



Ms Candice Pon
NSW Department of Planning, Industry & Environment
C/- candice.pon@planning.nsw.gov.au

Dear Ms Pon

Re: Submission in response to the Design Report for the proposed expansion of the Powerhouse Museum's Museums Discovery Centre (MDC) at Castle Hill

My name is Chris Betteridge and I am a heritage professional with over forty years' experience in the identification, assessment, management and interpretation of natural and cultural heritage. I was Technical Officer (Scientific) at the Museum of Applied Arts and Sciences from 1973 to 1977 and spent considerable time working at the Castle Hill Experimental Plantation and the Museum's other essential oil trial sites in NSW. I am writing as a concerned individual with professional expertise in heritage conservation and museology, not as a representative of any group.

I am writing to express in the strongest possible terms my objections to the approach being taken by Lahznimmo Architects / Aspect Studios in their proposed Building J Museums Discovery Centre SSD Application – Design Report.

I have previously expressed my concerns at the very inadequate due diligence reports prepared by the consulting arborists and heritage consultants on the site of the former Museum of Applied Arts and Sciences (MAAS) Experimental Plantation at Castle Hill.

Aspect Studios now have the temerity to ignore the very rich non-Aboriginal cultural heritage of the Castle Hill plantation site as part of more than a century of valuable phytochemical research carried out at MAAS by a succession of important figures in the study of essential oils and other plant products. To claim, as Aspect Studios have, that the "history of this plantation and its contribution to [the] burgeoning Eucalyptus oil industry blatantly ignored the pre-existing knowledge held by the Aboriginal people, but rather contributed to the industrialisation of this native resource" is 'Cancel Culture' writ large.

Many researchers at the Museum of Applied Arts and Sciences, from its first curator Joseph Maiden onwards, studied Australia's native plants and other natural products, including their use by our First Nations peoples. However, they did this without the

Betteridge Consulting Pty Ltd t/a Betteridge Heritage (ABN 15 602 062 297) 42 BOTANY STREET KINGSFORD NSW 2032
Mobile (Margaret Betteridge): 0419 238 996 Email: musecape@accsoft.com.au Mobile (Chris Betteridge): 0419 011 347

SPECIALISTS IN THE IDENTIFICATION, ASSESSMENT, MANAGEMENT AND INTERPRETATION OF CULTURAL HERITAGE

benefit of recent research into Australia's and Sydney's Aboriginal cultural heritage in publications such as Bill Gamage's *The greatest estate* (2011), Paul Irish's *Hidden in plain view: The Aboriginal people of coastal Sydney* (2011), James Kohen's *The Darug and their neighbours: The traditional owners of the Sydney region* (1993) and Bruce Pascoe's *Convincing ground: Learning to fall in love with your country* (2007) *Dark emu: Black Seeds: agriculture or accident?* (2014).

Aboriginal communities can and should benefit from the industrialisation of our native plant-based resources such as the Macadamia nut, quandong, finger lime and essential oils where traditional methods of growth and harvest would not be sustainable.

For Aspect Studios to claim that the plantation and its contribution to industry blatantly ignored pre-existing Aboriginal knowledge completely ignores the historical context in which the MAAS research was carried out and the very fact that one of the museum's primary roles from its inception, was to carry out research to support the development of new or existing industries. The primary significance of the Castle Hill site is not in its Aboriginal cultural values or its original plant ecological communities but in its role in phytochemical research and the benefits that research had for the development of plant-based industries, particularly the eucalyptus and tea-tree oil industries.

By all means, mention the traditional Aboriginal uses of plants in the landscaping of the MDC site but the primary focus of the landscaping should be the interpretation of the site as an important place in the history of phytochemical research. There are numerous other places where Aboriginal use of Australian flora and fauna and Aboriginal connection with land are emphasised including national parks, Aboriginal Places, botanic gardens and museums.

Before any further decisions are made about the expansion of the MDC, there needs to be a thorough reassessment of the botanical and non-Aboriginal heritage values of the former plantation site to redress the gross inadequacies in the due diligence reports so far prepared and to inform the design, landscaping and interpretation of the site in ways that are based on fact, not on a desire to 'Cancel Culture' and rewrite history.

My draft history on the history of phytochemical research at MAAS and its Castle Hill Experimental Plantation is attached.

Yours faithfully



Chris Betteridge BSc (Sydney), MSc (Museum Studies) (Leicester), AMA (London),
M.ICOMOS
Director
Betteridge Consulting Pty Ltd t/a Betteridge Heritage

The history of phytochemical research at the Museum of Applied Arts and Sciences and the significance of the museum's Castle Hill Experimental Plantation

by

Chris Betteridge, BSc (Sydney), MSc (Museum Studies) (Leicester), AMA (London).
M.ICOMOS, Director, Betteridge Heritage, and former Technical Officer (Scientific),
Botany Department, Museum of Applied Arts and Sciences

Acknowledgment of sources

Historical sources and reference material used in the preparation of this report are acknowledged and referenced in the footnotes and Bibliography. Reasonable effort has been made to identify, contact, acknowledge and obtain permission to use material from the relevant copyright owners.

Copyright

© Chris Betteridge, 2020. Unless otherwise specified or agreed, copyright in this report vests in the author and in the owners of any pre-existing historical source or reference material. Not to be copied in whole or in part without the authority of the author.

Moral rights

The author asserts his Moral Rights in this work, unless otherwise acknowledged, in accordance with the *(Commonwealth) Copyright (Moral Rights) Amendment Act* 2000. The author's moral rights include the attribution of authorship, the right not to have the work falsely attributed and the right to integrity of authorship.

Abstract

From their outset, Sydney's Museum of Applied Arts and Sciences and its precursor institutions focussed on the commercial, technological and decorative arts potential of Australian raw materials – plant, animal and mineral. The museum carried out significant chemical and botanical research into Australian plants from 1881 to 1979, just shy of a century of major scientific study, including the work of some of the leading scientists of their day. The laboratory research, field trials at sites across NSW and nursery developments at the museum's Castle Hill Experimental Plantation led to significant improvements in the understanding and production of essential oils, particularly Eucalyptus oil and tea tree oil. This research has had a long-lasting legacy in its contribution to the transformation of the Australian essential oil industry from cottage operations in the bush to sophisticated modern enterprises where oil-producing trees are grown as cash crops, mechanically harvested and processed in modern distilleries. This paper discusses the history of the museum's phytochemical research, the scientific teams who carried out the work and some of the results of their studies and trials. The significance of the Castle Hill Experimental Plantation as an integral part of this research is assessed with a view to its historical, associational, technical / educational values and rarity being adequately recognised, conserved and interpreted.

Key words: Museums, Chemistry, Botany, Scientific Research, Phytochemistry, Scientists, Essential oils, Plant products, Field trials, Museum of Applied Arts and Sciences, Castle Hill Experimental Plantation.

Introduction

The Museum of Applied Arts & Sciences (1950-?) and its precursors, the Technological, Industrial and Sanitary Museum (1880-1889) and the Museum of Technology and Applied Arts and Sciences (1945-1950) continued a proud tradition of European research into Australia's plants and their products stretching back to the collections of Joseph Banks and Daniel Solander at Botany Bay in 1770.

When the Sydney International Exhibition 1879 opened in the Garden Palace in Sydney's Domain, the exhibits promoting the Australian colonies showcased products made from Australian timbers, and samples of Eucalyptus essential oils, as well as decorative art objects, medallions, souvenirs and abundant pictorial material.¹ These were to become the embryonic collection of the Technological, Industrial and Sanitary Museum.

From its inception, the basic tenet of the institution was to encourage the study and "understanding of nature in general, and to empower the development of Australian commerce in particular. Indeed, until the 1960s (and the directorship of Jack Willis), the overriding image and reputation of the museum was that of a research institution."²

Joseph Maiden and the museum's beginnings

When botanist Joseph Maiden (1859-1925) became the first curator of the museum in 1881, he established a herbarium and a network of collectors and correspondents to ensure he had a ready supply of plant material for research. Inspired and supported by people such as Archibald Liversidge, professor of chemistry and mineralogy, and Dean of the Faculty of Science at the University of Sydney, and prominent British scientists and philanthropists of the day, Maiden worked quickly to rebuild the museum's collection after the disastrous fire that destroyed the Garden Palace in 1882. Emphasis was placed on material of potential economic value to the country. In 1889 the museum published Maiden's book *The useful native plants of Australia (including Tasmania)*. This major work was "intended for the manufacturer, the farmer and the 'adventurous traveller', it provided advice on how to secure water from the root of mallee trees – 'no adult in Australia should be ignorant of it' – and details on Aboriginal foods and drinks."³

Baker and Smith

After Maiden left the museum in 1895 to take up the post of government botanist and director of Sydney's Botanic Gardens, his assistant Richard Thomas Baker (1854-1921) was appointed acting curator, finally assuming the curatorship in 1898.⁴ Baker was opinionated, brusque and jingoistic but also very ambitious for the museum and

¹ Wade (ed.) 1979, pp.32-36, 41-43, 46-53

² Davidson & Webber (ed.) 2005, p.97

³ Maiden 1889, p.1 cited in Davison & Webber (eds) 2005, p.20

⁴ Willis 1979

highly productive. Whereas Maiden's major interest had been in the eucalypts, Baker expanded the museum's research topics, in collaboration with the economic chemist Henry George Smith (1852-1924). Starting at the museum in 1884 as a painter and ticket writer, Smith attended night classes in chemistry and in 1899 was appointed assistant curator and economic chemist, developing a reputation in phytochemistry.⁵ In the new Harris Street building they had the advantage of laboratories on each floor – chemistry on the ground floor, botany on the first floor and zoology on the second floor, with a still, built in 1896 at the back of the museum, for major distillations. Together Baker and Smith produced major works on the eucalypts and their essential oils⁶ on the pines of Australia⁷ and on wood fibres⁸. They looked forward to a time when science would discover new commercial openings for essential oils, with an increased share of production coming from NSW.

During the First World War, the museum's research showed that materials for such military items as rifle butts and army tent poles traditionally sourced from Europe, including from the enemy, Germany, could be replaced by Australian substitutes. Baker advised the Lithgow Small Arms Factory that the thornless wattle *Acacia salicina* (Cooba, Native Willow, Willow Wattle, Broughton Willow) could replace Italian walnut in gun stocks and advised the army that mountain ash, hoop pine and colonial pine were suitable for making tent poles.

Maiden had championed the wattle as Australia's floral emblem but Baker, fascinated by the decorative and symbolic possibilities of the Australian flora, promoted his choice, the waratah, which he declared was so noble that 'any other country would have placed [it] on the highest heraldic pinnacle'.⁹ When Baker retired in 1921 he left behind a strong research program but a building and exhibits that needed an overhaul. He was succeeded by George Hooper. Strapped for funding compared with its competitors, the Australian Museum, Geological and Mining Museum and the Art Gallery of NSW, the Museum of Applied Arts & Sciences languished for some years, with Hooper placing less emphasis on original scientific research.

Penfold, Smith and Morrison

The next curator, in 1927, was Arthur de Ramon Penfold (1890-1980), who had studied under H G Smith at Sydney Technical College, was appointed Smith's assistant at the Technological Museum in 1919, and the next year, on Smith's retirement, economic chemist. Penfold became curator in 1927 and studied technological museums overseas. Smith and Penfold were both assisted by Frank Richard Morrison (1895-1967) who had returned to the museum after service in World War I.¹⁰ These men reinvigorated the museum's long-running program of

⁵ McCarthy & Cohn 1993

⁶ Baker & Smith 1902

⁷ Baker & Smith 1910

⁸ Baker & Smith 1924

⁹ Powerhouse Museum Archives 1915 cited in Davison & Webber (eds) 2005, p.24

¹⁰ Holland & McKern 2000

scientific research into Australian natural products, particularly plants, to foster the economic exploitation of the country's natural resources.

“For the first time, the museum’s research took on an international dimension as Penfold embarked on a joint research project with the leading English phytochemist John Simonsen analysing the chemical structure of eucalyptus oils.”¹¹ Penfold and Smith demonstrated that thymol and menthol, two chemicals much used in pharmaceutical products, could be synthesised from piperitone, distilled from eucalyptus oil. After a time as a chemist at the Colonial Sugar Refinery Company (CSR), New Zealand-born Marcus Baldwin Welch (1895-1942) assumed the post of Assistant Botanist in 1919 and was Economic Botanist from 1921 to 1936, continuing Baker’s research on the properties of Australian woods. He went on to become Senior Research Officer, Division of Wood Technology, Forestry Commission of New South Wales.¹²

The most important joint contribution of Penfold and Morrison was to demonstrate the existence of chemical variation within a plant species: their findings refuted the assertion of their predecessors, Baker and Smith, that chemical constancy prevailed throughout a species to the extent that it could be used as a diagnostic feature in taxonomy. The Penfold-Morrison discovery was of great chemical, biological and commercial significance.¹³

During the Great Depression, the museum’s role in education was to play a huge part in helping the unemployed, soldier-settlers and the general public find new ways of making a living by using Australian natural materials. The museum responded to thousands of enquiries a year during this period, with a peak of 5,845 in 1934.¹⁴

By the end of World War II during which the museum was tasked with solving some problems later perceived to be often peripheral to the war effort¹⁵, financial constraints, loss of staff and increased competition from newer, well-funded research organisations such as the federal Council for Scientific and Industrial Research (CSIR), meant that the museum’s research program was reduced to phytochemistry of the ‘oil bearing flora of Australia’, with a special interest in the genetics and oil yields.¹⁶ When Howard Hamlet Gordon McKern (1917-2009)¹⁷ joined the chemical staff in 1945 he found Penfold and Morrison were no longer ‘active at the bench’ and the once highly valued phytochemical work was ‘desultory and considerably diminished’.¹⁸

¹¹ Barrett 1999, pp.206-214 cited in Davison & Webber (eds) 2005, p.103

¹² Smith 2001

¹³ Holland & McKern 2000

¹⁴ Davison & Webber (eds) 2005, p.270 endnote 40.

¹⁵ TM AR for 1941, p.1; TM AR for 1943, p.1 both cited in Davison & Webber (eds) 2005, P.270, ENDNOTE 44

¹⁶ PMA: MRS307-21/3, Scientific Research in the Museum of Applied Arts and Sciences [1950], cited in Davison & Webber (eds) 2005, p.270, endnote 47

¹⁷ Brown 2009

¹⁸ McKern p.10, cited in Davison & Webber (eds) 2005, p.271, endnote 49

The eucalyptus oil industry in decline

All but a few species of the genus *Eucalyptus*, including those species important for eucalyptus oil production, are endemic to Australia. However, by allowing the seeds of Australian essential oil producing tree species to be exported to many countries overseas, this country's share of the eucalyptus oil industry was declining. In countries with cheap labour such as South Africa, Brazil, Spain and Portugal, leaf obtained as a by-product of plantation timber grown for uses such as mine pit props, could be distilled for eucalyptus oil. The eucalyptus oil industry in Australia was at that time very much a cottage industry, with family-operated outfits cutting leaf from natural stands of oil-producing species and obtaining oil from bush stills operated by donkey engines. Australia's eucalyptus oil output peaked in 1946-47, with total production of almost 1000 tonnes but after that time production and market share was steadily declining.¹⁹ The museum hoped that the answer to this competition lay in the development of efficient plantation techniques, backed up by genetics and increasing fieldwork to discover high-yielding species.

Fighting back – the Castle Hill Experimental Plantation

In 1946, the museum's then Botanical Research Officer had been sent on a search for agricultural land to be used as an experimental eucalyptus plantation. The 20 acres (eight hectares) site he found at semi-rural Castle Hill, would be used over the next 30 years by the museum's scientists to conduct research aimed at assisting Australia's essential oil industry. The land was part of an original land grant to William Hancy and, later, part of Suttor's subdivision of the Parish of Castle Hill.²⁰

When the young single man who had been appointed by the museum as initial caretaker of the site resigned in 1952, Charleville-born bushman, jackaroo and returned serviceman Harold Leslie Crust²¹ took up residence at the plantation with his wife Kathleen and two daughters, Elaine, then aged six and Lynnette, aged four. Harold Crust was employed as Field Assistant and the family lived in a converted farmhand's quarters. The house had green-painted fibro walls and a pitched roof clad with corrugated asbestos cement sheeting. The 5-room house had an enclosed sunroom which had been an office area, with two glazed walls – it became the family's kitchen and dining area. The dwelling was very small, with a tiny bathroom and a toilet but later had additions which included another bedroom. The flat-roofed kitchen had only one louvred window over the sink and was very hot in the summer time.²²

The phone was connected via the manual operator-connected exchange at Kellyville and communication with the museum in Ultimo required trunk calls. Harold Crust was required to maintain a log of all incoming and outgoing calls which were for official use only. Private calls had to be made from a public phone box at the corner

¹⁹ Bolan, Brophy & House, p.4 cited in Davison & Webber (eds) 2005, p.271, endnote 50

²⁰ Jilly Warren, pers. comm., 26 August 2020

²¹ White 2007, pp.3-4 cited in Watson 2010, p.63; Elaine White, pers. comm. 26 August 2020

²² White 2007

of Windsor Road and Showground Road or pre-arranged calls could be received at a neighbour's house.²³

When the Crust family arrived, Elaine White (née Crust) remembers the site had lots of trees, scrubby vegetation and areas of long dried grass. On its northern side was a poultry farm owned and operated by the Dudley family and to its rear was an Australian Illawarra Shorthorn dairy with dairy, silo and farm outbuildings.

The house on the plantation was set well back from Showground Road and was separated from its garage by a concrete slab which the family used as a patio. The garage was later extended to form a workshop area and a shed for a tractor, Howard rotary hoe and other tools and equipment.

Each row of 20 trees in the early plantings was of a different species and each had a marker indicating genus, species, source, date of planting, date of pruning and any other relevant data which would help identify those trees producing the best volume and quality of essential oil. Early plantings included *Eucalyptus staigeriana* (Lemon-scented Ironbark) from Cape York Peninsula, *E. polybractea* (Blue Mallee) from West Wyalong and other species from Walcha, Sunny Corner and The Royal National Park.

Harold Crust went on seed-collecting trips with the museum botanists to West Wyalong, Sunny Corner, Warragamba / Silverdale, Scheyville and Audley. He then planted all the early trees in the plantation although many of these were removed when Castle Hill TAFE was built and the buildings for the Museums Discovery Centre constructed.

In the 1950s, glass houses were erected to complement the shade houses and they enabled seed to be germinated under controlled conditions and the seedlings produced planted out as tube stock. A large multi-bay building with four roller doors was erected with a concrete apron at its front and this building was used as a maintenance workshop and for storage of equipment, tools and pots.

In 1954 the plantation still house was built, with an internal boiler-house, attached coal shed, a high water tower on the western side of the still house for the condensing process, two rows of stills arranged on two levels, with apparatus and plumbing underneath, a laboratory area and test benches. Harold Crust travelled in to Ultimo to attend night classes at Sydney Technical College and obtained his boilermaker's certificate as a prerequisite to operating the boiler and distillery.

Cultivation of the plantation field plots was carried out at first with a Howard rotary hoe, a machine invented by Arthur Clifford Howard in the 1920s and from 1927 manufactured in the Howard Auto Cultivators factory at Northmead.²⁴ Elaine White recalls her father being enveloped in clouds of dust as he worked the rows with the cultivator.²⁵

²³ White 2007

²⁴ Quick 2006

²⁵ White 2007

By the early 1960s most of the Castle Hill site had been planted out with trees and shrubs for phytochemical research, with only a small area of Cumberland Plain Woodland ecological community remaining along the northern boundary. In 1963 a dam was built on the site by a local man Neville Langlands who had just started his own earthmoving business at Dural. He used his Caterpillar bulldozer to construct the dam, assisted by Harold Crust on the plantation's grey Massey Ferguson tractor. Elaine White remembers her father building a raft/pontoon on the dam for the enjoyment of the children and their friends when they used to swim in the dam on hot summer days.²⁶

In 1965 the museum built a new brick residence on the plantation site to a design used for resident school principals at country schools although a similar house was built at Kellyville public school about the same time. The new house was set back about 60 metres from Windsor Road and was large compared with the earlier house. It had 4 bedrooms, an eat-in kitchen, separate dining room and large lounge room with slow combustion heater. By this time, the Crust family had three new children, brother and sister twins John and Roslyn and the youngest, John. With their new house, the Crust family thought they had won the lottery!²⁷

The Crust children enjoyed the space and freedom which the plantation site afforded them – they built cubby houses, tree houses and imagined a whole world of adventure in and amongst the trees. They took delight in climbing the ladders up to the platform on the high cooling tower, playing cockatoo or standing watch from their lofty lookout. They could ride their bikes all day around the plantation and still be on home turf.²⁸

The Crust family time at Castle Hill came to a sad end in September 1967 with the sudden death of Harold Crust, leaving his widow to raise six children, including the youngest, David, who was then only three years old.²⁹

After succeeding Penfold in 1946 as economic chemist at the renamed Museum of Applied Arts and Sciences, Morrison had become deputy-director of the museum in 1949 and succeeded Penfold as director on 1 January 1956. Although Morrison may no longer have been involved in hands-on research, it remained a priority for the museum. The 1957 Annual report stated:

*Since the Museum deals principally with applied science, it has always been necessary to strike a balance between pure and applied research. Although opportunities occur for the prosecution of a certain amount of academic research, its applications to industry are never lost sight of.*³⁰

²⁶ White 2007

²⁷ Ibid.

²⁸ Ibid.

²⁹ Ibid.

³⁰ MAAS AR for 1957, p.6, cited in Davison & Webber (eds) 2005, p.106 and p.271, endnote 52

When, after 44 years' service with the museum, Morrison retired in 1960, in spite of funding stringency, he left the museum well prepared to undertake future challenges.³¹

The new guard – Willis and McKern

The reinvigoration of the museum's phytochemical research program was led by Jack Lehane Willis (1918-2004) and Howard McKern and their teams. McKern had been placed in charge of the chemistry department, directing research into essential oils. In 1957 he completed a master of science degree at the University of NSW, his thesis topic being 'Studies in the essential oil flora of Australia, with particular reference to physiological forms', much of it based on research he had done at the museum. The topic was at the forefront of a new area of research, which focused on volatile oils and taxonomy of Australian flora.³²

Willis had worked in industry as a chemist before becoming Botanical Research Officer at the museum in 1948, Deputy Director from 1956 to 1959 and Director from 1960, with McKern appointed as his deputy that same year. Willis planted the first seedlings at Castle Hill.

Willis and McKern were initially assisted in the chemical and botanical research by chemists R O Hellyer and W J Franklin and Botanical Research Officer B E J Small.³³ In the first year of Willis' and McKern's time in charge of the museum, the institution achieved a record visitation of 160,931, significantly up on the two previous years, attributed to a general revival of community interest in educational and cultural matters.³⁴

The close collaboration between the chemistry and botany departments was boosted in 1960 by the acquisition of an infra-red spectrophotometer which facilitated the identification of the numerous substances encountered in research on essential oil compositions by reducing the time factor and increasing certainty of identification. In conjunction with the gas/liquid chromatography apparatus previously acquired, the new equipment made accessible many problems in the phytochemical field which the museum had not been able to tackle.³⁵

In the 1960s and '70s, the plantation and still house at Castle Hill assumed increasing importance in the museum's scientific research program. Research into the potential of oils from eucalypts previously not studied was carried out with the help of progeny raised in the museum's glass house and plantation at Castle Hill. Chemical variation in *Melaleuca bracteata* and seasonal variation in *Eucalyptus radiata*, *E. dives*, *E. hemiphloia* and *Corymbia citriodora* (Syn. *E. citriodora*) were also being studied in plants grown at Castle Hill.

³¹ Holland and McKern 2000

³² Brown 2009

³³ MAAS AR 1960, p.2

³⁴ Ibid., p.3

³⁵ Ibid., p.14

Collaboration with the essential oil industry and other research organisations

Collaboration with commercial oil producers and with other scientific research organisations continued during the 1960s and '70s. The ability of the botany and chemistry laboratories to gain much more information on the various steam-volatile plant products being studied was greatly enhanced by the acquisition of a high-temperature, high-efficiency fractionating column, a highly sensitive flame ionisation detector for the gas chromatography apparatus and other modern instruments. The author also remembers the Botany Department acquiring what at the time was a very sophisticated but very large Olivetti programmable calculator for over \$1,000. While the machine enabled the staff to do complex calculations and process research data much more quickly than had previously been possible, a hand-held device with the same capability today would probably cost under \$100.

Helping the eucalyptus oil industry

Seed obtained from elite oil-bearing strains of *E. dives* from areas traditionally harvested by oil producers, was used to propagate trees planted in an experimental plantation at Uralla in the NSW Northern Tablelands with a view to developing this species as a competitive forest crop. While leaf was still being obtained from tall-growing eucalypts in the cool climate areas of the Northern, Central and Southern Tablelands of NSW, one of the major traditional eucalyptus oil-producing areas in the State was a triangular area around West Wyalong, Yalgogrin and Weethalle, the NSW distribution of *Eucalyptus polybractea* (Syn. *E. fruticetorum*) (Blue Mallee). This species had been important since the early days of the commercial essential oil industry in Australia when English chemist and pharmacist Joseph Bosisto (1824-1898) established his business in Victoria in 1853.³⁶ Bosisto sourced the leaf for his oils from various species and locations but much was from the stands of Blue Mallee in its relict Victorian distribution, around Bendigo, Wedderburn and St Arnaud.

Data on *Eucalyptus dives* from the plantation at Uralla and on *E. piperita* from the Castle Hill plantation showed that the growth of young trees cut annually from the time of planting out underwent an initial setback but this was only temporary and those trees subsequently regained their vigour. Leaf production was also increased by application of phosphorus to the trees at Uralla. A highly significant effect of stocking was obtained in spacing trials at Castle Hill where trees planted at 8 feet by 8 feet spacings yielded 128% more leaf than at closer spacings. Frequency of harvest trials conducted at West Wyalong and at Castle Hill confirmed the view that the age of a plant had a significant effect on oil production. These findings collectively had important implications for growing essential oil species as cash crops. In 1975 the plantation of *E. polybractea* at Yanco was split into two sections to study the seasonal effects of harvesting the leaf at two different times of the year.³⁷

In the 1970s the museum established a collaborative venture with G R Davis & Co, a company which had acquired a property 'Tallimbalong' near West Wyalong in an area where the natural stands of Blue Mallee had been harvested by locals including the Parkes family for decades. Company founder Geoff Davis (died 2019), his wife

³⁶ Griffin 1969

³⁷ MAAS AR 1977, p.25

Sybil and his brother Linton and Linton's wife Connie had all been associated with the firm of Plaimar, the large Perth based Australian essential oil company founded by Horace Victor Marr in 1919³⁸. HV Marr was Linton's father in law, and took an immediate interest in Geoff, eventually placing him as managing director of Plaimar's Sydney office straight out of University.

The establishment of the G R Davis & Co plantation operation at West Wyalong, facilitated by the museum's research, represented a break-away from the traditional working of natural stands of eucalypts and was the first attempt on a large scale in Australia to produce eucalyptus oil from cultivated trees.³⁹

The G R Davis & Co plantation at West Wyalong now covers an area of 7,166 hectares (17,700 acres) and the company is now one of the few to offer a premium 100% pure Australian eucalyptus oil, and the only company in the world that can offer regular large volumes of this premium Australian style oil. The company has been able to achieve this by continual investment in the production side of the business; developing a large scale oil production property, breeding improved trees with guidance from Australian research and development organisations, including the Museum of Applied Arts and Sciences, and introducing new, efficient and environmentally sustainable production methods.

The collaboration with the Davis family's operation at 'Tallimbalong' was complemented by work on other plantations of *Eucalyptus polybractea* at Cowra, on the Department of Agriculture's Agricultural College and Research Station at Yanco in the Murrumbidgee Irrigation Area (MIA) and at the Burrendong Botanic Garden and Arboretum established by botanist / nurseryman George Althofer (1903 -1993)⁴⁰ near Wellington, NSW.

Although 1977 was an abnormally dry year, reasonable yields of oil were obtained from the museum's plantations at Yanco, West Wyalong and Cowra, the last mentioned producing the equivalent of 320 kg. of oil per hectare per annum, a result better than the West Wyalong plots and the first indication of the species' response to higher rainfall.⁴¹

Collaboration with Professor Lindsay Dixon Pryor (1915 – 1998)⁴² of the Botanical Department, School of General Studies, Australian National University commenced in the 1960s with material supplied for the grafting of *Eucalyptus citriodora* plants for use in experimental work by the museum.⁴³ This collaboration continued in the 1970s when research into tissue culture of eucalypts was carried out in collaboration with the Botany Department at the University of New England with a view to mass production of high oil-yielding clonal material for plantations.

³⁸ Walker 1997

³⁹ MAAS AR 1977, p.25

⁴⁰ CHAH 2015

⁴¹ MAAS AR 1978, p.17

⁴² Walker 2001

⁴³ MAAS AR 1963, p.20

Helping the tea tree oil industry

The Castle Hill Experimental Plantation was also used for the propagation of a wide range of other species including *Melaleuca quinquenervia* (Five-veined Paperbark) and *M. alternifolia*, the latter species proving to be a valuable, high-yielding source of tea tree oil, a product with significant antibacterial and antifungal properties. In addition to the experimental plots of this species at Castle Hill, the museum established trials at Port Macquarie and in the Braemar and Whiporie State Forests, near Casino. It is thought that Aboriginal people of the Bundjalung Nation traditionally used the waters from nearby Bungawalbin Creek containing fallen leaves of *M. alternifolia* and mud containing the oil-rich leaves of the species to treat various ailments.

In 1925, Arthur Penfold, had published research findings showing that the antiseptic activity of the distilled oil of *Melaleuca alternifolia* was up to 13 times greater than that of carbolic acid, then a well-known germicide. General practitioners used the oil in treating throat infections, uncleaned wounds and fungal infections. At the outbreak of the Second World War in 1939, the Australian government commandeered all stocks of tea tree oil for the military and supplied all Pacific troops with tea tree oil in their first aid kits. Tea tree cutters were exempted from military service.⁴⁴

There is a direct link between the early research carried out by Penfold and the subsequent cultivation and harvesting trials conducted at Castle Hill and at other museum trial sites and the development of the current important tea tree oil industry, with companies such as Thursday Plantation having extensive plantations in the Bungawalbin wetlands and a distillation plant at Ballina.

Late developments at the Castle Hill Experimental Plantation

In 1964 the Department of Main Roads and the Metropolitan Water Sewerage and Drainage Board acquired part of the Castle Hill Experimental Plantation site for road widening and relocation of future water storage facilities. Following this the museum relocated the garage and tool and machinery shed and erected a new house on an adjacent site for the resident Field Assistant and his family.⁴⁵ By the start of the 1970s the museum's Department of Chemistry was under the charge of Erik Lassak (1934-2015), supported by Chemist Ian Southwell, two technical officers and a laboratory attendant. Brian Small was in charge of the Botany Department, with a technical officer, a laboratory attendant and two field officers, the last two working at Castle Hill.⁴⁶

The erection of a glass house with automatic misting facility at Castle Hill led to considerable success with the vegetative propagation of *Melaleuca alternifolia*, opening the way for the production of high quality tea tree oil from high-yielding elite plantations of the species. Trials at Castle Hill using open-rooted seedlings of *M. alternifolia* planted out by a mechanical tree planter proved quite successful, offering considerable cost savings over the previous use of seedlings raised in "jiffy" pots. Similarly, improved nursery techniques developed at Castle Hill for raising Blue

⁴⁴ Thursday Plantation website

⁴⁵ MAAS AR 1964, p.24

⁴⁶ MAAS AR 1970, p.3

Mallee seedlings enabled the nursery at Castle hill to accommodate 15,000 seedlings at a time.⁴⁷ The importance of the facility at Castle Hill was attested to by the visit to the site in 1970 by overseas post-tertiary UNESCO scholars in science teaching methods⁴⁸ and in 1975 by UNESCO sponsored chemists from Asian countries.⁴⁹

Important discoveries through research at the museum

In the mid-1960s, the continuing instability of the essential oil industry led the Chemical Laboratory at the museum to expand its research to a wide range of species in the families Myrtaceae, Rutaceae and Lamiaceae with a view to their possible economic use.⁵⁰ This work, carried out with the Botanical Laboratory, included screening of species such as the mint bushes *Prostanthera nivea* and *P. striatiflora* (Family: Lamiaceae), *Baeckea cunninghamii*, *Leptospermum trinervium* (Syn. *L. attenuatum*), *Melaleuca thymifolia* and *Xanthostemon chrysanthus* (Family: Myrtaceae) and *Eriostemon buxifolius* (Family: Rutaceae) to name just a few. The Botanical Laboratory's work on the nutrition of eucalypts and the distribution of oils in them continued, both in the field and at Castle Hill.

Another species being investigated as a source of tropane alkaloids was *Duboisia myoporoides* (Corkwood) leading to the establishment by the museum of a trial at Whiteman's Creek, near Grafton. These alkaloids are used in the pharmaceutical industry for the production of a wide range of medicines including stimulants, antispasmodics and analgesics. The leaves are also used in homeopathy for the treatment of eye complaints. *Duboisia* is probably one of the most important of the Australian native medicinal plants, its leaves being a valuable source of the alkaloid drugs, scopolamine and hyoscyamine.⁵¹

By this time, the museum had been researching Australian plants and their products for over eighty years but important new discoveries were being made every year. Gas chromatography of oil samples distilled from the leaves of a single tree of a type specimen of *Eucalyptus dives* grown at the Castle Hill Experimental Plantation revealed 85 separate components in the oil, fewer than twenty of which had already been identified by previous workers. The leaf was also shown to contain the glycoside, rutin, plus another crystalline compound for further investigation. Also found in capers and some other plants, rutin has been shown to strengthen capillaries and inhibit platelet clump formation in blood vessels. Both these actions of rutin help in smooth circulation of blood in the capillaries. It has found application in some trial treatments for haemorrhoids and varicose veins. It is also found to reduce LDL-cholesterol levels in obese individuals.⁵² The museum also carried out research into *Eucalyptus youmanii* (Youman's Stringybark), a cool climate eucalypt from the Northern Tablelands of NSW and the Granite Belt country around Stanthorpe in

⁴⁷ Ibid.p.17

⁴⁸ Ibid., p.16

⁴⁹ MAAS AR 1977, p.24

⁵⁰ MAAS AR 1964, p.21

⁵¹ Plants for a future website

⁵² Nutrition and you website

Queensland, as a source of rutin, which was thought to also have potential in the treatment of frostbite.

In the 1970s the museum's chemists carried out a comprehensive survey of the essential oil content of koala fodder and also worked on the metabolism of essential oils by possums. The work on koala metabolism of essential oils was published in at least two publications.⁵³ The koala research was done in collaboration with Sydney's Koala Park Sanctuary at West Pennant Hills. Leaf from koala fodder trees grown at Castle Hill were used to supplement the diet of koalas at Koala Park.

Also in the 1970s the Chemistry Department of the museum collaborated with the Narcotics Bureau, Department of Customs and Excise in the investigation of the essential oils of *Cannabis sativa* and Cannabis preparations. The Department also worked with the CSIRO Division of Land Management in Deniliquin to investigate the essential oils of two species of the Australian plant genus *Eremophila* (emu bushes) as part of goat and sheep fodder trials.⁵⁴ Another aspect of the Chemistry Department's work at this time was the preparation of Australian standards for resins, essential oils, including that of *Melaleuca alternifolia*, and certain plant-derived chemicals such as Eucalyptol (1, 8-Cineole), the major component in the essential oil obtained from *Eucalyptus polybractea*.

The continuing interest in tea tree oil throughout the 1970s led to the establishment of additional trials of *Melaleuca alternifolia* on the north coast of NSW at John's River and Kempsey. In collaboration with the NSW Department of Agriculture, a tea tree trial was also established at Duck Creek near Ballina, with open-root seedling stock raised at Castle Hill. These plantings not only demonstrated the feasibility of lifting, transporting and planting open-root stock but also substantially reduced the cost of plantation establishment. Success of the trial at Duck Creek was seen as important because there were considerable tracts of that type of land that could be available for tea tree cultivation in the lower Richmond River area.⁵⁵ *M. alternifolia* had been regarded as a nuisance by many property owners on the north coast because the fast-growing species spread quickly in their pastures in the humid climate of the region. Some of them came to regard the species more favourably when they realised it could be put to productive use for oil production in boggy areas less suitable for dairying.

Responding to the high cost of seedlings as a deterrent to plantation establishment, the Botany Department at the museum encouraged growers to set up facilities to raise their own seedlings. A number of growers applied these techniques and successfully raised over 500,000 *M. alternifolia* seedlings in 1977 for planting early in 1978.⁵⁶

Promotion of the tea tree oil industry increased in 1977 when Brian Small, the Botany Research Officer collaborated with the ABC in the production at the Castle

⁵³ Eberhard et al., 1975; Southwell 1975

⁵⁴ MAAS AR 1978, p.16

⁵⁵ Ibid.p.17

⁵⁶ Ibid.

Hill Experimental Plantation of a 6-minute segment featuring tea tree oil for the TV documentary series “Growing Things”. The programme was first shown to Sydney viewers on 30 November 1977 and later received Australia-wide coverage. This programme generated considerable interest in the industry with the museum receiving enquiries from as far afield as Western Australia.⁵⁷

The Museum of Applied Arts and Sciences Herbarium

The museum’s herbarium, established by botanist and first curator Joseph Maiden as a priority from the outset, contained thousands of preserved plant specimens vouchering for plant species under investigation by museum officers as well as others collected by staff members, donated by private individuals or sister institutions such as other herbaria. The herbarium aimed to have at least one representative specimen of each economically significant plant species on record and available for study. On the closure of the museum’s botany department in 1979, the herbarium specimens were transferred to other relevant repositories including the National Herbarium of NSW at the Royal Botanic Gardens, Sydney.

The end of an era

In a chapter of the book *Yesterday’s Tomorrows: The Powerhouse Museum and its precursors 1880-2005*, titled ‘Empowering: Applied research and the commercial museum 1880-1978’ by Roy Macleod and Kimberley Webber, the authors argue that it was surprising that the museum’s research team survived a succession of inquiries in the 1960s and ‘70s, given that there had been ‘few significant industrial outcomes’ and that the team was ‘housed in an old-fashioned building at the wrong end of town, with outdated laboratories and ageing staff’.⁵⁸ This state of affairs was perceived by the authors to have ‘little sense of the dynamic between museum and industry’ that the early curators and their supporters had envisaged.⁵⁹ This begs the question: What would have been the good end of town for a scientific research facility? This author argues that a site adjacent to Sydney Technical College and within easy walking distance of Sydney University made a lot of sense. The argument that few significant technical outcomes had been achieved by the museum’s scientists after the 1920s is also questioned. The authors who made that assertion were historians and it is not known how extensively they consulted with the museum’s former scientific staff or with the essential oil industry on the museum’s phytochemical achievements in the post - 1920s period.

MacLeod and Webber continue:

“In two reports commissioned by the Public Service Board on research at the museum – in 1972 and 1979 – this failure to have any real ‘application to industry’ was one of the major arguments given for closing down the laboratories. The 1972 inquiry found that ‘no work of importance seems to have emerged since that on menthol from piperitone in 1920, the development of the Tasmanian lavender industry in the 1920s and the work on oil of Melaleuca as a bactericide in 1927. The Public Service Board recommended the transfer of the research program to

⁵⁷ Ibid.

⁵⁸ Davison & Webber (eds) 2005, p.106

⁵⁹ Ibid.

the Department of Forestry. Willis, as director, fought hard against this decision, mobilising supporters such as the Tasmanian essential oil producer Bridestowe Estate. Its director, E F K Denny, wrote at length about the value of the museum's work, its 'unparalleled world wide prestige' and the commercial advantage of having an independent laboratory for analysing samples."⁶⁰

This author can attest to the esteem in which Bridestowe Estate held the museum's research work on essential oils when he visited that company's plantation in north-eastern Tasmania in March 1975 and met with the company's director E F K 'Tim' Denny.

Through a 'difficult struggle', Director Jack Willis managed to retain the research laboratories at the museum after the 1972 inquiry although some Chemistry Department staff were deployed to conservation.⁶¹ Unfortunately, this was just delaying the inevitable and in 1977 Willis was forced to admit to staff that the museum's research department had a limited life. That the writing was on the wall was clear to this author when he returned from completing the course work part of a Master's degree in Museum Studies at the University of Leicester in July 1977. Rather than risking an uncertain employment future in the wake of the impending closure of the scientific departments, the author resigned from the museum and took a position as a botanical investigations officer with the NSW National Parks and Wildlife Service.

When the NSW Government announced on 23 August 1978 its intention to redevelop the Museum of Applied Arts and Sciences on the site of the former Ultimo Power Station, this spelled the death knell for the Chemistry and Botany departments at the museum as they had existed for nearly a century. In 1979, the NSW Science and Technology Council recommended that research into essential oils at the museum be terminated and staff redeployed or relocated. Responsibility for technical advice was transferred to the Department of Agriculture.

MacLeod and Webber argue:

"Despite 99 years of research, the essential oil industry in Australia remained economically inconsequential. Moreover, in language that would have brought tears to Maiden's eyes, the council observed that:

"this field is not currently regarded as an important or fertile area in the general advancement of knowledge. This view is supported by the absence of effort by other institutions and workers in directing research resources to it."⁶²

The Science and Technology Council took an unfortunate short term view of the Australian essential oil industry, based on the fact that by 1977 Australia was contributing less than 10% to total world production and that spending 10% of the annual value of the eucalyptus oil industry on research and development could not be justified when the customary level of R & D by primary industry was only 1%

⁶⁰ PMA: MRS 309-3/1. Cited in Davison & Webber 2005, p.107, endnote 54, p.271

⁶¹ Willis, pp.237-238

⁶² Willis, p.242; PMA: MRS 204 78/1035, cited in Davison & Webber 2005, p.197, endnote 56, p.271

In challenging the council's report, the museum could point to no examples either in Australia or overseas where a science and technology museum included botany and chemistry as 'an integral part' of their operations. Senior chemist, Erik Lassak admitted that research suffered because of poorly equipped laboratories. On 16 May 1979 Dr Lindsay Sharp, the museum's new director and the first not to come from a pure or applied science background, wrote to the Premier's Department confirming the board of trustees' agreement to the closure of the chemistry and botany departments at the museum. Henceforth, science and research in the museum became "objects of study rather than modes of practice."⁶³

Hindsight is a wonderful thing and in the light of the subsequent demise of many homegrown Australian industries and the current view, in the midst of the COVID-19 pandemic, that Australia needs to be much more self-sufficient in its ability to produce many products, the decision to close the botany and chemistry departments at the museum and the Castle Hill Experimental Plantation was perhaps not so wise. While some staff went on to have significant careers in scientific research in the NSW Public Service, the nexus between botany and chemistry and between laboratory and field experiments was diminished and the promise showed by trials at Castle Hill was not permitted to continue.

The fate of the Chemistry and Botany staff

Both Director Jack Willis and Deputy Director Howard McKern retired in the late 1970s, McKern in 1977 and Willis in 1978. By the time McKern retired in March 1977, he had published more than 40 scientific papers and had been awarded the Royal Society Medal for services to science in 1968 and the Queen Elizabeth II Silver Jubilee Medal in his retirement year.⁶⁴ Willis had authored or co-authored many publications on economic botany and had served as President of the Museums Association of Australia from 1961 to 1967.

Chemistry Department staff Dr Erik Lassak, Ian Southwell, T Flynn and G Speirs elected to transfer to the Department of Agriculture's Biological and Chemical Research Institute at Rydalmere. Botany Research Officer Brian Small transferred to the Department of Agriculture's Division of Plant Industry in Rawson Place, Sydney.

Erik Lassak became Senior Research Scientist at the Biological and Chemical Research Institute and on retirement became an Honorary Research Associate at the Royal Botanic Gardens, Sydney, NSW, where he worked on chemotaxonomic studies on the essential oils of the NSW indigenous flora and on dangerous cycads. In addition to some 50 published research papers on essential oils and other plant products, Lassak co-authored with Tara McCarthy the major reference book *Australian Medicinal Plants*.

Ian Southwell went on to complete his PhD at the University of Manchester and rose to the position of Principal Research Scientist in the NSW Department of Primary Industries, a position he held until 2005 when he became Secretary of the Essential Oil Producers Association of Australia (2005-2015). Since 2015 he has been

⁶³ Davison & Webber 2005, p.109

⁶⁴ Brown 2009

Adjunct Professor of Plant Science at Southern Cross University. Individually and with other authors, Ian Southwell has published numerous papers on *Melaleuca alternifolia* and other essential oil species through avenues such as AgriFutures Australia (the trading name for the Rural Industries Research & Development Corporation) and in journals such as *Flavour & Fragrance Journal*, *Phytochemistry* and the *Journal of Chemical Ecology*. The Biological and Chemical Research Institute was abolished in 1992 but research into tea tree oil has continued in various locations.

The current state of the essential oil industry in Australia

The major Australian essential oil at the present time is tea tree oil produced from *Melaleuca alternifolia* and to a lesser extent from *M. linariifolia* and *M. dissitiflora*. Tea tree oil is used mainly as a cosmetics additive.⁶⁵

The Australian Tea Tree Industry Association Ltd (ATTIA), based in Casino, NSW, is the peak representative organisation for the Australian tea tree oil industry. It works to promote the interests of Australian tea tree oil producers, exporters and manufacturers. In doing so ATTIA aims to develop a stable, cohesive and internationally competitive tea tree oil industry. AgriFutures Australia is currently seeking expressions of interest in scoping studies into sustainable invertebrate pest and disease management in tea tree oil plantations and sustainable nutrition for productive tea tree oil plantations.⁶⁶

The bulk of eucalyptus oil produced at the present time is of the 1,8-cineole type from *Eucalyptus polybractea* and to a much smaller extent from *E. radiata* subsp. *radiata*. Some cineole-type oil is also produced in Western Australia from *E. plenissima*, *E. polybractea* and several other mallee species. In almost all cases the trees harvested are plantation grown.⁶⁷

Minor essential oils from other Australian plant species produced at the present time are from: *Melaleuca quinquenervia* (nerolidol type), *Backhousia citriodora* (Lemon Myrtle), *Anetholea anisate* (previously known as *Backhousia anisata*), *Leptospermum petersonii* (Lemon-scented Tea Tree), *Eucalyptus olida*, *E. staigeriana*, *Callitris intratropica* as well as *Santalum spicatum* (Western Australian Sandalwood). There is also a small production of *Boronia megastigma* absolute, a dark green coloured liquid with fresh, fruit-like aroma and a rich, floral undertone. This essence, prized for fragrance and flavour applications, is extracted from the fresh leaves and blossoms of Brown Boronia flowers through a solvent extraction process.⁶⁸

Essential oils from introduced species include: bitter fennel oil (a major oil), peppermint oil (about 10 – 30 tonne per annum depending on the season), dillweed

⁶⁵ Essential Oil Producers Association of Australia 2020

⁶⁶ Australian Tea Tree Industry Association 2020

⁶⁷ EOPAA 2020

⁶⁸ Ibid.

oil, parsley herb oil, hop oil, sweet orange oil and lemon oil. Small amounts of various *Lavandula* oils are also produced (mostly lavandins).⁶⁹

A lasting legacy of essential oil research at the museum

One of the museum's lasting legacies has been the development of useful, even life-saving, products containing essential oils which were researched at the museum. One such product is Water-Jel®, a product which contains tea tree oil from *Melaleuca alternifolia* as a bacteriological barrier to protect wounds against further contamination.

Tea tree oil has anaesthetic, anti-bacterial, antiseptic and anti-fungal properties. As such, it is valuable as a first aid treatment for a range of small complaints. It makes an excellent topical oil to prevent infections and accelerate the healing of small cuts and grazes, and bruises. It removes the itch and irritation caused by insect bites.

Water-Jel Fire Blankets are a one-step system for emergency first aid on burn victims. The blankets put out the fire, stop burn progression and cool the skin, relieving pain and protecting the burn area from contamination.

Water-Jel Fire Blankets consist of a scientifically formulated cooling gel and a special carrier. The 100% worsted wool blanket with intercellular weave can absorb up to 13 times its own weight. The blanket is soaked in a water-based/water-soluble, bacteriostatic and biodegradable gel. It can be placed directly over clothing and won't stick to burn injuries. The blankets are available in three sizes and are packaged in high visibility orange canisters, that can be mounted on a wall, or in flexible foil pouches where space is limited.

Water-Jel burn dressings utilise a non-woven carrier, pre-saturated with cooling clear gel - together they conform to the burn injury site as they cool and soothe the pain. The excess heat is absorbed and dissipated throughout the gel and released to the air as the skin temperature is stabilised. Water-Jel burn dressings cover and protect burn injuries to help prevent infection.

The fate of the Castle Hill Experimental Plantation

The museum, when it originally acquired the Castle Hill land in 1947, was a part of the Department of Public Instruction. Due to a technicality, it was that Department, not the Museum, which held title to the land. Therefore in 1974, when the Department of Technical Education decided they wanted to erect a technical college on the site, the museum, no longer part of that department, had to argue its case to keep even a portion of the land for its essential oil research. That research ended at the museum when the Chemistry and Botany Departments were abolished and the staff either retired, transferred to other NSW Government agencies or moved to other positions in the museum. The Castle Hill TAFE campus was developed on part of the plantation site, with a room in one of its buildings named the Melaleuca Room in a token interpretation of the site's rich research history. The TAFE development involved the demolition of the former museum Still House. However, an area of the plantation close to Windsor Road was retained and became the site of the Museums

⁶⁹ Ibid.

Discovery Centre (MDC), a store for bulky items including transport items and much of the museum's reserve collection, as well as facilities for the Australian Museum and Sydney's Living Museums.. A site between the MDC and Castle Hill TAFE is now proposed for an expansion of the MDC, requiring the removal of 337 trees previously part of the plantation.

The current threat to the former Experimental Plantation site at Castle Hill

As part of the Powerhouse Parramatta proposal, MAAS now intends to store the entire Powerhouse Collection on one site when not on display or loan, "greatly improving community access to the Collection"⁷⁰. This is to be achieved by a proposed expansion of the Museums Discovery Centre at 172 Showground Road, Castle Hill on a part of the adjacent TAFE site along the eastern boundary of the existing MDC site. The land will be transferred to Powerhouse from TAFE NSW.

"A new state-of-the-art building will be constructed on the site, and will include spaces for the storage, care, research and viewing of the Powerhouse Collection, as well as flexible spaces for education and public programs, workshops, talks and events.

*The proposed expansion will increase opportunities for storytelling, skill-sharing, education programs, tours, events, partnerships and temporary exhibitions, and provide greater access to the Powerhouse Collection for the people of Castle Hill and broader Sydney community."*⁷¹



⁷⁰ https://maas.museum/museums-discovery-centre-expansion/?utm_source=Email&utm_medium=Newsletter&utm_campaign=

⁷¹ Ibid.

The Powerhouse Museum and Create NSW have been progressing a planning proposal to rezone the site for the Museums Discovery Centre expansion. This proposal was placed on public exhibition by The Hills Shire Council and closed on 17 July 2020. This planning proposal is expected to be determined by end 2020.



Image: lahznimmo architects (artist impression, subject to final approvals)

The Powerhouse and Create NSW are developing a state significant development (SSD) application for the construction and operation of the new building for MDC. A request for Secretary's Environmental Assessment Requirements (SEARs) has been lodged with the NSW Department of Planning, Industry and Environment. The SSD application including an environmental impact statement and technical reports will be developed by Powerhouse and Create NSW to address the SEARs. Once lodged, this application will be placed on public exhibition which is expected to occur in Quarter 3 2020.

The expansion of MDC is a museum (information and education facility) that has a capital investment value in excess of \$30 million and as such the DA is submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979*. The project will therefore be exempt from the requirements for an Aboriginal Heritage Impact Permit (AHIP) in accordance with Section 90 of the *NSW National Parks and Wildlife Act 1974*.

This application will deliver expanded cultural facilities within the MDC at Castle Hill. The SSD DA seeks consent for expanded facilities as a single stage comprising: site preparation works, construction of the proposed new 'Building', construction of new vehicle access ways and subdivision of the proposed site.

The Powerhouse Museum invites local Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal object(s) and/or places in the area of the proposed expansion of Museums Discovery Centre to register an interest in a process of community consultation.

The significance of the former Castle Hill Experimental Plantation site.

The former Museum of Applied Arts and Sciences Experimental Plantation at Castle Hill is not currently listed on Schedule 5 Environmental Heritage, The Hills Local Environmental Plan 2019 or on the State Heritage Register. But then, neither the Powerhouse Museum at Ultimo nor the adjacent Harwood Building (the former Ultimo Tram Depot) is heritage listed in spite of their obvious historical, social, technical / educational and rarity values for NSW. That a place is not currently listed on a statutory heritage register does not mean it is not significant – it may not have been assessed or its listing may have been refused for one or more reasons, including possible political reasons.

Recent assessments of the arboricultural and heritage significance of the former Castle Hill Experimental Plantation site

SEARs Request

The Planning Secretary's Environmental Assessment Requirements (SEARs) request submitted to the NSW Department of Planning, Industry and Environment on 15 May 2020 by town planning consultants Milestone (Aust.) Pty Ltd on behalf of Create Infrastructure NSW which is managing the design, development and construction of the MDC Expansion in collaboration with the Powerhouse Museum contains the following statement (clause 5.7) about Heritage:⁷²

"The site is not heritage listed. The site is located adjacent to Windsor Road which is listed in Schedule 5 of [The Hills] LEP 2019 as '*Windsor Road from Baulkham Hills to Box Hill*' (Item I28). The proposal will be located 90m to the north east of Windsor Road and will have minimal heritage impact on the setting of the Windsor Road heritage item. A Heritage Impact Statement has been prepared by Curio Projects for the Planning Proposal to investigate the history of the site and concluded that '*The plantation also has no associations with any significant personnel at either a local or State level and therefore reinforces that the plantation holds no significance beyond the site itself*'."

The updated Arboricultural Impact Assessment / Tree Survey carried out by MacKay Tree Management for MAAS and dated 14 May 2019 has focussed on the affected trees from the viewpoint of their remnant ecological community value and statutory requirements rather than as part of a cultural landscape resulting from scientific experiments.

The Arborist Report prepared by MacKay Tree Management identifies 330 of the 337 to be removed for the MDC Expansion as plantation trees (planted in the 1940s).

The assessment concludes: "It is recommended that to restore the landscape amenity of the site replacement plantings of locally indigenous trees such as *Eucalyptus resinifera* (Red Mahogany), *Eucalyptus paniculata* (Grey Ironbark) and *Eucalyptus globoidea* (White Stringybark) and understorey native shrubs are planted in appropriate locations." This recommendation is aimed solely at canopy replenishment amenity landscaping and ignores the planting history of the site as an

⁷² SEARs request letter dated 15 May 2020

experimental plantation devoted to research into essential oils and other plant products.

In Milestone's response to the Hills Shire Council's letter dated 19 December 2019 requesting the submission of additional information to assist Council Officers in their assessment of the Planning Proposal for the MDC Expansion, Milestone provided the following response about 'Potential Cultural or Heritage Values'

"A Heritage Review of the plantation trees in the location of the Building J site has been undertaken by heritage consultants Curio Projects (refer to Attachment B). The Heritage Review includes an analysis of the history of the use of the site and concludes that based on the information available *"the eucalypt plantation has been deemed to have low significance"* from a heritage perspective for the following key reasons:

- *"The plantation is not significant in their [sic] own right to meet the threshold of significance at a local or State level"*
- *The plantation is not so significant at a local level that it would require insitu [sic] retention.*
- *The plantation also has no associations with any significant personnel at either a local or State level and therefore reinforces that the plantation holds no significance beyond the site itself.*
- *No heritage listings for the plantations or the research conducted from them on either a local or State level."*

MAAS states it is committed to preserve the removed trees where possible and will consider using timber from the removed trees for furniture in the new building and/or interpretive displays as part of the redevelopment of the site.

Additionally, MAAS is supportive of the recommendation of Curio Projects that *"archival recording before the removal of the trees could be conducted to retain information about the site"* as part of the future Development Application for the proposed Building J."

The Heritage Review by Curio Projects is based on scant historical research. Analysis of even a few of the summary reports in the MAAS Annual Reports for the years in which the Castle Hill Experimental Plantation was in operation would have revealed considerable information about the plantings, personnel involved and achievements made. Consequently, the following 'Conclusions & Recommendations' from the Curio report in relation to significance are refuted by this author (comments in square brackets).

"Based on the analysis of the above information, the eucalypt plantation has been deemed to have low significance. The following summary has been prepared in response to the history and significance of the plantations in relation to the subject site to provide guidance concerning the removal of the plantations to accommodate the construction of Building J.

1. Currently, there are no heritage listings for the plantations or the research conducted from them on either a local or State level. [See above comment on places not currently listed – non-listing is not necessarily an indication of lack of significance]
2. The plantation is not significant in its own right to meet the threshold of significance at a local or State level despite the commonality of the tree species (*Corymbia maculata*, Spotted Gum) within the local Cumberland Plain Woodland area. [The identification of these trees as *C. maculata* needs to be checked as the museum was more likely to have planted the similar-looking, oil-producing species *C. citriodora*]. The physical conditions of the plantations themselves have also been deemed to have low significance overall due to their poor condition and semi-mature nature. [Poor condition must not be equated with low significance – many places of great heritage significance are in poor condition]. This is in accordance with the STARS [Significance of a Tree Assessment Rating System] assessment criteria, where they specify the low significance for several reasons:
 - Growth is severely restricted by above or below ground influences and is unlikely to reach typical dimensions under normal circumstances. [The growth of these trees has been influenced by the very fact that they were planted in rows as experimental trials].
 - The tree is in good-poor condition and good-low vigour.
 - The tree is a young specimen which may or may not have reached dimension to be protected by local tree preservation orders or similar protection mechanisms
 - The tree has a wound or defect that has the potential to become structurally unsound.
3. Historically, the eucalypt plantation is interesting, however, its history could be interpreted throughout the redevelopment of the Building J site, as the plantation is not so significant at a local level that it would require insitu [sic] retention. [The Heritage Review by Curio Projects has not demonstrated this.]
4. The plantation also has no associations with any significant personnel at either a local or State level and therefore reinforces that the plantation holds no significance beyond the site itself.” [There is considerable documentary evidence that the plantation was associated with several major figures with numerous published works in the study of essential oils and other plant products in NSW including Arthur Penfold, Jack Willis, Howard McKern, Erik Lassak, Ian Southwell and Brian Small].

SEARs

The Planning Secretary’s Environmental Assessment Requirements (SEARs) required under Section 4.12(8) of the *Environmental Planning and Assessment Act 1979* and Schedule 2 of the Environmental Planning and Assessment Regulation

2000 for SSD-10472: Expansion of the Museums Discovery Centre, 2 Green Road, Castle Hill (Lot 102 DP1130271), does not list assessment of the non-Aboriginal Heritage of the site as a General Requirement or as a Key Issue to be addressed in the EIS.

Review of the plantation's heritage significance

The heritage significance of the former Museum of Applied Arts and Sciences Experimental Plantation at Castle Hill has been assessed by this author in accordance with the assessment criteria established by the Heritage Council of NSW.

Historical themes

The Australian Heritage Council identifies 9 national historical themes and the NSW State Heritage Inventory identifies 36 historical themes, which signify historical processes, but do not describe physical evidence or items in a study area. These national and state themes are very general, and many heritage items will relate to more than one theme. They do, however, help us to understand the historical context of individual items.

The Castle Hill Experimental Plantation is considered to have the ability to demonstrate the themes set out in the following table.

National Theme	State Theme	Notes	Typical Examples
3 Developing local, regional and national economies	Agriculture	Activities relating to the cultivation and rearing of plant and animal species, usually for commercial purposes, can include aquaculture	Hay barn, wheat harvester, silo, dairy, rural landscape, plantation , vineyard, farmstead, shelterbelt, silage pit, fencing, plough markings, shed, fish farm, orchard, market garden, piggery, common, irrigation ditch, Aboriginal seasonal picking camp.

National Theme	State Theme	Notes	Typical Examples
3 Developing local, regional and national economies	Environment - cultural landscape	Activities associated with the interactions between humans, human societies and the shaping of their physical surroundings	A landscape type, bushfire fighting equipment, soil conservation structures, national park, nature reserve, market garden, land clearing tools, evidence of Aboriginal land management, avenue of trees, surf beach, fishing spot, plantation , place important in arguments for nature or cultural heritage conservation.
3 Developing local, regional and national economies	Forestry	Activities associated with identifying and managing land covered in trees for commercial timber purposes.	Forested area, forest reserve, timber plantation , forestry equipment, saw mill, mill settlement, arboretum , charcoal kiln, coppiced trees , forest regrowth, timber tracks, whim.
3 Developing local, regional and national economies	Science	Activities associated with systematic observations, experiments and processes for the explanation of observable phenomena	Laboratory, experimental equipment, text book, observatory, botanical garden, arboretum , research station , university research reserve, weather station, soil conservation area, fossil site, archaeological research site.
3 Developing local, regional and national economies	Technology	Activities and processes associated with the knowledge or use of mechanical arts and applied sciences	Computer, telegraph equipment, electric domestic appliances, underwater concrete footings, museum collection , office equipment, Aboriginal places evidencing changes in tool types.

Assessment against Heritage Council criteria

Principles and basis for assessment

The concept of 'cultural significance' or 'heritage value' embraces the value of a place or item which cannot be expressed solely in financial terms. Assessment of cultural significance endeavours to establish why a place or item is considered important and is valued by the community. Cultural significance is embodied in the fabric of the place (including its setting and relationship to other items), the records associated with the place and the response that the place evokes in the contemporary community.

Cultural landscapes by their name imply human intervention but they may also include substantial natural elements. "They can present a cumulative record of human activity and land use in the landscape, and as such can offer insights into the values, ideals and philosophies of the communities forming them, and of their relationship to the place. Cultural landscapes have a strong role in providing the distinguishing character of a locale, a character that might have varying degrees of aesthetic quality, but, regardless, is considered important in establishing the community's sense of place."

The Australia ICOMOS charter for the conservation of places of cultural significance (the Burra Charter) was formulated in 1979, revised in 1999, with an updated edition published in 2013. The Burra Charter is the standard adopted by most heritage practitioners in Australia. The Burra Charter and its Guidelines for Assessment of Cultural Significance recommend that significance be assessed in categories such as aesthetic, historic, scientific, social and other. The 1999 amendments to the Burra Charter emphasise the importance of setting in the conservation of heritage items.

The *NSW Heritage Manual* outlines the same broad criteria for assessing the nature of significance. These criteria are considered in addition to an item's rarity and / or representativeness, criteria that relate to comparative significance. The seven criteria adopted by the Heritage Council of New South Wales for the assessment of items for potential listing on the State Heritage Register apply equally well for items of local significance. To qualify for listing on a LEP schedule or on the SHR, an item must satisfy at least one of the seven assessment criteria at a local or State level respectively, although many items will satisfy more than one criterion. Items are assessed firstly in relation to the heritage values and, secondly, in regard to the context in which the item is significant. Decisions on whether items are significant against each criterion are assisted by application of Inclusion and Exclusion Guidelines.

Historical Significance (Criterion A)

An item is important in the course, or pattern, of NSW's or an area's cultural or natural history.

Guidelines for Inclusion

- shows evidence of a significant human activity
- is associated with a significant activity or historical phase
- maintains or shows the continuity of a historical process or activity

Guidelines for Exclusion

- has incidental or unsubstantiated connections with historically important activities or processes
- provides evidence of activities or processes that are of dubious historical importance
- has been so altered that it can no longer provide evidence of a particular association

Types of items which typically meet criterion (a) include:

- items which demonstrate strong associations to past customs, cultural practices, philosophies or systems of government, regardless of the intactness of the item or any structure on the place;
- items associated with significant historical events, regardless of the intactness of the item or any structure on the place;
- significant cultural landscapes and other items demonstrating overlays of the continual pattern of human use and occupation; and/or
- items where the physical fabric (above or below ground) demonstrates any of the points described above.

The Castle Hill Experimental Plantation has substantiated connections with historically important activities, namely the cultivation of and research into Australian plants for their scientific significance and potential economic value. Regardless of its altered state due to construction of buildings on part of its original site, the plantation satisfies this criterion at a local level at least.

Historical Associational Significance (Criterion B)

An item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's or an area's cultural or natural history.

Guidelines for Inclusion

- shows evidence of a significant human occupation
- is associated with a significant event, person, or group of persons

Guidelines for Exclusion

- has incidental or unsubstantiated connections with historically important people or events
- provides evidence of people or events that are of dubious historical importance
- has been so altered that it can no longer provide evidence of a particular association

Types of items which typically meet this criterion include:

- items which demonstrate strong associations to a particular event, historical theme, people or philosophies, regardless of the intactness of the item or any of its structures;

- items associated with significant historical events, regardless of the intactness of the item or any structure on the place; and/or
- items where the physical fabric (above or below ground) demonstrates any of the points described above.

The Castle Hill Experimental Plantation has substantiated connections with important people significant in the scientific research of Australian plants for essential oils and other plant components. These people include Arthur Penfold, Jack Willis, Howard McKern, Erik Lassak, Ian Southwell and Brian Small, all of whom have published scientific papers and other material on the results of their research at MAAS including the plantation.

Regardless of its altered state due to construction of buildings on part of its original site, the plantation satisfies this criterion at a local level at least.

Aesthetic Significance (Criterion C)

An item is important in demonstrating aesthetic characteristics and / or a high degree of creative or technical achievement in NSW or an area.

Guidelines for Inclusion

- shows or is associated with, creative or technical innovation or achievement
- is the inspiration for a creative or technical innovation or achievement
- is aesthetically distinctive
- has landmark qualities
- exemplifies a particular taste, style or technology

Guidelines for Exclusion

- is not a major work by an important designer or artist
- has lost its design or technical integrity
- its positive visual or sensory appeal or landmark and scenic qualities have been more than temporarily degraded
- has only a loose association with a creative or technical achievement

Types of items which meet this criterion include:

- items which demonstrate creative or technical excellence, innovation or achievement;
- items which have been the inspiration for creative or technical achievement;
- items which demonstrate distinctive aesthetic attributes in form or composition;
- items which demonstrate a highly original and influential style, such as an important early (seminal) work of a major architect; and/or
- items which demonstrate the culmination of a particular architectural style (known as climactic).

Due to the loss of its original design and technical integrity and the diminution of its former landmark qualities, the Castle Hill Experimental Plantation is no longer considered to satisfy this criterion.

Social Significance (Criterion D)

An item has strong or special association with a particular community or cultural group in NSW or an area for social, cultural or spiritual reasons.

Guidelines for Inclusion

- is important for its associations with an identifiable group
- is important to a community's sense of place

Guidelines for Exclusion

- is only important to the community for amenity reasons
- is retained only in preference to a proposed alternative

Types of items which meet this criterion include:

- items which are esteemed by the community for their cultural values;
- items which if damaged or destroyed would cause the community a sense of loss; and/or
- items which contribute to a community's sense of identity.

Items are excluded if:

- they are valued only for their amenity (service convenience); and/or
- the community seeks their retention only in preference to a proposed alternative.

Social value is hard to quantify without detailed surveys of those who have been associated with a place or with the local community to assess whether the place contributes to the community's sense of place or identity. The former use of the plantation for scientific research has not been widely communicated to the community.

Without further research it is not possible to establish whether the Castle Hill Experimental Plantation satisfies this criterion.

Technical Significance and Research Potential (Criterion E)

An item has potential to yield information that will contribute to an understanding of NSW's or an area's cultural or natural history.

Guidelines for Inclusion

- has the potential to yield new or further substantial scientific and/or archaeological information
- is an important benchmark or reference site or type
- provides evidence of past human cultures that is unavailable elsewhere

Guidelines for Exclusion

- the knowledge gained would be irrelevant to research on science, human history or culture
- has little archaeological or research potential
- only contains information that is readily available from other resources or archaeological sites

The inclusion guidelines are pointers to assist in making an assessment against this criterion but should not constrict the consideration. Similarly, the attributes described in the exclusion guidelines can be used to check if the fabric of the item or place meets the criterion, or to check a judgment that an item does not meet this criterion. In addition to a detailed examination of surviving physical fabric, documents, oral history and other sources of evidence can often assist the assessment of whether a site can reveal valuable archaeological, technical, or scientific information. For example, it may become apparent that the buried footings of a colonial house have little integrity if there is historical evidence that the site has been so disturbed that there will be no additional archaeological deposits associated with the use of the house.

The Castle Hill Experimental Plantation is a reference site for the cultivation of Australian plants for essential oils and other plant products. The surviving trees from the plantation have some potential to provide further scientific data but the amount and significance of that data would require cross-checking with archival records held by MAAS or other repositories e.g. State Records.

At this stage it is not possible to fully assess whether the Castle Hill Experimental Plantation satisfies this criterion.

Rarity (Criterion F)

An item possesses uncommon, rare or endangered aspects of NSW's or an area's cultural or natural history.

Guidelines for Inclusion

- provides evidence of a defunct custom, way of life or process
- demonstrates a process, custom or other human activity that is in danger of being lost
- shows unusually accurate evidence of a significant human activity
- is the only example of its type
- demonstrates designs or techniques of exceptional interest
- shows rare evidence of a significant human activity important to a community

Guidelines for Exclusion

- is not rare
- is numerous but under threat

The inclusion guidelines are pointers to assist in making an assessment against this criterion but should not constrict the consideration. Similarly, the attributes described in the exclusion guidelines can be used to check if the fabric of the item or place meets the criterion, or to check a judgment that an item does not meet this criterion. For example, a park in a country town may be said to be a *rare* example of Victorian public garden design, but further research may reveal that it is a *representative* example, as there are many such parks in country towns in NSW. If it is one of the few remaining examples of an important 19th century garden designer, or contains species not found in similar gardens elsewhere, it may qualify as rare in the NSW context. Assuming it is the only garden of its type in the local area, it is likely it would also be rare in the local context. The level of heritage significance at State or local levels can only be determined by comparison with other like items or by proving that there is no documentation on similar items. This helps in determining the heritage significance of an item.

While there are other plantations associated with the scientific research of Australian plants for their economic potential, including other field trials established by MAAS at various sites in NSW, the Castle Hill Experimental Plantation is the only such plantation devoted to the research of such a wide variety of Australian species and is in danger of being largely lost due to proposed extension of the Museums Discovery Centre.

The plantation is considered to satisfy the criterion for rarity at a State level.

Representativeness (Criterion G)

An item is important in demonstrating the principal characteristics of a class of NSW's or an area's cultural or natural places or environments.

Guidelines for Inclusion

- is a fine example of its type
- has the principal characteristics of an important class or group of items
- has attributes typical of a particular way of life, philosophy, custom, significant process, design, technique or activity
- is a significant variation to a class of items
- is part of a group which collectively illustrates a representative type
- is outstanding because of its setting, condition or size
- is outstanding because of its integrity or the esteem in which it is held

Guidelines for Exclusion

- is a poor example of its type
- does not include or has lost the range of characteristics of a type
- does not represent well the characteristics that make up a significant variation of a type

The inclusion guidelines are pointers to assist in making an assessment against this criterion but should not restrict the consideration. A fine representative example

needs to demonstrate key characteristics of its type or class. The intactness of the physical fabric of an item (its integrity) is another attribute that can be used to qualify the rare or representative criteria. The attributes described in the exclusion guidelines can be used to check if the item or place meets the criterion or to check a judgment that an item does not meet this criterion. For example, a group of Victorian cottages in a place with many examples of 19th century architecture, such as Bathurst or the inner suburbs of Sydney, may have representative value. In another city or suburb in which most of the 19th century architecture has been replaced they may be assessed as rare.

The level of heritage significance at State or local levels can only be determined by comparison with other like items. The attributes described for criteria (f) and (g) will assist in the determination of significance. A heritage item is not to be excluded on the ground that items with similar characteristics have already been entered on a statutory list.

The Castle Hill Experimental Plantation is considered to have lost the full range of characteristics which represented its type, namely its still house, glass house, propagation sheds, numerous trial plantings and is no longer considered to satisfy the representativeness criterion.

Conclusions

Analysis of the documentary evidence relating to the history and operation of the Castle Hill Experimental Plantation, followed by assessment of the heritage values of the site against the Heritage Council of NSW significance criteria suggests that the site satisfies the criteria for historical, associational and rarity values at a local level at least.

The arboricultural survey and assessment by MacKay Tree Management for MAAS and dated 14 May 2019 and the Heritage Review carried out by Curio Projects are both considered to be based on insufficient information and research and do not meet best practice standards for due diligence.

The General Requirements and Key Issues for the SEARs for the MDC Expansion need to be amended to include assessment of non-Aboriginal cultural heritage of the plantation site, which should include preparation of a Conservation Management Plan for the place.

Acknowledgments

The author would like to thank Jilly Warren and Elaine White (née Crust) for their kind assistance in providing information, particularly about the Crust family's time living on the Castle Hill Experimental Plantation.

References

Abbreviations

ADB – *Australian Dictionary of Biography*

ANBG – Australian National Botanic Garden

ATTIA – Australian Tea Tree Industry Association Ltd.

EOPAA – Essential Oil Producers Association of Australia
 AR – Annual Report
 CHAH – Commonwealth Heads of Herbaria
 EOAS - *Encyclopaedia of Australian Science*
 ML – Mitchell Library, State Library of NSW
 MAAS – Museum of Applied Arts and Sciences
 PMA – Powerhouse Museum Archives
 SMH – *Sydney Morning Herald*

Anonymous 'Biographical Entry Willis, Jack Lehane (1918 - 2004)', *Encyclopaedia of Australian Science*, Accessed 21 August 2020
 <<https://www.eoas.info/biogs/P002208b.htm>>

Australian Tea Tree Industry Association Ltd 2020, 'Australian Tea Tree Oil', accessed 29 August 2020, <https://attia.org.au/read_more.php?id=674>

Baker, Richard T & Smith, Henry G 1902, *A research on the eucalypts, especially in regard to their essential oils*, Technical Education Series No.13, Technological Museum, Sydney.

Baker, Richard T & Smith, Henry G 1910, *A research on the pines of Australia*, Technical Education Series No.10, Technological Museum, Sydney.

Baker, Richard T & Smith, Henry G 1924 *Wood fibres of some Australian timbers: investigated in reference to their prospective value for paper-pulp production*, Government Printer, Sydney.

Barrett, Desmond 1999, 'A cuckoo in the nest? Chemical research in museums, with special reference to the origin, development, and demise of the phytochemical research programme at the Museum of Applied Arts and Sciences, Sydney, Australia, 1879-1979', unpublished PhD dissertation, University of NSW.

Brown, Malcolm 2009, 'Ahead of his time in closing art-science gap: Howard McKern, 1917-2009', *Sydney Morning Herald* 12 December 2009, accessed 22 August 2020, <<https://www.smh.com.au/national/ahead-of-his-time-in-closing-artscience-gap-20091212-koub.html>>

Castle Hill site model 2020, Museum of Applied Arts & Sciences, accessed 17 August 2020, <https://ma.as/373318>

Clark, Philip A 2007, *Aboriginal people and their plants*, Rosenberg Publishing, Dural, NSW, 191pp.

Council of Heads of Australian Herbaria 2015, 'Biographical notes, George Althofer (1903 – 1993)', accessed 29 August 2020,
 <<https://www.anbg.gov.au/biography/althofer-george-w.html>>

Cribb, A B & J W 1981, *Useful wild plants in Australia*, Collins, Sydney, 269pp.

Davison, Graeme & Webber, Kimberley (ed.) 2005, *Yesterday's tomorrows: The Powerhouse Museum and its predecessors 1880-2005*, Powerhouse Publishing in association with UNSW Press, Sydney.

Denny, E F K 2001, *Field distillation for herbaceous oils*, 3rd edition, McKenzie Associates, Lilydale, Tasmania, 275pp.

Eberhard, I H, J McNamara, R J Pearse and I A Southwell 1975, 'Ingestion and excretion of *Eucalyptus punctata* D C and its essential oil by the koala, *Phascolarctus cinereus* (Goldfuss)', *Australian Journal of Zoology*, 1975, 23, 169.

Essential Oil Producers Association of Australia 2020, 'The Essential Oils Industry in Australia', accessed 29 August 2020, <<https://eopaa.com.au/essential-oil-industry-australia/#:~:text=Australian%20essential%20oils%20and%20extracts%20presently%20produced%20on,10%20Boronia%20absolute%20%28%20Boronia%20megastigma%20%29%20>>

Fitzgerald, Shirley & Golder, Hilary 2009, *Pymont & Ultimo under siege*, 2nd edition, Halstead Press, Ultimo, NSW and Braddon, ACT, 160pp.

Foster, Steven & Johnson, Rebecca L 2006, *National Geographic Desk reference to nature's medicine*, National Geographic, Washington DC, 406pp.

Griffin, James 1969, 'Bosisto, Joseph (1824–1898)', *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, <http://adb.anu.edu.au/biography/bosisto-joseph-3027/text4439>, published first in hardcopy 1969, accessed online 22 August 2020. This article has been amended since its original publication. This article was first published in hardcopy in *Australian Dictionary of Biography*, Volume 3, (MUP), 1969.

Hall, Norman 1978, *Botanists of the eucalypts: short biographies of people who have named eucalypts, whose names have been given to species or who have collected type material*, CSIRO, Melbourne, 101 pp.

Hall, Norman 1979, *A supplement to Botanists of the eucalypts*, CSIRO Division of Forest Research, Canberra, 19 pp.

Holland, H G and McKern, H H G 2000, 'Morrison, Frank Richard (1895–1967)', *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, <http://adb.anu.edu.au/biography/morrison-frank-richard-11176/text19915>, published first in hardcopy 2000, accessed online 21 August 2020. This article was first published in hardcopy in *Australian Dictionary of Biography*, Volume 15, (MUP), 2000

Lassak, E V & McCarthy, T 2011, *Australian medicinal plants: A complete guide to their identification and usage*, 2nd edition, New Holland.

Lawler-Dormer, Deborah (ed.) 2020, *Success and failure*, Museum of Applied Arts and Sciences, Sydney, 215pp.

Lewis, Walter H & Elvin-Lewis, Memory P F 1977, *Medical botany: Plants affecting man's health*, John Wiley & Sons, New York et al., 515pp.

Low, Tim & Rodd, Tony (eds) 1994, *Magic and medicine of plants: A guide to hundreds of native and exotic plants and their healing powers*, Reader's Digest (Australia) Pty Ltd, Sydney, 464pp.

Maiden, J H 1975, *The useful native plants of Australia (including Tasmania)*, facsimile of 1889 edition published by the Committee of Management, The Technological Museum of NSW, Compendium Press, Melbourne.

McCarthy, G J & Cohn, Helen 1993, 'Biographical Entry Smith, Henry George (1852 - 1924)', EOAS, accessed 23 August 2020
<<https://www.eoas.info/biogs/P000786b.htm>>

Museum of Applied Arts and Sciences 1961, *Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31 December 1960*, V C N Blight, Government Printer, Sydney.

Museum of Applied Arts and Sciences 1964, *Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31 December 1963*, V C N Blight, Government Printer, Sydney.

Museum of Applied Arts and Sciences 1965, *Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31 December 1964*, V C N Blight, Government Printer, Sydney.

Museum of Applied Arts and Sciences 1971, *Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31 December 1970*, New Era Printing Co. Pty Ltd, [Sydney].

Museum of Applied Arts and Sciences 1977, *Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31 December 1975*, Ambassador Press, Granville, NSW.

Museum of Applied Arts and Sciences 1980, *Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31 December 1979*, New Era Printing Co. Pty Ltd, [Sydney].

Museum of Applied Arts and Sciences 2020, 'Expansion of Museums Discovery Centre, accessed 23 August 2020 <https://maas.museum/museums-discovery-centre-expansion/?utm_source=Email&utm_medium=Newsletter&utm_campaign=>

Nutrition and you website accessed 22 August 2020 <<https://www.nutrition-and-you.com/capers.html>>

Orchard, A E 1999, 'A history of systematic botany in Australia', *Flora of Australia* Vol.1, 2nd edition, ABRIS.

Penfold, Arthur de Ramon, and Willis, Jack Lehan 1961, *The eucalypts: botany, cultivation, chemistry, and utilization*, Leonard Hill, London.

Plants for a future website, accessed 22 August 2020
<<https://pfaf.org/user/Plant.aspx?LatinName=Duboisia+myoporoides>>

Powerhouse Museum Archives 1972, MRS 309-3/1, Incoming correspondence 1951-77, E F K Denny to Willis, 23 August 1972; PMA: MRS 309-3/2, Outgoing correspondence Willis to E F K Denny, 29 August 1972.

Powerhouse Museum Archives 1979, MRS 204 78/1035, Report on chemical and botanical research at the MAAS, W R Archer, 5 April 1979.

Quick, Graeme R 2006, *Australian Tractors: Indigenous Tractors and Self-Propelled Machines in Rural Australia*, Rosenberg Publishing Pty Ltd, Dural, NSW, 192pp.

Schery, Robert W 1952, *Plants for man*, Prentice Hall, New York, 564pp.

Simpson, Beryl Brintall & Ogorzaly, Molly Conner 1986, *Economic botany: Plants in our world*, McGraw Hill, New York et al., 640pp.

Small, B E J 1981, 'Effects of plant spacing and season on growth of *Melaleuca alternifolia* and yield of tea tree oil', *Australian Journal of Experimental Agriculture & Animal Husbandry*, 21 (111), pp.439-442.

Small, B E J 1986, 'Tea tree oil'. 2nd edition. (*Agfact* P6.2.1) Department of Agriculture, NSW.

Smith, Ailie 2001, 'Biographical Entry: Welch, Marcus Baldwin (1895 - 1942)', AEOS, accessed 28 August 2020 <<https://www.eoas.info/biogs/P004108b.htm>>

Southwell, I A 1975, 'Essential oil metabolism in the koala, III, Novel urinary monoterpenoid lactones', *Tetrahedron Letters*, 1975, p.1885.

Southwell, I A 1987, 'Essential oil isolates from the Australian flora. Part 2' *Flavour and Fragrance Journal*, Volume 2, Issue 1, pp.21-27.

Swerdlow, Joel L *Natures' medicine: Plants that heal: A chronicle of mankind's search for healing plants through the ages*, National Geographic. Washington DC, 400pp.

Thursday Plantation 2020, 'Our Brand Origins', accessed 22 August 2020, <<https://thursdayplantationretail.com/about-us/our-brand-origins/>>

Wade, John (ed.) 1979, *Sydney International Exhibition 1879: An exhibition celebrating the Centenary of the Sydney International Exhibition*, catalogue for an exhibition held at the Museum of Applied Arts and Sciences, September – November 1979, MAAS, Sydney.

Walker, Rosanne 1997, 'Biographical Entry Marr, Horace Victor (c. 1883 - 1960)', EOAS, accessed 29 August 2020 <<https://www.eoas.info/biogs/P002996b.htm>>

Walker, Rosanne 2001, 'Biographical Entry Pryor, Lindsay Dixon (1915 - 1998)', accessed 23 August 2020, <<https://www.eoas.info/biogs/P003875b.htm>>

Watson, Heather 2010, *Castle Hill: Where have all the orchards gone?* The Hills District Historical Society, Inc., Castle Hill.

White. E 2007, 'Powerhouse Museum – Castle Hill Site, *Hills Heritage News*, Vol.20, No.1, February 2007, pp.3-4.

Wee, Yeow Chin 2005, *Plants that heal, thrill and kill*, SNP Reference, Singapore, 172pp.

White, Elaine 2007, 'Castle Hill (Museum of Applied arts and Sciences) Experimental Eucalyptus Plantation Now the location of the HDHS Inc. Museum', Hills District Historical Society.

Williams, Cheryll 2010, *Medicinal plants in Australia: Volume 1: Bush pharmacy*, Rosenberg Publishing, Dural, NSW, 328pp.

Williams, Cheryll 2011, *Medicinal plants in Australia: Volume 2: Gums, resins, tannin and essential oils*, Rosenberg Publishing, Dural, NSW, 344pp.

Willis, J L 1979, 'Baker, Richard Thomas (1854-1941), botanist and museum curator' in *Australian Dictionary of Biography*, Bede Nairn and Geoffrey Serle, (eds), vol. 7, Melbourne University Press, Melbourne, pp. 154-155, accessed 22 August 2020.
<<http://www.adb.online.anu.edu.au/biogs/A070154b.htm>>

Wrigley, J. & Fagg, M 2010, *Eucalypts: A celebration*, Allen & Unwin, Crows Nest, NSW, 344 pp.

Zacharin Robert Fyfe 1978, *Emigrant eucalypts: Gum trees as exotics*, Melbourne University Press, Carlton, Victoria, 137pp.