years ago, and quickly became common and widespread in Australia, New Zealand and Antarctica. This pollen type remained abundant through the close of the Mesozoic

and into the early Tertiary, up to about million years ago. The *Dilwynites* pollen type then declined dramatically in abundance, at the same time as the decline in the rainforest cover of southern Australia. However, traces of this unusual pollen remained, and the most recent known have been recovered by oil drillings in Bass Strait, from deposits laid down only 2 million years ago. *Wollemia* appears to follow the typical gap dynamics growth patterns of other *Araucaria* species and many rainforest species. Light is probably a key to its success in recruitment from seedling to adult and a key-limiting factor to population expansion. There are very few young adults or large seedlings present and few seedlings survive to adulthood. Fire and other disturbance play a role in gap formation in the forest but may also threaten the species survival if disturbance is too frequent or too infrequent. *Wollemia* also bears large root nodules that contain both arbuscular mycorrhizae and ectendomycorrhizae that probably assist with nitrogen and phosphorus uptake - a beneficial attribute in a low nutrient environment. The in-situ stands are threatened by human visitation, as the species is susceptible to exotic root rot pathogens (*Phytophthora cinnamomi* and *Botryosphaeria* sp.) and trampling of seedlings. Long term monitoring will continue to track changes to stand dynamics.

Early dendrochronology results reveal that large trees up to 1 m in diameter are about 400 years old but since most of these have grown as a coppice from a rootstock, the rootstock may be many thousands of

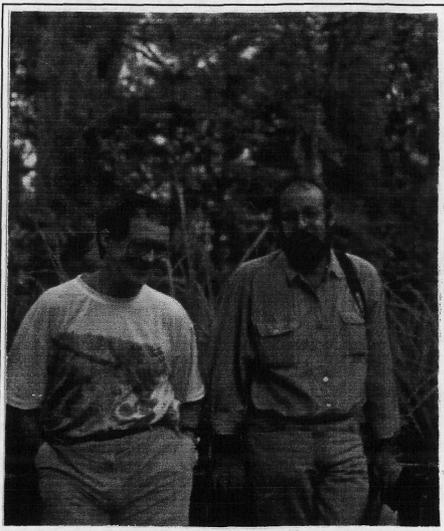


Fig.3 Ken Hill (right) and Rhys Gardner admiring kauri on the Arataki Nature Trail, Waitakere Ranges, Oct 2001. Photo: E K Cameron.

[]-years old. Growth rates vary over time probably depending on changing degrees of competition and long-term rainfall patterns.

The species produces about the same proportion of seed as other Araucariaceae (about 10% of 260 seeds are viable) and these readily germinate after a period of stratification. Cuttings are also relatively easy to grow but can be either lateral growing (plagiotropic) or vertical growing (orthotropic) in form depending on the position of the original cutting on the tree.

A consortium to commercially develop and release the Wollemi pine has been formed with the Queensland Forestry Service and their commercial arm Birkdale Nurseries, The National Parks and Wildlife Service of New South Wales and the Royal Botanic Gardens Sydney. Plants of *Wollemia* will be released for public sale worldwide in late 2005. Over the next 10 years more than 2 million trees will be grown for release.

In the meantime, the New South Wales National Parks and Wildlife Service is endeavoring to preserve its habitat and protect it from human-induced extinction in the wild. The site remains a closely kept secret, and

public access is forbidden.

James Woodford, an environmental journalist from Sydney Morning Herald, has written a book titled *The Wollemi Pine*, and the SMH web site can be searched for past stories on the Wollemi pine (www.smh.com.au). The book can be obtained through Australian. The RBG Sydney website (www.rbgsyd.nsw.gov.au) presents news and information on the Wollemi pine and a list of publications on the species.

This remarkable discovery has raised public awareness of botanical and conservation issues around the world. Research to date has shown that a vast store of knowledge is associated with the natural environment, and much of this remains untapped for even the commonest species. Further research over the coming decades will increase our knowledge of this charismatic species, but discoveries to date also should sound some warnings and ask some questions. What remains unknown about the common plants around us? What has been lost forever before even being discovered or acknowledged? And probably most importantly, what else is out there?



The afternoon trip to Scandrett Regional Park, on 16 Feb 02

Alistair MacArthur

We drove up the hill for just a few minutes to the top of the ridge leading out to Mullett Point, parking in a place where we could look back down on Martins Bay whence we had just left. Northwards we could look across the bays to the hills leading out to the Takatu Peninsula, and further on to higher country near Cape Rodney. A cattle stop indicated the point where the road passed over the park boundary, which is a straight line across the peninsula just at its base, touching down to the north end of the beach in Martins Bay. We walked down into the forest remnants on the south coast, which has been fenced out for about a year. Holiday baches and caravans are being removed, and some weedy garden areas have been cleared to bare ground already.

Changes are already noticeable, as I was well aware, having moved about on the area among flocks of sheep a year earlier when I was killing some clumps of Kahili ginger and a few woolly nightshade. Large puriri and pohutukawa trees are present in many places, several kahikatea, and significant numbers of other trees such as tawapou and kohekohe. I had seen two kohekohe loaded with a splendid crop of maturing fruit a few days previously on the northern slopes, and we found at least two more similar fruiting trees on the route we took on the south side. Regeneration should be rapid with these trees. Seedlings of some species

are already appearing. Very similar south facing slopes on other Regional Park peninsula areas such as Cudlip Point are rich with thriving saplings of various canopy trees. We made this visit right at the start of the process and it will be good to return in a few years.

The native grasses such as *Microlaena stipoides* var. *stipoides* and *Oplismenus hirtellus* subsp. *imbecillis* are establishing as they usually do in such areas when they are fenced off, but two places down the steep south facing bank proved more interesting as there were colonies of *Microlaena polynoda*. Now that I have seen this species, described as a "scrambling, bambusiform, rhizomatous perennial with stout bare internodes" in the Flora Vol V, I will know what to look out for when I move onto other parts of the coastal escarpment where there is a lot more of the same type of habitat.

I had worked around a substantial part of the northern face of the park a few days before, destroying a few woolly nightshade shrubs and photographing places where pines of various ages are growing in strong competition with pohutukawa. Amongst the main plantation of tall pines a little way inland from Mullett Point I was surprised to find two substantial colonies of *Adiantum aethiopicum*, and I was able to lead our group around to that spot. More recently, as I now get around to writing this in March, I came across another