a reflection of the variable growing conditions experienced in Christchurch, especially unusually dry spells.

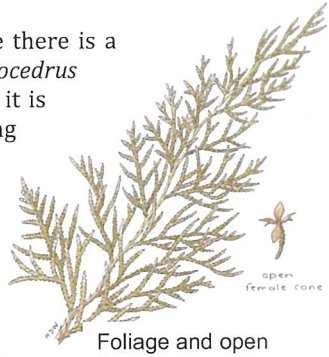
Interestingly, our 110 year-old brick villa was built by the first Professor of Chemistry at Canterbury College, Professor W. P. Evans, who studied the chemistry of the Tertiary lignites of Canterbury, Otago, and Southland. Evans wrote several papers on the plant fossils he found in these lignites, noting "Four of the five araucarians obtained from the lignites could not be distinguished from *Agathis australis,* and for these fossil woods the writer therefore proposes the name *Agathoxylon australe*"; later he noted that this and similar evidence from the lignites " appear to place the the existence of *Agathis australis* in the South Island during the Tertiary period beyond all doubt." (NZ J Sci & Tech, 18: 188-193, 1937).

Perhaps greater use should be made of the stately kauri as an amenity tree in Christchurch and other parts of Canterbury, not only as single specimen trees in private gardens, but also as stands of trees in parklands and other public places.

WHAT KILLED BANKS PENINSULA'S CEDARS?

Hugh Wilson
Hinewai Reserve, R.D. 3 Akaroa 7583

Near the Visitor Centre on Hinewai Reserve there is a 4m tall native cedar or pāhautea (*Libocedrus bidwillii*). At this time of year (late winter) it is laden with little brown female cones, gaping open, the seeds long shed.



Foliage and open female cone of pāhautea. Watercolour by Hugh Wilson

Some reserve visitors don't know that New Zealand has native members of the cypress family, Cupressaceae, and wonder out loud why an exotic conifer is planted in the arboretum. Other visitors know about *Libocedrus*, but are surprised to learn that it is native to Banks Peninsula. When a few paces further on they encounter a magnificent specimen of tōī or broadleaved cabbage tree (*Cordyline indivisa*) their surprised eyes open wider. This is because they know that both species thrive only in cool uplands with high rainfall. How can such conditions be met anywhere on drought-prone Banks Peninsula?

The natural presence of pāhautea and tōī underlines what rain gauges and permanent streams tell us – that rainfall on the Peninsula's highest ground is three times that along its coastlines (Figs. 1 and 2). To find naturally occurring native cedar elsewhere in Canterbury you would have to go far westwards, almost to the Main Divide. To find tōī you would need to *cross* the Divide.

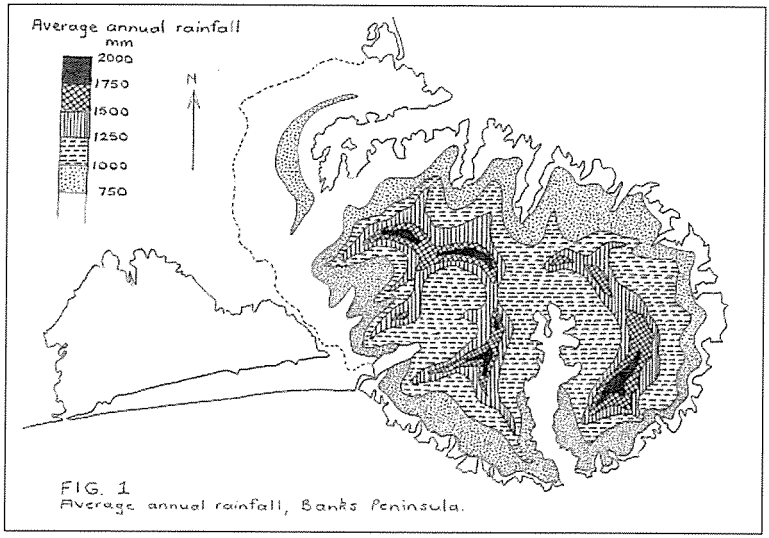


FIG. 1
Average annual rainfall, Banks Peninsula.

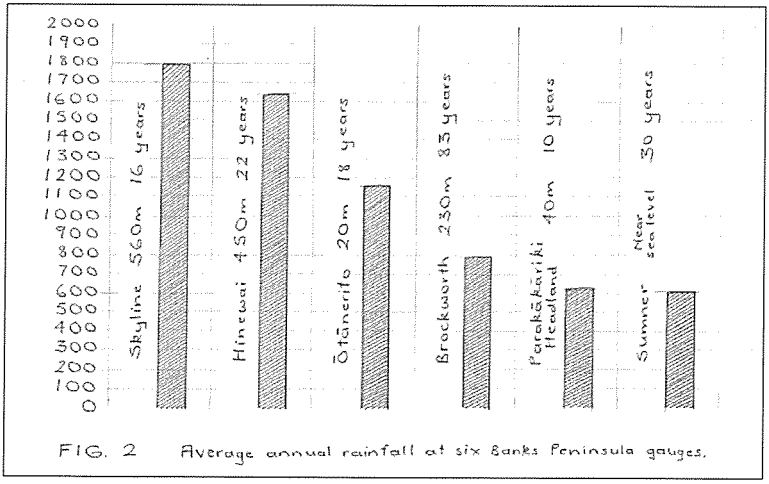


FIG. 2 Average annual rainfall at six Banks Peninsula gauges.

When European botanists started to note such things in the 19th and early 20th centuries, both species appear to have been common enough in the highest altitude forests on Banks Peninsula, even though by 1900 less than one percent of the original forest cover remained. Robert Laing, Leonard Cockayne and Arnold Wall all mentioned cedar and tōī, often growing together, (along with thin-barked tōtara *Podocarpus hallii*), as distinctive elements of the uppermost forest remnants.

Watercolour of pāhautea (*Libocedrus bidwillii)* by Hugh Wilson.

However, by the time Geoff and Diana Kelly surveyed the Peninsula's bush reserves in the late 1960s, cedar appeared to be heading for local extinction (Kelly 1972). Almost all the adult trees seem to have died in the 1950s and early 60s. Why?

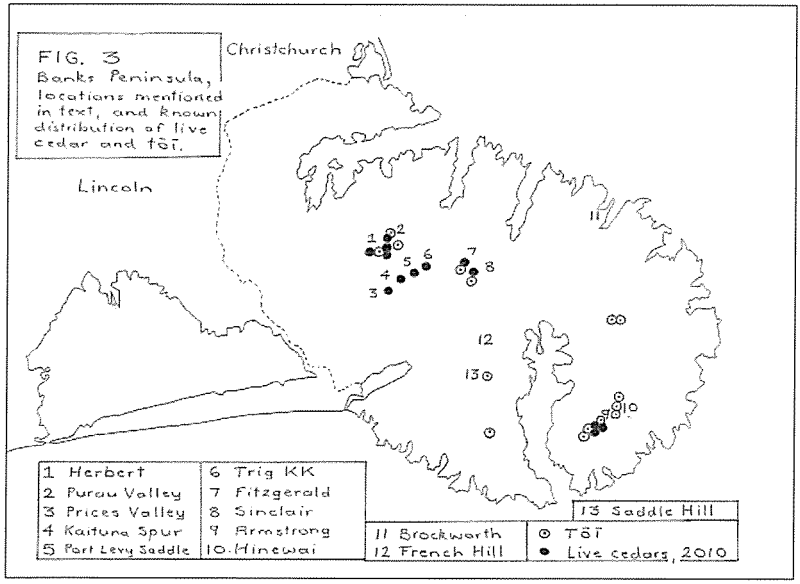
David Norton and Brian Molloy raised this question in a sharp little article in the Canterbury Botanical Society Journal of 1986. They noted that the distribution of cedar (and tōī) on the Peninsula was likely to be closely tied to rainfall, and inferred that the highest tops must receive 2000mm or more in an average year. They also surmised that drought might have been a significant cause of the cedar's sudden mortality. However they noted that other factors might have been involved, such as soil compaction by farm animals. They also observed that cedar depends not only on generous rainfall, but also on disturbance such as landslips, windthrows and fire to open up sufficient light gaps for regeneration. Thus it is hard to say (they said) just how common cedar was on the Peninsula before *Homo sapiens* began to throw his weight around and how the species might have reacted to forest clearance by fire during Polynesian settlement.

Norton and Molloy described groups of recently dead trees, also one surviving old-timer, and local areas of regenerating saplings, all in close proximity to dead adults. They counted some 500 saplings Peninsula-wide at a few scattered localities, from Mount Herbert in the west to Flag Peak (Armstrong Reserve) in the south-east. Armstrong Reserve alone boasted around 400, and seemed the best bet for the species' long-term survival on the Peninsula. Alas, their article also relates how a gorse burn-off on the Akaroa side of Flag Peak in June 1984 blazed out of control across the skyline, razing the upper part of Armstrong Reserve and killing most of the cedar saplings there.

Based on growth-ring counts Norton and Molloy estimated the age of the one adult survivor (near Trig KK, Fig. 3) at about 300. No age estimates were attempted for the dead cedars, nor were standing dead or lying cedars mapped.
They concluded their 1986 article by arguing for artificial management of cedar on Banks Peninsula to ensure its ongoing survival there.

The present article attempts to continue the discussion by throwing in some more information, assembled since 1986.

A few more sites are known now for sapling cedar, notably the head of Prices Valley, Kaituna Spur, and Port Levy Saddle (Fig. 3). Judging from the rainfall map (Fig. 1) cedar would be expected about Saddle Hill and French Hill, but if any are growing or are dead there they are still hiding.



We now have much relevant rainfall data (Figs 1, 2, 4 and 5). For the last 22 years Hinewai staff have recorded rainfall from coast to summit on and near the reserve, as well as gathering rainfall figures from co-operative farmers and other residents across many parts of Banks Peninsula. The rainfall map (Fig. 1) is a collation of all the data I can muster. It involves extrapolation that begs testing by further strategically placed gauges. I am very grateful to Mike and Ruth Williams of Brockworth, on the north side of the Peninsula (Fig. 3), who provided me with their 83 year record, and to Bob Crowder, who gave me additional data from Lincoln back to the 1880s. For thirty years I have accumulated observations on the effects of drought, unusually low temperatures, and possum browse, on Peninsula vegetation.

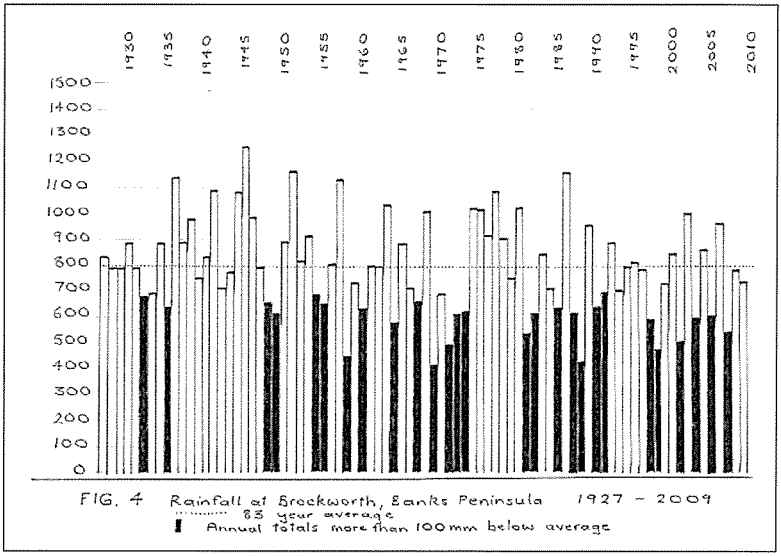


FIG. 4 Rainfall at Brockworth, Banks Peninsula 1927 – 2009
..... 83 year average
▮ Annual totals more than 100mm below average

Does the rainfall data lend support to a hypothesis that drought was the chief cause of sudden cedar mortality? Drought has certainly been implicated in widespread tree mortality in many parts of New Zealand from time to time. I have watched it myself at Arthurs Pass, Mount Cook, eastern Marlborough and Banks Peninsula. Typically, death is patchy, affecting individuals across all age classes on sharply drained sites such as spur crests, moraine ridges, and coarsely stony terraces, so that only a proportion (usually small) of a species' population within the wider vegetation fails to recover when moisture levels improve. I don't know of any documented case where a species has been eliminated by drought from the local flora of a region, although the sort of climate change we are foisting on the biosphere

now may well do just that. Certainly on geological time scales it has happened often.

In any event, elimination or near-elimination of a native species that has a history of thousands of years at a particular place is likely to require abnormally extreme climatic conditions. So, are such far-out extremes evident in rainfall records on Banks Peninsula relevant to the timing of the cedar deaths?

At first glance the 83 year Brockworth records (Fig. 4) appear to lend some weight to the "deadly drought" hypothesis. 1948 and 1949 were markedly dry after more than a decade of near average or above average rainfall, and 1958 was seriously dry. However the record also suggests that substantially drier than average years are a frequent feature of Banks Peninsula's climate, interspersed with years much wetter than average. Also, earlier records from Lincoln, just west of Banks Peninsula (Fig. 3) suggest even drier years, notably 1889-1890-1891, 1915 and 1922, which the cedars apparently sailed through unscathed.

Brockworth is a low-altitude site on the north side of Banks Peninsula (Fig. 3). Is it relevant to the high-altitude sites where cedar grows? A comparison between Brockworth and Hinewai (Fig. 5) shows a close congruence.

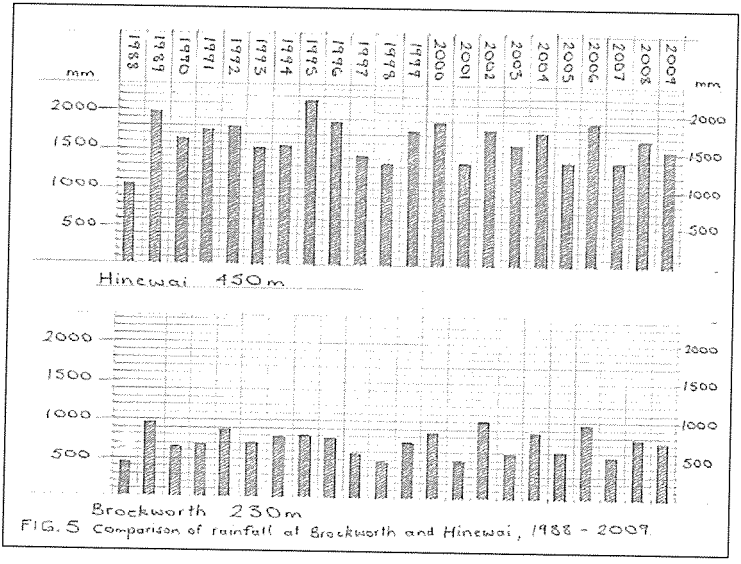


FIG. 5 Comparison of rainfall at Brockworth and Hinewai, 1988 - 2009

Although Hinewai has much more rain than Brockworth, a wet year at one place is nearly always mirrored by a proportionately wet year at the other. The same is true of dry years. There are anomalies from time to time (e.g.

1995) and even short-term events when substantially more rain can fall at lower altitudes than at high altitudes, but on an annual basis there is always much more rain at the higher altitude sites than the lower. Fig. 2 compares average rainfalls at six sites (not strictly comparable because the averages are based on differing numbers of years, but telling enough).

Of course it is not just below-average rainfall that determines "drought"; it depends how that annual total is distributed through the year. There are years of low but reasonably spread precipitation that do not see any stress on vegetation, and conversely years of average or above average precipitation when a few months may be so hot and dry that drought stress can become severe.

The points to make though are these:

- The 1950s are not so unusual.
- The high terrain where cedar occurs naturally on Banks Peninsula generally remains moist even through the driest years.
- While nearly all adult cedars died in the 1950s, one didn't.
- Most or all of the 500 known saplings survived the 1950s and subsequent dry spells.

Some of the youngsters were healthy when Doctors Norton and Molloy gave them a health check in the 1980s. Some presented as decidedly ill. The doctors diagnosed cold damage from southerly winds, which seems unlikely in such a cold-hardy, high-altitude species. The damage is possibly possum-browse. A study in North Westland (Coleman et alia 1985) shows cedar figuring prominently enough in preferred possum diet, albeit well behind fuchsia, fivefinger, *Coprosma*, rātā and kāmahi.

About 75 saplings survived outside the area reached by the 1984 destructive fire at Armstrong Reserve. Across the whole of Banks Peninsula some 140 are currently known, some still in poor health, some robustly well, some old enough now to produce abundant seed. Unlike podocarps, which bear male and female cones on separate trees, native cedars have both on each individual tree. A single cedar can produce viable seeds, as I know well from the 23 year old specimen in Hinewai's upper arboretum, at least 4 kilometres and two big ridge crests away from any sexually mature potential pollen sources.

The one known surviving adult near Trig KK is still alive and well, having coped with several more seriously dry years since the 1950s, especially 1969, 1988 and 1998. Department of Conservation staff visited it recently (July 2010) and found it in good health.

I have a possible explanation for the cedar scenario on Banks Peninsula:

Let us assume that in pre-human times there was far less disturbance to high altitude forest than now, and far less opportunity for cedars to regenerate. The species was probably uncommon. Downslope kānuka was probably rare for similar reasons. Māori settlement cleared a lot of the forest, including along high ridges and over summits. Lower down, kānuka exploded into such opportunities with its easily wind-dispersed, dust-like seed. Cedar's much larger seed, though flattened and winged, doesn't seem to travel far. Nevertheless we can envisage a burst of regeneration close to surviving or recently fire-killed adults. Such a situation may well have produced a scattered but more or less even-aged cohort of cedars, more numerous than the species had been before, some of which survived subsequent Māori and European burning.

What do we know of the life-span of an individual cedar ? At least one study (Dunwiddie 1979) suggests it is around 700 years. By the 1950s the cedars that had been established after the initial Māori fires would likely be near the end of their natural life-span. Perhaps the markedly (though not inordinately) dry year of 1958 was one of the final straws that nudged the old-timers over the edge. The 300 year old at Trig KK was only middle-aged and carried on as usual through this and even drier subsequent years.

This is a pageant acted out on nature's grand stage. Why blur the drama by planting in nursery raised plants? My suggestion is that we confine "management" to securing bigger reserves where the performance can continue to play with minimum interference, except for some diligent removal of some of the harm we have caused – possum-browsing, cattle-grazing, a handful of seriously competitive exotic weeds, and excessively frequent fires. Perhaps we could direct our efforts towards tackling anthropogenic climate change by curbing our ridiculously profligate lifestyles. That might help the cedars as well as ourselves.

But if you happen to live in upland Banks Peninsula where cedar belongs, far be it from me to dissuade you from growing some specimen cedars of appropriate local heritage beside your house. This is a different order of interference than planting out nursery-grown stock into wild ecosystems.

I have a few footnotes to this story:

- Another plant species closely dependent on *Libocedrus* seems to have disappeared altogether from Banks Peninsula. This is a distinctive filmy fern, *Hymenophyllum malingii*, which occurs in most of the places in New Zealand where cedar grows, and indeed is almost entirely restricted to growing on dead cedar wood. We have no solid evidence that this fern really did occur on the Peninsula as no

specimens are known. Laing (1919) could not confirm earlier records but included it in his careful listing "on the evidence of others" (namely Potts (1878) and Armstrong (1880)). Other filmy ferns listed by Laing on similar grounds have since been rediscovered. It would be marvellous to find that *Hymenophyllum malingii* is still part of Banks Peninsula's native flora.*

- The two New Zealand species of *Libocedrus* are a remarkable element of our flora. Belonging to the cypress family (Cupressaceae) they are relatives of macrocarpa, juniper, the northern incense cedars (*Calocedrus*) and the famous western red cedar (*Thuja*) with its beautiful wood, and its foliage closely resembling that of the New Zealand cedars.

  Botanists earlier defined the genus *Libocedrus* more broadly to include *Calocedrus* and others, but now limit it to five species – two in New Zealand and three in New Caledonia. About half the 125 species of Cupressaceae alive today are native to the northern hemisphere, and half to the south. Our lovely neighbour Tasmania has three, two in the genus *Callitris* and one in monotypic and uniquely Tasmanian *Diselma*. More closely related to *Libocedrus* is *Papuacedrus* of the Moluccan Islands and New Guinea, and *Austrocedrus* from Chile and Argentina.

- The word "cedar" is confusing though. The famous "cedars of Lebanon" and their close relatives (genus Cedrus) are not in the cypress family at all but in the pine family (Pinaceae). Other trees colloquially called "cedar" are not even gymnosperms.
- David Norton and Brian Molloy, along with numerous South Island foresters, call Libocedrus bidwillii kaikawaka. However Te Reo Māori clearly uses kaikawaka or kawaka for Libocedrus plumosa (Williams 1971), chiefly a North Island tree that extends across Cook Strait only to the northern tip of the South Island. Libocedrus bidwillii is known as pāhautea. The word means "white-bearded" in reference to the shaggy old man's beard lichen (Usnea) which characteristically drapes old trees (and pedantic old reserve managers) in cool wet uplands.

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*Editor's note: In his volume "Out in the Open A Budget of Scraps of Natural History Gathered in New Zealand" 1882, T.H.Potts described a quest to see Maling's fern on Banks Peninsula, having heard that it had been found there. From the summit of Mt Herbert he descended in a southeasterly direction on a path which was understood to lead to Port Levy. At the forest margin where compact forms of *Libocedrus* and graceful stems of *Cordyline indivisa* were conspicuous objects, a fine patch of the fern was found on a prostrate *Libocedrus*. A detailed description of the appearance of *Hymenophyllum malingii* and its habit followed. It had "an air of demure and quaker-like simplicity." Specimens taken for the fern house appeared to have safely established.

A NEW BOOK NEARS COMPLETION: "PLANTLIFE ON BANKS PENINSULA"

Hugh Wilson

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For an embarrassingly large number of years I have been working on an illustrated guide to the plants of Banks Peninsula, similar to field guides already published for Mount Cook National Park and Stewart Island. A nice wet winter in 2010 has kept me planted at the drawing board and it now looks as if I will have all the drawings completed by early 2011. The text is taking on a finished shape, receiving a few tweaks as the drawing progresses. There is nothing quite as good as *drawing* a plant for making you look closely at its details. Also, some new botanical discoveries roll in from the great outdoors (see Miles Giller's article in this journal) adding to what must be covered even at this late stage.